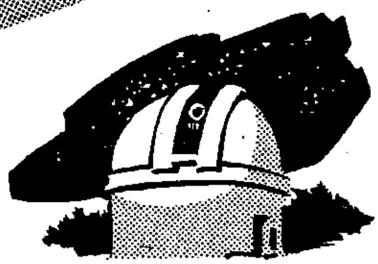

Master WATCHMAKING

A Modern, Complete, Practical Course

By

THOMAS B. SWEAZEY

and

BYRON G. SWEAZEY

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

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MASTER WATCHMAKING COURSE

Master Watchmaking

TOOLS and MATERIALS of the Trade

By

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FOREWORD

This text was prepared with two thoughts in mind: One, to give you in brief form an understanding of the common tools used in watchmaking, particularly those used with Lessons in Master Watchmaking. Second, to assist you in the oftimes difficult task of ordering materials. Lack of knowledge about proper tools and right ways to order materials can be serious stumbling blocks for newcomers to watch repair. I hope this text will remove these barriers to learning and enable you to concentrate your full attention on mastery of watch repair itself.

These pages may come as a revelation to those who have the impression that the only tools needed for watch repair are a loupe, screwdrivers, and a pair of pliers. Watch repair is precision work and demands precision tools. Skill and knowledge alone are not enough, especially if you intend to work for profit.

In the old days, watchmakers made most of their tools. Some still do. There is less need to do so now, since most tools are generally available at moderate prices. Indeed, dollar-wise watchmakers realize it is better to spend their time today in profitable watch repair than at arduous and unnecessary toolmaking. Moreover, it is possible to buy a first rate set of tools for a very modest sum if you buy wisely. You should look upon tools as an investment rather than an expense, because they will repay their initial cost many times over in their long years of service.

The tools described herein include the basic tools most likely to be acquired as well as some others you should know about. Not every tool can be covered in the limited space. Those described should be considered only as representative. No attempt has been made to compare the merits of one manufacturer's item against another's. All that is intended is to give you an understanding of what a tool should do. Knowing this, you can more ably judge the advantages claimed for any particular make.

Even so, the task of selecting tools is not easy. Manufacturer's catalogs present a tempting -- but bewildering -- array. The ever-present question is "Which tools should I buy first?" A few suggestions may help determine the answer.

First, consider your aim in watchmaking. Hobby? Or career? Obviously the needs for both are not the same. The professional ordinarily requires more tools than the amateur. This is not only because he handles a greater variety of work, but he must do it fast and economically if he expects to make a profit.

Next, consider how often you will use a tool. If you are going to have frequent use for it, and can do better work with it than without it, you probably should buy it. By limiting your first purchases to the tools you will habitually use, you avoid tying up money in special purpose or limited-use tools. These will come later when you see the need for more speed or more convenience.

A third consideration is what you can afford. It is sound advice to buy the best tools, if you can. This may not be possible in your situation. Students, especially, must often economize. If this is true of you, you should have a good understanding of what tools are used for. You can then more readily decide where you can hold off buying a tool, or can use a less expensive one, and where it would be a false economy to buy a cheap tool. For instance, it is no particular disadvantage to use an inexpensive set of screw drivers while learning. You can buy a better set later at no great cost. But it would be folly to buy a cheap truing caliper or similar tool where accuracy demands a precision tool of high quality.

As a further help for those who must economize while learning, this text suggests some substitutes for certain tools, enabling you to postpone their purchase until you can afford them. These substitutes make use of other tools you are likely to have or other methods for doing the work. Such makeshifts are usually adequate for training, but should be replaced with the genuine article the first chance you have. In any event, don't force any tool beyond the limits for which it was intended.

When it comes to ordering materials, you should find these pages of considerable help. Typical methods for ordering and the type of information required are included to guide you in getting the exact material you want. Vague orders are a great expense, both for you and your supply house. They can mean extra correspondence, time lost and dissatisfied customers. If you realize this, you will understand the importance of this training and the value of this section of the text.

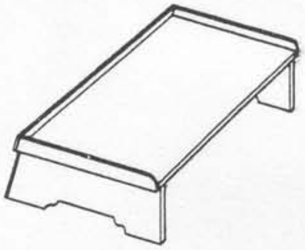
It ordinarily takes some years of practical experience to acquire the information that is presented so compactly here. I hope, therefore, that you will use these pages to advantage in speeding your progress.

B. G. S.

WATCHMAKER'S BENCH

Watchmaker's benches are generally made of wood. They come in different finishes such as mahogany, oak and walnut. The bench contains small drawers and compartments in which the watchmaker can place his tools and materials. Average height is about 38 inches, width 22 inches and length 42 inches.

AUXILIARY BENCH

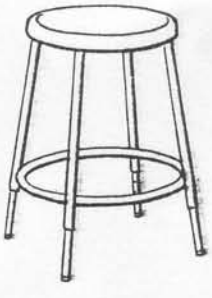


The beginner can improvise a working surface such as a table or drawing board. In order to raise the height of a table to 38 inches, it is advisable to make an auxiliary bench which can be set on an ordinary table and be readily removed and stored when not in use.

TOOL CHEST

This portable cabinet is convenient for holding tools and materials if a regular bench is not available. It measures about 20 inches long by 9 inches wide by 12 inches high.

STOOL



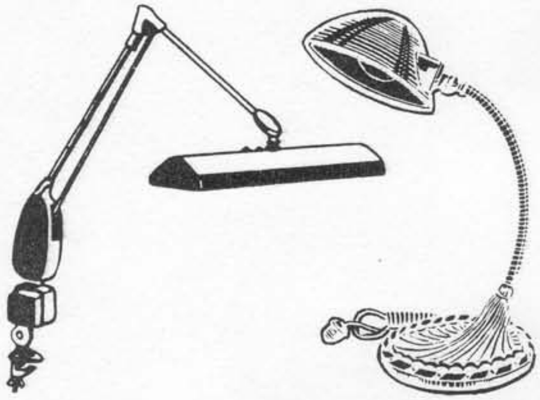
A small stool is the most common form of seat used by the watchmaker. It should be adjusted to a height which allows the workman to rest his arms on the bench, at the same time keeping his shoulders back. This allows him to work without tiring as the bench supports the arms and proper breathing results. The beginner can use an ordinary chair.

POSTURE CHAIR

The posture chair illustrated is becoming more and more accepted among watchmakers as a welcome addition to their equipment in making working conditions better. The better shops use this type of equipment, not only for watchmakers, but for all persons who sit down to do their work. It can be readily adjusted to fit the individual's requirements.

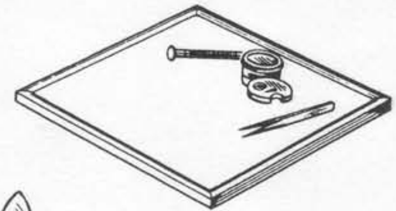
BENCH LAMPS

Good light is important. The watchmaker's bench should be placed as near to natural light as possible. North light is the most ideal. It is usually necessary to supplement the natural light with artificial light and there are many types of lamps for this purpose. A common gooseneck lamp with a round or oval reflector using about a 60 watt bulb is ideal. Another type is the fluorescent lamp which has been power corrected for watchmakers and is generally cooler.



BENCH PLATE

An auxiliary working surface of some sort of white material is recommended. A surface of hard enamel is not recommended. The beginner can use a piece of Bristol board or any white paper which will lie flat.

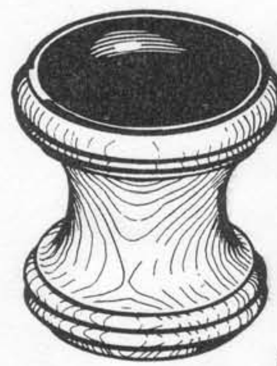


CASE OPENERS

A - Case openers are used to pry open the front and back of snap type cases. They come in many shapes and styles. They can be made from a piece of flat steel which has a curved edge and ground to a dull knife edge. It should be hardened and tempered. The beginner can use the blade of a small knife.

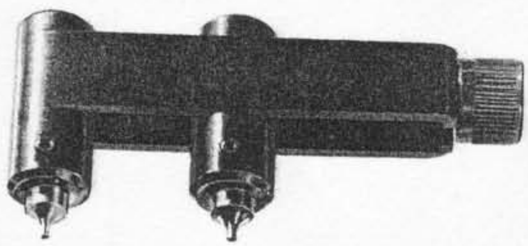
B - A rubber suction grip type of case opener can be used to remove the back and bezel on screw type cases of pocket size. The beginner may substitute a piece of rubber such as a small piece of inner tube.

A



B

C - A waterproof case opener is usually a type of wrench used to remove screw-back waterproof cases. There are many types of backs, requiring a variety of wrenches. The illustrated opener has reversible tips, which will open most types of screw backs.

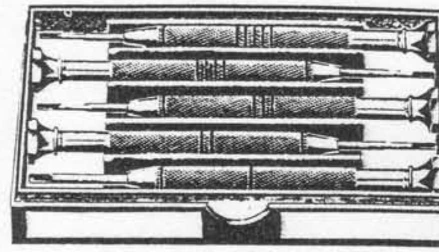


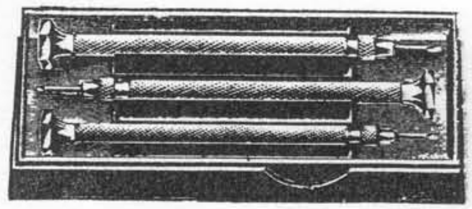
C

DOUBLE POLISHING CLOTH

This type of polishing cloth is comprised of an outer cloth, which keeps the hands clean when polishing metal, and an inner cloth which has been impregnated with rouge. It can be used to brighten all types of gold and silver jewelry, including the family silverware.

SCREWDRIVERS

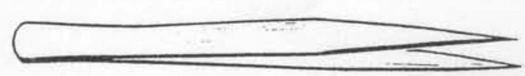




The blades of watchmaker's screwdrivers are made of hardened and tempered steel. The head of the screwdriver remains stationary against the finger which is placed upon it, while the stem and blade revolves freely when in use. Screwdrivers are made in a variety of blade widths to fit the wide variety of screw head diameters. It is necessary to select a screwdriver of a width slightly smaller than the screw head so as not to damage the screw head or the plate.

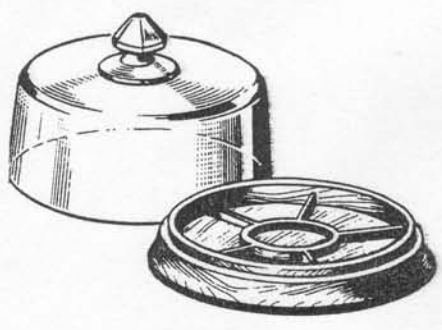
The smaller screwdrivers, used to remove jewel screws, range in size from .60 mm to .85 mm.

ASSEMBLY TWEEZERS



There are many types of watchmaker's tweezers. The assembly tweezer is a general purpose tweezer used for assembly work and handling watch material. The type illustrated is an excellent tweezer for general work but there are many other different styles and shapes f points.

ATERIAL TRAY AND COVER



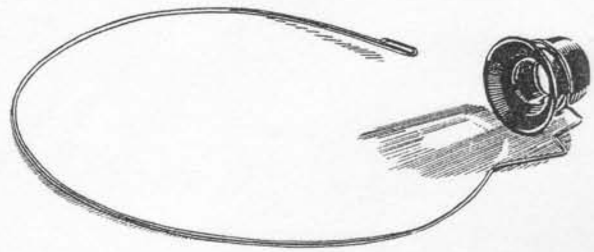
Most material trays are divided into secons in which to place the parts of a watch as is disassembled. For example, train wheels one section, balance and escapement in other, and so on. Most trays are covered in der to keep the parts free of dust and moist-e. The beginner may use a clean porcelain h, such as a saucer with an inverted glass.

TCH PAPER

Vatch paper is used when handling parts of hes or watch movements. It is made from grade, tarnish-proof tissue and usually s in sizes about 2-1/4 x 2-1/4 and 4-1/4 /4 inches. The tissue is placed between ingers and the movement or parts when ing. The beginner can substitute a good of tissue which has been cut to either of nensions given. Watch paper is also used ap parts of watches and materials when g samples to the supply house.

LOUPE OR EYEGLASS

For the person who is not required to wear glasses a single eyeloupe is recommended for all general purposes. It can be held in place by using a head wire. The loupe should be approximately a 3 inch focus. This is comparable to a magnification of 3.3 times.

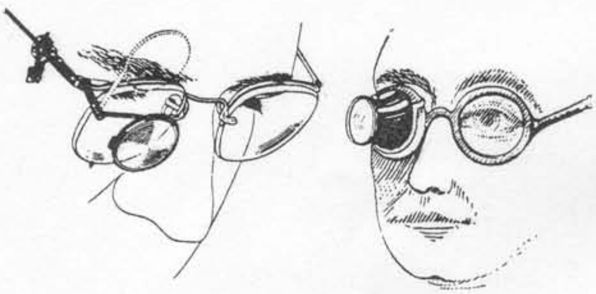


DOUBLE LOUPE

A two lens loupe used for close work and more magnification. The outer lens can be removed, thus reverting to a single loupe. Double loupes are available in many different powers and focus. The ideal double loupe for general work should magnify approximately 7-1/2 times.

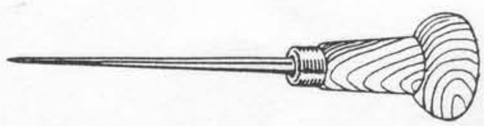
SPECTACLE LOUPE

For the person who must wear glasses to correct vision, this type of spectacle loupe is preferred. It is quickly attached and detached. A 3 inch focus is recommended for general bench work. For those wearing bone rim glasses, a loupe similar to this is made to fit the frame. A loupe holder may also be used to attach the regular loupe to the glass frame.



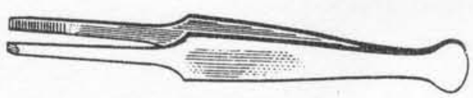
AWL

An ordinary awl is extremely handy around the watchmaker's bench. It can be used for punching holes in leather, opening clasps on bands and marking outlines in plastic etc. Any sharp pointed instrument may be substituted.



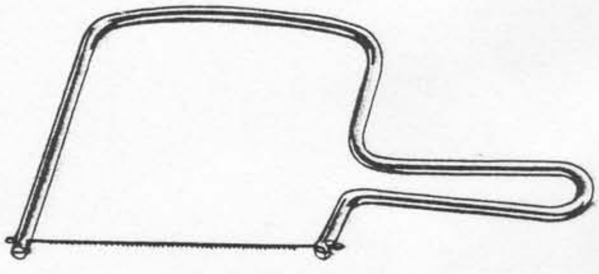
SOLDERING TWEEZERS

These tweezers are used to hold materials when heating, hardening and soldering. Some tweezers have a clamp as an added feature.



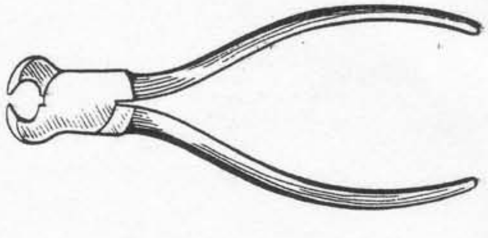
COPING SAW

A small inexpensive coping saw is useful for cutting wood and plastic. It can be obtained at most hardware stores.

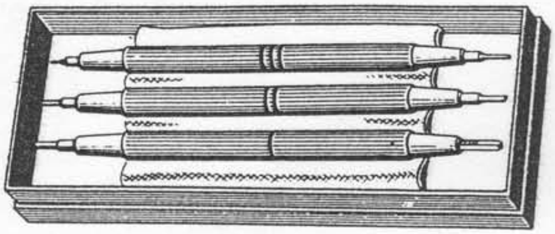


END CUTTING PLIERS

An end cutting plier of the type illustrated is another of the common type of watchmaker's pliers. It is made to cut soft steel, brass, nickel, and other materials.



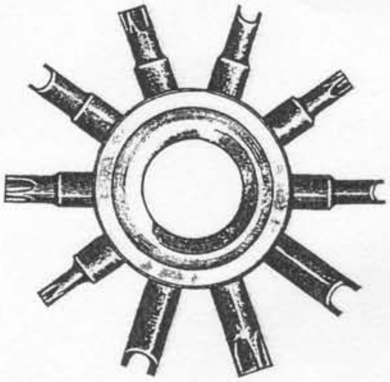
BENCH KEYS



These usually come in sets of three with double end and are used for winding and setting watches after removal from the case. They are seldom applicable to watches of Swiss manufacture, which use a different type of winding and setting arrangement. The beginner can readily make a set of bench keys from steel rod. After the pieces have been shaped to the proper size squares they should be hardened and tempered to a blue color. They can then be mounted in handles of metal or wood. The following dimensions are the most common:

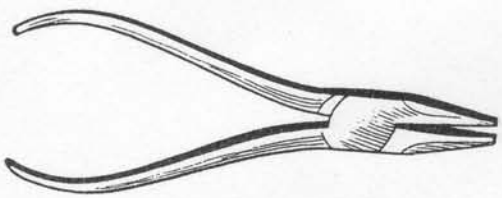
Length of square	Thickness of square
.6 mm	1.5 mm
5.5 mm	1.3 mm
4.5 mm	1.1 mm
4.5 mm	1.0 mm
3.3 mm	.8 mm
3.3 mm	.6 mm

SLEEVE WRENCH



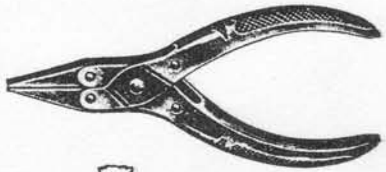
Sleeve wrenches have 3, 6 or 10 prongs. The prongs are of varied shapes and sizes and are used to remove or adjust sleeves, generally in pocket watch cases.

FLAT PLIERS



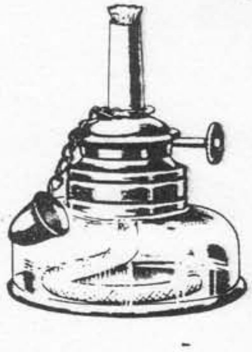
Flat pliers have a variety of uses to the watchmaker and jeweler. A flat plier of good quality, approximately 4-1/2 inches long, is ordinarily used. The beginner may use any type of plier by taking precaution not to mar the surface of the parts being worked on.

PARALLEL JAW PLIERS



Used to hold small objects more securely. They differ from the conventional flat nose pliers in that the jaws remain parallel whether open or closed.

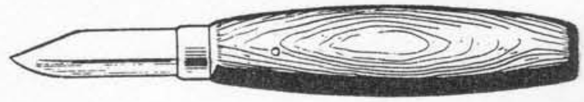
ALCOHOL LAMP



A small alcohol lamp similar to the one shown is a necessary piece of equipment for the watchmaker's bench. The fuel for these lamps is usually obtainable in a drug or paint store and is a denatured alcohol suitable for burning.

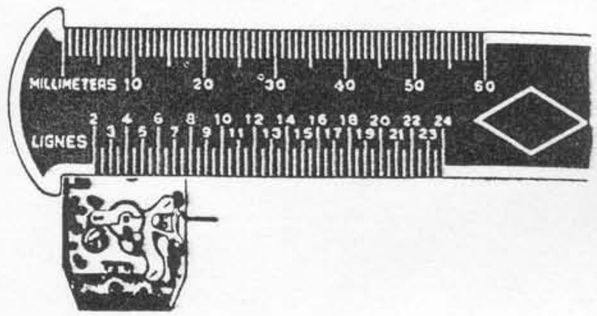
BENCH KNIFE

A small sharp knife used to sharpen peg wood. Any small pocket knife will suffice as a substitute.



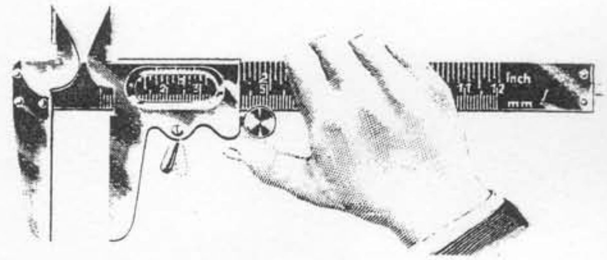
LIGNE GAUGE

A small ligne gauge is usually obtainable from your supply house. It is handy to measure the diameter of movements to determine the size; however, it is not generally as accurate as the millimeter gauge.



MILLIMETER GAUGE

The gauge illustrated is a common type of millimeter gauge with a vernier for subdividing the millimeters into tenths. It is used for measuring the length and outside diameter depth in millimeters. MM is the abbreviation for millimeter. Later a description will be given of the micrometer, which measures to one/one-hundredth of a millimeter.

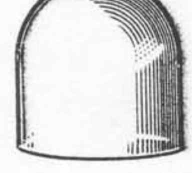


CLOCK OIL

Clock oil, while principally used for oiling pivots on a clock, is used by the watchmaker to oil mainsprings and the winding and setting parts of the watch. It should be kept covered at all times and in a dark place. It should be removed from the bottle several drops at a time and placed in an oil cup. This assures the watchmaker of having clean, fresh oil at all times. Do not add fresh oil to the oil cup without first disposing of any remaining old oil.

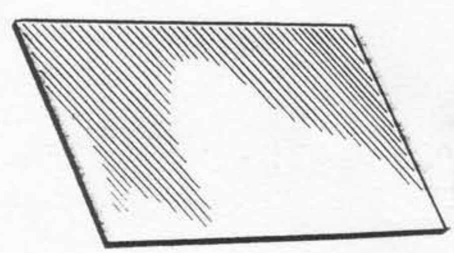
CRYSTAL FORMER

For the beginner, any half round object of glass or metal and about 4 inches across will serve. A smaller size is desirable for small crystals. The crystal is shaped over the former and should be formed high enough to let the hands of the watch rotate without rubbing.



CRYSTAL MATERIAL

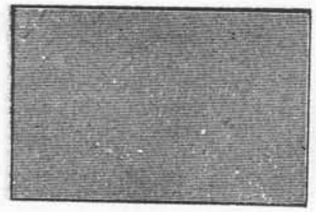
Crystal material for making and forming fancy shape watch crystals is usually of plastic, the most common of which is known by the trade name PLEXIGLASS. It can be formed and polished with a minimum of effort.



POLISHING PASTE

A good silver polishing paste can be used to polish the edges of a crystal after the rough edges have been smoothed with crocus paper. This polish can also be used to polish silverware and jewelry.

CROCUS PAPER



This is an abrasive material which is glued to smooth paper. It is used to remove scratches from metals and plastic. The student may use it to smooth the edge of non-breakable watch crystals.

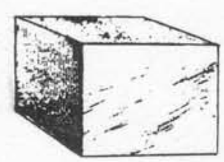
CRYSTAL CEMENT

Crystal cement generally comes in tubes. These tubes are made with a needle cap which allows the cement to flow freely. Replacing the cap will keep the cement clean and liquid. It is used primarily as a sealer between the bezel and the crystal to keep dust from entering and not to hold the crystal in place.

BRACELET CORD

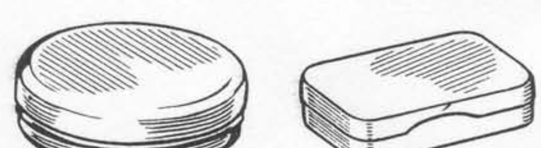
Replacement cords for ladies watch bands come in different diameters. The principal color is black. The old cord is used as a guide when replacing the cord. After the new cord has been cut to length, the ends should be dipped in hot wax.

PARAFFIN WAX



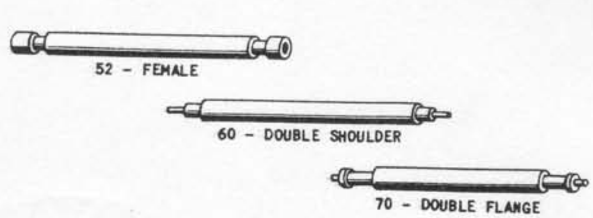
A small piece of paraffin wax is ideal for tipping the ends of the cord bands used on ladies' watches. The wax can be heated in a small material can.

MATERIAL CAN



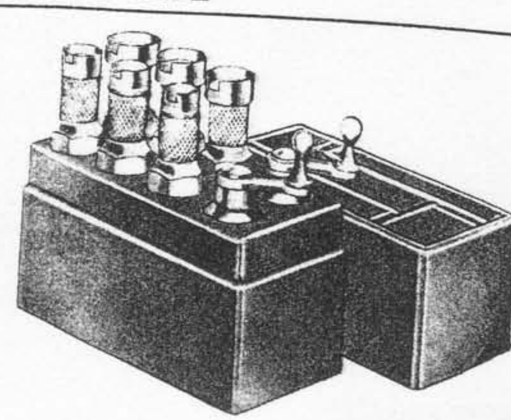
Small metal containers of varying shapes are known in the trade as material cans. They are usually furnished by the supply houses to hold watch material in mailing.

SPRING BARS



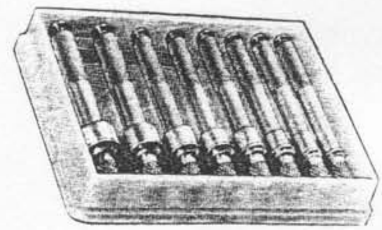
A small assortment of spring bars should be kept handy at all times. They come in assorted lengths in either regular or thin diameters.

MAINSPRING WINDER for Pocket Watches



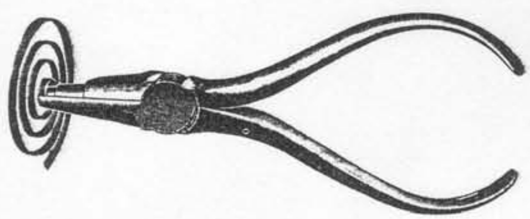
The mainspring winder is an indispensable tool used to insert the mainspring in the barrel. The winder illustrated has six loading barrels, the smallest being 8.8 mm, and is graduated up to 16.0 mm. It comes with two sizes of winding arbor. This winder is used on pocket size watches.

MAINSPRING WINDER for Bracelet Watches



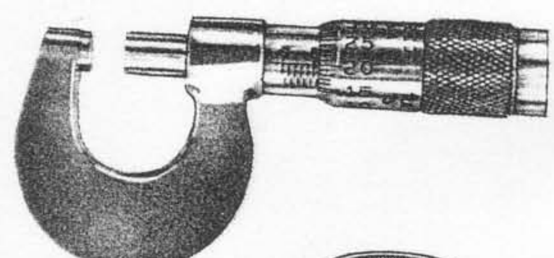
This set of 8 mainspring winders for bracelet watches ranges in size from 5 mm to 10 mm. They are a necessity for the watchmaker who works on small watches. There is no practical substitute for a mainspring winder.

MAINSPRING COILING PLIERS



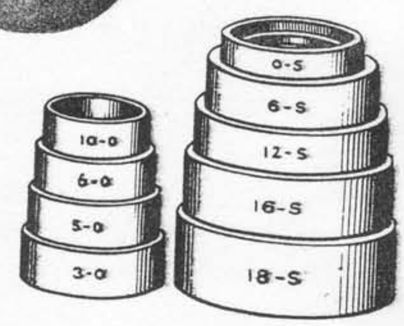
These pliers, with a specially designed end, are used to adjust the inner coil of a mainspring to fit the arbor. Slight alterations can be made with a pair of heavy tweezers if care is used not to snap off the end.

MICROMETER



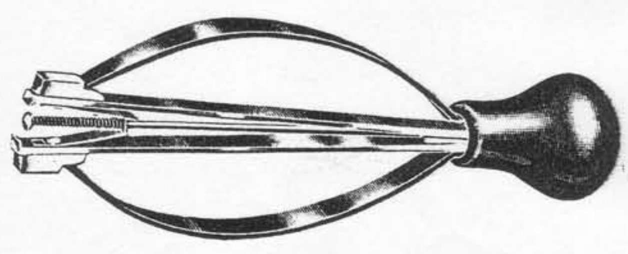
The illustrated metric micrometer is graduated in 1/100 of a millimeter. This is a must item for the beginner as well as the professional. Practically all working parts of a watch are gauged in hundredths of a millimeter.

ASSEMBLY BLOCKS



The assembly block is a cylinder used to hold the movement while working on it. The illustrated set is of plastic and ranges in size from 7-3/4 lignes to 18 size.

HAND REMOVER



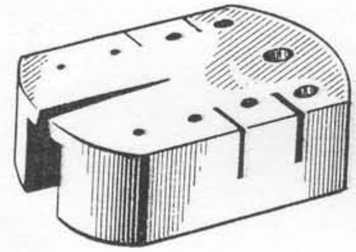
This tool is designed to remove the hands of a watch without damage to the dial. Some of the old time watchmakers use two small screw drivers to pry up the hands while protecting the dial with either celluloid or watch paper.

FLAT FILE

An ordinary file is in order around the watchmaker's bench. As a general rule, watchmakers have a variety of small files, but the reference here is to a flat file from six to ten inches long and with a medium cut.

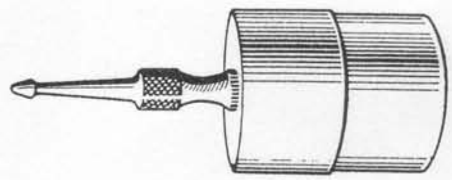
BENCH BLOCK OR ANVIL

This steel block has various size holes and slots to support different parts of the watch on which work is being done.



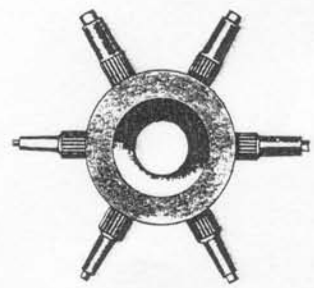
BLOWER

Used to blow off particles of lint or for drying certain parts of the watch, such as the balance and pallet fork. Not an essential item for the beginner, but a must for the professional. The beginner may substitute a small rubber syringe which can be purchased in a drug store.



JEWEL PUSHER

This tool is used to push out jewel settings such as a cap and balance jewel in setting. The tool has several size pushers to match different size settings. The beginner may use pegwood cut to the required size.

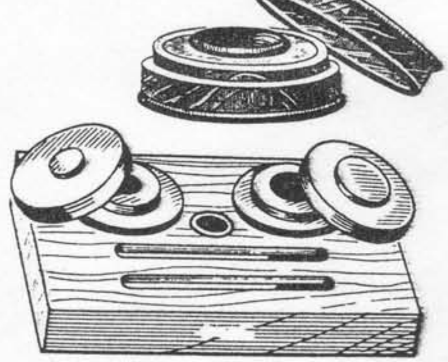


OIL CUP

Watchmakers use a small covered receptacle to hold oil. Only a little oil should be kept in the cup at a time and the cup should be cleaned frequently. The watchmaker should have at least three oil cups:

1 for clock oil
1 for regular watch oil
1 for bracelet watch oil

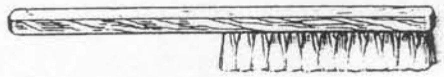
The beginner may be able to obtain small glass salt cups for this purpose.



HARD WATCH BRUSH

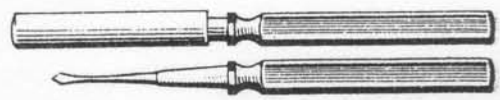
This brush is used in the hand method of cleaning watches to scrub plates and other parts. It is made of materials that will not set up a chemical reaction in the solutions, which might cause corrosion.

SOFT WATCH BRUSH

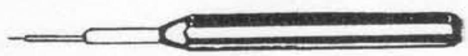


Used to remove any particles of dust or lint that may settle on the parts of the movement after cleaning. This brush should not be used after the movement has been assembled due to the presence of oil and the possibility of smearing it.

WATCH OILERS



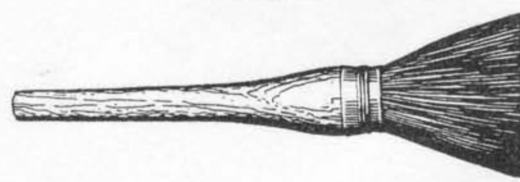
Used to oil the parts of the watch. They are usually made of steel or nickel ground to a diamond-shaped tip. They are available in a variety of sizes, the smallest being used to oil those parts requiring the smallest amount of oil, and so on. The beginner may make his own oilers from needles. The illustration shows the shape of the tip.



OIL INSERTER

This tool is used to induce oil through the balance hole jewel onto the cap jewel. The beginner may make one by reducing a fine piece of steel such as a needle to a very fine point, approximately 5/100 mm.

DIAL BRUSH



Used to brush off the dial after the movement has been assembled as well as to remove any dust or lint before casing the movement.

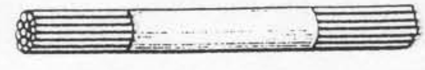
ALCOHOL CUP

Used by the watchmaker as a container for alcohol, benzine, naptha, and so forth. These are solutions used in cleaning. The alcohol cup is usually fitted with a ground glass top, which retards evaporation. The beginner may use any small glass jar.

GLASS JARS

These pint jars hold cleaning solutions. The beginner may use mason jars or any other good substitute so long as there is not a rubber seal on the jar. Cleaning solutions will cause rubber to dissolve and contaminate the solution.

BRASS WIRE



Used to string parts for hand cleaning. Also used in lathe work.

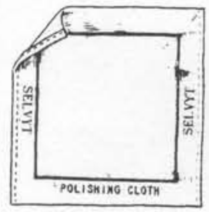
WATCH OIL

A fine grade animal or fish oil is used to lubricate the moving parts of a watch.

OILSTONE POWDER

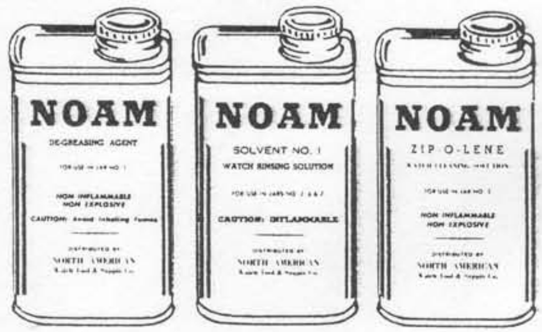
This abrasive powder is used in finishing metal. It is mixed with oil into a paste. When applied to a grinding slip, it may be used to grind pivots or other steel surfaces.

SELVYT CLOTH



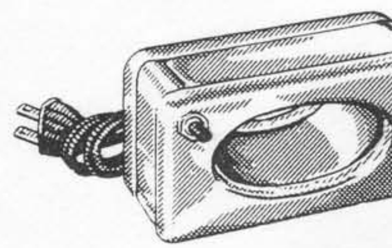
This type of cloth is used by watchmakers and jewelers in handling watches and jewelry to keep it free from finger marks. It is a lint-free, washable cloth.

CLEANING AND RINSING SOLUTIONS



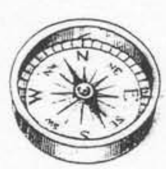
There are many commercially prepared cleaning and rinsing solutions in use. They are alike in this respect: they remove the old oil, clean and brighten the parts, and dry without leaving any sediment. Many watchmakers prepare their own solutions, using formulas that have been found to give satisfactory results.

DEMAGNETIZER



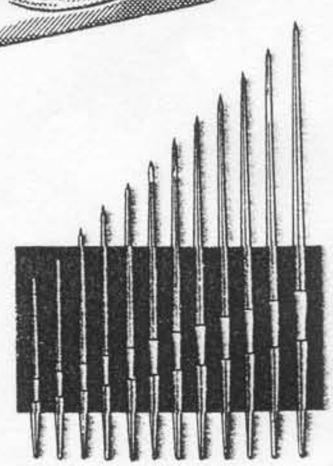
This is an electrical device used to remove magnetism from a watch movement. It is a desirable piece of equipment, for there is no other convenient method of demagnetizing.

COMPASS



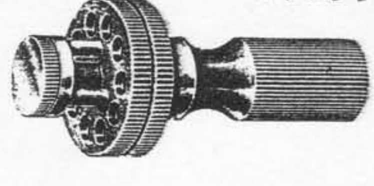
A small magnetic compass is used to detect magnetism in a watch.

LARGE BROACHES



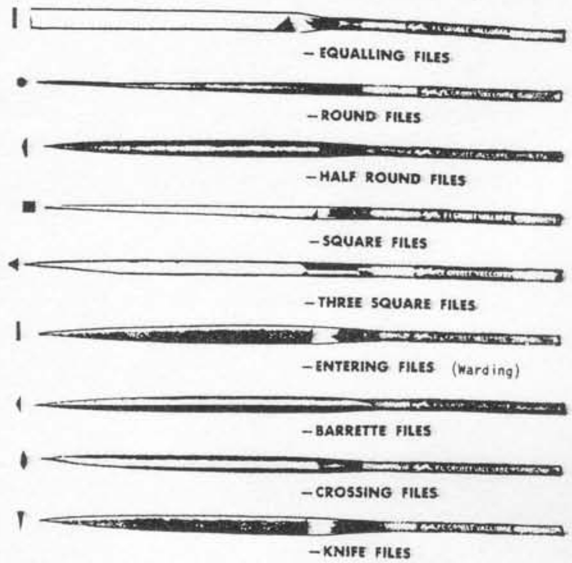
These are tapered cutting tools designed to enlarge holes. They are usually made up in assortments of different sizes. They are used in fitting hands to movements and similar jobs.

HAND BROACHING DEVICE



This vise-like device is used to hold hands while they are being broached.

NEEDLE FILES



These are small, fine-cutting files that come in a variety of shapes. They are used on many jobs requiring fine work, such as fitting and shaping of regulator pins.

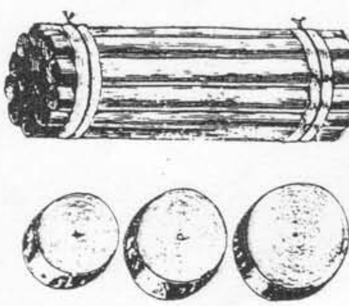
The first five files illustrated are the ones most commonly used by the watchmaker.

PEGWOOD

These are round sticks of Dogwood used for cleaning purposes. They are usually obtained from France. Pegwood comes in three sizes: small, medium and large. The last is usually called "clock pegwood" because its main use is for clock work. The medium size is more commonly used by the watchmaker. The smallest size is handy for tiny bracelet watches.

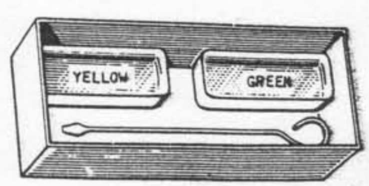
Pegwood can be sharpened to a point like a pencil. It is used in cleaning to reach hard-to-get-at places, such as pinion leaves. It can also be wet with naptha and used to peg out pivot or jewel holes. Cut to size, it can serve the beginner as a jewel pusher.

PITHWOOD



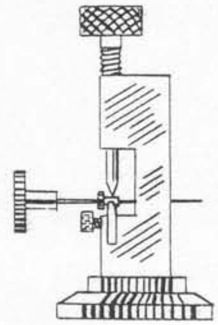
A soft, sap-free wood from the center of Elder tree branches. The watchmaker finds many uses for it. The sponge-like nature of the wood allows delicate parts to be pushed into it without damage. One use, therefore, is to clean oil from pivots before inspection. Another is to hold wheels, pinions and staffs while they are being measured or examined. Fine pointed tools, watch hands, and so forth can also be stuck into pithwood for safekeeping.

LUMINOUS PAINT KIT



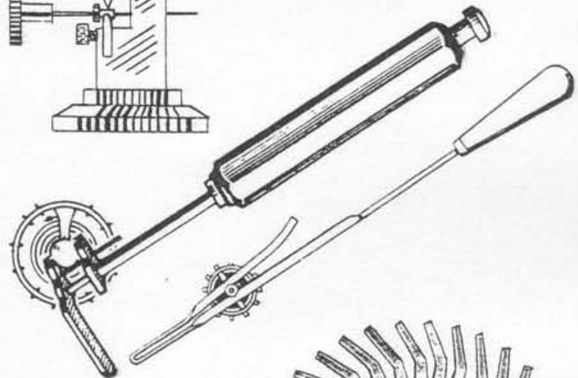
A compound which may be used to refinish luminous hands. The mixture has a wax base and comes in a paste form. It is applied to the hands with a metal applicator, which has been warmed and dipped into the pan of paint. The heat causes a small amount of paint to stick to the applicator and melts the paint enough to flow it onto the hand while still warm. If the result is uneven, it may be trimmed with a knife blade.

CANNON PINION TOOL



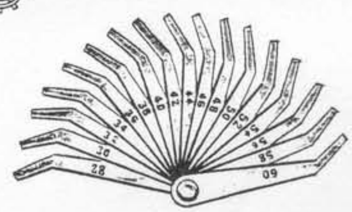
Used to tighten a cannon pinion. There are other methods used to close or fit a cannon pinion but the cannon pinion tool is considered the most practical and safest method.

ROLLER JEWEL SETTER



Used to hold and conduct heat to the roller table in order to set or make adjustments to the roller jewel.

ROLLER JEWEL GAUGE



A feeler gauge used to measure the pallet fork slot to determine the proper size of roller jewel.

TIMING WASHERS

These are small brass washers used in poising balance wheels and timing of watches. They come in assortments, and are segregated in sizes and weights to fit the different sizes of watches. The weight is designated by a listing of the approximate amount of time it will alter a watch, such as 1 minute, 2 minutes, etc. This listing refers to a pair of washers placed on opposite screws near the neutral point on the balance wheel rim.

GENUINE AUNES
For American and Swiss Watches

COMPLETE ASSORTMENT No. 5
TIMING WASHERS
From 3¾ Ligne to 18 Size

Bottle	Ligne	Min.	Bottle	Size	Min.
47	3¾	2	57	10/0	1
48	4¼	1	58	10/0	2
49	4¾	2	59	0	1
50	5¼	1	60	0	2
51	6	2	61	6	1
52	6½	1	62	6	2
53	7		63	12	1
54	8		64	12	2
55	9		65	16	1
56	10		66	16	2
			67	18	1
			68	18	2

STUD PINS

Small tapered brass pins used in studding hairsprings. May also be used in replacing regulator pins etc.

SHREDDED SHELLAC

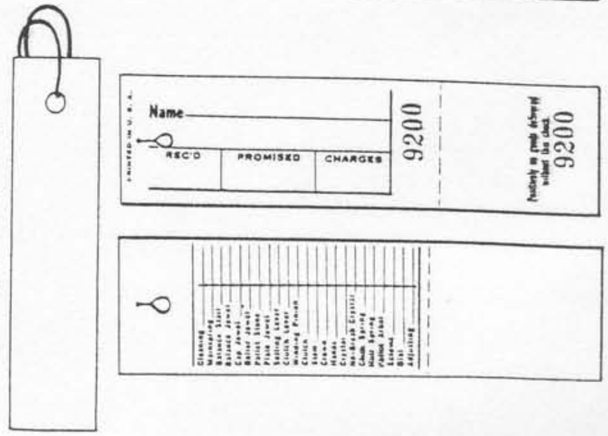
This shellac is used in cementing roller jewels.

STICK SHELLAC

Used with the lathe in cementing jewel settings, staffs, etc. This cement may also be used for setting roller jewels if you have no shredded shellac.

WATCH TAGS

Tags are used by a watchmaker to identify a customer's watch during repair. These tags may be plain, in which case you will fill in the desired information, such as name, date, charge, and so forth. More elaborate tags include a tag number, space for explanation of work performed, and the like. Tags are excellent for the beginner to use in recording repairs made in his practice work.

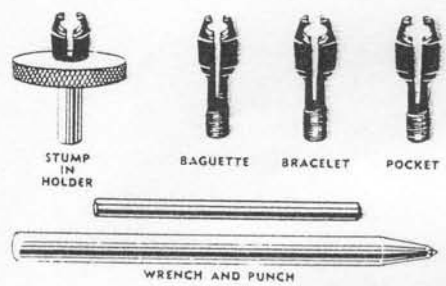


ROLLER JEWELS

When doing repair work it is desirable to have an assortment of roller jewels in a complete range of sizes, including both short and long jewels to fit both single and double rollers. The "D"-shape jewels are the most commonly used. They are gauged in 1/100 mm.

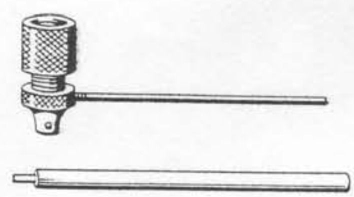
ROLLER REMOVER

This tool is used to remove roller tables and is designed for use with a bench block or staking tool. See page 22.



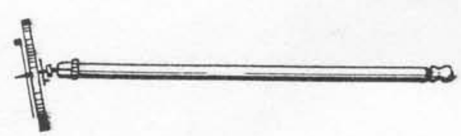
STAFF REMOVER

This tool is designed for use with the staking tool and is used for removal of riveted balance staffs. See page 22.



PIVOT ROUNDER

This small tool is fitted with a sapphire end which is placed over the bent pivot. Revolving the rounder between the fingers forces the pivot back to its original position. It also removes burrs and polishes the pivot.



PIN VISE

A small hand vise is used to hold small objects, such as a stem, needle, and similar items.

SCREW HEAD FILE

A very fine-cutting, knife-edge file used to cut the screw driver slot in the head of a screw. It is also used to shape regulator pins and the like.

FRICTION JEWELING TOOLS

This tool is used to ream, press in and make adjustments to friction jewels. If the jewel to be replaced is a friction jewel, you need only press out the cracked or otherwise damaged jewel, determine the size of the hole (if the hole is not damaged), press in a friction jewel of the proper diameter and pivot hole size and adjust for proper end-shake. If the hole has been damaged, you should ream it with the next size reamer and then press in the proper size jewel.

In replacing other types of jewels with friction jewels, a more thorough knowledge of jewels and jewel settings is needed. This additional information can be found in Lessons in Master Watchmaking 12, 13 and 14.

BASIC SET

The basic set will usually consist of the following:

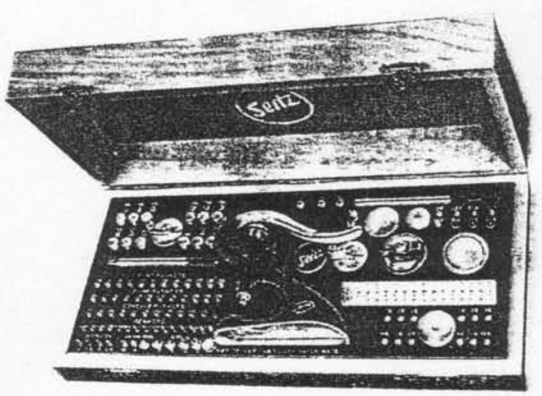
- Friction jeweling tool (with micrometer adjustment to control depth)
- Reamer holder
- Reamers (12 to 15)
- Pusher holder
- Pushers (12)
- Anvils (5)

COMPLETE SET

The complete set will usually include in addition to the basic parts:

- Concave pushers
- Pump pushers
- Hole reducing punches
- Set of tools for setting friction pallet arbors.

DELUXE SET



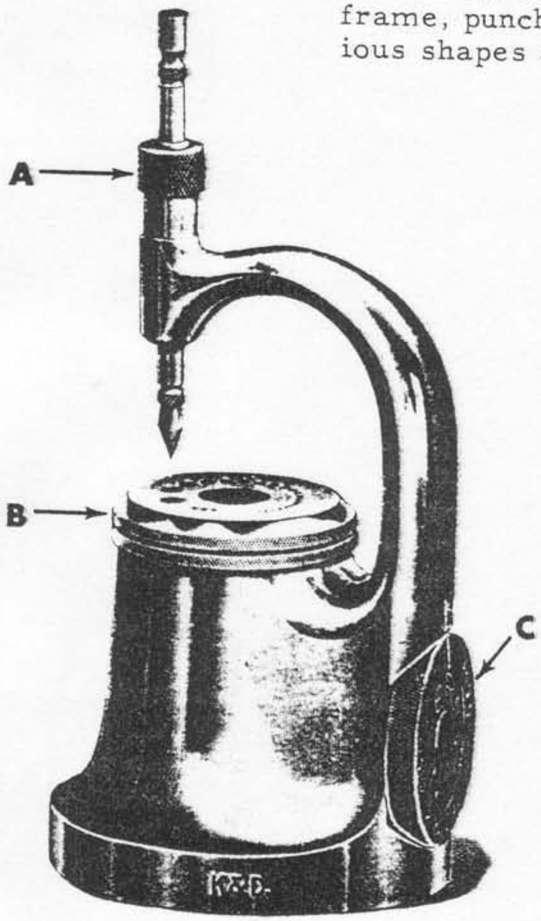
The deluxe set will usually include in addition to the parts listed above:

- Grinding stone (for refacing pushers)
- Holder for jewel settings
- Face plate with additional clamps
- Set of centering points
- Set of pushers and anvils for setting hands.
- Handle with set of chucks
- Tool for straightening pivots
- Pivot gauge
- Uprighting pump tool

THE STAKING TOOL

The staking tool is a tool of many uses, such as, removing and replacing a balance staff, closing pivot holes, removing or replacing pinions, replacing hands, replacing a hairspring, etc. With a few exceptions the following information will apply to all staking tools.

The staking tool consists of the following parts: the staking frame, punches in various shapes and sizes, and stumps in various shapes and sizes.



STAKING FRAME

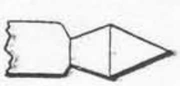
STAKING FRAME

The punch guide A is aligned with the die plate B so that the punches will always be perpendicular to the die plate. The die plate may be turned so that any hole may be aligned with the punch. Turning the knurled wheel at C will lock the die plate in any desired position. The holes in the die plate are gauged and centered and give you the right spread of sizes from small to large.

STAKING PUNCHES

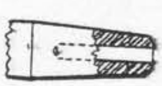
Practically all work on the staking tool will require that the proper hole in the die plate be aligned with the punch. The centering punch serves this purpose.

CENTERING PUNCH



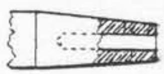
First determine the hole in the die plate to be used. Then insert the centering punch through the punch guide into the hole in the die plate and lock the die plate in position before removing the punch.

ROUND FACED HOLLOW PUNCH



Its most common use is in staking balance staffs. After the die plate has been centered, the staff with wheel in place is placed in the die plate, and a round faced hollow punch of a size just slightly larger than the collet seat is used to spread the rivet on the staff.

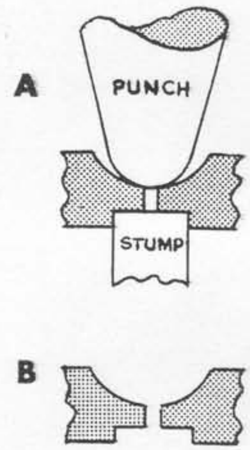
FLAT FACED HOLLOW PUNCH



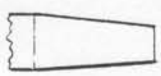
Used for finishing the riveting of balance staffs. After using a round faced hollow punch to spread the rivet, a flat faced hollow punch of the same size hole is used to finish off the top of the rivet. This punch has many other uses, such as pressing the hairspring collet on the staff, hands on watches, and the like.

ROUND FACED SOLID PUNCH

Generally used for closing pivot holes etc. The proper size of punch to use is determined by the size of the oil cup and should fit as shown in illustration A. The bottom of the plate should be properly supported with a stump or inverted punch and if there is a recess as shown in illustration B, the stump should be of a size which will fit the recess. This punch has a variety of other uses such as closing the hole in a minute hand, closing the hole on a single roller, and so forth.

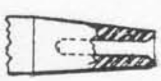


FLAT FACED SOLID PUNCH



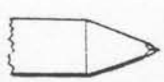
Generally used as an inverted stump.

HOLLOW TAPER MOUTH PUNCH



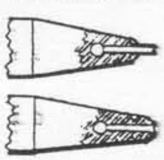
Used for closing holes, such as hour hand, and for closing collets etc. Use care in selecting the proper size of punch.

STAR PUNCH



Sometimes known as the triangular point punch. It is used to close the hole in rollers by raising small burrs equidistant around the edge of the hole.

CROSS HOLE PUNCHES

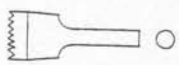


Used in removing and replacing Waltham friction staffs. These punches are designed to fit over the pivot and rest on the cone rather than against a shoulder.

ROLLER DRIVING PUNCH

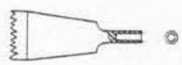
This punch was designed to replace single rollers. It is a flat face hollow punch with a slot cut in the edge to accomodate the roller jewel. Modern methods of replacing a roller do not require the use of this punch.

SCREW KNOCKING PUNCH



This punch is designed to drive out a screw which has been broken off in the plate. This is practical only if you have an oversize screw available and also a tap of the proper size to cut new threads, as the old threads will be stripped. The more practical method of removing a broken screw is to use an acid solution which will dissolve the steel screw and leave the brass or nickel threads intact.

INCABLOC ROLLER PUNCH



This punch is designed for use in replacing an incabloc roller. The incabloc roller has a raised edge on the bottom. This punch fits within this edge and so minimizes the possibility of damage to the roller.

STUMPS

The manufacturers have done little to modernize their assortment of stumps. In most staking sets may be found stumps no longer in common use, as more modern tools and methods have been devised. Using the inverted style of tool, any of the punches can be turned over and used as stumps.

FLAT FACE SOLID STUMP

This type of stump has a variety of uses. Most staking sets have several of these stumps in different sizes. They may be used any time a flat solid surface is desired.

FLAT FACE HOLLOW STUMPS

Most staking sets are equipped with these stumps in a variety of sizes. They may be used to support a plate when drilling, broaching, etc.

FLAT FACE TAPERED HOLLOW STUMPS

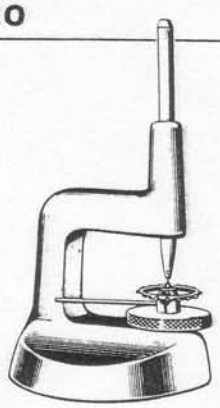
Used to support the hub on a Waltham friction type balance when the staff is being removed.

FLAT FACE STRAIGHT HOLE STUMP

Used to support a Waltham friction staff while the wheel is being staked on.

ROLLER REMOVING STUMPS

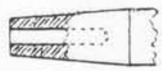
These stumps were designed for use in removing roller tables. More modern tools and methods have been devised to remove rollers.



A PRACTICAL STAKING SET for Beginners

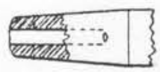
This set consists of a small, solid base frame, ten punches, five stumps, plus a reamer holder, reamer, and jewel pusher for friction jeweling. The various pieces are all standard size and may be used in other staking sets. Additional punches, stumps or attachments, such as a roller remover (illustrated), can be added.

FLAT FACED HOLLOW PUNCHES



This type of punch is used to replace wheels on pinions, and to finish the riveting on balance staffs. It is a very versatile punch.

ROUND FACED HOLLOW PUNCHES

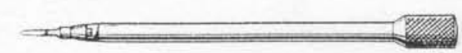


Round faced hollow punches are most commonly used to rivet over the countersinks on balance staffs and pinions.

ROUND FACED SOLID PUNCHES

This type of punch is used for peening (flattening or spreading metal) and for closing holes in plates or bushings.

REAMER HOLDER AND REAMER



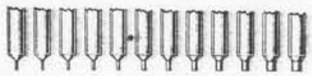
The reamer holder and reamer are used in friction jeweling. They will fit all standard staking frames. Reamers for this holder are available in the following sizes (millimeter measurement):

12 Fine Steel Reamers

.69	.99	1.39	1.79
.79	1.09	1.49	1.99
.89	1.19	1.59	2.29

FRICTION JEWEL PUSHER

This pusher is made with end sizes as listed below, which enables the watchmaker to remove, replace and adjust friction jewels and bushings, or to remove and replace balance hole and cap jewels in settings. Pushers can be made from 3/16 inch (4.7 mm) round steel stock, which should be hardened and tempered to a blue. These end measurements are in millimeters



12 Polished Steel Pushers

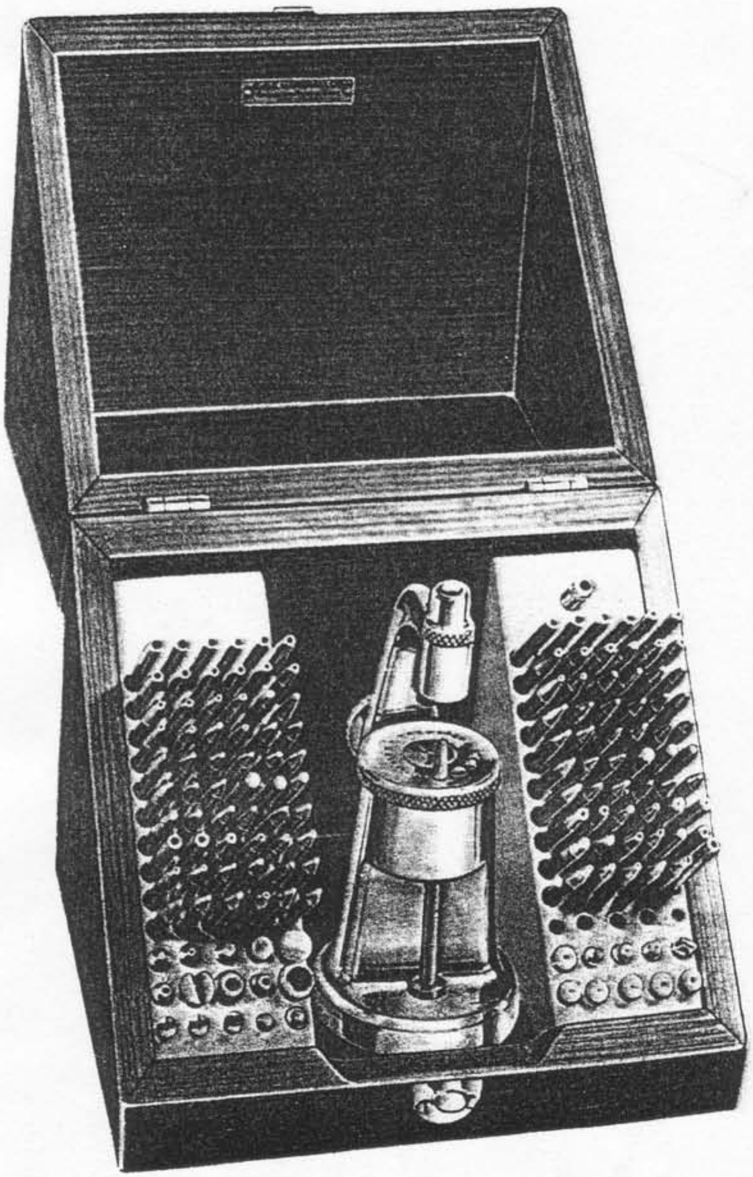
.55	.85	1.30	1.85
.65	.95	1.50	2.10
.75	1.05	1.60	2.65

STUMPS

Stumps are useful when milled or recessed surfaces are to be worked on. The base of the frame is drilled to accomodate the stumps, as well as other attachments, such as a roller remover, which also can be used on the frame.

WATCHMAKER'S STAKING SETS

The professional watchmaker's staking set usually contains from 80 to 120 punches and 20 stumps. More punches allow a greater variety of sizes to be handled. This is important to the watchmaker who has to work on many different makes of watches. Having the proper size punch readily available will speed up the work. For the beginner who intends to follow up watchmaking as a career, this investment should be carefully considered. The set illustrated here has 120 punches and 25 stumps and can be equipped with a friction jeweling attachment. The punches can be inverted as illustrated. As shown in the table below, it is also possible to start with a smaller set and add other punches as necessary or as you can afford them. A staking set will last a lifetime, if given average care.



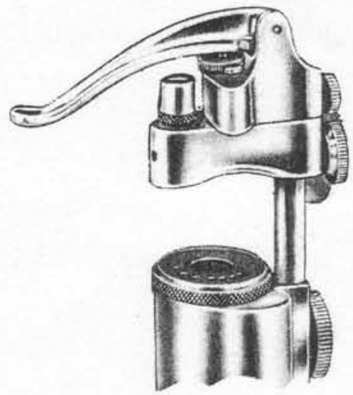
Staking tool sets can be purchased in different combinations, the most common of which are listed below:

133	punches	25	stumps
120	"	20	"
*100	"	20	"
* 80	"	20	"
60	"	12	"
** 48	"	8	"
** 36	"	6	"
** 24	"	4	"

* These sets come in boxes drilled for 120 punches and 30 stumps. Thus, you can add punches and stumps to these sets at any time.

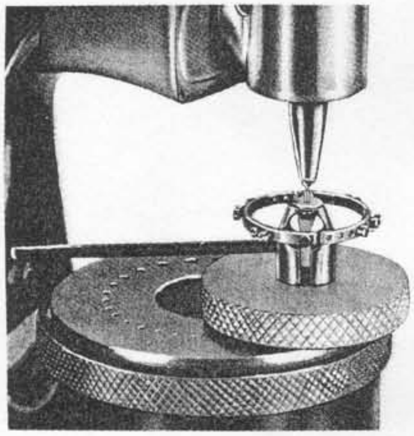
** These sets come in boxes drilled for 60 punches and 15 stumps, enabling you to add punches and stumps to these sets at any time. They are useful starter sets.

FRICTION JEWELING ATTACHMENT



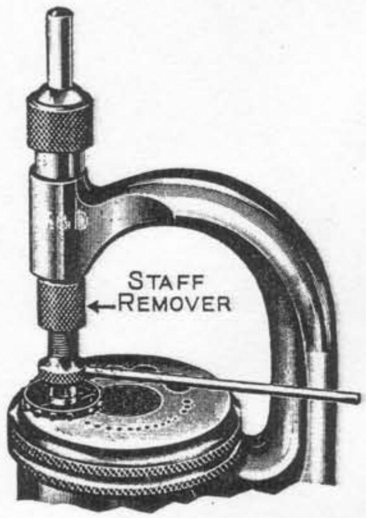
Many manufacturers of staking sets also make a friction jeweling attachment to fit the staking frame. It is more desirable to have a separate friction jeweling tool, but for those doing watch repair as a hobby or side line, this attachment will take care of most needs. With the attachment are included reamers, reamer holder and pushers. This attachment may be permanently attached to the staking frame without interfering with normal use of the tool.

ROLLER REMOVER



This tool, used in the removal of single or double rollers, is designed for use with the staking tool. The illustrated tool has three adjustable stumps in different sizes which allows the tool to be used to remove rollers in practically any size watch.

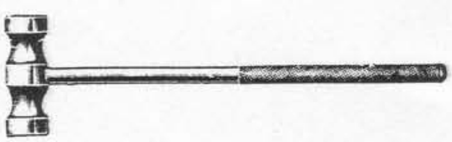
STAFF REMOVER



This tool, also designed for use with the staking tool, is used in the removal of riveted balance staffs. The staff and wheel are placed on the die plate in a hole just large enough to accommodate the hub of the staff. Using the screw adjustment on the staff remover, the arms of the wheel are pressed down firmly against the die plate, thus preventing the arms from bending when the staff is driven out.

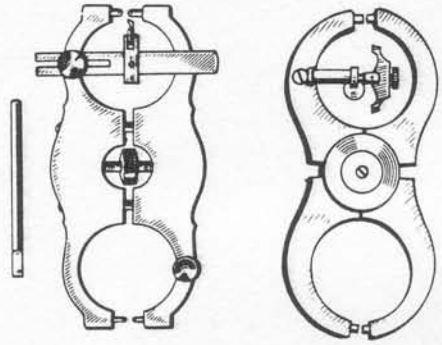
(A more desirable method than this of removing a balance staff, is to place it in a lathe and cut away the hub. This method minimizes the chance of damage to the wheel.)

BRASS HAMMER



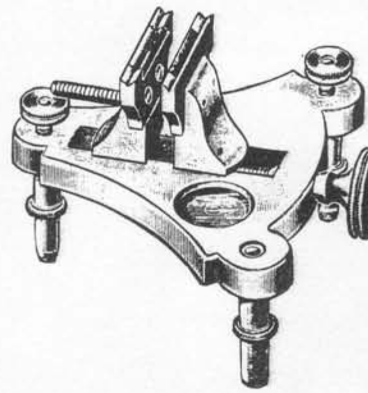
This brass hammer is used with the staking tool. A steel hammer should never be used as it will damage the punches. About 3 oz. weight is the proper size hammer.

TRUING CALIPERS



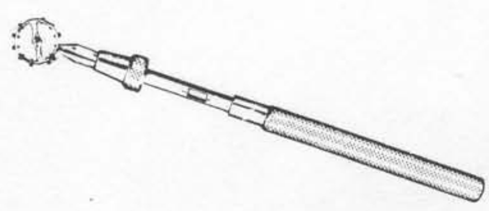
A tool in which to place a balance wheel to check for truth in round and flat and make the necessary adjustments. Two types of calipers are illustrated; one with a screw adjustment to open and close, and the other which works with hand pressure. Each tool has a moveable indicator and a wrench to make adjustments of the arms of the balance.

POISING TOOL



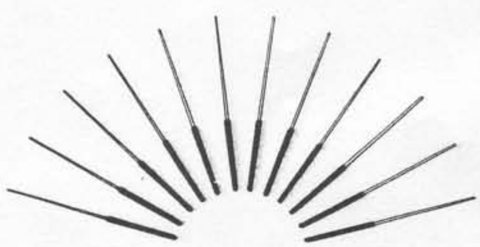
This tool is used in checking the poise of a balance wheel. The one shown has three legs. Two of these are adjustable so as to level on your working surface. The jaws are of highly polished sapphire or ruby jewels. With general use and care, these jaws will never need refinishing. The adjustable jaws make it possible to use this tool for any size of balance. Poising tools also come equipped with highly polished steel jaws and this type is equally serviceable if the jaws are kept highly polished.

BALANCE SCREW HOLDER



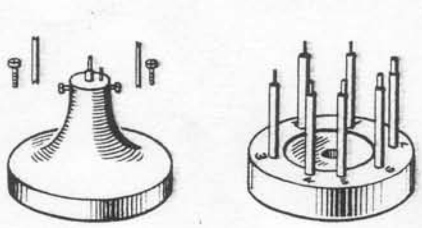
This tool is used to hold and remove a balance screw after it has been loosened with a screw driver. Undercutting to remove weight can be done after removing the screw from the holder while timing washers may be added without removing the screw from the holder.

PIVOT BROACHES



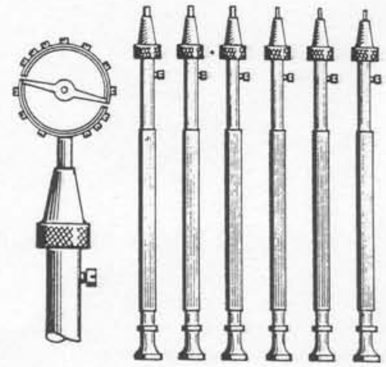
These come usually in assortments of twelve and are available in sizes to correspond with the smallest pivots. They are used to broach or clean pivot holes in train bushings or plates.

UNDERCUTTERS



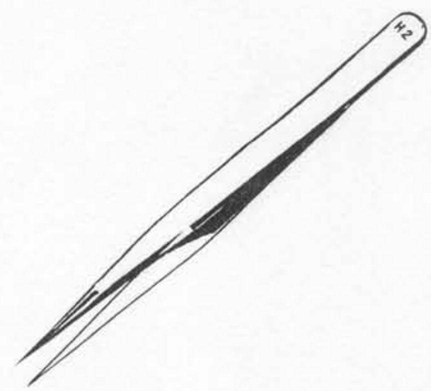
Used to remove weight from a balance screw by cutting from the under side of the screw head. A set ordinarily has the variety of sizes necessary to undercut the different size balance screws.

BALANCE SCREW CUTTERS



This is a Swiss type balance screw cutter used to remove weight from the balance wheel. It cuts a cone in the head of the screw without taking the screw from the wheel. The preferred method is to undercut with the lathe or the undercutting tool; however, many Swiss manufacturers use this type of cone cutter.

HAIRSPRING TWEEZERS

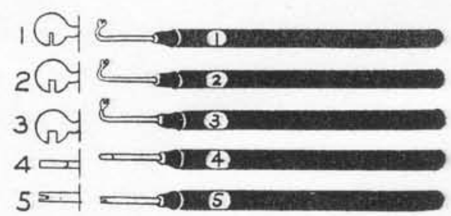


These are fine-pointed tweezers used only on hairsprings. Due to the delicate points it is not recommended that you use these tweezers for any other work. The tips are graded from very fine to coarse. Each manufacturer has a different system for designating the fineness of the tips. Usually the largest number will designate the finest tip. The beginner should start with a medium-fine tip and then add others as the need arises.

TAPER PIN

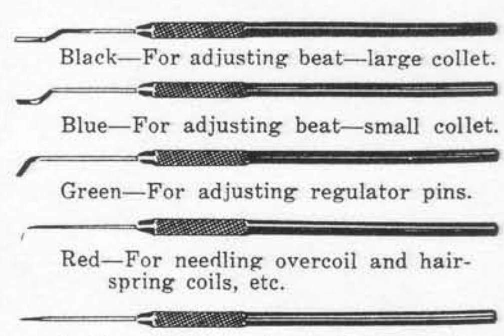
A steel pin used in working on hairsprings. It is mainly used as a holding tool for the collet and hairspring. It is tapered to a size that will accomodate all sizes of collets. You may substitute a broach or other tapered steel rod.

HAIRSPRING LEVELER SET



This set of five tools is designed to make adjustments to the hairspring while in the watch. It has three sizes of hairspring leveler tools, one tool for centering and one tool to adjust the regulator pins. These tools are not necessary for the beginner.

HAIRSPRING 'PIX'



Black—For adjusting beat—large collet.

Blue—For adjusting beat—small collet.

Green—For adjusting regulator pins.

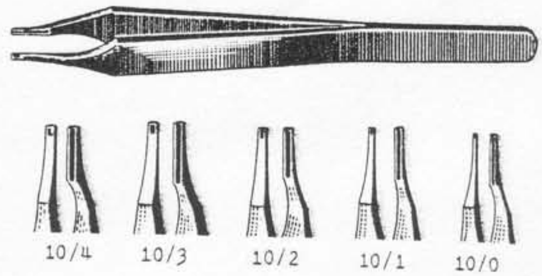
Red—For needling overcoil and hairspring coils, etc.

Yellow—For removing stud pins, curb pins, etc.

This set of five tools is used in the manipulation of the hairspring. The illustration explains the use of each tool.

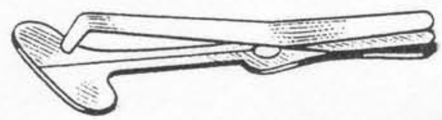
OVERCOILING TWEEZERS

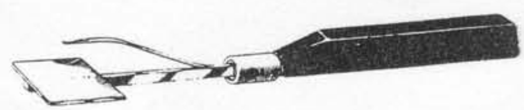
These tweezers are used to form the overcoil of a hairspring over the body of the spring. The illustrations show the different sizes of curved tips. 10/0 or 10/1 are recommended for general use. This tool is not essential for the beginner as the overcoil may be formed by using a pair of hairspring tweezers and a taper pin.



PALLET WARMER

This tool is used to hold and apply heat to a pallet fork. The pallet stones are cemented into the fork with shellac. This cement will melt when heat is applied. Therefore, this becomes an essential tool whenever a pallet stone has to be adjusted or replaced. Heat should never be applied directly to the pallet fork, as direct heat will draw the temper from the steel fork and arbor. The part of this tool which holds the pallet fork is split to allow each pallet to be heated separately.



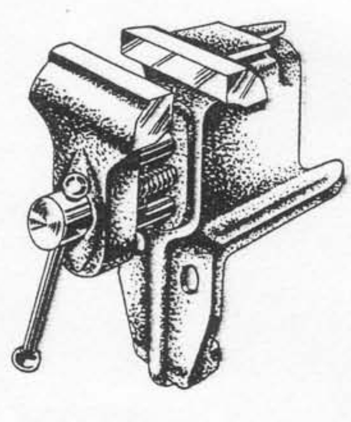


BOILING CUP AND BOTTLE

When ever it is found necessary to remove shellac from any part of a watch, such as the pallet fork, roller, etc., the recommended method is to boil the part in alcohol. The illustrated bottle with hole cut in cap is used to contain the part and alcohol (half full will be sufficient). A small amount of water is placed in the boiling pan, the bottle placed in the pan and heat applied until the alcohol boils sufficiently to dissolve the shellac. A low flame, such as an alcohol lamp, should be used to minimize the chance of igniting the alcohol fumes. Alcohol is highly inflammable.

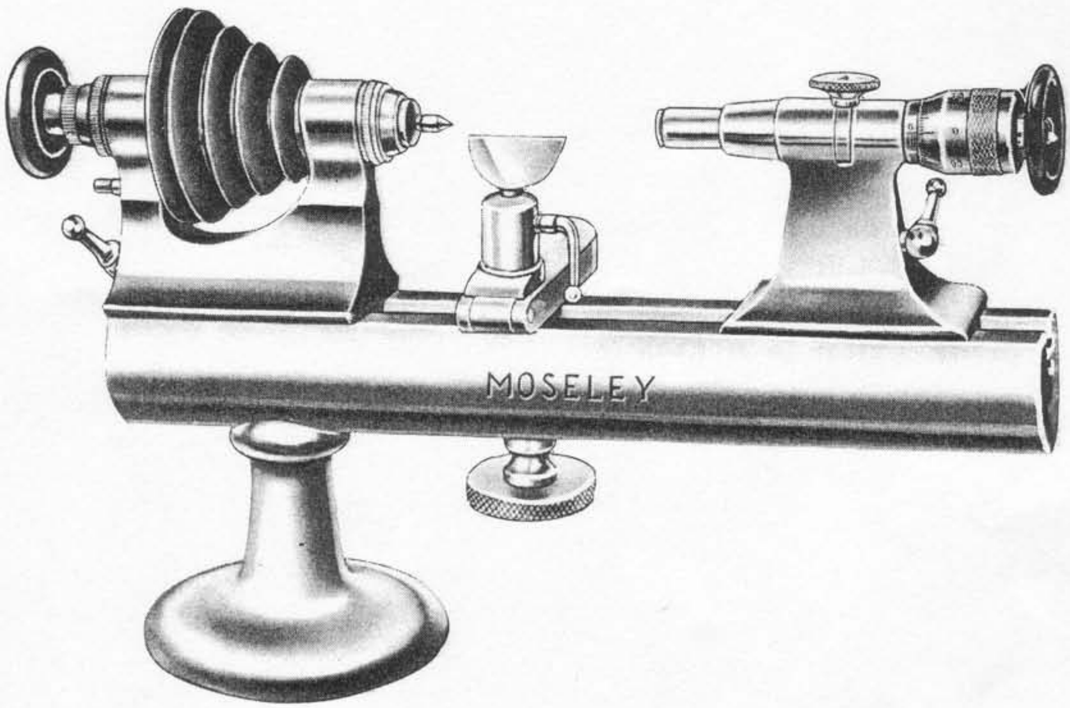
BENCH VISE

The bench vise has always been part of the watchmaker's equipment. It is used in the making or refinishing of tools and other small watch parts. The beginner will find it necessary to make certain tools which cannot be purchased, and so a bench vise should be a part of his equipment.



THE WATCHMAKER'S LATHE

The watchmaker's lathe is the most versatile tool at his command. With the lathe and its attachments, all manner of work can be done, from delicate, precision fitting of parts to making a complete watch, if need be. It enables the watchmaker to handle repairs he might ordinarily have to send out. And many jobs can be done in minutes with a lathe that would take hours to do by hand.



No simpler or more effective machine has yet been devised to do the multitude of jobs that the lathe can handle. Wheel cutting, jeweling, polishing, grinding pallet jewels, making balance staffs, opening wheels and jewel holes, uprighting, tapping screw holes, pivoting staffs -- these are but a few of the tasks that can be done efficiently on a lathe. Even though it is possible today to buy practically any part for any watch, many of these will need alteration to make a perfect fit. Alterations like changing the diameter of the roller seat, the collet seat, or the wheel seat on a balance staff can be done properly only on a lathe. As a result, the lathe is an investment that is well worth while. Even if used but a few minutes a day, it will repay its purchase price many times over. Properly used and maintained, the lathe will last a lifetime. It is considered a "must" tool for the professional.

THINGS TO LOOK FOR IN SELECTING A LATHE:

Choosing a lathe is largely a matter of personal choice and available budget, for today it is possible to find good lathes in almost every price range. However, price alone should not be the deciding factor, as accessories and minor features, such as finish, somewhat control the price. There are more basic things to look for:

The lathe bed should be of firm construction and preferably formed from a single casting. The head stock should be movable on the lathe bed, so the pulley can be aligned with the pulley on the motor. The pulley should be a step pulley to permit adjustment of speed and power desired. It should also turn freely, bearings should be fitted, and no end shake or side shake should be apparent. It should be possible to adjust the bearings.

The spindle should take standard size chucks and have a key way to assure each chuck fitting in the same position. Both lathe and chucks should run perfectly true.

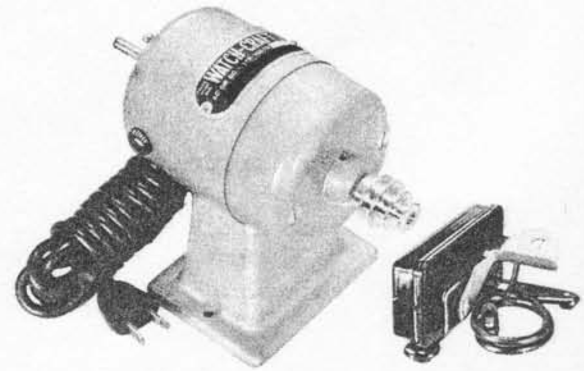
An index should be affixed to the pulley. An index is a circular plate with evenly spaced holes into which an index pin may be placed to lock the moving parts in any desired position. The lathe also should have a hinged or tip-over T-rest.

The tailstock is less used than formerly when the individual watchmaker had to make most of his parts himself. The beginner can postpone purchase of a tailstock. The professional usually acquires one in time.

There are many accessories that can be had for use with the lathe. A few are described in the following pages, but these are by no means all that are available. Some are necessities. Others are simply an added convenience on certain jobs and can be considered special-purpose tools in nature. The type of work habitually done as well as available funds will largely determine the worth of an accessory to the individual watchmaker. The beginner is advised to start with just the basic items and add others only as a need is felt for them.

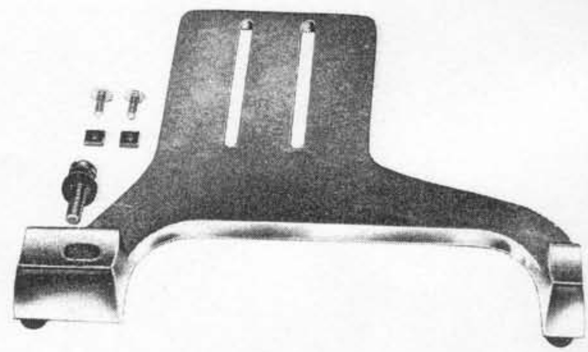
Space here permits but a hint on the selection and usefulness of the lathe and its accessories. For detailed information on its possibilities, we refer you to Ward Goodrich's authoritative book on the subject: "The Watchmaker's Lathe."

LATHE MOTOR



In years past the lathe was powered by a foot wheel. This may still be used in areas of the world where there is no electric power available. The modern method is to use a small, electric, reversible motor, about 1/10 horsepower, equipped with a foot rheostat to control the speed of the motor. It is best to select a motor designed for use with the lathe. The paint, enamel or chrome finish on the motor casing may somewhat control the price.

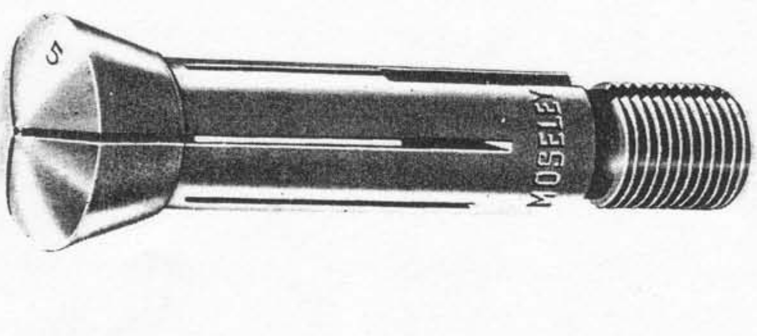
LATHE MOUNT

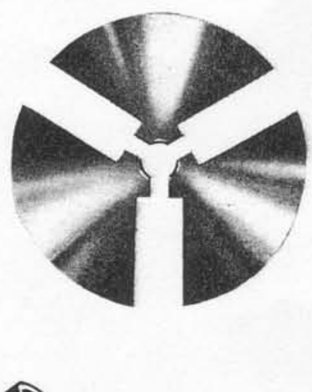


A portable lathe mount on which the lathe and motor are fastened is recommended for those who have no permanent working surface or who do not wish to mount the lathe and motor directly on the bench.

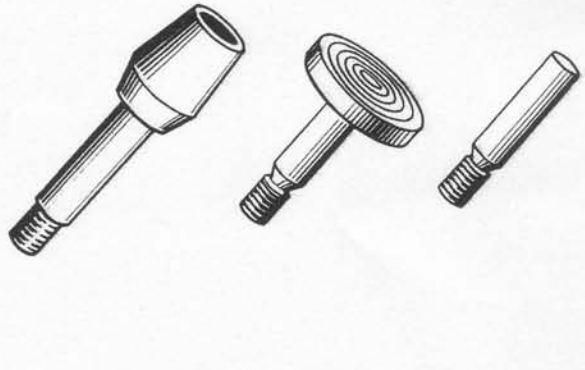
CHUCKS

Chucks are gauged in tenths of a millimeter. A number 20 chuck is twenty-tenths (20/10) of a millimeter. A No. 7 chuck is seven-tenths (7/10) mm., and so on. A beginner should have Nos. 16, 20, 32, and 40 chucks, plus a chuck for holding a cement brass. Other chucks may be added as the need arises. A chuck should be used only with metal stock of the same size, as spreading or compressing the jaws of a chuck will cause damage to the gripping surface and also cause the chuck to be off center.



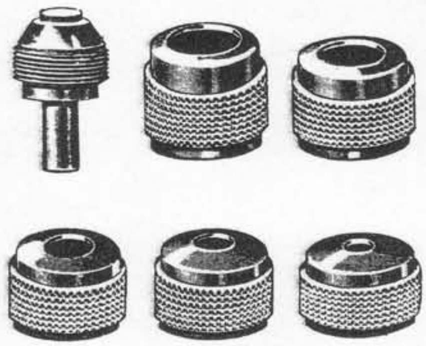


SCREW CHUCK WITH CEMENT BRASSES



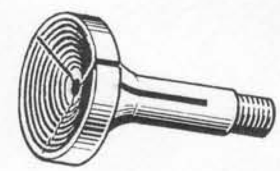
The cement brass is used on the lathe as a working surface for small parts that cannot be held in an ordinary wire chuck. The part, such as a jewel setting, is cemented and spun true on the cement brass.

CROWN CHUCKS



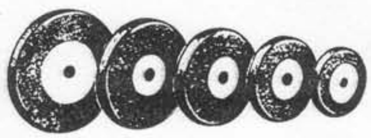
These chucks are used to hold crowns which have to be opened on the under side to fit over the pipe on the pendant of a case. They are designed primarily for crowns for pocket size watches. In lieu of this type chuck, as well as for smaller sizes, the crown may be cemented to a cement brass and the opening enlarged with a graver.

WHEEL CHUCK



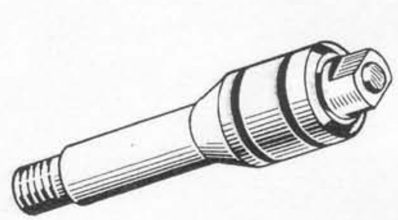
This chuck is used to hold a train wheel in the lathe when polishing pivots, and so forth. The chuck will hold more than one size wheel. This chuck grips the ends of the teeth and so care should be taken to use the proper size chuck and not apply too much pressure or the teeth will be damaged. This chuck need be used only when too little of the pinion extends past the wheel to be gripped with a wire chuck. Another method of setting up this wheel would be to cement it to a cement brass.

CARBORUNDUM WHEELS



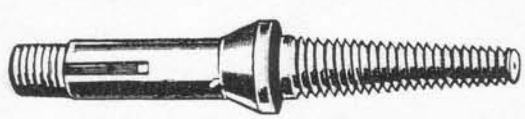
Small carborundum wheels can be mounted on an arbor chuck for grinding small steel work. When using these wheels on the lathe, take care to keep particles of carborundum from the bearings. Clean the lathe carefully after using carborundum.

ARBOR CHUCK



This chuck has a solid body and can be used to carry circular saws, wheel cutters, and the smaller size carborundum wheels.

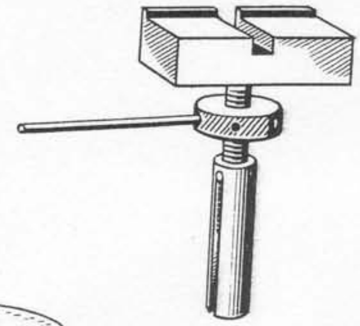
BUFF CHUCK



This solid body chuck has a tapered screw on which to mount polishing buffs. Buffing should be confined to small jobs and the same care should be taken of the lathe as when carborundum is used.

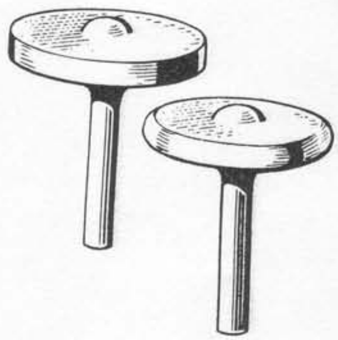
FILING FIXTURE

This fixture replaces the rest on your T-rest. It is used when filing across work held in the lathe, as when filing the square on a stem.



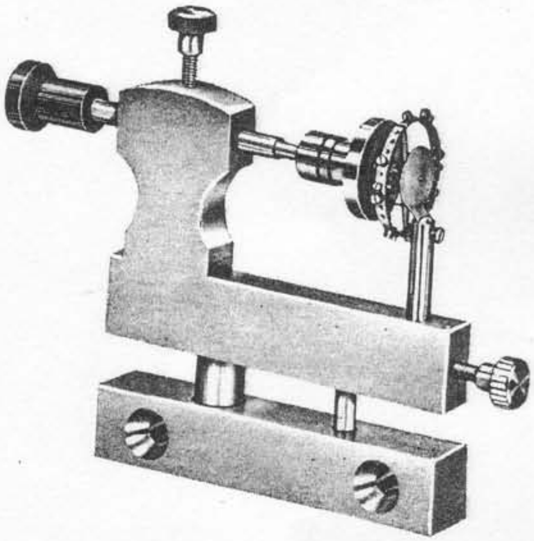
CARBORUNDUM WHEEL WITH ARBOR

This type wheel comes in several shapes and grades. It can be had in hard Arkansas stone and Aloxite for grinding watch crystals. However, as mentioned before, it is not advisable to use grinding wheels to excess in your lathe.



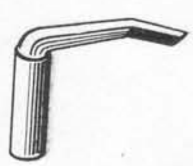
PIVOT POLISHER

This attachment is mounted on the lathe and is used to hold pivots while they are being straightened, burnished, ground, or polished. It is adjustable to fit all balance staffs. The pivot to be worked on extends all the way through the end bearing plate.



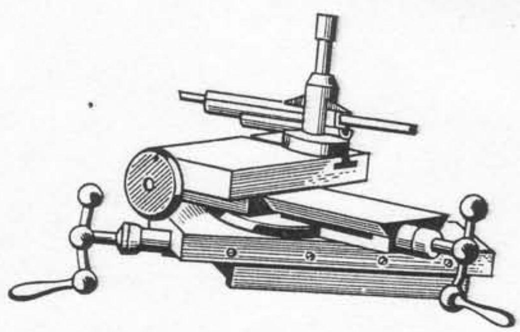
"L" TOOL REST

This tool rest is used with the face plate. Its design will allow close adjustment to the plate.

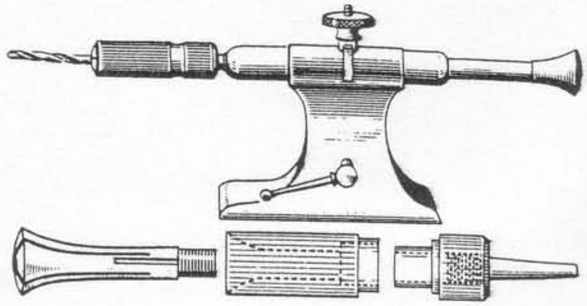


SLIDE REST

This lathe attachment is of little use to the average watchmaker of today. It has various uses for the watchmaker who specializes in making watch parts. It is also used by model makers.

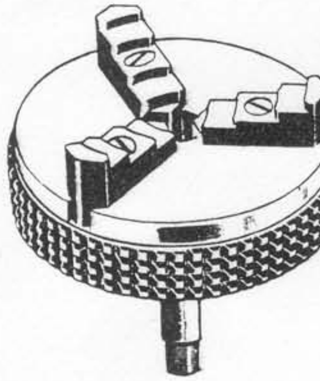


TAIL STOCK CHUCK HOLDER



This device is used to hold regular wire chucks in the tail stock. This is desirable when drilling so as to hold the drill in direct line with the work.

THREE JAW CHUCK

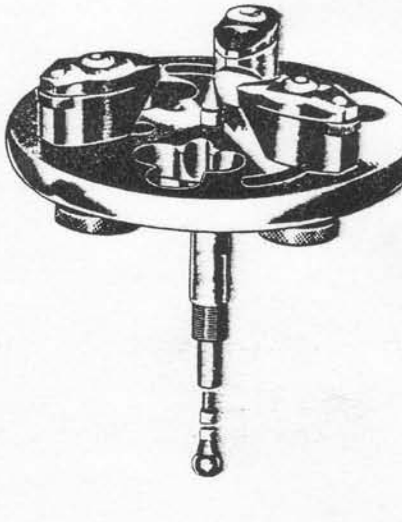


This chuck is used for heavier kinds of work. The jaws are adjustable and reversible. This chuck can be used for holding clock barrels and work by model makers.

BEZEL CHUCK

This is a special chuck used primarily for holding bezels, either by the inner or outer edge.

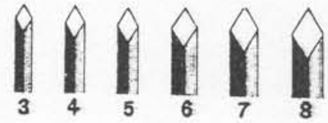
FACE PLATE



This lathe attachment is used to mount watch parts, such as plates, for uprighting a pivot hole. The jaws are adjustable, which allows free movement of the plate to any desired center.

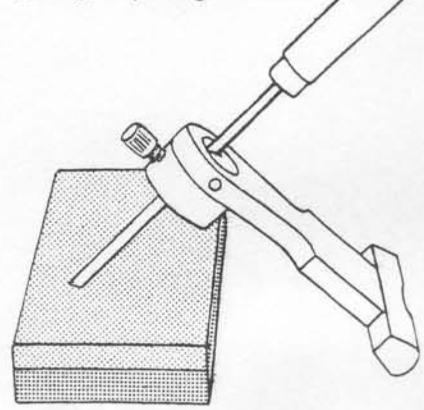
GRAVERS

The tools used for cutting on the lathe are known as gravers. They come in many shapes and sizes. The gravers most commonly used are the #4 or #6 square. It is essential that gravers be kept sharp.



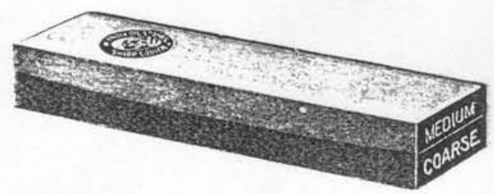
GRAVER SHARPENER

Gravers may be sharpened by hand, but it takes considerable experience to get the right result. An easier and more convenient method is to use a graver sharpener, which holds the graver in a fixed position during the sharpening process. The tool may also be used to shape the tip on a new graver or to reshape a broken tip. Engravers may likewise use this tool.



OILSTONE

For sharpening gravers, a combination oilstone with coarse and fine sides is reccommended. Kerosene or light machine oil should be used on the stone at all times.

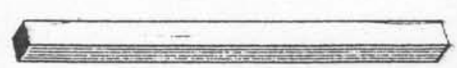


CARBOLOY GRAVER SET

This carboloy steel graver set is used on hardened or tempered steel, as when cutting out balance staffs from the balance wheel. When the gravers need sharpening, they must be ground on a special diamond-impregnated wheel. A set usually includes blades, handle, lap wheel, and compound.

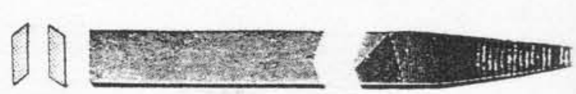
BOXWOOD SLIP

This slip is a hard, almost grainless wood used to polish pivots. Polishing compound, such as diamantine or rouge, is applied to the slip. Full explanation of the use of the boxwood slip will be found in Lesson 31, Master Watchmaking.

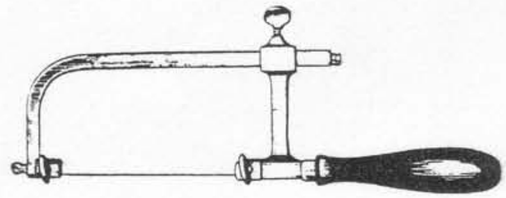


PIVOT BURNISHER

This tool is used to burnish a pivot, remove burrs and so forth. It is a very hard steel with a slightly rough surface. No grinding or polishing compound is ever used on this tool. When used as illustrated and described in Lesson 31, Master Watchmaking, it will compress, harden and close the pores in steel, thus giving it a smooth, hard and polished surface.



JEWELER'S SAW FRAME



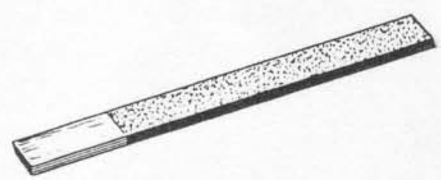
A saw frame designed to hold saw blades that are used to cut metal.

JEWELER'S SAW BLADES

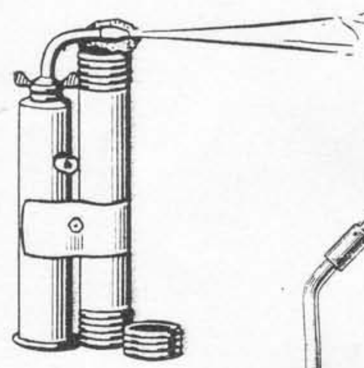
For use in jeweler's saw frame. They are made of narrow, tempered, flexible steel wire into which teeth have been cut. The teeth in a jeweler's saw should point toward the handle of the saw frame. The sizes are 5-4-3-2-1-1/0-2/0-3/0-4/0-5/0-6/0-7/0-8/0. The most useful size to the watchmaker is No. 2.

EMERY BUFFS

These are small strips of wood covered with abrasive cloth or paper. They are graded from coarse to fine grit: 2, 1, 0 2/0, 3/0, 4/0. They are used to polish steel surfaces by starting with the coarse buff and working to the fine ones.

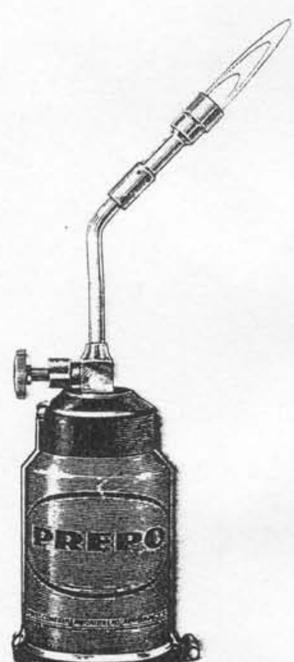


ALCOHOL TORCH



All watchmakers will at some time need to harden and temper a piece of steel. The beginner will find it advisable to practice hardening and tempering steel to make pivots, etc. A small torch will usually supply enough heat to harden properly. The beginner may use any gas flame that will give sufficient heat.

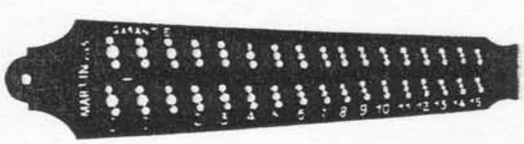
"PREPO" TORCH



This torch is ideal for use by the watchmaker or jeweler. It will produce a minimum heat of 2200 degrees F. It is equipped with a "throw-away" type of container which holds a liquid gas under high pressure. Ordinarily the container should last a minimum of four hours of continuous use. The empty container is easily removed and replaced with a new one.

SCREW PLATE

A threaded die plate with graduated hole sizes used in threading screws or making taps.



ORDERING MATERIAL

It is possible to get nearly any part for almost any watch now being manufactured as well as for many obsolete watches. Watch parts made by the maker of the watch are known as genuine parts, but other companies make replacement parts which have proven satisfactory in general. However, it is best to use genuine parts whenever they are available because they usually require less alteration.

Parts such as balance staffs, stems, crowns, mainsprings, roller jewels, friction jewels, friction bushings, and the like, may be purchased in assortments or singly. The advantage in having assortments is that you will have the part needed when you need it. You'll have no delay in completing the repair job and can give your customer faster service. The cost per part in assortments is usually less than the single part price, so there is some saving of money as well as time. You may make up your own assortments by ordering in 1/4 or 1/2 dozen lots as the need arises.

Before ordering a part for a watch, you must identify the watch by make, size, and model. To order a part for an American watch, it is advisable to include the manufacturer's name, size, number of jewels, and serial and/or movement number, which is stamped on the bridge of the watch. Some late model American watches have a model or grade number stamped on the bridge. Include this number also. When ordering staffs or wheels, list the pivot diameter size. In ordering jewels, list the hole size of the jewel or the diameter of the pivot on which the jewel is to fit.

The identification of a Swiss watch is a little more involved. The name on the dial means little in establishing the manufacturer of a Swiss-made movement. Bulova watches are usually identified by a model or caliber number stamped on the bridge, such as 7ap, 6am, 6ak, and so on. This is the only identification needed. Gruen watches usually have a model or caliber number stamped on the pillar plate and which can be seen between the barrel and train bridges or under the balance wheel. If no identification can be made on this side of the movement, remove the dial. You may then find a model or caliber number such as AS 976 or ETA 735. This listing will identify the maker and the model number.

You may find only a symbol to identify the maker. Most material catalogs list all well-known symbols and manufacturers who use them. If you find only a symbol, you still must identify the watch by model or caliber number. You can do this by means of the setting parts; that is, the set bridge, set lever and clutch lever. Manufacturers make their models with setting parts slightly different in size and shape. Material catalogs show these setting parts according to their size and shape and list their identifying model number. Close comparison of the setting parts in the watch at hand with these listings should enable you to identify the watch. If you are not familiar with this method of identification, a few minutes' study of a material catalog will make it clear to you.

Occasionally, you may have some trouble identifying a movement due to improper listing. If you are not able to positively identify a movement, you should send it to your material jobber for identification. Be sure, however, to wrap it carefully so it will not be damaged in transit.

Besides the identification, it is well to include the part you want replaced as a sample for comparison. Always package sample parts in a material can or similar container to insure safe arrival.

When ordering a balance staff for a Swiss watch, you should designate the type of balance jewels; that is, regular, Incabloc or Shock-resist. When ordering a regulator, you should indicate the type of hairspring; that is, flat or overcoil. When ordering a cannon pinion, you should furnish the exact length, if no sample is available, as cannon pinions for some Swiss watches come in as many as nine different lengths.

The following pages will guide you further in ordering specific parts. If you always include all the information shown in the samples, you should experience little trouble in getting exactly what you want.

When ordering material for a watch, the following information should be furnished:

Make:
Size:
Model or Grade (if known):
Serial Number (American only):
Number of jewels:
Description of part (Include factory number, if known):

SAMPLE ORDER (American)

FROM Your Name

Your Address City State

QUANTITY	ARTICLE	PRICE
1 only	Train jewel in setting, upper 4th wheel.	
	Pivot hole size .28 mm. Factory part	
	No. 6492. (Sample enclosed)	
	For Elgin, 12/s, 17J, No. 2304978.	

VIBRATE HAIRSPRING	CRYSTAL	DIAL ☐ As is
☐ Flat	☐ Waterproof ☐ Cylinder	☐ Change finish to:
☐ Breguet	☐ Regular ☐ Flat Top	☐ Change figures to:
	☐ Unbreakable ☐ Heavy	
	☐ Other	

WATCH TOOL & SUPPLY CO.

SAMPLE ORDER (Swiss)

FROM Your Name

Your Address City State

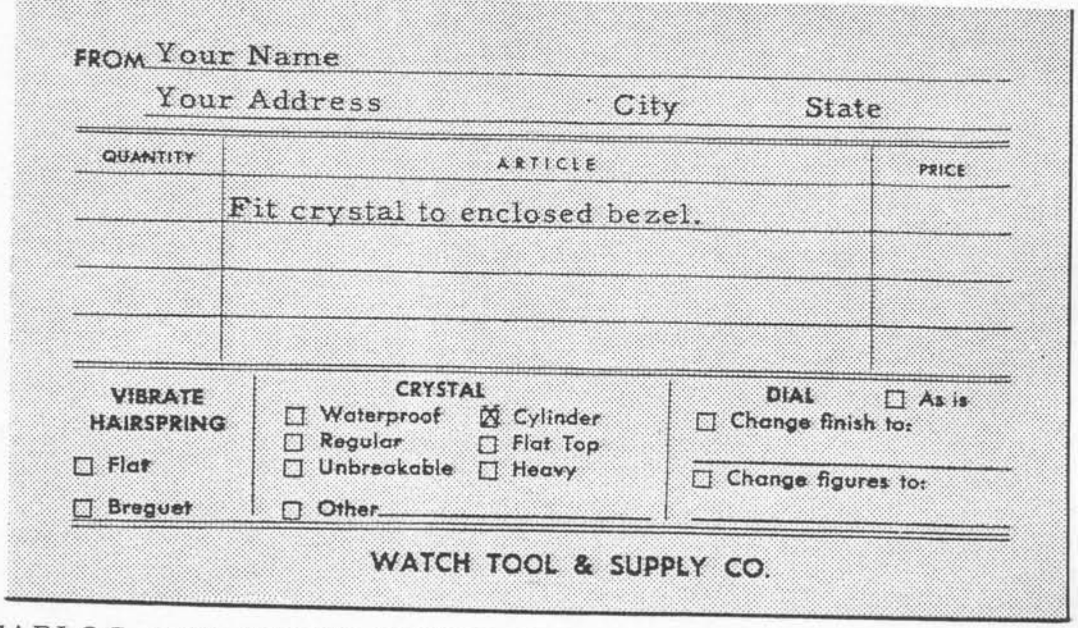
QUANTITY	ARTICLE	PRICE
1 only	Set bridge for Eta 735.	
	Ebauche part No. 445.	
1/4 doz.	Stems for Bulova 7AP.	
	Newall series No. 729-3/4. (Samples enclosed)	

VIBRATE HAIRSPRING	CRYSTAL	DIAL ☐ As is
☐ Flat	☐ Waterproof ☐ Cylinder	☐ Change finish to:
☐ Breguet	☐ Regular ☐ Flat Top	☐ Change figures to:
	☐ Unbreakable ☐ Heavy	
	☐ Other	

WATCH TOOL & SUPPLY CO.

CRYSTALS

Crystal jobs can be sent out to be fitted. Your material jobber will handle this for you. Be sure to indicate the type of crystal desired.



FROM Your Name

Your Address City State

QUANTITY	ARTICLE	PRICE
	Fit crystal to enclosed bezel.	

VIBRATE HAIRSPRING
☐ Flat
☐ Breguet

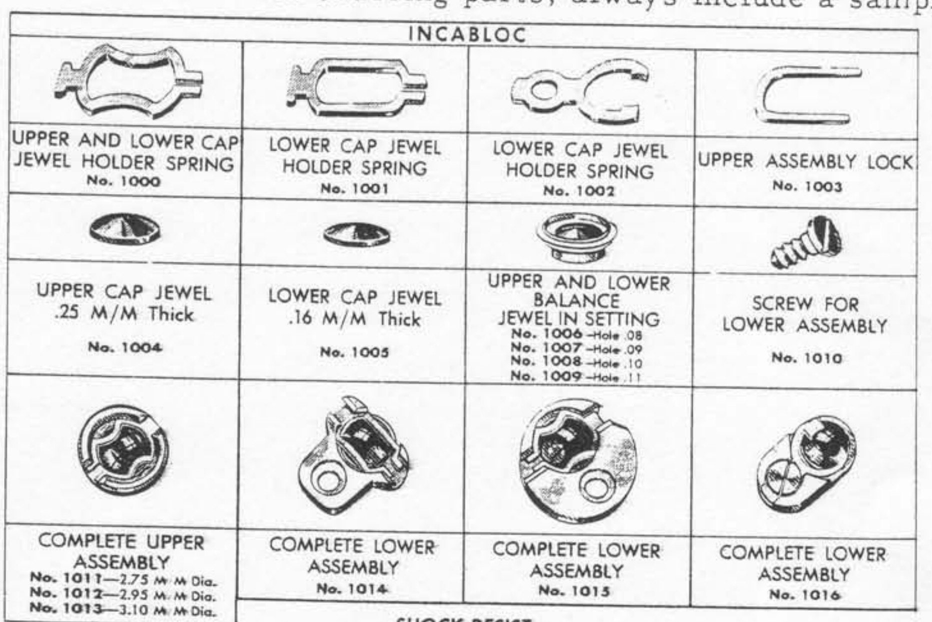
CRYSTAL
☐ Waterproof ☒ Cylinder
☐ Regular ☐ Flat Top
☐ Unbreakable ☐ Heavy
☐ Other

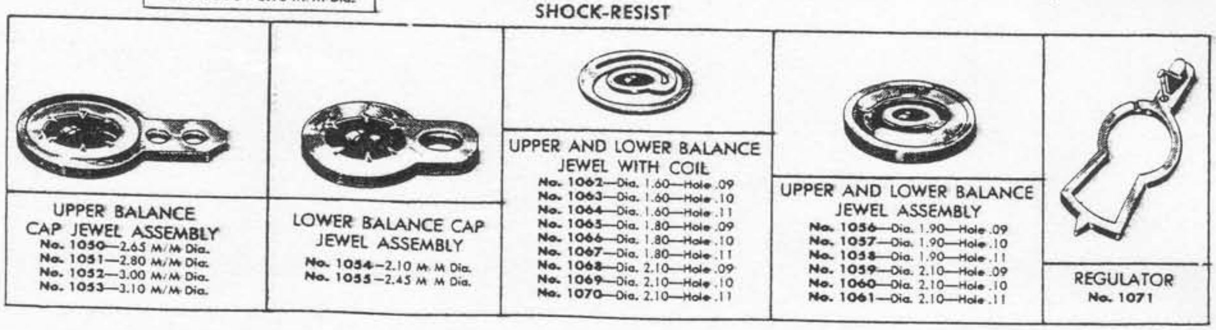
DIAL ☐ As is
☐ Change finish to:
☐ Change figures to:

WATCH TOOL & SUPPLY CO.

INCABLOC AND SHOCK-RESIST JEWELS

Replacement parts may be purchased from your jobber. You may also obtain assortments. When ordering parts, always include a sample.





TRAIN WHEELS

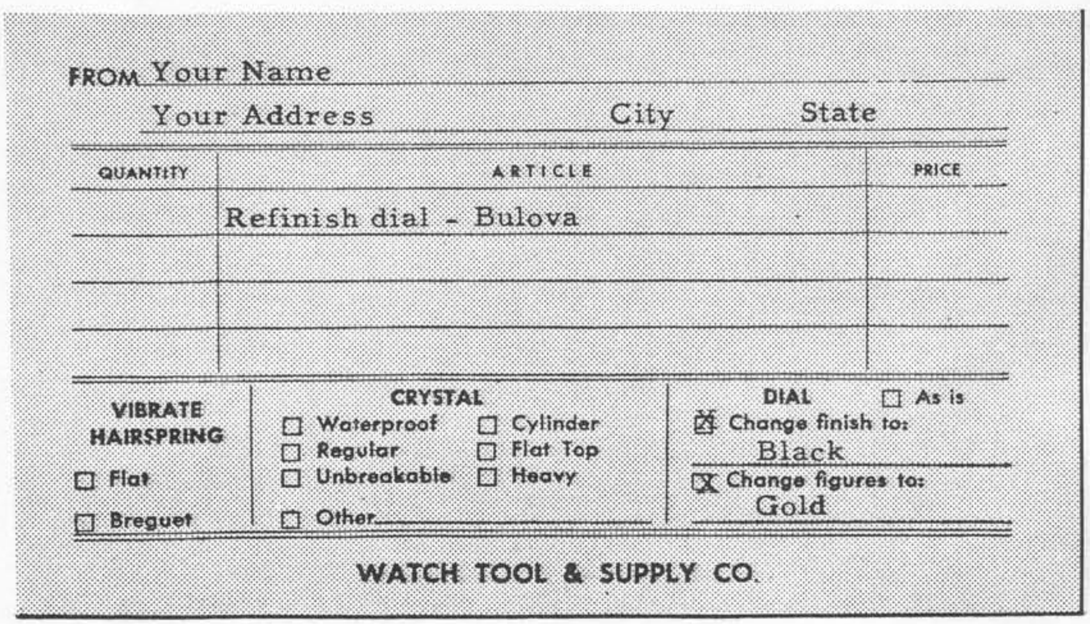
In addition to identifying the watch, when ordering train wheels, you should furnish the pivot size and indicate if the pivots are square shoulder or conical. Always enclose sample.

SCREWS

When ordering plate screws, jewel screws and the like, indicate if the screw should be regular or oversize. Damaged threads in the plates may sometimes be corrected by replacing with an oversize screw. It is helpful to buy assortments of screws from which you can usually select the one you need.

DIAL REFINISH

Dial refinishing is usually sent out to a specialist in that line. Your material jobber will handle this for you. On the material envelope you should give the name you want printed on the dial and the finish of dial and figures. If you want the dial refinished as it was originally, indicate "As Is". If a change is desired, indicate the change.



FROM Your Name

Your Address City State

QUANTITY	ARTICLE	PRICE
	Refinish dial - Bulova	

VIBRATE HAIRSPRING: ☐ Flat ☐ Breguet

CRYSTAL: ☐ Waterproof ☐ Cylinder ☐ Regular ☐ Flat Top ☐ Unbreakable ☐ Heavy ☐ Other

DIAL: ☐ As is ☒ Change finish to: Black ☒ Change figures to: Gold

WATCH TOOL & SUPPLY CO.

SPRING BARS AND BANDS

Spring bars come in assortments of sizes and styles or may be purchased individually. It is good practice to keep an assortment on hand for necessary replacements. It is also good to have on hand a few leather bands for mens' watches as well as replacement cord for ladies' watches. Your material jobber can inform you on available assortments of these items.

FROM Your Name

Your Address City State

QUANTITY	ARTICLE	PRICE
1 only	Balance staff. Pivot size .08 mm.	
	Hamilton 14/0 size. Model 980.	
	(Sample enclosed)	

VIBRATE HAIRSPRING	CRYSTAL	DIAL ☐ As is
☐ Flat ☐ Breguet	☐ Waterproof ☐ Cylinder ☐ Regular ☐ Flat Top ☐ Unbreakable ☐ Heavy ☐ Other____	☐ Change finish to: ☐ Change figures to:

WATCH TOOL & SUPPLY CO.

NOTE: When ordering a balance staff, give the pivot size. If both pivots are broken, send the upper and lower jewels so that a proper staff can be fitted. Always enclose sample staff (removed from the wheel) for comparison.

Swiss staffs are ordered in the same manner.

BALANCE HOLE JEWELS AND CAP JEWELS

Furnish the hole size of the jewel. In many American watches, the cock (balance bridge) jewel setting is of a different size, so you should mention whether cock or foot jewel is needed. Enclose sample.

Upper and lower cap jewel settings in both American and Swiss movements are usually different in size. Also, Swiss balance hole jewels are usually either friction-fit or burnished in the plate. They should be replaced with friction jewels.

ROLLER

In addition to identifying the movement, you should indicate if the roller is single, combination, two-piece, Incabloc or Shock-resist.

BALANCE COMPLETE

This includes a balance wheel, staff, roller and hairspring which has been colleted, vibrated and fitted to the wheel. In ordering, you should identify the movement and designate whether the hairspring is flat or breguet (overcoil).

FROM Your Name
Your Address City State

QUANTITY	ARTICLE	PRICE
	Furnish and vibrate hairspring.	
	Balance wheel and balance bridge	
	enclosed. FF120.	

VIBRATE HAIRSPRING	CRYSTAL	DIAL
☒ Flat ☐ Breguet	☐ Waterproof ☐ Cylinder ☐ Regular ☐ Flat Top ☐ Unbreakable ☐ Heavy ☐ Other	☐ As is ☐ Change finish to: ☐ Change figures to:

WATCH TOOL & SUPPLY CO.

HAIRSPRINGS

New hairsprings can be sent out to a specialist to be vibrated and fitted to the wheel and bridge. Your material jobber will handle this for you. When ordering a new hairspring for either an American or Swiss watch, you should identify the watch and include the following parts:

a. Balance wheel with staff and roller. It must be true in the round and flat and in poise. Pivots must not be bent or broken.
b. The collet and stud.
c. Balance bridge with regulator. Balance and cap jewels should be clean and in place on the bridge.

Wrap and package all parts carefully to prevent damage.

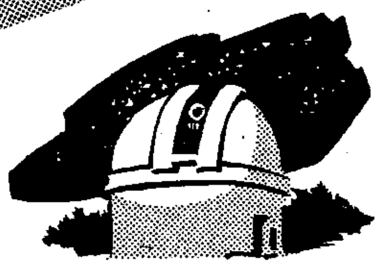
NOTE: A hairspring fitted in this manner may need some further adjustment when fitted to the watch.

FROM Your Name
Your Address City State

QUANTITY	ARTICLE	PRICE
1/4 doz.	Mainsprings AS 1194. Tongue end.	
	1.60 x 10 x 10-1/2.	

VIBRATE HAIRSPRING	CRYSTAL	DIAL
☐ Flat ☐ Breguet	☐ Waterproof ☐ Cylinder ☐ Regular ☐ Flat Top ☐ Unbreakable ☐ Heavy ☐ Other	☐ As is ☐ Change finish to: ☐ Change figures to:

WATCH TOOL & SUPPLY CO.



Master WATCHMAKING

A Modern, Complete, Practical Course

By

THOMAS B. SWEAZEY

and

BYRON G. SWEAZEY

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

69-1

MAKING

Assignments for ...aking Home Study Course

Equipment, Casing

WATCH

B. S

THIS ... NING GUIDE

Its purpose is to steer you through your watch repairing course.

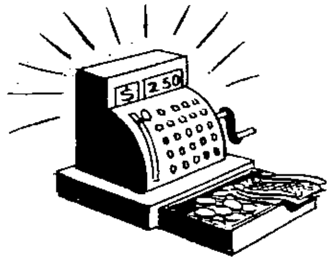
You will find herein ... ctions on WHAT TO STUDY, HOW MUCH to study at one time, QUESTIONS to guide your study, a list of IMPORTANT POINTS (Key Points) in what you are ...ing, and SUGGESTIONS FOR PRACTICE WORK. You will also find ADDI... EXPLANATION and information on NEW DEVELOPMENTS. At the end of the ... nents for each lesson is a REQUIREMENT which tells you WHAT TO ... SCHOOL for examination and grade.

YOUR A M

In any endeavor, it is important to know where you are headed. Before going on, let's clearly establish YOUR AIM in studying this course. You are going to learn to REPAIR WATCHES -- not make watches nor design watches -- but REPAIR WATCHES. We emphasize this because of the confusion of terms which exists. As you will read in Section 3 of this lesson, people in the trade when speaking of "watchmakers" actually have in mind the watch repairman...the man who cleans watches, replaces mainsprings, balance staffs, jewels, hands, crystals, and many other broken parts, adjusts the delicate mechanism so it runs right and regulates it to keep accurate time. In our lessons, when we speak of "watchmaker," it is this man we also have in mind.

In the old days, the watchmaker had to make, form and fit all new parts to replace broken ones. Our present day watchmaker or repairman does not usually make his own parts, although he may do so when necessary. Ready made parts are produced in factories and are available at small cost from material supply houses. They cost far less than the cost of the time it would take the repairman to make them. Parts nowadays are much more standardized and will usually fit without alteration or with slight ones. Sometimes a part cannot be had. The repairman then can either make his own or have a specialist in making parts do it for him if the repairman doesn't wish to do it himself or lacks the equipment to do so.

LOOK FOR THIS CASH REGISTER!



Not everyone who studies this course intends to do watch repairing professionally and how you use this training is up to you of course. But everyone, whether or not he intends to work for pay, is interested in knowing what watch materials cost and how much the repairman gets for his labors. You will find that information wherever you see this CASH REGISTER in these assignment sheets. Wherever we can, we give you typical costs and average return for the repairs being discussed. Watch repairing can be profitable for the one who knows repair procedures and does them well. This will help you to realize it.

If you intend to be a sure and confident workman, you must use the instructions laid out for you. This course will tell you WHAT to do, WHY you are doing it, HOW to do it, but your success as a watch repairman depends on how much and how well you apply yourself in doing it. Turn the page now and let's get ...

KEY POINTS OF LESSON ASSIGNMENTS 1, 2, 3, 4:

- ow to set up your work bench.
- w the sizes of American watche[illegible] ned.
- proper names for the parts o[illegible]
- o use watchmaker's tweezers, s[illegible] rivers and eye loupe.
- s used to remove and replac[illegible] ovements in cases.
- w to remove and replace movement in cases.

SSIGNMENT NO. 1: Study Sections 1 through 11.

NOTE: The questions in each assignment are to help you study and direct your learning. Go over the lesson material until you are satisfied you can answer these questions. (They are for your own benefit and answers [illegible] not be sent to the School.) Also make use of the Check Yourself quizzes to [illegible] on [illegible] in you know the content of the lesson.

What are the important things to remember when setting up a place to work?

Height of working surface? Height of stool or seat?
What kind of light? How should the shop be kept?

Recommended Practice:

Locate and set up your work bench. Make an auxiliary bench, if desired, using the Plan for Table Top Bench printed later in this lesson.

ASSIGNMENT NO. 2: Study Sections 12 through 25.

Supplement to Section 13: A movement or ligne gauge is ordinarily used to measure watch movements. Such gauges can usually be obtained from your material supply house. Their use is fully explained in Lesson Text No. 4. American watches are measured in sizes, as discussed in Section 13. These sizes are written 18s (eighteen size), 16s, 12s, 6/0s (six oh size), 0s (oh size or naught size), and so on. Swiss watches are measured in lignes (pronounced lines) and this is covered in detail in Lesson 4.

The beginner is sometimes at a loss to know how to tell an American-made watch from a Swiss-made watch. Lesson 4 also covers these differences and how identification is made. For now you need only know that American watches are identified chiefly by the name of the manufacturer. The most prominent of these are Elgin, Waltham and Hamilton. Swiss watches ordinarily have some wording such as "Swiss", "Switzerland", "Swiss Made", or "Made in Switzerland" stamped on the bottom of the dial and on the plates. A manufacturer's mark is also frequently found, as will be discussed in Lesson 4.

1. How are sizes of American watches determined?
2. What is a case screw and what is its purpose?
3. Why are full head case screws considered better than half head?
4. What is the crown and what is its purpose?
5. What is a bezel?
6. Why are screw bezels and snap bezels so called?
7. What is a screw back?
8. What is a back back?
9. What is the center?

ASSIGNMENT NO. 2 (Continued)

Recommended Practice:

1. Examine as many watches as you [illegible] available. Locate the pendant [illegible] bow, center, back, and bezel.
2. See if the bezels and backs are of the screw or snap type.
3. Determine the size of these watche

ASSIGNMENT NO. 3: Study Sections 26 through 40.

1. What tools are required to remove and replace a movement in its case?
2. What is the right way to hold and use screw drivers?
3. What is the correct way to hold tweezers?
4. What steps are necessary to remove and replace a movement in the case?
5. Why should you use tissue when handling watch movements?
6. Why should the movement be placed in a tray and covered?
7. How should a case be polished?

Recommended Practice:

1. Practice looking at objects through the eye loupe. (It doesn't matter whether you wear the loupe on your right or left eye. Do what feels most natural. If you can, keep both eyes open to avoid eye tension while wearing the loupe.)
2. Get used to handling the screwdrivers and tweezers as directed in the text.

ASSIGNMENT NO. 4: Read through the Job Sheets at the back of this lesson.

As indicated in Section 27 of the Lesson text, a large pocket watch is best for your first practice. Nonetheless, any size watch can be used as a practice watch. The principles are the same in all watches regardless of size. Your Shop Method-Job Guide Sheets will assist you if your practice watches are not the same as those discussed in the text.

The 18 size (See Section 13), which was the first mass-produced pocket watch in the United States, is rapidly becoming extinct because of its bulkiness. 16 or 12 size watches are the best all-around practice watches, but the new 16 size watches are being more and more confined to the costly railroad grade. Suitable alternates are the 6 and 0 sizes, which were originally made for ladies and were cased in hunting cases. They are no longer manufactured, but are still around and make good practice watches.

When the first men's wrist watches came into use, the American factories used the 0 size and 3/0 for their original models. (Most parts of the 3/0 are interchangeable with an 0 size of the same make.) These also make good practice watches and are generally available.

Unless you've had some previous experience, you are urged to use inexpensive practice watches at the start. This enables you to develop finger dexterity and skill in use of screwdrivers, tweezers and other tools without fear of ruining a costly movement. Once you are accustomed to these things, you can begin to work on better movements.

ASSIGNMENT NO. 4 (Continued):

Recommended Practice: While doing this work, follow each step by reference to the lesson text.

Use an American-made watch in open face case:

1. Remove the bezel and back.
2. Pull out crown until it is in setting position.
3. Select screw driver of proper size and remove case screws (Fig. 22).
4. Remove movement from case, using watch paper or tissue to protect from fingers and place under cover (Fig. 25).
5. Replace bezel and back and polish case, using double polishing cloth. Wipe off any powder that may be left on case (Sec. 37).
6. Again open bezel and back and wipe out inside of case preparatory to replacing movement in case.
7. Start movement in case by inserting end of stem in winding arbor and let movement slide into its proper place. Be sure that stem is in setting position before doing this.
8. Replace case screws. See that stem is in winding position in case and is properly lined up with the figure 12 on dial before setting case screws down to position. If movement is hunting, the figure 3 on the dial will line up with the stem instead of 12.
9. Test winding to see that stem turns freely.
10. Replace bezel and back and wipe off finger marks.

The average time for this job is approximately four minutes. After you have learned these steps, practice until you can do the work within this time limit. Use your Job Guide Sheets to try these procedures with other movements.

REQUIREMENT:

Answer the Test Questions for Lesson No. 1 and return to us for grading.

SUMMING UP

In this first lesson, you have learned that you should have a well-lighted, clean and orderly place to work with a bench and seat of proper height. You have discovered that watchmaker's tools take special handling and that practice and use are necessary to accustom yourself to them. You have learned that there are several types of cases and you now know the names of their various parts. You also know the standard sizes of American watches. You have found that even as simple a procedure as taking a watch from a case requires care and orderly procedure and you should now be setting up good habits of workmanship.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 1
Sections 1 to 40

Lesson 1.—Fundamental Principles, Equipment, Casing Watches

Section 1 IN Watchmaking as in any vocation, your degree of success will come according to your love for the work and the amount of time and labor you are willing to put into it.

To the man who likes things mechanical and takes pride in doing his work just a little bit better than the other fellow, there is a fascination in Watchmaking difficult to describe to the uninitiated, and an opportunity for financial returns which few outsiders appreciate.

No matter how long he has followed this trade, there is always the greatest satisfaction to such a man in seeing a fine timepiece again functioning properly, the result of his own skill in taking it, a broken or abused movement, utterly useless, and restoring it to its original condition.

However, such skill can be attained only by conscientious effort, wisely directed, and an irrepressible determination to "make good".

The success of my resident school has been due largely to my having been able to direct each student, to see that he followed the instructions exactly, mastering each step or problem before being allowed to advance to another, and worked diligently all the time he was in attendance.

If you are willing to give the same amount of conscientious effort that you would be compelled to give were you in a first class resident school, I see no reason why you cannot make the same degree of progress.

Sec. 2 — Method of Studying the Lessons

My endeavor has been to make this course so simple that a student with no experience in this line, one who has never seen the inside workings of a watch, may follow with ease every step from taking the movement out of the case to the matching of the escapement in a modern timepiece. Not only will he understand it but if he performs each operation until he has really mastered it, he will be surprised at the progress he makes and the ease with which he is able to do work that would now seem utterly beyond him.

The mere act of reading these lessons as you would a work of fiction will help you very little in attaining a mastery of Watchmaking. They should be studied by taking one problem at a time, never leaving this one until it is thoroughly understood and mastered.

The first step should be to *read carefully the entire lesson* endeavoring of course to understand every portion of it. If any part should not be entirely clear, start again at the beginning and read until you come to the first point that seems the least particle confusing. Such confusion is generally caused by misunderstanding some previous paragraph, and in order to clear this up it will be necessary for you to go back to the beginning and over the entire preceding paragraphs of that particular subject.

This rule should be followed with all your lessons. If necessary study them over and over. The same method should also be followed in doing the practical side of the lessons. Whatever you may be doing, fitting mainsprings, cleaning, jeweling, turning, assembling — if at any point you see where you can improve it, start again and when you come to that certain part, make it better. This should be your constant aim, to always improve the quality of your work.

In this practical work don't be satisfied when you have merely succeeded in doing the work once. Do it until you are expert in that particular thing. If you are putting a mainspring in a barrel do it over and over until you can almost do it with your eyes shut. In this way you not only get ability to do good work but you acquire speed as well.

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One of the advantages of our method of studying this fascinating subject is that you are not held back by some other student. You are in a class by yourself and your progress is determined entirely by the way you apply yourself to the work. One thing I want you to guard against. Right at first there is a tendency to rush your work — in other words trying to get it out quickly without really keeping up to the standard that I want. Just remember that to make a success you must first master each step in every job and then your speed will come with practice. *The man who aims at perfect work soon surpasses the man who merely works to get his job done.*

Sec. 3 — Watch Repairing

The average man associates the word Watch with the combination of the watch movement and the case in which it is carried. These two are separated into two classes by those who are engaged professionally in this line, and the work of making and repairing them differs greatly, the man who works on watch cases being known as a casemaker while the workman who specializes on watch movements is known as a watchmaker.

By the term watchmaker throughout the jewelry trade, is meant one who repairs rather than one who actually manufactures watch movements. In the present day, watch factory methods have reduced the making of watches to a point where the factory worker generally specializes on one operation, working on some certain part, and it may be not even knowing what office that part performs in the completed watch.

Such a worker might be an expert in his one specialty on one make of watches — in fact he is a "factory expert" — but as a watchmaker in the true sense of the word he needs much further training. The factory man even in most advanced work, works only on one make of watch and that in the latest model while the Master Watchmaker must be able to repair any make of watch, Swiss or American, regardless of age or model.

In our lessons, Watchmaker refers to the repairer of watch movements. However, the man who really wishes to qualify as an expert must be able to calculate and make some of the parts, and thoroughly understand the relations and actions of the different mechanisms that go to make up the complete watch.

Sec. 4 — First — Master the Larger Sizes

In these instructions we will divide the work into two general groups, POCKET WATCHES and WRIST WATCHES, and all our preliminary work will be upon the pocket watches. The mechanism of these two groups is of the same order, the parts of wrist watches necessarily being smaller and more delicate than are those of the larger pocket watches.

Do not attempt to work upon wrist or bracelet watches until you have thoroughly mastered the pocket size watches. I know that after you are able to do the work of the first few lessons on large watches there is a great temptation to try your hand upon the small sizes, but if you will hold off until you have acquired the proper skill in handling small parts, you should then have no difficulty in repairing the small size watches for which the experts get such big prices.

Sec. 5 — Table or Bench

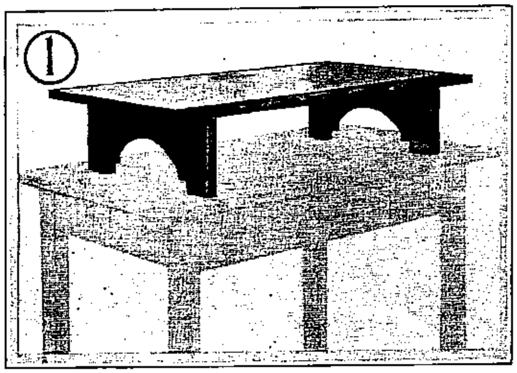
The repairing of watches is a clean occupation so that it is not necessary for the prospective Watchmaker to don overalls or go out to the garage to practice his chosen profession.

It is essential that you have a bench or table of some kind on which to work. The kitchen, library or dining table is from 30 to 31 inches high and for fine work is too low for a comfortable position. It is most important that you have a working surface of the correct height from the floor if you are to do your work without tiring. With the top of your bench at the right height and a chair or stool to match, it is possible to work for long periods without fatigue.

Sec. 6 — Watchmakers Auxiliary Home Bench

In our resident school, especially among the night students, I found a demand for some kind of a portable bench for home work. Owing to the fact that many of our students were staying with private families where there was not much room to spare, it was necessary that it occupy as little floor space as possible without sacrificing the size of its working surface.

This idea of an auxiliary bench to be used in connection with a table occurred to me and the model shown in figure 1 was thus developed. This has proven most convenient for the beginner who does not wish to invest in a regular watchmakers bench. By using it on top of a dining room table, a library or kitchen table it is possible to have a real practical bench of the correct height, strong and durable yet light enough to be lifted easily on and off any convenient table.



There are two supports which bring the surface to just the right height to make the most comfortable working position and these supports are protected by felt pads so there is no danger of marring the finish on any piece of furniture with which it is used. Its solid top is finished with a groove near the front edge as are the most expensive watchmaker's benches. It is large enough to mount a watchmaker's lathe with motor, yet easily stored in a small closet when not in use.

All in all this Auxiliary Home Bench makes an ideal accessory for Watchmakers and is recommended not only to our students in their home work but also to the Master Watchmaker who wishes to have a portable bench which is accessible at all times for any extra work he may wish to do at home.

Sec. 7 — The Master Bench

For those who wish a Master Watchmaker Bench, I would recommend the model shown in figure 2. Here is a bench that is an ornament to any home or store, beautifully finished, with ample storage space — one that will last for a life time and serve you well.

This flat top bench has eight drawers and a compartment with door in lower right hand corner. Underneath the long center drawer can be seen the "apron slide", A in figure 2. This is a frame on which should be tacked a canvas, muslin or oil cloth bottom. The purpose of this apron is to catch anything which may slip off the bench or from the hands while seated at the bench.

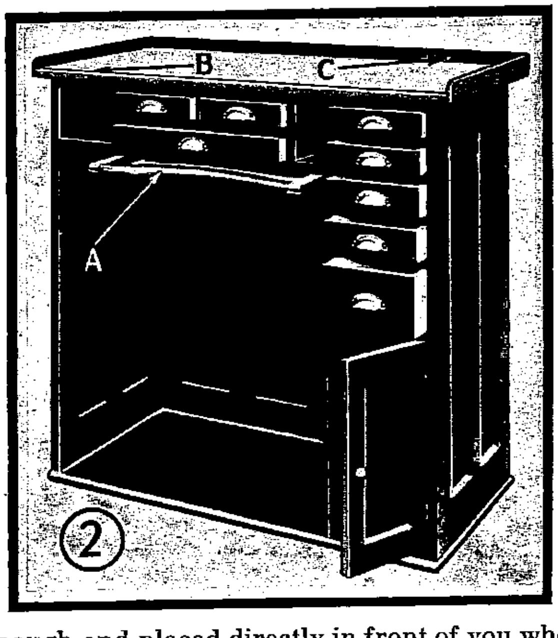
About ⅜ of an inch from the front edge of the top at B is a groove running the entire length of the bench. This groove catches many small pieces that might otherwise roll off. The other three sides of the top are protected by solid guard rails as shown at C.

This bench also can be furnished with drawers all the way down on the right side which some watchmakers prefer to the cupboard-like arrangement shown here.

Sec. 8 — Working Surface

The top of a bench does not present the best kind of a surface to work upon. It is much easier to see and work against a white background avoiding as much as possible any glare. Some Watchmakers use a piece of glass with white paper underneath but this is not always satisfactory as the hard surface of the glass is liable to damage certain parts of the watch if they are dropped upon it and there is more or less direct reflection of light, causing glare, unless it is ground glass. Others use a sheet of paper such as linen surfaced writing paper. This however, is soiled or torn easily and liable to rub into a sort of lint which has a tendency to stick to the watch parts.

I have found a much better working surface to be a flat piece of fairly heavy white celluloid with a matte or dull surface. It is not necessary that this cover a large portion of the bench. A piece 8 inches long and 5 inches wide is large



enough and placed directly in front of you when seated at the bench and with the front edge flush with the back edge of the groove will be found most satisfactory. Test by trial the best location for you to work upon and then tack to the bench. Should the celluloid become soiled it can be cleaned easily with soap and water.

Do not lay any heated objects upon the celluloid and be careful not to get a flame too close.

Sec. 9 — Keep Your Bench In Order

A standard bench is provided with drawers in which to keep your tools and these should be placed and arranged so that you will know where each tool is and can reach it with the least effort. It is a good idea to have the drawers partitioned into various sized compartments.

In place of partitions you can use different sizes of pasteboard boxes. If boxes are used, see that you have enough to completely fill the drawer so that they cannot shift around. In the upper center drawers place your most used tools such as tweezers, screw drivers, bench keys, calipers, gauges, etc.

With the exception of tweezers, screw drivers, loupes or other tools which you are constantly using it is well to get in the habit of replacing each one in its proper place as soon as you are through with it. Not only does a profusion of tools scattered over the top of your bench make a bad impression upon your customers but it tends to slow you up as well. Train yourself to be systematic in all your work. Have a place for everything and then see that everything is in its place. When you leave your bench after a day's work see that all the small tools are cleared away and then when you start work the next day, take out these tools only as you need them.

Sec. 10 — Proper Light

Whatever you use, bench or table, try to have it located near a well lighted window. It is better to have a good natural light, North preferred, than to depend upon any artificial light.

If you find it necessary to use artificial light do not use it too strong. A 40 or 60 watt frosted light is strong enough and will not dazzle and tire the eyes as a stronger one will.

This should be so situated that the light will shine directly on the work but not into the eyes. Where electric current is available this can be arranged by means of an ordinary desk or bench lamp with shade.

Sec. 11 — Height of Seat

Nearly all beginners use too high a seat while working. With a stool or chair too high the body must assume a stooped position which proves tiresome within a comparatively short time.

The standard height of the watchmaker's bench is 38 inches and for the average man an ordinary straight back chair with a seat seventeen or eighteen inches from the floor proves very satisfactory when used with such a bench. At first this may seem a trifle low but after one gets used to it, he can work much longer without fatigue than with a higher one.

While working at the bench the apron should be drawn out until it touches the body and the elbows may rest upon the frame work of the apron slide. This allows the body to assume an easy position and brings the work in just about the right location to be examined and observed.

In the more advanced work when using the lathe, extra height should be added to the chair or stool to make it about 22 inches from the floor. This may be in the form of a pad five inches thick.

Many workmen at the bench use an ordinary four legged stool of a height best suited to their own individual needs.

Sec. 12 — Pocket Watches

The first watches seem to have been made about the year 1500. About 1587, Watchmaking as an industry was introduced into Geneva, Switzerland by Ch. Cusin although a few watches had been made in Switzerland previous to that date. Enamel dials were invented in 1635 by Paul Viet, a Frenchman. The balance spring was invented in 1658.

Until 1687 watches had been made with only an hour hand but at this time the minute hand was introduced. However, the minute hand had been used in clocks as early as 1610.

About 1700, jewels as bearing for the pivots came into use. The compensating balance was first introduced in 1749.

About 1780 the second hand came into use.

The earlier watches were all hand made, each watch with its case presenting an individual problem.

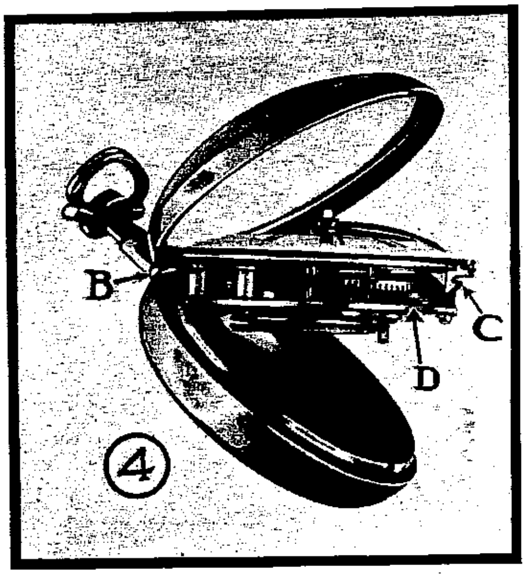
Sec. 13 — Sizes of American Watches

In 1849 Aaron L. Dennison an American Watchmaker began to build machinery for manufacturing watches on the interchangeable system.

In order to do this successfully it was necessary to have certain standard sizes and some system for determining these sizes. Mr. Dennison has been credited with having originated the method for sizing that has become a standard for American manufacturers of watches. His system was based upon the English inch and thirtieths of an inch.

The first watch made by Mr. Dennison and his associates of the American Horologe Company was 18 size and this size was determined by taking one inch and adding 6|30 of an inch for "fall", then each additional 1|30 of an inch formed a size. Thus the 18 size watch would measure one inch, plus 6|30, plus 18|30 which equals one and 24|30 inches the full diameter of the watch measuring on the pillar plate.

This so called allowance for "fall" was borrowed from the English. The English Watch Movements were usually hinged to the cases as shown in the Old English Verge in figure 4, and



the top plate, indicated by the arrow D was made enough smaller in diameter to permit the movement to "fall" or drop into its position in the case without striking.

In the American sizes from 16 size down to naught (0) size, only 5|30 was added for fall. Thus a 16 size movement measures one inch, plus 5|30 (fall) plus 16|30 (for size) equals 1 21|30 inches. 12 size measures 1 inch, plus 5|30 plus 12|30 equals 1 17|30 inches etc.

Thus was begun the making of watches to standard sizes, and as a natural sequence the making of parts that were of standard sizes and interchangeable in watches of the same make and like models.

This first factory was started in Boston and in 1854 was moved to Waltham, Mass.

Some idea of the wonderful strides that have been made, can be obtained when we learn that in 1854 this factory was employing ninety hands and making about five watches a day.

Today by means of improved methods and automatic machinery some of which almost seems human in its work, one of the leading factories has a capacity of over 4500 watches a day, while employing over 4000 people.

Sec. 14 — Swiss Watches

The Swiss manufacturers lagged behind the American in their adoption of automatic machinery and the making of interchangeable parts. It has been but a comparatively few years since it was no uncommon thing to find in the same Swiss watch, train bridge screws of different sizes — even different pitch of thread.

It was customary in taking apart these older Swiss movements to have a *"screw stand"*, consisting of a round plate drilled with a series of holes into which the workman placed the screws in the order in which he removed them so that when he assembled his watch, the screws could be replaced in their proper holes without confusion.

In the modern Swiss watches as made by the leading factories this fault has disappeared and the factory material is now on an interchangeable basis, making it possible to get material and parts for these watches as well as for American.

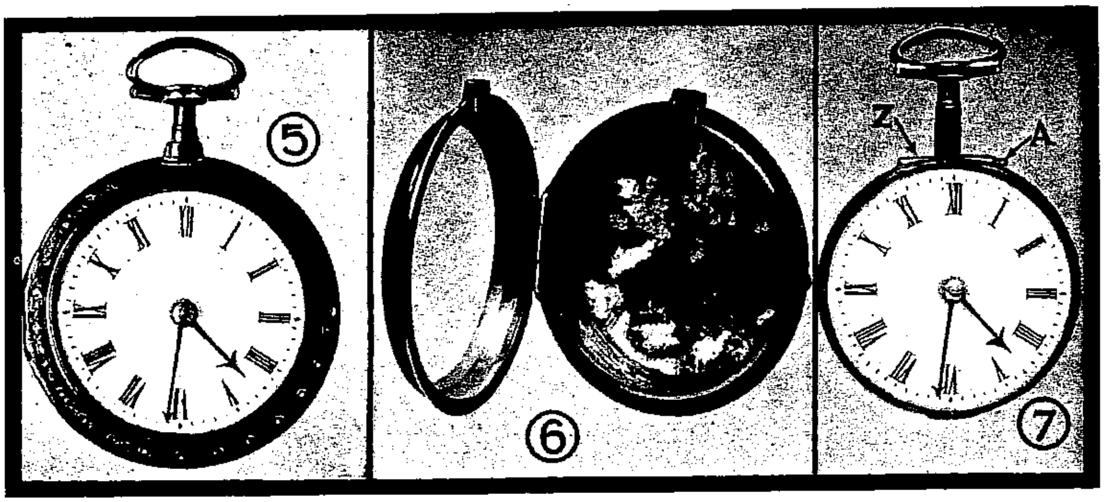
As the interchangeable feature of Watchmaking came into its own, the manufacture of cases came to be independent of the Watch factory, so that today the manufacturing of cases is an entirely different industry from that of manufacturing watch movements.

Sec. 15 — Casing of Pocket Watches

The older pocket watches were cased in double cases consisting of an inner and outer case. In figure 5 is shown an old English Verge movement in such a pair of cases.

The outer case closes with a snap fit and is opened to the position shown at figure 6 as we would a modern snap case. The inner case containing the movement fits into this outside part and can be lifted out as in figure 7.

The movement is hinged or jointed to this inner case by the same pin which connects the two parts of the inner case. At Z in figure 7 is shown this joint with its pin protruding from the other end at A. At B in figure 4 is shown the joint when this case is opened.

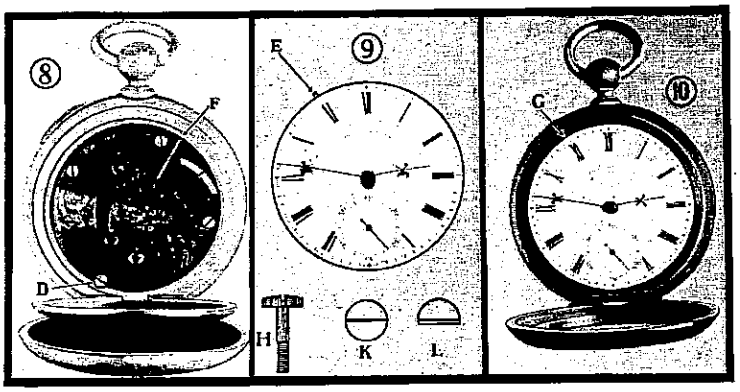


At C in figure 4 is shown the catch which holds the movement in the case and this catch must be pressed in order to lift the movement to the position shown in figure 4. To take the movement entirely out of the case it is necessary to push the pin from the joint at A in figure 7, this being the same joint shown at B in figure 4.

Sec. 16 — Case Screws

In the American system of casing movements, the movement was not jointed to the case but held in place by means of case screws.

These case screws at first were merely short screws similar to pillar screws and screwed into the top plate so close to the outside edge that the heads projected far enough outside the plate to catch on the case and thus hold the movement in place. At D in figure 8 is shown such a case screw.



In the lower plate, that is on the dial side of the movement, was placed a pin, E in figure 9. This pin fitted into a hole drilled in the case directly under the point of the arrow G in figure 10. In this way the movement would be held in the case at two opposite points, the case screw at D and the pin which would be on the dial side and directly under the point of the arrow F in figure 8.

This pin also served another important purpose. By means of it the movement was always placed in the case in a fixed position so that the figure 12 on the dial was in exact line with the center of the pendant as shown in figure 10.

Sec. 17 — Half Head and Full Head Case Screws

Next the case screws were made long enough to extend through the top plate and threaded into the lower plate. These screws were made with half heads, so that by turning the screw half way round, the movement was released and could be taken out of the case. These half head screws however, being of tempered steel, had the effect of a milling cutter and in some instances by much use, the screw would cut through the softer metal of the case making it necessary to put a washer under the head of the screw in order to hold the movement in the case.

This cutting of the case by the half head case screws has been overcome by using full head screws instead, and with this style it is best to take the screw entirely out before removing the movement from the case.

By half head is meant a screw in which nearly half the head is cut away. Full head screws are those in which the heads are left full round as the screw at D figure 8.

At H in figure 9 is a drawing of a full head case screw. At K is shown a full head screw as it appears from above and at L a half head.

Sec. 18 — Modern Casing

Formerly the retail dealer in American watches was accustomed to buy separate movements and cases and then do his own "casing" by which is meant the fitting of the watch movement to the watch case. In American watches this "casing" was not at all difficult on account of the precision with which both the movements and the cases were made. Thus it would require very little skill to fit any standard American made 16 size open face movement into a 16 size open face case made by some other American manufacturer — sometimes in pendant set movements a slight alteration in the stem or adjustment of the sleeve. In lever set movements it might be necessary to file a slot in which the lever could slide.

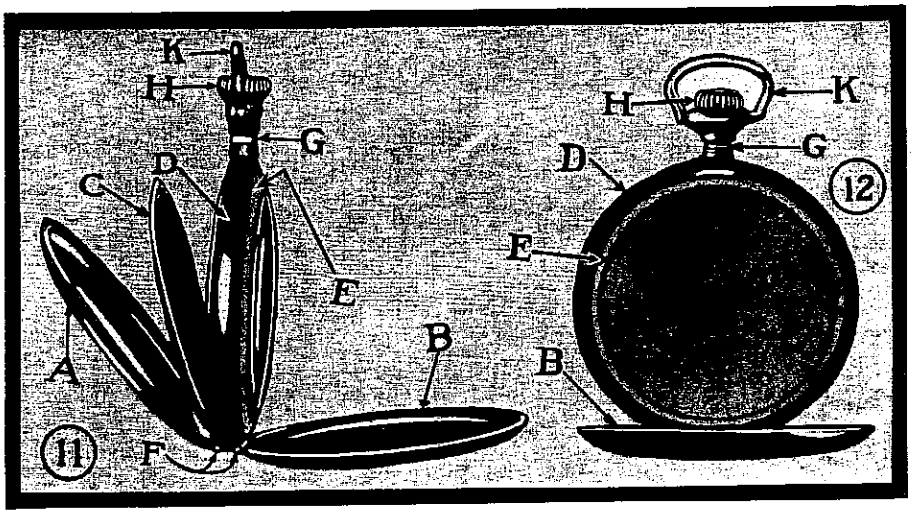
The Swiss movements, cased in American or Imported cases, presented a more difficult problem on account of their lack of being standardized to the extent that the American products were.

Now nearly all American and Swiss movements are being cased by the manufacturer or importer, coming to the retail dealer ready to be delivered to his customers so that the watchmaker has less of this work to do than formerly. However, it will be necessary for you to do some casing in any store but by understanding the relationship of certain parts which will be explained to you, this work should offer very little difficulty.

Sec. 19 — The Hunting Case

Formerly the Hunting Case was popular in both men's and ladies' watches, but today the favorite in all sizes is the Open Face. By Hunting Case we mean that kind of a case with two lids or backs as shown in figure 11, one of which, on the dial side, can be opened by pressing on the crown at H.

The different parts that make up a Hunting Case are as follows: the two backs A and B in figure 11, B on the dial side in the language of the casemaker known as the "front back" and A as the "back back". Generally this is shortened to "front" and "back".



C is the "cap".
D is the "center".
E in which the watch glass or crystal is fitted is the "Bezel".

The two "backs" are hinged to the "center" by what are known in the trade as "joints" as shown at F.

The "cap" also is connected to the "center" by means of a "joint".

The "bezel" is snapped on the "center".

G is the "pendant".
H is the "crown".
K is the "bow".

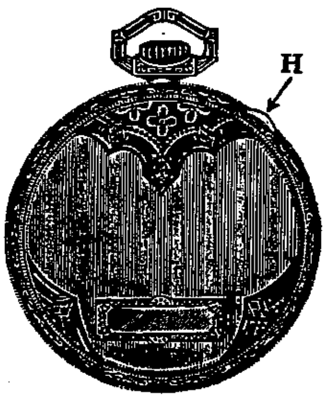
The "stem" by means of which the watch is wound is attached to the "crown", generally being screwed into that part so that the "crown" and "stem" act as one solid unit.

In figure 12 is shown a dial view of the Hunting Case with front opened. In this photograph the letters represent the same parts as in figure

11. Thus the arrow D indicates the center, B the front, K the bow, H the crown, G the pendant, and E the bezel.

Sec. 20 — Open Face Cases

The Hunting Case is rapidly becoming a thing of the past, the open face case now being the only style of pocket watch that is carried by modern retail jewelers. However, like other older time-pieces there will be some Hunting Cased watches brought to the watch repairers for a long time to come.



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Like everything else there is a constant evolution in the styles of watch cases. Some of these changes are brought about in a comparatively short time as when the ladies' bracelet watch was introduced. Others come much more slowly as the change from the Hunting style to the Open Face. Of late years there has been a tendency toward pocket watches of more distinctive shapes and designs as compared to the round shapes that have been standard for so many years. Manufacturers have recognized this tendency and created a variety of new and interesting patterns. Some of the popular shapes are the Pentagon or five sided, the Octagon or eight sided, the Decagon or ten sided, the square and cushioned shaped cases, all of these in open face models.

Sec. 21 — Assembling "Snap" Cases

In Open Face cases the bezels and backs are assembled either by having them threaded and then screwed into place or by having such a close fit that it is possible to snap the parts together. This latter style is known as a "Snap Case".

In some snap cases the back and bezel are jointed to the center while in others they are entirely free.

When the back and bezel are jointed to the center, the case would then be much like the Hunting Case shown in figures 11 and 12, if the cap and bezel were removed and the front was cut out to take a watch glass or crystal.

When the back and bezel of a snap case are attached to the center by joints, they of course always will occupy the same position when snapped together, but where the bezel and back come off entirely it is necessary to have some means of replacing them as they were originally, especially on engraved cases in order that the engraving may be in the position intended by the manufacturer or engraver.

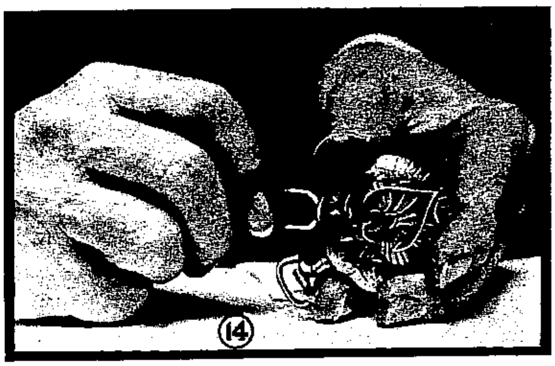
Sec. 22 — Position of the Lip

In this style of the regular round case there is generally a lip for the case opener to rest against or if not a lip, a small cut out place to facilitate the entering of a case opener or other wedge shaped object.

In replacing a back and the same of course applies to the bezel, this lip or cut out should be a little to the right side of the pendant as shown at H in figure 13.

As stated before this lip is for the purpose of inserting a thin blade, such as a case opener, in order to pry open the case.

In figure 14 is shown the manner of holding a case when opening it with a case opener.



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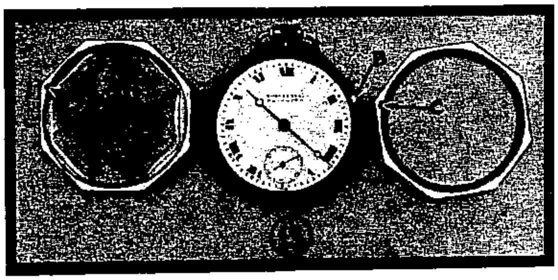
The case opener which is thin at the edge is inserted between the center and back and by means of a twisting motion pries open the case. Care must be used in order that the edge of the case opener does not come in contact with the movement caused by using too much pressure or that it doesn't slip across and mar the case.

Sec. 23 — Assembling Fancy Shaped Cases

The Fancy Shaped Cases come under the class of "snap cases" and are generally provided with a key or pin on the center which fits into a "key seat" or opening on the bezel or back.



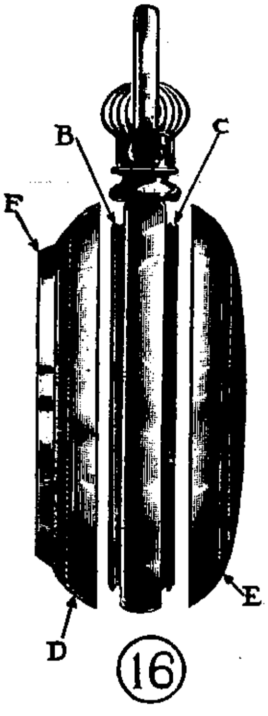
In figure 15 is shown a movement in an octagon shaped case with the bezel and back removed from the center. At B is shown the key on the dial side and at C is shown the key seat on the bezel.

In replacing the bezel it is necessary that the key seat be exactly over the key.

On the other side of the center there is a similar key which fits into the key seat on the back shown at D.

Sec. 24 — Screw Bezel and Screw Back Cases

The screw bezel and screw back case is one of the most common styles used in open face pocket watches.



In figure 16 I have purposely used a cut of an old style heavy screw bezel and back case in order that you may see more easily the method of assembling it.

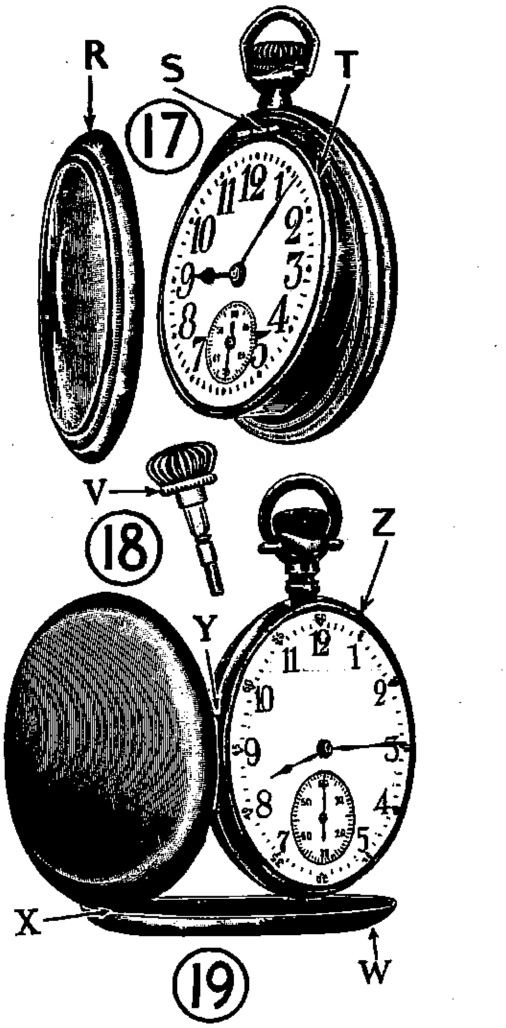
As you can see from the drawing the "center" is threaded on each side at B and C. In assembling the case the back E is screwed up tightly on thread C and the bezel D, into which the glass F is snapped, is screwed on B. Each of these is a right hand thread.

The screw bezel and back case is generally abbreviated by the manufacturers and jobbers as S. B. and S. B.

Sec. 25 — Swing Ring Cases

Figure 17 shows a swing ring case. In this the back is solid — in other words the back and center are all in one piece while the bezel R is a Screw Bezel.

The ring T into which the watch movement is fitted is jointed to the case at the point S and in taking out or replacing the movement it is necessary to swing the ring out much further than is shown here to get at the case screws and to do this it is necessary to first pull the stem out to the setting position. At the lower edge of the ring you will find a groove or lip in which to place the edge of your case opener. This is necessary as the swing ring fits closely and the edge being flush with the case is hard to start otherwise.



Even then there may be a slight sticking as it is opened due to the stem holding in the movement. If so, you may be compelled to twist the stem back and forth by means of the crown, at the same time pulling out on the swing ring.

In figure 18 is shown a dust proof assembly of Crown, Stem and Sleeve, which is used in many Swing Ring Cases.

At V is a nut which screws down on the *outside* of the pendant of the case. Inside this nut is a leather washer which together with the solid back makes this style case practically dust proof.

In making any adjustments in the position of the sleeve or to remove the stem and sleeve it is first necessary to unscrew the crown from the stem and then the nut V from the pendant.

Figure 19 shows a case in three parts in which the bezel W is jointed to the back at the point X. The movement holding ring Z to which is attached the pendant, is jointed to the side of the back at Y which permits the movement to be easily fitted. This is a snap case.

Sec. 26 — Practical Elementary Training

When a watch comes to you for repairs it is already cased as a general rule, so that your first step in making the necessary alterations or replacements will be to take the movement out of the case.

It is necessary that you understand the various types of cases that have been shown in this lesson because in your work as a Watchmaker you will be called upon to take movements out and recase them in all these styles.

Another necessary step is to have the proper tools for each problem that comes up and then practice until you are really competent to use them in a professional way. It hardly pays to attempt to do this work with poor tools.

The real expert would be greatly handicapped in attempting to do the quality of work expected of him if compelled to use inferior tools, and the beginner is often discouraged without realizing how much easier it would be to do his work provided he had the right equipment. For that reason I have selected just the ones that I have found to be best suited for each particular class of work and advise you to provide yourself with these sets. Get them in perfect order — do not attempt to do your work with second hand tools of whose condition you are not yet competent to judge.

Sec. 27 — Your First Job

In your elementary work it is best to have as your first practice watch, one that is not too valuable and also one that is fairly large, in order that the parts may be as strong as possible. By this I mean a standard grade of watch, not the cheap clock watches that are found on the market.

Although the 18 size watch is rather out of date as far as being sold in the modern retail jewelry store, there are still many of this size in use and they no doubt will be brought in for repairs for a long time to come.

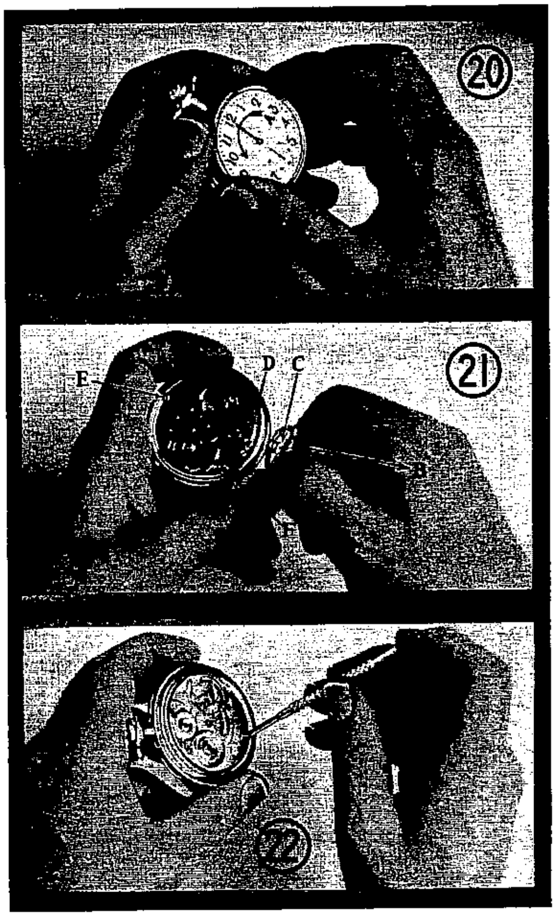
It should not be difficult to secure one of these larger style movements, and owing to its size this is a nice model for you to use in your first problem of taking out and replacing a movement in its case.

However, if you do not have access to such a large watch, a 16 size or 12 size will do, but I would advise you not to use smaller than 12 size on the first few lessons.

If it is pendant set, the same watch may be used in several of the lessons that follow, but if possible it is better to vary the make of watch on which you practice, so that you may become acquainted with the models made by the different factories.

Sec. 28 — Remove Bezel and Back

Starting at the beginning the first step will be to remove the movement from the case, and in order to do this, take off the bezel and back. In unscrewing a bezel hold it in the position shown in figure 20, twisting the bezel to the



left in the direction of the arrow A. Turn the watch over and do the same thing to the back. Our watch then will appear as shown in fig. 21.

If instead of a S. B. and S. B. your first job should be upon a jointed case then of course you merely open front and back with your case opener.

In all probability this watch will have a pendant set movement, but whether pendant or lever set, in order to take it out of the case it will be necessary to pull out the stem to a pendant set position by grasping the crown as shown in figure 21 and pulling straight out in the direction of arrow B.

Sec. 29 — Cases Without Sleeves

In some of the older style cases for *lever set* movements where there is no sleeve, you will find a screw in the pendant of the case at a point indicated by the arrow C figure 21 which fits in a slot in the stem, thus holding the stem in proper position. In such a style case it is necessary to back this screw out far enough to allow the stem to be withdrawn from the case by means of the crown and then it is an easy matter to slip the movement out.

Sec. 30 — Using a Screw Driver

At this point it is well to test your ability to manipulate a watch screw driver.

The head of the screw driver turns freely on the shank so that by placing the first finger on this head and holding the shank between the thumb and second finger you can turn the shank and of course the blade with it, by merely rolling it between the thumb and finger. See figure 22.

At times where the screw is difficult to start some prefer putting the head of the screw driver in the palm of the hand and using the first and second fingers on one side and the thumb on the other to secure a little more leverage in turning.

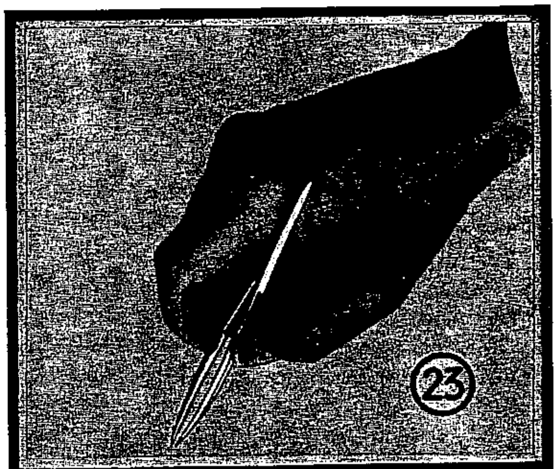
Sec. 31 — Selecting Proper Size of Screw Driver

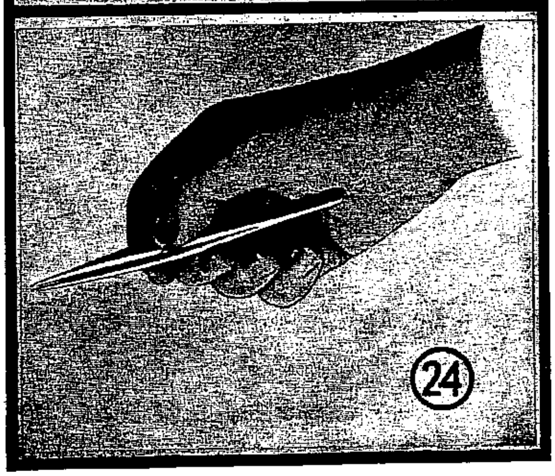
In selecting a screw driver for any particular screw try to have the blade as near as possible the same width as the diameter of the screw head in order to prevent twisting the point of the blade or marring the head of the screw, also where a screw is in a recessed plate never have the screw driver any larger than the head of the screw, otherwise you will mar the plate.

Sec. 32 — Use Tweezers When Handling Watch Parts

Use the proper size screw driver and turn each screw D and E figure 21 until it is entirely free. Then with your tweezers lift each case screw out and place in your material tray.

The most common and natural way of holding the tweezers when manipulating any small object is as shown in figure 23. Here you can see the tweezers are held in much the same way that a pencil is held in writing. One side rests upon the second finger while the pressure necessary to hold an object is applied by means of the thumb and first finger.





Sometimes where more force is necessary as in pulling at some part that has become stuck, the tweezers are held inside the hand as shown in figure 24, the pressure being applied by means of the first and second fingers on one side and the thumb on the other. It is also more convenient at times, to handle the tweezers this way in holding small objects than as first described. Practice each method and you will soon find yourself using the one that is best adapted for the work you are doing.

Nearly all beginners use too much pressure on the tweezers. Use only enough to maintain the necessary grip when picking up or placing any watch parts or material. By using unnecessary pressure there is always danger of snapping the piece out of the tweezers.

At first it will seem awkward to handle small objects in this manner but with practice it will come easier until finally you will have no trouble in manipulating the smallest parts with tweezers.

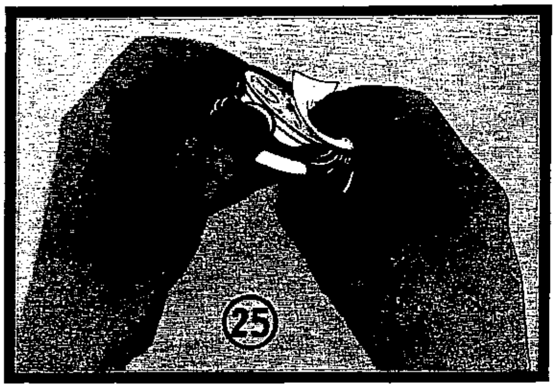
Sec. 33 — Taking Movement From Case

Having removed the case screws, a slight pressure on the movement usually will cause it to slip from the case into the hand held ready to catch it.

If the movement sticks slightly it may be forced from the case using the thumb nail of the right hand as shown in figure 25. By bending the thumb at the first joint in order to bring the nail in contact with the movement, rather than the ball of the thumb you avoid getting unsightly finger marks on the watch plate.

Sec. 34 — Do Not Get Fingermarks On Movement

Here let me warn you against getting finger marks on either plate or dial of a movement. When you press the movement out of the case, grasp it by the *edge*. Whenever you pick up a movement, pick it up by the *edge*.



In taking the movement out of the case, it is well to place a piece of watch paper between the fingers and the dial as shown in figure 25.

Sec. 35 — Use a Material Tray and Movement Cover

At the beginning of your work get into the habit of placing the small parts in some kind of a material tray or cup which you should have placed in a convenient position on your bench. When you remove the case screws place them immediately in your material tray.

While working upon the case, having removed the movement, should you allow the movement to set uncovered upon your bench it woud be liable to accumulate some dust and there is a risk of something falling upon it and breaking some delicate part. Therefore as soon as you take the movement out of the case it is well to set it in a material tray or on a piece of watch paper and cover it with the movement cover. In this way it is protected from any stray dust that may be in the air.

Sec. 36 — Polish the Case

Whenever you clean or repair a watch it is also necessary to thoroughly clean the case so that no dirt remaining may come in contact with the movement. In the lesson on cleaning watches I will give you in detail the best methods for cleaning the case but at this time it is not necessary for you to attempt such a thorough cleaning of the watch case on which you are working.

However it is well to wipe off all dirt or oil that may be on the watch case and then after being sure that it is dry, polish with a double polishing cloth.

This cloth has two surfaces, the inside or red cloth being for polishing and the outside cloth to protect the hands from this red color.

In using this polishing cloth see that the watch case is dry but if badly tarnished a slight moistening by blowing on the tarnished part will aid in restoring the original finish.

Of course in using this cloth to polish the case it is necessary to have replaced the back and bezel or in a jointed case to have closed the back and front.

Sec. 37 — Using the Polishing Cloth

Then by opening the polishing cloth as you would a book, placing the case between the two red sides, gripping the outside cloth in the hands and rubbing vigorously, you can restore the polished finish to a large degree.

This cloth can be used for polishing other objects in gold or silver such as jewelry, silverware, table ware and trophies. The red color is harmless and can be washed. If any powder remains on the surface of the object cleaned it can be removed by using the outside cloth. This will also give an additional polish.

Sec. 38 — Replace Movement in Case

After polishing your case remove the bezel and back, see that the crown is in the setting position then replace your movement in the case by starting the stem in the winding arbor and allowing the balance of the movement to slip easily into the case. In doing this keep the dial side uppermost so there will be less danger of the movement falling out.

After you have the movement in its proper position, hold it in the left hand if you are right handed, with the nail of the first finger pressed against the dial side while gripping the case with the thumb and second and third finger, as shown in figure 26. Holding it in this position

turn the hand over so that the dial side of the watch is down. With your tweezers in your right hand pick up one of the case screws and place in position. Then with a screw driver turn this screw down until it is just holding the movement in place. Do the same with the other case screw.

Sec. 39 — See That Movement Is Centered

Before you screw the case screws clear down, press the crown into the winding position so that you will be sure to have the movement centered properly in the case. If you do not do this you are liable to have it slightly to one side with the stem going in at an angle which will make it bind somewhat while winding. Having the stem in the winding position before setting the case screws, turn the crown back and forth to see that the stem turns easily. If it does then set your case screws down in place. Case screws however, are not set as tightly as other screws in the movement. If too tight the heads are easily broken off by a jar that might not injure the movement. However do not make this an excuse for having the case screws turned into place too lightly. Turn down tight but not as far as it is possible to turn them.

Now examine dial and back of movement for finger marks, thereby gauging your ability to handle a movement without leaving such traces of an amateur. Replace the bezel and back on the case. Again try the winding and setting by means of the crown, wipe off any further finger marks on back or glass and credit yourself with having finished your first step in your progress toward becoming a Master Watchmaker.

Sec. 40 — Practice for Speed

The mere act of going once over the work described in each of the Master Lessons that are given you or the completing of the step by step methods shown in the Master Work Sheets does not make for finished skill in Watchmaking. If you are to be a Master Watchmaker you must have speed as well as ability and you must practice every problem described until you can do the work in the time specified on the Master Work Sheet. Some are able to acquire this speed with only a few hours practice while others must go over the work many times before being able to make the grade.

However you should realize that only by such effort can you attain the goal and that these problems once mastered are the real steps toward your success.

A watch is a machine; when it is right it will perform properly and not before. The man who works upon this machine should never slight any part, but should always strive to do his very best. Remember that you can never do your work too well.

First then, master the *How* of doing each proposition before attempting to acquire speed. After you are able to do your work as it should be done, practice each step over and over, never letting down on the quality. You will be surprised how easily the work comes after the first few problems if you will follow these simple directions and always strive to make each following job the best you have ever done.

CHECK YOURSELF

Progress Check 1A | A Self Test Review of Lesson 1

Study Sections 1 through 11; then see if you can answer these questions without looking back. DO NOT SEND THIS QUIZ TO THE SCHOOL FOR GRADING. You'll find answers at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. A man who repairs watch movements is commonly called a ____________________.	3
2. Watches are generally classified as ____________________ watches and ____________________ watches.	4
3. The most important thing about a bench for proper work is its ____________________.	5
4. A Master Bench has an ____________________ to catch anything which might slip off the bench.	7
5. Additional means to keep small parts from rolling off are ____________________ ____________________.	7
6. Watch work is best done on a ____________________ surface.	8
7. The tools used ____________________ should be stored nearest at hand.	9
8. To avoid tiring the eyes, the watchmaker should have ____________________.	10
9. Watchmaker's benches have a standard height of __________ inches.	11
10. A ____________________ seat is desirable at the bench.	11

==

ANSWERS TO PROGRESS CHECK 1A:

1. watchmaker
2. pocket
   wrist or bracelet
3. height
4. apron
5. guard rails and
   a groove
6. white, glarefree
7. most often
8. good light
9. 38
10. low

CHECK YOURSELF

Progress Check 1B

A Self Test Review of Lesson 1

After you have studied Sections 12 through 25, see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The first watches were made about the year ________________.	12
2. In 18 size watches, the amount allowed for "fall" is ________ thirtieths of an inch.	13
3. In 16 size and smaller watches, only ________ thirtieths of an inch is allowed for "fall".	13
4. American manufacturers use ________________________ to hold the movement in place.	16
5. The best type of case screw has a ____________________ head.	17
6. A watch which has two lids or backs is said to have a ______________ case.	19
7. When the bezel and back can be snapped on, the case is known as a ____________________ case.	21
8. Some types of cases must be opened with a ________________________.	22
9. When both bezel and back screw on, the case is known as a ____________________________________ case.	24
10. Where the movement is contained in a hinged inner ring, the case is called a ______________________________ case.	25

ANSWERS TO PROGRESS CHECK 1B:

1. 1500
2. six
3. five
4. case screws
5. full
6. hunting
7. snap
8. case opener
9. screw back and screw bezel
10. swing ring

CHECK YOURSELF

Progress Check 1C

A Self Test Review of Lesson 1

After you have studied Sections 26 through 40, see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers at the end of the test. If you miss any, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The first step in taking a movement from its case is usually to remove the ______________.	28
2. Next, the stem is ordinarily ______________ to free the movement.	28
3. The width of the screw driver blade should be ______________ the width of the screw head.	31
4. Watch parts are preferably handled with ______________.	32
5. ______________ pressure whould be applied to tweezers in working with watch parts.	32
6. You can avoid finger prints by using ______________ in handling the movement.	34
7. A movement should always be held by the ______________.	34
8. A good habit to form is to place small parts in a ______________.	35
9. Cleaning a watch should also include cleaning the ______________.	36
10. It is important to ______________ the movement before tightening the case screws.	39

ANSWERS TO PROGRESS CHECK 1C:

1. back
2. pulled out
3. equal to or slightly less than
4. tweezers
5. light
6. watch paper
7. edge
8. material tray
9. case
10. center

SUPPLEMENTARY INFORMATION

Case Metals and Markings:

It is useful to know the metals and markings used for cases. Metals may be combined or alloyed to make a solid metal or one can be plated on another. Where gold is used, the amount of gold in the metal is indicated by the number of "Karats" it has. Fine gold is 24 karats. One karat equals 1/24. Thus, 14 karat gold means the metal is 14/24 fine gold and the rest or 10/24 is the metal alloyed with it. The usual alloy metals are silver, copper, zinc, and nickel.

A. KARAT GOLD (Abbreviations 10K, 14K, and so on.)
Cases stamped 10 Karat (10K), 14 Karat (14K), 18 Karat (18K) are sometimes spoken of as solid gold cases. Gold can be yellow, red or pink, green and white in color.

a. Red Gold (Pink gold)
Gold alloyed with copper.

b. White Gold
Gold alloyed with a white metal, usually nickel or palladium in sufficient quantity to efface the yellow color.

c. Green Gold
Gold alloy containing a relatively high proportion of silver.

B. GOLD FILLED (Abbreviated G.F.)
This term refers to articles made of base metal, upon one or more sides or surfaces of which a shell of Karat Gold is affixed. The term "Gold Filled" is used when the karat gold covering the article is 1/20 or more of the total weight. Both the fractional gold content and karat fineness must be shown. For example: 1/10 14K Gold Filled.

C. ROLLED GOLD PLATE (Abbreviated R.G.P.)
This is the same as gold filled, except it has thinner platings. As for gold filled, the gold must be at least 10 Karat fineness and the fractional content must be shown. For example: 1/30 10K R.G.P.

D. GOLD ELECTROPLATE
Usually made by electrolytically depositing fine gold on base metal.

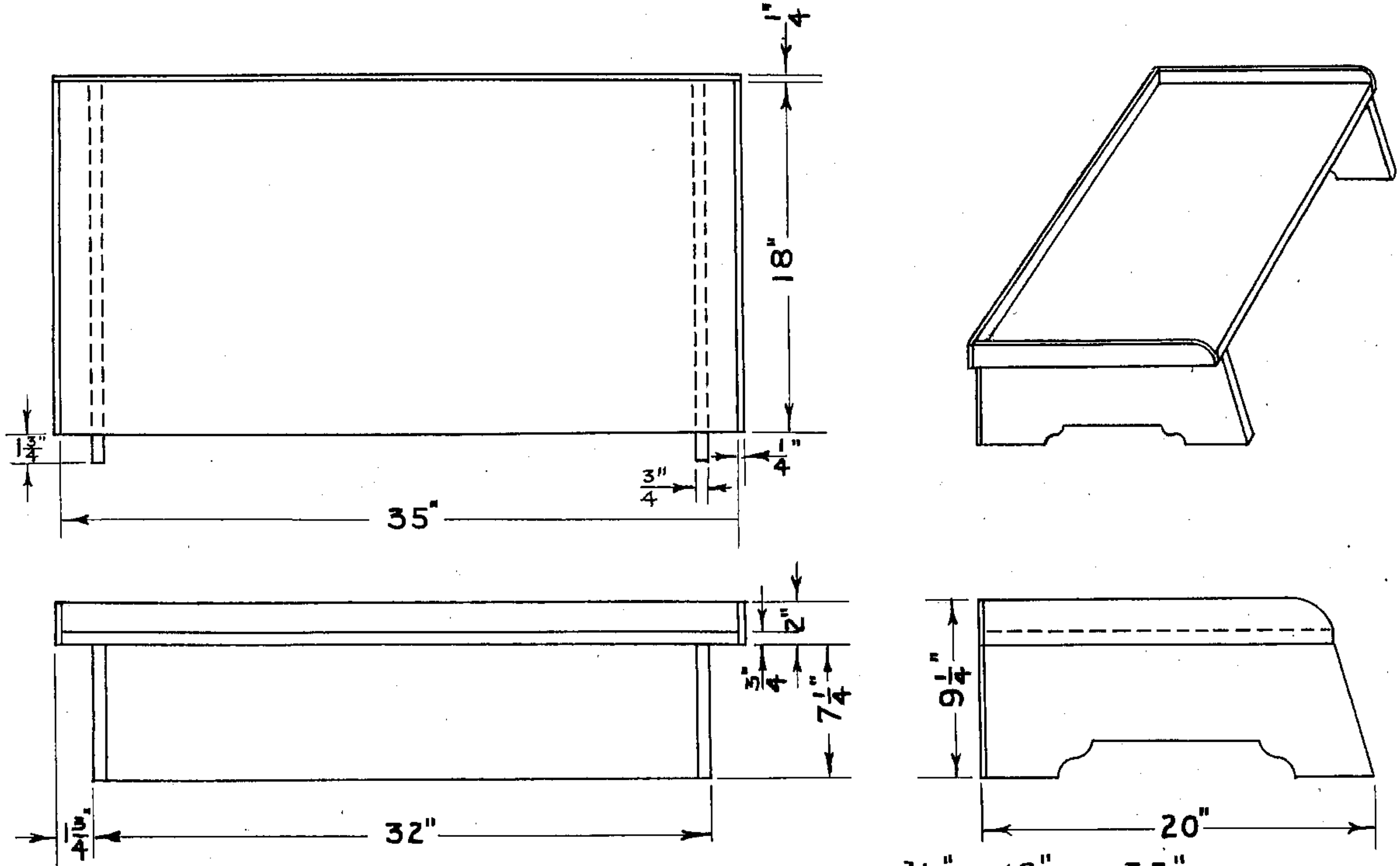
E. SILVER
Sterling silver contains 925 parts fine silver with 75 parts of some other metal, usually copper. U.S.A. coin silver has 900 parts silver and 100 parts copper.

F. NICKEL SILVER - GERMAN SILVER - SILVERINE - SILVEROID - And so on.
So called because of some color resemblance to the precious white metal and not because of any silver content.

G. STAINLESS METAL
Generally used for backs of watch cases which have a R.G.P. bezel or for water-resistant cases.

TABLE TOP WORK BENCH

CHICAGO SCHOOL OF WATCHMAKING



MATERIALS REQ.

CLEAR PINE OR PLYWOOD

1	TOP	3/4"	× 18"	× 35"	
2	SIDES	3/4"	× 7 1/4"	× 19 3/4"	
1	STRIP	1/4"	× 2"	× 35 1/2"	
2	STRIPS	1/4"	× 2"	× 18"	
1	BACK	1/4"	× 7 1/4"	× 32"	OPT.

HOW TO REMOVE AND REPLACE A MOVEMENT IN AN OPEN FACE CASE.

Tools, Equipment and Supplies:

Assembly tweezers   Case Opener   Screwdrivers

PROCEDURE:	REFERENCE:
1. Remove bezel.	Sec. 28
2. Remove back.	Sec. 28
3. Pull out crown into setting position.	Sec. 28
4. Remove case screws.	Sec. 30, 31, 32
5. Remove movement from case.	Sec. 33, 34, 35
6. Replace movement in case.	Sec. 38
7. Push stem into winding position.	Sec. 39
8. Replace case screws.	Sec. 39
9. Replace back and bezel.	Sec. 39

LESSON	1
CASING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L1-J2

HOW TO REMOVE AND REPLACE A MOVEMENT IN A TWO PIECE WRIST WATCH CASE.

Introductory Information:

This is the most common case used for men's and ladies' wrist watches. It is generally spoken of as a dress watch.

Tools, Equipment and Supplies:

Case Opener or Bench Knife.

PROCEDURE:

A. Removal

1. Hold case with back up, crown toward you.
2. On the right end of the back of the case locate either a lip or groove. Pry upward at this point with case opener. Back of case containing the movement will snap free of the bezel.
3. The movement generally fits snugly into the back of the case and may be removed by jiggling the crown. If this does not free the movement it may be necessary to pry carefully upward on the protruding edge of the pillar plate with case opener or blade of bench knife. Care should be used so as not to damage train wheels, balance wheel or barrel, which may have little clearance when movement is lifted from the back.

B. Replacement

1. Set back of case on a block or similar elevation with stem slot to the right and edge of case back even with the edge of the block. (This is to prevent crown from resting on the block.)
2. Place movement in the case back, aligning stem with stem slot.

   NOTE: If crown is one of the various types of dust proof crowns, pull stem into setting position. Some movements are fitted with a dust guard. This is a small tube through which the stem passes, attached to a tissue-thin flexible metal flange between the case and the movement. Another type of dust guard is notched. This type fits over a lip in the case.

3. Snap movement and back into bezel.

LESSON 1

CASING

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

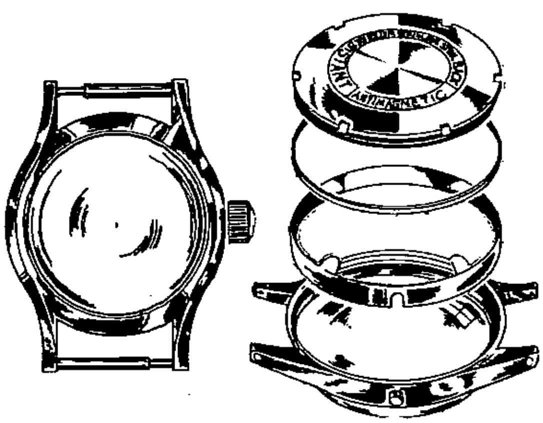
JOB SHEET

L1-J3

HOW TO REMOVE AND REPLACE A MOVEMENT IN A SCREW BACK WATER-PROOF, WATER-TIGHT, OR WATER-RESISTANT CASE.

Introductory Information:

Backs on this type of case have various indentations, such as a knurl, slot, flat, hole, and so on. A key or case wrench is applied to unscrew the back. Case wrenches for individual models are not always available. In general, it is best to get a good universal type of case wrench as it may be adjusted to fit practically all of this type case. Hold the case in a case vise for safe handling. Replace damaged gaskets with new ones.



Tools, Equipment and Supplies

Assembly Tweezers   Case Wrench   Case Vise   Screwdrivers

PROCEDURE

A. Removal

1. Place case in case vise.

2. Select case wrench to fit the knurling or indentations on back.

3. Unscrew back counter-clockwise.

4. Remove lead or rubber gasket. (Some remain on back.)

5. Release the stem and crown by turning set lever screw (detent screw) about 1-1/2 turns in a counter-clockwise direction. (See Lesson 2, Sec. 61.)

6. Remove the case from case vise.

7. Pull stem and crown from the case. If stem does not come out, unscrew set lever screw a bit more.

8. Lift out movement retainer ring. (This ring may be gripping the movement so firmly that the movement comes out with the ring.)

9. Lift out the movement.

(Over)

PROCEDURE:

B. Replacement.

Note: Check the relation of hands to each other and to the dial. (See Lesson 11, Sec. 278.)

1. Place movement in the case with stem opening in movement aligned with stem opening in the case.

2. Place stem in position.

3. Tighten set lever screw to lock stem in position. Test by pulling stem into setting position and setting the hands.

4. Replace movement retainer ring.

5. Replace gasket. (Use new one, if necessary.)

6. Clamp case in case vise.

7. Place back on case.

8. Tighten back with case wrench.

HOW TO REMOVE AND REPLACE A MOVEMENT IN A SWING RING CASE.

Tools, Equipment and Supplies:

Assembly Tweezers   Case Opener   Screwdrivers

PROCEDURE: REFERENCE:

A. Removal.

1. Remove bezel. (Screw type) — Sec. 25, Fig. 17
2. Pull crown into setting position.
3. Lift ring and movement with case opener. — Fig. 17
4. Remove case screws. — Sec. 30, 31, 32
5. Remove movement from ring.

B. Replacement.

1. Insert movement in ring. (Make certain winding arbor square is centered in hole of ring.)
2. Replace case screws.
3. Swing movement and ring into back of case with stem and crown in setting position. Turn crown to be sure square of stem engages with square of arbor.
4. Test winding to see that stem turns freely.
5. Replace bezel.

HOW TO REMOVE AND REPLACE A MOVEMENT IN A SWING RING CASE.

Tools, Equipment and Supplies:

Assembly Tweezers   Case Opener   Screwdrivers

PROCEDURE:	REFERENCE:
A. Removal.	
1. Remove bezel. (Screw type)	Sec. 25, Fig. 17
2. Pull crown into setting position.	
3. Lift ring and movement with case opener.	Fig. 17
4. Remove case screws.	Sec. 30, 31, 32
5. Remove movement from ring.	

B. Replacement.

1. Insert movement in ring. (Make certain winding arbor square is centered in hole of ring.)
2. Replace case screws.
3. Swing movement and ring into back of case with stem and crown in setting position. Turn crown to be sure square of stem engages with square of arbor.
4. Test winding to see that stem turns freely.
5. Replace bezel.

LESSON	1
CASING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L1-J7

HOW TO REMOVE AND REPLACE A MOVEMENT IN AN OPEN FACE CASE WITH A SWISS TYPE SETTING MECHANISM.

Introductory Information:

There are some models of Swiss and American watches which have a stem that is part of the movement. In order to take this movement from its case, it is necessary to remove the stem, which is locked into the movement by a set lever and screw (detent and detent screw), as explained in Sections 60 and 61 of Lesson 2. Further detail will be found in Lesson 9, Section 233.

Tools, Equipment and Supplies:

Assembly Tweezers   Case Opener   Screwdrivers

PROCEDURE:	REFERENCE:
A. Removal.	
1. Remove back of watch case.	Sec. 24, 28
2. If snap case, open with case opener.	Sec. 20, 21, 22
3. Loosen the set lever screw by turning it counter-clockwise. This will release the set lever so its pin can be disengaged from the slot in the stem. Remove the stem.	Les. 2, Fig. 40 Les. 9, Sec. 233
4. Remove bezel.	
5. Remove case screws.	Sec. 16, 17, 29, 30, 31, 32
6. Remove movement from case.	Sec. 33, 34

B. Replacement.

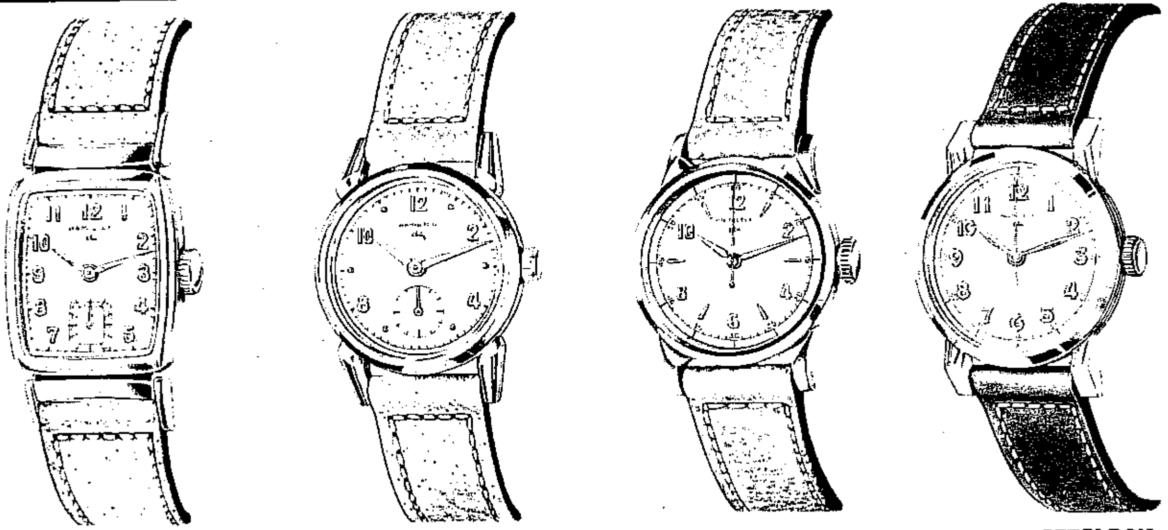
1. Replace movement in case, aligning stem opening in movement with stem opening in pendant.
2. Insert stem.
3. Tighten set lever screw.
4. Test stem by pulling into set position and turning.
5. Replace case screws and again test stem to see that it is not binding.
6. Replace bezel and back.

LESSON	1
CASING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L1-J8



BRANDON *10 K Gold-filled* — LANGDON *10 K Gold-filled*, LANGE *14 K Gold* — NORDON *10 K Gold-filled*, NORDE *14 K Gold* — STEELDON *Stainless Steel*

cld CASE SERVICE DATA

ON THE BRANDON, LANGE, LANGDON, NORDE, NORDON and STEELDON MODELS

HAMILTON cld SEALED AGAINST MOISTURE AND DIRT

ESSENTIAL INFORMATION

ON OPENING, CLOSING, AND OTHER CASE SERVICE OPERATIONS

SERVICE SUGGESTIONS

How to open cld cases

Hold the watch in a dial-up position. Insert a case opener under the lip on the bezel (located at 6 o'clock on some models; at 12 o'clock on others), and gently pry open as in opening a conventional watch case. Because the case bezel and case back fit together with telescopic friction all around, the bezel does not snap free from the back when the case opener is inserted under the case lip. It will be necessary to lift the bezel free from the case back.

How to remove the movement from the case

Do not attempt to pull the crown out—beyond the set position. The crown-stem construction on cld cases is of an interlocking type—not the claw type usually employed—so it can *not* be pulled out without damage to the stem until the movement is removed from the case back.

Do this to remove movement from case: with the bezel removed, turn the crown until the interlocking key joint of the (two-piece) stem (to right of 3 o'clock on the dial) is parallel to the top and bottom of the case; then simply invert the case over the (tissue-covered) palm of the hand and the movement will drop out. Should the movement tend to stick, return the case to "dial-up" position, check the alignment of the interlocking joint of the two-piece stem and re-invert the case. If the movement then does not come out of the case, return to the dial-up position and carefully insert a case opener between the movement and case at 12 o'clock to loosen it. The movement can then be lifted free of the case.

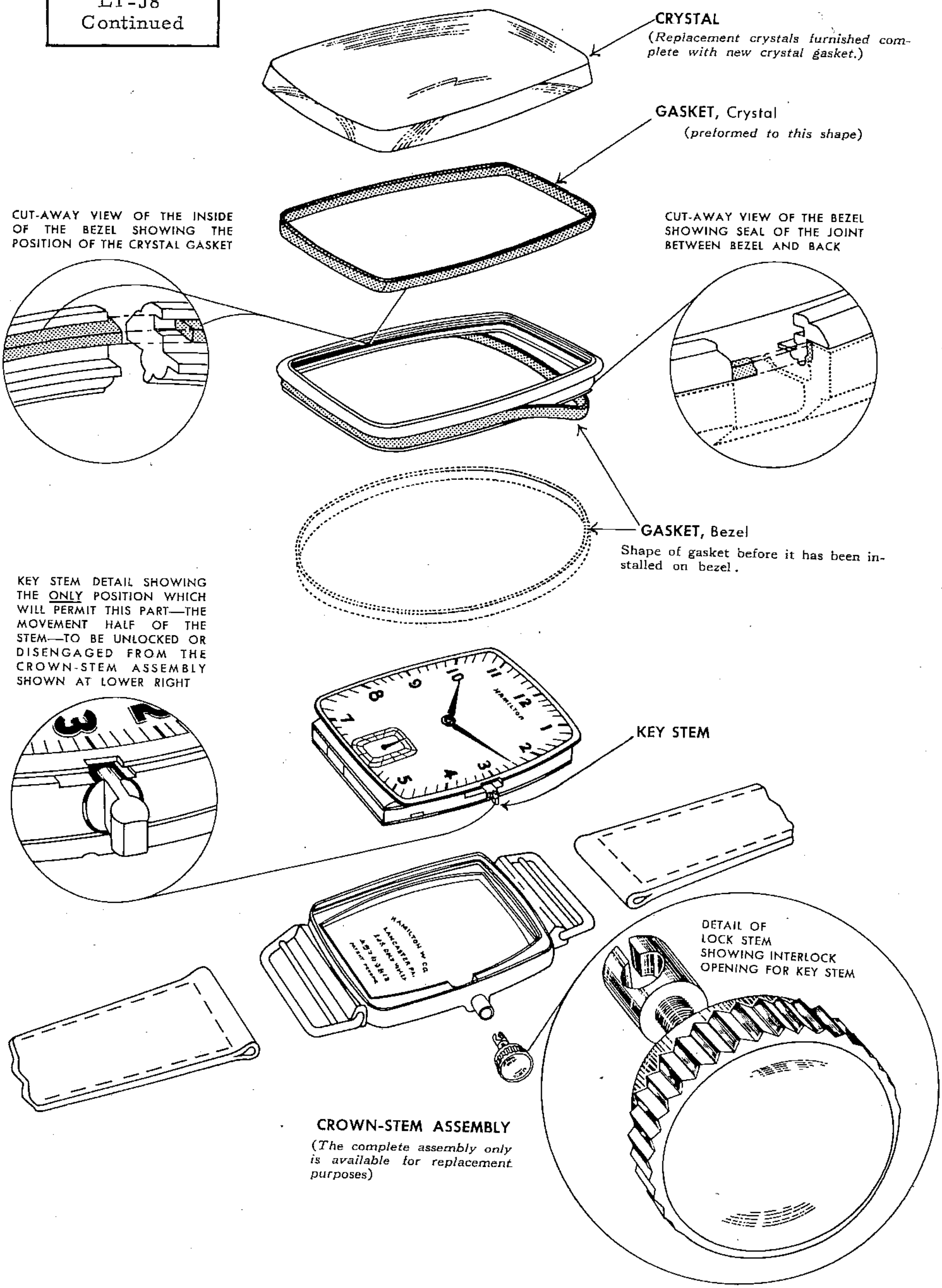
How to replace the movement in the case

Turn the crown so that the Lock Stem—the part containing the female interlocking slot in the crown half of the stem (between 3 o'clock and the case edge) is parallel to the top and bottom of the case. Turn the Key Stem—movement half of the stem—so that it

Continued

JOB SHEET
L1-J8
Continued

EXPLODED VIEW OF CASE ASSEMBLY



will key or interlock with the Lock Stem or crown half of the stem. Then insert the movement in the case in the usual manner and replace the bezel. **CAUTION:** Be sure the bezel gasket is not twisted and that it is located and fitted as shown in Fig. 1 or you will not be able to close the case. On cld models which are not round in shape, it is recommended that the bezel be replaced by first seating it at either the 12 or 6 o'clock end and then working towards the opposite end. Be careful not to dislodge or distort the bezel gasket. When the bezel is properly seated, the bezel and the back should be firmly pressed together to insure a tight fit.

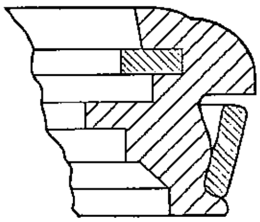


FIGURE 1

How to replace a broken crystal

With the bezel held between the index finger and thumb of each hand—bezel inside towards you—exert a firm even pressure with both thumbs until crystal is released. If crystal is cracked or broken, use care to prevent cutting thumbs. *If the crystal is broken a new, genuine Hamilton crystal and crystal gasket must be fitted to restore the original protective qualities of the case.* These components are available only at the Hamilton factory. Replacement crystals are supplied complete with gaskets. With the new crystal gasket properly seated, a new crystal is installed by simply positioning it in the bezel opening from the front and seating it by applying firm, even pressure with the thumbs.

How to replace a broken stem

Stem breakage occurring in the Lock Stem—the crown half of the stem—requires a new Crown-Stem assembly. Breakage in the Key Stem—the movement half of the stem—requires a new part, which is replaced in the conventional manner.

Routine service check points

Whenever a cld model is submitted for service or repair the following inspections should be made:

(1) Check the condition and fit of both the bezel and crystal gasket. If they are not in prime condition, replace them. Gaskets are very inexpensive so you can replace them freely.

(2) Check the seal of the crown gaskets by winding and back winding the crown. A properly sealed crown has a definite drag or resistance under your fingers when you wind or back wind. If there is little or no drag, open the case, take out the movement and withdraw the crown stem; then tighten the gasket nut as shown in Fig. 2 using a two prong sleeve key. This will compress the gaskets and force them into contact with the pipe on the case thus restoring the seal of the crown. When crown gaskets are worn beyond adjustment, a new crown-stem assembly should be installed.

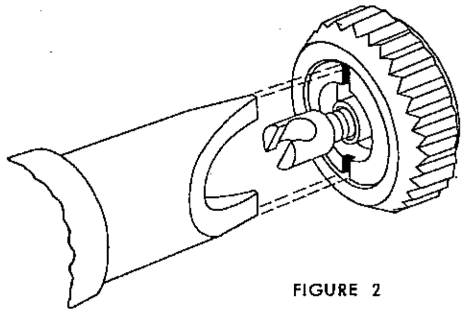


FIGURE 2

Where and how to order crystals, gaskets, stems, and crowns

Genuine Hamilton replacement Crystals, Gaskets, Key Stems, and Crown-Stem Assemblies for cld models are available only thru your Hamilton Material Wholesaler. It is of primary importance that only genuine replacement parts be used, otherwise the original protective qualities of the case can not be assured. And please use both part name and material number on orders for replacement parts.

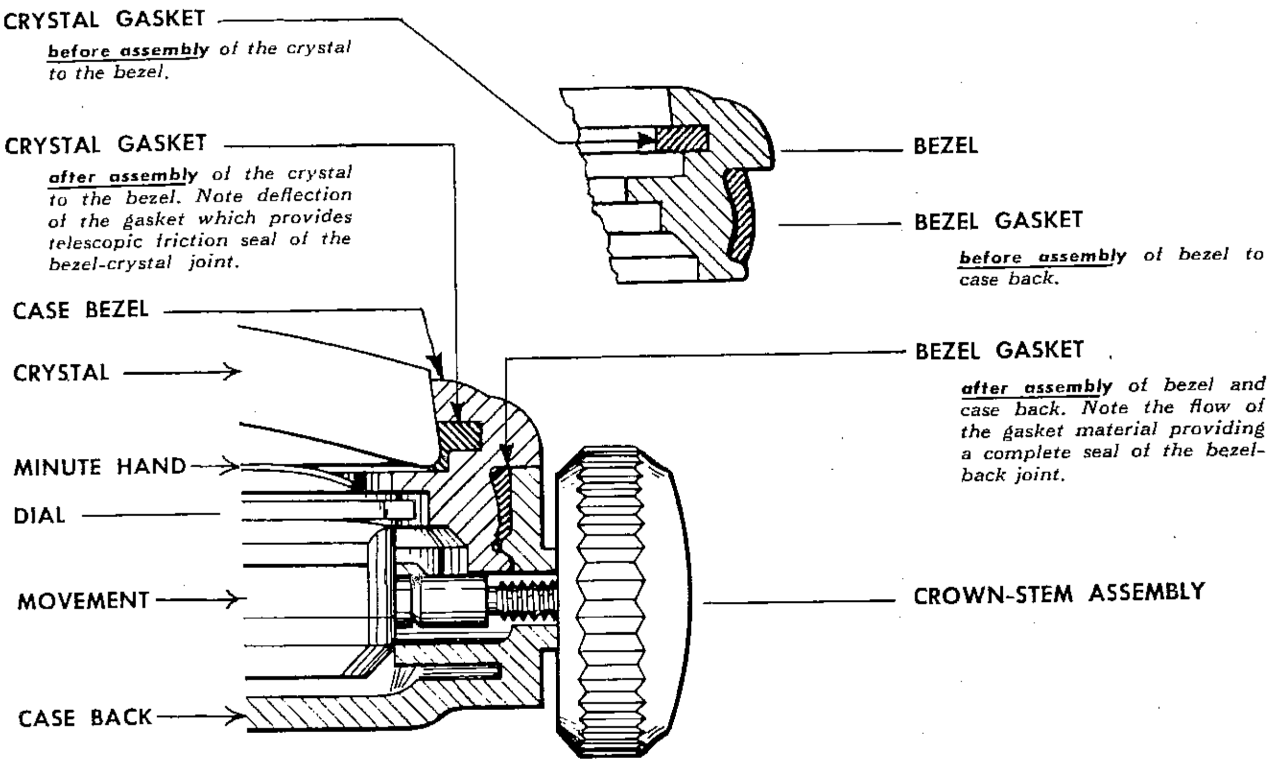
CAUTION: Do not use watch cleaning solutions on cld gaskets. Some cleaning solutions will attack and weaken the gaskets.

Case Replacement Parts

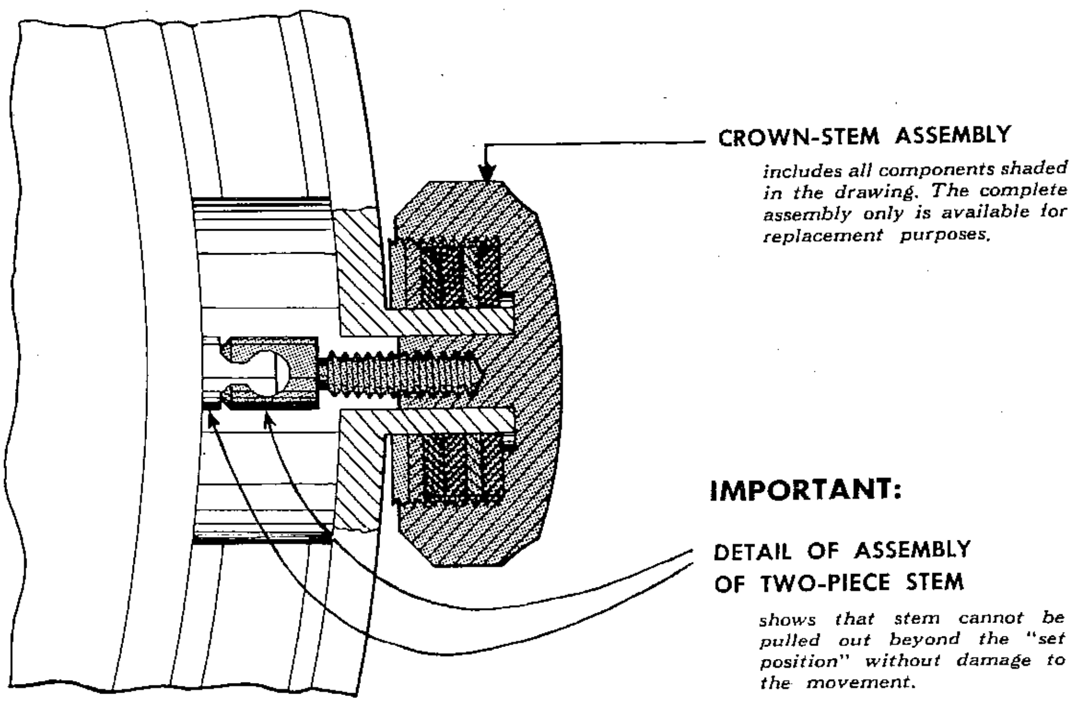
MODEL	CROWN-STEM ASSEMBLY	CRYSTAL	GASKET, CRYSTAL	GASKET, BEZEL	KEY-STEM
BRANDON	MATERIAL NO. 700	MATERIAL NO. 701	MATERIAL NO. 702	MATERIAL NO. 703	MATERIAL NO. 704
LANGDON / LANGE	MATERIAL NO. 705	MATERIAL NO. 706	MATERIAL NO. 707	MATERIAL NO. 703	MATERIAL NO. 708
NORDON / NORDE	MATERIAL NO. 705	MATERIAL NO. 706	MATERIAL NO. 707	MATERIAL NO. 703	MATERIAL NO. 708
STEELDON	MATERIAL NO. 709	MATERIAL NO. 710	MATERIAL NO. 711	MATERIAL NO. 703	MATERIAL NO. 708

JOB SHEET
L1-J8
Continued

CROSS SECTION DETAIL OF CASE ASSEMBLY



CROSS SECTION DETAIL OF CROWN-STEM ASSEMBLY



LESSON	1
CASING	

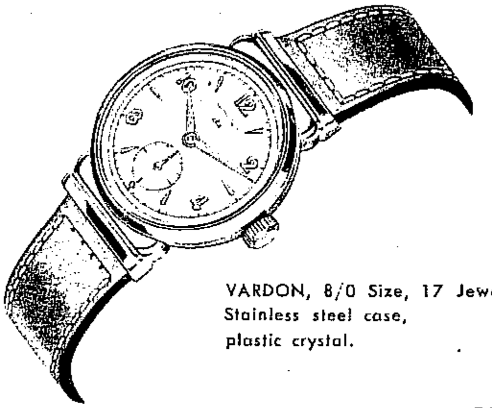
Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L1-J9

IMPORTANT SERVICE INFORMATION ON A NEW AND DIFFERENT CLD MODEL*

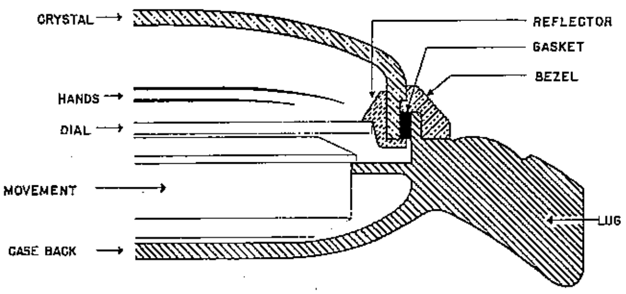


VARDON, 8/0 Size, 17 Jewels, Stainless steel case, plastic crystal.

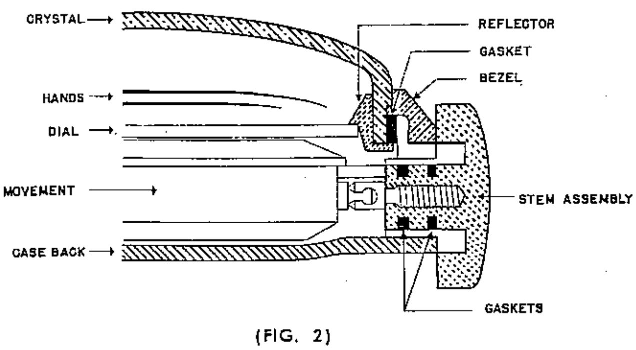
The CLD (sealed) principle of construction is basically the same in all Hamilton CLD models. *It is important to note*, however, that the application of the principle in this model is somewhat different and that it employs a plastic crystal. See Figures 1 and 2 for case construction detail.

* Patent applied for.

SERVICE INFORMATION



(FIG. 1)



(FIG. 2)

How to open the case

Hold the watch in a dial-up position. Insert a case opener under the lip on the bezel (located at 12 o'clock) and gently pry open as in opening a conventional watch case. Because the case bezel and case back fit together with telescopic friction all around, the bezel does not snap free from the back when the case opener is inserted under the case lip, it will be necessary to lift the bezel free from the case back.

How to remove the movement from the case

Do not attempt to pull the crown out—beyond the set position. The crown-stem construction on CLD cases is of an interlocking type—not the claw type usually employed—so it can *not* be pulled out without damage to the stem until the movement is removed from the case back.

Do this to remove movement from case: with the bezel removed, turn the crown until the interlocking key joint of the two-piece stem (to right of 3 o'clock on the dial) is parallel to the top and bottom of the case; then simply invert the case over the (tissue-covered) palm of the hand and the movement will drop out. Should the movement tend to stick, return the case to "dial-up" position, check the alignment of the interlocking joint of the two-piece stem and re-invert the case. To restore movement to case, reverse the order of steps in removing it from the case.

How to close the case

Seat the bezel assembly on the back. Be careful not to dislodge or distort the gasket. Then close the case by firmly pressing the bezel and back together to insure a sealed fit. If the case does not close smoothly, re-open and check the gasket; it may have become dislodged or twisted.

How to replace a damaged crystal

Secure a genuine new Vardon model crystal and gasket from any Hamilton Materials Wholesaler. Do not attempt to use other than a genuine crystal or the original protective qualities of the case cannot be assured. Assemble the crystal to the bezel from the *top* side as is done with a conventional crystal. From the *under* side of the bezel, assemble the reflector to the installed crystal. Then insert the gasket *edgewise* in the groove between the bezel and the crystal. The bezel assembly is then ready to be joined with the case back.

How to replace a broken stem

Stem breakage occurring in the Lock Stem—the crown half of the stem—requires a new Crown-Stem assembly. Breakage in the Key Stem—the movement half of the stem—requires a new part, which is replaced in the conventional manner.

Routine service check points

Whenever a cld model is submitted for service or repair the following inspections should be made:

(1) Check the condition and fit of the bezel-crystal gasket. If it is not in prime condition, replace it. Gaskets are very inexpensive; use them freely.

(2) Check the seal of the crown gaskets by winding and back winding the crown. A properly sealed crown has a definite drag or resistance under your fingers when you wind or back wind. If there is little or no drag, the gaskets are worn and a new crown-stem assembly should be installed.

Where and how to order replacement parts

Genuine Hamilton replacement Crystals, Gaskets, Reflector Rings, Key Stems, and Crown-Stem Assemblies for the Vardon cld model are available only thru your Hamilton Material Wholesaler. It is of primary importance that only genuine replacement parts be used, otherwise the original protective qualities of the case cannot be assured. And please use both part name and material number on orders for replacement parts.

CAUTION:

Do not use watch cleaning solutions on cld gaskets. Some cleaning solutions will attack and weaken the gaskets.

Case Replacement Parts

MODEL NAME	CROWN-STEM ASSEMBLY	PLASTIC CRYSTAL	CRYSTAL-BEZEL GASKET	REFLECTOR RING	KEY STEM
VARDON	MAT. NO. 712	MAT. NO. 713	MAT. NO. 714	MAT. NO. 715	708

ELGIN "SNAP-BACK" WATERPROOF CASES.

Introductory Information:

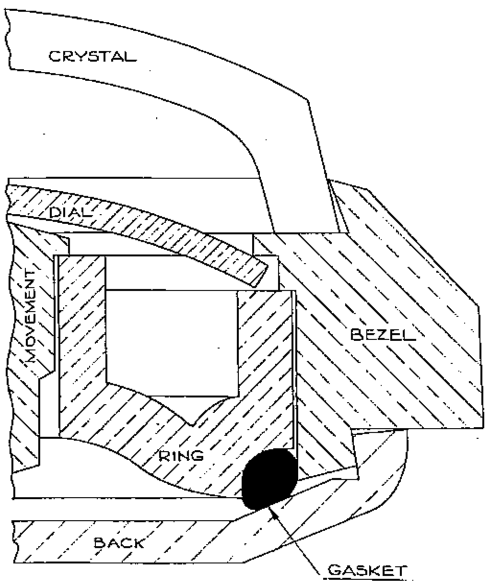
Elgin's snap-back waterproof case requires no special opening tools or wrenches. It can be closed either manually or with the Elgin Waterproof Case Closer, described in this Job Sheet.

An extremely thin gasket is used to seal out moisture. The gasket is made of a specially developed plastic material that resists body acids, is soft enough to mold itself to the case and yet keep its resiliency. but still tough enough to avoid burring or tearing.

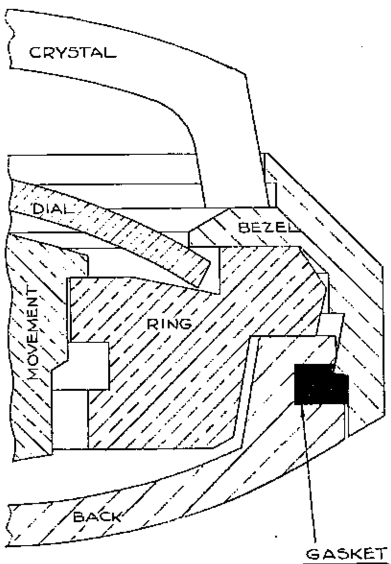
Older type screw-back cases have the disadvantage that the threads corrode from perspiration so that often the case is impossible to open. In this newer type, the back merely snaps on, as in most regular dress watches, with the gasket blocking water. Crystals are snapped in under pressure with the gasket again blocking water.

The snap-back principle permits a much thinner watch and one smaller in diameter, since not as much metal is needed either for threads or corner screws. These cases are made in several styles, as shown in the cross section drawings below:

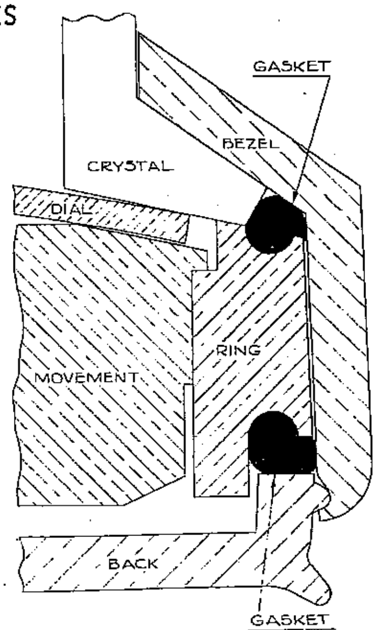
ELGIN "SNAP-BACK" WATERPROOF CASES



ROUND-TYPE "A"



ROUND-TYPE "B"



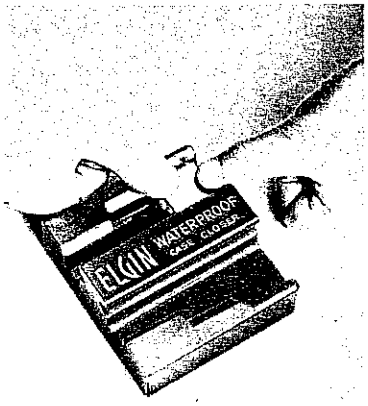
SQUARE TYPE

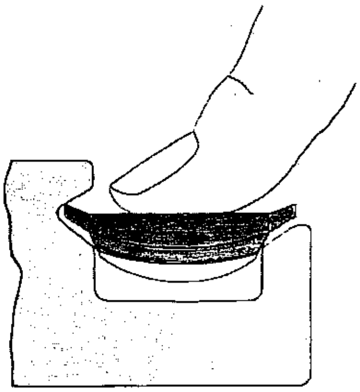
(Over)

JOB SHEET
L1-J10
Continued

INSTRUCTIONS FOR USE OF ELGIN'S WATERPROOF CASE CLOSER

The following points should be observed when assembling Elgin snap-back waterproof cases using gaskets. (See illustrations below):





1. In models with two gaskets the following procedure should be used:
   a. Both gaskets should be in good condition. Place one gasket on top of the crystal, or into the bezel. Make sure the gasket fits into all four corners.
   b. The back gasket should be seated evenly in the groove provided for it in the movement holder.
   c. Place the case in the proper slot of the Elgin waterproof case closer. Note: There are six different sized slots, hence care must be taken in selecting the proper one. A slot giving maximum support to the bezel, yet one which still allows the crystal to clear, is the proper one. Do not use a position which supports the ends of the lugs only, since this will result in undue strain on the case.
   d. After the watch is placed in position, the back is snapped on by applying pressure evenly on both sides. This will snap the case shut evenly without wrinkling or doubling up the gaskets.

2. In models using one gasket on the back side the following procedure should be used:
   a. Check the condition of the gasket and then make sure it is seated evenly without any wrinkling or gaps.
   b. Place the back into position and press down evenly on both sides. Be sure the back is not placed into position by starting one side first. It must be placed straight down or the gaskets will wrinkle.

3. In ladies' models using a round gasket as an integral part of the back, the following procedure should be used:
   a. Check the condition of the gasket and apply a small amount of some good gasket lubricant.
   b. Place the back evenly on the bezel by rocking it back and forth until it is ready to enter the bezel evenly. When it is in position apply pressure on both ends of the back and snap into position.

LESSON	1
CASING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L1-J11

Mido MULTIFORT Superautomatic Powerwind

HOW TO REMOVE AND REPLACE A MIDO MULTIFORT POWERWIND.

Information by Mido Watch Company of America, Inc.

Tools, Equipment and Supplies:

Case Wrench   Case Vise   Screwdrivers   Tweezers   Pegwood

PROCEDURE:

A. Removal.

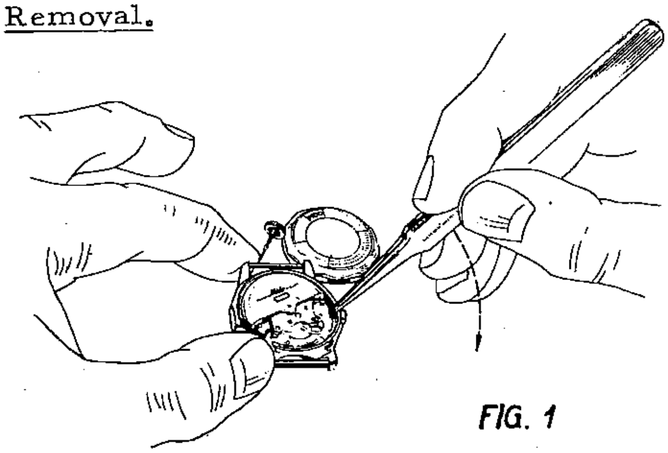


FIG. 1

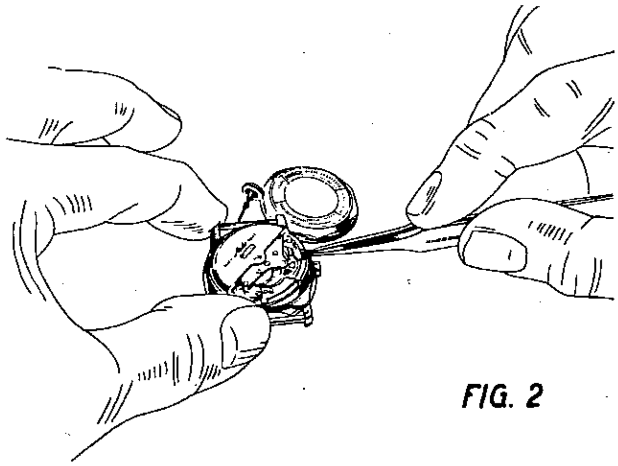


FIG. 2

1. Unscrew back of case with proper wrench.
2. Pull out stem in handsetting position, loosen detent screw and remove stem.
3. Insert tweezer into stem hole of the movement (Fig. 1), lift movement (Fig. 2), now loose, out of the case.

B. Replacement.

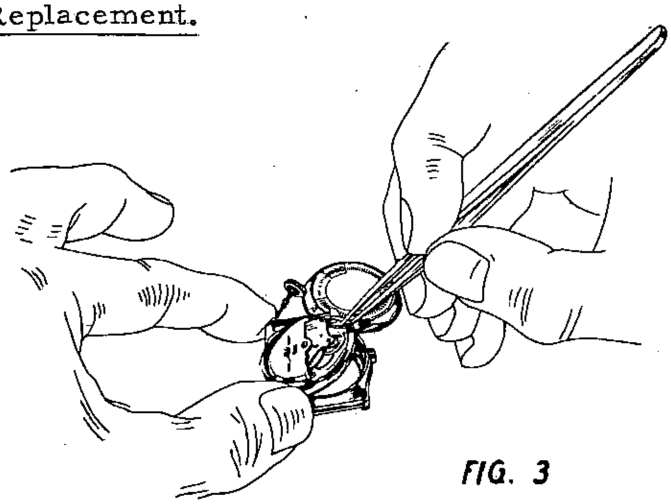


FIG. 3

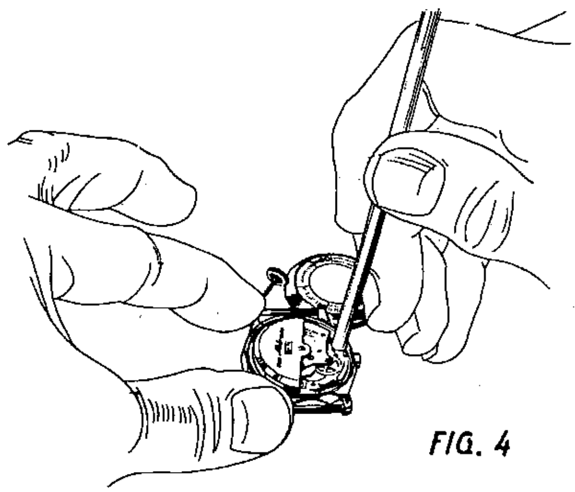


FIG. 4

1. Hold and insert movement into the case opposite stem hole (Fig. 3) under the bent ring of the case.
2. Push movement strongly down into the case (Fig. 4), with a wooden stick on the barrel bridge.
3. Insert stem, screw on tightly detent, close the case, and check air- and waterproofness with the MIDO SUPERWATERTEST machine.

HOW TO CLEAN A PENDANT TYPE CASE

Introductory Information:

A customer judges a watch by appearance as well as performance, so make every effort to give the watch case the best possible appearance.

Tools, Equipment and Supplies:

Laundry Soap Stiff Brush Denatured Alcohol

PROCEDURE:

1. Wash case thoroughly with soap and water, using a stiff brush.

2. Rinse with warm water.

3. Dry bezel and crystal with soft cloth. (Crystals other than glass may be damaged by alcohol.)

4. Dip remaining parts of case in alcohol. Flush alcohol through stem and sleeve. If a hunting case, flush thoroughly in back of lift springs to remove all traces of water.

5. Dry with soft cloth.

6. Warm over heat until all trace of alcohol is removed.

NOTE: If crystal is loose, cement edges with crystal cement. (See Lesson 3.)

HOW TO CLEAN A TWO-PIECE WRIST WATCH CASE.

Tools, Equipment and Supplies:

Laundry Soap Stiff Brush

PROCEDURE:

1. Wash case thoroughly with soap and water, using a stiff brush.
2. Rinse with warm water.
3. Dry with soft cloth.

NOTE: If crystal is loose, seal edges with crystal cement. (See Lesson 3.)

HOW TO POLISH A CASE WITH A POLISHING MOTOR.

Introductory Information:

Solid metal cases can be quickly polished with a polishing motor where such equipment is available. This method can be used for cases made of the following metals: Karat Gold (10K, 14K, etc.), Silver (Sterling or Coin), Nickel Silver (German Silver, Nickeloid, etc.), Platinum. A polishing motor should not be used on cases made of other metals such as gold filled, rolled gold plate, and the like, because of the possibility of damaging the finish. Use just the double polishing cloth as in Sections 36 and 37 for such cases.

Tools, Equipment and Supplies:

Polishing Motor   Polishing Head   Tripoli Buff   Rouge Buff   Tripoli   Rouge

PROCEDURE:

1. Remove all dirt and oil. Wash the case, if necessary.
2. If crystal is other than glass, remove it. (See Lesson 3 for replacement.)
3. Polish with tripoli.
4. Wash thoroughly in soap and water to remove all traces of tripoli.
5. Wipe dry with a soft cloth.
6. Polish with rouge.
7. Wash thoroughly in soap and water to remove all traces of rouge.
8. Dry with a soft cloth.
9. Seal crystal with crystal cement. (See Lesson 3.)

NOTE:

Remove leather straps when polishing. Cord bands, such as silk or nylon, can be left on and washed with case. Metal or expansion bands should not be polished with tripoli but do not have to be removed from case. It is important, however, that all expansion bands be dipped in alcohol after being washed with water. Dry with a soft cloth and warm over heat to remove alcohol.

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Student Consultation Sheet

Date ____________________ Student No. ____________

Lesson No. ______

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Name	
Address	
City State Zip Code	

Please check ( ) if you have CHANGED YOUR ADDRESS.

Detach or cut off page and use this sheet - - if you have questions on the course.

ASK YOUR QUESTIONS HERE...	WE'LL ANSWER HERE...
	INSTRUCTOR: Return an unused sheet with each used one.

(If necessary, use other side.)

Student Consultation Sheet

Master WATCHMAKING

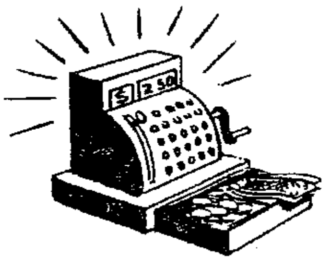
Lesson 2

CROWNS, STEMS, SLEEVES, and BOWS

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

INTRODUCTORY INFORMATION



Replacement of crowns and stems is a common repair. Sleeves are needed less often. Such work pays very well. Crowns and stems cost about 70¢ each while sleeves are now about $2. 50. For fitting these, the repairman will earn $3. 00 to $5. 50 for a crown, $3. 00 to $5. 50 for a stem and $4. 50 to $9. 50 for both together. Sleeve replacement brings about $4. 50. So it is well worth your while to master the simple replacement procedures involved.

MATERIAL ASSORTMENTS

Most watchmakers find it useful to carry assortments of frequently used parts such as crowns and stems. Having the right material on hand makes it possible to get the jobs out sooner. The customer likes this better than days of waiting. It also saves time for the repairman. It isn't necessary to get large quantities. By buying in small assortments you can have a supply that will fit most of the jobs that come in.

There are two kinds of assortments. One is a bulk assortment which has a variety but is not separated. The other is a pre-sorted type which saves you time but obviously costs more. However, material costs less in assortments than when bought singly. But if you are just starting in watch repairing, you are better off to pay a little more and buy just one or three as you need them. After you know what you need for your shop, you can then start buying assortments.

AMERICAN SETTING ARRANGEMENTS

American watches use three types of setting arrangements:

1. The PENDANT SET watch uses a stem and sleeve in the pendant of the case for winding and setting purposes. It is sometimes called NEGATIVE SET. Used primarily in American pocket watches and older American wrist watches.

2. The SWISS STYLE has the stem as part of the movement rather than part of the case as in 1 above. This style is also known as POSITIVE SET. It came into use in later pocket watches and most current wrist watch movements of both American and Swiss manufacture. It is the most widely used style.

3. A LEVER SET watch has a slot in the case to accommodate a set lever that is manually operated with the finger nail. You'll find it only on pocket watches. This is the style used for railroad pocket watches.

The first two styles are touched on briefly in this lesson (sections 41 and 56). All three types will be covered in detail in Lesson 9.

KEY POINTS OF LESSON ASSIGNMENTS 5, 6 and 7:

- The purpose of a stem and sleeve.
- How to remove the crown from the stem.
- Removing a sleeve and stem.
- Replacing crowns, stems and sleeves.
- Where to oil the stem and sleeve.
- The difference between a screw type sleeve and a reversible sleeve.
- Types of bows.
- Swiss style of setting
- Swiss style of stem.
- Selecting and ordering crowns.
- Replacing pendant posts.
- The two-piece stem.
- Types of dial screws.

ASSIGNMENT NO. 5: Study Sections 41 through 53.

1. How do stem and sleeve work together?
2. Is a sleeve wrench needed for all watches?
3. What other tools are used when working with the winding stem?
4. What part of a sleeve is most likely to wear?
5. Is it necessary to replace the entire sleeve and stem assembly?
6. Where should the winding stem and sleeve be oiled?

Recommended Practice:

Remove and replace the crown, stem and sleeve in any pendant set American pocket watch with a screw-type sleeve. If you have none, go on to the next assignment.

ASSIGNMENT NO. 6: Study Sections 54 through 60.

1. How many types of sleeves are there?
2. How does the screw type sleeve differ from the reversible sleeve?
3. What is a bow? Are all bows the same shape?
4. How does the stem in a Swiss style setting differ from the stem in an American style setting?
5. How is a Swiss stem held in place?
6. What information is needed when ordering or selecting crowns?

Supplement to Section 56: Two types of set lever and means for holding it in place are used in Swiss style settings. Most common is the screw type mentioned in Lesson 1 and section 56 of this lesson. Figure A shows the winding and setting mechanism as you would see it with the watch out of the case and with dial and hands removed. However, to remove the stem, you need only take off the back of the watch and loosen the set lever screw as shown in figure 40, section 56, in this lesson. Turn the screw counterclockwise about a turn and a half. (Again, we caution you not to turn this screw more than is needed to free the set lever from the pillar or lower plate, figure 48. Doing so will disengage the screw from the set lever. You will then have to disassemble the watch to replace the screw.) Hold the screw down with your screwdriver while you pull out the stem.

When you want to replace the stem, hold the set lever screw down again while you push in the stem. Then turn the screw clockwise until snug.

FIG. A

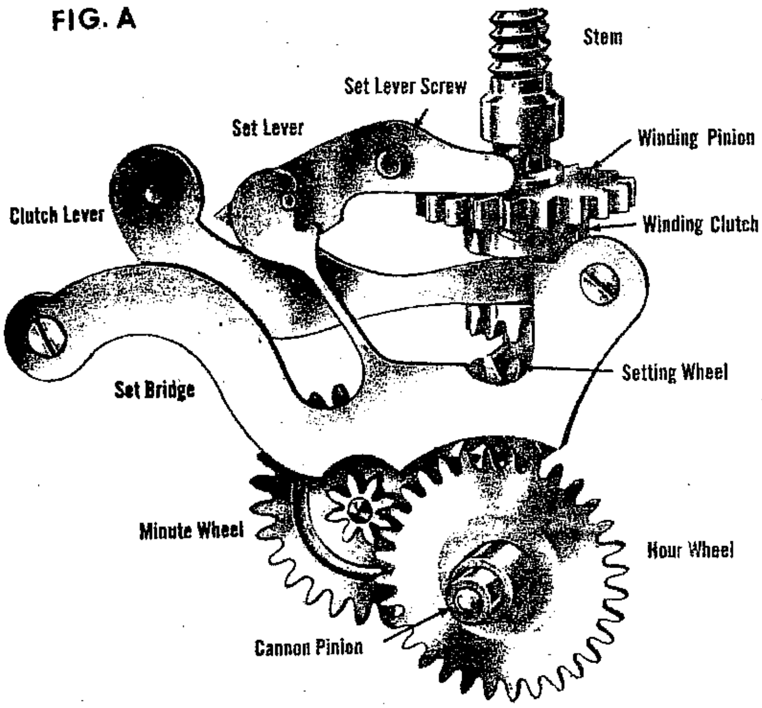
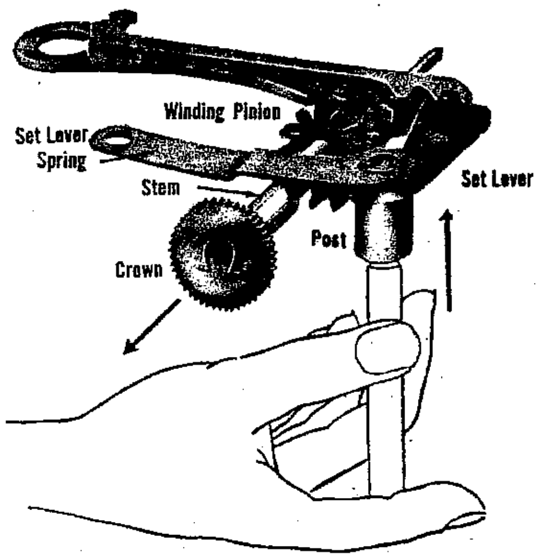


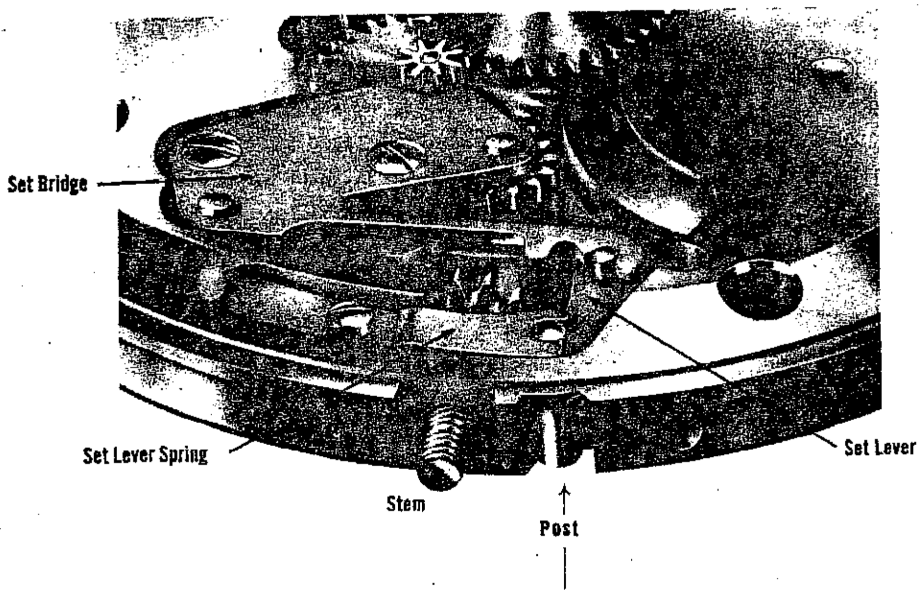
FIG. B



A second type of set lever -- much less common -- uses an axle or post in place of the set lever screw, figure B. This post is cast as an integral part of the set lever. A flat spring on the dial side of the pillar plate holds the set lever firmly in place. To release the stem, merely press down on the post from the back of the movement just enough to free the stem. When you release pressure on the set lever, it will move back into lock position. To replace the stem, push down on the post again, slide the stem into place and release the pressure.

Figure C shows this type installed in an Omega wrist watch. You can recognize this type by the cupped end of the post and absence of a screw slot.

FIG. C



ASSIGNMENT NO. 6: (Continued)

Recommended Practice:

1. Examine a Swiss stem. Note how it differs from an American stem.
2. Examine a watch or a movement with a Swiss style setting. What type of crown is used? Does the stem function properly? Remove and replace the stem and crown.
3. Make a tap gauge. The sample stems furnished in your instructional material kit for Lesson 2 can be used for this. Taps 6, 8 and 10 are the three most popular sizes for wrist watches. These gauges are used when you need to know the thread size inside the crown when matching a crown or stem or when selecting a crown from a bulk assortment. The thread size of both crown and stem should be the same for a correct fit. Directions for making these gauges are on Job Sheet L2-J11 in your Shop Training Job Guides at the back of this lesson manual.

ASSIGNMENT NO. 7: Study Sections 61 through 66.

1. What is the purpose of pendant posts?
2. How do two-piece stems differ from those studied earlier?
3. Where are they used?
4. What is a dial screw?
5. What are the different types of dial screws?

REQUIREMENT:

➧ Answer the Test Questions for Lesson 2 and return to us for grading.

SUMMING UP

In this lesson you have continued your study of the parts of a watch case. Perhaps you have been impatient to work into the movement itself and wonder why we do not do so at once. By now you should realize that watches for repair come to the watchmaker already cased. He must start from the outside and work in. So this course is planned to lead you step by step through the same procedures the professional follows in examining and repairing a watch. As you go along, you will learn the purpose of each part of the watch, how it is removed and replaced, and the variations you can expect to find as a result of differences in manufacture.

By now you know that the crown is simply the topmost piece of the winding and setting mechanism and that its shape varies in design. You have learned that the sleeve is a retainer for the stem, which activates the winding and setting parts. The purpose of the bow is to provide a place to fasten a watch chain or cord.

You have learned the difference between American and Swiss setting arrangements: The American style has a stem and sleeve as part of the case, while in a Swiss style setting the stem is part of the movement. Finally, you should now be able to remove and replace the various parts covered in this lesson.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 2
Sections 41 to 66

Lesson 2. — Crowns, Stems, Sleeves and Bows.

Section 41 EXCEPT in Railroad watches, the modern watch is "pendant set". By this we mean that to set the hands, the crown (and of course with it the stem) is pulled out to a different position than when winding the mainspring. In one position the winding parts are thrown into gear while in the other the setting parts are brought into play.

This necessitates some means of holding the winding stem in two different positions. In most American pocket watches this is accomplished by means of an adjustable "sleeve" screwed into the pendant of the case and through which the stem extends.

At 1 in figure 27 is shown the stem and sleeve assembled, ready to be inserted in the pendant of an Open Face case. The upper part of the sleeve at H is threaded and the inside of the pendant of the case is likewise threaded so that the sleeve with the stem attached is screwed into the proper position in the pendant by means of a sleeve wrench.

At 2 is shown the sleeve alone and at 3 the stem.

The lower part of the sleeve at J is divided into four parts so that it really makes four steel fingers. These fingers grip the stem in either one of the slots K or L holding it in position, yet allowing the stem to turn freely inside the sleeve.

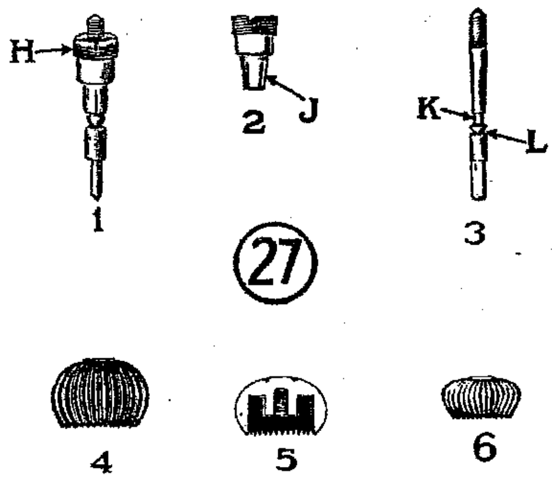
When the stem is in the winding position these fingers grip the upper slot at K. When the watch is to be set the stem is pulled straight out until the fingers of the sleeve are forced over the shoulder on the stem and are holding in the slot L. Bear in mind that this sleeve, once placed in its position in the case is stationary; the stem slides within this sleeve.

As seen at 1 the stem is held by the sleeve in the winding position.

The crown as shown at 4 is screwed on the upper end of the stem after the sleeve with stem is in place in the pendant of the case.

At 5 is shown a sectional view of the crown, the center being drilled and threaded to fit the upper threaded part of the stem.

The crown shown at 4 is known as a round crown, used only on the older style cases, while 6 is a more modern antique shape.



Sec. 42—Movement from Case

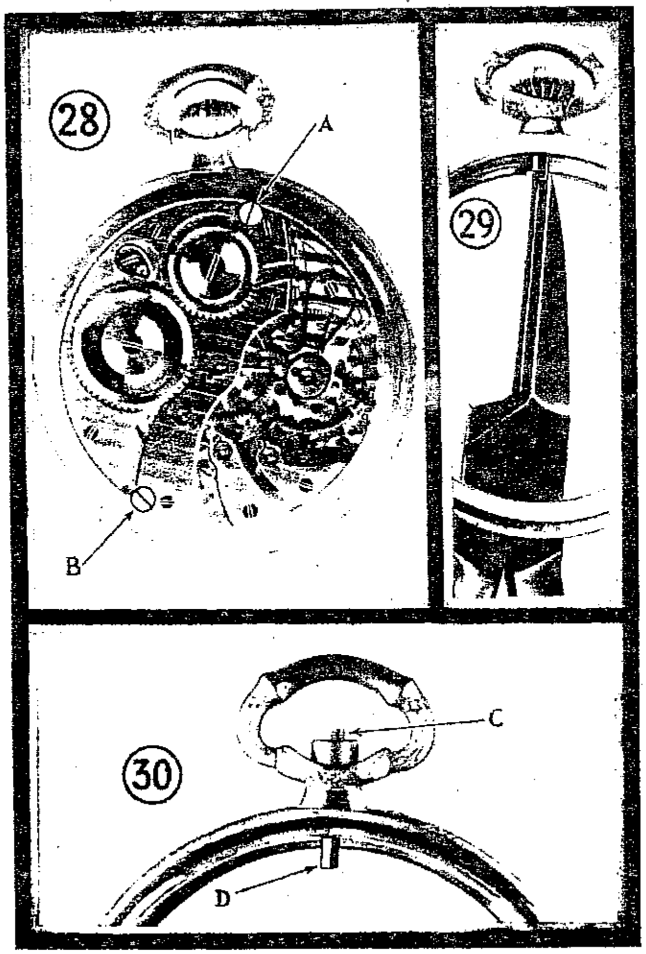
In demonstrating this job we will use a twelve size Illinois movement in a S. B. and S. B. Case. After removing the back from the case the movement will appear as in figure 28.

The two case screws at A and B are full head as explained before. In lesson 1 we explained that it was best to take out the full head case screws whereas with half head it was only necessary to turn them part way around when taking the movement from the case.

With this case it is only necessary to remove the screw B and then by loosening A a few turns and pulling the crown out to the setting position the movement comes easily from the case.

Sec. 43— Removing the Crown

In order to get at the sleeve after the movement is out of the case, it is first necessary to remove the crown from the stem and this is done by holding the lower end of the stem by means of a pair of flat pliers held in one hand as shown in figure 29 and with the fingers of the other hand twist the crown to the left continuing to turn it until it is separated from the stem. Now it will appear as in figure 30, the upper threaded end of the stem from which the crown



has been removed showing at C while the lower or square end may be seen at D; this photo being enlarged in order to show these parts better.

Sec. 44—Using a Sleeve Wrench

One of the popular forms of sleeve wrenches is shown in use in figures 31 and 32. Each of the several prongs on this model is shaped at the end into a wrench giving a variety of sizes suitable for most of the sleeves in pocket watches. In adjusting the sleeve, a prong is selected of the proper size and shape to go inside the pendant and fit into the slots in the upper part of the sleeve. These slots can be seen at the top of the sleeve in 1 and 2 in figure 27. Some sleeves have two slots on the top, while others have four. On the sleeve wrench some of the prongs are made with two projecting lugs and others with four to fit the two styles of sleeves. When selecting the proper prong on the wrench observe whether you need it for two or four slots.

On older cases these slots may be so worn that you can't remove the sleeve. In this event, push on the threaded part of the stem until the stem is out of the sleeve. Then drive a tapered square file or broach into the sleeve hole and unscrew the sleeve.

When adjusting the sleeve the crown is removed from the stem but the stem is left in its place through the center of sleeve.

Another type of sleeve wrench has but four prongs, suitable for the smaller sleeves and is known as a bracelet sleeve wrench. This wrench works on the same principle as the one shown in figure 31 and 32.

Sec. 45—Removing Sleeve and Stem

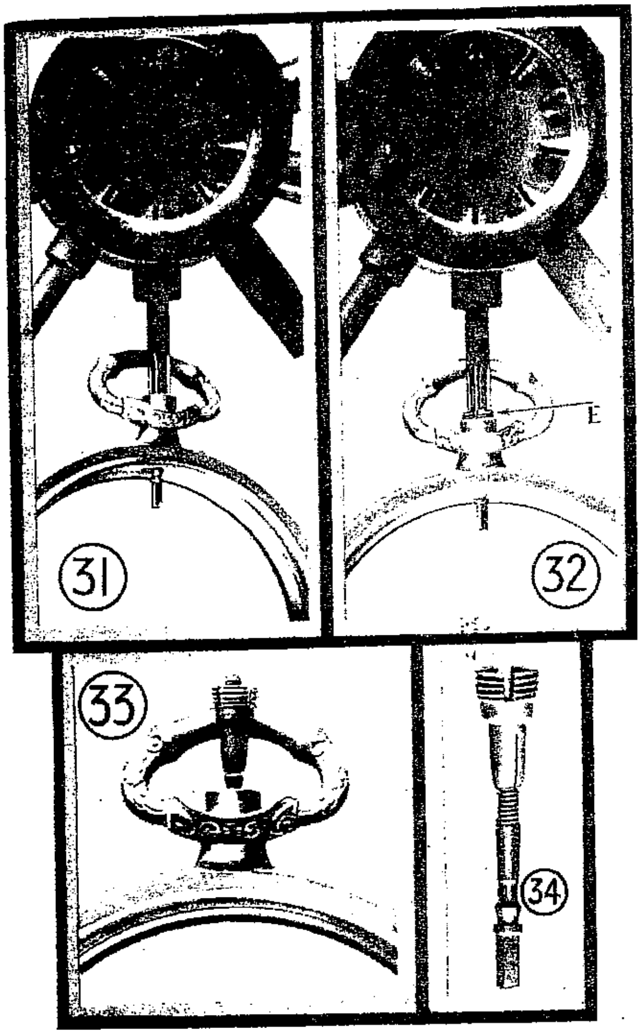
Selecting a prong of the right size to go into the pendant without friction and of a style to suit the sleeve, place the tip in the slots of the sleeve inside the pendant as shown in figure 31. Be sure that your sleeve wrench prong is not too large in diameter or it may cut and ruin the threads on the inside of the pendant. With the wrench in the position shown in figure 31 it is now possible to twist the sleeve to the left and as you continue turning, the sleeve and with it the stem will gradually come out as shown in figure 32, where the threaded part of the sleeve is shown at E part way out of the pendant. Continue until the sleeve is free when it may be removed from the case.

At figure 33 is shown the assembled sleeve and stem as lifted part way out.

After removing from the case, the sleeve may be pulled off the threaded end of the stem as shown in the enlarged view in figure 34.

Sec. 46—New Sleeves

In any watch depending upon a sleeve to hold the stem in proper position for winding or setting, you as a watchmaker will have jobs coming in needing replacements of these parts — a new sleeve, stem or crown. A customer brings in his watch complaining that it suddenly gains or loses an hour or more without apparent cause. Upon testing you may find that the stem slips from the winding to the setting position and the chances are that the lower part of the sleeve which grips the stem has become worn to such an extent that it will not hold the stem in place. Sometimes one or more of the steel finger-like tips has been broken. In either case replace with a new sleeve.



Sec. 47—Selecting a Sleeve

In selecting a sleeve it is necessary that the threaded portion A, figure 34A, is the correct diameter, that the threads are of correct pitch and the length B is right.

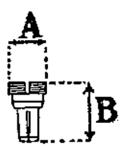


FIG. 34A

If you find it necessary to order a new sleeve, give the size of the case for which it is intended and the manufacturers name or trade mark found in the back. Also be sure to send in the old sleeve as a sample. In ordering *any* piece of material for a watch or case *always* send in the old piece as a model from which to make a selection. This is very important and will often save delays and misunderstandings.

Sec. 48—New Crowns

When your customer complains that his watch winds too hard you may find upon examination that the crown is worn so that it tends to slip between the fingers unless gripped tight enough to tire the hand. Occasionally the crown may be too small in diameter. In either event replace with a new crown of proper shape and size.

Again the stem may be broken right at the crown with a small piece of the steel remaining inside so that it is impossible to twist it out. If the crown is of gold, gold filled or nickel the piece of stem can be dissolved by means of a dilute solution of sulphuric acid or a saturated solution of alum in water. The sulphuric acid solution is made by pouring one part of the acid slowly into three or four parts of water. Never pour the water into the acid as this causes a violent chemical reaction. Even when pouring the acid slowly into the water there will be quite a little heat generated. This solution should be made in a glass or porcelain cup and the crown immersed in it. Of course there should be no oil or grease on the piece of stem imbedded in the crown if the solution is to work at its best. The solution should start working on the steel part at once as can be seen by a tiny row of bubbles arising from it. This should continue until the steel is entirely dissolved.

Be careful not to get any of the sulphuric acid solution on your clothes, as it will destroy any cotton threads or goods with which it comes in contact. Also avoid inhaling the fumes.

A saturated solution of alum in water will affect steel the same way and on account of its being less dangerous might be better for the beginner to use. It works slower than the acid solution. The action of either of these solutions can be hastened somewhat by heating.

Before attempting to dissolve the steel end of a stem from a crown it is best to examine the crown to see that it is worth the extra effort.

The majority of watchmakers do not go through this process except with a valuable crown but instead sell the customer a new stem and a new crown whenever such a job comes in.

Sec. 49—Replacing Crowns

In replacing a crown see that the new one is of proper shape and color to match the bow and case, that the threaded portion fits the stem and that the crown is free on the pendant of the case. Of course it should be of the same quality as the case, a gold crown on a solid gold case, a gold filled crown on a gold filled case and a nickel crown for a nickel case.

In ordering a new crown it is well to give size and style of case and of course send old crown for sample. If crown is lost send case with stem in place and crown can be supplied to match size, color and shape of case.

Sec. 50 — New Stems

If the stem is broken or worn, obtain a new one of proper shape and size. After pushing the old stem out of the sleeve, press the new one far enough through that the fingers of the sleeve are in the proper notch on the stem. The stem is placed in the sleeve by starting the threaded portion through the lower or finger end and pressing into place, see figure 34. It often requires quite a pressure before it goes into place.

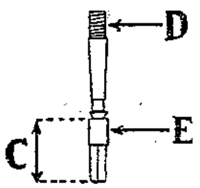


FIG. 34B

Whenever you find it necessary to put in a new stem, check that the distance from the end of the square to the slot for the sleeve, C figure 34B, is correct.

See that the round part at E is about the same length as the old one and that the whole stem is at least as long as the old stem.

Be sure to try the square of the stem, E figure 34B, in the winding arbor of the movement to see that the square is the right size and fits properly. Also try the threaded end D in the crown to be sure that the threads are of correct pitch and diameter.

These tests take only a few seconds and should always be made.

When ordering a stem for a case give same particulars as in ordering a sleeve and don't forget to send the sample stem.

Sec. 51—Replacing Stem and Sleeve

In replacing the stem and sleeve assembly in the case it is necessary to adjust the sleeve so that when the stem is pushed in, it will wind and when it is pulled out you will be able to set the hands. In removing an old or broken sleeve or stem, it is a good plan to remember approximately how far the sleeve was screwed in the pendant so that when you replace the new one you can place it in about the same position as it was before.

After turning in the sleeve and stem to the distance you judge is correct, screw the crown on the end of the stem and then replace the movement in the case. Do not try the winding and setting until the case screws are in place and holding the movement in the same position it will occupy when the job is completed and ready to be given to the customer.

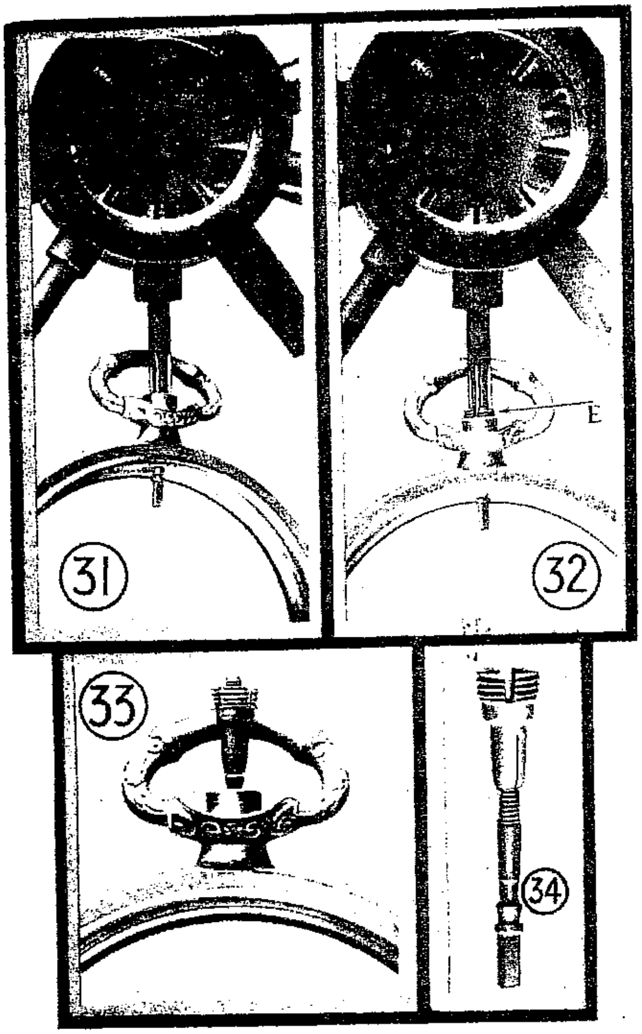
If you find that you can set the hands correctly but upon pushing in the crown and stem to the winding position you cannot wind the watch, the sleeve has not been screwed in far enough. Then remove the crown and screw down the sleeve until it winds properly.

Should you find that the watch winds properly in the case but does not set when the stem is pulled out to the setting position it will be necessary to turn the sleeve out until it will set.

If you have difficulty in making it set or wind, which you do not seem able to overcome by making these adjustments, there may be some trouble in the setting arrangement in the movement itself. Take the movement out of the case and test with one of your bench keys, selecting a key of proper size. Press the key into the movement and try the winding. Then pull the key out slightly and see that the setting is O. K. If the set and wind work outside the case you should have no trouble in adjusting the sleeve so they will work while in the case.

Sec. 52—New Stem Too Long

In replacing a new stem for an old one you occasionally may find the square is so long that it would be impossible to make the watch set without having the sleeve too far out of the pendant. Then it is only necessary to file off the proper amount from the lower end of the square to make it work. The same is true of the other end. If the threaded part is so long that the crown is held too high, this end should be cut off. But be sure the fault lies in the stem being too long before you start filing. If you must file take off a little bit at a time. It is an easy matter to cut off too much.



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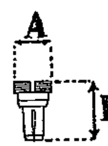

FIG. 34A

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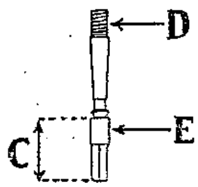

FIG. 34B

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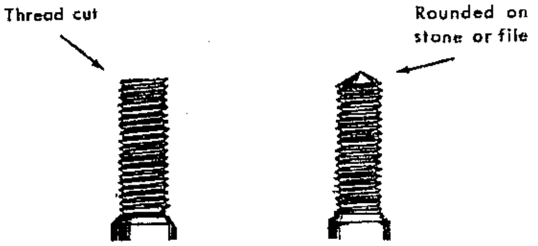


FIG. 34C

If you must cut the threaded end of the stem, hold the stem afterwards in a pin vise and stone or file the cut end round and smooth, figure 34C.

It is advisable also to run the stem through a screw plate to reset the thread. Then replace stem in sleeve and fit into case.

Sec. 53—Oiling Stem and Sleeve

If the stem and sleeve are dry it is necessary to oil the parts where they come in contact with each other. This will make it easier to move the stem back and forth when shifting from winding to setting position and will eliminate a slight squeak that may occur in winding and setting when these parts are not oiled.

To take care of this, place a very small amount of watch oil at the point K or L on the stem (see 3 in figure 27) after the stem is in the sleeve.

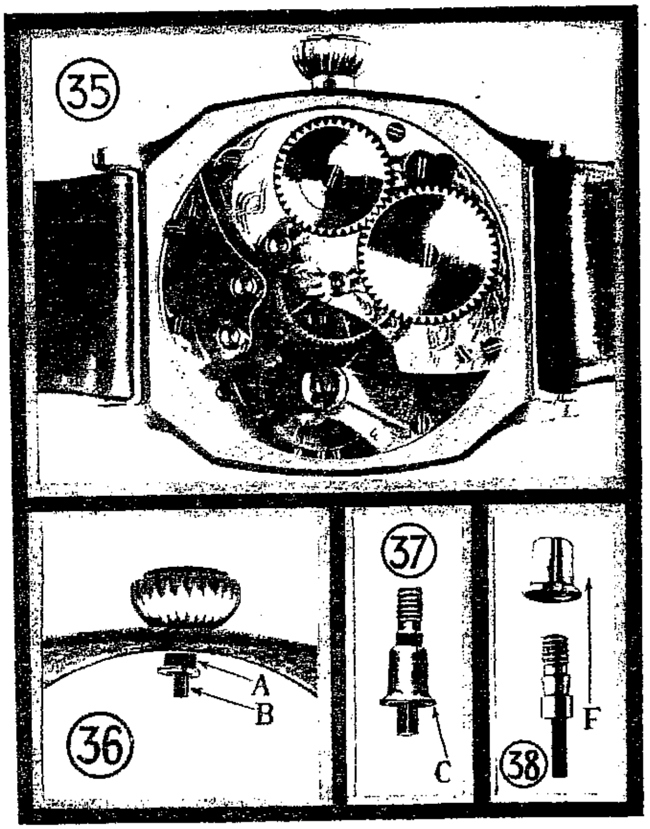
Sec. 54—The Reversible Sleeve

Another type of sleeve that was in use for a time is known as the reversible sleeve. It has been obsolete for many years and you are not likely to see it in your daily work. However, you may sometime run across one in a collector's item. Should you do so, you can see how to remove and replace it from this example and particularly figures 37 and 38.

Figure 35 is a view of a Waltham Wrist watch with the back removed. This is the snap form of case so that the back is pried off with a case opener.

After taking out the case screws and removing the movement from the case, the crown, stem and sleeve will appear as in figure 36. Here you will notice that the sleeve at A is not held firmly in the case but when the movement is taken out falls to the position shown.

By gripping the square at point B with a pair of pliers the crown may be twisted off as described before. The stem and sleeve come out easily and will appear as in figure 37. Here you will notice that the sleeve itself has no threaded portion, merely the shoulder at C. When the stem and sleeve are in the case the sleeve is held in its proper position by the pressure of the movement against this shoulder C. There is a slight recess in the case into which this shoulder is pressed by the watch movement so that only



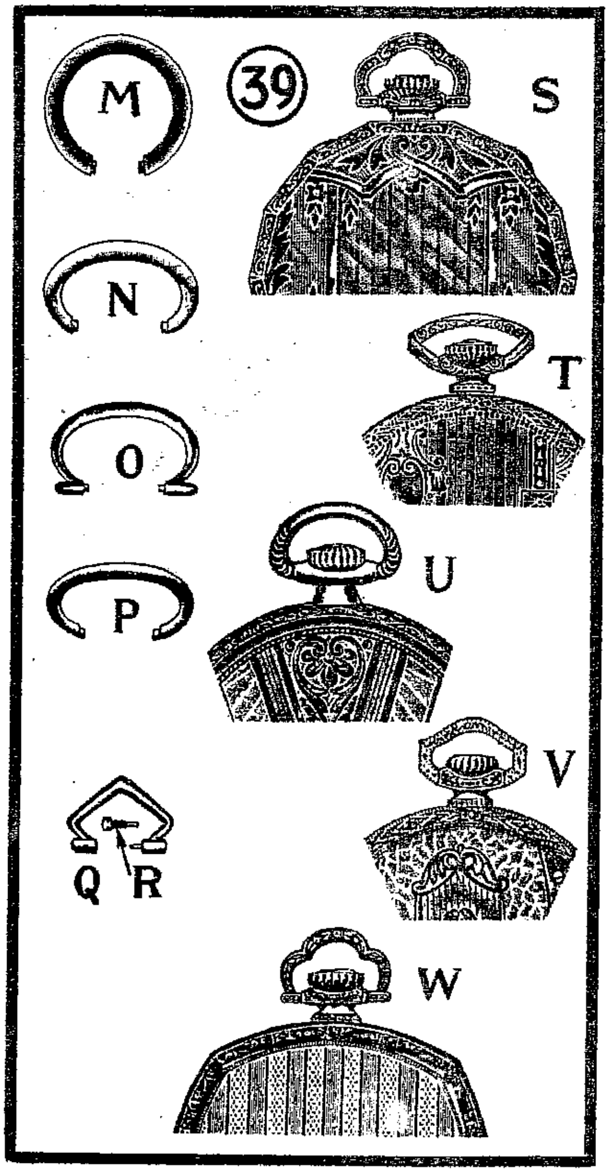
when the movement is in the case is the stem and sleeve in position to function properly.

In figure 38 the stem and sleeve are shown separated.

In comparing this assembly with that of the other type of sleeve you will notice that the larger portion of the sleeve is toward the square end of the stem. In other words in replacing this the threaded portion goes through the sleeve in the direction of the arrow F figure 38.

Sec. 55—Bows

Figure 39 shows some of the many shapes of bows used on pocket watches. The round form shown at M was used only on the older models. The plain antique at N is a later model than the round bow. At O is shown a French antique bow and at P a so called stream line bow. All these bows are plain polished.



Later bows moved away from these plain standard shapes and were quite varied in design. S, T, U, V, and W show the pendants and bows of several different American made cases.

Most bows are fitted to the case by merely springing them into place. The pendant has a recessed place or ear on each side into which the end of the bow fits. The bow is usually sprung on by spreading it with a pair of bow pliers or a bow expander until it will just slip into place. Sometimes a bow is too loose. It is then necessary to close it up slightly with a bow plier or a bow tightener.

Some fancy bows are held in position with screw pegs instead of being sprung into place. You simply unscrew the pegs to remove the bow and tighten them to replace it. At Q in figure 39 you can see one of the bows with one peg removed and shown by itself at R.

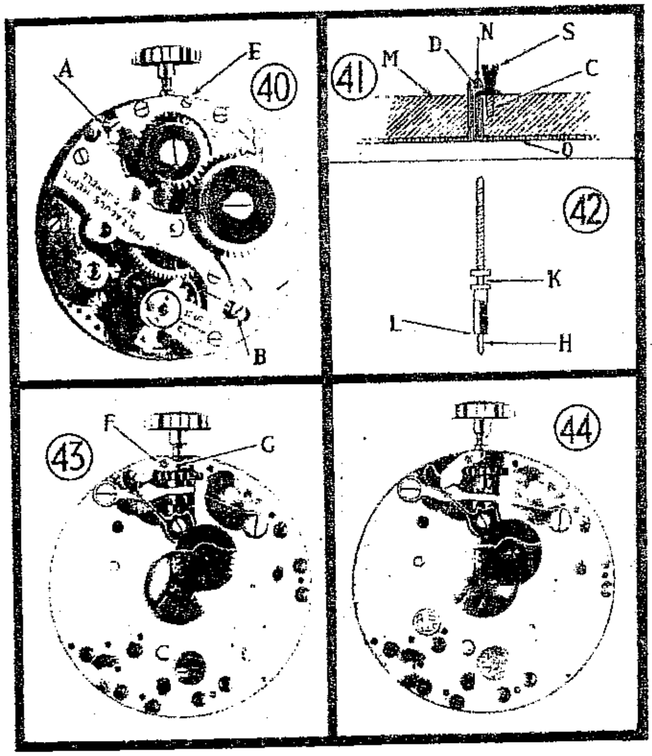
It is best to order new bows only as you need them. Be sure the bow is of such size that when it is sprung on the pendant there will be no play or shake. It must also match the case in color and quality.

Sec. 56—Style Swiss of Setting

The use of a sleeve held in the case to control the wind and set mechanism in American pendant set watches was common until about 1916. About that time some American pocket watch manufacturers and later most wrist watch manufacturers shifted to a Swiss style setting. In this style, the mechanism is held in position by a set lever in the movement itself. This is connected to and controlled by the stem.

The big difference between the two systems is that the American system had a stem and sleeve assembled with the case. In the Swiss style, the stem is made by the manufacturer of the movement and comes with it.

We're not going into detail now on the working of the winding and setting mechanism in Swiss style movements. That will be covered in a later lesson. At this time you need only know how the stem operates on the set lever.



In figure 40 at E you will see the head of the set lever screw. This set lever screw extends down through both plates and is threaded into the set lever on the dial side as seen at F in figure 43. On the other side of the set lever is a pin the riveted end of which shows at G. This pin fits into a slot in the stem and when the set lever screw F is tightened it holds the pin in the slot so that as the stem is pulled out to the position shown in figure 44 it pulls the set lever right along with it throwing the parts into the setting position. And when it is pushed back it carries the set lever back to its former position with the mechanism in the winding position as shown in figure 43.

Sec. 57 —Swiss Stem and Crown

In figure 42 is shown a drawing of one of these stems. As you will notice it differs somewhat from the style of American stem already shown to you in figure 27. At the lower end, H, is shown the pilot. This fits in a hole in the plate of the watch to keep the stem properly aligned. At K is shown the slot into which the pin on the set lever fits.

You will notice that the upper end of this stem is threaded for a much longer distance than the American style. This long thread enables the watchmaker to fit this stem to practically any thickness or width of case or length of pendant. In fitting one of these stems it is cut off on the threaded end until it is the proper length so that the crown projects the right distance from the case.

Sec. 58 —Ordering Swiss Stems and Crowns

In ordering a new stem or crown it is best to send a sample of the old one. This is possible with the stem as it is nearly always in the movement even if the crown is gone. Often, however the crown is lost but with an assortment of crowns it is an easy matter to select one matching the case.

In selecting a new stem for a Swiss watch endeavor to have the pilot about the same length and diameter as the old one, the square the same length and the slot K the same distance from the lower end of the square at L. Of course if you have the old crown it is necessary to see that the threads fit.

Sec. 59—Types of Crowns

There are many types of crowns as this illustration shows. They are available in assortments, but until you find out what you need for your shop, you are better off to order just one or three.

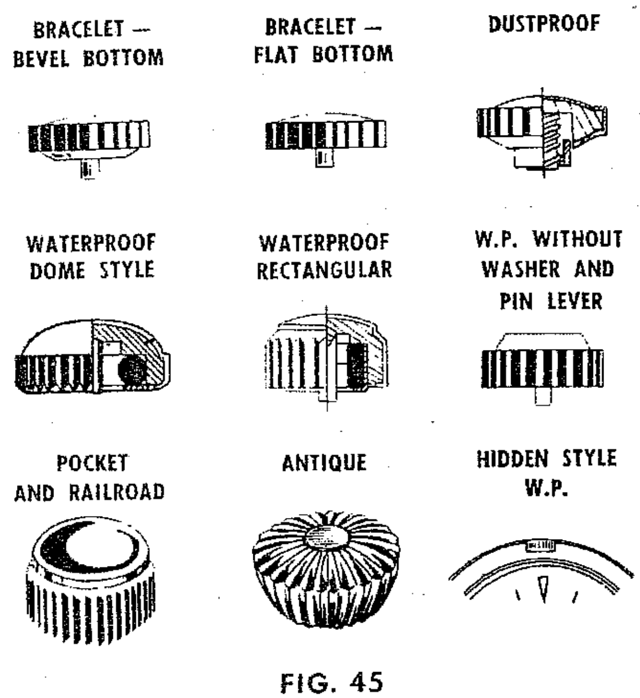


FIG. 45

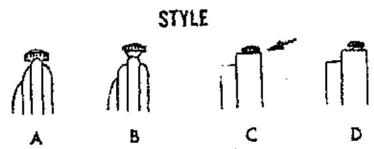
With so many kinds available, you must give the material house full information. It is not enough, for example, to tell them you want a crown for a $10\frac{1}{2}$ ligne watch. They need to know the style, color, tap size, and diameter. That's why it is best to send a sample or the case, as we told you earlier.

Sec. 60—Selecting Crowns

When you have your own assortment this same information can guide your selection of the proper crown.

In determining the style of the crown, the type of bottom used is an important consideration. Either the crown or the case construction must provide fingernail space so the crown can be readily pulled out for setting. This space is usually about .1 mm. Crowns set too high are easily broken off while those set too low will rub on the case.

FIG. 45A



In the illustration, A shows the correct use of a flat bottom crown. B shows an incorrect use. The bevel bottom crown used on the same case raises the crown too high.

When the case is flat, a flat bottom crown will not provide fingernail space and is therefore not correct (C). Here a bevel bottom crown is the correct one to use (D).

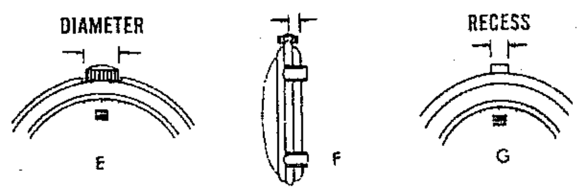


FIG. 45B

The diameter of the crown depends upon the opening in the case (E) and/or the thickness of the case (F). Crowns for bracelet watches should not extend beyond the back of the case or they will press into the wrist of the wearer.

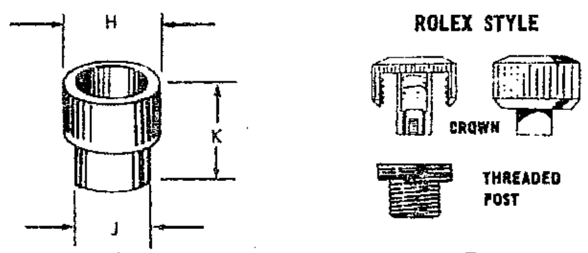
The diameter of crowns for pocket watches is usually determined by the opening in the pendant. This is why we told you earlier to send the case with stem in place if the pocket watch crown is lost.

A recessed crown is used to fit over a tube (Sec. 61) projecting from the case. By determining the diameter of the tube the correct opening can be selected (G).

Sec. 61—Pendant Posts

Where the stem enters the case of a water tight watch, it runs through a tube called a pendant post. This tube or post supports the stem when you pull out the crown to set the watch and also gives a good seal for water tight cases.

The tube can be removed and replaced when it is damaged or missing. Most are friction fit and pressed into the hole of the case. You may have to drive it into place with a brass hammer.



A FIG. 46 B

In the Rolex style, figure 46B, the tube is threaded into the case with a round gasket. A special wrench is used to replace this style.

Pendant posts are available from material houses in assorted sizes. Measurements needed are crown shoulder H in figure 46A, case shoulder J and total length K.

Sec. 62—The Two-Piece Stem

The split stem is most commonly used with one-piece water tight cases which do not have a removable back. The stem is in two pieces which lock together when snapped into position. The lock is strong enough that the pieces will not separate when crown and stem are pulled out to the setting position. The two pieces are generally called the stem and crown neck.

Both stems and crown necks come in a variety of lengths. Stems may have either a male tip locking end or a female lock slot. Crown necks are obtainable with either male and female lock ends and with either male or female thread. They may also be had with both ends female or both ends male.

Shown here are the most popular styles of split stems used in Bulova, Benrus, Wyler, and French movements:

STEMS:

CROWN NECKS:

Male lock

Split post
Female lock with exterior thread

Female lock

Male lock with female thread

Male lock with exterior thread

FIG. 47

In order to take the movement from the case, you must detach the crown neck from the stem. Do this by pulling hard on the crown. The crown neck will snap free from the stem half which is attached in the movement by a set lever. Remove the crystal, turn the case over, and the movement will fall out through the front. Release the stem half by turning the set lever screw.

Hamilton Watch Company uses a key style split stem that will not snap apart. (See Job Sheet 8 in Lesson 1.) For this style you remove the crystal first and then lift the movement out of the stem neck.

When ordering stems or crown necks, always send correct identification of the movement (Lesson 4). If a sample of the required part is not available and included with order give the following information for the stem half: distance between set lever slot and end of stem and whether male or female stem. For ordering the crown neck, give the length and tell whether male or female locking and thread are needed.

The watchmaker usually carries a small selection of different lengths of stems and crown necks for use in replacement.

Sec. 63—American Type Dial Screws

The dial of a watch is attached to the pillar or lower plate by means of dial feet. These are pins fastened to the back of the dial which are inserted through holes in the pillar plate to hold the dial in place. To insure that dial feet do not shift position, they are held tight with dial screws. In most American movements, these screws are inserted in the edge of the pillar plate, figure 48. When the dial feet are held in this way, you must take the movement out of the case in order to remove or replace the dial.

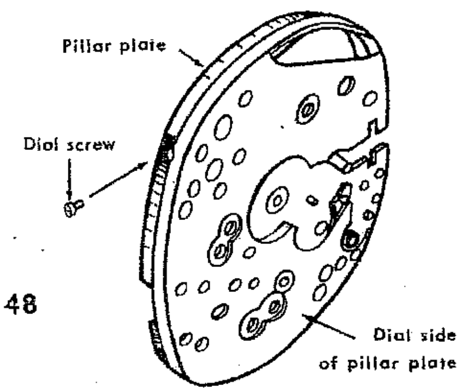


FIG. 48

Sec. 64—Swiss Type Dial Screws

Figure 40 shows a typical Swiss $10\frac{1}{2}$ ligne movement slightly enlarged. Instead of having the dial screws in the edge of the plate as above, they are placed on the plate as shown at A and B and fit into a slot in the dial feet.

In figure 41 is shown a drawing of one of these dial screws as fitted in the plate. N represents the dial foot extending through the plate M and attached to the dial O. S is the dial screw, the threaded part of which at C screws into the plate. The base of the screw fits in a slot in the dial foot as shown in the drawing at D. Part of the base of this dial screw is cut away, somewhat like the head of a half head case screw so that the dial foot can be pushed through the plate far enough for the slot to come in line with the base of the dial screw.

Before doing this the dial screw should be screwed down on the plate with the open side of the base directly over the dial foot hole. See A figure 40. After pressing the dial in place so that the foot comes through the hole, the screw is backed out and the base of the screw fitting in the slot of the foot, lifts the dial foot until the dial is held against the plate on the other side.

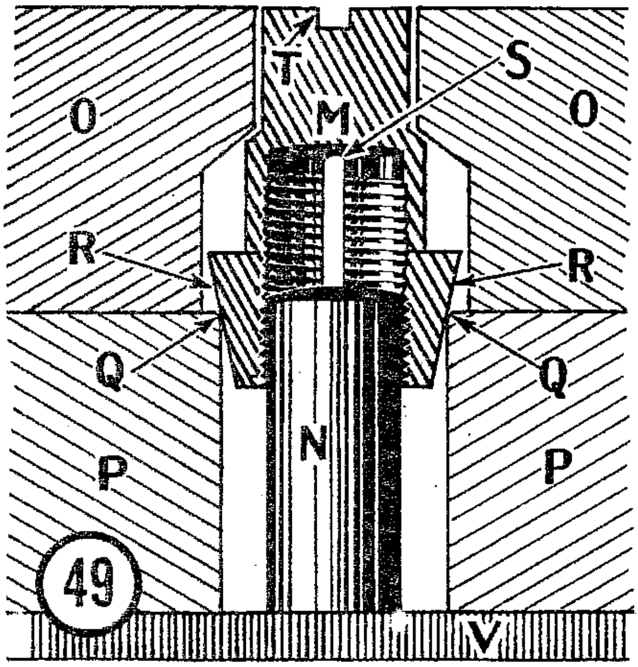
This dial screw having a right hand thread is turned down, or to the right when you release the dial foot and backed out, or to the left when you wish to tighten it.

In the Swiss style in figure 40 it is possible to remove or replace the dial while the movement is in the case. In other words, if it is necessary to take off the dial at any time to examine the pillar plate you can do so without taking the movement out of the case. Whenever you make repairs which require the removal of the dial on this type of watch, it is good practice to postpone replacing the dial until you have the movement in the case. This gives you an opportunity to see that the winding and setting mechanism is assembled correctly.

Sec. 65—A Later Type of Swiss Dial Screw

Another type of Swiss dial screw is shown in figure 49. Here the hollow dial screw M is somewhat in the form of a split chuck fitting in a recess formed by holes drilled through the two plates, the hole in the upper plate being small enough at the top to prevent the dial screw from falling out. In this drawing O represents the upper plate and P the lower plate. The edge of the recess in the lower plate is slightly beveled at Q and the portion of the dial screw at R is cut on a taper. The hollowed out portion of the dial screw is threaded and slotted, having four slots similar to the one shown at S.

This screw fits over the dial foot N and is tightened by pressing down with the screw



driver in the slot at T, the tapered side of the screw at R pressing against the plate at Q forces the threads into the soft metal of the dial foot N. Then by turning the screw to the right with a screw driver in the slot T the threads act on the metal of the dial foot at the same time drawing the dial V firmly against the lower plate P. The dial screw being of tempered steel and the foot N being of soft copper allows the hollow thread of the screw to hold firmly on the dial foot.

In loosening this type of a dial screw it is only necessary to give it a partial turn to the left when it immediately frees itself from the dial foot. The same is true in tightening it, that is, it requires only a part of a turn after pressing the screw down to hold the dial foot and the dial firmly in place.

Before taking off the dial on either of these types of Swiss movements it is necessary to remove the minute and second hands. The hour hand may be left attached to the hour wheel and brought away from the movement with the dial. After the dial is removed the dial side of the movement will appear as in figure 43.

Sec. 66—Pin Lever Type Dial Screws

A fourth type of dial screw is found in pin lever movements (no jewel style). On these the manufacturer simply runs two screws through the face of the dial on its outer edge where they will be hidden by the bezel. No dial feet are used.

CHECK YOURSELF

Progress Check 2A

A Self Test Review of Lesson 2

After you have studied Sections 41 through 53, see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. A pocket watch in which the stem must be pulled out to set the hands is said to be ____________________.	41
2. The tool used to remove and replace screw type sleeves is called a ____________________.	41 & 44
3. After the movement is out of the case, the first step in removing the sleeve is to separ te the __________ __________ from the __________.	43
4. In selecting a sleeve, it is necessary to check the __________ of the threaded portion and the overall __________.	47
5. In replacing pocket watch crowns, check __________, __________, __________, and __________ on pendant of case.	49
6. When fitting a new stem in a pocket watch, try the __________ of the stem in the winding arbor and the __________ in the crown.	50
7. If the watch sets but does not wind, screw the sleeve __________.	51
8. If the watch winds but does not set, screw the sleeve __________.	51
9. If you cut the threaded end of a stem, be sure to round the cut end with a __________ or __________.	52
10. A dry stem and sleeve should be __________.	53

ANSWERS TO PROGRESS CHECK 2A:

1. pendant set
2. sleeve wrench
3. crown
stem
4. diameter
length
5. shape, color
thread, freedom
6. square
threaded end
7. in
8. out
9. stone
file
10. oiled

CHECK YOURSELF

Progress Check 2B

A Self Test Review of Lesson 2

After you have studied Sections 54 through 66, see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. One difference between a reversible and an adjustable sleeve is that the former is assembled with the ________ portion of the sleeve toward the square end of the stem.	54
2. Bows are usually ________ into place.	55
3. A Swiss style stem uses a ________ instead of a sleeve.	56
4. The thread on a Swiss style stem is ________ than the American style.	57
5. In selecting a Swiss style stem, check these points: ________ of the pilot. ________ of the square. ________ of the slot for the set lever pin from the lower end of the square.	58
6. The minimum information needed when ordering a new crown is ________, ________, ________, and ________.	59
7. The diameter of a crown depends upon the ________ in the case and/or its ________.	60
8. Measurements needed for a pendant post replacement are: ________. ________. ________.	61
9. Cases which do not have a removable back generally use a ________ stem.	62
10. The dial is held in place by means of ________ and ________.	64-66

ANSWERS TO PROGRESS CHECK 2B:

1. larger
2. sprung
3. set lever
4. longer
5. length and diameter
length
distance
6. style, color, tap size
diameter
7. opening
thickness
8. case shoulder O.D.
crown shoulder O.D.
total length
9. two-piece
10. dial feet, dial screws

LESSON	2
STEMS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L2-J1

HOW TO REPLACE A NEW STEM IN PENDANT TYPE CASE USING SCREW TYPE SLEEVE.

Tools, Equipment and Supplies:

Sleeve Wrench   Flat Pliers   Screwdrivers   File   Case Opener

PROCEDURE:	REFERENCE:
1. Remove movement from case.	Les. 1
2. Remove crown.	Sec. 43
3. Remove stem and sleeve assembly.	Sec. 44, 45
4. Select new stem.	Sec. 50
5. Insert stem into sleeve. Oil at point of contact.	Sec. 50, 53
6. Screw sleeve with stem into pendant to where the sleeve was before.	Sec. 51
7. Replace crown.	Sec. 49, 51
8. Replace movement. Put case screws in place and tighten.	Sec. 51
9. Snap crown into winding position. Check winding.	Sec. 51
10. Pull crown into setting position. Check setting.	Sec. 51
11. Make any needed adjustments of stem. Re-check winding and setting.	Sec. 51, 52

LESSON	2
SLEEVES	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L2-J2

HOW TO REPLACE A SCREW TYPE SLEEVE.

Tools, Equipment and Supplies:

Sleeve Wrench   Flat Pliers   Screwdrivers   Case Opener   Assembly Tweezers

PROCEDURE:	REFERENCE:
1. Select the correct sleeve.	Sec. 47
2. Assemble stem and sleeve. Oil at point of contact.	Sec. 50, 53
3. Screw stem and sleeve assembly into pendant to where the sleeve was before.	Sec. 51
4. Put on crown.	
5. Replace movement in case. Tighten case screws.	
6. Check winding and setting.	
7. If sleeve position requires adjustment, remove movement and crown and make adjustment.	
8. Recheck winding and setting.	

HOW TO REPLACE A NEW STEM IN CASE WITH REVERSIBLE TYPE SLEEVE.

Introductory Information:

These stems are selected by the size of the square, length, and tap size. Send sample of stem and sleeve when ordering.

Tools, Equipment and Supplies:

Flat Pliers   Bench Block   Case Opener   Screwdrivers

PROCEDURE:

PROCEDURE	REFERENCE:
1. Remove movement from case.	Les. 1
2. Remove crown from stem. Stem and sleeve should slip out.	Figs. 29, 37
3. Remove stem from sleeve.	Fig. 38
4. Select stem.	Sec. 50
5. Insert stem into sleeve.	Fig. 38
6. Replace stem and sleeve and screw on crown.	Sec. 54
7. Replace movement.	Les. 1
8. Make certain movement is in line and will wind and set properly.	
9. Replace back and bezel.	

NOTE: If crown does not fit close to case ring when in winding position, make necessary adjustment of threaded portion of stem.

HOW TO REPLACE A REVERSIBLE SLEEVE.

Tools, Equipment and Supplies:

Flat Pliers   Screwdrivers   Case Opener   Assembly Tweezers

PROCEDURE:	REFERENCE:
1. Select the correct sleeve.	
2. Assemble stem and sleeve.	Figure 38
3. Oil point of contact between stem and sleeves.	Sec. 53
4. Place stem and sleeve in pendant and put on crown.	Figs. 36, 37
5. Replace movement in the case.	
6. Check winding and setting for proper function.	
7. Make any needed adjustment.	
8. Recheck winding and setting.	

NOTE: When ordering an individual sleeve, send sample sleeve and the stem. If sample sleeve is not available, send case also.

LESSON	2
STEMS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L2-J5

HOW TO REPLACE NEW SWISS STYLE STEM.

Tools, Equipment and Supplies:

End Cutting Pliers   File   Pinvise   Screwdrivers   Case Opener
Assembly Tweezers

PROCEDURE:	REFERENCE:
1. Remove movement from case. Three-piece and water-proof type of case require removal of stem before movement can be taken out.	Sec. 56 See L1-J3
2. Remove the old stem.	Sec. 56
3. Identify movement and select stem.	Lesson 4 Sec. 50
4. Insert new stem into movement. Make sure it is in winding position.	
5. Replace movement into case and cut off the excess threaded portion which protrudes from case.	Sec. 57
6. Remove stem.	
7. Place stem in lathe or pinvise and smooth end of threaded portion with a file or stone.	Fig. 34C
8. Replace crown.	
9. Replace stem and crown in movement.	Sec. 56
10. Tighten set lever screw.	
11. Replace movement in case.	Les. 1

HOW TO FIT A TWO-PIECE STEM

Tools, Equipment and Supplies:

Screwdrivers   Flat Pliers

PROCEDURE: REFERENCE: Sec. 62

1. Select the correct stem for the movement.
2. Insert stem in the movement.
3. Tighten set lever screw.
4. Test for proper function of the stem.
5. Put movement in back of case.
6. Assemble bezel, crystal and back.
7. Select the correct crown neck.
8. Screw the crown neck into the crown.
9. Place crown and neck in stem opening of the case.
10. Turn crown slowly as you press inward until parts snap in place interlock.
11. Test winding and setting.

NOTE: If you are replacing only the stem, follow steps 1, 2, 3, 4, 5, 6, 9, 10, 11.

If you are replacing only the crown, follow steps 4 through 11.

LESSON	2
CROWNS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L2-J7

HOW TO REPLACE A PENDANT TYPE POCKET WATCH CROWN.

Tools, Equipment and Supplies:

Case Opener   Screwdrivers   File   Flat Pliers

PROCEDURE:	REFERENCE:
1. Remove movement from case.	Les. 1
2. Select crown of proper size, shape, tap size, and color to fit case.	Sec. 59, 60
3. Place crown over the pendant opening. (Should fit freely.)	
4. Screw crown on stem.	
5. Snap crown into winding position and make sure the crown covers the pendant opening. NOTE: If crown does not cover pendant opening, a shorter post crown is required. If it does not snap into winding position, a longer post crown is needed.	
6. Replace movement into case.	

HOW TO REPLACE THE CROWN IN A REGULAR SWISS TYPE BRACELET WATCH.

Tools, Equipment and Supplies:

Case Opener Screwdrivers File Flat Pliers

PROCEDURE: REFERENCE:

1. Remove the movement from the case.
2. Remove the stem from the movement.
3. Select a crown of the color, size, opening, post length, and thread size to fit the case and stem. Sec. 59, 60
4. Screw the crown on the stem.
5. Replace stem and crown in movement.
6. Replace movement in case.
7. Check for proper clearance of crown and case.
8. Check for proper winding and setting.

NOTE: If winding and setting are not functioning properly, you may need to correct as indicated here:

If the crown rests against the case and the movement does not wind properly, this usually indicates that a crown with a longer post or a new stem is needed.

If there is too much clearance between case and crown, either replace crown with a short post crown or reduce the length of the thread on the stem.

HOW TO REPLACE A WATER-PROOF CROWN.

Introductory Information:

In selecting a crown for a water-proof case, it is necessary to know the tap size (See L2-J11), the case pipe or tube diameter, length of crown post and color.

Tools, Equipment and Supplies:

Flat Pliers   Screwdrivers   Case Opener   Case Vise

PROCEDURE:

1. Open case.
2. Remove stem from movement.
3. Place crown over case pipe tube. Make certain it fits all the way down to the case ring. (The crown has a gasket inside so it will fit quite tight.)
4. Screw crown on stem.
5. Replace stem into movement.

NOTE: If crown does not fit down to case ring, you can shorten the stem.

If crown will not snap into winding position, you should replace with a crown that has a longer post or replace the stem with a new one.

LESSON	2
PENDANT POSTS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L2-J10

HOW TO REPLACE A PENDANT POST IN A WATER TIGHT WATCH.

Introductory Information:

Damaged or missing tubes should be replaced to insure a good seal. These tubes are available in assorted sizes from your material supply house.

Tools, Equipment and Supplies:

End Cutters, Pin Vise, Broach, Brass Hammer, MM Ruler or Gauge

PROCEDURE: — REFERENCE

1. Remove old tube with end cutters. (If tube is broken off clean, you will have to broach out the old tube.) — Sec. 61
2. Measure hole of case and select a tube that will just start in stem hole.
3. Press tube in place.
4. Tap with brass hammer to insure the tube is tight.

HOW TO MAKE A TAP GAUGE.

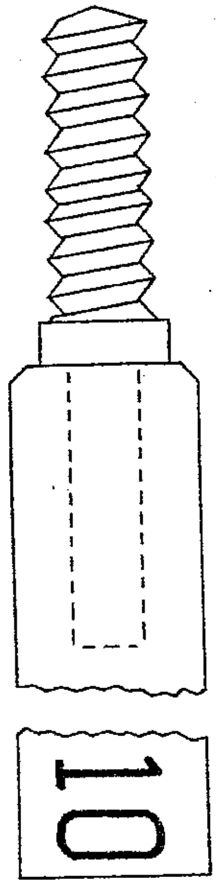
Introductory Information: Swiss and American Tap Sizes.

SWISS STEMS. Sizes Tap #0 to #10:

	Outside Diameter:	
Tap	In MM	In Inches
0	2.15	.085
1	1.95	.077
2	1.55	.061
3	1.40	.055
4	1.35	.053
5	1.30	.051
6	1.25	.049
7	1.20	.047
8	1.10	.043
9	1.00	.039
10	.90	.035
11	.80	.031

AMERICAN STEMS. Sizes from 18s to 3/0:

	Outside Diameter:	
Size	In MM	In Inches
18s	2.27	.089
16s	1.45	.057
12s	1.18	.046
6s	1.18	.046
0s	1.18	.046
3/0s	1.18	.046



Tools, Equipment and Supplies:

Stem of known tap size. Wood, plastic or metal Handle.
Drill.

PROCEDURE:

1. Use a stem whose tap diameter you know.

2. Break off pilot.

3. Drill a hole in the handle that is slightly smaller than the square on the stem.

4. Mount stem in handle.

5. Mark tap size on handle.

NOTE: These sizes may vary as much as .03 to .04 of a millimeter, but are generally close enough to determine the right thread size of a crown.

LESSON	2
BOWS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L2-J12

HOW TO REPLACE A BOW.

Introductory Information:

When ordering a new bow, indicate style of bow, size of case, color, and measurement between contact points.

Tools, Equipment and Supplies:

Combination Bow Pliers (Opening and Closing)

PROCEDURE:

REFERENCE: Sec. 55

1. Select bow of proper size and style to fit the case.
2. Spring bow open with bow pliers and snap into place on pendant.
3. Check for snug fit.
4. If too loose, tighten with bow pliers.

Detach page or cut along this line — and send to the School for grading

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 2

Name: No.: Date:

Circle the ONE BEST answer: SUBJECT: Crowns, Stems, Sleeves, Bows

1. In a watch which uses a stem that is assembled with the case, what holds the stem in place?

   The sleeve | The case | The movement | A screw

2. When putting a stem and sleeve in the case, what is the first thing to do?

   Screw the crown on the stem | Put the stem in the case | Put the sleeve in the case | Assemble the stem and sleeve

3. Which one of the following is LEAST LIKELY to be caused by a worn or broken sleeve?

   Stem pulls out | Stem slips from winding position to setting position | Watch winds or sets too hard | Watch suddenly gains or loses an hour or more

4. On which of the following is a sleeve wrench used?

   Swiss style setting | All types of sleeves | Reversible sleeve | Screw type sleeve

5. Where should the stem be oiled?

   At the threads | Below the threads | Where stem and sleeve contact | Not at all

6. Where are you most likely to find a two-piece stem?

   On one-piece cases with non-removable back | On screw back and screw bezel cases | On snap cases | On hunting cases

7. How many types of dial screws are mentioned in this lesson?

   Four | Three | Two | One

8. If the threaded portion of a Swiss style stem is too long, which of these will be affected?

   The winding of the watch | The space between crown and case | The setting of the hands | The setting of the watch

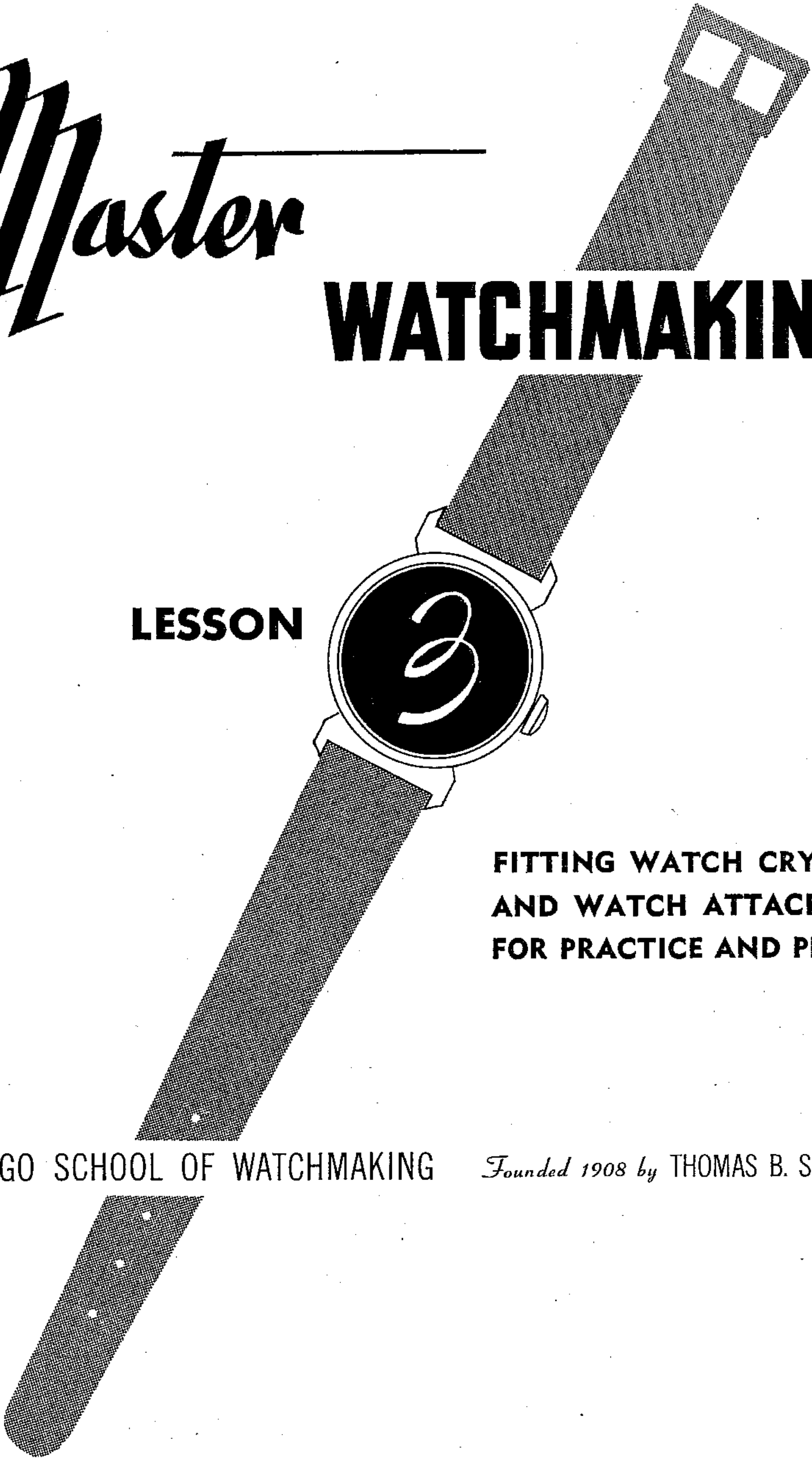
9. The tube through which the stem passes on a water-tight watch is called a:

   Split post | Pendant post | Crown neck | Sleeve

10. What difference, if any, is there between a Swiss pendant setting mechanism and an American pendant setting mechanism?

    There is no difference | Swiss stem is shorter | Swiss stem is held in place by set lever | American stem has coarser threads

Master WATCHMAKING



LESSON 3

FITTING WATCH CRYSTALS AND WATCH ATTACHMENTS FOR PRACTICE AND PROFIT

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

Printed in the United States of America

Revised 1969

INTRODUCTORY INFORMATION

In these Lessons in Master Watchmaking, you are taking the watch apart approximately in reverse order to its assembly. For example, in the first lesson, you learned how to remove the movement from the case. In the second lesson you studied the winding and setting mechanism controls; that is, the crown, stem and sleeve. The entire course is based on this practical, step-by-step method. It is obvious that it would be hard for the beginner to replace mainsprings unless he first knew how to take a watch from its case.

Your next consideration is the setting of watch glasses or crystals. This is one of the most important phases of the watch repair business. Ready-made crystals of the simpler types will run from 35¢ to 60¢ in cost for the repairman, while fancy types range from $1.25 to $2.00. A usual charge for crystal replacement is $2.00 to $4.00 for the simpler ones, while fancy shapes start at $4.00.

Although the average watch repairman seldom makes his own crystals, it is a good idea for the beginner to make at least one crystal as outlined in Lesson 3. By so doing you will learn the purpose of doming and fitting a crystal to the bezel so that it will always snap into place. Many beginners have the idea that a watch crystal is held in place by cement. Actually, the crystal is snapped into place and the cement is used only as a sealer.

The first watch crystals were made of glass and were frequently broken. The watchmaker then was called upon to replace the glass, and in so doing, had at times to be able to adjust hands and remove broken particles of glass from the movement. These broken particles would cause the watch to stop. In such instances, the watchmaker had to explain to the customer that the watch must be taken apart to remove the bits of glass. Obviously, a repairman cannot do this and charge only for the price of the crystal. In consequence, he should determine when a customer brings him a watch for a crystal that the watch is in running order.

Today we have the non-breakable crystal, which has, in most cases, eliminated stoppages caused by broken glass. Non-breakable crystals have one disadvantage in that they may dull or scratch easily and give a cloudy effect. Recently, the manufacturers have developed other styles of heavy glass crystals in various cuts and shapes to enhance the appearance of the watch.

KEY POINTS OF LESSON ASSIGNMENTS 8, 9, 10, 11:

- The common units of measure used in watchmaking.
- How to read a millimeter gauge.
- The names of various types of watch crystals and types of cases on which they are used.
- How to cut, dome and fit a watch crystal from raw material.
- The different styles of spring bars.
- How to replace a watch strap.
- How to replace the cord on a lady's watch.

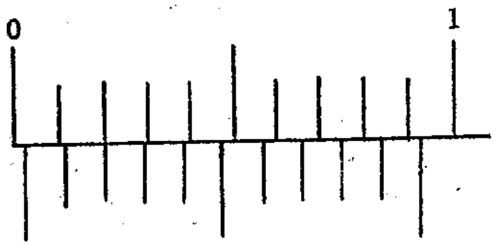
ASSIGNMENT NO 8: Study Sections 70 through 73.

Study Questions:

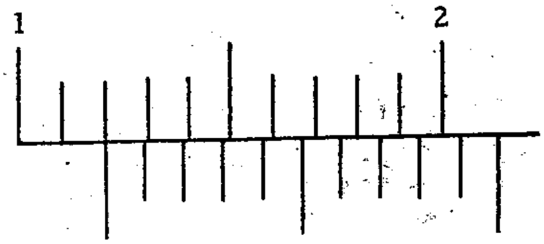
1. Which system of measurement is preferred in watchmaking? Why?
2. What unit of measure is used on the Vernier scale of the millimeter gauge?
3. How do you measure depths with the millimeter gauge?
4. How do you take outside measurements? Inside measurements?

Recommended Practice:

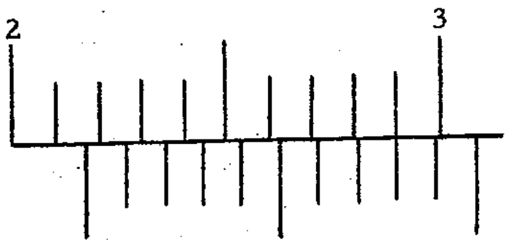
1. Check your ability to use a millimeter gauge by giving the readings for these settings: (Do these problems before looking at the answers below.)



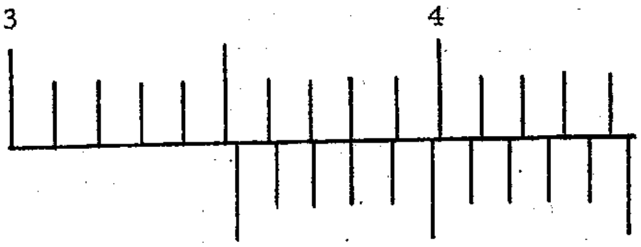
a. Ans. ____________



b. Ans. ____________



c. Ans. ____________



d. Ans. ____________

Answers: (a) .2 mm (two-tenths millimeters). (c) 21.8 mm (twenty one and eight-tenths millimeters).
(b) 12 mm (twelve millimeters) (d) 35.3 mm (thirty five and three-tenths millimeters).

2. If you failed to get all the above right, re-read the text again until you understand how these answers were arrived at.
3. As soon as you can, practice with an actual millimeter gauge. Measure anything at hand until you are sure you know how to use it.

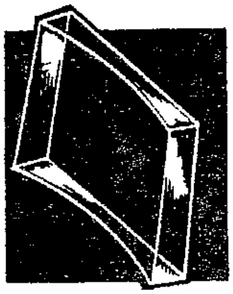
ASSIGNMENT NO. 9: Study Sections 74 through 80 and the back page of the lesson text.

Supplement to Section 74: Until a watch repairman has an established shop, it is probably more practical to replace watch crystals by sending the bezel to a firm which specializes in crystal fitting. Most large cities have such firms and they give good service. Your material jobber will handle this for you. The difference between what the firm charges and what the watch repairman charges is

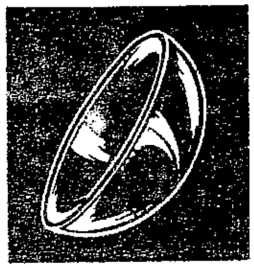
ASSIGNMENT NO. 9 (Continued):

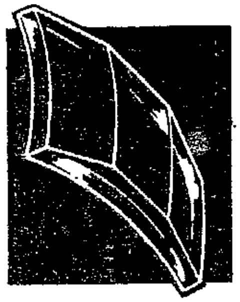
his profit. Such an arrangement makes unnecessary a large inventory of crystals or crystal blanks. When ordering a crystal in this way, it is not advisable to send the watch. Send only the bezel. When the crystal is returned, it is a good precaution to run crystal cement around the edge of the bezel and let it dry. This seals it against dust.

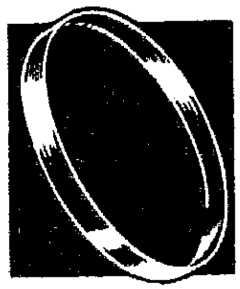
Supplement to Section 80: Many interesting varieties of ultra-fancy, molded crystals have been developed for special applications, such as waterproof styles or a smart "modern" look. A few of these are shown below. They can be purchased in assortments or ordered from a crystal fitting house as just mentioned.


FANCY FLAT TOPS


CYLINDRICALS


ROUND BALLS


GABLE TOPS


ROUND FLAT TOPS

(Illustrations courtesy of Fulton Watch Crystal Corporation)

1. What are the different styles of crystals used in pocket watches?
2. For what types of watches is each one best suited?
3. What means has the watchmaker for determining the size of the new crystals?
4. How do you insert a round crystal by hand?
5. What are some common shapes of fancy crystals?

Recommended Practice:

Examine all the watches you have available and determine the size and shape of each crystal.

ASSIGNMENT NO. 10: Study Sections 81 through 83.

1. What tools are used in making and fitting plastic watch crystals?
2. Why is doming a crystal important?
3. How do you form a round crystal?
4. How do you form a fancy crystal?
5. Why is crystal cement used?

Recommended Practice:

1. Form and fit a crystal to a bezel.
2. Fit some ready-made crystals.

ASSIGNMENT NO. 11: Study Sections 84 through 86.

Supplement to Sections 85 and 86: Bands and straps are available in other materials besides leather. Cloth and nylon are preferred by some. Both are

ASSIGNMENT NO. 11 (Continued):

washable but relatively short-lived. Cord for women's watches is also made in nylon.

Metal bands for both men and women are gaining popularity. Their cost depends upon their quality and the metal used. A good quality is advisable for satisfactory service. We recommend that beginners not try to repair metal bands. Send them to your jobber for repair. Also keep in mind that styles are constantly changing. Many people will readily buy a new band, if shown one, instead of having their old band repaired.

1. What is a spring bar?
2. Are all spring bars of the same size?
3. Which size leather band is most common?
4. How do you replace a cord band on a lady's watch?

Recommended Practice:

1. If you have a wrist watch with removable spring bars, remove them, measure and replace.
2. If you have a lady's watch fitted with a cord band, remove and replace the cord.

REQUIREMENT:

➧ Answer Test Questions for Lesson 3 and return to us for grading.

SUMMING UP

In this lesson you have studied the remaining external features of a watch -- crystals, spring bars, watch bands, straps and cords. They are important to the repairman because they must so often be replaced and can be a source of considerable profit. It has been estimated that a wrist watch, in its 20-25 year life span, may require on the average as many as five watch bands or forty watch straps! †

Now you are about ready to turn your attention to the movement. But before entering into a detailed study of it, you will find it worthwhile to learn the common names for the various parts. In this way, you can more easily understand the explanations to follow. This study of "nomenclature", or names of parts, will be taken up in Lesson 4.

† Tobias Stern: "Building Business with an Accessory Jewelry Department" Ben Sacheim Inc., Publisher, New York, 1942.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 3

Sections 70 to 86

FITTING WATCH CRYSTALS AND WATCH ATTACHMENTS FOR PRACTICE AND PROFIT

Sec. 70 — Millimeter — A Unit of Measure

Throughout your course and career in Watch Repairing, make it a practice to carefully determine the exact measurement of every piece of material used for replacements. Do not attempt to "guess." Guesswork is the method invariably used by careless workmen. Watches are made to exact measurements and gauges must be used to determine correct measurements for replacing or making parts.

Several standards of measurement are used by watchmakers. The English measures of length consisting of the inch, foot, etc., are not practical for our work. For instance, the inch is divided into so many divisions—16ths, 32nds, 64ths, 128ths, and 1000ths—that it requires mathematical skill to figure out the decimal equivalent of the parts of an inch. One cannot tell instantly that 7/64ths of an inch written decimally equals .10938 inch unless he has the equivalents memorized or a printed table at his elbow. Both methods are in common use.

In your work, you will use a unit of measure called a millimeter. The metric unit of length is the meter which is equal to 39.37 English

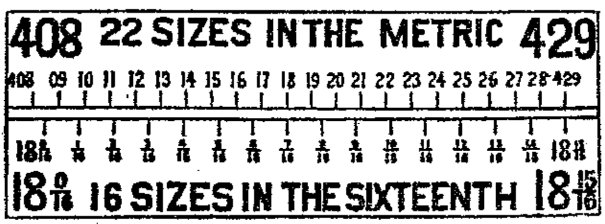


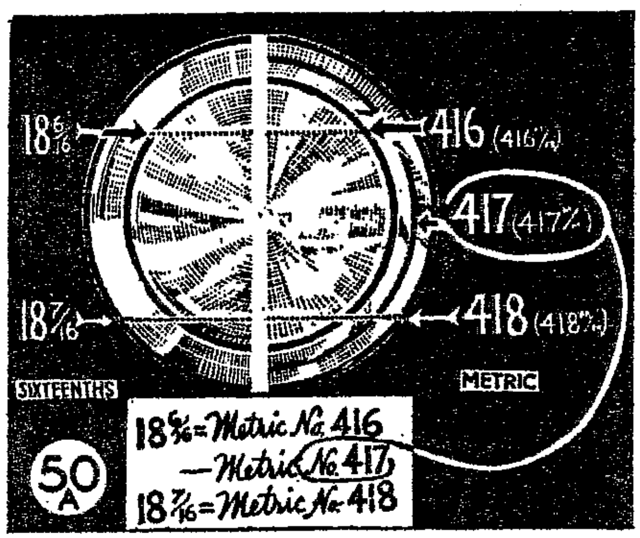
FIG. 50

inches. The millimeter is the one-thousandth part of a meter and the abbreviation is mm. Thus 1 mm equals 1 millimeter, 6 mm equals 6 millimeters, 20 mm equals 20 millimeters.

Pivots in watches, outside diameters of jewels and jewel holes are gauged in hundredths of a millimeter. Later a micrometer will be used which measures to 1/100 of a mm. Mainsprings and watch glasses are being gauged by the metric system much more than formerly.

Sec. 71 — Lignes

The French "ligne" (line) is also used in watchmaking. The sizes of French and Swiss watches are designated in lignes. The ligne is 1/11 of an English inch and 1/12 of a French inch. A ligne equals 2.25 mm.



Sec. 72 — Comparison of Sixteenth and Metric Systems

Among the older watchmakers, there are many who use the sixteenth system. Figure 50 shows the units of 18s divided into sixteen parts, 18-0/16th to 18-15/16ths. The most modern system is the METRIC SYSTEM. In figure 50, notice the metric numbers 408 to 429, divided into 22 parts of 1/10th of a millimeter each. You have 22 sizes in the metric system and only 16 sizes in the sixteenth system. In other words you have more in-between sizes, figure 50A.

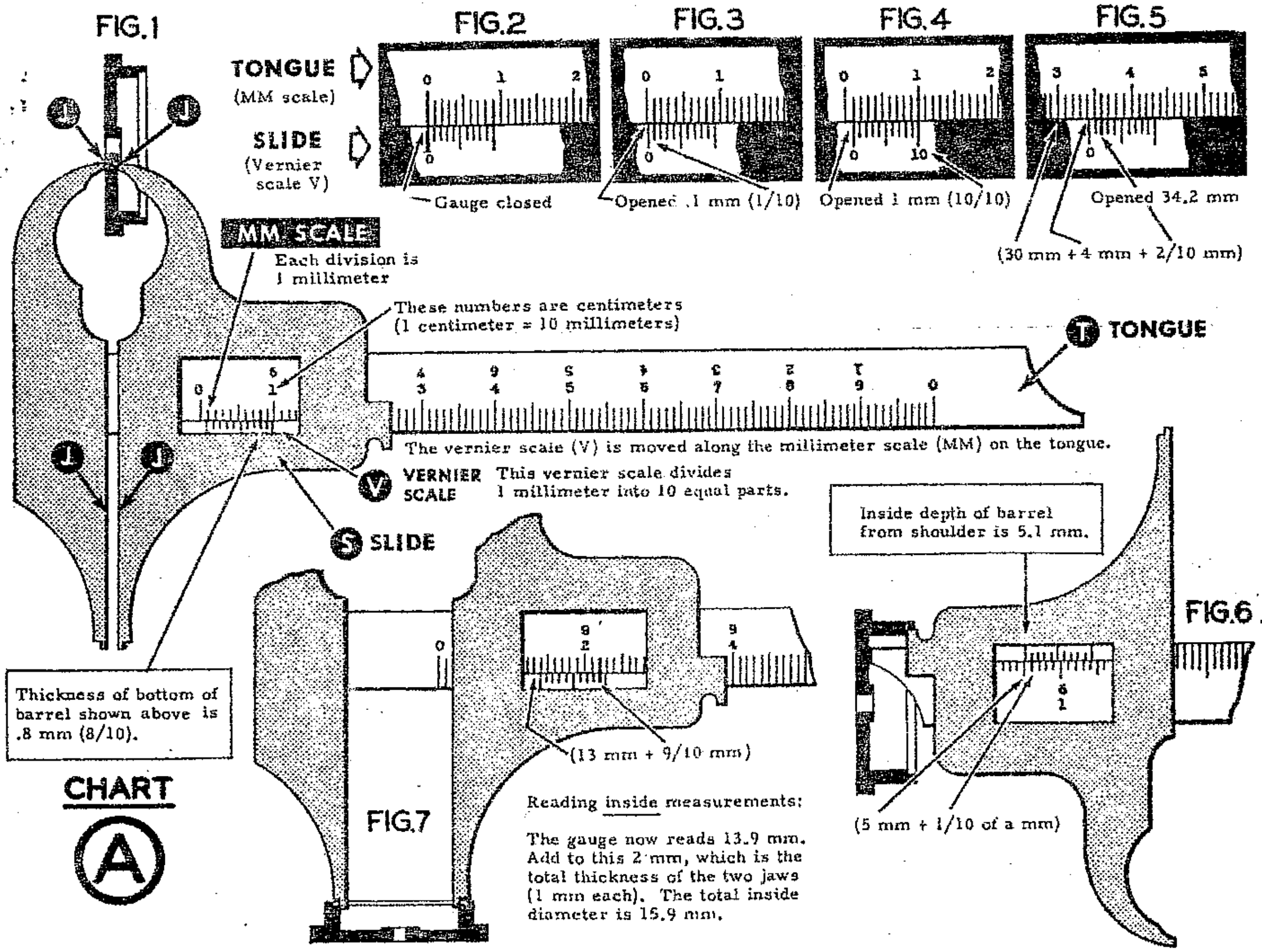
Sec. 73 — Reading a Millimeter Gauge

Chart A, figure 1, illustrates a common type of millimeter gauge. The jaws at J, figure 1, are for outside measurements. T is the tongue. S is the slide which contains a scale at V. This scale is NOT divided into millimeters. It is a Vernier Scale, and is used to divide a millimeter into 10 equal parts, making it possible to measure in tenths of a millimeter with a gauge of this type.

Notice the first ten divisions from 0 to 1 on the tongue, figure 2. Each one of these divisions equals 1 mm. The Vernier Scale located on the slide (figure 2) is divided into 10 equal sections and these ten divisions equal 9 divisions on the tongue. If the slide were moved so that the second line on this slide coincides exactly with the second line on the tongue scale, figure 3, the jaws of our caliper would be open one-tenth of a millimeter—3 lines two-tenths, 4 lines three-tenths, etc. Figure 4 shows a reading of 1 mm. If the line marked 0 on the slide, figure 4, were moved to the next line on the tongue, it would read 2 mm and so on up the tongue which has a total of 100 mm. The small inverted figures on the tongue, figure 1, are for reading when the gauge is used for depth measurements as illustrated in figure 6.

Figure 5 illustrates the slide measuring 34-2/10ths millimeters. Count the number of lines on the tongue before the 0 on the Vernier Slide. This is 34. Now notice which line on the Vernier Scale coincides with a line on the tongue scale (only one will coincide exactly); in this particular case, it is the third line or the end of the second division. This equals 2/10ths of a millimeter. Now add 34 plus 2/10ths written 34.2 mm. All measurements are read exactly the same way in measuring the depth, figure 6, and outside measurements, figure 1.

Inside measurements are taken as shown in figure 7. In this particular case, the gauge reads 13.9 mm. However, as this reading is the measurement between the jaws, it is necessary to add 2 mm, the thickness of the two jaws (one mm each), to the total making a total inside measurement of 15-9/10ths mm. It will take some time to become accustomed to measuring in millimeters if you have never used the metric system before. You should practice by using your millimeter gauge at every



opportunity. There is very little in watch repairing, especially in the more advanced work, that does not require the use of either a millimeter gauge or micrometer.

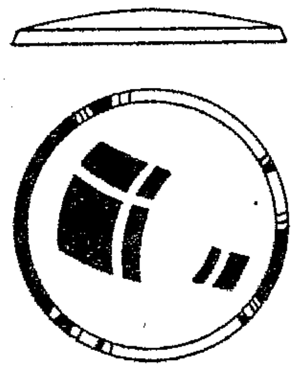
Interest, accuracy and progress in watchmaking will be assured when reading of the millimeter gauge is mastered.

Sec. 74 — Profits from Watch Crystals

The fitting of watch crystals or watch glasses is a lucrative part of the watch repair business. Practically every watch purchased in the United States is brought into the watch repair shop for a new crystal at some time. It is an essential part of the repair business and the watch repair man can create an abundance of good will and an excellent profit if he can give quick service. The repair man who is on his toes realizes that quick service without sacrificing quality is a sure way to keep his customers. Many stores carry an immense stock of crystal blanks. It would be impossible for the beginner to stock the thousands of sizes and shapes of watch crystals. Part of this lesson will explain how you can make watch crystals fit practically any style watch case with a little practice and without a great deal of investment.

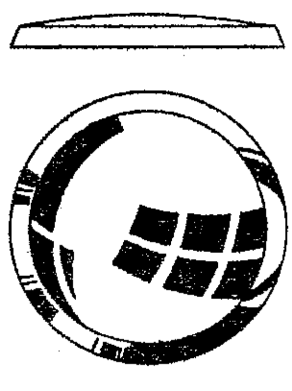
Sec. 75 — Fitting Round Watch Glasses

The first step is the fitting of round watch glasses. Glass is probably the best material for use in protecting the face of a watch. Glass has one fault; it will break. However, it



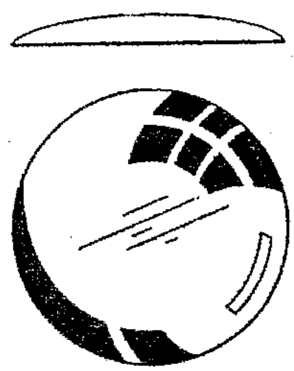
MICONCAVES

Miconcave crystals are finished with a sharp beveled edge and used on the ordinary open face watch case.



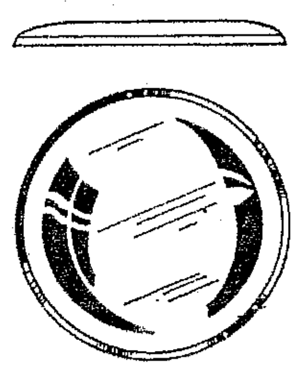
EXTRA THICK MICONCAVES

The extra thickness adds double strength. Edges are sharp and clean cut. Recommended for use on silver and silverine open face watches—such as are carried by railroad engineers, etc.



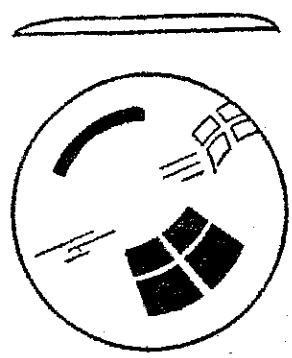
LENTILLES

A high grade watch glass, intended for use on the better grade open face watches. Their streamline dome shape is a true compliment to the better quality open face watch.



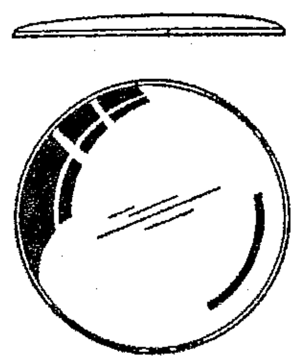
EMPIRE CHEVEES

Less expensive, but equally as practical as Lentille Chevee Crystals. A thin, bevel-edged glass for bracelet and pocket watches. Unexcelled for the thin model lower priced, open face watches.



LENTILLE CHEVEES

Similar in shape and of the same quality as the Lentille crystal. The height of the Lentille Chevee near the edge is the same as at the center, giving the hands sufficient room to pass. Especially adapted for high grade thin model watches.

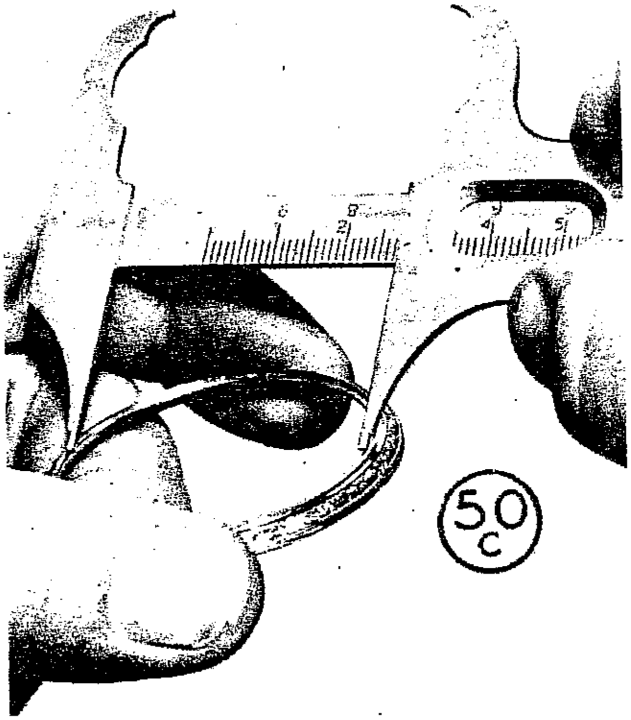


GENEVAS

Geneva crystals are furnished in various heights for closed face or hunting watch cases.

FIG. 50B

does not scratch easily and if "snapped in" properly, it will not come out. You may have customers who are constantly breaking crystals and will desire one that will not break. A good repair man is always equipped to give his customers what they prefer. Unbreakable watch glasses are clear and flexible. The round No Breaks are most always inserted with force. The main objection to non-breakable watch



glasses are that they will scratch and, in some instances, when too much pressure is exerted on the center of the non-breakable glass, there is a possibility that the hands or the center pinion may be damaged. Some have a tendency to shrink and, after a long period of time, there is a possibility of the non-breakable crystal falling out.

Sec. 76 — Types of Round Crystals

In figure 50B are shown the characteristics of round glasses with the trade names listed below each illustration.

For all practical purposes, the Lentille is probably the most satisfactory for use on open face watches, as it allows more room for the hands and is neater.

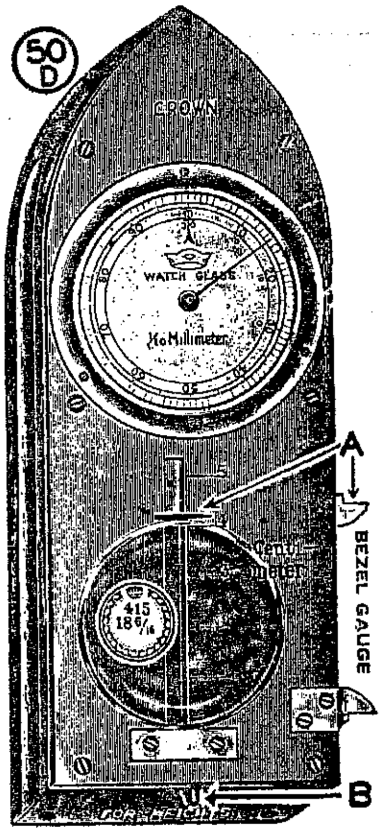
The Miconcave and extra thick Miconcave are used on the older types of watches and on railroad models where more strength is needed than can be supplied by a Lentille.

Sec. 77 — Fitting Crystal to Open Face Watch

To fit a watch glass to an open face watch, remove bezel. Be certain the bezel is clean and that no broken bits of glass or dirt remain. Figure 50C illustrates the method used in measuring a bezel with a millimeter gauge. The reading of the scale in this case is exactly 39.5 mm. However, we are not using the inside of the jaws which is the distance the 39.5 mm represents. It is necessary to allow for the thickness of the jaws (1 mm each) or 2 mm making our actual measurement 41.5 mm. On the modern metric crystal charts the decimal point and the mm are dropped leaving only the figure 415 which represents the size of our crystal. 41.4 mm equals No. 414; 21.6 mm equals No. 216, etc.

Figure 50D illustrates a type of crystal gauge which measures in the metric system.

In figure 50-D notice the two arrows at A. The longer arrow indicates the movable jaw used to measure the outside diameter of a round watch glass. The shorter arrow indicates the



movable jaw used to measure the opening in the bezel. The divisions shown on the vertical scale are centimeters which we convert into millimeters as follows:

1	Centimeter	= 10	Millimeters
2	"	= 20	"
3	"	= 30	"
4	"	= 40	"
5	"	= 50	"

The circular scale is divided into tenths of a millimeter. The total is obtained by combining the reading on the vertical scale and circular scale:

Example:
Reading on Vertical Scale: 40 mm
Reading on Circular Scale: 1.5 mm

Total: 41.5 mm

Remove the decimal point and the size of glass illustrated is 415.

Sec. 78 — Inserting

In the modern shop, you would select from stock glass No. 415. If the glass selected did not snap in, you would try another of the same measurement until you found the correct size.

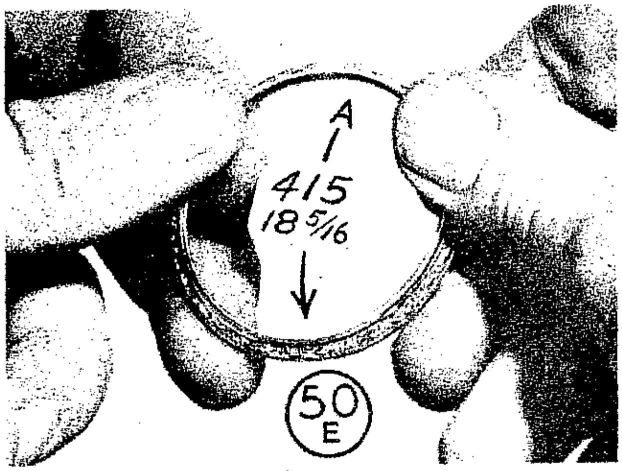


Figure 50E shows how to insert glass. Put glass in lower edge of bezel with thumbs and fingers, draw the glass in direction indicated by Arrow A until glass snaps in. Remove label, clean watch glass both inside and out, dry thoroughly and replace on case.

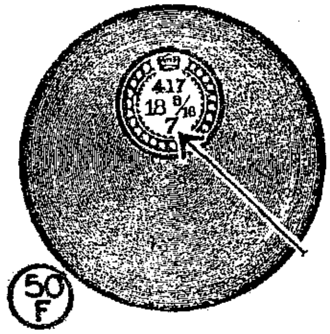
Sec. 79 — The Geneva Crystal

The Geneva is used only on hunting case watches, Lesson 1, figure 11. These crystals are very thin and although the sizes are metrically the same, they would break if used on an open face watch.

For measuring the height of Geneva crystals, the gauge illustrated in figure 50D can be used as follows: Press the underside of the watch glass against the small rod projecting through the lower end of the gauge at B and the pointer will indicate the height on the inner circle figures 0, 10, 20, and 30 as follows:

24=Height 4
20=Height 5
16=Height 6
12=Height 7
8=Height 8

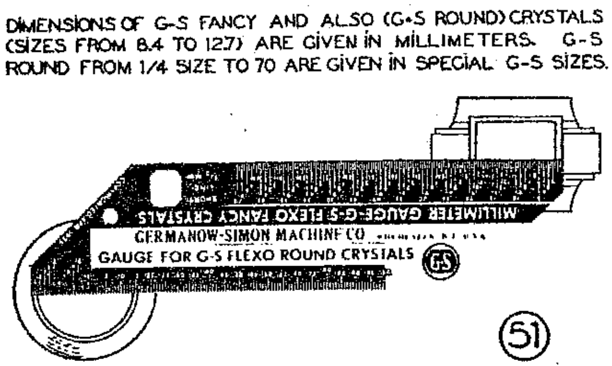
Notice in figure 50F this label has a small number printed on it, in this case, No. 7. This refers to the height of the crystal. In the older types of hunting case watches, this number would usually be No. 5, meaning 5 high. The different heights are 4, 5, 6, 7 and 8. The thinner



models use 7 or 8 high. There are so few of these watches in use today it is hardly profitable for the average man to carry a complete stock of Geneva glasses. It is more profitable to order from a regular material house. Be sure when ordering to send the bezel and, if possible, the case so that the correct height may be selected.

Sec. 80 — Selecting Fancy Watch Crystals

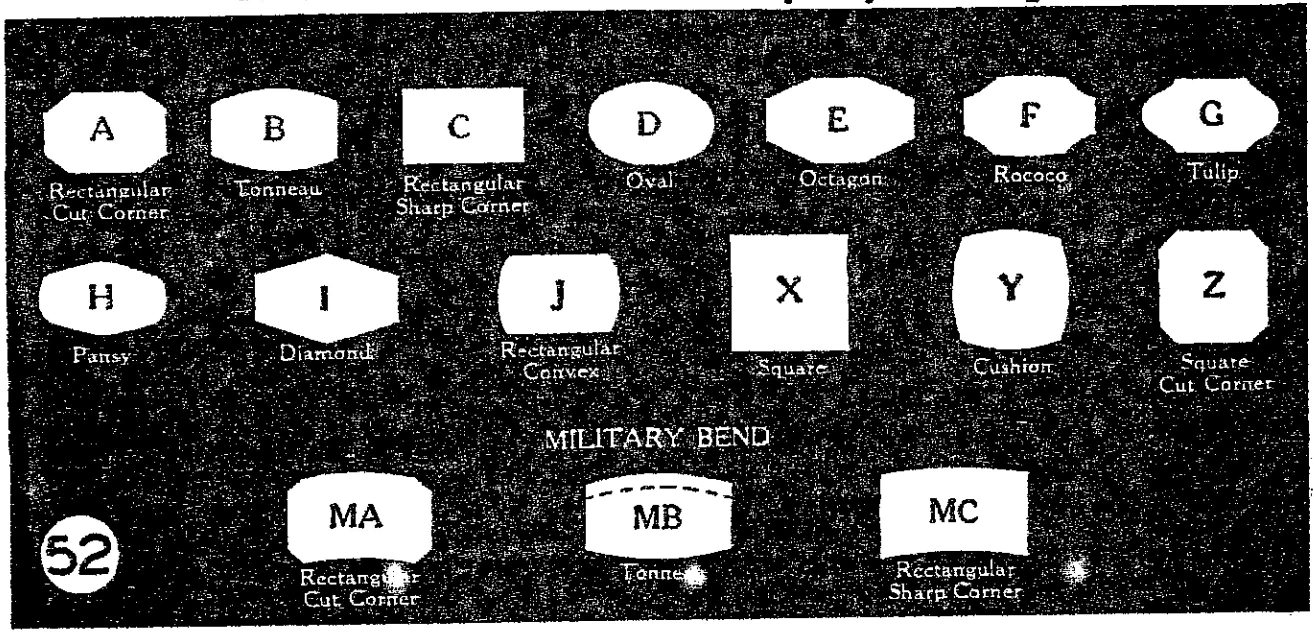
Figure 51 is a crystal gauge for measuring fancy and round crystals. When measuring a fancy case with a G-S Crystal Gauge, it is difficult to obtain its exact size to a tenth of a millimeter. SOME G-S Crystals are made 1 to 4 TENTHS OVERSIZE to fit cases which vary



slightly in size. Therefore, when selecting a crystal, always try a size from 1 to 4 tenths smaller. You will often find that this crystal will fit correctly with very little filing, if any.

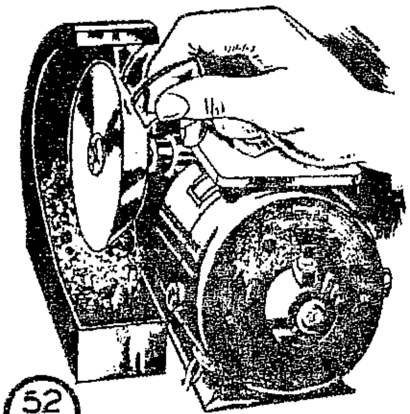
More than ever the fancy watch crystals are becoming more popular. There are thousands of different sizes and shapes.

This is the Chart of KK Fancy Crystal Shapes

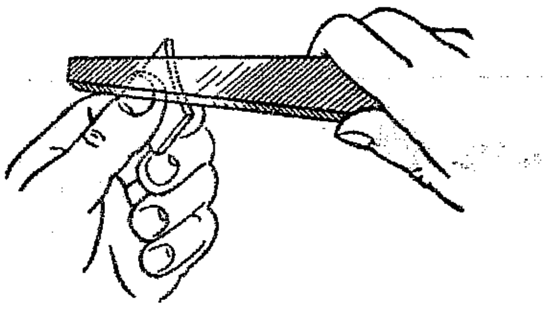


52

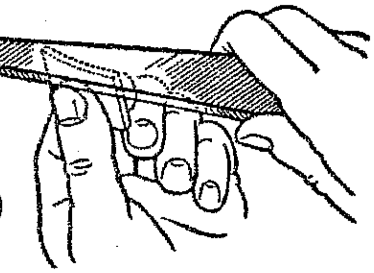
Figure 52 shows an illustration of a few of the many shapes. These shapes can be obtained in glass or non-breakable and usually have to be touched up with a glass grinding wheel, figure 52A, or with a file, figure 52B, for the non-breakable.



52 A

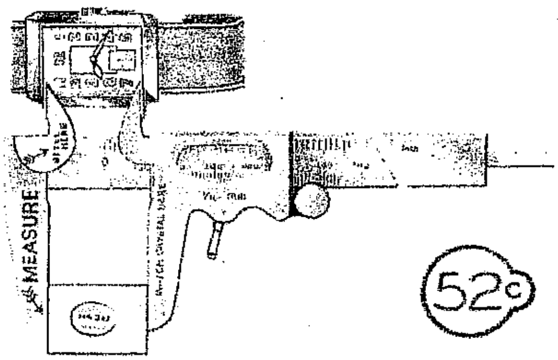


Wrong way of filing—Do not file crosswise.



52B

Right way of filing—Hold as illustrated with the thumb on dome side of crystal. File lengthwise on edge and form a slight bevel on crystal.

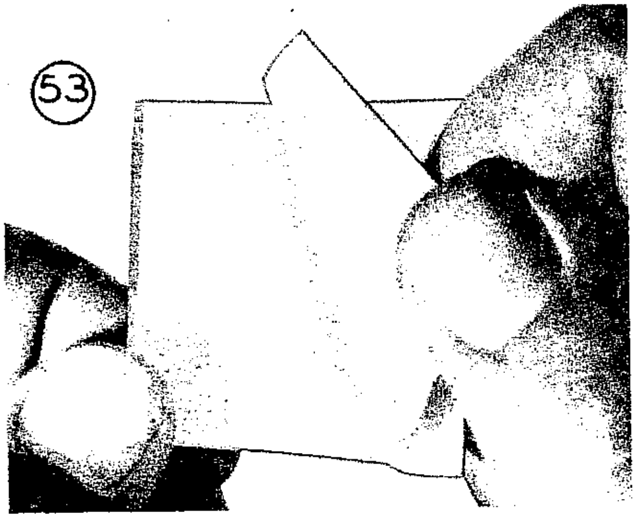


52C

In ordering fancy crystals, first determine the shape as in figure 52. Measure the length and width in mm, fig. 52C, or as illustrated in fig. 51. Now select your crystal according to shape, length and width and fit into bezel. There are many shapes on the market and you should obtain a crystal catalog from the concern you select as your supply house.

Sec. 81 — Tools and Material to Make Your Own Crystals

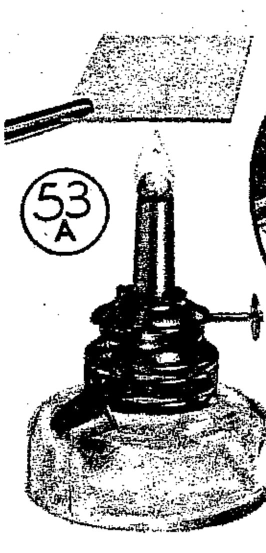
As has been explained, the better equipped shops carry many different styles and shapes of watch crystals. This enables them to give quick service. However, for the man starting in

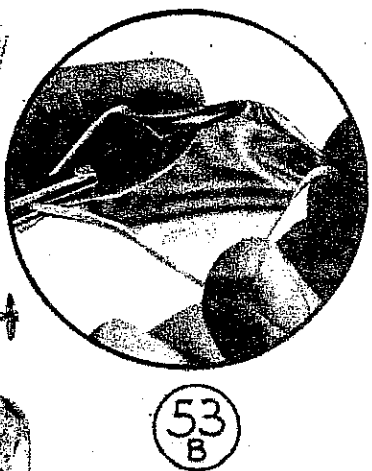


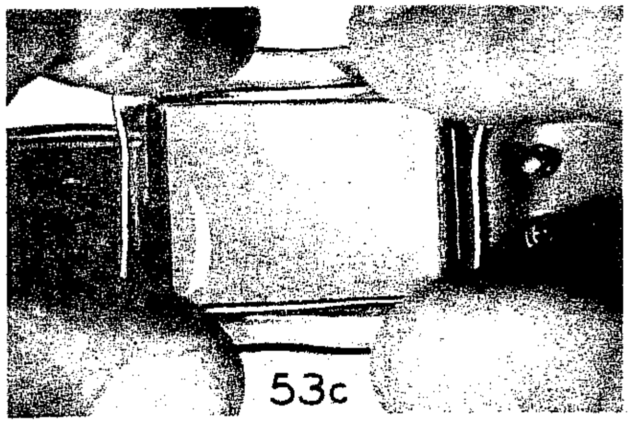
business, it is profitable to make his own crystals. This also gives practice fitting different shapes of bezels. When you have advanced far enough to take a job it will be a simple matter to touch up crystal blanks that come very close to being the correct size. For this lesson, we will need beside our crystal blanks, the following:

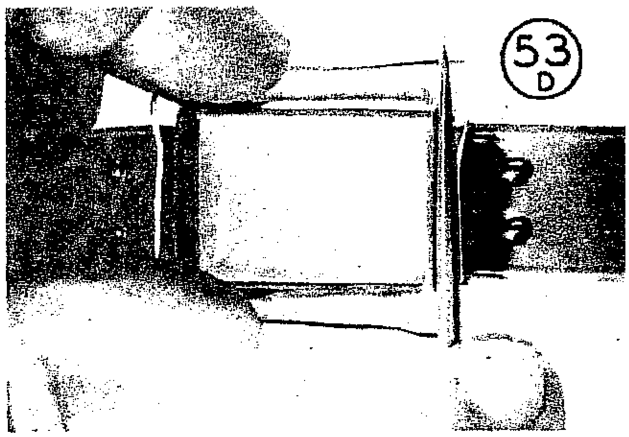
Alcohol lamp
Flat file
Cutting pliers
Coping saw
Crocus cloth
Silver paste
Crystal cement
Stylus or awl
Dome shaped glass lense or paper weight
Soldering tweezers

Clean bezel thoroughly, removing dirt and bits of broken crystal.





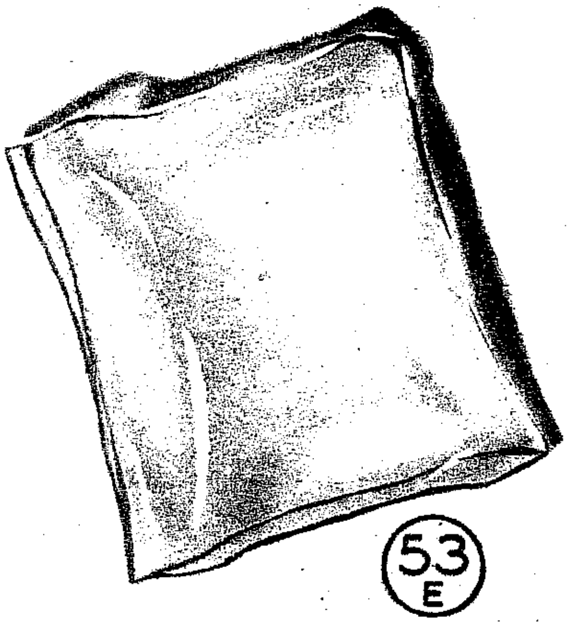




Sec. 82 — Cutting and Shaping Material

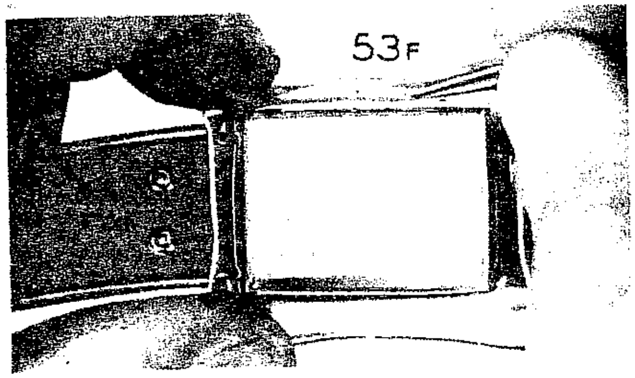
The procedure in cutting and shaping material is as follows:

Remove paper cover from crystal blank, figure 53. The size of the crystal blank should be



approximately ½ inch longer and wider than the bezel to be fitted.

Heat crystal blank over alcohol lamp as shown in figure 53-A until blank is soft and pliable.



Quickly place blank over frame of bezel, figure 53-C, and with fingers mould edges over sides of case.

Carefully apply heat to ends of blank and using the awl form over each end of case as in figure 53-D.

The blank should appear similar to the one illustrated in figure 53-E. The amount of curve or dome to the crystal should be of sufficient height so that the hands will have ample clearance.

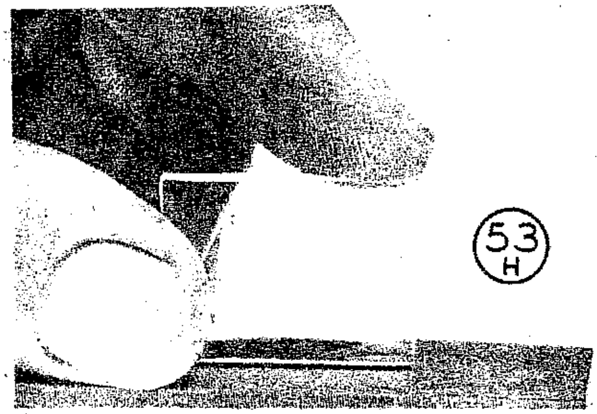
With a scribe, scratch outline of the bezel as in figure 53-F allowing about 1/16th inch for finishing.

Using coping saw, cut away surplus material from both ends and sides, figure 53-G.

Place flat file on bench and draw crystal across cutting teeth of file, figure 53-H, until edges are straight and smooth and crystal will snap in bezel.

To polish edges of crystal repeat the above method, using crocus cloth and silver paste, figure 53-J.

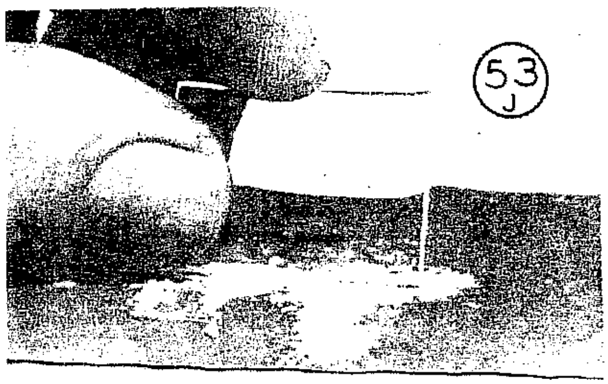
This is the simpler form of watch crystal and if on your first attempt you do not get a perfect fit, do not be discouraged. It will take practice but eventually you will be able to turn them out rapidly.



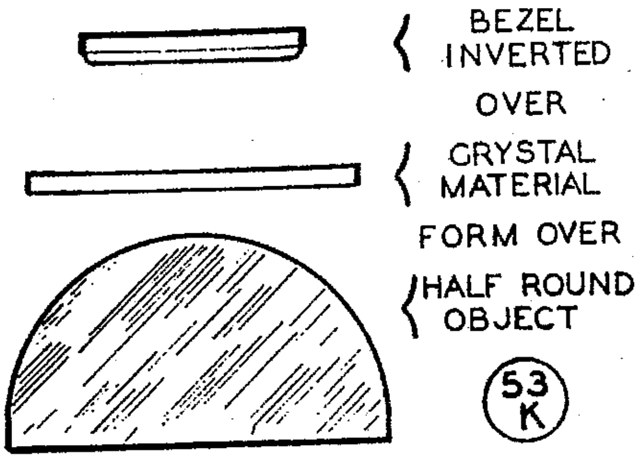
NOTE: Always file two opposite sides to fit first.

Sec. 83 — Doming Round Crystals

Your ingenuity will be taxed in making the various sizes and shapes that will be encountered. Individual instructions cannot be given on the thousands of different sizes and shapes. These instructions are basic instructions. In fitting other crystals such as square, round, etc., it is necessary to dome our crystal by another method. It would be fine if a mold for each different size could be made, but this is im-

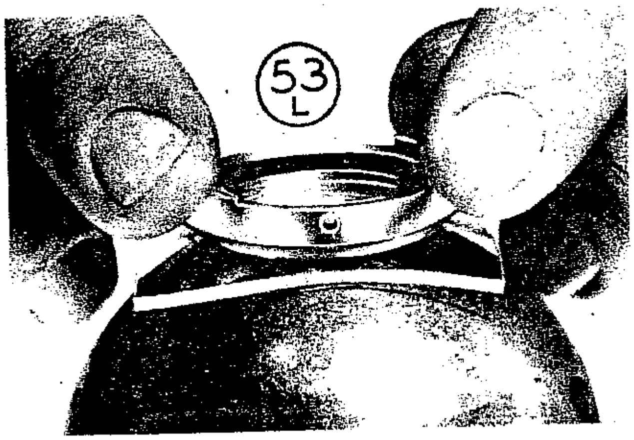


practical and expensive. A round glass paper weight, optical lense or wood block about 2 inches in diameter and 1½ inches high with a smooth surface can be used for this purpose. Figure 53-K is a sectional view of such an object.



53 K

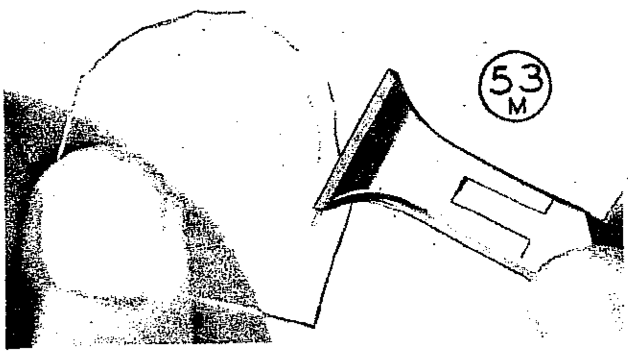
After selecting a blank, heat over alcohol lamp as before until blank is pliable. Now quickly place blank over block and with the bezel to be fitted inverted, hold blank until cool, figure 53L. Remove and you will have an outline of the bezel in the blank which now should be domed



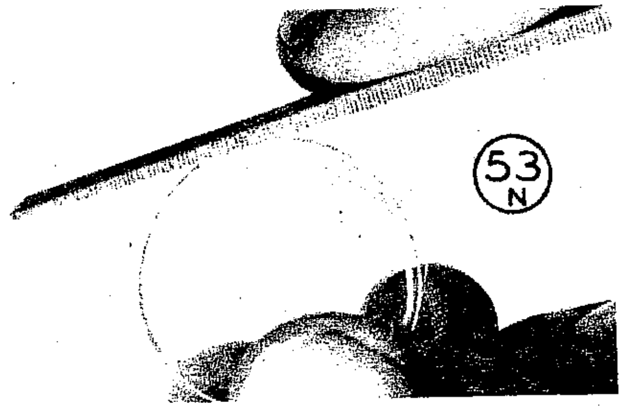
53 L

high enough for hands to pass. At this point, there are likely to be a few bubbles in the glass. If so, pass blank through flame two or three times until bubbles disappear. Trim and finish as before.

Use cutting pliers instead of saw to trim crystal blank as illustrated in figure 53-M.



53 M



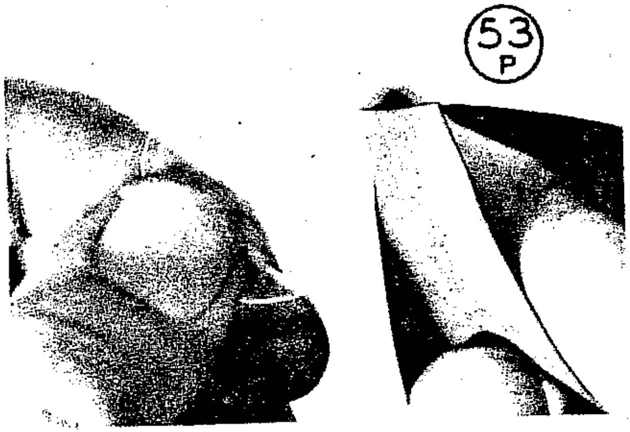
53 N

Figure 53-N illustrates the method used to file a round crystal.

Figure 53-P illustrates the use of crocus cloth or crocus cloth and silver paste to polish edge.

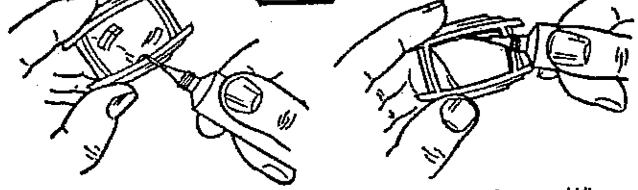
Use the methods described or combination of methods best suited for each job.

53 P



After crystal is snapped in, flow crystal cement around edge of bezel sealing it against dust, figure 53R. A properly fitted crystal should snap in; the cement is used primarily to exclude dust. Practice on as many different types of watch bezels as possible and you will soon be in a position to turn them out rapidly. It will not be hard to reach the speed of 3 to 5 an hour at substantial profit.

53R



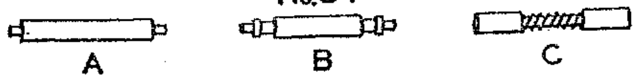
1. For Dustproofing—After crystal is inserted, apply point of tube around outside edge of groove and crystal. Press tube very lightly, cement will fill in any openings.

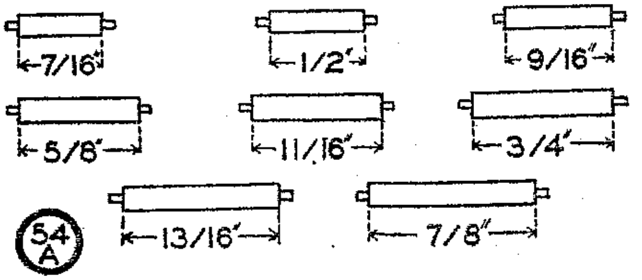
2. For Cementing — When crystals are fitted improperly, loose or in very shallow grooved cases; apply cement direct to groove; then insert crystal.

Sec. 84 — Spring Bars

This is another profitable part of your business. Most men's wrist watches and some models of ladies' sport watches use leather straps to

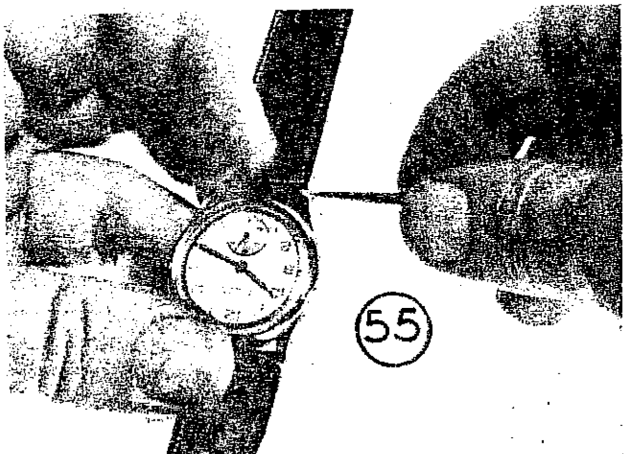
Fig. 54



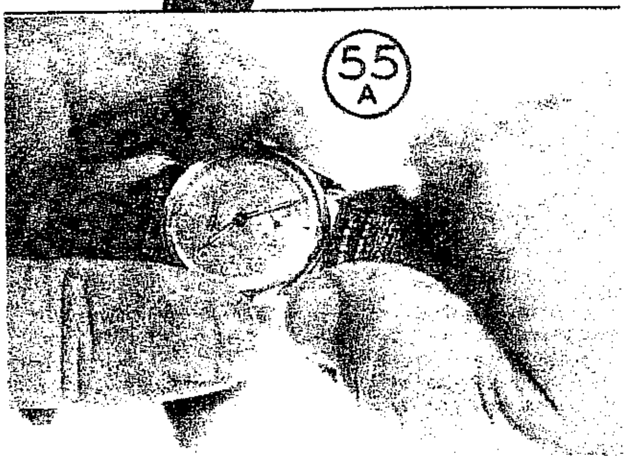


54A

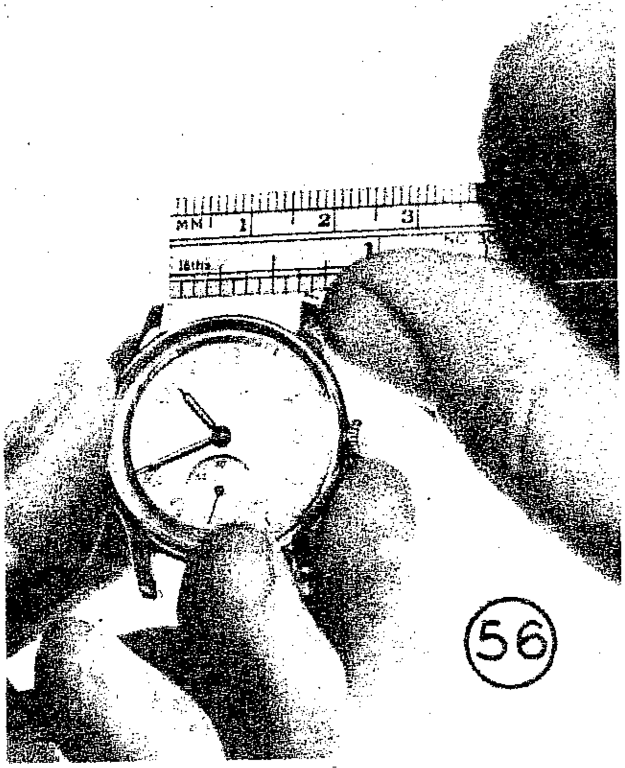
keep watch in place. The majority of leather straps are held in place by spring bars, figure 54. This is enlarged to show detail. Figure 54A shows actual sizes with the corresponding measurement listed below each spring bar. Figure 54 illustrates three types of spring bars: A, the single shoulder, B, the double shoulder, and C, the Female spring bar used with cases



55



55A

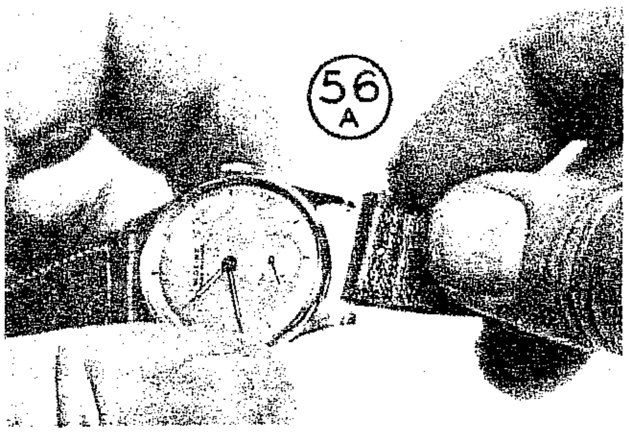


56

having pins instead of holes in the lugs of the case figure. The double shoulder spring bar is the one preferred in most cases. Remove as in figure 55 or figure 55A.

Sec. 85 — Fitting Watch Straps

Leather straps can be purchased from 1/2 inch to 15/16 inches wide. In order to select the correct size of strap or spring bar, measure distance between lugs, figure 56, with an ordinary rule which measures in sixteenths of an inch. Select strap of the same width and after slipping spring bar through strap, figure 56A, replace on watch. Usually the shorter piece of strap contains the buckle and is replaced between lugs on section of case near the figure twelve on dial.

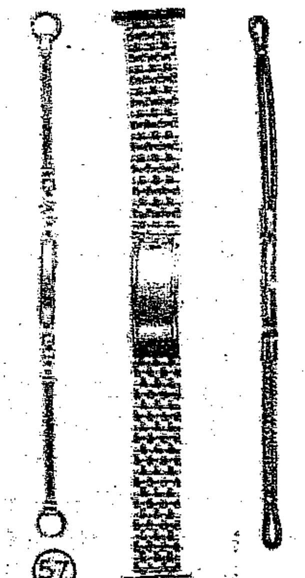


56A

Always determine which way customer prefers strap by examining position of buckle when removing old strap. There are many good qualities of straps and your dealer can supply most any kind desired. In most cases, the regular length is used but there are times when a man with an extra large wrist needs an extra long strap or, in other cases, where it is necessary to use an extra short strap. In either case, when ordering straps, be sure and specify Regular, Extra Long or Extra Short. Example:

1 Regular Calfskin 5/8 Inch Regular
6 Pigskin
  2 Regular 3/4 Inch
  2 Extra Short 5/8 Inch
  2 Extra Long 1/2 Inch

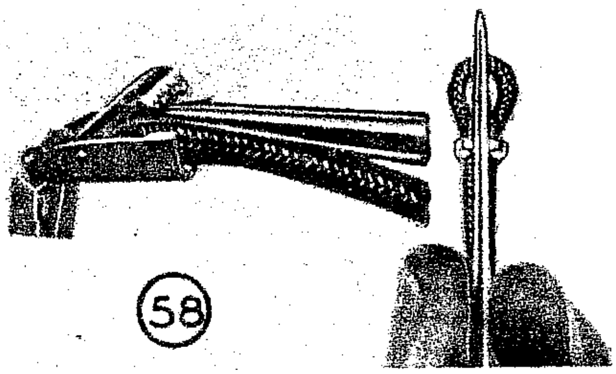
Keep a good supply of spring bars and straps on hand. The 5/8 inch width is the most commonly used.


57

Sec. 86 — Replacing Cords

Most ladies' watches, especially the smaller sizes, are held in place on the wrist by cord or metal bands. Figure 57 illustrates three common types of watch bands or watch attachments. A is a metal watch band for ladies' watches. B is a metal watch band for men's watches. C is the cord type of attachment used mainly on ladies' watches. In most cases, metal bands cannot be repaired except by the factory. The cord type ladies' watch band frequently needs new cords and these are easily replaced at a profit.

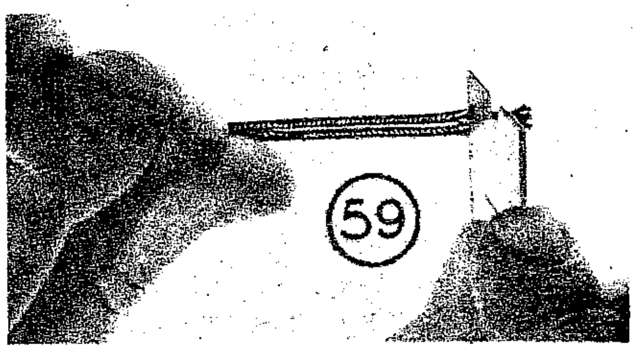
When the cord is worn out on band, it is only necessary to replace the cord. The metal attachments, in most cases, are used over again. Metal bands come in a great many styles


58

and from a variety of manufacturers. Usually when broken, the customer is delighted if shown a new one. However, replacing cord bands is another way to give a customer quick service. It is only a matter of a few minutes and small investment to replace cords quickly. There are several different diameters of cords used and other colors than black, such as rose and brown, are available. The most used size is called .075.

Material: Cord
Ordinary Paraffin
Alcohol Lamp
Awl

Melt a small amount of paraffin into a metal container such as a material box, figure 59-A. Remove the catches and the small clamps at each end of cord with awl, figure 58. Cut a piece of new cord for each side exactly the same length as the ones you are replacing. Use a razor blade, figure 59. Heat wax until it is melted and dip ends of cord into melted parafine and remove quickly, figure 59-A. Let cool, replace cords, clasps and clamps and job is done.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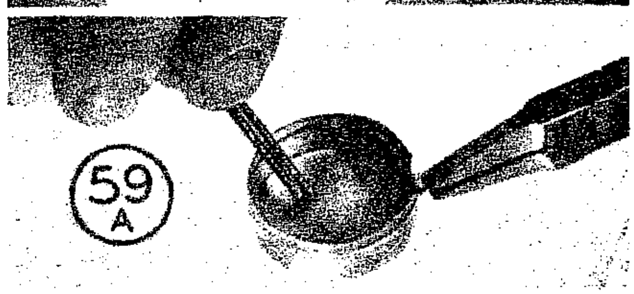

59 A

HOW TO FIT G-S FLEXO ROUND CRYSTALS

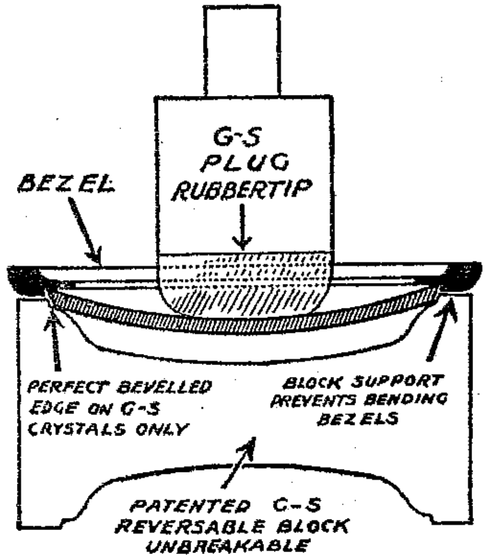
1. Measure bezel with G-S gauge exactly across center. The size is where the line on gauge meets groove. Use crystal not more than ½ size larger than bezel.

Example—when bezel measures 40½—use crystal size 41. **Do not use size 41½.**

Exception—For pocket watches with deep grooved bezel, a crystal one size larger may be necessary. Never stretch crystal over one size larger than bezel.

2. Select block marked No. 41, (same size as crystal). Number in center of each block indicates number of plug to be used.

3. Lay crystal in groove of block (sharp edge up). Hold bezel over crystal (do not lay it down). Press foot pedal lightly to hold crystal in place. Then catch edge of crystal on groove of bezel on one side and gently with gradually increasing pressure on foot lever reduce crystal enough to snap into bezel groove. (When crystal is inserted do not remove hands from bezel until foot pressure is released.)

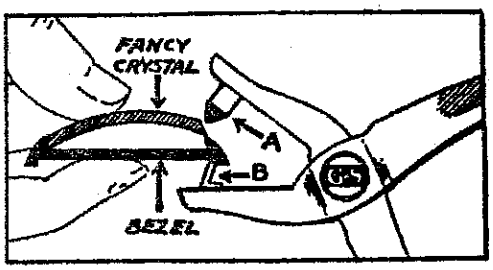


This illustration shows the only practical and successful Round crystal inserting method.

G-S Crystal is placed in groove of Block. Plug is pressed down in center, the beveled edge of crystal raises on the curve of block, entering the groove of bezel, holding firmly under compression.

HOW TO USE THE G-S FANCY CRYSTAL INSERTER

When fitting a G-S Fancy crystal, it is often difficult to force the final edge of the crystal into the bezel with fingers. Crystal can be forced into bezel more easily and quickly with the aid of a G-S Crystal Inserter, as illustrated.



G-S Crystal Inserter—Patent No. 1916024

1. Do not apply inserter on crystals that are too large. Crystal should be only a trifle larger than case, and fitted into most of the groove by hand before inserter is applied.
2. Hold the fitted part of crystal and bezel tightly with fingers as illustrated.
3. Place anvil (B) of inserter on inside of bezel.
4. Hold bezel or case parallel to lower jaw of inserter so that rubber (A) is in contact with exposed edge of crystal. With a rocking motion, apply SLIGHT PRESSURE, while gradually following exposed edge of crystal until completely inserted. BE VERY CAREFUL ON THIN SOFT METAL CASES.

COURTESY GERMANOW-SIMON MACHINE CO.

CHECK YOURSELF

Progress Check 3A — A Self Test Review of Lesson 3

After you have studied Sections 70 through 80, see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The unit of metric measure used to gauge watch parts, such as pivots, jewels and mainsprings, is the ____________ which is abbreviated ____________.	70
2. The French ligne equals ____________ millimeters.	71
3. The ____________ system of measuring watch crystals has been replaced by the more modern ____________ system.	72
4. The Vernier scale on the millimeter gauge enables one to measure in ____________ of a millimeter.	73
5. The 10 divisions of the Vernier scale are equal to ______ divisions on the slide.	73
6. In measuring inside measurements, ____________ are added to make up for the thickness of the two jaws.	73
7. Materials commonly used for crystals are ____________ and ____________.	75
8. The first step in fitting a round crystal is to measure the ____________.	77
9. A round crystal of the right size should ____________ into place.	78
10. A characteristic of Geneva crystals is their extreme ____________.	79
11. In ordering fancy crystals, it is necessary to determine the ____________.	80

ANSWERS TO PROGRESS CHECK 3A:

1. millimeter
mm
2. 2.25
3. sixteenths
metric
4. tenths
5. 9
6. 2 mm
7. glass
plastic
8. bezel
9. snap
10. thinness
11. shape,
length and
width

CHECK YOURSELF

Progress Check 3B — **A Self Test Review of Lesson 3**

After you have studied Sections 81 through 86, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of the test. If you miss any questions, review the section on which the statement is based.

	Section Ref.
DIRECTIONS: Number in proper order these steps for making a simple crystal:	
1. ( ) Polish edges with crocus cloth and paste. ( ) Remove paper from crystal material. ( ) Dome crystal. ( ) Clean bezel thoroughly. ( ) Heat blank over alcohol lamp until blank is soft and pliable. ( ) Using coping saw, cut away excess material. ( ) File edges until straight and smooth. ( ) Fit softened blank over bezel and form sides with fingers and ends with awl. ( ) Scratch an outline of the bezel with a scribe, leaving about 1/16th of an inch for finishing.	82
DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces:	
2. To dome a round crystal, a ______________ object is used.	83
3. ______________ are usually used instead of a saw to trim a round crystal blank.	83
4. Crystal cement is used primarily to ______________.	83
5. Three principal types of spring bars are: ______________, ______________, and ______________.	84
6. Spring bars are measured in fractions of an ______________.	84
7. The ______________ piece of a watch strap usually has the buckle and is replaced on the end nearest the figure 12 on the dial.	85
8. The most commonly used strap is ______________ of an inch.	85
9. The most common size of lady's cord band is called ______________.	86
10. The tips of cord bands should be dipped in ______________.	86

ANSWERS TO PROGRESS CHECK 3B:

1. (9)
(2)
(5)
(1)
(3)

1. (continued) (7)
(8)
(4)
(6)

2. half round
3. cutting pliers
4. seal out dust
5. single shoulder
double shoulder
female

6. inch
7. shorter
8. 5/8
9. .075
10. paraffin

HOW TO FIT A ROUND GLASS TO AN OPEN FACE CASE.

Tools, Equipment and Supplies:

Case Opener

PROCEDURE: (OPEN FACE CASE)	REFERENCE:
1. Remove bezel.	
2. Clean bezel.	
3. Determine inside diameter of bezel.	Fig. 50C and 50D
4. Select glass.	Fig. 50B
5. Insert crystal and seal with cement.	Fig. 50E
6. Clean.	Sec. 78
7. Replace bezel on case.	
8. Check hands for clearance.	

PROCEDURE: (HUNTING CASE)	REFERENCE:
1. Remove bezel.	
2. Clean bezel.	
3. Determine inside diameter of bezel.	Fig. 50C and 50D
4. Determine height. (Heavy case - Height 6) (Medium case - Height 7) (Average heavy case - Height 8)	Fig. 50F
5. Select glass.	
6. Insert crystal and seal with cement.	Fig. 50E
7. Clean.	Sec. 78
8. Replace bezel on case.	
9. Check hands for clearance.	

LESSON	3
CRYSTALS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L3-J2

HOW TO REPLACE ROUND UNBREAKABLE CRYSTALS.

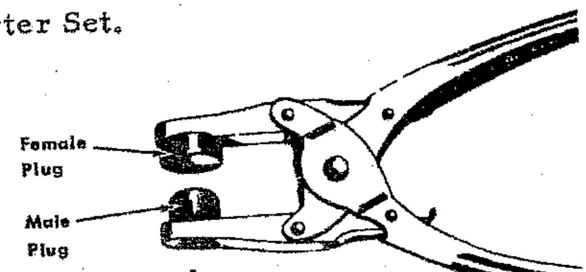
Introductory Information:

Unbreakable watch crystals are rapidly replacing watch glasses. The plastic now being used has been developed to hold its transparency and not be affected by solvents, such as alcohol, benzine, or watch cleaning solutions. Nonetheless, it is recommended than non-breakable watch crystals be cleaned only with water.

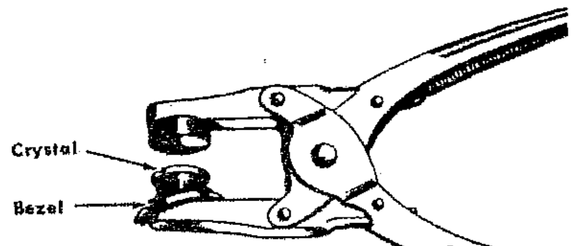
Tools, Equipment and Supplies:

Crystal Gauge or Millimeter Gauge. Inserter Set.

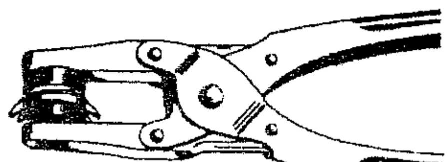
PROCEDURE:



A



B



C

1. Remove bezel.

2. Clean bezel.

3. Measure bezel with crystal gauge or millimeter gauge.

4. Select crystal. Allow 1/4 size larger. Or, if you are using the metric system, allow about 15/100 mm larger. If you are using the inch system, allow about 6/1000 of an inch larger.

5. Select male and female plugs and place in the inserting tool (Figure A). The female plug should be the largest that fits <u>into</u> the groove of the bezel. The male plug should be the largest that goes <u>through</u> the bezel (about 2/3 of inside diameter of the bezel).

6. Place bezel over male inserter plug. (Figure B.)

7. Place the crystal face upward on the male inserter plug. (Figure B.)

8. Bring the bezel against the crystal as you squeeze the two plugs together with just enough force to snap the crystal into the bezel. Do not press too hard. (Figure C.)

9. Release pressure slowly to seat crystal.

10. Clean crystal and replace bezel on case. Check clearance of hands.

LESSON	3
CRYSTALS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L3-J3

HOW TO REPLACE THE ELGIN "WRAP-AROUND" CRYSTAL

Introductory Information:

Elgin's new "Horizon Look" watches are fitted with Elgin's newly developed "wrap-around" crystals. The crystals, made in two types, the "inside" and "outside" as illustrated in the cross section sketches below, create an appearance of thinness.

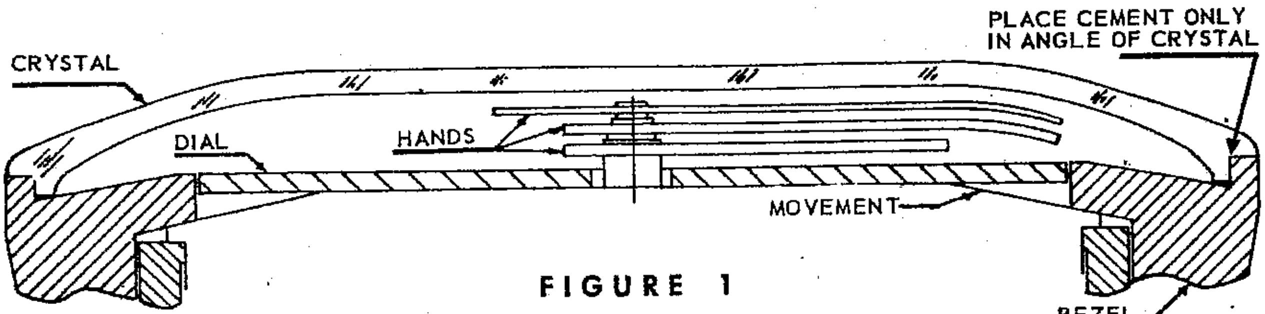


FIGURE 1

INSIDE WRAP-AROUND CRYSTAL

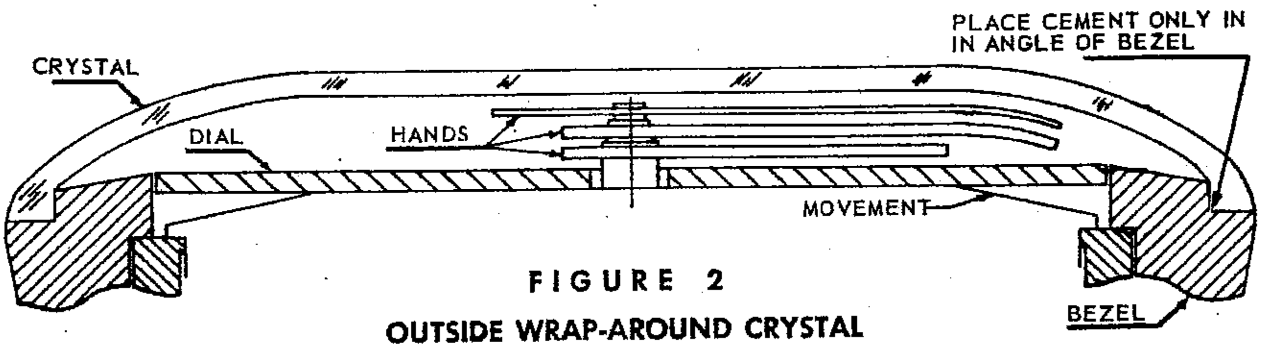


FIGURE 2

OUTSIDE WRAP-AROUND CRYSTAL

REPLACEMENT OF CRYSTALS

Replacement of crystals of either type is simple. It can be done with a plastic or non-breakable crystal inserting machine or tool, but the following steps should be performed carefully to ensure best results:

1. Remove old crystal by any suitable means, such as knife, case opener, etc.
2. Wipe off new crystal and clean the case to ensure freedom from dirt, grease, old cement, fingerprints, etc.
3. (It is considered desirable to cement all replacement wrap-around crystals.) Select a crystal cement which does **not** contain solvents injurious to plastic. One such cement is G & S, which has been tested and found satisfactory. Use just an adequate amount of this cement. Place it only in the angle as indicated in Figures 1 and 2, in order to avoid smearing onto lacquered bezel.

(continued)

4. (a) "**INSIDE" TYPE:** (See Figure 3)

Place the new crystal in a crystal inserting machine or tool. Flex the crystal enough to allow its easy entry into the crystal seat of the bezel and place it in proper position.

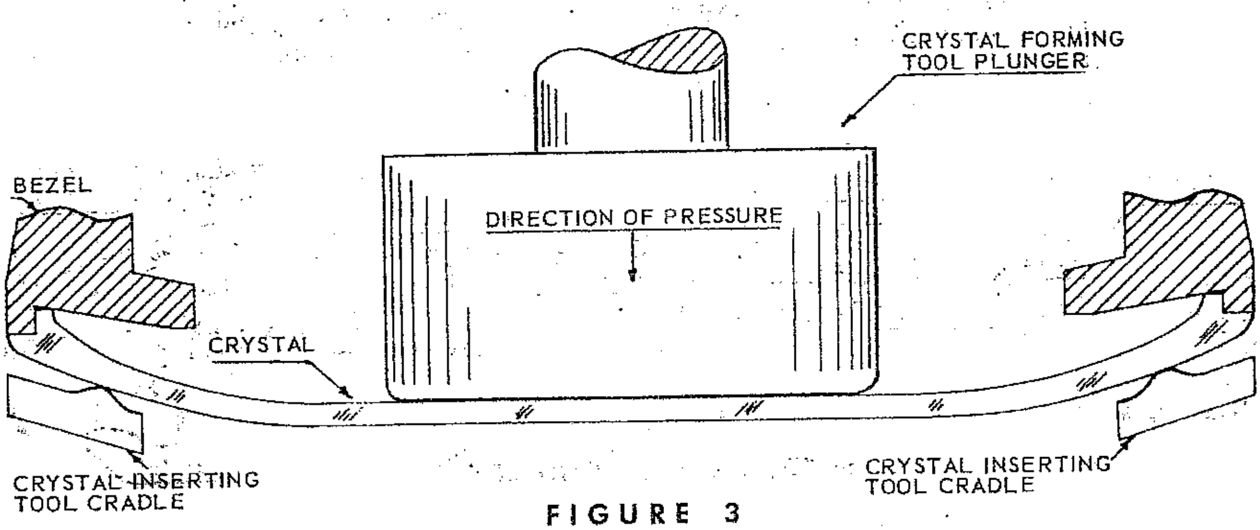


FIGURE 3

REPLACING INSIDE WRAP-AROUND CRYSTAL

(b) "**OUTSIDE" TYPE:** (See Figure 4)

Place new crystal in position over the bezel. Press with thumb at center enough to "spread" crystal until it snaps into place over the bezel edge into and against the crystal seat.

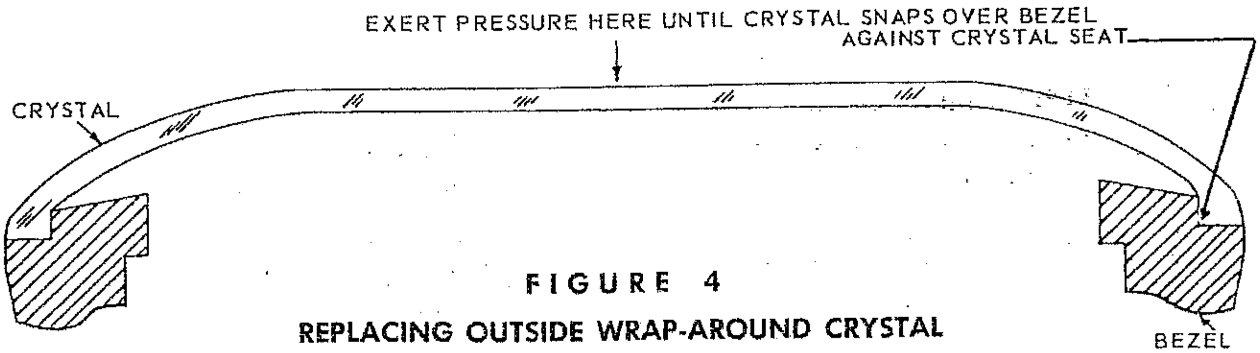


FIGURE 4

REPLACING OUTSIDE WRAP-AROUND CRYSTAL

5. Do not disturb the crystal by succeeding operations until the cement has hardened.

LESSON	3
CRYSTALS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L3-J4

HOW TO FIT FANCY SHAPED WATCH CRYSTALS.

Introductory Information:

The beginner will usually find it more profitable to have his fancy crystals fitted by a material dealer who handles this work.

Tools, Equipment and Supplies:

Glass Grinding Wheel or File   Crystal Gauge   Crystal Cement

PROCEDURE:	REFERENCE:
1. Remove movement from case.	
2. Remove broken glass and clean bezel.	
3. Determine shape.	
4. Measure length and width with crystal gauge or millimeter gauge.	
5. Shape glass on grinding wheel until it snaps into bezel. If unbreakable type, shape with file.	Fig. 52A Fig. 52B
6. Cement edge and allow to dry.	Fig. 53R
7. Clean with damp cloth and replace movement.	
8. Check hands for clearance.	

LESSON	3
SPRING BARS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L3-J5

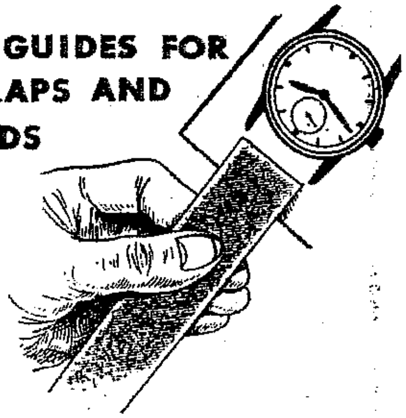
HOW TO REMOVE AND REPLACE SPRING BARS

Tools, Equipment and Supplies:

Spring Bar Remover

PROCEDURE:	REFERENCE:
1. Check holes in lugs of case to see if they are through.	
2. If holes are through the lugs, use pin end of spring bar remover to depress and release the spring bar.	Fig. 55
3. If holes do not come through, insert flat end of spring bar remover (or suitable substitute) between lug and shoulder of spring bar and force back the end.	
4. In the case of a metal band which fits snugly between the lugs, a jeweler's saw may be used to cut the spring bar.	
5. Measure space between lugs.	Fig. 56
6. Select and replace spring bar.	Fig. 56A

MEASURING GUIDES FOR WATCH STRAPS AND BANDS

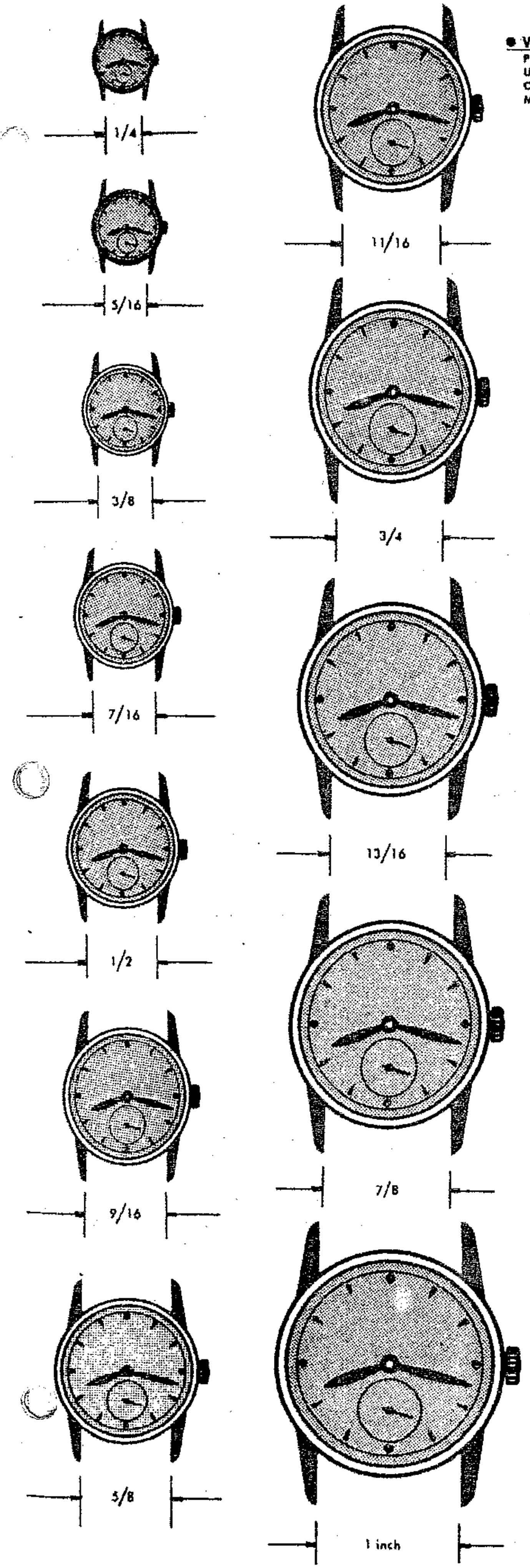


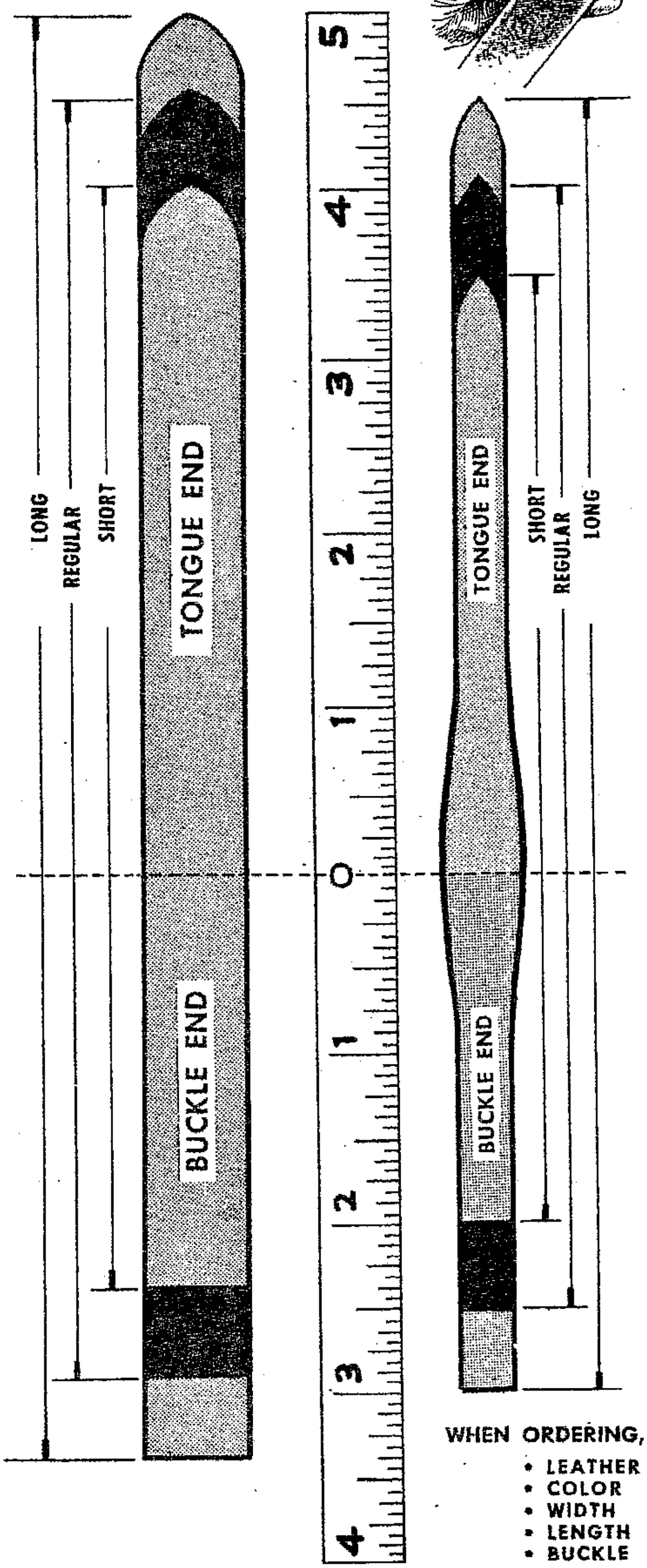
• WIDTH

PLACE STRAP BETWEEN ILLUSTRATED WATCH LUGS FOR CORRECT WIDTH MEASUREMENT REQUIRED.

• LENGTH

LAY BAND ALONG ILLUSTRATED STRAP NEXT TO RULER FOR CORRECT LENGTH MEASUREMENT REQUIRED.





WHEN ORDERING, SPECIFY

- LEATHER
- COLOR
- WIDTH
- LENGTH
- BUCKLE

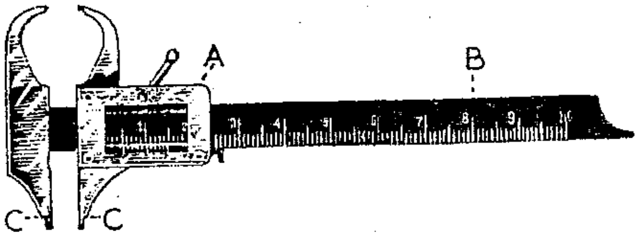
Detach page or cut along this line — and send to the School for grading

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — *Master Watchmaking* — *Lesson No. 3*

Name: No.: Date:

SUBJECT: Fitting Watch Crystals and Watch Attachments for Practice and Profit

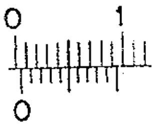


1. Identify the three lettered parts of this millimeter gauge by writing the letter on the short line in front of the correct name:
   ____ Jaws
   ____ Tongue
   ____ Slide

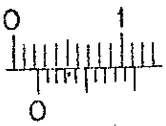
The following illustrations show a portion of the tongue of a MM gauge and the complete vernier scale. What is the correct reading for each measurement?

____ 2. A 1 mm
B 1.10 mm
C 10 mm
D 11 mm

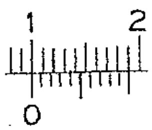
____ 3. A .11 mm
B .5 mm
C 9.5 mm
D 10.5 mm



____ 4. A .4 mm
B 2.10 mm
C 2.2 mm
D 12.1 mm

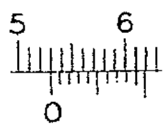


____ 5. A 1 mm
B 3.10 mm
C 10 mm
D 19 mm



____ 6. A 3.6 mm
B 4.10 mm
C 30 mm
D 30.6 mm

____ 7. A 9.10 mm
B 52.9 mm
C 53 mm
D 53.9 mm



In questions 8 through 17, write the letter of the ONE BEST answer on the short line in front of the question number.

____ 8. What is the main fault of glass crystals?
A. May scratch
B. May catch hands
C. May break
D. May fall out

____ 9. What is the main fault of non-breakable crystals?
A. May scratch
B. May shrink
C. May discolor
D. May fall out

____ 10. Which measurement is the most important when fitting a crystal?
A. Outside bezel width
B. Inside bezel width
C. Inside bezel depth
D. Thickness of crystal

____ 11. Why is the metric system preferred in measuring round crystals?
A. Easier to work with.
B. Shorter way of measuring.
C. More in-between sizes.
D. None of the above.

____ 12. Why is 2 mm added to the reading on the millimeter gauge when measuring a bezel for a crystal?
A. To provide oversize measure for tight fit.
B. To allow for thickness of bezel.
C. To allow for thickness of jaws.
D. None of the above.

____ 13. What leather strap width is most common?
A. 1/2 inch
B. 5/8 inch
C. 3/4 inch
D. 15/16 inch

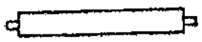
____ 14. Which round crystal is best for a hunting case?
A. Geneva
B. Lentille
C. Miconcave
D. Lentille Chevee

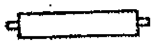
____ 15. Which round crystal is best for a railroad watch?
A. Geneva
B. Lentille
C. Empire Chevee
D. Extra thick Miconcave

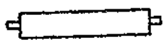
____ 16. Which round crystal is best for an ordinary open face watch?
A. Geneva
B. Lentille
C. Lentille Chevee
D. Extra thick Miconcave

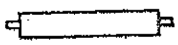
____ 17. How do ultra fancy crystals differ from ordinary ones?
A. Usually thicker.
B. Usually thinner.
C. Made of plastic.
D. Varied shapes.

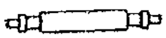
What width watch strap should be ordered for the following spring bars? (Answer should be in inches.)

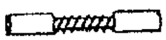
________ 18. 

________ 19. 

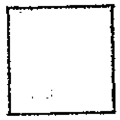
________ 20. 

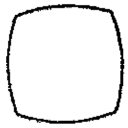
________ 21. 

________ 22. 

________ 23. 

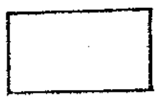
Write the correct name of each shape of watch crystal shown below on the line following the number:

 24. ________________

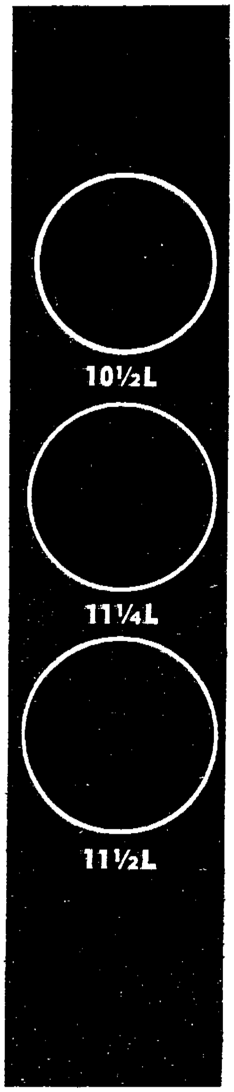
 25. ________________

 26. ________________

 27. ________________

 28. ________________

Master WATCHMAKING



LESSON 4

NOMENCLATURE AND SIZES OF WATCHES

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

INTRODUCTORY INFORMATION

The terms "Nomenclature and Correlation" simply mean the names of parts, their relationship and their function in a watch movement. It is important that you know the names of each part so that you can follow the explanation in the texts and later be able to order new parts. You will note, after studying Sections 120 through 123, that all manufacturers do not use the same name for each part. As you progress in this course you will better understand these differences.

KEY POINTS OF LESSON ASSIGNMENTS 12, 13, 14:

- The different models of watches.
- The difference between open face and hunting movements.
- The function of each plate.
- The function of the train.
- The difference between teeth and leaves.
- The function of the balance.
- Names for watch parts.
- Watch sizes and how to use a movement gauge to measure them.
- How to convert millimeters to lignes and sizes by use of conversion tables.
- How to identify American and Swiss watches as to model and make.
- Information needed in ordering American and Swiss watch material.

ASSIGNMENT NO. 12: Study Sections 106 through 109.

Study Questions:

1. What are the different models of pocket watch movements?
2. What is the difference between an open face and hunting style movement?

Recommended Practice:

Examine all the watches you have available. Determine the model. Determine the style.

ASSIGNMENT NO. 13: Study Sections 110 through 114.
Study Sections 120 through 124.

1. What is the train?
2. What wheels make up the train?
3. What are teeth?
4. What are leaves?
5. What is the function of the balance in a watch movement?

Check your understanding of Nomenclature:

Complete Progress Check 4C and compare your answers with those on the Answer Sheet for Progress Check 4C.

ASSIGNMENT NO. 14: Study Sections 115 through 119.

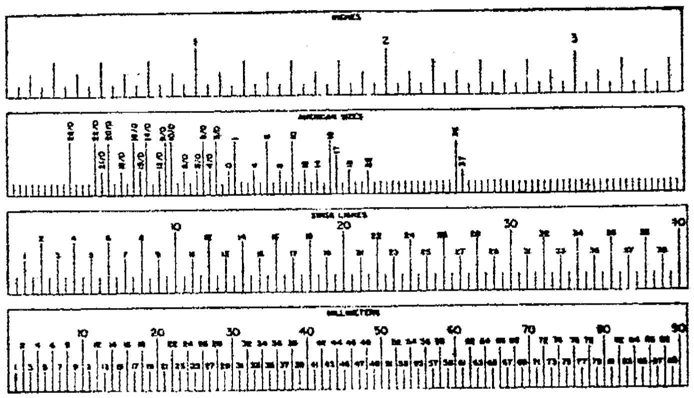
1. How are American watch movements measured?
2. How are Swiss watch movements measured?
3. What are some possible variations in watch movements?
4. How are American movements identified?
5. What are three ways to identify Swiss movements?
6. What information is desirable when ordering parts for American watches?
7. What information is needed to order parts for Swiss watches?

Recommended Practice:

1. Measure all the Swiss and American movements you can to gain familiarity with the sizes in common use. If you lack a movement or ligne gauge at this time, you can use the gauges below:

WATCH MOVEMENT GAUGE

Use this gauge for measuring movements, traveling clock cases, etc. Used properly, its very accurate calibrations will give you the exact size.



2. Identify each movement you encounter so you can order material for it if needed.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 4 and send in for grading.

SUMMING UP

In this lesson you have been introduced to the basic parts of watch movements. You should now have a general idea of what they are for and know the name for every part. You have seen that there is a certain confusion of terms because of different systems of manufacture, but this lesson has shown you a simple way to recognize the same part no matter what it is called. You have learned more about watch sizes, how they are measured, and how Swiss and American watches can be identified. You have been introduced to the information you will need when ordering watch material.

Of course, it takes experience to have all of this knowledge at your command. Therefore, apply this information as much and as often as you can. Review these lessons as often as possible. Try to obtain as many different types of watches as you can and learn to tell sizes and identifying characteristics quickly. Simply reading these lessons over a few time will not make you a good watch repairman. You must practice and review them continually.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 4

Sections 106 to 119

NOMENCLATURE AND SIZES OF WATCHES

In former years, about the only place on a watch case where the designer could give vent to his talents was on the ornamentation. It was not unusual to see a man carrying a large heavy gold case with raised gold ornaments, hand engraved, perhaps with one or more diamonds set in it, having a round bow strong enough to carry such a heavy piece of adornment.

The shapes, sizes and parts of bow and crown were conventionalized and all manufacturers followed practically the same model.

Gradually sizes were reduced, movements made thinner, dials made more ornamental, bows and crowns were designed to harmonize with the rest of the case, so that today the modern watch is not only a serviceable time piece but a thing of beauty as well.

The first men's wrist watches followed the same lines as pocket watches, round cases with a lug or attachment to which a strap or bracelet could be fastened. As the popularity of these styles increased, more attention was given to the shape of the case, so that now wrist watches have square, rectangular and oval shapes.

Earlier models of ladies' watches were made in 10 size and were in hunting cases. Today this size is used for thin model pocket watches.

Ladies' watches were reduced first to 6 size, then to 0 and 000 size, and were popular until the arrival of the bracelet watch.

With the advent of the bracelet watch, designers gradually produced more watches made in the oval or rectangular shape.

The most popular shapes found in bracelet watches are round, rectangular, cushion, diamond, oval and octagon.

Watch cases are made of nickel, stainless metal, silver, yellow, green and white gold, rolled gold plate, gold filled and platinum.

Sec. 106 — The Watch Movement

Follow the instructions in the order in which they are given. Close attention will make the various steps easy which will lead to your success as a Master Watch Repairer.

The beginner often tries to force parts together when such action is not needed, with the result that some of the more fragile pieces may be bent or broken. Before attempting to force any part of the watch into its position, be sure that you have the part in the proper location and above all things, "use force sparingly."

In your study and practice, try to obtain movements that can be easily taken apart and reassembled. Do not start on the clock watches — the so-called dollar watches.

For your first attempt, obtain a watch movement of the older style 16 size Elgin, Waltham or Hamilton, similar to figure 60. Any of these sturdy movements can be easily procured in most localities at a low cost. However, any three-quarter plate or bridge model American movement will be satisfactory for the beginner, provided it is a 12 size or larger.

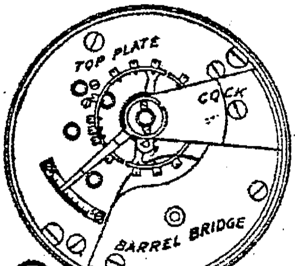
Figure 61 illustrates an 18 size full plate movement.

Figure 62 illustrates a drawing of a 16 size ¾ plate movement.

Figure 63 illustrates a drawing of a 16 size ¾ plate bridge model.

Figure 64 illustrates a 12 size bridge model.

Learn to speak of a watch as a 16 size ¾ plate Elgin or 12 size bridge model, etc.



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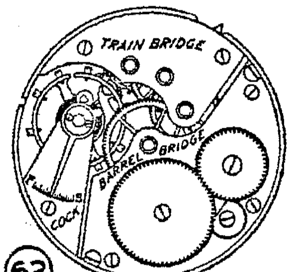

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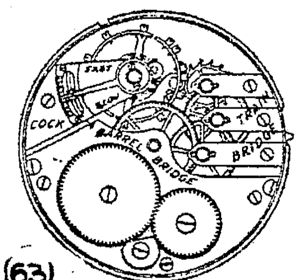

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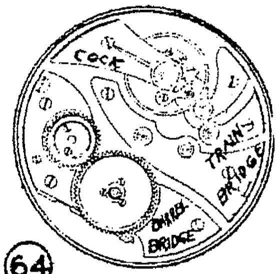

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Sec. 107 — Hunting and Open Face Watches

Most American pocket watches are either Hunting or Open Face. The difference is readily understood if you will remember that an open face model winds at 12 and a hunting face model winds at 3 regardless of the style of the case.

Watches winding at 3 were made originally for hunting cases and watches winding at 12 were made for open face cases. Now there are many watch movements formerly in hunting cases that, for one reason or another, have been transferred to open face cases. In these instances, you may have an open face watch with a hunting movement watch winding at 3 instead of 12. You may find some hunting case watches that wind at 12.

From now on, we will refer to a watch as a 16 size ¾ plate hunting movement or a 12 size open face bridge model, etc.

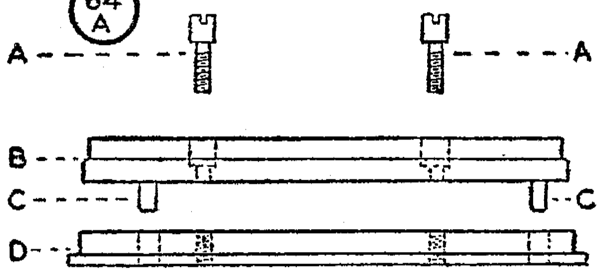
Men's or ladies' Swiss watches are not referred to as hunting or open face movements. This will be explained later in this lesson. Practically all wrist watches wind at 3.

Sec. 108 — The Plates

The plates of a watch are made of a flat piece of metal of uniform thickness. The lower plate sometimes referred to as the pillar plate is used as a base for assembly. The dial and portions of the winding and setting parts are supported by this plate. Upon the lower plate are erected pillar posts to which the top plate is held in place by screws. In some of the very old watches the top plates were held in place by tapered brass pins forced through holes in the pillar posts. These methods of securing plates are generally found in the older watches of which the 18 size American movements are excellent examples.

The plates of most watches are held together by a combination of screws and steady pins which are illustrated in figure 64-A. The lower or pillar plates of watches of like size are similar in shape. Size of the watch is determined by the size of this plate. The plates of watches are made of solid nickel, solid brass, as well as nickel and gold plated.

64 A



A.---------PLATE SCREW.
B.---UPPER PLATE OR BRIDGE.
C.-----------STEADY PIN.
D.---LOWER OR PILLAR PLATE.

Formerly the brass plates finished with a matt surface and a very light plate of gold were most common and were known as gilt plates. After being cleaned and handled a few times, the light gilding would be worn off leaving a dingy looking set of plates.

Silver and nickel plates are the most popular types used today.

Sec. 109 — Top Plate

18 size and old model watches are about the only watches that have a top plate. Top plates have been replaced by bridges. These bridges serve the same purpose but are much easier to assemble.

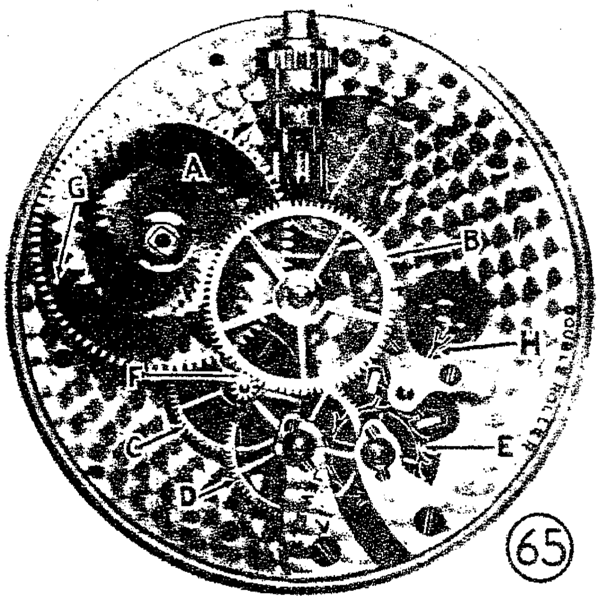
Sec. 110 — What is Meant by The Train?

A series of connected gearings is called a train. Thus in a watch or clock, the series of gears which transmit the power from the mainspring to the escapement is the train.

By the escapement is meant that part or device in a watch or clock which controls the power and distributes it uniformly. In other words, it keeps the train moving at an even speed.

Sec. 111 — Wheels and Pinions

The wheel which receives the power and gears it into a much smaller wheel is called a pinion. This pinion is fastened to another wheel,



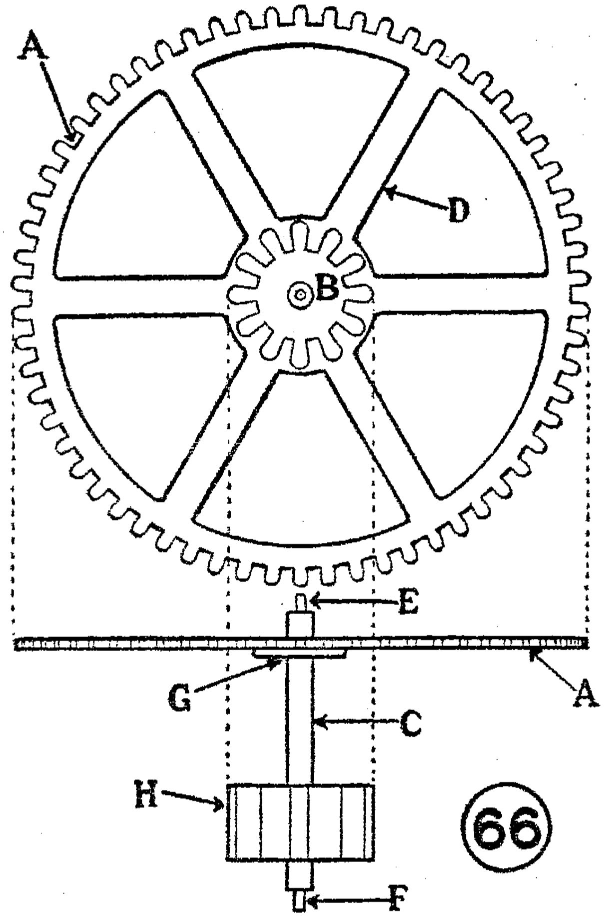
the two having a common center; this second wheel gears into a third pinion on which is also fastened a wheel, and so on to the last pinion and wheel. The wheels are generally made of brass and the pinions of steel. In watches the wheels are usually gold plated but in some cases are made from rolled gold plate.

In figure 65 is shown the train of an Illinois watch movement. The wheels and pinions are lettered beginning with the barrel or first wheel at A. The next is the second wheel or center wheel at B, third wheel at C, fourth wheel at D and escape wheel at E.

Each of the wheels from the center wheel down is carried on a pinion and these pinions are numbered in the same way, 2nd or center pinion, 3rd pinion, 4th pinion and escape pinion. The wheels gear into these pinions and thus transmit the power from the mainspring, which is contained in the barrel or first wheel. In this photograph may be seen the center wheel gearing into the third pinion at F.

Sec. 112 — Teeth and Leaves

Figure 66 is a drawing of a wheel and pinion showing end and side view, in which A represents the wheel and B the pinion. The indenta-



tions on the outer circumference of the wheel are called teeth, while those on the pinion are called leaves.

The six spoke-like parts, at D, are called arms, this being a six arm wheel.

The part C together with the leaves H and the pivots at E and F are all cut from one piece of steel. In the center of the wheel is a hole of such diameter that the pinion, when forced through at G, will be tight enough to keep the wheel from slipping on the pinion when power is applied. Usually the center of the wheel is reinforced with a thicker piece of brass in order to give a greater bearing surface for the pinion as shown at G.

In most American watches, the wheels of the train outside the center are fitted to the pinion in this manner. Where a greater percentage of power is applied a larger shoulder is cut on the pinion, directly on the leaves and this is fitted in the center hole of the wheel, the steel being riveted or staked over the brass of the wheel.

Generally in clocks you will find that wheels are fastened to the pinions in this way.

In the finer grade of Swiss watches, the pinions are nearly always staked on the wheel and are finished with a long undercut. The beautiful finish given these Swiss pinions is something that the watchmaker should strive to equal in his own work.

Sec. 113 — Oscillations of a Pendulum or Balance

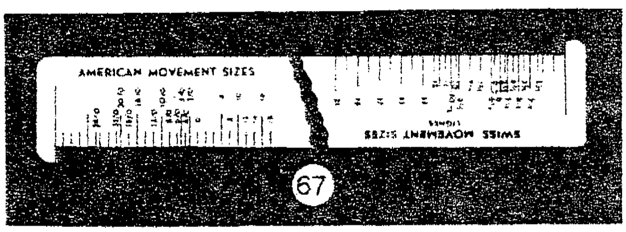
The balance wheel of a watch or the pendulum of a clock oscillates (swings back and forth) in regular periods of time, depending in the one case upon the diameter and weight of the balance together with the length and strength of the hairspring, and in the other, upon the length of the pendulum.

The rate of a timepiece depends upon the regularity of these oscillations which are induced by the impulses given through the escapement, which in turn receives the power by means of the train.

Sec. 114 — Purpose of the Train

The whole purpose of the time train then is to apply the power to keep these oscillations going and to calculate and indicate just how many oscillations occur during a given period.

For instance, the fourth wheel of a watch, with its pinion (carrying the second hand) makes one complete turn in one minute. The train must be so arranged that the center wheel with its pinion (carrying the minute hand)

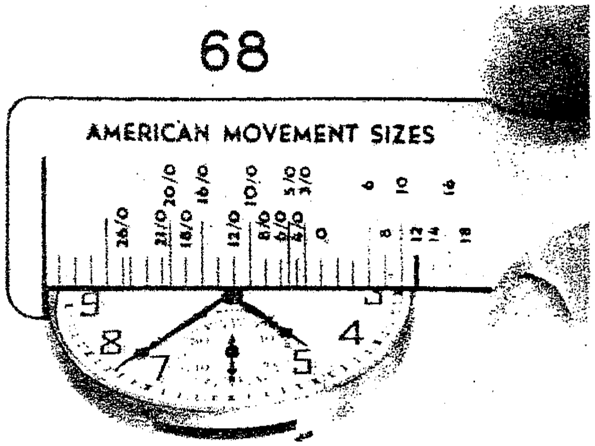


67

makes a complete turn in one hour. Hence, the fourth wheel must make sixty turns to one of the center wheel.

Learn the names of each and every part of these watches. Do not be content to read this over once and take it for granted you can remember the terms. Each time you work on a watch, repeat to yourself the name of the part you are working upon. If you do not know, refer

68



to illustrations. In figure 65, you will notice how many wheels actually exist in the train of the average watch:

A Mainspring Barrel and Arbor
B Center Wheel and Pinion
C Third Wheel and Pinion
D Fourth Wheel and Pinion
E Escape Wheel and Pinion
H Pallet Fork and Arbor

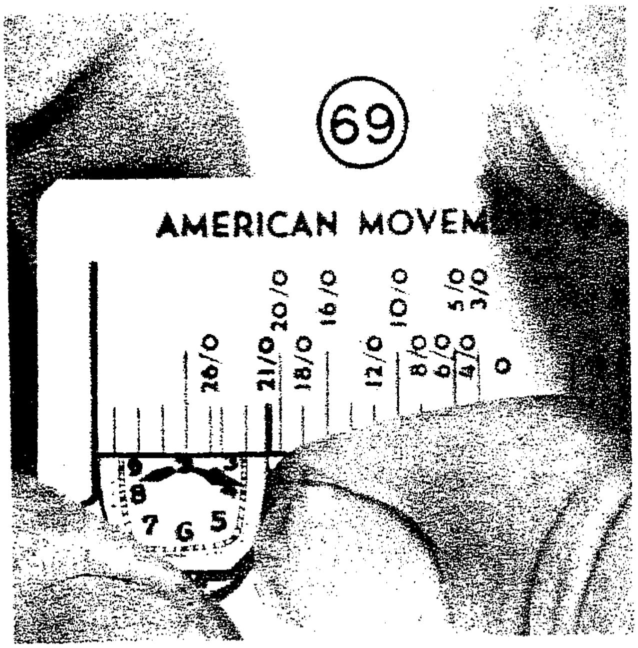
These, plus the balance, comprise the actual parts that make the watch run and probably 80% to 90% of repairs are concerned with these few wheels. Of course, there are more wheels in other types of watches, such as Automatic Wind, Repeaters, Chronographs, and Sweep Second watches, but even in the above-named watches there are basically the same number of wheels that give cause for repair.

Sec. 115 — Sizes of Watches

In watchmaking, you will learn to know and speak of a watch by its name and size, or, as in Swiss watches, by the manufacturer's name and the size. Swiss watches are imported into this country by the millions, under many different names. However, the watch movements are made in relatively few factories. For identification purposes in the Swiss watches, the Newall Fingerprint system of Swiss watches is explained. There are other systems but they are similar. Some watch material supply houses furnish gauges similar to figure 67.

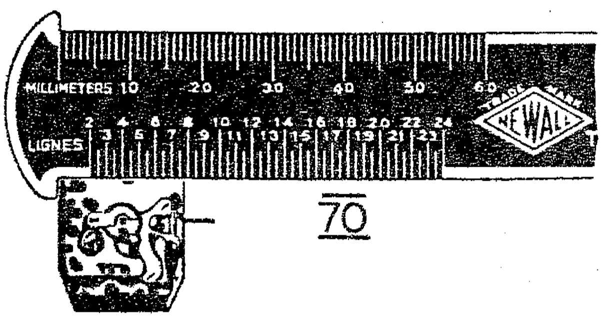
American watches are measured in sizes such as 18 size, 16 size, 3/0 size and 21/0 size. See Sec. 117. Using the gauge illustrated in figure 67, measure across the pillar plate in round watches at their widest point.

Figure 68 illustrates the correct method of measuring a 12 size movement. To measure the size of an American movement that is any other



shape than round, measure across the shorter distance as in figure 69, which, in this case, is a 21/0 size (pronounced twenty-one-oh-size).

Swiss watches are not measured in sizes, but in lignes. Figure 70 illustrates how to correctly measure a 7¾ ligne (pronounced seven and three-quarter line) Swiss watch with a ligne



70

gauge. In some Swiss watches you will find that the dial extends over the pillar plate so it will be necessary to remove the dial, in order to accurately determine the correct size.

The charts illustrated in Secs. 116 and 117 are a comprehensive list of the different sizes of watches, both American and Swiss. The measurements obtained with your millimeter gauge are compared with the list of watch sizes. Example: If the pillar plate measures 45.7 mm, you will see that an 18 size watch measures 45.7 mm. Therefore, figure 71 is 18 size. Remember this: the first factor to be determined is whether or not the watch is an American or a Swiss watch. For example, a 10/0 American watch measures 22 mm; a 9¾ ligne Swiss watch measures 21.99, practically the same size. However, you would not say it was a 10/0 size unless it was an American made watch.

Below are listed a great many different sizes. This is for your reference, and as you progress with the work it will be interesting to note that only a few Swiss sizes are used in our every day work such as 5½ ligne, 6½ ligne, 8¾ ligne, 9¾ ligne, 10½ ligne, etc. With continued practice you should be able to identify the size of watches without referring to the chart.

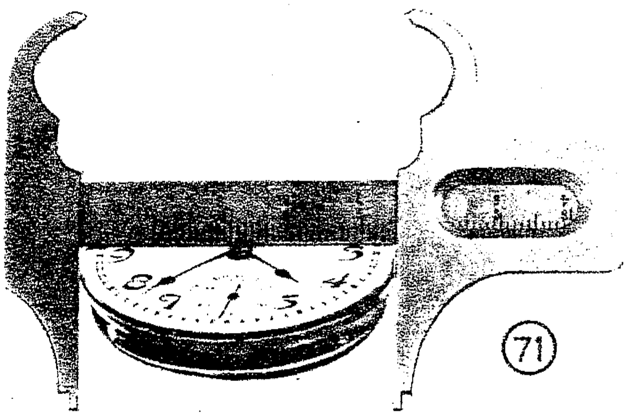
Sec. 116 — Sizes of Swiss Watches

LIGNES	MM	LIGNES	MM
3	6.77	11¾	26.51
3¼	7.38	12	27.07
3½	7.87	12¼	27.63
3¾	8.42	12½	28.20
4	9.03	12¾	28.79
4¼	9.59	13	29.33
4½	10.15	13¼	29.89
4¾	10.72	13½	30.45
5	11.28	13¾	31.02
5¼	11.84	14	31.58
5½	12.40	14¼	32.15
5¾	12.97	14½	32.71
6	13.53	14¾	33.27
6¼	14.10	15	33.84
6½	14.66	15¼	34.40
6¾	15.23	15½	34.98
7	15.79	15¾	35.53
7¼	16.35	16	36.09
7½	16.92	16¼	36.66
7¾	17.48	16½	37.22
8	18.05	16¾	37.78
8¼	18.61	17	38.35
8½	19.17	17¼	38.91
8¾	19.74	17½	39.48
9	20.30	17¾	40.04
9¼	20.87	18	40.60
9½	21.43	18¼	41.17
9¾	21.99	18½	41.73
10	22.56	18¾	42.30
10¼	23.14	19	42.86
10½	23.69	19¼	43.42
10¾	24.45	19½	43.99
11	24.81	19¾	44.55
11¼	25.38	20	45.12
11½	25.94		

Sec. 117 — Sizes of American Watches

One Ligne = 2.258 MM.
One Inch = 25.4 MM.

SIZE	MM	SIZE	MM
18	45.7	6/0	25.4
16	43.1	8/0	23.7
14	41.5	10/0	22.0
12	39.8	12/0	20.31
10	38.1	14/0	18.6
8	36.4	15/0	17.8
6	34.7	16/0	16.9
4	33.0	18/0	15.2
0	29.6	20/0	13.5
3/0	27.9	21/0	12.7
4/0	27.09	22/0	11.8
5/0	26.2	26/0	8.5



71

Sec. 118 — Important Factors for Identifying American and Swiss Movements

A Swiss watch is one which is made in Switzerland. A Swiss watch may also consist of a movement made in Switzerland and contained in a watch case made in the U. S. A. An American watch is one which is made and cased in the U. S. A. The most common are Elgin, Waltham, and Hamilton. But the watchmaker may still find many other watches produced by manufacturers who are no longer in business. Among these are Illinois, South Bend, Rockford, Burlington, Studebaker (made by South Bend). In fact, there are thousands of watches, both American and Swiss—some many years old —which are still in use. This fact, together with the many new models turned out now, makes the problem of identification seem complex when parts are needed. However, there are only a few ways to identify movements whether they are American or Swiss.

Movements are either round or shaped. Shaped movements are any shape other than round. This applies to both American and Swiss movements.

Another designation of movements is by their distinguishing features. Some possible variations are listed below:

Regular Lever Movement. This has a detached lever escapement. The jeweled lever movement is the most common type of watch which the watchmaker is called upon to repair. Therefore, this course is based on this type of movement.

Bascule Setting. (Employs a Rocker Arm instead of a Clutch.)

Pin Lever (or Pin Pallet). The pallets are in the form of pins instead of pallet stones. Found in mass-produced, inexpensive American and Swiss watches.

Chronographs. A movement equipped with a center second hand which can be started, stopped, and returned to zero. It differs from a timer because it also carries the normal hour and minute hands, indicating the time of day. (Principally Swiss.)

Self-Winding Watch (or Automatic Wind Watch). This is a watch with a device whereby the movements of the wearer keep the mainspring wound.

Roskopf. A type of movement without the conventional center wheel. The cannon pinion fits *loosely* on a center arbor, and is driven by the minute wheel, which is fastened friction-tight to the mainspring barrel cap. Roskopf watches generally have pin lever escapements, which are sometimes erroneously termed Roskopf escapements. Actually, very few pin lever watches are Roskopf watches.

Cylinder. Refers to the type of escapement.

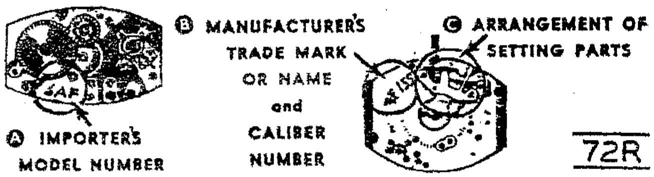
Both Cylinder and Roskopf are considered unreliable and the watchmaker usually will find it not profitable to repair them.

AMERICAN movements are identified principally by:

The manufacturer's name
Size
Movement and/or model number or name
Number of jewels

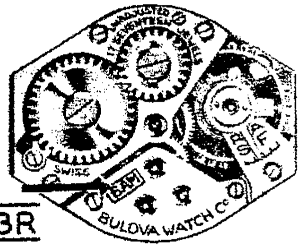
and in the case of pocket watches, whether
Hunting (winds at 3), or
Open face (winds at 12).

There are three common ways to identify SWISS movements:

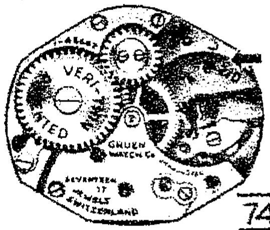


72R

A. Large *importers*—among them Bulova, Benrus and Helbros—have their name and model designations stamped on the upper plates or bridges, figure 73R. The name of the importer plus the model designation is positive identification of the movement regardless of the name appearing on the dial.



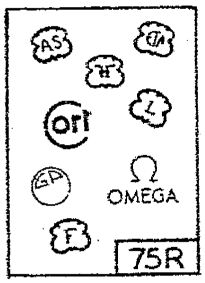
73R



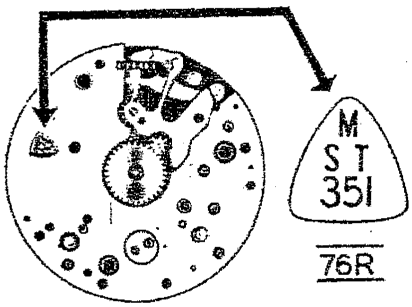
74R

B. The second method is the name or trade mark of the *manufacturer* plus the caliber or reference number. Names of manufacturers are usually found stamped on the upper bridges of plates. Caliber or reference numbers in these instances are under the balance wheel on the lower plate (figure 74R), or between the barrel and train bridges on the lower plate. In some cases it is necessary to remove the balance cock and balance to see the caliber or reference number. This type of model identification is common with Gruen movements.

An alternate identification is by factory trade mark. There are many of these trade marks. A few are shown in figure 75R. This trade mark is stamped on the dial side of the lower plate, figure 76R, and is also positive identification and should be used when method A does not apply.



75R



76R

NOTE: There are a few exceptions to the above. Some factories, such as ETA, stamp their insignia or trade marks on the dial side of the lower plate, but stamp their caliber or reference number on the lower plate under the balance wheel.

C. The method of identifying movements by their setting parts is rapidly falling into discard, because identification is not always positive. However, if the methods shown in A and B above cannot be applied, then the illustrations of setting parts found in most material catalogs can be used. Not all material dealers use the same methods of identification. However, because the basic principle is the same, only one of many systems is explained here.

The Newall "Finger Print System":

Models are listed under Newall series numbers and will be found in two sections. Fancy shape movements are located in the first section; round shape movements in the second. Movements within each section are arranged by size. Each section begins with the smallest movement and proceeds to the larger sizes.

To locate the proper Newall series number for a movement, first identify its shape. Next, remove the dial and measure across the pillar plate with a movement gauge or millimeter gauge (figure 70) to get the correct size. Now turn to the proper section, whether fancy or round and locate the size in the section. Compare the setting parts of the movement with the illustrations and the proper Newall series number will be established.

Buren

77R

The number shown in figure 77R shows the serial number to be 1101. This number would be given when ordering parts from *any* material dealer. However, the series number should be preceded by the caption *Newall*. Thus, Newall Series Number 1101.

In the Newall catalog, a number of the illustrations of setting parts incorporate the symbol DISC. This symbol denotes manufacture of movements and material for this particular model has been discontinued by the factory. However, it does not mean material is no longer available, for in some instances stocks of materials are in the possession of the manufacturer, the importer or the distributor.

The mechanics of most material catalogs are the same and are clearly explained at the beginning. No matter what system you use, proper identification is most important, both to you, who want to obtain the correct material, and the dealer, who wants to get it to you as quickly as possible.

Sec. 119 — How to Order Material for American and Swiss Watches

The material dealer from whom you order parts cannot possibly have every part for every watch which has ever been made. However, in many cases, he is able to obtain material for obsolete and old movements. At times parts may be ordered from Switzerland. The important point is that ordering parts by just giving the name of the movement or by individual names found on the dial is not enough and is not always reliable.

Give the material dealer as much information as possible. Most dealers now prefer complete information in order to eliminate the matching of samples, which may or may not be correct. Sending samples of material has been an accepted practice for many years, but with the ever increasing reliability of the material catalogs, this practice is also being discarded. Nonetheless, the burden of identification and correct name of the desired parts is still the watchmaker's responsibility and anything which contributes to that end should be considered. The more exact information you give, the less chance there is for error and delay on the part of the dealer.

After correct identification, the next important step is to give the CORRECT NAME of the *part* desired. Next, the *quantity.* If only one is wanted, write *1 only.* If three are wanted, write *3* or ¼ *dozen,* and so on.

Here are some samples of parts orders for American watches:

Hamilton, 16s, 21 jewel, Htg. (Hunting), ¾ plate. Movement No. 1,051,201. Grade 993.
1 only balance staff (double or single roller).
Pivot ______ (State pivot diameter required).
1 only balance jewel in setting (State *cock* or *foot*).
Hole ______ (Give diameter of hole wanted.)

Elgin, 8/0, 17 jewel, Movement No. V805,299, Grade 555.
1 only mainspring, double brace ______ (width), ______ (strength), ______ (length).
¼ doz. stems.

Waltham, 6½ ligne, 15 jewel, Oval Movement No. 26,469,011, Model 650.
1 only balance complete (State whether flat hairspring or Breguet hairspring). ¼ doz. dial screws.

When ordering material for Swiss watches, you need to give the material dealer:

Either the Importer's name and model designation, *or*, the Manufacturer's name or trade mark with the caliber number or reference number.
Size of movement.
Number of jewels.
THE CORRECT NAME OF THE PART.

IMPORTANT: It is often necessary to give additional information because of variations in manufacture. Therefore, when ordering:

Parts, such as:	*Be sure to specify:*	*Abbreviated thus:*
Escape wheels and pinions	Both pivots conical	c/c
	Both pivots straight	s/s
	Lower pivot conical	s/c
	Lower pivot straight	c/s
Cannon pinions	Give height in millimeters	
Hour wheels	Give height in millimeters	
Balance staffs	Give collet and roller measurements in millimeters, especially with Gruen. Also, whether shockproof, Incabloc or regular.	
Balance complete	Shockproof, Incabloc or regular.	
Hairspring	Breguet or flat.	
Regulators	State if shockproof, Incabloc or regular model and whether hairspring is a flat or Breguet (Overcoil).	
Minute wheels	Long pinion for curved models. Short pinion for flat models.	
Pallet arbors	Thread or friction fit.	

Here are some samples of parts orders for Swiss watches:

BULOVA 6AP

1 only mainspring ______ (width), ______ (strength), ______ (length).
¼ doz. stems.

FF60

¼ doz. balance staffs
1 pair gilt hands (give length in millimeters).

GRUEN 430

1 balance complete (Specify whether Breguet or flat hairspring).

Newall Series Number 1101

1 escape wheel and pinion s/s
1 mainspring barrel
1 barrel arbor

IF THE INFORMATION YOU HAVE IS INCOMPLETE, SEND A SAMPLE.

There is generally quite a substantial saving to be had by purchasing frequently used watch material in quantities of ¼ dozen or more at a time. This is an excellent method of building your own master material cabinets. It not only saves money on each piece, but it also helps you give your customer quicker service when you have the material on hand.

Summary Chart 4A — HOW TO ORDER WATCH PARTS

When ordering, give information in this sequence: (See below for explanation of numbers)

SWISS

Quantity	Name of Part and/or Ebauche Part Number	Other Features Information	Movement Identification
No. 1	No. 2	No. 3	No. 4

SWISS

Quantity	Name of Part and/or Ebauche Part Number	Other Features Information	Name of Movement	Ligne Size and Shape
No. 1	No. 2	No. 3	No. 5-A	No. 5-B

Include sample part. See No. 5-C.

AMERICAN

Quantity	Name of Part	Make of Movement	Size	Number of Jewels	Hunting or Open-Face	Model, Grade and/or Movement Number
No. 1	No. 2	No. 6-A	No. 6-B	No. 6-C	No. 6-D	No. 6-E

Include sample part. See No. 6-F.

No. 1. Print the quantity desired. (1 only) (¼ doz.) (1 pair)

No. 2. Print the name of the part. (Give Swiss Ebauche dictionary part number if known.)

No. 3. Print any other information or features that may apply to the part you need. When ordering:

Parts, such as:	Be sure to specify:
Pallet arbors	Thread or friction fit.
Balance complete	For flat or breguet hairspring. "Type" of Shockproof.
Balance staff (Swiss)	Collet and roller shoulders measurements in millimeters, especially Gruen. "Type" of Shockproof.
Balance staff (American)	Pivot size. Send sample with roller(s).
Cannon pinion	Give height in millimeters. Regular or sweep second.
Crowns	Color (Yellow - Pink - White). Long or short post (for pocket watch cases, send sample of crown or the case).
Hands	Color (Blue - Gilt - Radium). Length in millimeters.
Jewels (Swiss)	"Type" of Shockproof.
Jewels (American)	Cock or foot and hole size.
Jewels (Friction)	Diameter and hole size in millimeters.
Mainsprings	Width - strength - length.
Regulator	For flat or breguet hairspring. "Type" of Shockproof.
Roller	Regular or Shockproof.
Stems	Regular or snap style. If snap style, state whether male or female and send sample if possible.
Train wheels, escape wheel and pallet arbor.	Both pivots straight. Abbreviated: S/S Lower pivot straight. C/S Lower pivot conical. S/C Both pivots conical. C/C

Also for:

Third wheel	Regular or sweep second.
Fourth wheel	Regular or sweep second.
Center wheel	Regular or sweep second.
Hour wheel	Regular or sweep second. Height in millimeters.
Sweep second pinion	Length.
Sweep second wheel and pinion	Length.

No. 4.

Identify the movement. Use this order for Swiss.

A. Use Importer's name and caliber number which is usually found stamped on the upper bridge plate.

B. Manufacturer's name and caliber number which is usually found stamped on the upper bridge plate. However, if not there, the caliber number or model may be found on the lower plate under the balance wheel. Note: Letters stamped on the top of the balance bridge do not identify the movement.

C. Manufacturer's trade mark or symbol and the caliber which may be found:

1st. Both on the dial side of the lower plate.

2nd. Both on the upper side of the lower plate near the escape wheel.

3rd. Both on the upper side of the lower plate near the balance wheel.

No. 5.

If you cannot identify the movement by any of the above methods the movement may be obsolete. In this case:

A. List the name of the movement.

B. List the ligne size and the shape.

C. Include the setting bridge and sample of the part. Enclose all parts or samples in metal container when sending by mail.

No. 6.

Use the following order for American watches.

A. Give maker's name.

B. List size of movement.

C. List number of jewels.

D. State whether hunting or open-face.

E. Give model number, grade, and/or movement number.

F. Include sample part. Pack in metal container.

CHECK YOURSELF

Progress Check 4A — A Self Test Review of Lesson 4

After you have studied Sections 106 through 113, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The trend in watch design has been toward ____________ movements and case shapes other than round.	Par. 3, Les. 4
2. A rule to remember in fitting watch parts is to " ____________ ____________".	106
3. A Hunting movement winds at ________ while an Open Face winds at ________.	107
4. The lower plate of a watch is more correctly called a ____________ plate.	108
5. Top plates have been largely replaced by ____________.	109
6. The series of gears which transmits power from the mainspring to the escapement is called the ____________.	110
7. The part which receives the power and passes it to a smaller wheel is called a ____________.	111
o. Wheels are generally made of ____________ and pinions of ____________.	111
9. The indentations on the outer edge of a wheel are called ____________ while those on a pinion are called ____________.	112
10. The regular swing of the ____________ sets the rate of the watch.	113

ANSWERS TO PROGRESS CHECK 4A:

1. smaller and thinner
2. "Use force sparingly"
3. 3
   12
4. pillar
5. bridges
6. train
7. pinion
8. brass
   steel
9. teeth
   leaves
10. balance wheel

CHECK YOURSELF

Progress Check 4B — A Self Test Review of Lesson 4

After you have studied Sections 114 through 119, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The ratio of the fourth wheel to the center wheel is ________ to ______.	114
2. The five wheels which make up the train are: ________________ ________________ ________________ ________________ ________________	114
3. American watches are measured in ________________ while Swiss watches are measured in ________________.	115
4. The size of a watch is determined by the dimensions of the ________________________.	108 & 115
5. A Swiss watch measuring 12.40 mm is a ________________ ligne.	116
6. An American watch which measures 39.8 mm is a ____________ size.	117
7. Movements are either ________________ or ________________ so far as appearance goes.	118
8. American movements are identified by ________________________, size, movement and/or model number or name, and number of ________________.	118
9. Three common ways to identify Swiss watches are: a. ________________ model number. b. ________________ trade mark or name and caliber number. c. Arrangement of ________________________.	118
10. In ordering material, it is most important to ________________ the movement and give the ________________________ of the part.	119

ANSWERS TO PROGRESS CHECK 4B:

1. 60 to 1
2. Barrel or First Wheel
   Center or Second Wheel
   Third Wheel
   Fourth Wheel
   Escape or Fifth Wheel
3. sizes
   lignes
4. pillar plate
5. 5-1/2
6. 12
7. round
   shaped
8. manufacturer's name
   jewels
9. Importer's
   Manufacturer's
   setting parts
10. identify
    correct name

Sec. 120 — NOMENCLATURE

(The terms used in any Art or Science)

Sec. 121, 122 and 123 consist of three pages. Sec. 121 pertains to the generally accepted nomenclature of Swiss watch parts. This section also illustrates the correlation of the parts. Sec. 122 refers to the nomenclature of a 16 size Elgin movement; Sec. 123 of an 18/0 Grade 989 Hamilton movement. The principal parts with the correct terms or names opposite the illustrations (Sec. 121) are numbered from 1 to 50, and lettered A, B, C, etc., in the correlation illustration (Sec. 121). Compare these as follows:

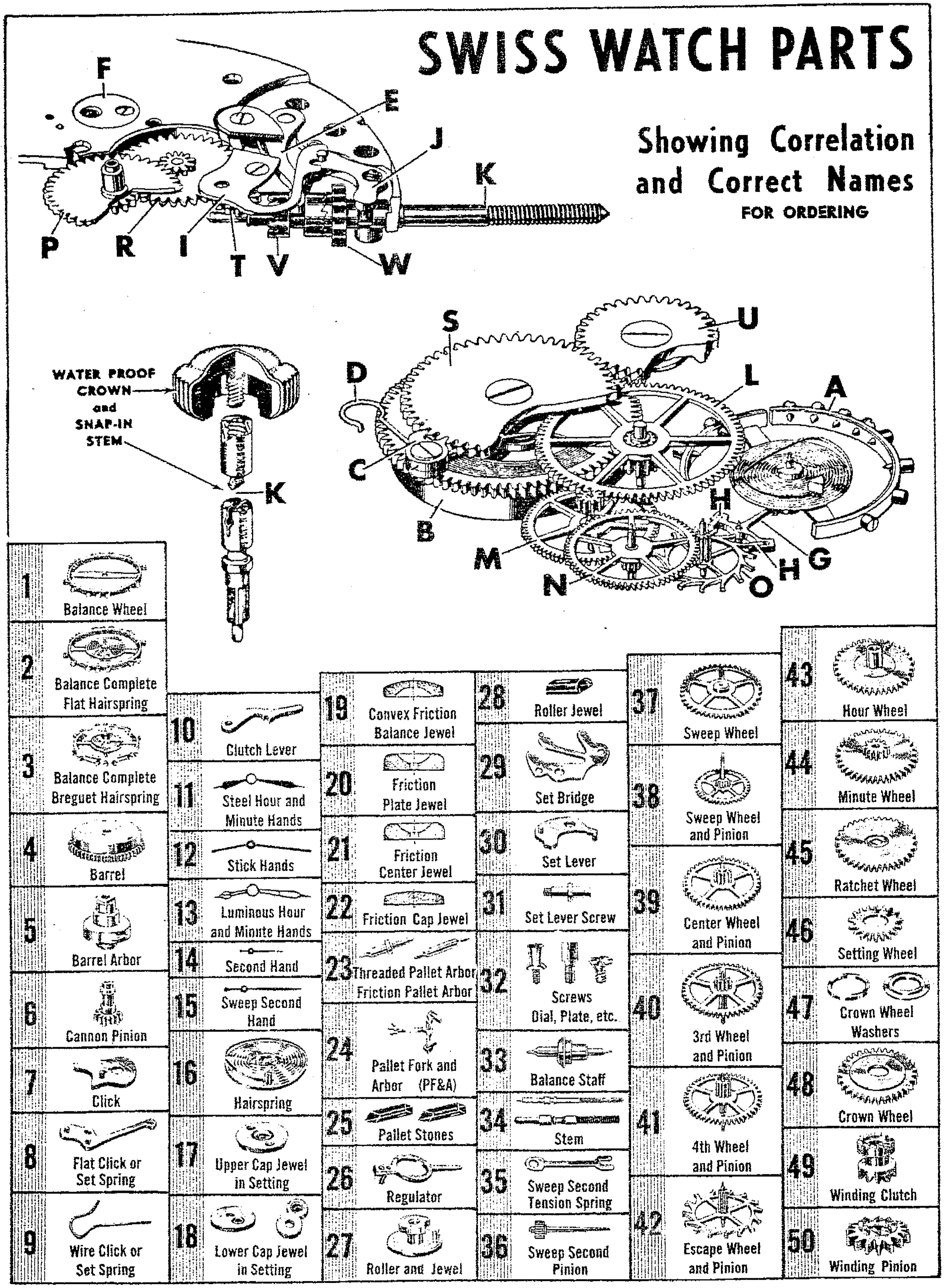
Letter - - - - -	compares with - - - - Name of Parts	**Number**
A	Balance complete with Breguet Hairspring	3
B	Barrel with Mainspring	4
C	Click	7
D	Click Spring	9
E	Clutch Lever	10
F	Lower Cap Jewel in Setting	18
G	Pallet Fork and Arbor (PF&A)	24
H	Pallet Stone Set in PF&A	25
I	Set Bridge (although illustration is not same style as)	29
J	Set Lever	30
K	Stem (2 Styles shown)	34
L	Center Wheel and Pinion	39
M	3rd Wheel and Pinion	40
N	4th Wheel and Pinion	41
O	Escape Wheel and Pinion	42
P	Hour Wheel	43
R	Minute Wheel	44
S	Ratchet Wheel	45
T	Setting Wheel (Visible under Set Bridge I	46
U	Crown Wheel	48
V	Winding Clutch	49
W	Winding Pinion	50

Now compare the letters (A, B, C, etc., Sec. 121) with corresponding numbered parts (1, 2, 3, etc.) and try to find these parts in Sec. 122 and 123. For example:

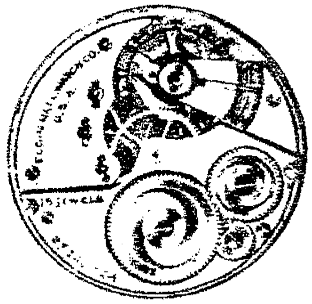
Letter A, Sec. 121 Number 3, Sec. 121 Number 104, Sec. 122 Number 217, Sec. 123	Are all Illustrations of a Complete Balance

Use this method to familiarize yourself with the names and parts shown. The ease with which you will be able to name the different watch parts and order material will soon be apparent to you, as well as others with more experience.

Sec. 121 — Nomenclature and Correlation: Swiss Watch Parts

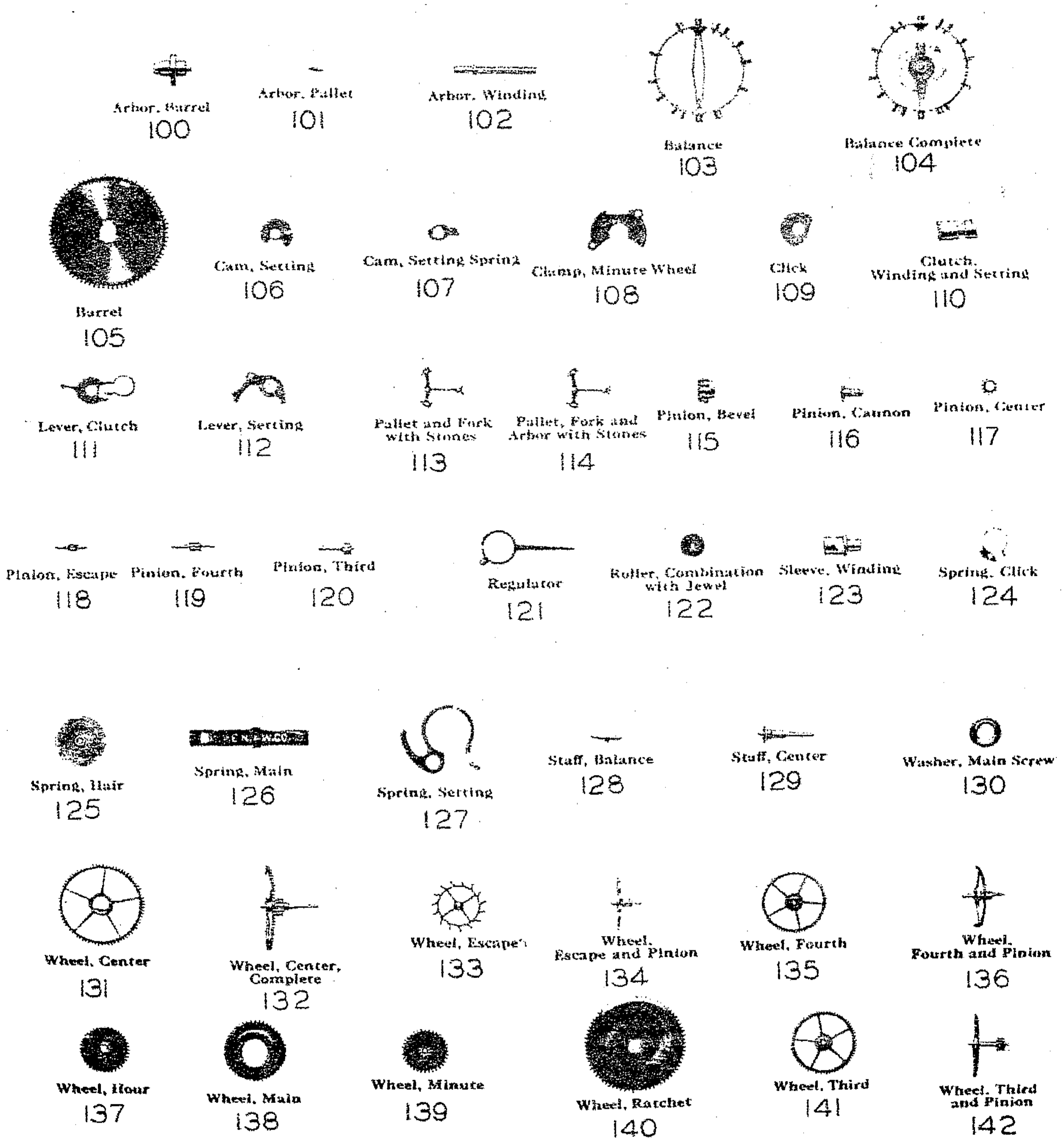


Sec. 122 — Nomenclature: Elgin Watch Parts

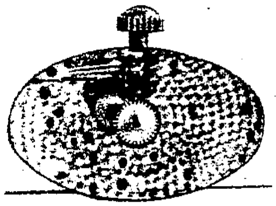


The illustrations in this section show in a general way the shapes and kinds of material used in practically all Elgin Watches.

The movement shown is a 16 size Pendant setting watch, and the named parts below are the principal ones in the watch. This type of watch was also made lever setting and some of them had steel barrels.

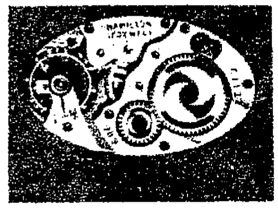


Sec. 123 — Nomenclature: Hamilton Watch Parts

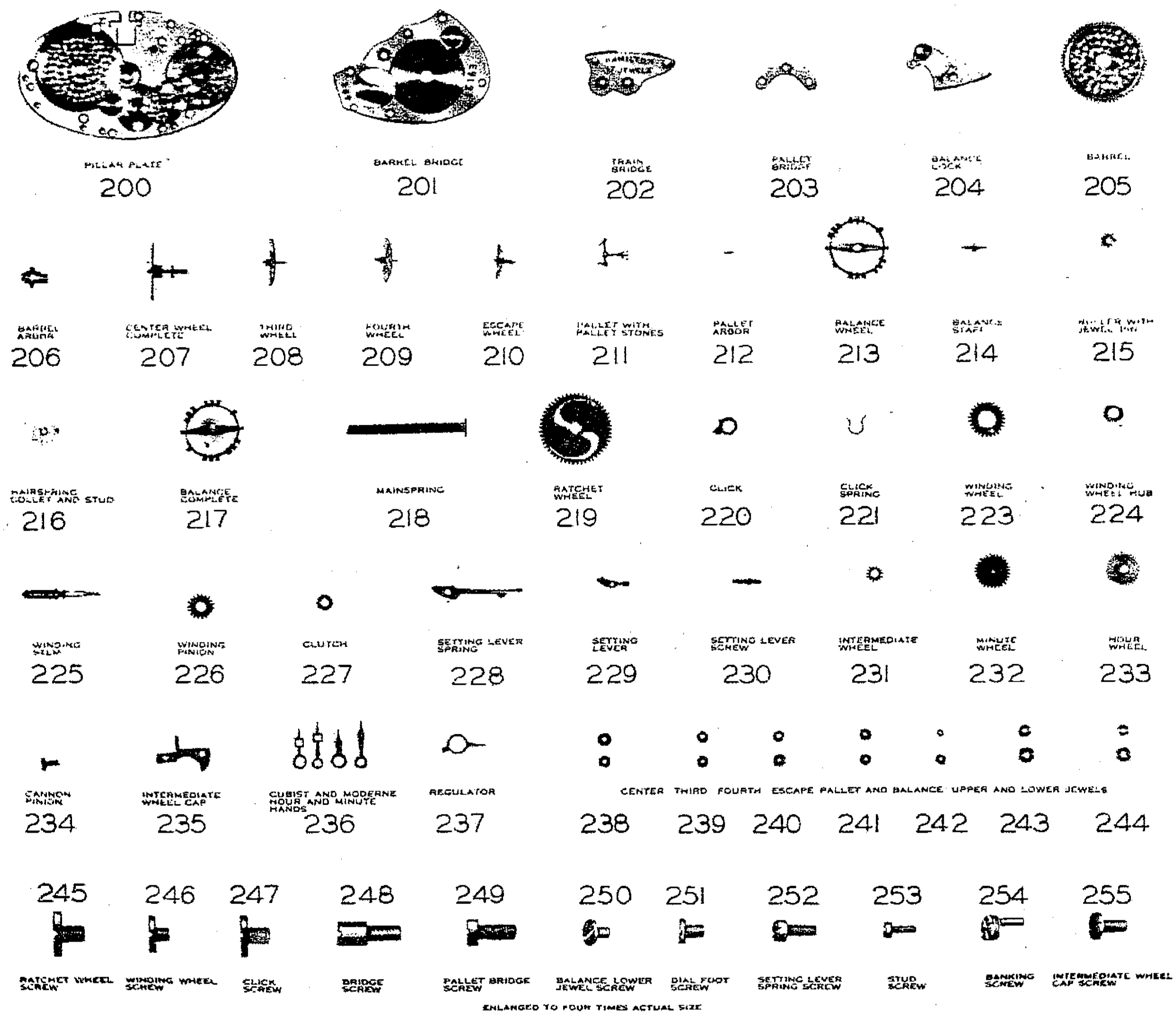


Dial Side of Movement

A Factory Nomenclature of Individual Parts or sub-assembled parts of the Hamilton 18/0 Grade 989 Movement is shown below:



Train Side of Movement



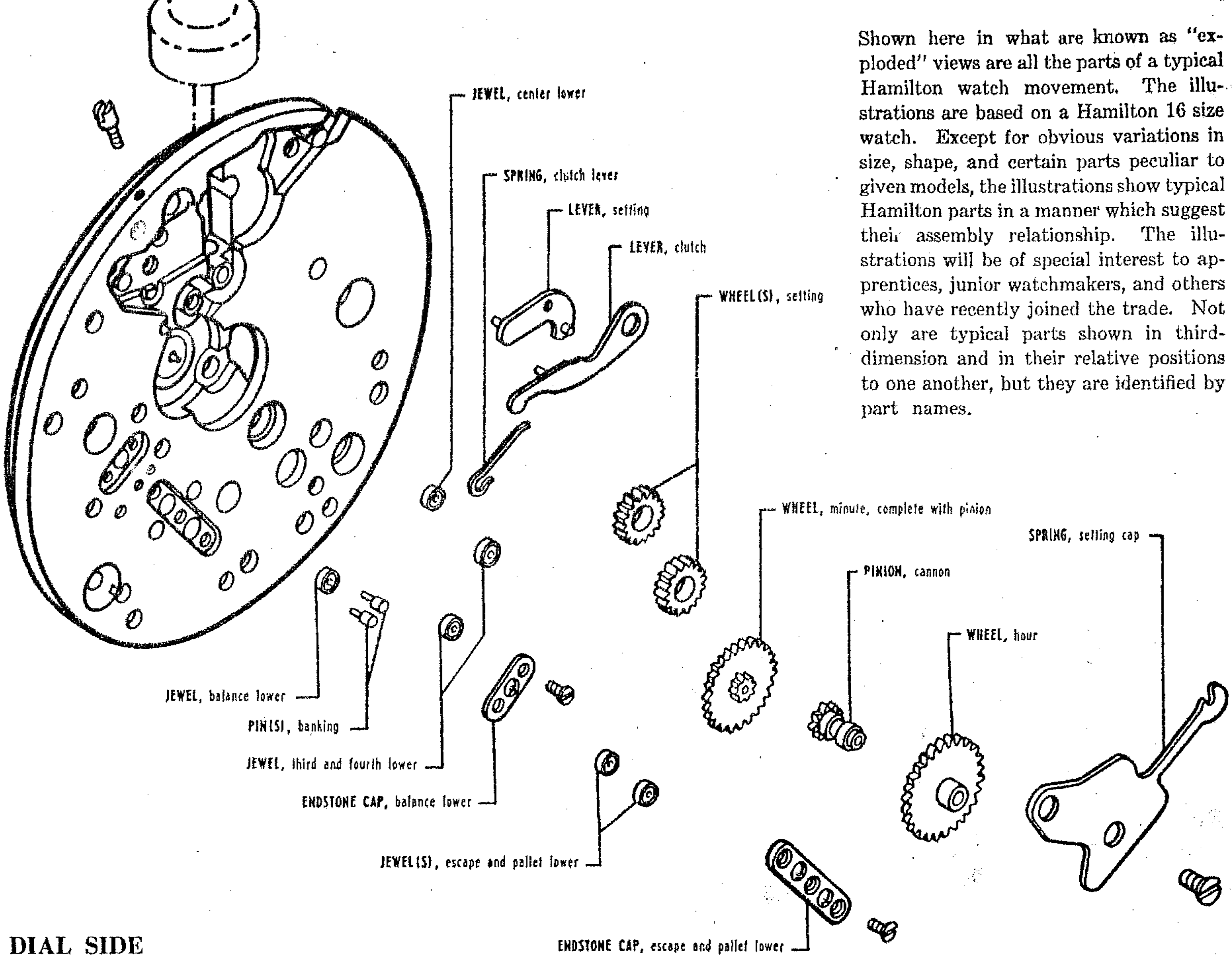
" The better part of every man's education is that which he gives himself."

-- James Russell Lowell

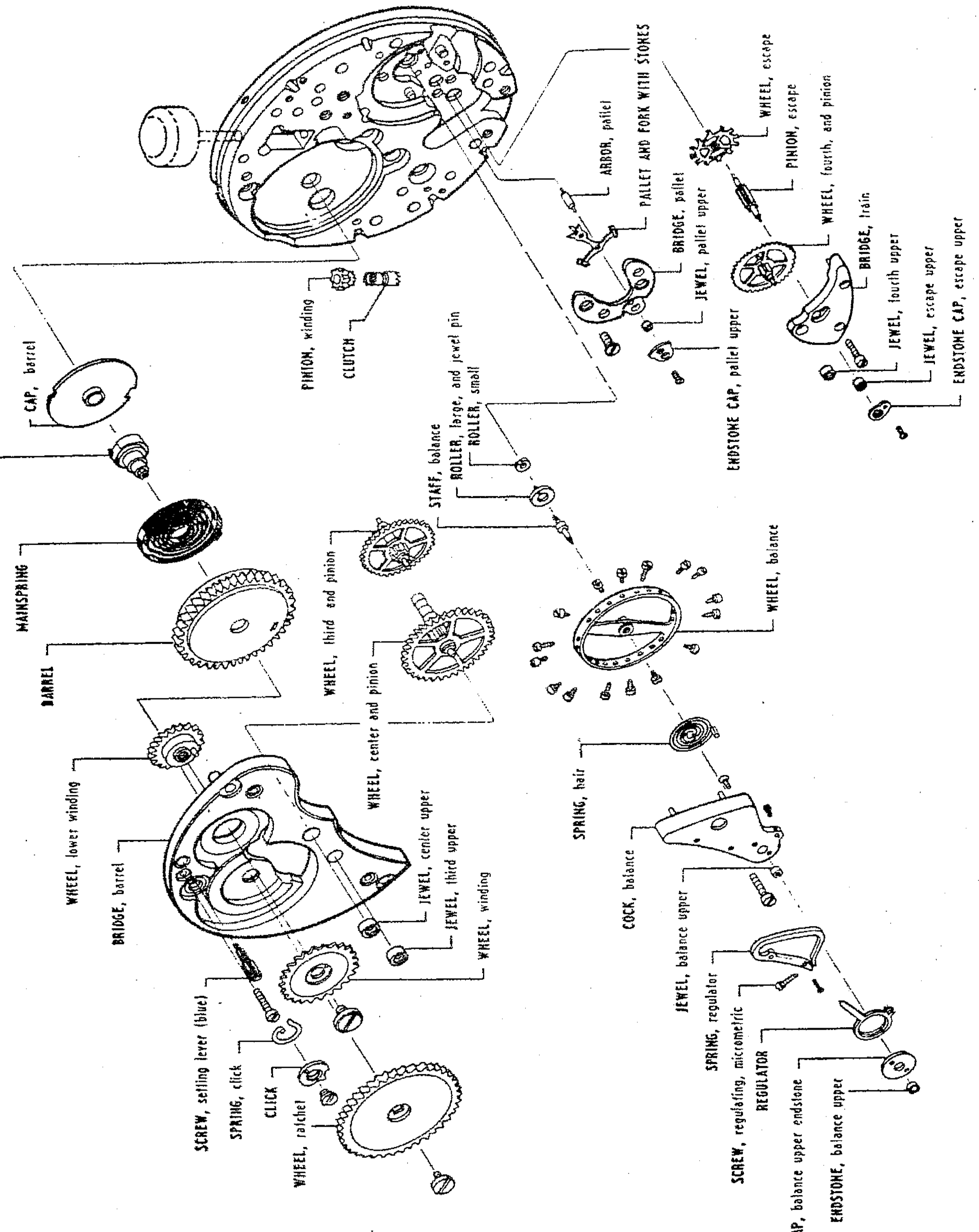
EXPLODED VIEWS OF A TYPICAL HAMILTON WATCH MOVEMENT

TYPICAL PARTS OF A HAMILTON MOVEMENT

Shown here in what are known as "exploded" views are all the parts of a typical Hamilton watch movement. The illustrations are based on a Hamilton 16 size watch. Except for obvious variations in size, shape, and certain parts peculiar to given models, the illustrations show typical Hamilton parts in a manner which suggest their assembly relationship. The illustrations will be of special interest to apprentices, junior watchmakers, and others who have recently joined the trade. Not only are typical parts shown in third-dimension and in their relative positions to one another, but they are identified by part names.



DIAL SIDE


ARBOR, pallet
PALLET AND FORK WITH STONES
WHEEL, escape
PINION, escape
WHEEL, fourth, and pinion
BRIDGE, pallet
JEWEL, pallet upper
BRIDGE, train
JEWEL, fourth upper
JEWEL, escape upper
ENDSTONE CAP, escape upper
ENDSTONE CAP, pallet upper
PINION, winding
CLUTCH
CAP, barrel
ARBOR, barrel
MAINSPRING
BARREL
STAFF, balance
ROLLER, large, and jewel pin
ROLLER, small
WHEEL, third and pinion
WHEEL, center and pinion
WHEEL, balance
SPRING, hair
COCK, balance
JEWEL, balance upper
SPRING, regulator
SCREW, regulating, micrometric
REGULATOR
CAP, balance upper endstone
ENDSTONE, balance upper
WHEEL, lower winding
BRIDGE, barrel
JEWEL, center upper
JEWEL, third upper
JEWEL, winding
SCREW, setting lever (blue)
SPRING, click
CLICK
WHEEL, ratchet

TRAIN SIDE

CHECK YOURSELF

Progress Check 4C

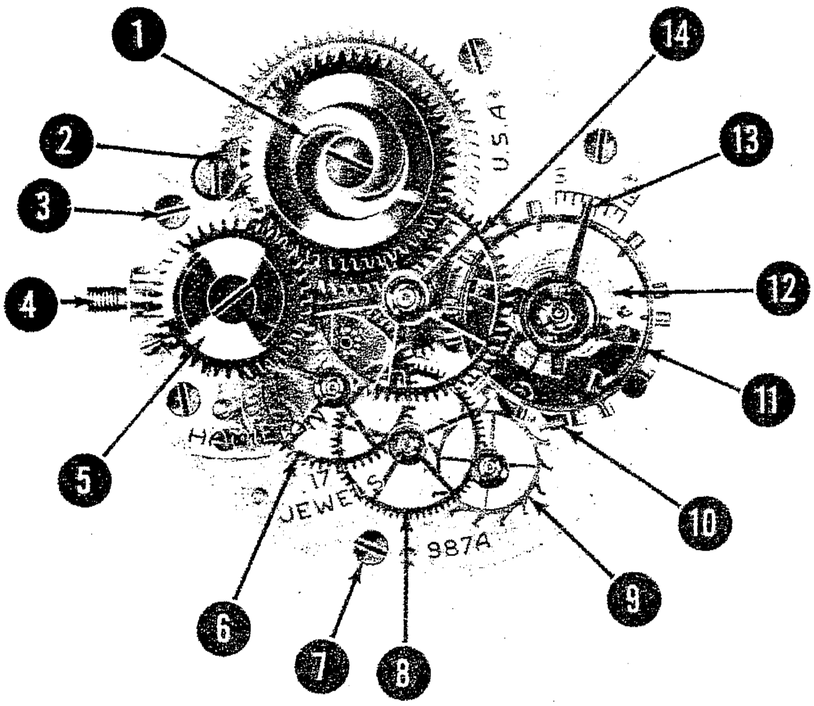
A Self Test Review of Lesson 4

This test is to help you to see if you understand the comparison of similar parts in Swiss and American watches which you studied in Sections 120, 121, 122, and 123. You will need to refer back to those sections to successfully complete this test. DO NOT SEND THIS TEST TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson.

DIRECTIONS: In the columns below under each section, you are given either a letter or a number. Look up the part referred to in that section. Then examine the other sections and see if you find a similar part. Write its letter or number in the column for that section on the same line as you started. Also write the name of the part in the last column. Follow the sample on line 1. The letter and numbers you see there all refer to the same part; in this case, a balance complete. Start your work on line 2. Leave a blank space where you do not find a comparable part.

	Letter Sec. 120	Sec. 121	Sec. 122	Sec. 123	Name of part
(Sample) 1	A	3	104	217	Balance complete
2			137		
3		49			
4				232	
5		42			
6	C				
7				209	
8			112		
9	K				
10		24			
11				221	
12	F				
13			142		
14		46			

	Letter Sec. 120	Sec. 121	Sec. 122	Sec. 123	Name of part
15	I				
16		4			
17				226	
18	U				
19			140		
20		25			
21			111		
22				228	
23				207	



Identify above movement by: ______________________________
Name Model No. Number of jewels

Identify the parts numbered in above illustration and list below.

1. ____________________ 8. ____________________
2. ____________________ 9. ____________________
3. ____________________ 10. ____________________
4. ____________________ 11. ____________________
5. ____________________ 12. ____________________
6. ____________________ 13. ____________________
7. ____________________ 14. ____________________

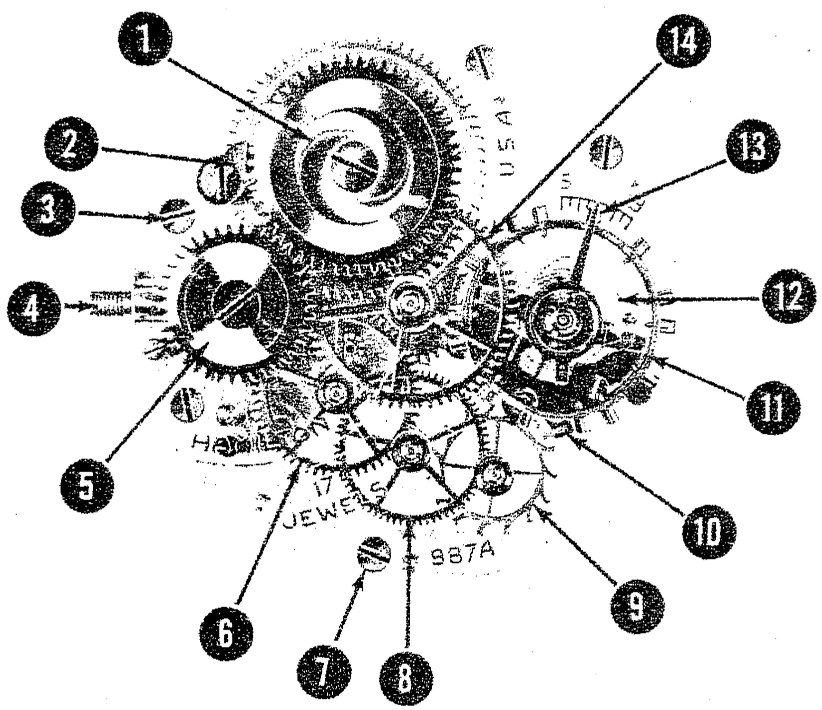
ANSWERS TO
PROGRESS CHECK 4C:

The following symbols are used to call your attention to other pertinent facts:

* Included with other parts.
** No comparable part.
§ Not illustrated.
† Part of case. Not illustrated.
¶ Designated by Elgin as Main Wheel.

	Letter Sec. 120	Sec. 121	Sec. 122	Sec. 123	Name of part
1	A	3	104	217	Balance complete
2	P	43	137	233	Hour wheel
3	V	49	110	227	Winding and setting clutch
4	R	44	139	232	Minute wheel
5	O	42	134	210	Escape wheel and pinion
6	C	7	109	220	Click
7	N	41	136	209	Fourth wheel
8	J	30	112	229	Setting lever
9	K	34	†	225	Stem
10	G	24	114	211-212	Pallet fork and arbor
11	D	9	124	221	Click Spring
12	F	18	§	244	Lower cap jewel in setting
13	M	40	142	208	Third wheel and pinion
14	T	46	**	231	Setting wheel (Intermediate wheel)

	Letter Sec. 120	Sec. 121	Sec. 122	Sec. 123	Name of part
15	I	29	**	**	Set bridge
16	B	4	105	205	Barrel
17	W	50	115	226	Winding pinion (Bevel pinion)
18	U	48	138¶	223¶	Crown wheel (Winding wheel)
19	S	45	140	219	Ratchet wheel
20	H	25	113*	211*	Pallet stones
21	E	10	111	228	Clutch lever
22	**	**	127	228	Setting lever spring
23	L	39	132	207	Center wheel and pinion



Identify above movement by: Hamilton (Name) 987A (Model No.) 17 (Number of jewels)

Identify the parts numbered in above illustration and list below.

1. Ratchet wheel
2. Click
3. Pillar or plate screw
4. Stem
5. Crown wheel
6. 3rd wheel
7. Pillar screw
8. 4th wheel
9. Escape wheel
10. Pallet fork
11. Balance wheel
12. Hairspring
13. Regulator
14. Center wheel

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 4

Name: No.: Date:

SUBJECT: Nomenclature and Sizes of Watches

Directions:

In questions 1 through 20, select the ONE BEST or correct answer by writing the letter of the correct answer (A, B, C, D, E, or F) on the short line in front of the question.

___ 1. You are cautioned to "use force sparingly" in watch work because (A) you may break or bend parts (B) you may have assembled the parts in the wrong order (C) parts may not fit.

___ 2. Hunting movements wind at 3 (A) only in hunting cases (B) only in open face cases (C) in both hunting and open face cases (D) in wrist watch cases.

___ 3. Assembly of the movement begins with the (A) time train (B) barrel bridge (C) pillar plate (D) dial train

___ 4. The advantage of bridges over top plates is (A) easier manufacture (B) easier assembly (C) saving of metal (D) improved appearance.

___ 5. The purpose of the gear arrangement in the time train is to (A) reduce speed and gain power (B) gain speed and reduce power (C) maintain even power.

___ 6. One wheel in the time train which does not engage into a pinion is the (A) center (B) third (C) fourth (D) escape

___ 7. The wheel in the train which makes the greatest number of complete turns each minute is (A) center (B) third (C) fourth (D) escape.

___ 8. The two wheels in the time train which turn in the same direction, one of which turns once each hour while the other turns once each minute, are the (A) center and third (B) center and fourth (C) third and fourth (D) third and fifth.

___ 9. The gauge which immediately shows the size of a watch movement is the (A) millimeter gauge (B) movement gauge (C) micrometer gauge

___ 10. The rate of a watch depends on the regularity of oscillations of the (A) escape wheel (B) hairspring (C) balance wheel (D) pallet fork.

___ 11. The most common type of watch or movement is (A) automatic (B) cylinder (C) Roskopf (D) chronograph (E) lever (F) bascule

___ 12. In identifying Swiss movements, the method to try first is (A) name of manufacturer and caliber or reference number (B) identification by means of setting parts (C) importer's name and model designation.

Detach page or cut along this line — and send to the School or grading

Abbreviations: s-size. j-jewels. OF-Open Face. Htg-Hunting. mm-millimeters.

_____ 13. You want to order a mainspring for a Waltham 17j. movement, No. 16,188,033, which winds at 3. The diameter of the pillar plate across the dial side measures 45.7 mm.

(A) 1 mainspring for Waltham 16s. 17j. Htg. Movement No. 16,188,033
(B) 1 " " Waltham 18s. 17j. Htg. Movement No. 16,188,033
(C) 1 " " Waltham 18s. 17j. OF. Movement No. 16,188,033
(D) 1 " " Waltham 16s. 17j. OF. Movement No. 16,188,033

_____ 14. You want to order one quarter dozen (1/4 doz.) balance staffs for an Elgin 17j., winds at 12 and the diameter of the pillar plate across the dial side is 39.8 mm. Movement No. 30,631,248.

(A) 1/4 doz. balance staffs, pivot 10, 10s. Elgin 17j. OF. Movement No. 30,631,248.
(B) 1/4 " " " " 10, 12s. Elgin 17j. Htg. Movement No. 30,631,248.
(C) 1/4 " " " " 10, 12s. Elgin 17j. OF. Movement No. 30,631,248.
(D) 1/4 " " " " 10, 10s. Elgin 17j. Htg. Movement No. 30,631,248.

_____ 15. You want to order 1/4 doz. stems for an Elgin 17j. movement, number 35,661,234. Diameter of the pillar plate across the dial side is 23.7 mm.

(A) 1/4 doz. stems for 8/0 Elgin 17j. Movement No. 35,661,234.
(B) 1/4 " " " 6/0 Elgin 17j. Movement No. 35,661,234.
(C) 1/4 " " " 4/0 Elgin 17j. Movement No. 35,661,234.

_____ 16. You want to order an escape wheel and pinion for an Elgin 21/0. Model 662.

(A) 1 Escape wheel and pinion for Model 662.
(B) 1 " " " " " Elgin 21/0, 17 jewel.
(C) 1 " " " " " Elgin 21/0, Model 662.
(D) 1 " " " " " Model 21/0, 17 jewel.

_____ 17. You want to order a balance complete (balance wheel, staff, roller and flat hairspring) for a Welsboro 6-3/4 x 8 ligne Swiss watch with the symbol FF120 stamped on the dial side of the pillar plate.

(A) 1 balance complete with flat hairspring for FF 120.
(B) 1 " " (balance wheel, staff, roller and flat hsp.) for FF Welsboro.
(C) 1 " " (balance wheel, staff, roller and flat hsp.) for Welsboro 6x8.
(D) 1 " " (balance wheel, staff, roller and flat hsp.) for Swiss 6x8.

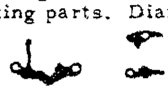
_____ 18. You want to order a 4th wheel and pinion for a Benrus BK, 10 1/2 ligne, 15 jewel movement. Stamped on the dial side of the pillar plate is the symbol ETA 1080.

(A) 1 4th wheel and pinion for Benrus, (ETA 1080) 10 1/2 ligne
(B) 1 " " " " " ETA 1080, 10 1/2 ligne, round, 15j.
(C) 1 " " " " " Benrus, (ETA 1080) 10 1/2 ligne, 15j.
(D) 1 " " " " " Benrus BK, (ETA 1080)

_____ 19. You want to order a Breguet hairspring for a Bulova 6AH. Symbol on pillar plate-dial side is **FF120**

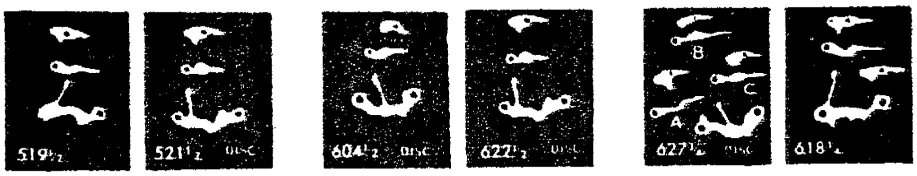
(A) 1 Breguet hairspring for Bulova, FF120.
(B) 1 " " " FF120, 6AH.
(C) 1 " " " Bulova, 6AH.

_____ 20. You want to order 1/4 doz. set bridges for a Swiss watch which, in this particular case, can be identified only by comparison of setting parts. Diameter of pillar plate at the stem is 14.66 mm. Oval.

The setting parts look like this: 

Compare setting parts with these illustrations:

(A) (B) (C) (D) (E) (F)



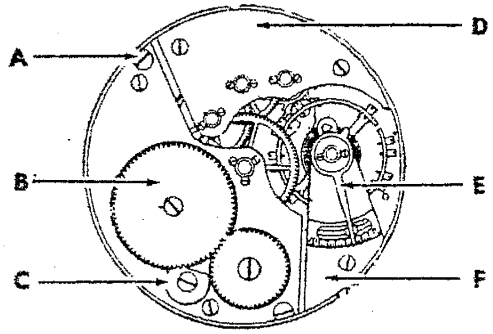
5 1/2 ligne 6 1/2 ligne 6 3/4 ligne

Which Series Number would you use to order the 1/4 doz set bridges?

Name: ______________________ No.: __________

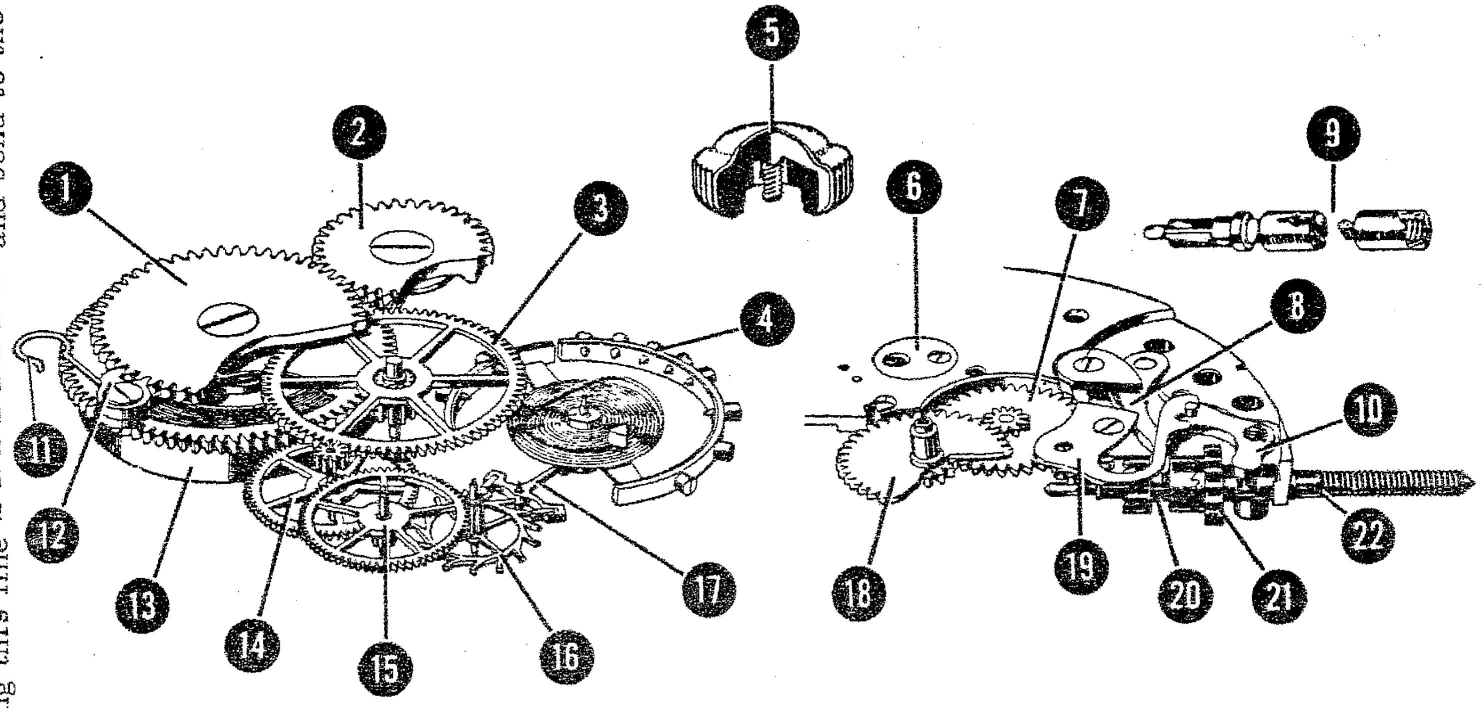
Test Questions

21. Write the letter of each part indicated by an arrow in front of its correct name below: (Note: There are more part names than needed.)



( ) First Wheel
( ) Crown Wheel
( ) Ratchet Wheel
( ) Dial Screw
( ) Case Screw
( ) Set Lever Screw
( ) Train Bridge
( ) Barrel Bridge
( ) Balance Cock or Balance Bridge
( ) Regulator
( ) Click

22. Write the number of each watch part in front of its correct name in the list below:



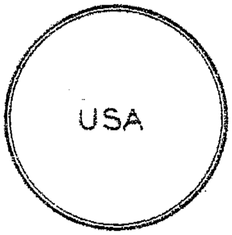
( ) Winding Pinion
( ) Set Lever
( ) Minute Wheel
( ) Snap-In Stem
( ) Center Wheel and Pinion
( ) Ratchet Wheel
( ) Upper Cap Jewel in Setting
( ) Click
( ) Clutch Lever
( ) 3rd Wheel and Pinion
( ) Crown Wheel
( ) Cannon Pinion
( ) Escape Wheel and Pinion
( ) Balance Complete
( ) Stem
( ) Hour Hand
( ) Waterproof Type Crown
( ) Mainspring Barrel
( ) Setting Bridge
( ) Lower Cap Jewel in Setting
( ) Pallet Fork and Arbor
( ) Click Spring
( ) Hour Wheel
( ) 4th Wheel and Pinion
( ) Winding Clutch

- - - Detach page or cut along this line - - - - and send to the School for grading - - -

What is the correct measurement in millimeters and correct size for each of the movements shown below? Write the letter of the correct answer on the short line in front of each question number.

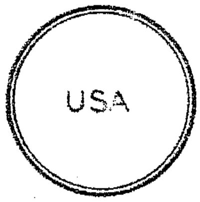
MILLIMETER MEASURE: | MOVEMENT SIZE:

____ 23. A. 16 mm
B. 28.20 mm
C. 29.6 mm
D. 39.8 mm



____ 24. E. 16/0
F. 12 1/2 ligne
G. 0/s
H. 12/s

____ 25. A. 23.69 mm
B. 23.7 mm
C. 25.38 mm
D. 25.4 mm

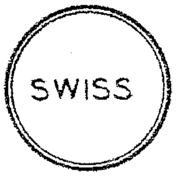


____ 26. E. 10 1/2 ligne
F. 8/0
G. 11 1/4 ligne
H. 6/0

____ 27. A. 15.2 mm
B. 15.23 mm
C. 22 mm
D. 27.9 mm

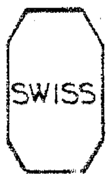
____ 28. E. 18/0
F. 6 3/4 ligne
G. 10/0
H. 3/0

____ 29. A. 20.3 mm
B. 21.43 mm
C. 21.99 mm
D. 22 mm



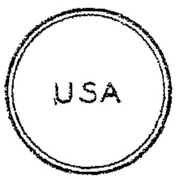
____ 30. E. 9 ligne
F. 9 1/2 ligne
G. 9 3/4 ligne
H. 10/0

____ 31. A. 11.84 mm
B. 12.7 mm
C. 12.97 mm
D. 19.74 mm



____ 32. E. 5 1/4 ligne
F. 12/0
G. 5 3/4 ligne
H. 8 3/4 ligne

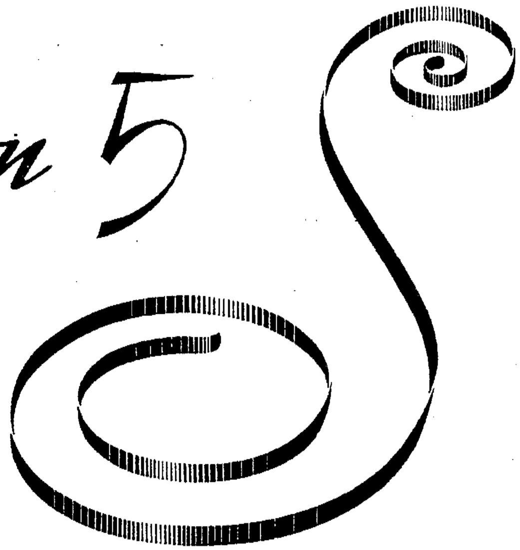
____ 33. A. 20.31 mm
B. 21.99 mm
C. 22.0 mm
D. 24.81 mm



____ 34. E. 12/0
F. 9 3/4 ligne
G. 10/0
H. 11 ligne

Master WATCHMAKING

Lesson 5



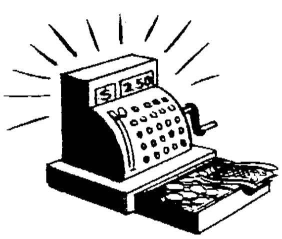
MAINSPRINGS IN WATCHES

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

INTRODUCTORY INFORMATION

In Lesson 4 you read that a mainspring furnishes the power that makes a watch run. Now, through a detailed study of the mainspring and related parts, you will go further into this matter of power or motive force, as it is called, and see how it is developed in a watch.

The principle is simple. The elastic force found in spring metal is behind it all. This force makes a coiled spring unwind. A watch mainspring is nothing but a coiled spring held at both ends inside a cylinder called the barrel. As the mainspring unwinds, it turns the barrel. This controlled action is carried to the balance wheel by a series of wheels known as the train, which you studied in Lesson 4. When the mainspring breaks, the watch, of course, stops.



Replacing broken mainsprings is a profitable part of the watchmaker's business due to the small cost of the spring (from $1.25 to $2.50 for a white alloy spring) and the little time involved. In the larger cities, a usual charge for mainspring replacement is $3.50 to $7.50, which usually covers both the cost of the part and the labor charges.

One problem that comes up in connection with mainspring replacement is this: Most customers feel that if the mainspring breaks in their watch, it need only be replaced and the watch will again keep time. This is not always true. Besides a new mainspring, the watch may need other work, such as cleaning, oiling and regulating. The watchmaker can hardly be held responsible for the time keeping quality of the watch unless he does <u>all</u> the necessary work. This should be made clear to the customer at the time of estimate.

It is possible to purchase mainsprings for practically any watch. Your material jobber can furnish you with a mainspring catalog which lists mainsprings for American and Swiss watches. Your first step in replacing a spring is to find out the proper size spring for the watch. You should not assume that the spring that was in the watch was the correct one. It <u>should be</u> but many times is not. It is best to identify the movement, and then, by reference to the mainspring catalog, select a spring of the dimensions listed for that movement. You can purchase assortments of springs in popular sizes, or you can gradually build up an assortment by buying in lots of 1/4 or 1/2 dozen as the need arises.

KEY POINTS OF LESSON ASSIGNMENTS 15, 16 17, 18, 19:

- The barrel and fusee type of motive power.
- What is meant by the going barrel.
- How to remove the mainspring barrel from a watch.
- How to take the mainspring from the barrel.
- The different styles of mainspring tips.
- How long a watch should run on one winding of the mainspring.
- How to use a mainspring winder.
- How to replace a mainspring in a barrel.
- A rule to remember on the direction of coils in the barrel.
- How to reassemble the movement.
- How to test the mainspring after assembly.
- The purpose of a stop works.
- Non-breakable mainsprings and sealed barrels.

ASSIGNMENT NO. 15: Study Sections 125 through 129.

Study Questions:

1. What is meant by a Fusee?
2. What is its purpose?
3. In a barrel and Fusee arrangement, how is the barrel geared to the train?
4. Is the Fusee type of motive power in common use today?
5. In what type of timepiece is the Fusee most likely to be found?

NOTE: As explained in the text, early watches sometimes had a Fusee, but it is not practicable for the student to work on Fusee watches at this time. They are something of a rarity and are usually prized as antiques, so that your chances for getting one to repair are slim. While it is true that the Fusee is still used on ships' chronometers, it is unlikely that these will be brought into the average shop for repair.

ASSIGNMENT NO. 16: Study Sections 130 through 138.

1. What is a going barrel?
2. What are the steps in disassembly to remove a barrel?
3. How are the barrel cap and arbor removed?
4. How do you take the mainspring from the barrel?

ASSIGNMENT NO. 17: Study Sections 139 through 144 and the Supplementary Information on Mainspring End Braces following Section 162B.

What are the different forms of mainspring tips?

Recommended Practice:

1. If sample mainsprings are included with this lesson, examine them and determine the form of tip on each.
2. Compare your answers with the answers given in the Solution for Assignment 17.

ASSIGNMENT NO. 18: Study Sections 145 through 160.

Supplementary Information: A condition sometimes met with, particularly in old watches, is a "set" mainspring. A "set" mainspring is one which has lost

ASSIGNMENT NO. 18 (Continued):

its resiliency. Such a spring should normally be replaced, even though it is not broken. The illustrations A through D in Figure 97 show how a set spring has no power to expand.

Compare one of the new springs furnished with this lesson with Figures A-D, Figure 97. Note how the coils of the new spring spread apart while the coils in the set spring are much closer together. A mainspring starts to lose its resiliency the first time it is wound up in a mainspring winder. But if a mainspring becomes set at first winding, it is generally because of improper tempering; in other words, it is too soft.

1. How long should an ordinary watch run on one winding of the mainspring?
2. What is a distorted mainspring?
3. What causes this distortion?
4. Should a set or distorted mainspring be put back in the watch?
5. What is the proper method of replacing a mainspring?
6. How is a mainspring winder used?
7. Is there any other satisfactory method of inserting a mainspring than with a winder?
8. How is the inner coil of the mainspring formed?
9. How can you tell in which direction the coils of the mainspring should lie in the barrel?
10. What type and how much oil should be used on mainsprings?
11. What causes mainsprings to break?

Recommended Practice:

Using your practice movements, remove and replace the mainspring in the barrel, oil the mainspring, and replace the arbor and cap. Use the lesson manual and Job Sheets as guides for this work. Repeat on the same movement and different movements until you are proficient in this job.

After you have replaced the arbor and cap, you must check to see that the arbor has a little freedom or end shake. If it is tight and the barrel does not turn freely, it is quite possible that you have put the cap on upside down. Test the arbor end shake by holding the barrel in your fingers with the arbor vertical. Grasp the arbor with tweezers and see if you can move it slightly up and down. If you can, your assembly should be OK.

ASSIGNMENT NO. 19: Study Sections 161 and 162.

1. What is the Stop Work?
2. What is its purpose?
3. How does it accomplish this purpose?

Recommended Practice:

Make a rough pencil sketch of the stop work or study it closely to fix it in your mind and assure yourself that you can recognize it if you find one later in your repair work. At that time you can refer back to this lesson for functions and method of replacement.

REQUIREMENT:

➧ Complete Test Questions for Lesson 5 and send in for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

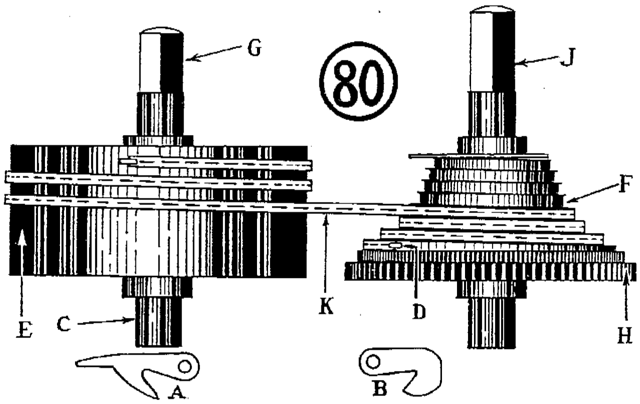
Lesson 5

Sections 125 to 162

Lesson 5 — Mainsprings in Watches

Section 125 THE early watch mainspring moved around the arbor of the wheel in much the same way as in a clock, and was limited in the extent of its expansion by four upright pins driven into the plate of the watch with the arbor as a center.

The next step was the introduction of the barrel to contain the mainspring. The barrel is a metal box of cylindrical shape in which the mainspring is confined. This barrel was used in connection with a fusee.



Sec. 126 — The Fusee

The FUSEE, sometimes spelled FUZEE,is an ingenious cone shaped arrangement, with a spiral groove, mounted on a toothed wheel, the first wheel of the watch, which gears into the center pinion. The barrel containing the mainspring is without teeth and turns on a stationary axis. The barrel and fusee at first were connected by a piece of gut, but later this was replaced by the fusee chain as shown at K figure 80.

The arrangement of the fusee and barrel with properly formed mainspring practically equalizes the motive force in the watch.

Figure 80 is a drawing of a fusee and barrel from an imported chronometer. The step like arrangement F represents the fusee while the first wheel is shown at H. This wheel gears into the center pinion. The fusee may be turned upon the wheel for the purpose of winding the chain from the barrel.

Sec. 127 — Fusee Chain

This steel fusee chain, somewhat resembling a miniature bicycle chain, has a hook at each end, one hook with a brace extending at the tip as shown at A being hooked into the barrel and the other hook shown at B into the fusee.

Sec. 128 — The Barrel

The mainspring itself is contained in the Barrel E, the outside end of the mainspring being hooked into the shell of the barrel and the inside end being hooked to the arbor C which extends straight through and on which the barrel turns. When the mainspring is connected, one end with the barrel, and the other end with the arbor, it is easy to see that any circular force given to the arbor C will be transmitted to the barrel through the mainspring. If the arbor C is held by some means and the barrel forcibly turned, it will cause the mainspring to be wrapped around the arbor, inside the barrel.

The natural elasticity of the mainspring in trying to assume its original position will cause a pull to be exerted on the barrel and this in turn by means of the chain will be extended to the fusee and first wheel at H, thus transmitting the power to run the train.

Sec. 129 — Assembling Fusee and Chain

In assembling these parts the chain is first wound around the barrel by turning the square at G, which is a continuation of the arbor C, using care to have the chain spaced evenly on the barrel and leaving only enough of the chain extending from the barrel to hook into the fusee at D.

The point D should be adjusted so that it is as near as possible to the barrel before hooking in the chain. The square end of the arbor at G is long enough to permit a ratchet wheel being mounted upon it.

After the chain is wound around the barrel and one end fastened to the fusee, the square at G is given from ½ to ¾ of a turn and the click set against the ratchet wheel to hold it in this position, thus having a reserve power of at least ½ turn of the mainspring when the watch is entirely run down.

When the ratchet on the barrel arbor is once properly set it is not moved afterwards. The mainspring is wound by turning the square on the fusee at J, figure 80, carrying the chain with it and unwinding it from the barrel. As shown in the drawing it is about half way down.

In the modern watch the bulky fusee has given way to the "going barrel" and "motor barrel". It is probable that you as a watchmaker will not be called upon to repair a watch having a fusee, unless it is one kept as an antique. However in the larger time pieces with detent escapement, such as ships chronometers, the fusee is still used and if you happen to be located in a seaport you may have many opportunities of working upon these interesting instruments.

Sec. 130 — The Going Barrel

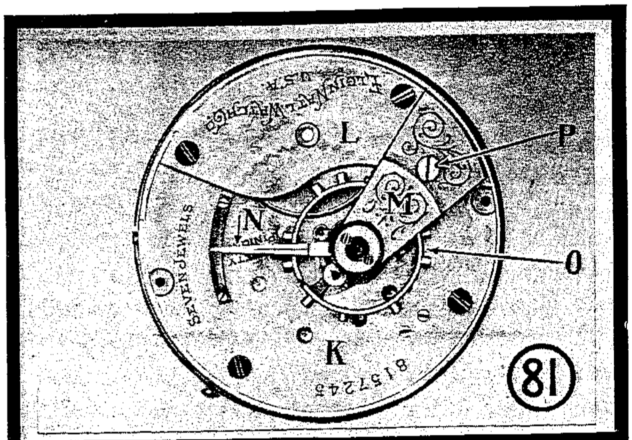
Let us now take up the study of the Going Barrel. By this we mean a barrel which has teeth cut in its circumference, these teeth gearing directly into the leaves of the center pinion. This then is also the first wheel in the train and when the watch is running the barrel turns and transmits the power from the mainspring through the train to the escapement.

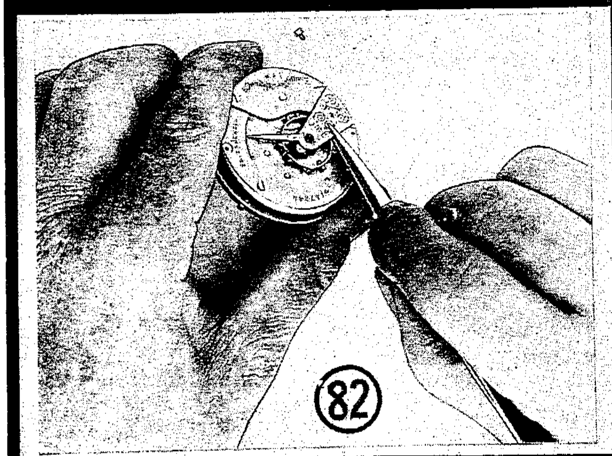
Your first practical work on a mainspring in a Going Barrel is best done on a large size American movement. If you do not have a movement similar to the one shown here, use any American or Swiss made movement and Job Sheet L5 — J2 in this lesson.

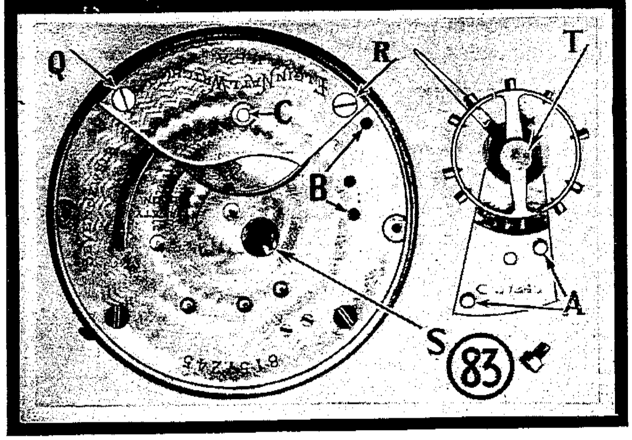
In the demonstration work for this lesson we will use an 18 size full plate Elgin movement. After removing from the case it will appear as in figure 81. In this photograph K is the top plate, L the barrel bridge, M the balance cock or balance bridge, N the regulator and O the balance wheel or balance.

Sec. 131 — Remove the Balance

In a full plate movement of this type it is best to remove the balance with the balance cock before attempting to take out the mainspring barrel. With the proper size screw driver remove the balance cock screw at P figure 81 then take hold of the balance cock with your tweezers as shown in figure 82 and carefully lift it up bringing the complete balance suspended by the hairspring. When you set the







balance down turn the balance cock right over so that it will set upside down as in figure 83.

If we were to rely entirely upon the balance cock screw P figure 81 to keep the balance cock in its proper location, it would be necessary to adjust it each time we assembled these parts in order to have the upper balance hole jewel exactly over the lower balance hole jewel. You will find on the lower side of the balance cock where it comes in contact with the upper plate, two *steady pins,* see A fig. 83. These pins are fastened firmly in the balance cock and fit closely in the two holes at B in the plate. By means of these steady pins the balance cock is kept in its proper place on the plate.

If your movement has a dust band it is necessary to remove it. The one shown here is snapped in place and can be removed by prying off with a screw driver as shown in figure 84. It is quite a common thing to find movements cased by some repairer with the dust band left off but you should make it a rule to always replace it on every movement that is supplied with one when it comes to you. In replacing a dust band see that the hole for the stem is exactly over the winding pinion in the movement. Many movements in the newer models are not supplied with dust bands.

Sec. 132 — Let Down the Power

Before going any further it is well to test the power, that is, see if there is any power from the mainspring to the train of the watch, and if so, "let it down". In this model there is a small hole in the lower plate into which may be introduced a wire, and by pressing down on this wire as at S figure 85 and at the same time holding the power with the bench key in the winding arbor at T the power may be eased down by allowing the key to revolve slowly in the hand.

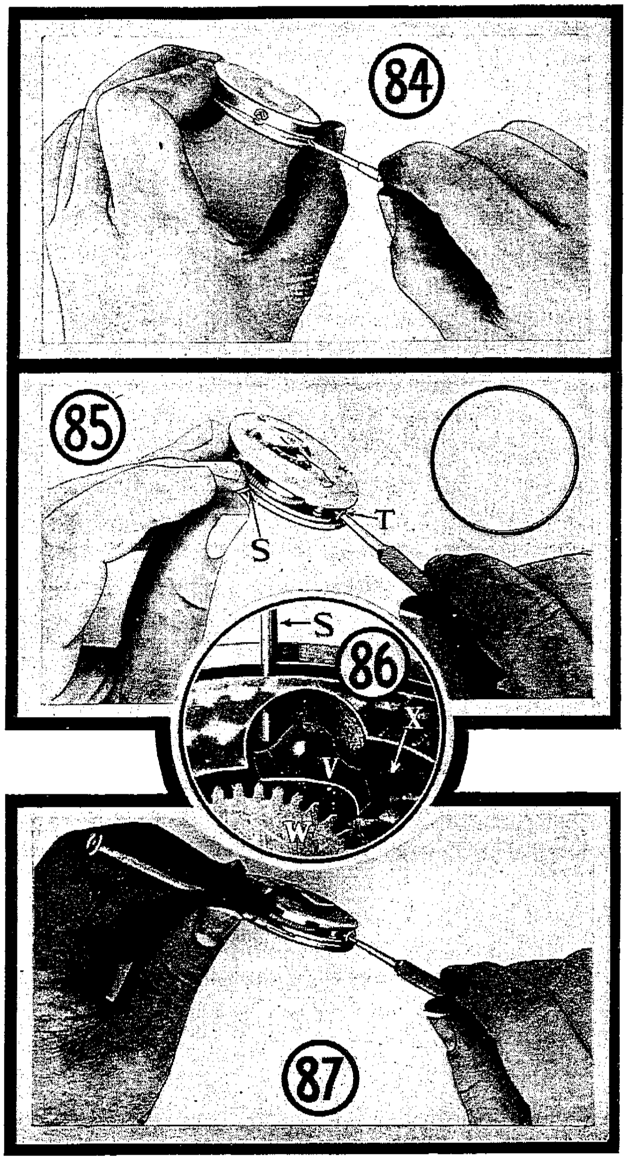
At figure 86 is shown (much as it appears when viewed through an eye glass) how the wire S extends through the hole in the edge of the pillar plate and presses against the end of the click V raising the other end away from the teeth of the ratchet wheel at W so that this wheel may turn backwards in letting down the power. At X is the click spring, which holds the click against the ratchet wheel teeth. The ratchet wheel, click and click spring also may be seen approximately actual size in figure 90.

In some models of movements the end of the click extends to the edge of the pillar plate and while letting down the power this may be held back by a small screw driver as in the Waltham movement in figure 87 which demonstrates the method used with this model.

Sec. 133 — Always Test Amount of Power

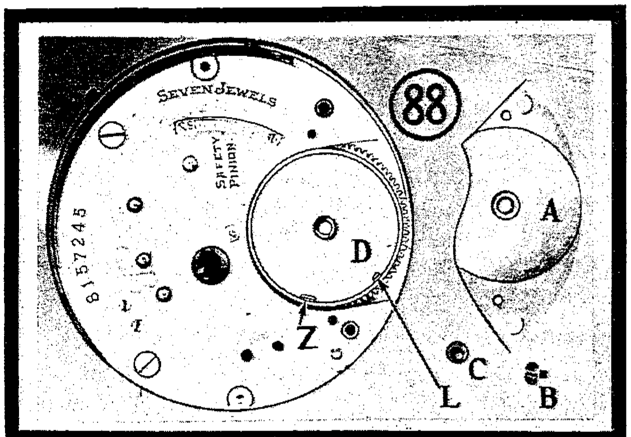
Though a mainspring may be broken it is well to see if there is any power left in the barrel by going through the same procedure as just outlined. If the mainspring is broken near the outer end, there still might be enough power to cause damage when you lift out the barrel without having "let down" the power.

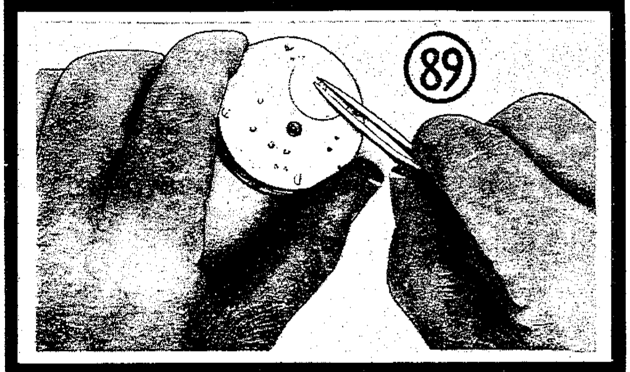
If the mainspring is not broken and is wound to anywhere near the full amount, much damage may be caused by attempting to take the watch apart without "letting down" the power.

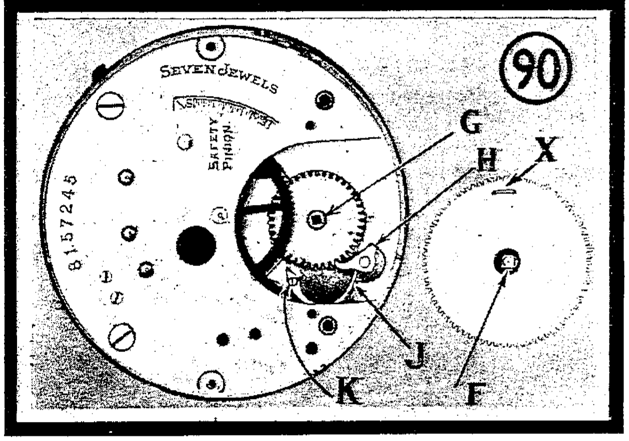


Sec. 134 — Remove the Barrel Bridge

After letting down the power the next step is to remove the barrel bridge by taking out the screws Q and R figure 83 and lifting it off with your tweezers to the position shown in 88. Here may be seen the barrel bridge A with the two screws B and C which held it in place and the barrel D in the position that it occupies in the watch. On the barrel bridge also may be seen the two steady pins which perform the same office for this bridge as those previously mentioned do for the balance cock.







Sec. 135 — Take Out Barrel

Now that your power is all down the barrel may be removed by taking hold of the end of the barrel arbor as shown in figure 89 and carefully lifting it out, bringing the barrel right along with it.

In figure 90 the barrel is turned over showing the lower side and at F the square of the barrel arbor which fits into the square hole in the ratchet wheel at G with the click in its place at H and the click spring J pressing against it. The click spring is held in position by means of the click spring screw at K.

Sec. 136 — The Cap

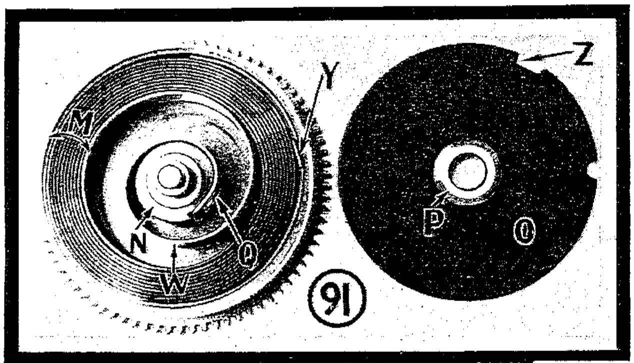
The cap fits in the barrel with a snap fit and may be removed by prying off with a screw driver or other lever like instrument. The cap has an opening at the edge in which to insert the screw driver at L figure 88. Of course, the cap is pried out after you have taken the barrel from the movement.

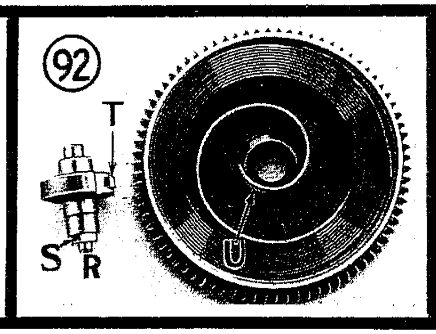
Having removed the cap, the barrel with the mainspring appears as in the enlarged photo in figure 91 in which M represents the coils of the mainspring, N the barrel arbor and O the cap removed and with the inner side out. As you can see at P the cap is reinforced around the center by a thicker portion of metal so that it gives a heavier bearing and support for the upper end of the arbor.

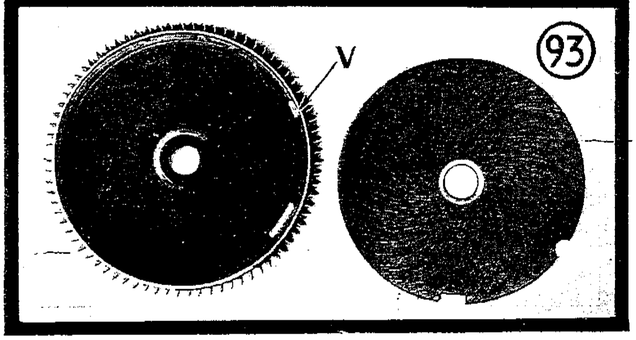
Sec. 137 — The Barrel Arbor

By arbor we mean an axle or spindle. Thus we here have the barrel arbor to which one end of the mainspring is attached and which in a going barrel, turns only when the mainspring is being wound. There are other arbors, the pallet arbor, setting arbor, winding arbor and sometimes the balance staff is called the balance arbor.

In most watches with going barrels the barrel arbor and hub are in one piece. By the hub







we mean the center part of larger diameter which carries the pin or hook for the inside end of the mainspring.

In some of the old Swiss watches the hub screws onto the arbor and it is necessary to unscrew this before it is possible to separate the arbor from the barrel.

The barrel arbor shown here is of one solid piece and by disconnecting the inside end of the mainspring from the hook at Q you will find it possible to lift the arbor right out of the barrel as in figure 92 in which the arbor is shown at R. The barrel is also furnished with a re-inforcement in the center for the purpose of giving a heavier bearing at this end for the barrel arbor. In this picture you can see the square on the barrel arbor at S which fits into the square hole of the ratchet wheel shown at G figure 90. At T, figure 92, is shown the hook which fits into the hole in the inner end of the mainspring at U.

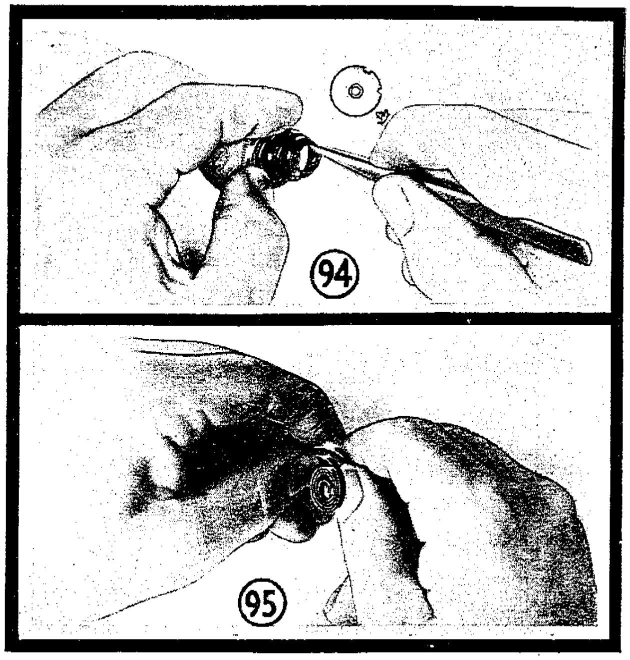
Sec. 138 — Taking Out the Mainspring

Now you are ready to remove the mainspring from the barrel. Hold the barrel in the left hand in the position shown in figure 94, and grasp the inside coil of the mainspring with a pair of tweezers, pulling it out so that three or four of the inner coils are outside as shown in the photograph, holding the balance of the coils in the barrel with the thumb of the left hand.

Lay your tweezers down and slip the thumb of the right hand under the extended coils of the mainspring as shown in figure 95. Now you control the balance of the coils in the barrel with the thumb of the right hand and by releasing your hold with the left hand the natural resiliency of the mainspring will force the coil out on this side. By alternating the position of your hands, that is by holding the coils in the barrel, first on one side and then on the other the mainspring can be released one half a coil at a time until it is entirely out of the barrel and only holding at the extreme end or "tip". This can be easily released and you have removed your first mainspring from a watch.

Be careful that you do not release your hold on the barrel and mainspring else they may suddenly shoot out of your hands. Should such an accident occur examine your barrel very carefully to see that it is not damaged. Often teeth are bent in this way and great care must be used in straightening them.

After you have removed the mainspring, the barrel and cap will appear as in figure 93. At



V is the hook in the barrel over which the hole in the tip of the mainspring fits.

Sec. 139 — Form of Tips

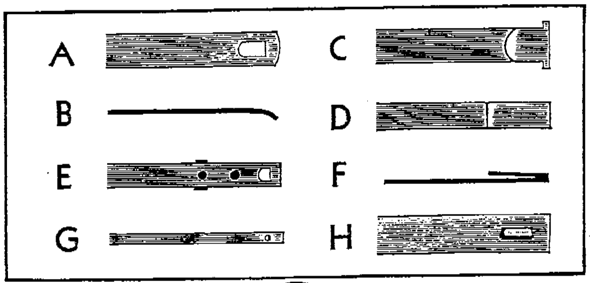
The outer end of a mainspring is commonly called the "tip" and its shape varies with the watch for which it is intended. There are several styles of tips on mainsprings but each is for the same purpose — to have some kind of an attachment to make the end of the mainspring hold securely on the inside of the barrel yet easily released when it is necessary to remove the mainspring on account of its being broken or set.

Sec. 140 — Hole End

The first and simplest style of "tip" is a hole end as shown at A in figure 96. With this style of a tip it is best as a general rule to curve the end of the mainspring right at the tip so that it will conform to the shape of the barrel as shown in the drawing of the side view at B. If this is not done the mainspring will often pull off the hook.

Sec. 141 — T End

C shows another style of "tip" known as the "T" end. With this style it is not necessary to have a hook in the barrel, but instead a hole in the bottom of the barrel and a hole or notch in the cap. One end of the "T" fits into the hole in the bottom and when the cap is pressed into its place on the barrel the other end of the "T" fits into the hole in the edge of the cap thus holding the tip securely in place. In figure 65 at G is shown the end of such a tip in an Illinois movement. (See Lesson 4)



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Sec. 142 — Tongue End

The tongue end is shown at D. This style tip is used in many Swiss watches although not so popular with American manufacturers. F is a side view of this tongue end.

Sec. 143 — Double Brace

The style of "tip" used on the mainspring which we have been showing in this lesson figures 91 and 92, is called a "double brace hole end", and is shown at E. As you can see there is a hole which fits over the hook in the barrel. This style is held in place by means of the double brace, one end of which fits into a slot in the barrel, as shown at X figure 90, while the opposite end which can be seen at Y in figure 91, projects far enough to be held by the slot in the cap shown at Z figure 88 also Z in figure 91.

At G and H, fig. 96, are shown two types of pin ends. The pin on the tip, of this type of mainspring ends, fits into a hole of proper size in the wall of the barrel. The type shown at H is often used on mainsprings for ships chronometers in barrels used with a fusee.

These are the more popular forms of mainspring tips or ends but there are others which you will find in our mainspring charts, showing widths, strengths and shape of tips on 135 different Mainsprings for American Watches.

Sec. 144 — Factory Packing of Mainsprings

Formerly it was the custom for manufacturers to pack mainsprings in lots of one dozen of a size as shown at H in figure 98, but in recent years the individually packed mainsprings have become more popular with watchmakers until now nearly all of the better mainsprings as they come from the factory are held in separate containers, each in an envelope or wrapper.

Figure 98 shows three mainsprings in different styles of individual containers, F being held in a heavy piece of aluminum wire, G in a flat card container and K with a fine wire twisted around and holding it.

Notice that none of these springs is wound as tightly as it would be in the barrel of a watch. New mainsprings often lie in stock for rather long periods and if they were wound up nearly to the limit there would be a tendency for the coils to set in this position and not give the best of service.

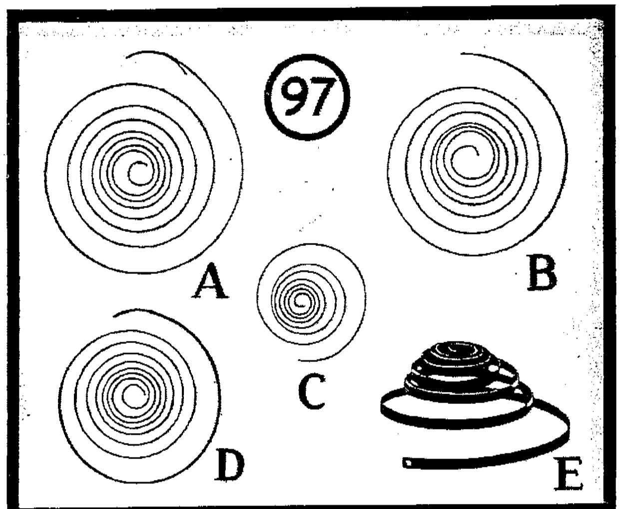
In removing the spring from its container hold the coils by the edge and let them expand slowly, never let them come out all at once.

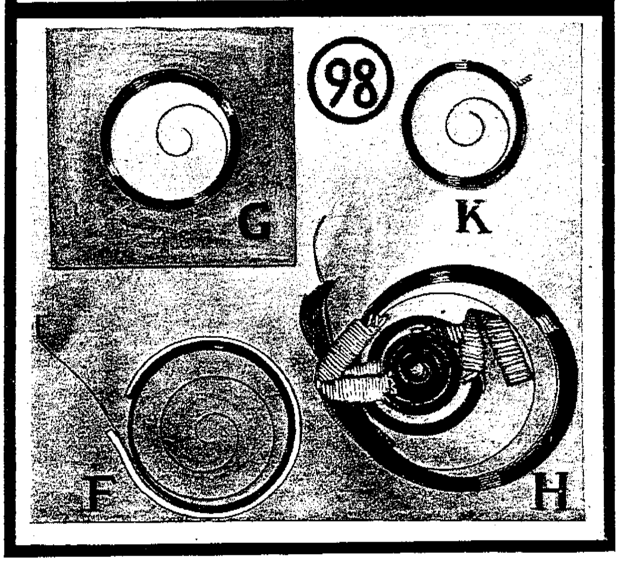
Sec. 145 — A Watch Should Run Over 30 Hours

The mainspring in a modern watch must be of such strength and temper that it will have enough power to make the balance take a good motion after a 24 hour run and yet it must not be so strong that it gives the balance an excessive motion when first wound up. Some of the modern Railroad Watches will run for 60 hours with one winding and an ordinary grade of watch should run from 32 to 36 hours.

Sec. 146 — Replacing the Mainspring

Many watchmakers replace mainsprings in barrels with their fingers, without the use of a mainspring winder. In doing this they reverse





the process of taking the mainspring out as we have shown you in previous paragraphs. The "tip" of the mainspring is caught in the barrel and then the balance of the mainspring is backed into it by pressing first on one side and then on the other. In doing this, however, you are bound to distort the mainspring and cannot get the best service out of it.

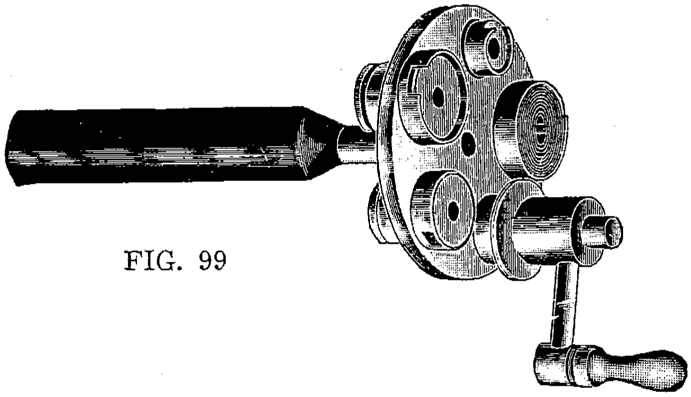


FIG. 99

Sec. 147 — Distorted Mainsprings

E figure 97 shows a mainspring as it appeared after having been replaced with the fingers by an amateur watchmaker. As you can see the mainspring is so badly distorted that there would be a constant friction on the cap and bottom of the barrel as the mainspring expands.

By all means get a good mainspring winder and use it every time you replace a mainspring.

There are several styles of mainspring winders on the market that use the same principle. That is by using a barrel small enough to slip inside the mainspring barrel in the watch. The mainspring is first wound into the winder barrel and then transferred to the barrel of the watch without distortion.

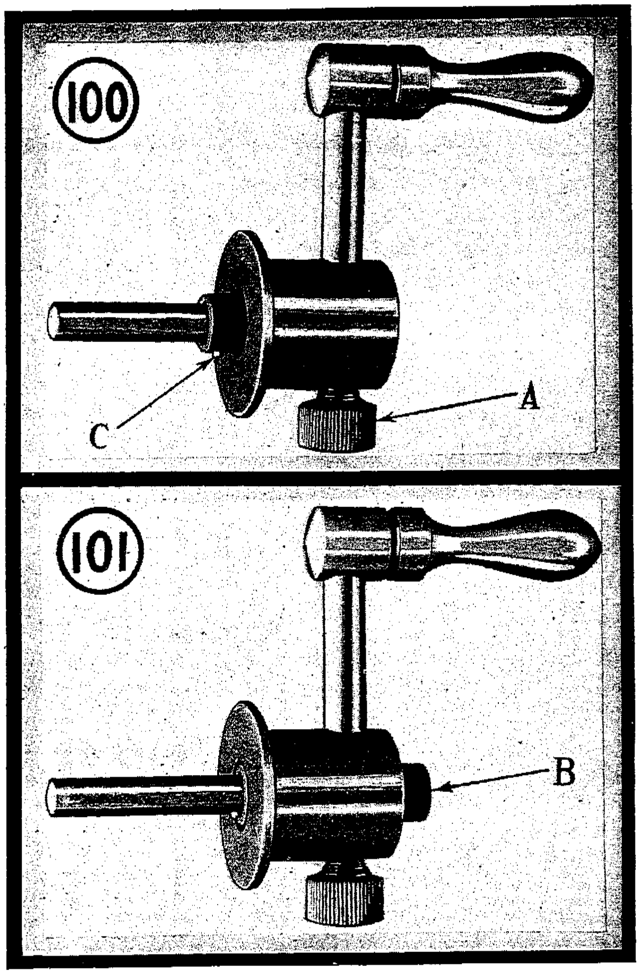
Sec. 148 — A Satisfactory Mainspring Winder

In figure 99 is shown a type of mainspring winder that proves satisfactory in all sizes of pocket watches and also can be used on some of the larger of the wrist watches. In this style the different sized barrels are arranged on a round plate fastened on a handle. The winder arbor is separate and can be used in combination with any of the barrels.

In using this type of mainspring winder, select one of the barrels that fits easily inside the mainspring barrel in which you are going to place the mainspring. If you are using a 16 or 18 size watch it would necessitate taking the largest barrel on the winder.

This winder has two arbors, the larger one held in place by the set screw at A, figure 100. When the screw is released the larger arbor springs back to the position shown in figure 101. Here the smaller arbor is in position for use on small barrels. In pocket watches the larger arbor should be used and may be brought into position by pressing at B, at the same time turning down the set screw A in order to hold the arbor in this position shown in figure 100.

The inner end of the mainspring should be shaped to fit closely around this arbor by means of the mainspring coiling pliers shown at figure 102. One of these jaws is convex and the other concave so that by grasping the inside end of the mainspring and squeezing with the pliers it can be shaped to the curve needed.

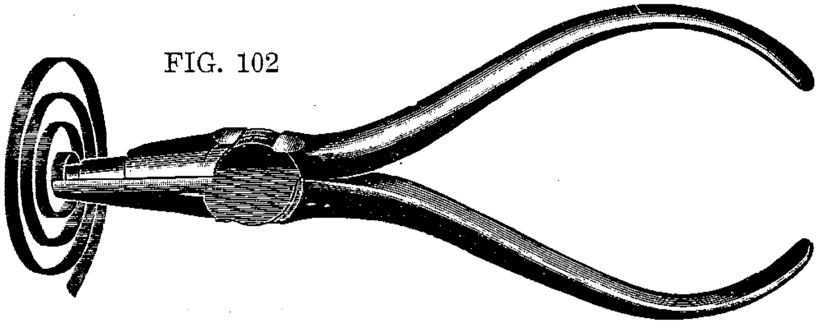


Sec. 149 — Operating the Winder

Hook the inside end of the mainspring over the pin in the arbor at C, figure 100 and then press into the proper sized barrel as shown in figure 103 holding it in this position while turning to the left with the right hand. At G figure 103 is shown the appearance of the mainspring when first started in the winder barrel.

Continue to wind until the mainspring is in the barrel as shown at H in figure 104 with only the tip extending enough to enable you to hook the outer end into the mainspring barrel of the

FIG. 102



direction. In this barrel, we speak of the mainspring as being wound to the right. If you will look at figures 91 and 92 you can see what is meant by having the mainspring wound to the right.

In the mainspring winder as seen at H in figure 104 the mainspring is wound or coiled to the left but when transferred to the barrel of the watch the spring lies coiled to the right as seen in figures 91 and 92.

watch. Reverse the motion of the winder in your right hand until the inner end of the mainspring is free from the hook on the winding arbor. Now it is ready to transfer to the barrel of the watch.

Sec. 150 — Transferring to Watch Barrel

Catch the outer end or tip of the mainspring over the hook in the watch barrel, at the same time slipping the watch barrel over the winder barrel.

Press the watch barrel firmly against the mainspring at the same time pressing with the thumb against the ejector part of the winder at D as shown in figure 104. In this position press the ejector at D hard enough to transfer the mainspring into the watch barrel at E. As shown here the finger is pressing directly upon the barrel but in actual practice it is best to place a piece of watch paper between finger and barrel in order to avoid leaving finger marks.

After getting the mainspring into the barrel, examine it to see that the end is properly hooked. At first, you may have difficulty in keeping the tip of the mainspring on the hook in the barrel as you press the mainspring out of the winder. Sometimes this is caused by having too much of the mainspring projecting from the winder barrel and sometimes by not holding the watch barrel firmly enough against the mainspring when transferring it.

When replacing T end mainsprings, have only the tip projecting from the winder barrel and even then you may have some trouble in keeping the tip from slipping out of the hole in the watch barrel when transferring from the winder barrel. If this happens you may be able to push the tip to its proper place after it is in the watch barrel, by means of a screw driver.

Sec. 151 — Directions of Coils

Of course when you replace a mainspring in a barrel of a watch it is not difficult to notice which way the old mainspring was wound into the barrel and replace the new one in the same

Sec. 152 — A Rule to Remember

There is a rule in this connection that is well for you to remember and applies to mainsprings in "going barrels". Just remember that when the cap of a barrel is up when in its position in the watch as in figure 88 the mainspring winds to the right in the barrel.

If the cap is down as in figure 65 the mainspring winds to the left. In nearly all watches with going barrels, outside of 18 size you will find the cap down.

After assuring yourself that the tip of the mainspring is properly hooked, replace the arbor in the position shown in figure 91. The inner end of the mainspring must be so shaped that it will fit closely around the arbor as shown here. For this purpose use the mainspring coiling pliers. Set the arbor in place and see just where the inner end of the mainspring must be bent to fit properly. Take out the arbor and then make the necessary bend by gripping the mainspring at the proper point with the coiling pliers. Do not squeeze too hard. A little practice will soon show you the proper amount of pressure to use.

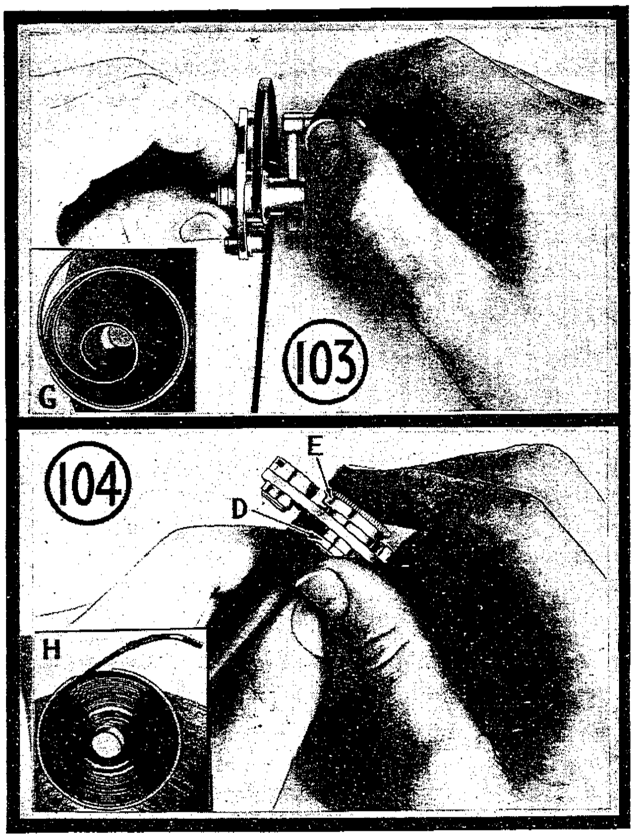
Sec. 153 — Oiling Mainspring and Arbor

The coils of the mainsprings must now be oiled. The oil to use should be somewhat heavier than watch oil and of a quality that will easily spread. Most watchmakers use clock oil for this purpose but the type of so called *non-spreading* clock oil *should not* be used on the mainspring.

The proper way to apply the oil is by means of a clock oiler. Dip the tip of the oiler into the clock oil and transfer a small drop to the coils of the mainspring in the barrel. Do this at four different points on the mainspring. The oil should immediately disappear between the coils. There should be enough oil to lubricate all the coils but do not apply too much. If the oil remains in a body on top of the coils you have applied more than is necessary. Also place a small drop of oil on the flat outer side of the inner coil at W figure 91 spreading it lengthwise in each direction from this point in order that this coil may be assured lubrication.

The price of watch and clock oil seems excessive to the uninitiated but the best quality of oil for this purpose is cheapest in the long run. In experiments in school work I have found some oils that at the end of a twelve months period have evaporated and left only a gummy sediment. Even after six months in a running watch such oils leave the pivots so dry that the motion slows down and in some instances the watches have stopped from lack of lubrication. A first class oil properly applied will be on the job as a good lubricant even after a year's service. When we consider the exceedingly small amount of oil necessary to oil a complete watch it is easy to see that the difference in cost per watch between the highest priced oil and the cheapest amounts only to a small fraction of a cent and it hardly pays to take the risk of poor service and dissatisfied customers for such a small saving.

Snap the cap back into the barrel using care to see that the slot Z of the cap is set directly



over the brace at Y figure 91 and that the reinforced portion of the cap at P is set next to the mainspring. Occasionally a beginner will replace the cap wrong side out and when he has assembled the rest of his movement finds that "something's wrong" because the movement won't perform as it should. Watch every step in assembling a watch. After you have practiced enough, you will be able to tell at a glance whether the parts are arranged as they should be but at first you should study each step and be sure you are right before going on to the next step.

In snapping the cap back into the barrel use watch paper so that the fingers do not come in direct contact with either the cap or barrel, press one edge of the cap into place and while holding that edge in position against the barrel, push the opposite edge of the cap into place by pressing it firmly against the edge of your bench until it snaps into position.

Apply a small amount of clock oil at each end of the arbor where it comes through the barrel. When the dial is left on the plate as has been done here, it is also necessary to place a small drop of oil in the hole in the lower plate into which the lower pivot of the arbor fits. This is done by lifting out the ratchet wheel and applying the oil directly under G, figure 90. If the dial is off this part is oiled from the other side, after the barrel has been replaced.

Sec. 154 — Assembling

Replace the barrel in the watch in the position shown in figure 88, taking care to see that the ratchet wheel, click and click spring are in their proper places. In your first attempt you may have some slight difficulty in getting the square of the arbor in its proper place in the ratchet wheel.

After setting the barrel in its place twist the arbor around toward the right (in order not to unhook the inner end of the mainspring) by means of a pair of brass lined pliers or heavy tweezers, as shown in figure 89 until the lower square end of the arbor drops into the square hole of the ratchet wheel. Pliers work better than tweezers as you can grip the end of the arbor more firmly.

Replace the barrel bridge and set the two screws in place. Many beginners in assembling a watch do not set the screws tight enough, so see that you screw these screws down fairly hard, not hard enough to strip the threads from the plate, but so that it takes a little effort to start the screws out. Now your movement will appear as in figure 83. Place a small drop of clock oil on the pivot of the mainspring arbor where it comes through the barrel bridge at C figure 83.

Sec. 155 — Tests

Apply a little power by using your bench key and giving it three or four turns while winding; listen for the sound of the click as it falls into the teeth of the ratchet wheel.

If when you release your key after winding, the power of the mainspring turns it back to its first position it is probable that your click or clickspring is not in its proper place. It will act the same way when the click spring is broken.

If when winding there seems to be no resistance of the mainspring — it is probable that the inner end is not properly hooked on the arbor.

If after you have wound several turns there is a sound of something slipping and apparently no power, the outer end or tip may be unhooked.

In replacing a new mainspring having a double brace or T end, always compare it with the thickness of the barrel and cap to see that the brace or tip does not extend beyond these parts and if you find that it does, grind or file off the proper amount to make it flush with the outside when assembled. Some do this after the mainspring has been placed in the barrel but it is just as easy to shorten these parts before as after and then there is no danger of having ugly file marks, the marks of the unskilled workman, left on the finished surface of the barrel. If the tip is left projecting from the barrel it is liable to catch on the center wheel or other part and stop the watch.

Sec. 156 — Replacing Balance

After finding that the mainspring and winding parts are working, replace the balance and balance bridge. If the power is transmitted properly to the fork it will be held over on one side as may be seen at S figure 83.

In order to have the watch run, the roller jewel (seen on the roller at T figure 83) must enter the fork from the open side, in this example at the right. Hold the balance bridge as in figure 82 but instead of holding it directly over its final position as shown here twist it around with a circular motion to the left until the roller jewel is on the open side of the fork.

Lower the balance bridge until the lower pivot of the balance staff is in the lower balance jewel, then twist the bridge around to its proper place as in 82 and your roller jewel should enter the fork and the balance start immediately to oscillating.

Sec. 157 — Use Care

Use care in replacing the balance. The pivots are small and easily bent. These parts should slip into place without using much pressure. You may need some practice before you can do it correctly every time, but it's surprising how soon these things come to you by doing them over and over.

Much care should be used in setting in place the balance bridge screw. As you screw it home see that each balance pivot is in its proper place and that the balance wheel is perfectly free.

This may be tried by giving the movement a slight twist with the left hand and if the balance should suddenly stop as you twist the screw, find out what is holding it. Do not set the screw tight unless the balance is free to vibrate.

Sec. 158 — Watch The Hairspring

In manipulating the balance into its proper place, it is suspended from the bridge by means of the hairspring so do not give any sudden jerk or hard pull as you are liable to damage your hairspring.

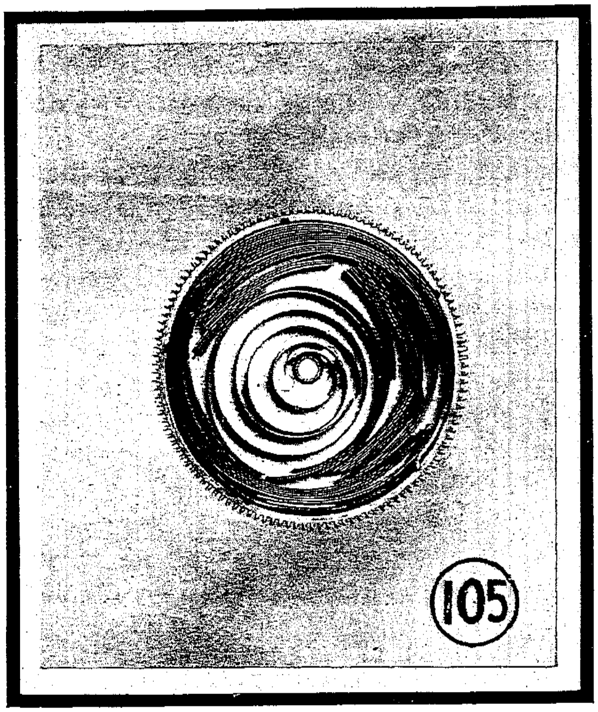
Replace the movement in the case, set your case screws in their proper positions, and notice how many finger marks you have left on the dial and plates. They can be removed sometimes with a clean polishing cloth, but the proper way is to use more care and protect with watch paper so that the fingers do not touch the parts.

Sec. 159 — Preliminary Tests

The first test given a watch when brought in for repairs is to try the winding. Often a customer, especially with a watch having a small or worn crown, complains that his watch stops, and upon examination you may find that he is only winding it a few turns. Again another customer may be afraid to wind his watch as it should be wound, for fear he'll break the mainspring.

Test your own ability and count how many turns it takes you to wind your watch after it has run 24 hours. It is not necessary to turn the crown in one direction only — rather roll it back and forth between the thumb and first finger and count this back and forth motion as one. By knowing how many turns it needs you can tell whether a watch is entirely run down when brought to you.

If when you attempt to wind a watch you can turn the winding stem any number of times without resistance from the mainspring it is probable that the mainspring is broken and should be replaced with a new one.



Sec. 160. — What Causes a Mainspring to Break

Regardless of how careful the manufacturer may be in tempering or how great the care used in handling the mainspring, there still remains the danger of sudden breakage through unexplained causes.

There seems to be no satisfactory explanation of just what causes some mainsprings to break, while others, made from the same steel and under the same conditions do not. Mainsprings that are tempered highly enough to perform the best are liable to break and the fact that one brand of mainsprings causes no trouble due to breakage while another brand does occasionally break, should cause the watchmaker to suspect that the first kind is softer and more apt to set. There's an old saying among Watch Experts that "a broken mainspring is better than a set mainspring", meaning that there is no question as to the cause of trouble from a broken mainspring while the cause of poor motion from one that is set, is not as easy to locate.

No doubt you will find some rather odd examples of broken mainsprings in your work. As a general thing when a mainspring breaks in a watch it will break near the outer or inner end and in only one or two places, but occasionally you will find one like the one shown in figure 105 which has apparently "exploded".

During the summer months there is a greater percentage of mainsprings breaking than any other season of the year. Some claim that this is caused by electrical disturbances in the air and as proof, the fact has been cited that often workmen in shops where a large number of watches were hanging on the racks have noticed the breaking of several mainsprings at almost the same time; this being followed in some cases by an electrical storm.

Rust no doubt is one of the common causes of breakage in mainsprings. There are watchmakers who cannot touch steel without causing it to rust, and yet many of them insist on putting in mainsprings by hand, not only causing the spring to rust, but distorting it as well. The fact that such a percentage of breakage occurs during the time when the air holds the most moisture would also cause us to suspect rust as a partial cause at least.

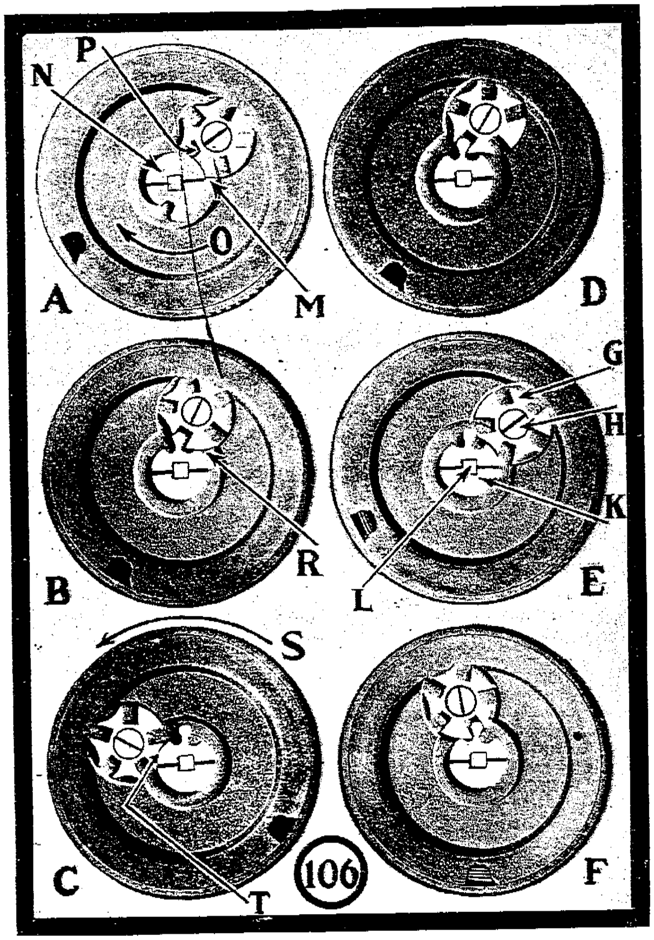
The mainspring should be kept well oiled at all times not only for its lubricating effect but also to help prevent rust.

Sec. 161 — Stop Work

As already explained the fusee was developed in order to equalize the power of the mainspring as the movement runs down.

There is another mechanism known as the *Stop Work,* which prevents the mainspring from being wound completely up and also prevents it from running entirely down, thus using that portion of the mainspring during which the power is applied most nearly equal.

The arbor of the going barrel as demonstrated in the preceding sections of this lesson is supported at both ends, the upper end by the barrel bridge and the lower by the pillar plate. Occasionally you will come in contact with another style of going barrel which is supported only at the upper end. This type, known as an "overhanging barrel" generally will be found where economy of space is desirable, such as in complicated watches or thin models. The barrel shown in photos A to F fig. 106, is of this type although you will also find stop work applied to the other style of barrels.



The stop work consists of two parts, the one at G in photo E figure 106 being somewhat in the shape of a Maltese Cross which turns upon a shoulder in a recessed portion of the barrel, being held in place by the screw at H. The other part of the stop work known as the male shown at K, is placed firmly upon the end of the barrel arbor at L and has a projection or *tooth* which gears into the notches of the cross. This part as shown here must be removed in order to take the cap from the barrel as in replacing the mainspring or cleaning the watch. The cross however may be left in its position.

If you examine the cross you will see five arms, the ends of four of these being concave while the fifth is convex.

In assembling the stop work the mainspring is first wound up as far as it will go after which the cross is so arranged that the convex end at M will be in the position shown in photo A. The male part is then pressed lightly on the square of the arbor and *above* the surface of the cross as shown at N. Now the power is let down and as this is done the arbor turns in the directions of the arrow O carrying the male part with it until the tooth is directly above the notch in the cross at P.

The part on the arbor should then be pressed down as far as it will go with the tooth engaged with the first notch of the cross as shown in photo B. If you attempt to wind the mainspring with the stop work in this position you will find that the arbor is prevented from turning further by the convex arm at R, thus preventing the mainspring from being completely wound around the arbor by nearly three fourths of a turn.

As the watch runs down the barrel turns around the arbor, which is stationary, in the direction of the arrow S photo C, which also shows the position of the stop work after the barrel has made part of a turn. In going in this direction the concave end of the arm at T allows the cross to move around the circular portion of the male part as shown until the second notch catches on the tooth (see photo D) and starts to turn the cross up another notch and so it proceeds turning up one notch for each turn of the barrel until it again comes to the convex arm of the cross which stops its turning further in this direction as shown in photo F. Thus the stop work prevents the mainspring being wound to the limit and also does not allow it to expand to its full capacity.

In winding the watch this process is reversed, the arbor turning and the tooth on the male part picking up a notch on the cross for each turn until it can be turned no further as shown in photo B. If the mainspring should be broken the stop work performs in the same manner and you will not be able to use the test described in the last paragragh of section 159.

Sec. 162 — Later Improvements

You should now be ready to master later improvements relating to the mainspring and our next lesson will make you acquainted with motor barrels, safety pinions, recoiling clicks and give demonstrations of assembling different makes of jeweled barrels. These are found on the higher grades of American watches and in order to be a Master Watchmaker it is essential that you understand the benefits obtained by these improvements and that you are thoroughly familiar with the methods of assembling them.

Sec. 162A - Non-Breakable Mainsprings

The current trend in mainsprings is the non-breakable type. These are made from an alloy instead of steel. Because they do not "set" as a steel spring does (section 144), they are packaged fully coiled in a special ring. A mainspring winder is not needed to insert them in the barrel. The ring is placed against the barrel and the spring pushed out, as shown in the illustration.

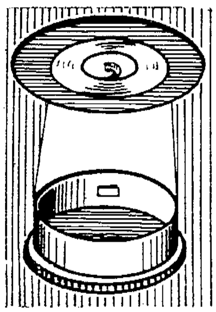


FIG. 107

Although guaranteed unbreakable, they are not 100% so and careless handling by the repairman can result in the tip snapping off.

Sec. 162B - Sealed Barrels

Another recent development is a permanently dry-lubricated mainspring in a sealed barrel which you normally should not open. The only cleaning necessary is to brush the barrel teeth.

Most of these barrels do not have a cut-out in the cap to discourage you from prying them open. However, from time to time you will find the spring will break or the tongue end will snap off. When this happens you can pop off the cap by holding the barrel in your fingers and pressing on the arbor. Then you only need to order a spring and replace it. However, if the teeth are damaged or the barrel arbor is rusted, the complete unit should be replaced.

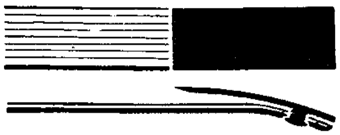
Longines has a sealed barrel that you cannot open so you have no choice but to replace the complete unit.

Most of these barrels are stamped <u>Sealed Unit</u> or <u>Sealed Barrel</u>. Longines are marked <u>Do Not Open.</u>

SUPPLEMENTARY INFORMATION

End Braces Used on Mainsprings

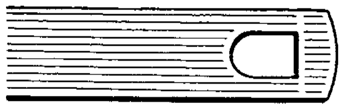
These enlarged illustrations show how the basic types of end braces have been modified by different manufacturers. They include the popular models, but you may also find other variations not shown here. The bridle end brace is used on automatic wind watches and provides a slipping action necessary to keep them from jamming. Depending on the manufacturer, this type is also known by other names, such as slip spring or tension spring. End brace names are often shortened in catalog listings as shown in bold type under the full name.



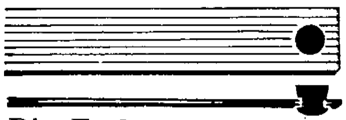
Regular Swiss Tongue End
Tongue

Special Tongue End
Spec. Tongue

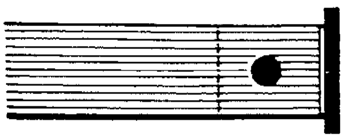
Patent B End
Pat. B



Hole End
H



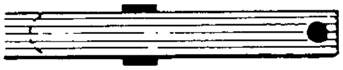
Pin End
Pin



T End
T

Longines T End
Longines T

Double Brace
D. B.



Double Brace Anchored
D. B. A.

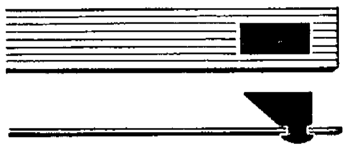
Motor Barrel Brace
M. B.

Double Brace and Hole End
D. B. & H.

Double Brace Pin End
D. B. & P.

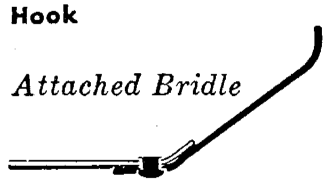
Double Brace and T End
D. B. & T.

T Brace
T. B.



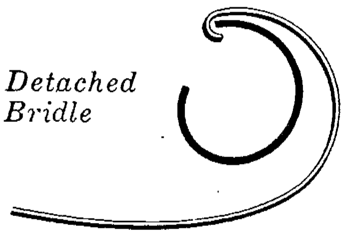
Undercut Hook
Hook

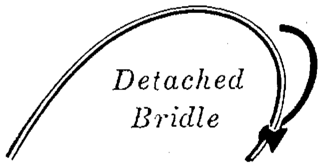
Attached Bridle



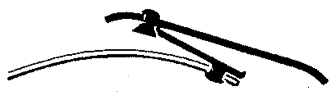
Detached Bridle

Detached Bridle





Detached Bridle



Detached Bridle

Detached Bridle (used with regular Swiss tongue-end mainsprings)

CHECK YOURSELF

Progress Check 5A — A Self Test Review of Lesson 5

Study Sections 125 through 144. Then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The purpose of the mainspring barrel is to keep the mainspring from ____________________ too far.	125
2. The purpose of the fusee is to ____________________ the power.	125
3. The mainspring barrel used with a fusee has ________________ teeth.	125
4. A going barrel is one which has ____________________ in its circumference.	130
5. The balance cock is kept in place by two ________________________ .	131
6. Before removing the barrel bridge, always ________________________ ________________________ .	132
7. The part which holds the click against the ratchet is called a ________________________ .	132
8. Four common styles of mainspring tips mentioned in this lesson are: ____________________ end; ____________________ end; ____________________ end; ________________________ end.	139
9. New mainsprings are not wound as tightly in their container as in a watch to avoid ____________________ the coils.	144
10. Number in proper order these operations in removing the mainspring from a mainspring barrel in an 18 size full plate Elgin movement: ( ) Remove barrel bridge. ( ) Remove balance cock screw ( ) Remove dust band, if any ( ) Let down power by releasing the click. ( ) Remove the balance cock ( ) Turn balance cock upside down ( ) Pry off cap ( ) Take out barrel ( ) Unhook and lift out barrel arbor ( ) Release mainspring tip ( ) Remove mainspring from barrel, one half coil at a time	130 thru 138

==

CHECK YOURSELF

Progress Check 5B — A Self Test Review of Lesson 5

Study Sections 145 through 162; then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any, review the section indicated.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. An average good watch should run over ________ hours on one winding.	145
2. A disadvantage of replacing the mainspring with your fingers is that you may easily ________________________ the mainspring.	146
3. A type of mainspring which does not require the use of a mainspring winder is the modern ________________________________.	162A
4. In using a mainspring winder, you should select a barrel which easily fits ______________________ the mainspring barrel of the movement.	148
5. Mainspring ______________________________ are used to shape the inner end of the mainspring to fit closely around the arbor.	148
6. The first step in transferring the mainspring from the winder to the watch barrel is to secure the ____________________ of the mainspring in the barrel.	150
7. In replacing a mainspring, be sure the coils are wound in the ____________________ direction as the old mainspring.	151
8. If the cap of the going barrel is up when in position in the watch, the mainspring winds to the ____________________ . If the cap is down, the mainspring winds to the ____________________.	152
9. The ______________________ of the mainspring should be oiled in three or four places with a heavy, easily spread oil (usually clock oil).	
10. When the cap is snapped back on the barrel, the reinforced portion of the cap should be __________________________ the mainspring or the cap will be wrong side out.	153
11. The arbor should be oiled at ____________________ where it comes through the barrel.	153
12. The _____________________ of the mainspring arbor should also be oiled where it comes through the barrel bridge.	154
13. A ______________________________ is used to apply power when testing a new mainspring.	155
14. In replacing the balance, be careful not to bend the _________________.	157

Progress Check 5B (continued)

	Section Ref.
15. In examining a watch brought in for repairs, the first test should be to try the ______________________.	159
16. Mainsprings are more likely to break in the ______________ months.	160
17. The stop work keeps the mainspring from being ______________ to its limit and also from ____________________ to its full capacity.	161
18. A sealed barrel mainspring is permanently lubricated with a ______________________.	162B

ANSWERS TO
PROGRESS CHECK 5A:

1. expanding
2. equalize
3. no
4. teeth
5. steady pins
6. let down the power
7. click spring
8. hole
   T
   tongue
   double brace
9. setting

10. (6)
   (1)
   (4)
   (5)
   (2)
   (3)
   (8)
   (7)
   (9)
   (11)
   (10)

ANSWERS TO
PROGRESS CHECK 5B:

1. 30
2. distort
3. non-breakable
4. inside
5. ceiling pliers
6. tip
7. same
8. right
   left
9. coils

10. next to
11. each end
12. pivot
13. bench key
14. pivots
15. winding
16. summer
17. wound
    expanding
18. dry lubricant

HOW TO CHANGE A MAINSPRING IN A WATCH WHICH HAS A FUSEE.

Tools, Equipment and Supplies:

Tweezers	Movement Holder	Oiler	Mainspring Winder
Screwdrivers	Bench Key	Oil	

PROCEDURE: REFERENCE:

1. Remove balance and cock. — Sections 125 through 129.
2. Release power.
3. Remove barrel bridge.
4. Turn barrel around so you can unhook chain.
5. Lift barrel from movement.
6. Remove barrel cap.
7. Remove barrel arbor and mainspring.
8. Replace proper spring.
9. Replace arbor and oil.
10. Replace cap.
11. Test arbor end shake. (A small amount of end shake is necessary.) — Assignment 18
12. Place barrel in movement.
13. Replace barrel bridge.
14. With key on barrel arbor, hook the end of the chain to barrel and coil chain around barrel.

    NOTE: If chain slides down on barrel or under barrel, a slight amount of oil or grease on barrel edge will hold chain in place while you are winding chain around barrel.

15. With key on winding arbor, your watch should start to wind.

    NOTE: If watch does not wind but chain is uncoiling from barrel, your spring is not hooked in barrel arbor.

    If chain does not coil around first wheel, your chain has unhooked from the first wheel.

HOW TO REPLACE A MAINSPRING IN A SWISS OR AMERICAN WATCH WITH AN EXPOSED RATCHET AND CROWN WHEEL.

Tools, Equipment and Supplies:

Tweezers	Movement Holder	Bench Key	Oil
Screwdrivers	Mainspring Winder	Oiler	

PROCEDURE:	REFERENCE:
1. Release power. CAUTION: Always test the power and release it before removing a barrel from a watch.	
2. Remove ratchet wheel screw. (This is a right hand thread in American watches; left hand thread in some Swiss watches.)	
3. Remove barrel bridge.	
4. Remove barrel.	
5. Remove cap, arbor and spring.	Sec. 136-138
6. Select new mainspring.	Les. 7, Sec. 199
7. Wind new spring into proper mainspring winder.	Fig. 104
8. Inject spring into barrel. Be sure it's hooked.	Fig. 150
NOTE: When placing a mainspring in the barrel, you will find it necessary to place the tip of the spring in its proper place and hold it there while the spring is being ejected from the mainspring winder.	
9. Replace arbor.	Fig. 91, Sec. 152
10. Oil spring and arbor.	Sec. 153
11. Replace cap. Test for arbor end shake.	Assignment 18
12. Place barrel in movement.	
13. Replace barrel bridge and screws. Check to see that crown wheel teeth mesh with winding pinion.	
14. Replace ratchet wheel and screw.	
15. Test winding.	

LESSON	5
MAINSPRINGS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L5-J3

HOW TO REPLACE A MAINSPRING IN A FULL PLATE MOVEMENT.

Tools, Equipment and Supplies:

Tweezers	Movement Holder	Bench Key	Oil
Screwdrivers	Mainspring Winder	Oiler	

PROCEDURE:	REFERENCE:
1. Remove balance cock and balance wheel.	Sec. 131
2. Let down power. CAUTION: Always test the power and release it before you remove the barrel from a watch.)	Sec. 132-133
3. Remove barrel bridge.	Sec. 134
4. With tweezers lift barrel arbor up (Fig. 89) then slide barrel out of movement.	Sec. 135
5. Remove barrel cap and arbor.	Sec. 136-137
6. Remove mainspring.	Sec. 138
7. Select new mainspring.	Les. 7, Sec. 199
8. Wind spring into proper mainspring winder.	Sec. 148-149-152
9. Inject spring from winder into barrel, making sure end is hooked.	Sec. 150
NOTE: When placing a mainspring in the barrel, you will find it necessary to place the tip of the spring in its proper place and hold it there while the spring is being ejected from the mainspring winder.	
10. Replace barrel arbor.	Sec. 152
11. Oil spring and arbor.	Sec. 153
12. Replace cap, making sure that it is in line if you have a "T" end or a double brace.	Sec. 153
13. Test arbor for end shake. A small amount is necessary.	Assignment 18
14. Replace barrel and barrel bridge.	Sec. 154
15. Check winding.	Sec. 155
16. Replace balance and cock.	Sec. 156

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 5

Name: No.: Date:

Circle ONE correct answer: SUBJECT: Mainsprings in Watches

1. The advantage of the fuzee in connection with the mainspring is that it:

   Supplies even power | Is easier to wind | Takes up less space | Causes fewer broken mainsprings

2. The going barrel:

   Is always made of steel | Turns while the arbor stands still during winding | Has the arbor permanently attached | Has teeth cut in its circumference

3. What is the least number of steady pins found on each bridge?

   One | Two | Three | Four

4. Why is it necessary to test the power before removing the barrel bridge?

   To determine if mainspring is broken | To make sure it is wound up tight | To make it easier to remove the bridge | To prevent damage to the watch

5. The purpose of the click spring is to:

   Hold the click against the ratchet | Prevent ratchet from coming loose | Keep from winding mainspring too tight | Keep tension on the barrel arbor

6. In most watches with going barrels, the barrel arbor:

   Screws into the hub | Is made with the hub in one piece | Is held into the hub by 2 driven pins | Is held into the hub by means of 2 screws

7. Which one of these types of oils should be used on mainsprings?

   Very thick | Very thin | Non-spreading | Spreading

8. How many hours should an ordinary watch run with one winding?

   60 | 40 to 48 | 32 to 36 | 24 to 28

9. The main reason for using a mainspring winder is to:

   Shape up the mainspring | Reform the inner end | Wind the mainspring tighter | Keep from distorting the spring

10. The purpose of the stop work is to:

    Prevent slippage of mainspring | Prevent the mainspring from being wound up completely as well as from running down entirely | Prevent winding the watch too fast | Stop the watch when used as a stop watch

11. Which one of the following tests is unnecessary after replacing a mainspring?

    Apply power with a bench key and listen to the sound of its click | Apply power and see if there is resistance of the mainspring | Test end shake of stem | Release bench key and see if it turns back to first position

12. A non-breakable mainspring:

    Need not be cleaned | Does not require a mainspring winder | Is permanently lubricated | Never needs replacement

Detach page or cut along this line — and send to the School for grading.

Master WATCHMAKING

Lesson 6

MOTOR AND JEWELED BARRELS

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

Printed in the United States of America

INTRODUCTORY INFORMATION

American manufacturers do not use motor barrels as a rule. However, there are several models of Waltham watches which do have a motor barrel, as well as a few other makes in railroad grade watches.

The study of jewel barrels at this time is to acquaint the student with some of the finer work to be met with in watchmaking or watch repairing. This type of barrel is usually found in railroad watches and not in the average pocket or wrist watch of today. The student should not expect to apply this information immediately, as it takes considerable experience to repair these fine grade watches. This type of work can be undertaken after greater knowledge and proficiency has been gained, at which time these lessons will be a valuable reference. It is again emphasized that inexpensive practice watches are best for the learner, so that little is lost if a slip is made in repairing.

KEY POINTS OF ASSIGNMENTS 20, 21 and 22:

- The location and purpose of the safety pinion.
- How to recognize a motor barrel, and how it functions.
- The purpose of the recoiling click.
- How to remove the motor barrel.
- The parts of the motor barrel.
- How to reassemble the motor barrel.
- Jeweled barrels.

ASSIGNMENT NO. 20: Study Sections 165 through 173.

Study Questions:

1. What is a safety pinion?
2. What is its function?
3. What is a motor barrel?
4. How does it differ from the going barrel?
5. What is a recoiling click?
6. How is the motor barrel removed?
7. What are the parts of the motor barrel?
8. How is the motor barrel reassembled?

ASSIGNMENT NO. 21: Study Sections 174 through 178.

1. What is the difference between the ordinary motor barrel and the jeweled barrel?
2. How does the Howard jeweled barrel differ from the Waltham jeweled barrel?
3. What other makes of watches use a jeweled barrel?

ASSIGNMENT NO. 22: Study Sections 179 through 181.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 6 and send in for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 6

Sections 165 to 181

Lesson 6. — Motor and Jeweled Barrels.

Section 165 WHEN the mainspring breaks and its power is released all at once, there is a sharp recoil on the barrel and when this is transmitted to the train there may be pivots and teeth not strong enough to stand the blow. Before the advent of the safety pinion it was no uncommon thing to find broken or bent train pivots and teeth due to this recoil from a broken mainspring.

Sec. 166 — The Safety Pinion

The introduction of the safety pinion protected the train from this shock. This pinion is mounted on the center staff in such a way that it can turn in one direction but is held in its proper position when the power is applied from the barrel.

One form is shown in figure 110, in which the pinion A is hollow and threaded to fit the threaded part of the center staff at B. When the pinion is screwed in place the power from the barrel has a tendency to tighten it on the staff.

Should the mainspring break in the watch the recoil forces the barrel in the other direction and loosens the pinion from the staff allowing the barrel to spin without damage to the teeth or pivots. In figure 111 the pinion is shown in about the position it would assume when driven off by the recoil of a broken mainspring. Before replacing in the watch the pinion should be screwed down to the shoulder at C.

Later the motor barrel of the type shown in the next section was introduced and this too protects the train from the shock of a broken mainspring, in fact it is sometimes called the safety barrel.

Sec. 167 — The Motor Barrel

In the going barrel as we learned in our previous lesson, the teeth for the first wheel of the watch train are cut in the barrel making it the first wheel of the watch. In the motor barrel shown here, the barrel and first wheel are two separate parts and are connected to each other by the mainspring — one end of the mainspring being hooked to the barrel and the other end to the first wheel.

A very good example for the students first work in this type of barrel is found in a Waltham 16 size movement shown in figure 114. This model is known as a three quarter plate movement as opposed to the older full plate model used in our last lesson and is much easier for the beginner to take down and reassemble. Practically all pocket watches now are either three quarter plate or bridge models.

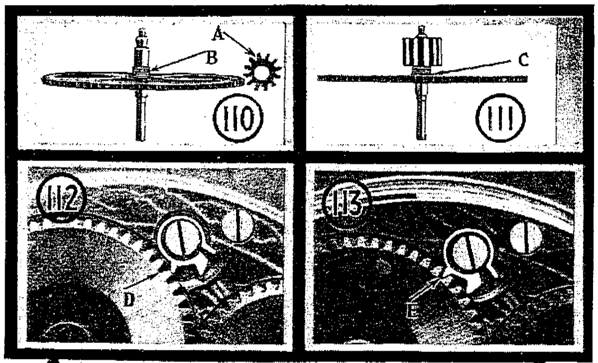
Sec. 168 — Recoiling Click

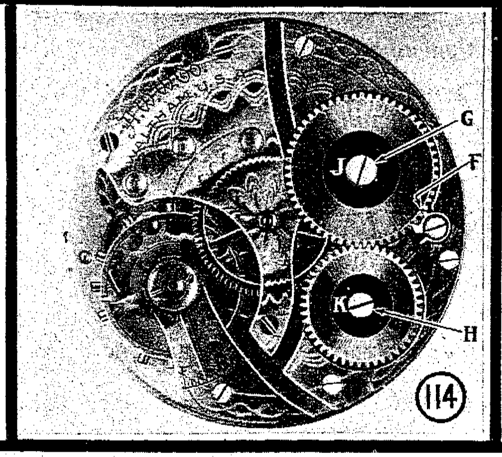
This movement has exposed winding wheels with a recoiling click. The advantage of this style is that after winding as far as possible the click allows the ratchet wheel to back up and the coils of the mainspring are not drawn too tightly together. With the click shown in our last lesson in figure 90 it is possible to wind the coils of the mainspring so closely together that there is a sort of adhesion produced by friction on each other and the balance does not attain a full motion until the watch has run long enough to loosen these coils.

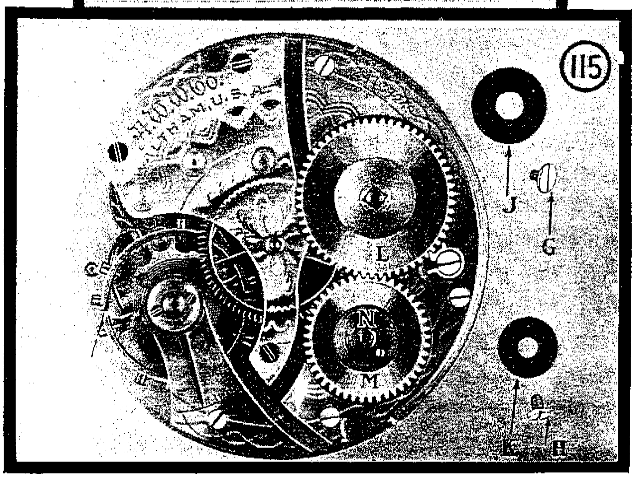
In figure 112 is shown this recoiling click, over twice its actual size, just ready to drop off the tooth of the ratchet wheel. After it has dropped into the space at D the power of the mainspring pulls it back as shown at E figure 113 and F figure 114, thus allowing the ratchet wheel to "recoil" or back up slightly after having been wound to its highest point.

Sec. 169 — Replacing a Mainspring in Motor Barrel

With this model it is not necessary to remove the balance in order to get at the mainspring. The winding wheels and click being exposed some prefer to let down the power before taking the movement from the case. This can be done by holding the crown while pressing back the click by means of a screw driver. If the movement is out of the case use the proper







sized bench key as described in the previous lesson to release the power.

Next take out the two screws at G and H figure 114 and remove the two steel discs J and K after which it will appear as in figure 115 in which J represents the ratchet wheel disc, G the ratchet wheel screw, K the crown wheel disc and H the crown wheel screw.

Lift off the ratchet wheel at L and the crown wheel at M. When you remove the crown wheel at M it will bring with it the crown wheel washer at N. It is not necessary to take off the crown wheel in order to replace a mainspring as the barrel bridge is easily removed with this wheel in place but as this lesson is to familiarize you with this part of the watch it is well to take it down just as I have done in these illustrations.

In figure 116 are these parts as they appear after being removed. L the ratchet wheel, M the crown wheel, and N the crown wheel washer. Notice the hole at O in the crown wheel washer which fits over the screw P on the barrel bridge.

The hole Q in the ratchet wheel is finished square as may be seen in this photograph and fits over the square end of the barrel arbor at R. In figure 115 this can be seen as it appears when assembled.

Sec. 170 — Remove the Barrel Bridge

Loosen and remove the barrel bridge screws at S figure 116, and with a pair of tweezers lift off the barrel bridge to the position shown in figure 117. This leaves the barrel and first wheel at T exposed. The Barrel Bridge at U is turned over in order that you may see how it appears from the lower side.

In section 131 of the last lesson I described and showed the steady pins on the balance cock of the movement used in demonstrating a going barrel. Not only are steady pins used on the balance cock but on any bridge which it is necessary to locate accurately on one of the plates. On the bottom of the barrel bridge in figure 117 are shown the two steady pins at A, which fit into the holes B on the lower plate.

Steady pins should be so fitted in their holes that there is no side play yet must allow the bridge to be released easily when the screws are removed. These requirements are met in the Waltham style of steady pins, which are tapered and fit in holes bored to match the pins. This insures an easy method of separating or assembling the bridges and balance cock.

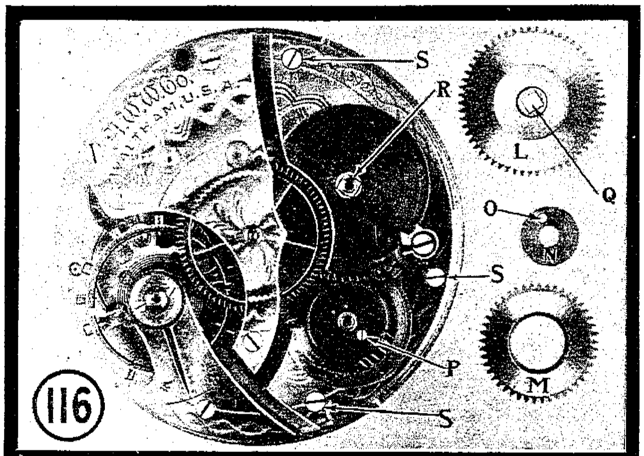
The barrel with the first wheel is easily lifted out as shown in figure 118. It is seen turned over with the steel barrel, V, uppermost. The barrel arbor may be lifted out or it could have been removed when in the position shown in figure 117, by grasping the barrel arbor with a pair of tweezers and lifting straight up.

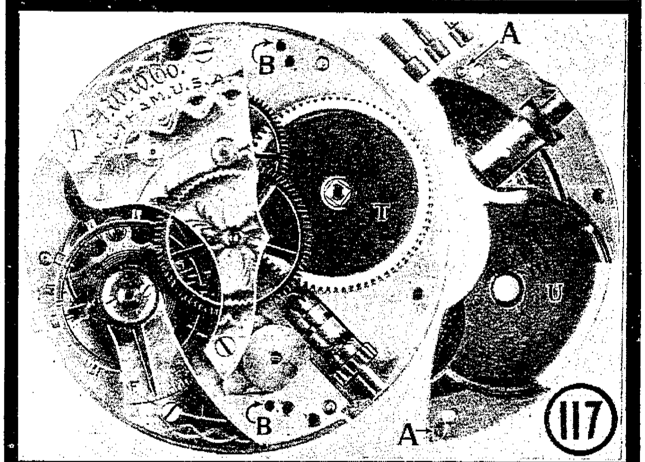
Sec. 171 — Disengage Inner End of Mainspring

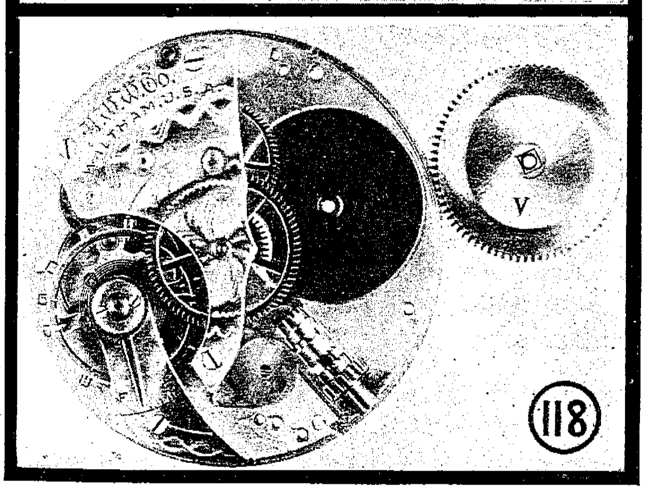
Take hold of the barrel with one hand and the first wheel with the other and disengage the inner end of the mainspring by twisting toward the right.

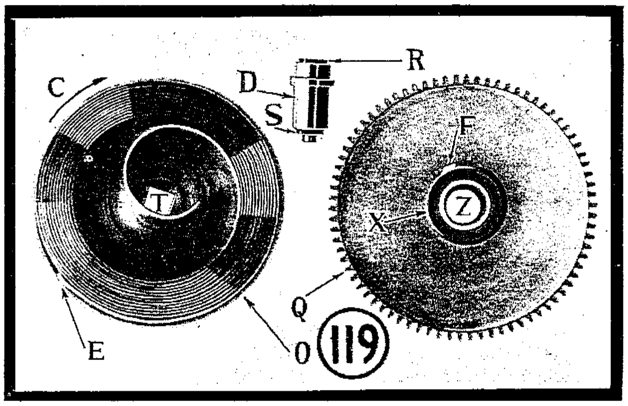
In figure 119 is shown an enlarged view of the barrel at O with the mainspring in place, the barrel arbor at D and the first wheel or main wheel at Q. The mainspring has a hole end that slips over the hook in the barrel at E. As explained before this type of mainspring should be bent to a shorter curve right at the tip in order to keep it from pulling off the hook. This bend can be seen at E.

In the going barrel described in our last lesson, the barrel turned with the wheel and the arbor turned only while the watch was being wound. In this style of barrel the arbor turns while the watch is being wound and the lower square end at S fits into the square hole of the barrel at T causing the barrel to turn with the arbor. That portion D of the arbor fits in the hole in the first wheel at Z and is the axis upon which the first wheel turns when the watch is running.









The hub at X with its hook for the inner end of the mainspring at F instead of being secured to the barrel arbor is fastened to the first wheel.

Sec. 172 — Ratchet Wheel, Arbor and Barrel, Turn As One Piece

When the ratchet wheel L figure 115 is turned in winding the watch, it turns the arbor, the upper square of the arbor at R figure 116 being held in the square hole in the ratchet wheel at Q figure 116. The arbor extending through and turning on the inside of the first wheel at Z figure 119 also turns the barrel in the direction of the arrow C.

The inner end of the mainspring being hooked to the hub on the first wheel at F is held still as the barrel revolves in winding and the mainspring is wound around the hub at X and the power is applied to the first wheel from this hub.

If the mainspring breaks the recoil is taken through the barrel and ratchet wheel rather than through the first wheel and train, consequently no shock is transmitted through the train to the injury of the smaller parts.

In replacing a mainspring in this model select a barrel in your winder of the proper size to fit this steel barrel and wind in your mainspring, leaving enough of the tip protruding, to hook easily into the watch barrel, and transfer from the winding barrel to the watch barrel. Notice that this mainspring is coiled to the left in the watch barrel.

Shape the inner end to fit closely around the hub on the first wheel, testing it to see that it is hooked, and then oil your mainspring as in the going barrel. Adjust the hole in the first wheel until it is directly over the square hole in the barrel and put a small amount of clock oil on the part D, slip the arbor into position and manipulate by grasping the square at R with a pair of tweezers, until the lower square end slips into the square hole in the barrel and it will appear as shown in figure 118.

Sec. 173 — Assembling This Type.

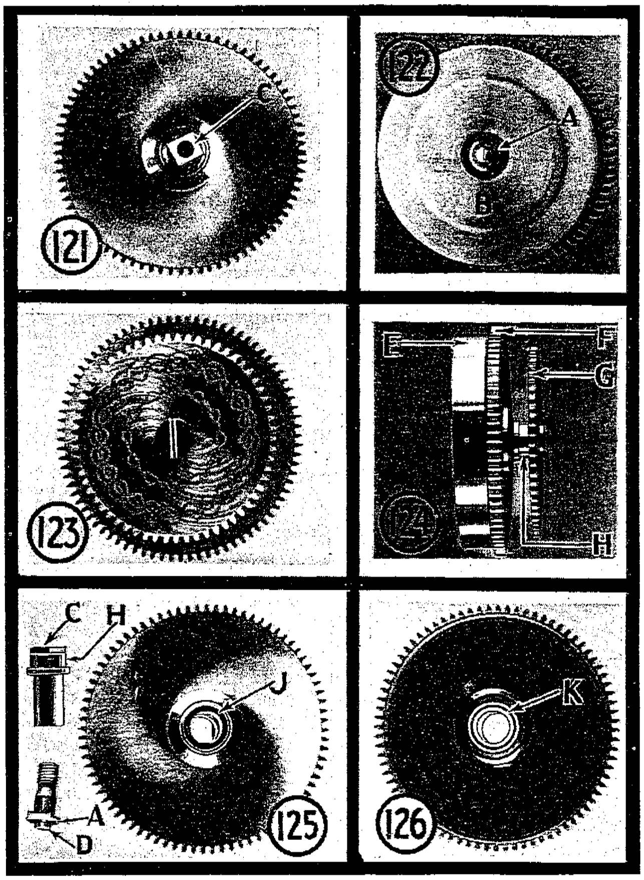
Assemble these parts by reversing the process of taking down, set the barrel in its position as in figure 117 being careful not to allow the lower square of the arbor at S figure 119 to slip out of the square hole in the barrel at T.

Replace the barrel bridge and set the screws as in figure 116. With your oiler place a small amount of clock oil where the upper end of the barrel arbor comes through the barrel bridge and also a like amount where the lower end or pivot of the arbor comes through the bottom plate. Set the crown wheel in place. Place a little clock oil in the shoulder of the crown wheel where the crown wheel washer came in contact with it. Now set the crown wheel washer in its place with the hole O figure 116 directly over the screw P. Replace the ratchet wheel with the square hole fitted on the square of the winding arbor and the click on the outside of the wheel as in figure 115. Place the steel discs in the proper positions and set the screws holding them in place and your movement should appear as in figure 114.

Sec. 174 — Jeweled Barrel

The addition of jewels for bearings in watches in place of the metal bushings which were formerly used has been a great factor in reducing the friction found in the train and escapement. Many of the uninitiated get the idea that the jewels are placed in a watch merely for their intrinsic and ornamental value, the same as diamonds in a watch case.

This is not the reason but rather on account of their extreme hardness and the fine polish that can be given to them are they used as



bearings to reduce the friction of the pivots. The hole jewels used for this purpose in the train are made of hard stone such as ruby, sapphire or garnet. Each has a hole drilled through it, this hole being highly polished and of a diameter to fit the pivot for which it is intended.

As jewels became popular in watches, customers were inclined to judge the value of a watch by the number of jewels that it contained. Some manufacturers endeavoring to get as many jewels as possible in their watches placed jewels at each end of the barrel arbor, these jewels being set in the upper and lower plates. If you will refer to section 137 in lesson 5 you can see that the only time such jewels would reduce friction would be in winding the watch because the barrel arbor in the type of barrel then in use, that is the going barrel, turns only when the watch is being wound.

However, with the introduction of the motor barrel it became possible to use jewels that would actually reduce the friction on these heavier parts when the watch was running.

Sec. 175 — Waltham Jeweled Barrel

In figure 120 is shown a Waltham movement in which is found a barrel much on the order of the one I have been describing in previous sections of this lesson. This barrel however is jeweled but may be removed from the movement by taking off the ratchet wheel and barrel bridge the same as with the other one.

Figure 121 shows the top of this jeweled barrel and figure 122 the lower side. At A in figure 122 is a shoulder or flange on the lower end of the arbor which holds the steel barrel B in place.

The arbor in this jeweled barrel consists of two parts as shown in figure 125, the upper part with its square at C being the same end that is shown at C in figure 121 and the lower part with the pivot D and the shoulder at A is the part that shows in figure 122.

In order to take this barrel apart it is necessary to unscrew these two parts of the arbor which is done by placing the ratchet wheel on the square end holding it there with the ratchet wheel screw as shown in figure 123. Figure 124 is a side view of this assembly with the ratchet wheel and ratchet wheel screw in place, in which E represents the barrel, F the first wheel and G the ratchet wheel, while the arbor may be seen extending out of the first wheel at H. This corresponds to the part H of the arbor shown in figure 125.

Grasp the barrel part E in one hand and the ratchet wheel G in the other and twist to the left, just as you would in taking off the screw bezel of a watch case. When you do this the upper portion of the barrel arbor may be removed with the ratchet wheel while the lower part will come out of the barrel section.

The jewels are set in the main wheel, one of them being in the upper part as indicated by the arrow at J figure 125, and the other one in the lower part of the hub as shown at K in figure 126.

In replacing a mainspring we go through the same operation that we did in replacing one in the motor barrel shown in figure 119.

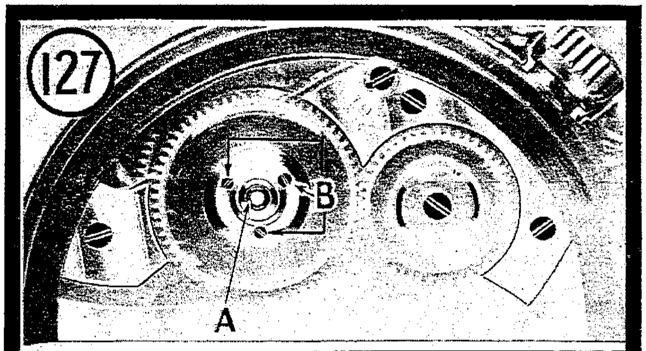
Sec. 176 — Howard Barrel with Jewels

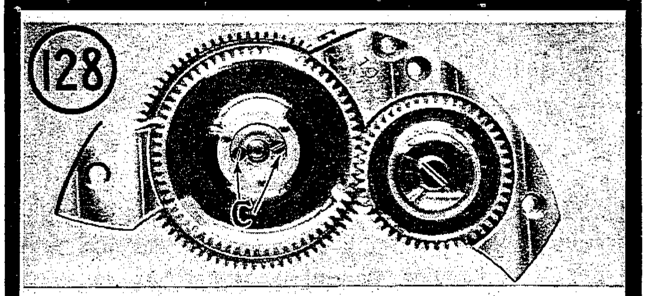
In the Howard Watch, the winding parts of which are shown in figure 127, the jeweling of the barrel is treated in a different way.

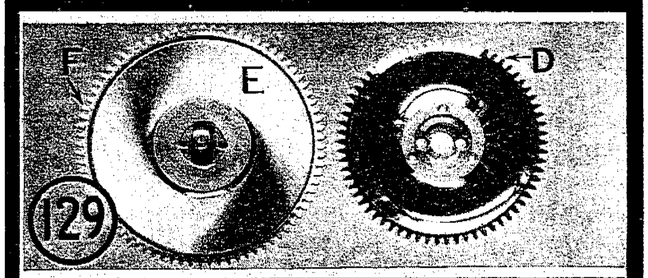
The jewel at A is in the setting held in a recess in the ratchet wheel by means of the three screws at B. Removing these three screws and lifting out the jewel in its setting, the ratchet wheel appears as in figure 128. In this photograph I have shown this assembly with the barrel bridge removed from the plate in order to avoid confusion.

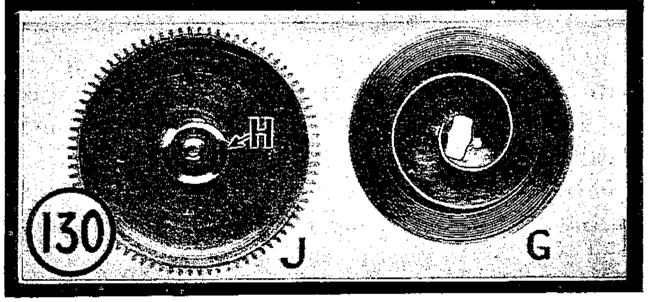
The ratchet wheel is secured to the steel barrel by means of the two screws shown at C in figure 128. By removing these two screws you are able to lift off the ratchet wheel and separate the barrel and first wheel from the barrel bridge as in figure 129, where D is the ratchet wheel, E the barrel and F the first wheel of the watch. After releasing the inside end of the mainspring from the arbor which is connected with the first wheel F, the barrel can be lifted out as shown in figure 130 where the barrel with its mainspring is seen at G and the first wheel at J.

The arbor, first wheel and the hub H act as one piece and when the watch is being wound the ratchet wheel and barrel rotate much the same as the Waltham Jeweled Barrel described in the previous section.

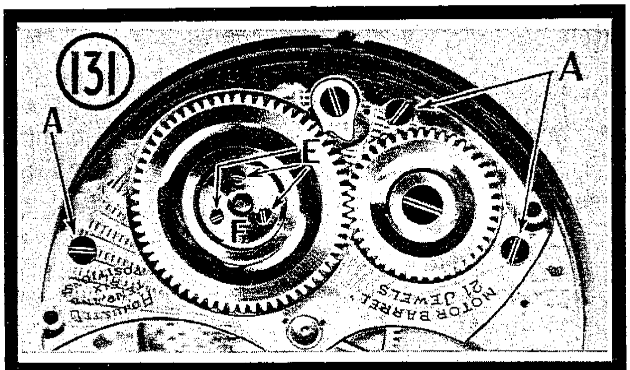


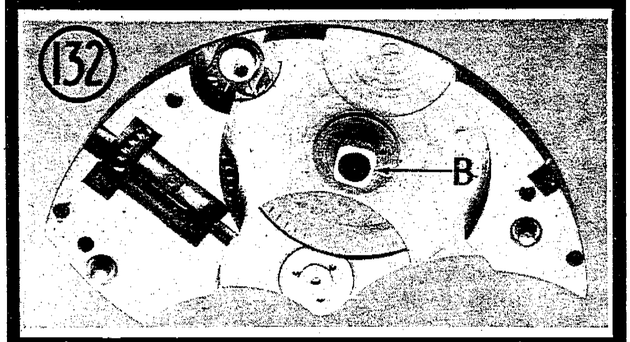






In this type the effect of having the first wheel running in jeweled bearings is reached by a different plan, the ends or pivots of the arbor running in the jewels, the upper one in a setting held in the ratchet wheel — A figure 127 — the lower jewel in the lower or pillar





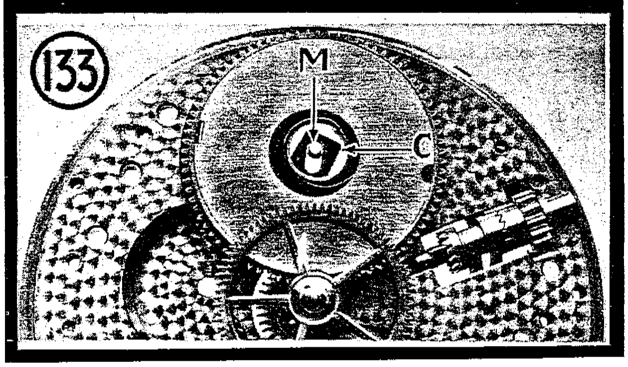


plate of the movement. The jeweled bearings being placed at the extreme ends of the barrel arbor permit the use of smaller pivots, thus reducing the friction to a minimum. This advantage of smaller pivots in the jewels is also found in the Illinois and Hamilton types described in the next two sections.

Sec. 177 — Illinois Barrel

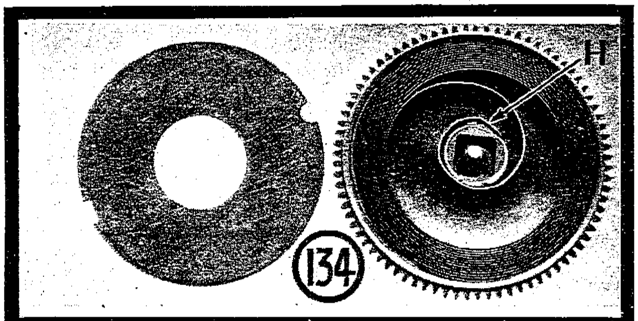
In figure 131 is shown the barrel bridge of a 16 size Illinois movement in its position on the lower plate, together with the ratchet and crown wheel.

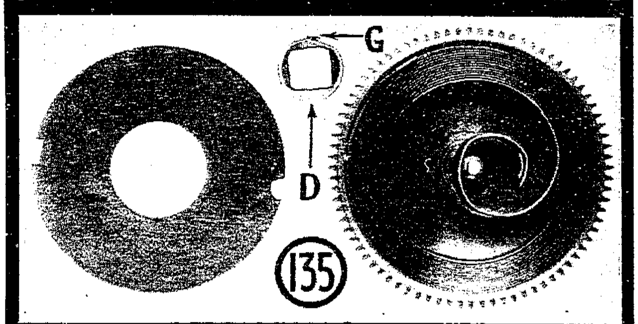
This type of Illinois barrel is different from the other models shown in that it is not necessary to take apart the ratchet unit in order to get at the barrel. Remove the three bridge screws shown at A, and it is possible to lift the barrel bridge and with it the ratchet unit without disturbing the barrel.

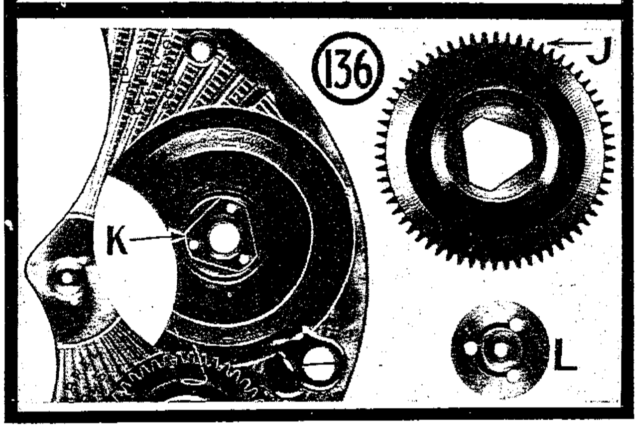
Figure 132 is this assembly on the barrel bridge after it has been lifted off the bottom plate and turned over in order to show it from the other side. Figure 133 shows the way the barrel appears after lifting off the bridge. The square on the ratchet hub at B, figure 132, fits into the square hole of the snailed hub at C figure 133.

In figure 134 is shown the barrel with the cap or barrel cover removed and again in figure 135 the barrel and cap with the snailed hub taken out and shown at D. This hub carries the hook at G on which the inner end of the mainspring catches. See H in figure 134.

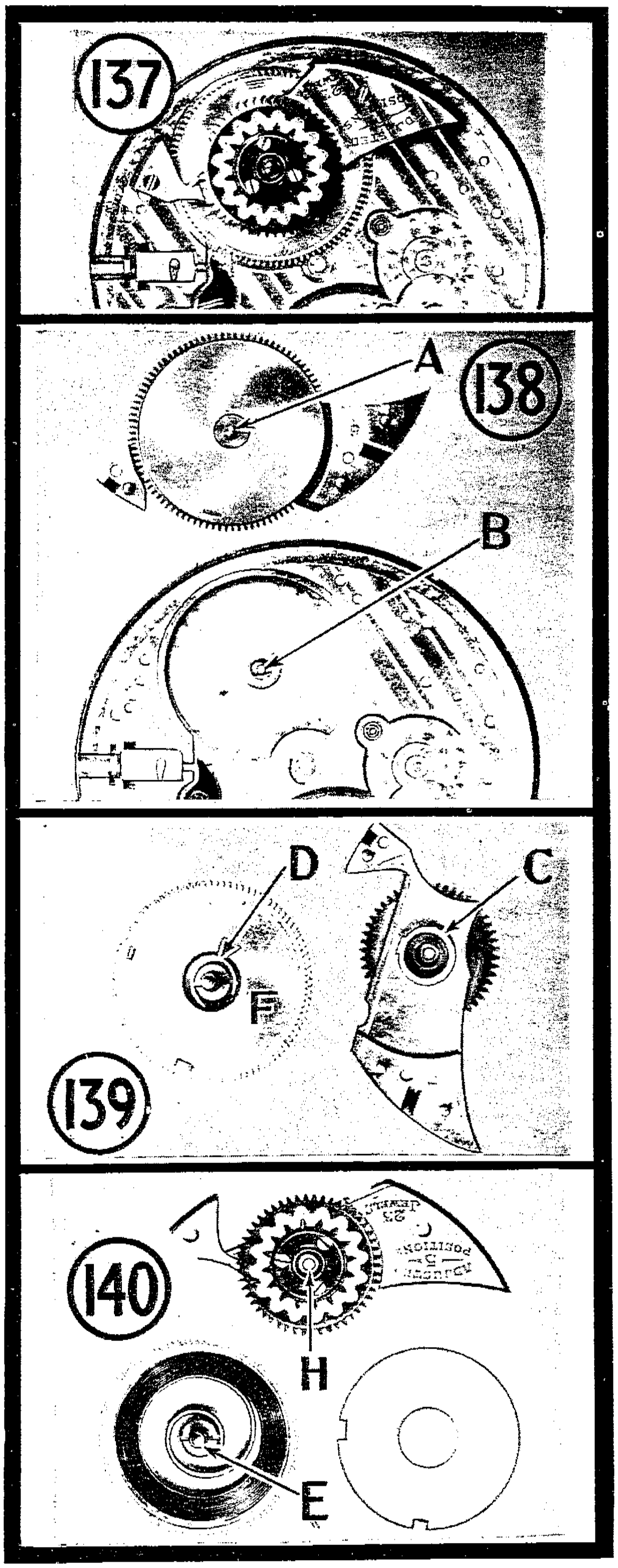
Only when you want to make a thorough cleaning of the watch is it necessary to take







apart the ratchet unit and to do this remove the three screws shown at E in figure 131, lift out the cap F and remove the ratchet wheel. The parts are shown in figure 136 where J re-



presents the ratchet wheel with the triangular shaped opening which fits over the tri-squared top of the ratchet hub at K. At L is shown the lower side of the ratchet cap. This cap is made of nickel and the bearing for the upper end of the barrel staff or arbor at M figure 133 is in the cap. In the 23 jeweled movement this cap is fitted with a jewel for the barrel staff bearing. In cleaning this unit it is necessary to clean each part individually and re-oil as you assemble it.

In replacing the barrel bridge with ratchet unit attached as shown in figure 132 and with the barrel in its place on the lower plate as in figure 133, come down from the top with the barrel bridge with the square at B over the motor barrel staff at M and gently press on the barrel bridge. See that your center wheel and pinion is in place and with your tweezers revolve the ratchet wheel and the parts should fall together easily. Place the barrel bridge screws in place, tighten down and your assembly is complete.

Sec. 178 — Hamilton Barrel with Jewels

The barrel from a 12 size, 23 jeweled Hamilton watch shown in figure 137, like the Illinois, may be removed without taking the ratchet unit apart. Loosening the barrel bridge from the plate and turning it over as in figure 138 gives an opportunity to view the lower part of the barrel and the pivot at A which fits in the lower jewel set in the plate at B. By manipulating the barrel and unhooking the inner coil of the mainspring from the hub it is possible to separate the parts as shown in figure 139 in which C is the hub, D the inner coil of the mainspring and F the cap of the barrel. In order to oil the barrel bridge for ratchet wheel and hub or when cleaning the watch, it is necessary to disassemble these parts and this is accomplished by grasping the barrel bridge and ratchet wheel in the left hand and with a pair of brass lined pliers grip the hub (C figure 139) and turn toward you.

Figure 140 shows the bridge with the upper jewel in its place in the ratchet unit, also the cap removed from the barrel showing the position of the coils of the mainspring. E is the upper pivot of the barrel arbor which fits in the jewel at H.

Right at this time you may not have the opportunity of working upon these different styles of motor and jeweled barrels but as they come in to you for repairs, it will be possible to take them down without trouble if you follow the instructions found in this lesson.

It is an easy matter to handle them providing you know how they are assembled but difficult to study out the proper steps in taking apart and re-assembling without such knowledge.

Sec. 179 — Earning While Learning

Having mastered this and the preceding lessons, you may feel inclined to realize some financial returns on your knowledge thus acquired. This, of course, depends upon your ability, previous experience, and the circumstances under which you work. Some states require you to be a registered watchmaker before you enter the field of watchmaking. In others, you can do work if you are an apprentice under the supervision of a watchmaker who is registered. (The laws vary in license states.) In most states, watch repairing, like many other fields, is open to the individual's talent and does not require a license.

This does not imply that an incompetent workman can succeed. Your best chance for success rests upon your ability to do expert watch repairing and to give the public its money's worth.

Because you have satisfactorily progressed with your lessons to this point, it does not follow that you now are qualified to handle all watch repair work. Trying to do all kinds of repair at this time may easily lead to trouble and dissatisfied customers. It is better to wait until you are further trained to make general repairs.

Remember, the person who carries a watch wants the same time keeping qualities it had when it came from the factory. Most of all, he wants reliable service at a fair price rather than inferior work at cut rates. Be fair to your customer and to yourself. If you are not able to make repairs for people, however much you would like to, explain your reasons to them. You won't hurt their feelings but you might hurt their watch.

If you are in a position to accept minor repairs, do not attempt anything with which you are not familiar.

Sec. 180 — A Good Rule to Follow

A rule that has helped many watchmakers toward success is not to make five and ten cent adjustments on watches. Moving the regulator, tightening a screw, or similar minor adjustments, which take only a moment's time, should be considered opportunities to establish "good will." Doing small favors like these make people look upon you as a friend and influences them into being future customers.

It takes practice on many types of watches before you will recognize the repairs which are required; therefore, practice on watches—and lots of them—until you acquire the ability to make repairs quickly and efficiently. Build your name as one who is learning to be a Master Watchmaker, tend strictly to your learning, and it won't be too long before you will be entitled to do work and get a proper return for it.

Sec. 181 — Learn the Vocabulary of Your Vocation

Make it a point to become familiar with the proper technical or trade names of the different parts of a watch so that you can talk of them with other members of the trade and make yourself understood. It is no uncommon thing to hear of a "ring" on a watch case when "bow" is meant, "shaft" for "balance staff", "chain drive" for "fusee", "Face" for "Dial" etc.

In these lessons be sure you know the proper pronunciation of the words used. Do not pronounce bow as you would the bow of a ship but rather as you would in bow and arrow. In this new vocabulary which you are learning, make use of your dictionary. Look up the pronunciation of each new word and then memorize it. Make it a habit to talk about your work with your friends and members of your family and in your conversation use these new words. See if they know the correct names used in describing parts of a watch but do not go beyond your own depth! Keep on the safe side and discuss only that with which you are thoroughly familiar. In other words, don't discuss Escapements while you are still studying Mainsprings in Watches.

Looking Forward

In the lessons so far it has been taken for granted that the mainspring in each practice watch was of correct dimensions for that particular movement but in the next lesson you will be taught the methods of selecting mainsprings and also shown some interesting experiments relating to the proper length required to get the most service from them.

Your lesson will include several charts showing the Dennison and Metric measurements along with an illustration of each tip on 135 mainsprings. These charts will help you select mainsprings for American watches. For Swiss and other American mainsprings not listed, use a material catalog.

CHECK YOURSELF

Progress Check 6A — A Self Test Review of Lesson 6

After you have studied Sections 165 through 173, see if you can answer these questions without looking back. DO NOT SEND ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you have missed any questions, review the section on which the statement is based.

DIRECTIONS: In the first nine questions below, place a + in front of each correct statement.	Section Ref.
____ 1. The safety pinion protects the train from the recoil shock of a mainspring which breaks.	166
____ 2. The motor barrel also protects the train from the shock of a broken mainspring.	166
____ 3. In a motor barrel, the barrel and first wheel are one piece.	167
____ 4. A recoiling click keeps the mainspring from being wound too tightly.	168
____ 5. In removing any type of barrel, the balance should be taken out first.	169
____ 6. It is necessary to remove both ratchet wheel and crown wheel when removing a Waltham motor barrel.	169
____ 7. Steady pins assure accurate positioning of bridges on plates.	170
____ 8. On a motor barrel, the hub for the inner end of the mainspring will be found on the first wheel instead of the barrel arbor.	171
____ 9. Mainsprings in motor barrels should be oiled the same as in going barrels.	172
10. Number in proper order these steps in removing a motor barrel from a 16 size Waltham, three quarter plate model: ( ) Remove ratchet wheel disk ( ) Remove ratchet wheel ( ) Let down the power ( ) Lift out barrel and first wheel ( ) Disengage inner end of mainspring ( ) Remove barrel bridge	Secs. 169 thru 171

ANSWERS TO PROGRESS CHECK 6A:

1. + true
2. + true
3. ___ false
4. + true
5. ___ false
6. ___ false
7. + true
8. + true
9. + true
10. (2)
(3)
(1)
(5)
(6)
(4)

CHECK YOURSELF

Progress Check 6B — A Self Test Review of Lesson 6

After you have studied Sections 165 through 173, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The reason jewels are used in watches is to ______________________ .	174
2. To disassemble a Waltham jeweled barrel, it is necessary to take apart the ______________________ .	175
3. In a Waltham jeweled barrel, the jewels are set in the ______________________ .	175
4. In a Howard watch, the upper jewel is set in the ____________ wheel and the lower jewel in the ______________________ .	176
5. Placing jeweled bearings at the extreme ends of the barrel arbor in Howard, Illinois and Hamilton jeweled barrels has the advantage of permitting ______________________ to be used, which reduces friction to a minimum.	176
6. In removing the Howard jeweled barrel, the first step is to remove the ______________________ in the ratchet wheel.	176
7. In the Illinois and Hamilton jeweled barrels shown in the lesson, it is unnecessary to take apart the ______________________ to get at the barrel.	177
8. To disassemble the barrel bridge and ratchet wheel on the Hamilton jeweled barrel, use ______________________ to turn the hub.	178

ANSWERS TO PROGRESS CHECK 6B:

1. reduce friction
2. arbor
3. main wheel
4. ratchet wheel
   pillar plate
5. smaller pivots
6. jewel setting
7. ratchet unit
8. brass lined pliers

HOW TO REMOVE AND REPLACE MAINSPRING IN WALTHAM MOTOR BARREL.

Tools, Equipment and Supplies:

Screwdrivers	Movement Holder	Bench Key	Oil
Tweezers	Mainspring Winder	Oiler	

PROCEDURE:	REFERENCE:
1. Let down the power, either before or after removing the movement from the case.	Sec. 169
2. Remove the ratchet wheel.	
3. Remove the barrel bridge.	Sec. 170
4. Lift out barrel with first wheel and arbor.	
5. Remove barrel arbor.	Sec. 171
6. Disengage the inner end of the mainspring from hub on first wheel and separate the first wheel from the barrel.	
7. Remove the mainspring.	
8. Select new mainspring, if needed.	
9. Insert mainspring in the barrel and oil.	
10. Place first wheel on barrel engaging the hub with the mainspring.	Sec. 173
11. Replace arbor and oil.	
12. Put barrel assembly in the movement.	
13. Replace barrel bridge and ratchet wheel.	
14. Check winding.	

NOTE: When installing a new spring it is advisable to form the outer end of the spring to match the curve of the barrel so the spring will engage with the hook and not slip when wound.

HOW TO REMOVE AND REPLACE MAINSPRING IN WALTHAM JEWELED BARREL.

Tools, Equipment and Supplies:

Screwdrivers	Movement Holder	Bench Key	Oil
Tweezers	Mainspring Winder	Oiler	

PROCEDURE: REFERENCE:

1. Let down the power, either before or after removing the movement from the case. Sec. 175
2. Remove the ratchet wheel.
3. Remove the barrel bridge.
4. Lift out barrel with first wheel and arbor.
5. Replace ratchet wheel and screw.
6. Unscrew the two piece arbor.
7. Disengage the inner end of the mainspring from the hub on first wheel and separate the first wheel from the barrel.
8. Remove the mainspring.
9. Select new mainspring, if needed.
10. Insert new mainspring in the barrel and oil.
11. Place first wheel on barrel, engaging the hub with the mainspring.
12. Replace the two piece arbor and tighten.
13. Remove the ratchet wheel.
14. Put barrel assembly in the movement.
15. Replace barrel bridge.
16. Replace ratchet wheel.
17. Check winding.

LESSON	6
MAINSPRINGS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L6-J3

HOW TO REMOVE AND REPLACE MAINSPRING IN HOWARD JEWELED BARREL.

Tools, Equipment and Supplies:

Screwdrivers	Movement Holder	Bench Key	Oil
Tweezers	Mainspring Winder	Oiler	

PROCEDURE:	REFERENCE:
1. Let down power, either before or after removing the movement from the case.	Sec. 176
2. Remove screws and jewel setting in ratchet wheel.	Fig. 127
3. Remove ratchet wheel.	Fig. 128
4. Remove barrel bridge.	
5. Unhook mainspring and separate first wheel from barrel.	Fig. 130
6. Remove mainspring.	
7. Select new mainspring, if needed.	
8. Insert mainspring in barrel and oil.	
9. Place first wheel on barrel, engaging inner end of mainspring with hub.	
10. Put barrel assembly in movement.	
11. Replace barrel bridge.	
12. Replace ratchet wheel.	
13. Replace jewel setting.	
14. Check winding.	

HOW TO REMOVE AND REPLACE MAINSPRING IN ILLINOIS MOTOR BARREL.

Tools, Equipment and Supplies:

Screwdrivers	Movement Holder	Bench Key	Oil
Tweezers	Mainspring Winder	Oiler	

PROCEDURE: REFERENCE:

1. Let down the power, either before or after removing the movement from the case.
2. Remove the barrel bridge without disturbing the ratchet wheel. Sec. 177
3. Lift out the barrel.
4. Remove the cap from the barrel.
5. Remove the mainspring.
6. Select a new spring if needed.
7. Insert spring in barrel and oil.
8. Replace barrel cap.
9. Put barrel in movement.
10. Replace barrel bridge and ratchet wheel.
11. Check winding.

LESSON	6
MAINSPRINGS	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L6-J5

HOW TO REMOVE AND REPLACE MAINSPRING IN HAMILTON JEWELED BARREL.

Tools, Equipment and Supplies:

Screwdrivers	Movement Holder	Bench Key	Oil
Tweezers	Mainspring Winder	Oiler	

PROCEDURE:	REFERENCE:
1. Let down the power, either before or after removing the movement from the case.	
2. Remove the barrel bridge. (Barrel is attached and will come out with bridge.)	Sec. 178 Fig. 137-138
3. Unhook inner end of mainspring and lift off barrel.	Fig. 139
4. Remove barrel cap.	
5. Remove the mainspring.	
6. Select new mainspring if needed.	
7. Insert mainspring in barrel and oil.	
8. Replace cap.	
9. Engage inner end of spring and assemble barrel, hub and ratchet assembly.	
10. Replace barrel and bridge.	
11. Check winding.	

NOTES

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 6

Name: No.: Date:

Circle the correct answer or answers: SUBJECT: Motor and Jeweled Barrels

1. The purpose of the safety pinion is to:

Lock the barrel after watch is wound	Keep the center wheel from turning backward while watch is wound	Keep outer end of mainspring from slipping in barrel	Take up the shock of broken mainsprings

2. The difference between a going barrel and a motor barrel is: (Circle all correct answers)

The motor barrel will accommodate only T-end mainsprings	The teeth of the motor barrel assembly are located on the main wheel	The arbor of the going barrel turns only while watch is being wound	The going barrel turns when the watch is running

3. The advantage of the recoiling click is that it:

Makes it easier to set watch	Makes it easier to wind watch	Does not let the mainspring wind too tight	Takes up the shock of a breaking mainspring

4. The advantage of tapered steady pins is:

Less wear on moving parts	Easier to take apart and assemble watch	Easier to make tip of mainspring catch	Watch can be made thinner

5. The model of the movement pictured in figure 114 is:

Bridge model	Full plate	3/4 plate	Key wind

6. The model of the movement pictured in figure 120 is:

Bridge model	Full plate	3/4 plate	Key wind

7. The Waltham motor barrel assembly in figures 121 to 126:

Is cap jeweled at the ends of the arbor	Has 2 jewels in the main wheel	Is jeweled in the barrel bridge	Is jeweled in the pillar plate

8. Which one of these parts does NOT need to be removed when removing the mainspring?

Crown wheel	Ratchet wheel	Barrel bridge	Mainspring barrel

9. How does the Waltham arbor in figure 119 differ from the one in figure 125?

Squares are on opposite ends	Figure 125 arbor must be taken apart before disassembling barrel.	Figure 119 arbor is pressed tight in main wheel	Figure 119 arbor turns when watch is running

10. What advantage would you say results from placing jewels at the ends of the arbor of a going barrel?

No advantage	Reduces mainspring breakage	Enables us to use thinner mainspring	Makes the watch keep better time

11. What is the principal difference between the type of Waltham motor barrels shown in figures 121 to 126, and those used in Illinois and Hamilton movements, figures 134, 135, 139 and 140?

Figures 134, 135, 139 and 140. Arbors must be unscrewed from barrel when replacing mainspring	Figures 121 to 126. Barrel turns when watch is running	Figures 121 to 126. Barrel may be removed without taking off ratchet wheel	Figures 121 to 126. Has jewels inside main wheel while in figures 134, 135, 139 and 140, ends or pivots of arbor run in jewels

—Detach page or cut along this line—and send to the School for grading

CHICAGO SCHOOL OF WATCHMAKING

310 LINCOLN AVENUE, FOX RIVER GROVE, ILLINOIS

Student Consultation Sheet

Date ______________________ Student No. ______________

Lesson No. ________

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Name	
Address	
City State Zip Code	

Please check ( ) if you have CHANGED YOUR ADDRESS.

ASK YOUR QUESTIONS HERE...

(If necessary, use other side.)

WE'LL ANSWER HERE...

INSTRUCTOR: Return an unused sheet with each used one.

Cut along this line and use this sheet if you have questions on the course.

Student Consultation Sheet

Master WATCHMAKING

Lesson 7

SELECTING THE MAINSPRING

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

Printed in the United States of America

INTRODUCTORY INFORMATION

In this lesson you will learn to select mainsprings, and in so doing, you must learn the correct way to measure them. There are two commonly used systems for doing this: the Dennison and the metric.

The Dennison gauge has the disadvantage of being subject to error and limited in use. It is true that a watchmaker who has used one for many years may, through his experience, offset the errors which might occur in using it. The student, however, usually has trouble in measuring the thickness of the mainspring. This is because the slot illustrated at A in Figure 145, Lesson 7, becomes worn. The old timer has learned through experience just how much pressure to use and consequently can do a good job.

The point we want to stress is that the Metric Micrometer is more accurate and will give a consistent measurement no matter who uses it. Most manufacturers give both metric and Dennison measurements, so either can be used. You should note that the Dennison gauge is used only for mainsprings, whereas the metric micrometer may also be used to measure other parts of watches.

KEY POINTS OF ASSIGNMENTS 23, 24, 25:

- The methods used in measuring mainsprings.
- The Dennison system of measurement.
- The metric system of measurement.
- The parts of the micrometer.
- What part of the area of the barrel should be occupied by the mainspring?
- How to calculate the strength of a mainspring.
- How mainsprings are listed and how to read mainspring charts.

ASSIGNMENT NO. 23: Study Sections 185 through 195.

Study Questions:

1. What methods are used to measure mainsprings?
2. What are the parts of a metric micrometer?
3. How do you read the micrometer?
4. How do you measure the width of a mainspring with a metric micrometer?
5. How do you measure thickness?
6. How much of the area of the barrel should the mainspring occupy?

Recommended Practice:

1. Measure your practice mainsprings until you are proficient in the use of a mainspring gauge or metric micrometer. Note: Some manufacturers of mainsprings list the measurements in centimeters. You may also find one measurement, such as the width, in millimeters and the other, the strength, in centimeters. One centimeter equals 10 millimeters. To change a centimeter measurement such as .300 to a millimeter measure-

ASSIGNMENT NO. 23 (Continued):

ment, move the decimal point one place to the right (3.00). With a little experience, you will be able to recognize these varied units of measure and change one to the other without difficulty.

2. Locate and compare the measurements you have taken with those listed for these same mainsprings on the charts in the back pages of this lesson or in any other mainspring chart you have.

Note: Some manufacturers of mainsprings make their springs to slightly different measurements than those recommended by the manufacturer of the watch. These differences are usually slight and have practically no effect on the way the watch performs. The difference will usually be found in the width, and then may amount to only 2 or 3 hundredths of a millimeter.

ASSIGNMENT NO. 24: Study Sections 196 through 200.

1. How can you determine the approximate strength a mainspring should be?
2. What conclusions do you draw from the experiments described in the text?

Recommended Practice:

1. Examine a watch barrel and determine if the mainspring occupies the proper space.
2. Using the formula outlined in Section 196, calculate the proper spring for this watch and compare your result with the spring found in the barrel.

Note: With reference to (b), Section 196, the percentage shown will apply only to watches of 15 jewels or more. For watches having 7 jewels, use 46 per cent.

ASSIGNMENT NO. 25: Study the Mainspring Charts in the back of the text as well as any other mainspring charts or listings you have.

1. What are the most commonly used styles of tips?
2. On the chart in the text, compare an Illinois double brace tip with an Elgin double brace tip. Are they the same?
3. Is the style of tip used in Elgin watches generally used in other makes?

REQUIREMENT:

➧ Answer the Test Questions for Lesson 7 and return to us for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

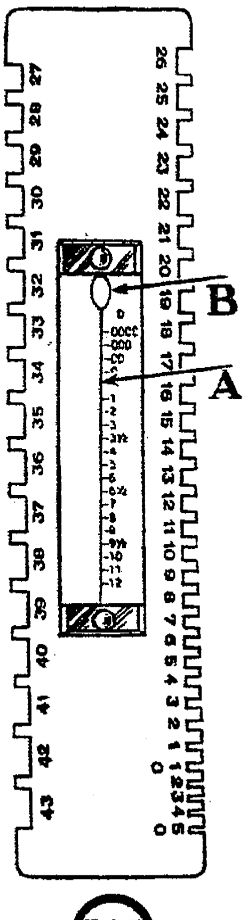
Founded 1908 by Thomas B. Sweazey

Lesson 7

Sections 185 to 200

Lesson 7 — Selecting the Mainspring

Section 185 IN the preceding lessons you have learned the importance of replacing set mainsprings, the necessity of using good oil and how it is applied, the more popular forms of tips made by manufacturers, and certain tests that are used in locating errors in winding caused by either broken or improperly attached mainsprings. You have been shown the proper methods of placing mainsprings in watches without distorting them and have been impressed with the importance of using a good winder in your work.



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All these things are essential but your knowledge has little value unless applied to a mainspring that is suited to the watch you are working upon. Not always will you find the old one of proper size and you must be capable of judging by its appearance in the barrel whether it is of standard dimensions and if wrong, to select one that is right. Should a broken mainspring as it lies in the barrel, appear to be of correct size it is best to replace it with one of the same dimensions as to width, thickness and length, and with the proper tip.

Sec. 186 Dennison Type of Gauge

Your first step then is the selection of a good mainspring gauge. The one illustrated in figure 145 has been standard for a long time, but in recent years mainsprings are being gauged more and more by means of the metric system with its measures of greater accuracy.

Sec. 187 — Width

This gauge in figure 145 consists of a plate with notches of varying widths around the edge. In gauging for width, the mainspring is tried in these until one is found in which the flat side of the mainspring will just fit. If it will enter the notch marked 18 when held flat against the gauge, but will not enter 17 we consider the mainspring 18 wide by this system

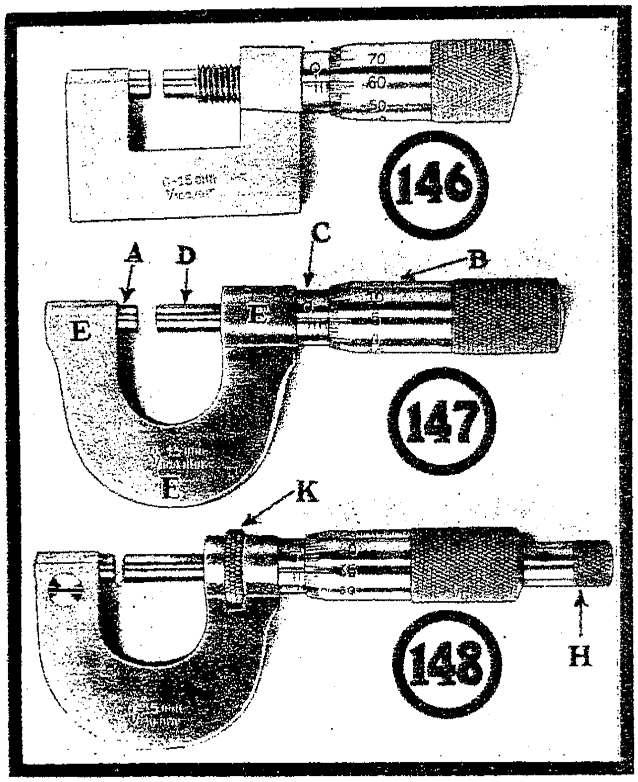
Sec. 188 — Strength

The thickness or strength of a mainspring is shown by the tapered slot at A. Push the mainspring, tip end first, through the hole at B, and lightly press down in the slot until it stops and note what figure is opposite the lower edge. This figure will give you the strength.

In listing dimensions from this gauge the width and strength are often shown with an x between as follows: 19x5 meaning that the mainspring is 19 wide, by 5 strength.

This type of gauge is not always accurate. The difference between each succeeding notch is approximately one tenth of a millimeter, number 1 being one millimeter wide, number 2 one and one tenth millimeters, number 3 one and two tenths millimeters (1.2mm), number 11, two millimeters — number 21, three millimeters, etc. In some watches mainsprings are used with a width of 10½, 11¾ or 19½ according to this method, but with this gauge there is no way of measuring such widths accurately.

The slot for measuring the thickness becomes worn and even on new gauges there often will be found a variation, if comparisons are made between given positions on the scales. Again the numbers on the slot are confusing in that the larger the number the smaller the actual measurement, number 5 on the thickness gauge measuring about .18 mm while number 10 is equivalent to .11 mm.



Sec. 189 — Gauging by the Metric System

The metric system was rendered legal for all transactions in the United States by an Act of Congress, approved July 28, 1866, and is now legal or obligatory in all commercial countries. In many parts of the world including Europe, more metric measurements are in use than any other system.

The metric unit of length for watchmakers is the millimeter, or one thousandth of a meter, and this is being used more and more in the gauging of watch parts and material. One inch equals almost exactly 25.4 millimeters.

The diameters of pivots are gauged in hundredths of a millimeter as are the holes in jewels. The outside diameters of balance jewels and train jewels are gauged in tenths of a millimeter while roller jewels are gauged in hundredths of a millimeter. All fancy watch glasses or crystals are gauged in tenths of a millimeter and many manufacturers of round ones are also gauging their products in tenths of a millimeter.

There are several types of metric gauges that are used for different purposes, such as the pivot gauge divided into hundredths of a millimeter; vernier slide caliper for inside and outside diameters, combined with a depth or shoulder gauge, measuring in tenths of a millimeter; the degree type of gauge, or spring caliper with vernier capable of measuring to 1/100 mm and the finest and most accurate of all, when properly made, the micrometer caliper in hundredths of a millimeter, which can be used in measuring dimensions of staffs, pinions, wheels, pivots, jewels, mainsprings and which should be found in every Master Watchmakers set of tools.

Sec. 190 — The Metric Micrometer Caliper

In figure 147 is shown a popular type of metric micrometer caliper. The spindle D is attached to the thimble B and they turn as one piece, the spindle passing through the sleeve C. The sleeve C is fastened to the frame E and remains as a fixed part of the frame. Part of the spindle is threaded to fit threads inside the sleeve. When the thimble is revolved to the left it causes the spindle to recede from the anvil A and when turned the other way the spindle advances toward the anvil.

The piece to be measured is held between the anvil A and the end of the spindle D. The spindle is then brought against the piece by turning the thimble B. This should only be turned as far as it will go with a light pressure.

Memorize these parts:

A—Anvil

B—Thimble

C—Sleeve

D—Spindle

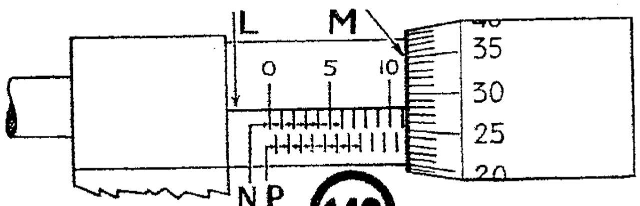
E—Frame

The amount of the opening is indicated by the lines and figures on the thimble and sleeve. The thread on the concealed part of the spindle is of such a pitch that one turn advances the spindle and with it the thimble, one half or 50/100 of a millimeter. The short vertical lines on the sleeve correspond to the pitch of the thread. The upper series of these lines indicated by N touch the horizontal line L as shown in the drawing at figure 149 and indicate the millimeters. The lower short vertical lines at P are half way between the upper lines N and indicate the half millimeters. Every fifth line of the upper series is longer than the rest and numbered, 0, 5, 10 etc. These numbers indicate the number of millimeters when the thimble is opened to this point.

The beveled edge of the thimble at M is marked with 50 divisions, every fifth division being numbered from 0 to 45. Knowing that one whole turn of the thimble moves the spindle lengthwise 50/100 of a millimeter it follows that turning the thimble 1/50 of a complete turn or the distance from one division line to the next on the thimble will move the spindle 1/50 as far or 1/100 of a millimeter.

Sec. 191 — *Reading the Micrometer*

A little practice will enable you to read your micrometer on any sized opening up to its capacity. Start by turning the spindle until it



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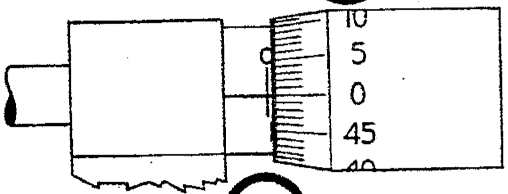

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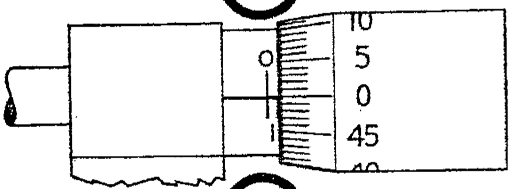

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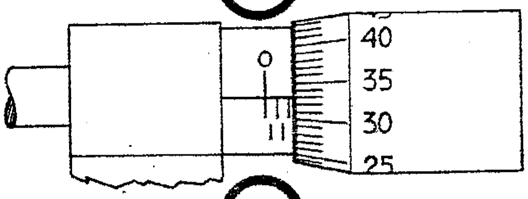

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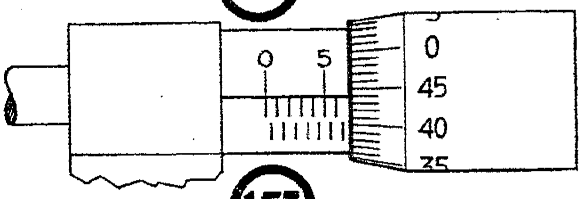

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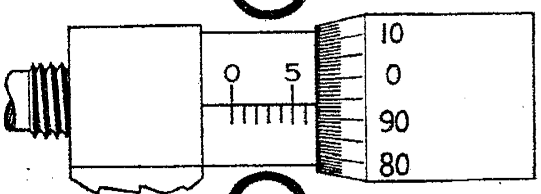


154

is against the anvil. The beveled edge of the thimble then should be even with the zero line on the *sleeve* and the zero line on the *thimble* should coincide with the *horizontal* line L on the sleeve.

Occasionally you may find that the anvil and spindle do not come together on account of there being dust between them. If your lines do not coincide as described above, draw the spindle away from the anvil and insert a clean piece of watch paper, then turn the spindle until the paper is held but can be withdrawn without tearing. After pulling the paper out, without releasing the spindle, no doubt you will find that your caliper registers correctly.

When measuring with a micrometer caliper always bring the anvil and spindle together with a light pressure. By using undue force it is easy to spring the tool and ruin it for accurate measurements. For this reason the beginner will get better results by having his micrometer equipped with a ratchet stop and thus get the same amount of pressure at all times.

Having your micrometer caliper closed to register at 0, open it by giving one full turn of the thimble until the 0 on the thimble again registers on the horizontal line on the sleeve as illustrated at figure 150. Notice that the beveled edge of the thimble now coincides with the first of the lower series of vertical lines on the sleeve, indicating one half or 50/100 of a millimeter usually written .50 mm. (see figure 150). If you turn the thimble two full turns from the anvil until it is even with the first of the upper series of vertical lines counting from the 0 line it indicates one millimeter, written 1 mm. (see figure 151).

When the horizontal line on the sleeve does not coincide with the 0 line on the thimble it is necessary to add the extra hundredths indicated. In figure 152 the thimble is a trifle past the 2 millimeter line and the 33 line on the thimble coincides with the horizontal line on the sleeve this showing exactly two and thirty-three hundredths millimeters, written 2.33 mm.

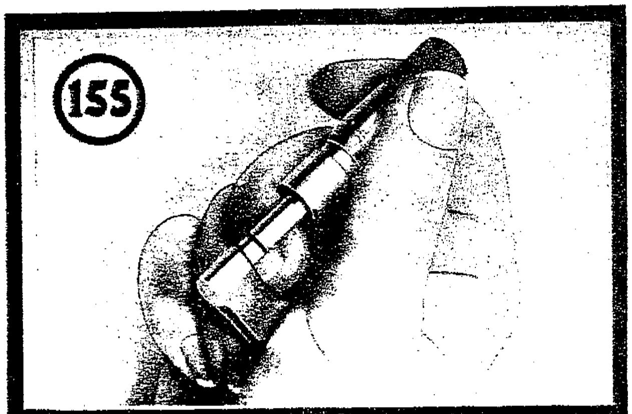
In figure 153 the thimble is drawn out still further. Here it is past the line indicating 6.50 mm and shows .44 on the thimble. Adding 6.50 and .44 gives 6.94 mm.

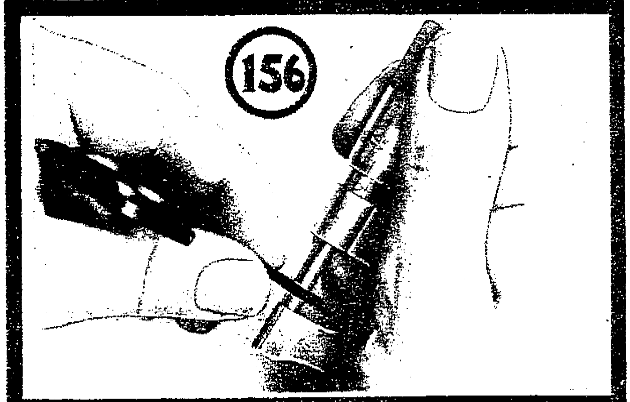
The pitch of the spindle thread on the micrometer shown in figure 146 is coarser and one turn of the thimble moves the spindle exactly one millimeter instead of one half millimeter as in the other. On this spindle there is but one series of vertical lines, each line being one millimeter apart.

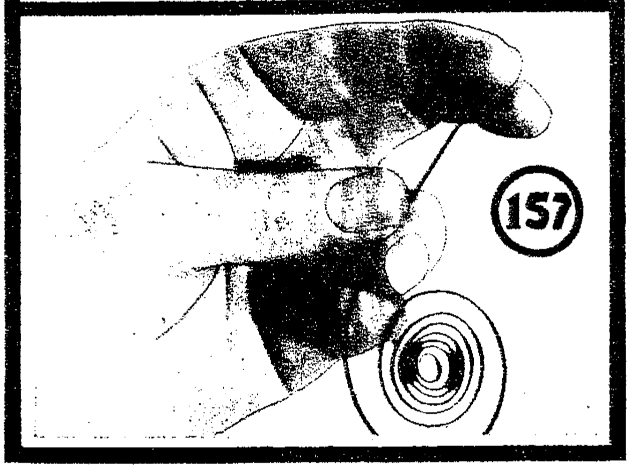
On the thimble there are 100 divisions, each division indicating one one-hundredth of a millimeter. Thus if you back the spindle from the anvil one full turn it will have moved exactly one millimeter. The drawing at figure 154 shows the difference between the two methods of indicating the same measurements. The drawing at 154 shows 6.94 mm by this system and figure 153 shows 6.94 mm by the other system.

Figure 148 shows much the same type of micrometer as figure 147 with the addition of a ratchet stop and lock nut. The ratchet at H will slip when more than a certain amount of pressure is applied on the spindle and removes the danger of springing the tool. The lock nut at K enables you to lock the micrometer in any position.

A satisfactory way to hold the micrometer is shown in figure 155. Here the frame is held against the hand by the second finger leaving the thumb and first finger to manipulate the thimble.







Sec. 192 — Metric Width

In measuring a mainspring to find its width in millimeters the outer coil is held between the frame and anvil as shown in figure 156 and the thimble is turned until the mainspring is held with slight pressure, after which the reading is taken as explained before. The measurement for the metric width is expressed in millimeters and for this particular mainspring it is two and eighty three hundredths millimeters or in decimals, 2.83 mm.

Sec. 193 — Metric Strength

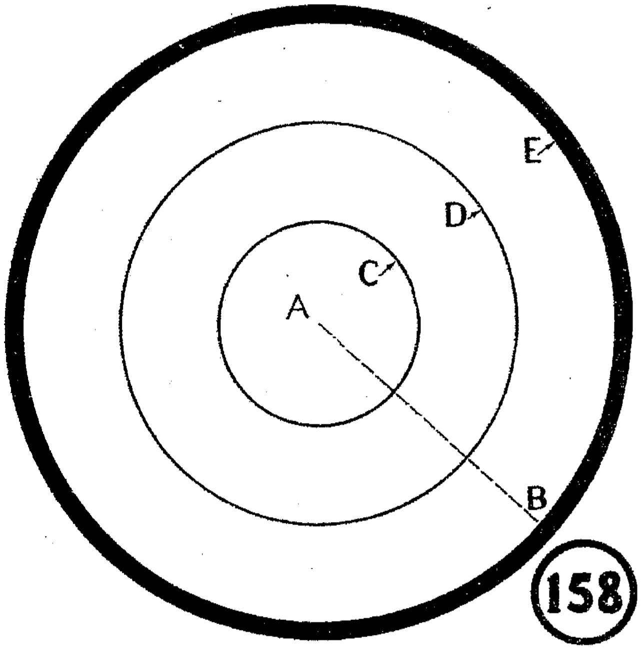
To obtain the strength or thickness of an old mainspring it is sometimes necessary to straighten a portion of it, especially if it is set. Otherwise the curved part lying between the spindle and anvil, will give a higher reading than the actual strength of the mainspring. By holding the spring between the fingers as in figure 157 it is possible to straighten out enough of it to gauge the actual thickness by applying the micrometer caliper to this straight portion.

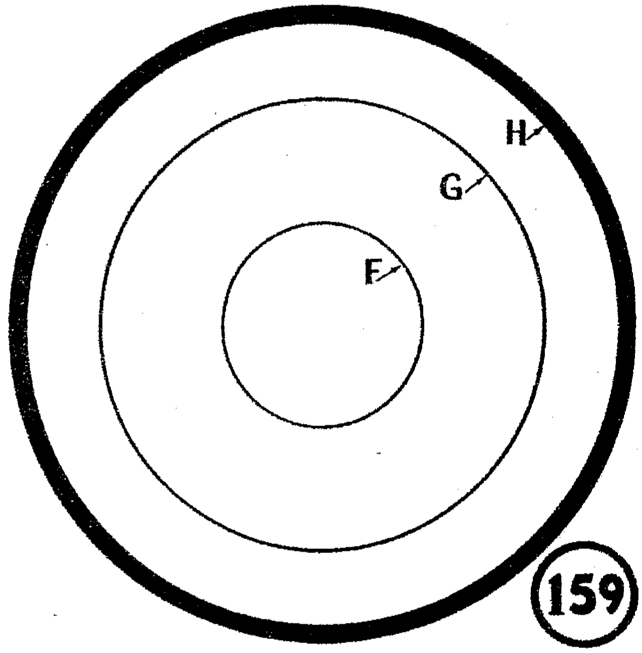
It is seldom necessary to take the measurements on new mainsprings especially for American watches, as in the better grades, each one comes packed in a separate envelope with the Dennison and metric measurements plainly marked on the outside, but you may have occasion to measure new ones for Swiss movements or to check up on American sizes and it is possible to follow this same procedure without injury to the spring.

Sec. 194 — Length

The length of a mainspring determines the number of coils in the barrel. If your mainspring is of correct thickness and length, it will occupy the proper space in the barrel and will have the right number of coils.

The average watch should have 11 or 12 coils in the barrel and these coils should occupy one half the area between the arbor and the outer shell of the barrel. If you will exam-





ine the photograph in figure 91 lesson 5 you will see there are almost 12 coils counting from the tip inward toward the arbor.

Some of the finer R. R. movements are fitted with longer and thinner mainsprings having more coils, yet occupying the proper amount of space in the barrel — one half the area between the arbor and the outer shell — this giving a longer running period on one winding. A very good example of this type is shown in figure 134 from a Bunn Special Railroad movement. This mainspring with nearly 14 coils occupies one half the area between the hub and the outer shell of the barrel and is known as a 60 hour mainspring.

Sec. 195 — A Rule to Remember

One of the rules applying to the mainspring is that in order to obtain the greatest number of turns the length and strength should be such that the occupied part of the barrel outside of the arbor is equal to that of the unoccupied part; in other words a mainspring should occupy one half of the area between the outer diameter of the arbor and the inside shell of the barrel. Some watchmakers apply this rule by dividing the radius into three equal parts, giving the arbor one third, the unoccupied part one third and that part occupied by the mainspring, one third.

This rule applies fairly well as far as the arbor is concerned as you will find it is generally just about one third the inside diameter of the barrel — in the majority of watches being under rather than over this proportion, but the distance from the arbor to the inner shell of the barrel should be divided into two equal areas, when comparing the open space with that of the space occupied by the mainspring, and the area of these two equal spaces are not contained as equal radial measurements.

In figure 158 I have drawn two circles inside an outer circle in order to divide the radius A B into three equal parts. This however does not mean that the total space, enclosed by C is equal to the total space between the circle C and D or that the space between C and D is equal to the space between D and E. As a matter of fact as the diameters increase the areas increase.

In figure 159 the circle F is the same size as C in figure 158 but the circle G divides the space between F and H into two equal *areas*, that is the area of the space between the circles F and G is the same as that of the space between G and H. If the heavy circle H were to represent the shell on the watch barrel and the circle F the diameter of the arbor, a properly fitted mainspring will exactly fill the space between G and H when entirely run down and in like manner occupy the space between F and G when wound tightly around the arbor. You will find that the diameter of the circle G representing the inner coil of the mainspring when run down is almost exactly three fourths the diameter of the circle H representing the inside shell of the barrel.

Keeping this in mind it is an easy matter to tell by the appearance of a mainspring in the barrel whether it is of correct thickness, provided you know how many coils it should have. By knowing what proportion the mainspring should occupy you can figure out its proper strength for any barrel.

In like manner, knowing the strength of a given mainspring it is possible to figure how many coils should be in the barrel to give the best results.

Sec. 196 — To Calculate Strength

Here is a simple rule that will give you the approximate strength of a mainspring with any given number of coils where you have the inside diameter of the barrel and the diameter of the arbor.

(a) Subtract one half the diameter of the arbor from one half the inside diameter of the barrel (AB minus AC figure 158).

(b) Take 38¼ per cent of this difference.

(c) Divide the result by the number of coils desired and this will give proper strength of mainspring to give most turns on the barrel.

Let us take as an example the Hamilton barrel shown in figure 140.

The inside diameter is 15.5 mm.

The diameter of the hub, (F in figure 159) is 5 mm.

Number of coils 12.5

(d) Subtracting one half the diameter of the arbor (2.5 mm.) from one half the inside diameter of the barrel (7.75 mm.) we obtain 5.25 mm.

(e) 38¼ per cent of 5.25 mm. gives 2 mm.

(f) Dividing 2 mm by 12.5 (number of coils) gives .16 mm as the proper strength for a mainspring for this movement.

Sec. 197 — To Calculate Number of Coils

Given the strength of a mainspring to find number of coils.

(g) Divide 38¼% of space by strength of spring.

In the above barrel if the mainspring we wish to put in the barrel is strength .16 mm. Divide 2 mm (e in sec 196) by .16 mm equals 12½, number of coils for best results.

Sec. 198 — Some Interesting Experiments

The majority of watchmakers have their own ideas as to the amount of space that a mainspring should occupy in a barrel but few know the correct method of determining this space and what the proper proportions are. You will find that a great many go on that idea of one third of the space on the radius as explained in section 195.

The watchmaker of an investigating turn of mind will get some rather interesting results if he will go to the trouble of making a few experiments on an ordinary grade of watch. He will find that some factories provide their watches with mainsprings that are too long. In order to overcome friction and poor adjustment on these movements it is necessary to provide springs of goodly strength and in doing this they apply a stronger spring of the same length as the weaker springs on higher grade movements.

In my work of instructing I have made various experiments and have shown where more turns of the barrel often could have been secured by shortening the mainspring. At A figure 160 is a barrel from a 16 size 7 jeweled American watch with a 16 size mainspring as recommended by the manufacturer of the movement. This mainspring is .20 mm thick and would be accepted as the proper size by a great many watchmakers.

The unoccupied space on the radius of the barrel is about the same as that covered by the mainspring and as I have said before, this is the rule that many watchmakers use in determining whether the mainspring is of correct strength and number of coils.

Experiment A.

If we compare this portion however to the drawing in figure 159 we find that the mainspring is occupying altogether too much of the barrel. In experimenting with this mainspring barrel in the movement, I found that by winding it up as far as it would go and then allowing it to run down, the minute hand made 36 2/5 revolutions or if we could imagine that the watch would run as long as this with its escapement in place, 36 hours and 24 minutes.

Experiment B.

I next took this mainspring out of the barrel, broke off 33 millimeters from the outside end, put on a new tip and wound it into the barrel as shown at B. Replacing in the movement and winding up as before, it ran down with 37 2/3 turns of the minute hand. Here you see the mainspring was 33 millimeters shorter and yet ran an hour and 16 minutes longer.

Experiment C.

Again I removed the mainspring and broke off 29 millimeters from the end and replaced in the barrel as shown at C. Upon winding this mainspring and letting it run down it showed turns amounting to a trifle more than 38 hours.

Experiment D.

Next I broke off 25 millimeters more and the mainspring appeared as in D. When this

Experiment E.

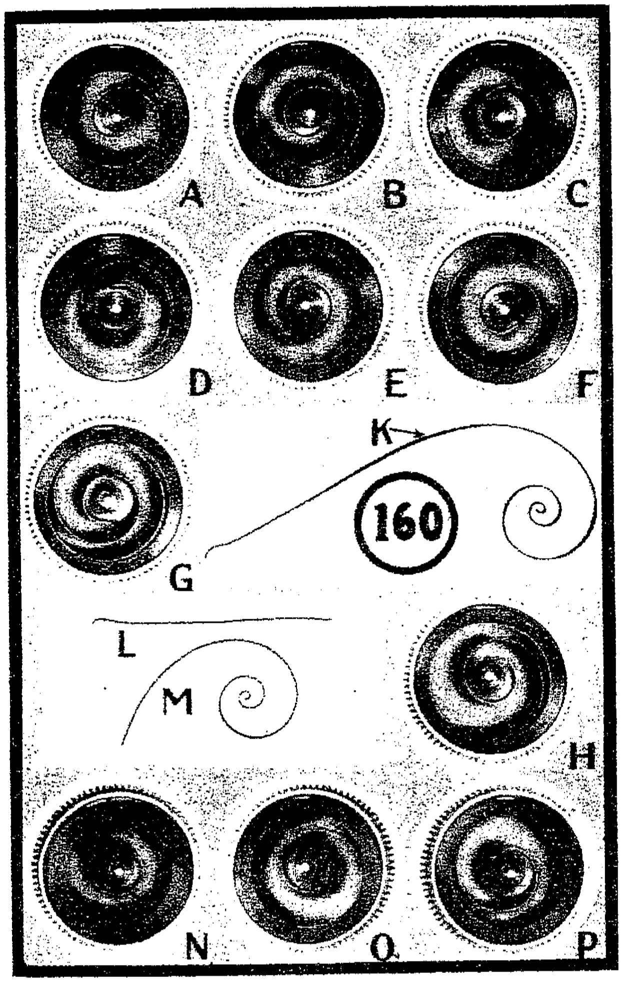
The portion of mainspring shown at E, 25 millimeters shorter than D, ran 37 hours and 58 minutes.

Experiment F.

F, 25 millimeters shorter than E ran nearly the same as E, 37 hours and 52 minutes.

Experiment G.

Finally I broke off 50 millimeters more making the mainspring at G 50 millimeters shorter than F yet it ran down showing 36 hours and 42 minutes.



was wound up and allowed to run down it showed 38 hours and 14 minutes, a gain of nearly two hours over the full length mainspring shown at A.

If you will examine the proportions shown in D you will find that they approach very nearly our ideal shown in the drawing in figure 159.

I continued breaking off portions of the mainspring and testing them with the train in the movement with the following results:

Comparing figure A with figure G you should appreciate the fact that having a longer mainspring does not always make the watch run a greater length of time. Here in figure A we have the full length mainspring which gives turns amounting to 36 hours and 24 minutes. At figure G the same mainspring after breaking off a large portion and then having been wound up so many times that it began to show the effects on the inner coil, which is set, gives more turns than in A.

Experiment H.

Taking another new mainspring of the same make and the same strength as the one used in experiment A, I broke it off at the point K, thus dividing it into two parts as shown at L and M, the portion L being about 180 mm. or a trifle over seven inches long. I then placed a tip on the end of portion M and wound it into the barrel as shown at H. Placing this shorter mainspring in the movement and winding it up completely I found that it made turns equivalent to 37 hours and 22 minutes before it was completely run down.

Here again, is demonstrated the paradox of making a mainspring give more turns to the barrel by taking off a generous portion. It would appear as though much of the part L of this mainspring was of little value in the watch as we get better results by using the part M alone. Comparing the results of this short mainspring with the complete mainspring used in the barrel at A, we find that this short one ran 58 minutes longer than when using the entire spring.

If we substitute a weaker mainspring of about the same length, we may expect a greater number of turns as a result of winding it up and letting it run down. What we gain in turns however, we lose in power. Thus it is that the finer the workmanship on a movement in a given size the less the strength needed in the mainspring to give a proper motion to the balance.

Experiment N.

In this same movement I placed a mainspring with a thickness of .16 mm which filled the barrel as shown at N figure 160. This spring you will observe has only a fraction more than the number of coils in the stronger spring shown at A but comes nearer to occupying the ideal space in the barrel.

On account of the better proportions of space and mainsprings we should expect this to give more turns on the barrel than any of the previous mainsprings.

The result of winding and allowing it to run down gave a number of turns equal to 51½ hours.

Experiment O.

Breaking off 31 mm, which gave approximately one coil less as shown in O, gave the number of turns equal to 53⅓ hours, a gain of nearly two hours.

Another test was then tried with No. 0 by placing the balance and escapement in the movement, winding the mainspring up to its limit and allowing the watch to run in one position until it stopped which it did in 51 hours and 58 minutes, this lacking about 1⅓ hours of running as long as it did when there was no resistance to the train.

Experiment P.

As a further test I broke off 24 mm more as shown in P and allowed it to run down which it did with a number of turns equal to 52½ hours as compared with 53⅓ hours with O.

Here it is evident that I have broken off a trifle too much, and the mainspring occupies less than one half the actual area between the arbor and inner rim of the barrel, and does not give as much power as with the length shown at O.

You should now see the fallacy of thinking that because a watch does not run as long as should be expected, it has a mainspring that is too short. There are probably more mainsprings by a large majority of a greater length than is necessary than there are mainsprings too short, being carried in watches today.

From these last three experiments you might get the idea that all that is necessary is to keep reducing the strength of the mainspring and the watch will give better service but this will not prove true. The power needed is determined to a great extent upon the condition of the movement. Thus it is that a 21 jeweled grade uses a weaker spring than does a 7 or 15 jeweled movement made by the same manufacturer. Not only do the extra jewels reduce the friction in the train but in the higher grade movements the escapements are matched closer.

It is not customary to break off the end of a mainspring in order to get the correct length for American watches. As a general rule you will find that some manufacturers have a tendency, especially in the lower grades, to use springs of too great a length, but it will hardly pay for you to change the length of every one you put in.

The better way is to put each one of your repair jobs in such good condition that a weaker mainspring will make the watch motion properly.

Sec. 199 — Choosing a Mainspring for An American Watch

Before taking any mainspring from its barrel examine carefully to see that it occupies the proper space, has the correct number of coils and that the upper edge of the outside coil comes a trifle below the shoulder in the barrel where the cap snaps in place, this showing the proper width.

Remove the mainspring and gauge it for width and strength. Notice the type of tip and then from the mainspring chart you should be able to select the proper mainspring for that movement.

On the following pages you will find descriptive charts of mainsprings for eleven different American made Watches. Some of the factories making these movements have gone out of business but as long as these watches continue to be brought in for repairs it is necessary to list mainsprings to fit them even as it is necessary to list those for discontinued models made by the more successful factories.

In these charts the various types of tips are illustrated and this will help you in selecting a mainspring to match any particular one. Following the style column is given the company's number, then the size followed by the column giving the description of that particular mainspring or the movement for which it is intended. The next two columns give the Dennison width and strength as found by the gauge shown in figure 145.

The columns designated as Width Metric and Thickness Metric are the ones to be used for those using the metric system of gauging. Under the Width Metric Column are shown the widths of the mainsprings in millimeters and in the next column are shown the Strengths or Thicknesses in Millimeters, usually in hundredths and occasionally in thousandths of a millimeter.

Suppose that a 16 size Hamilton Watch is brought to you and you find it needs a new mainspring. How will you go about selecting a new one? After seeing that it fills the proper proportion of the barrel, remove and measure its width and thickness. You find that it has a T end and measures 2.85 mm. wide and .19 mm. thick. Looking on the chart, under Hamilton, 16 size, you find that number 355 in the first column is the one needed. In like manner you can find the proper spring for any American Watch.

Sec. 200 — Carrying Mainsprings in Stock

Broken mainsprings are among the most common replacements made by the Master Watchmaker and it is of the greatest importance that he shall have a fairly complete assortment on hand in order to give his customers prompt service. It is not necessary that this should consist of a great quantity of each size nor that you carry every number listed on our charts. Generally you will find that certain makes of watches are most popular and your stock of mainsprings should be heaviest on these lines. You can purchase assortments already made up in sizes to suit nearly every purse. By purchasing an assortment you are able to buy at the dozen or gross price which makes quite a saving as compared to the cost when only one mainspring is selected.

The cost of good quality mainsprings is so small compared to the retail price for replacing them in watches, that it does not pay to buy the cheapest quality or job lots. The cheaper mainsprings nearly always will be found of inferior quality and the few cents more profit will hardly make up for the loss of a good customer when such a mainspring "sets" in his watch.

CHART SHOWING WIDTH AND STRENGTH IN MILLIMETERS and EQUIVALENT IN DENNISON NUMBERS

WIDTH		WIDTH		WIDTH		WIDTH		STRENGTH	
M.M.	Denn.	M.M.	Denn.	M.M.	Denn.	M.M.	Denn.	M.M.	Denn.
.50	5/0	1.80	9	3.40	25	5.00	41	.20	3½
.60	4/0	1.90	10	3.50	26	5.10	42	.19	4
.70	3/0	2.00	11	3.60	27	5.20	43	.18	5
.75	2/0½	2.10	12	3.70	28			.17	6
.80	2/0	2.20	13	3.80	29			.16	6½
.85	1/0½	2.30	14	3.90	30			.15	7
.90	1/0	2.40	15	4.00	31	STRENGTH		.14	8
.95	½0	2.50	16	4.10	32	M.M.	Denn.	.13	9
1.00	1	2.60	17	4.20	33	.29	0000	.12	9½
1.10	2	2.70	18	4.30	34	.27	000	.11	10
1.20	3	2.80	19	4.40	35	.26	00	.10	11
1.30	4	2.90	20	4.50	36	.25	0	.09	12
1.40	5	3.00	21	4.60	37	.24	0½	.08	13
1.50	6	3.10	22	4.70	38	.23	1	.07	14
1.60	7	3.20	23	4.80	39	.22	2	.06	15
1.70	8	3.30	24	4.90	40	.21	3	.05	16

Always use a Metric Gauge for measuring mainsprings. Most Dennison gauges are not accurate. After being in use a short time, the thickness gauge becomes spread or worn. If your Dennison gauge does not give the same reading as shown on the above chart when compared with metric measurements, it should not be used.

Accurate gauging of mainsprings can be accomplished only by using a precision gauge calibrated in hundredths of millimeters.

CHECK YOURSELF

Progress Check 7 — A Self Test Review of Lesson 7

After you have studied Sections 185 through 200, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The notches around the outer edge of the Dennison Gauge are used to measure the ________ of the mainspring, while the tapered slot in the center is used to measure the ________ .	187 & 188
2. One inch equals ________ millimeters.	189
3. A typical metric micrometer has these parts: (a) ________ (b) ________ (c) ________ (d) ________ (e) ________ .	190
4. Each mark on the thimble indicates the spindle of the micrometer will move ________ of a millimeter.	190
5. The lower vertical lines on the sleeve of the micrometer indicate an opening of ________ mm.	190
6. Anvil and spindle should be brought together with a ________ pressure.	191
7. The average watch has ________ in the barrel.	194
8. The most important rule for mainsprings is the one which states the mainspring should occupy one half the ________ between the arbor and the outer shell.	195
9. If a watch doesn't run as long as expected, it is probable that the mainspring is too ________ .	198 Experiment P.
10. Movements of better grade require a ________ mainspring.	Exp. P
11. When replacing a mainspring, it is rarely necessary to calculate the strength or number of coils because a mainspring chart will list the ________ and ________ recommended by the manufacturer.	199

ANSWERS TO PROGRESS CHECK 7:

1. width
   strength
2. 25.4
3. (a) anvil
   (b) thimble
   (c) sleeve
   (d) spindle
   (e) frame
4. 1/100
5. 50/100 or 1/2
6. light
7. 11 or 12
8. area
9. long
10. thinner or weaker
11. width
    strength

MAINSPRINGS FOR AMERICAN WATCHES

WALTHAM

Our No.	STYLE	Co.'s No.	Size	Description	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
130		2232	8 day	Auto & Desk..	37	1½	4.60	.22	30
100		2202	18	Old Model....	19½	2	285	.22	23
101		2203	18	17J	20	2	290	.22	21
102		2204	18	Nar'w Bar'l...	16	2	250	.22	21
103		2205	18	Wide 7 to 15J.	21	2	300	.22	21
104		2222	18	Mod. 1892....	23	5	325	.18	25
107		2208	16	Lever Set.....	14	2	230	.22	21
108		2218	16	P. S. 7 to 15J.	19	4	280	.19	25
106		2227	16	P.S. 17 to 23J	19	5	280	.18	25
109		2210	14	Lever Set.....	12	2½	210	.21	19
110		2211	14	L. & P. S.....	16	2	250	.22	19
112		2224	12	Hook End....	12½	7	2.15	.15	19¼
113		2224A	12	Hole End.....	12½	7	2.15	.15	19¼
128		2234	12	Colonial A....	4	5½	130	.175	19
129		2237	12	Colonial B	8	6	170	.165	19¼
114		2214	10	¾ Plate K. W	14	3	230	.21	19
115		2215	6	Lever Set.....	10	2	190	.21	16
116		2217	6	L. & P. S.....	10	4	190	.19	16
117		2219	0	Steel Bar'l....	12	7	210	.15	16
118		2216	1 & 0	S. W	8	6	170	.165	16
120		2228	0	Model 1900...	8	9	170	.13	15
119		2220	0	Model 1891 ..	6	7	150	.15	16
121		2230	0	Model 1907 ..	12	9½	206	.12	15
122		2221	00	S.W. & P.S ..	6	7	155	.15	14½
123		2226	Jewel Series	6/0 Mod. 1898	6	9½	150	.12	13⅓
124		2235	Jewel Series	6/0-Mod. 1912	4	9	130	.13	13½
125		2229	10L	Ten Lignes...	6	11	150	.10	10¼
126		2233	9L	1913 Model...	2	11	108	.10	10¼
127		2236	7¼L	5¼L. Rect...	2	13	110	.08	9
131		2238	7¼L	Rectangular...	4	11	130	.11	12½
132		2239	6½L	Oval	2	12	110	.09	

HAMILTON

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
351		15	18	17J	19	3¼	2.85	.205	22
352		15	18	19 to 21J	19	3½	2.85	.20	22
354		232	18	Motor Barrel...	22	5	3.10	.18	25½
353		14	18	Motor Barrel ..	23	5	3.20	.19	25½
355		318	16	17J	19	4	2.85	.19	22
356		317	16	10 to 21J ...	19	5	2.85	.18	22
358		534	16	Motor Barrel ..	19	6½	2.75	.16	22
359		1228	12	Motor Barrel..	8	5	1.70	.18	20½
361		1536	0	Lady Ham....	5	7	1.40	.15	14
362		1535	0	Motor Barrel ..	5	7½	1.40	.145	14
363		1721	6/0	17J	4	8½	1.30	.135	11¼
364		2321	6/0	17J.	5	9½	1.40	.12	
365		2621	6/0	979 Model......	5	9¾	1.40	.115	
366		2721	18/0	6¾L Oval......	2	12	1.10	.09	

ILLINOIS

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
400		53	18	19 to 23J........	20	3¼	2.90	.202	21½
402		53	18	Up to 17J.......	20	2	2.90	.22	21½
404		365	16	Old Model.......	16	3	2.50	.22	20
406		573	16	N. M. to 17J.....	18	3½	2.70	.205	20½
407		573	16	N. M. 19-23J....	18	5	2.70	.18	20½
405		124	16	N. M., Wide.....	20	4	2.90	.19	20½
409		1759	16	60 Hour.........	21	6½	3.00	.16	27½
408		1952	16	Mot. Bar........	17	6	2.70	.18	22½
410		1236	12	New Model......	11	4	2.00	.19	18½
411		1845	12	Mot. Bar.......	5	5	1.40	.18	18½
412		1953	12	M.B. Thick Model	11	6	2.00	.17	18½
413		171	6	....	9	5	1.80	.18	14
414		981	0	....	8	8	1.70	.14	13
416		1422	6/0	....	3	9	1.20	.13	10½
419		358	12/0	....	3	9½	1.20	.12	
417		2092	18/0	Tongue End...	3	10	1.20	.11	9¾

MAINSPRINGS FOR AMERICAN WATCHES

ELGIN

Our No.	STYLE	Co.'s No.	Size	Description	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
221		4457	37	8 Day........	37	0	4.63	.24	29
202		812	18	17 J	20	1½	290	.225	21 1/2
203		812	18	7 to 15J.....	20	1	290	.23	21 1/2
201		812	18	21 to 23J.....	20	2½	290	.22	21 1/2
200		1956	18	Steel Barrel ..	30	5	390	.18	25 1/2
204		817	16	17 to 21J.....	17	4	265	.19	21 1/2
206		817	16	7 to 15J.....	17	3½	265	.205	21 1/2
207		2542	16	Steel Barrel....	17	4	264	.19	21
208		1712	12	Steel Barrel....	13¼	4	2.23	.19	20
209		1720	12	Wide.........	13¼	4	2.23	.19	20
210		2339	12	Narrow.......	11½	4	205	.19	20
211		2874	12	Thin Model....	7	6	1.65	.18	20 1/4
212		824	6	15J...........	10	5	190	.18	17 1/2
214		825	0	Narrow.......	4	7	127	.16	16
215		2097	0	Wide.........	7½	8	1.65	.14	16 1/2
216		2097	3/0	D. B..........	8	8	1.65	.135	16 1/2
222		4789	4/0	Legionnaire ...	10	10	190	.11	15 1/2
217		2706	5/0	7J...........	4	8½	125	.13	10 3/4
218		2890	5/0	15J...........	4	10	125	.115	11 1/2
219		2890	6/0	15J...........	4	10	125	.115	11 1/2
220		1057	10/0	15J...........	4	10	125	.115	9 3/4

HOWARD

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
600		55	18	Old Model... ...	19	3½	2.80	.20	23 1/2
602		328	16	23J. New Model..	18	6	2.70	.17	21 1/2
603		329	16	19J. New Model...	18	5	2.70	.18	21
604		552	12	17-21J. New Model	10	7	1.90	.15	19 1/2
605		553	12	17-21J. New Model	8½	7	1.75	.15	19
606		796	10	Tongue End... ..	6	7	1.50	.15	16

INGERSOLL MODELS

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
654		344	16	Trenton.	15	1½	2.40	.225	17 1/2
650		365	16	Ing. Trenton......	15	3½	2.40	.20	19
651		1365	16	Ing. Reliance.....	11	1	2.00	.23	17 1/2
652		2365	16	Ing. Reliance.....	12	2½	2.10	.21	18 1/2
653		316	12	Ing. Waterbury....	12	7	2.10	.15	19 3/4
655		6335	6/0	Alden.	7	7	1.60	.15	

SETH THOMAS

Our No.	STYLE	Co.'s No.	Size	Description	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
701		536	18	New Style........	24	4½	3.30	.185	21 1/4
702		720	18	Cent., wide..	24	2	3.30	.22	20

MAINSPRINGS FOR AMERICAN WATCHES

NEW YORK STANDARD

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
500		2189	18	Reg. Model......	20	1	2,90	.23	20
501		2190	18	New Model......	21	1½	3,00	.23	20
502			16	Excelsior.......	14	2½	2,30	.215	22½
505		3196	16	New Model......	16	2	2,50	.22	20½
504		3349	16	Thin Model......	15½	2	2,45	.22	20½
513		1321	16	Crown..........	15½	5	2,45	.18	20
506		4144	12	Model "B"......	10	2	1,90	.22	19
507		4284	12	Model K........	9	3½	1,83	.20	18
514		1322	12	Crown..........	11	5	2,00	.18	19
509		7080	10	Model K........	6	6½	1,50	.16	16¼
510			6	Reg. Model......	10	4½	1,90	.185	16½
511		5134	6	New Model......	10	5	1,90	.18	16
512		6133	0	New Model....	6	7	1,50	.15	15
515		1323	000	Crown.........	7	7	1,60	.15	13
516		1324	10/0	Crown..	3	12	1,20	.09	9½

SOUTH BEND

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
550		19528	18	1st and 2nd Model..	21	3¾	2,97	.195	21½
551		217528	16	1st Model.........	17	5	2,59	.18	20½
552		27528	16	2nd Model.........	19	5	2,82	.18	21¾
553		55528	12	1st Model.........	11	5½	1,98	.175	19
554		3528	6	1st Model.........	10	4½	1,88	.185	16½
555		22528	0	3rd Model.........	7½	8	1,65	.14	13½

ROCKFORD

Our No.	STYLE	Co.'s No.	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
450		644	18	1888 Model......	20	2	2,90	.22	22
451		822	16	New Model......	18	3½	2,70	.20	20½
452		932	12	[illegible] Model......	11	5½	2,00	.172	18¾
453		1077	0	1st Model....	8	8	1,70	.14	13¾

HAMPDEN

Our No.	STYLE	Co.'s No	Size	DESCRIPTION	Average Dennison Width	Average Dennison Strength	Width Metric mm	Thickness Metric mm	Length Inches
301		1696	18	7 to 15J. ...	20	1	2,90	.23	21¾
300		1696	18	17 to 23J........	20	3	2,90	.205	21¾
302		2696	16	Model 1890......	20	4	2,90	.19	21¾
303		3696	16	¾ Plate Mod....	18	3	2,65	.20	21½
304		3696	16	Bridge Mod......	18	4½	2,65	.185	21
305		4697	16	Pat. Barrel......	18	5	2,65	.18	21
306		5097	16	Pat. Barrel......	18	5	2,70	.18	21½
307		6696	12	7 to 17J.......	9	5	1,80	.18	18½
308		12696	12	Paul Revere....	5	5½	1,35	.172	19
309		8696	6	7 to 15J..	8½	6	1,75	.165	16¼
310		9696	3/0 5/0	[illegible] to 15J	5½	6½	1,45	.16	13
311		15696	8/0	Mary Jane.... Josephine.....	3½	8	1,23	.14	8¼
312		11696	11/0	... .	3	10	1,20	.11	9¼
313			5½L	Rectangular.. .	1	12	1,00	.09	

SIZE	CO.NO.	NU VIGOR NUMBER	WIDTH	STR.	LENGTH	METRIC WIDTH	METRIC STR.	METRIC LENGTH	END	DESCRIPTION
FOR:	**ELGIN**									
8 DAY	4457	75	37	0	29	4.63	.25	737	DB&H	
18	812	76	20	3	$21\frac{1}{2}$	2.90	.21	546	DB&H	21 JLS.) 18S FULL PLATE
18	812	77	20	$2\frac{1}{2}$	$21\frac{1}{2}$	2.90	.215	546	DB&H	15 JLS.) 18S $\frac{3}{4}$ PLATE WITH
18	812	78	20	2	$21\frac{1}{2}$	2.90	.22	546	DB&H	7 JLS.) GOING BARREL
18	812	79	20	1	$21\frac{1}{2}$	2.90	.23	546	DB&H	7 JLS.)
18	1956	81	30	6	$25\frac{1}{2}$	3.90	.17	648	HOOK	21 JLS.) 18S $\frac{3}{4}$ PLATE WITH
18	1956	80	30	5	$25\frac{1}{2}$	3.90	.18	648	HOOK	19 JLS.) STEEL SAFETY BARRELS
16	6164	125	20	4	$24\frac{1}{4}$	2.93	.19	622	DB&H	GRADES 571 THRU 575 INCLUSIVE
16	817	82	17	$4\frac{1}{2}$	$21\frac{1}{2}$	2.60	.185	546	DB&H	21 JLS.) ALL 16S MODELS
16	817	83	17	4	$21\frac{1}{2}$	2.60	.19	546	DB&H	17-19 JLS.) WITH GOING
16	817	84	17	$3\frac{3}{4}$	$21\frac{1}{2}$	2.60	.195	546	DB&H	17-19 JLS.) BARRELS
16	817	85	17	$3\frac{1}{2}$	$21\frac{1}{2}$	2.60	.20	546	DB&H	7-15 JLS.)
16	2542	86	17	5	21	2.60	.18	533	S.B.	19 JLS.) ALL 16S WITH STEEL
16	2542	87	17	4	21	2.60	.19	533	S.B.	17 JLS.) SAFETY BARRELS
12	1712	88	13	$4\frac{1}{2}$	20	2.26	.185	508	S.B.	7-15 JLS.) 2ND&3RD MODELS
12	1712	89	13	4	20	2.26	.19	508	S.B.	7 JLS.) WITH STEEL BARRELS
12	1720	90	13	$4\frac{1}{2}$	20	2.26	.185	508	DB&H	
12	1720	91	13	4	20	2.26	.19	508	DB&H	
12	2339	92	11	$4\frac{1}{2}$	20	2.00	.185	508	DB&H	15 JLS.) 2ND & 3RD MODELS
12	2339	93	11	4	20	2.00	.19	508	DB&H	7-15 JLS.) WITH THIN GOING
12	2339	94	11	$3\frac{3}{4}$	20	2.00	.195	508	DB&H	7 JLS.) BARRELS
12	2874	95	7	5	$20\frac{1}{4}$	1.60	.18	514	DB&H	19 JLS.) 4TH MODEL
12	2874	96	7	$4\frac{1}{2}$	$20\frac{1}{4}$	1.60	.185	514	DB&H	17-19 JLS.) STREAMLINE AND
12	2874	97	7	4	$20\frac{1}{4}$	1.60	.19	514	DB&H	17 JLS.) CORSICAN
10	5726	127	$7\frac{1}{2}$	7	$17\frac{1}{2}$	1.65	.15	445	DB&H	17-21 JLS.) 5TH & 6TH MODELS
10	5726	126	$7\frac{1}{2}$	6	$17\frac{1}{2}$	1.65	.17	445	DB&H	15 JLS.) WITH GOING BARREL
6	824	99	10	6	$17\frac{1}{2}$	1.90	.17	445	DB&H	7-15 JLS.) 1ST & 2ND
6	824	98	10	$5\frac{1}{2}$	$17\frac{1}{2}$	1.90	.175	445	DB&H	7-15 JLS.) MODELS
0	825	100	4	7	16	1.30	.15	406	DB&H	7-15 JLS.) 1ST MODEL
0	825	101	4	$6\frac{3}{4}$	16	1.30	.155	406	DB&H	7-15 JLS.)
3/0&0	2097	102	$7\frac{1}{2}$	8	$16\frac{1}{2}$	1.65	.14	419	DB&H	7-15 JLS.) 2ND & 3RD MODELS
3/0&0	2097	103	$7\frac{1}{2}$	$7\frac{1}{2}$	$16\frac{1}{2}$	1.65	.145	419	DB&H	7 JLS.) WITH GOING BARRELS
4/0	4789	104	10	10	$15\frac{3}{4}$	1.90	.11	400	DB&H	17 JLS.) 1ST MODELS
4/0	4789	105	10	$9\frac{1}{2}$	$15\frac{3}{4}$	1.90	.12	400	DB&H	7-17 JLS.) WITH GOING
4/0	4789	106	10	9	$15\frac{3}{4}$	1.90	.13	400	DB&H	7 JLS.) BARRELS
5/0	2705	107	$3\frac{1}{2}$	9	$10\frac{3}{4}$	1.25	.13	273	DB&H	15 JLS.) 1ST MODEL USED
5/0	2705	108	$3\frac{1}{2}$	$8\frac{1}{2}$	$10\frac{3}{4}$	1.25	.135	273	DB&H	15 JLS.) ONLY IN GRADE 380
6/0	2890	109	$3\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	1.25	.095	292	DB&H	15 JLS.) 1ST & 2ND
6/0	2890	110	$3\frac{1}{2}$	11	$11\frac{1}{2}$	1.25	.10	292	DB&H	7-15 JLS.) MODELS
6/0	2890	111	$3\frac{1}{2}$	10	$11\frac{1}{2}$	1.25	.11	292	DB&H	7-15 JLS.)
6/0	2890	112	$3\frac{1}{2}$	$9\frac{1}{4}$	$11\frac{1}{2}$	1.25	.125	292	DB&H	7 JLS.)
8/0	5219	121	$7\frac{1}{2}$	10	12	1.65	.11	304	DB&H	15-17 JLS.) 1ST MODEL
10/0	1957	115	$3\frac{1}{2}$	11	$9\frac{3}{4}$	1.25	.10	248	DB&H	15-17 JLS.) 1ST MODEL
10/0	1957	113	$3\frac{1}{2}$	10	$9\frac{3}{4}$	1.25	.11	248	DB&H	7-15 JLS.) 4TH&5TH MODELS
10/0	1957	114	$3\frac{1}{2}$	$9\frac{1}{4}$	$9\frac{3}{4}$	1.25	.125	248	DB&H	7-15 JLS.)
15/0	5550	123	$3\frac{1}{2}$	10	$12\frac{1}{4}$	1.27	.11	311	DB&H	17-21 JLS.) 1ST MODEL
20/0	5015	119	2	12	$8\frac{1}{4}$	1.10	.09	210	DB&H	15-17 JLS.) 1ST MODEL, OVAL
21/0	5327	122	$3\frac{3}{4}$	$11\frac{3}{4}$	$9\frac{1}{2}$	1.28	.095	241	DB&H	7-15-17 JLS.) 1ST MODEL
21/0	5724	124	$3\frac{1}{2}$	$12\frac{1}{2}$	7-3/8	1.25	.085	187	DB&H	19 JLS.) 4TH MODEL WITH GOING BARRELS
26/0	5131	120	2	13	$8\frac{1}{4}$	1.10	.08	210	DB&H	7-17 JLS.) 1ST MODEL

10/0 SIZE MAINSPRINGS GENERALLY MAY BE USED FOR 16/0 AND 18/0 SIZES

SIZE	CO.NO	NU VIGOR NUMBER	WIDTH	STR.	LENGTH	METRIC WIDTH	METRIC STR.	METRIC LENGTH	END	DESCRIPTION
FOR:	HAMILTON									
18	14	225	23	4½	25	3.25	.185	635	HOOK	
18	15	226	19	3½	21	2.80	.20	533	TEE	
18	15	228	19	3¼	21	2.80	.205	533	TEE	
18	15	227	19	3	21	2.80	.215	533	TEE	
18	232	229	22	5	25	3.10	.18	635	MB	
16	5348	252	21	6¾	23½	3.00	.155	597	MB	MODEL 992B
16	317-318	231	19	5	21	2.80	.18	533	TEE	
16	317-318	230	19	4	21	2.80	.19	533	TEE	
16	318	232	19	4½	21	2.80	.195	533	TEE	
16	534	235	19	6¾	22	2.80	.165	559	MB	MODEL 992
16	534	234	19	6½	22	2.80	.16	559	MB	MODEL 992
12	1228-3028	236	8	5½	21¼	1.70	.175	540	MB	REGULAR
12	6021	250	6	6	17¼	1.52	.17	438	DB	MODELS 917,921,923
12	3328	238	5	6½	18½	1.40	.16	470	MB	MODEL 400
0	1536	239	5½	7¾	14	1.45	.145	356	TEE	MODEL 981,983
0	1535	240	5½	7¾	14	1.45	.145	356	MB	MODEL 985
6/0	2621	245	5	9¾	11½	1.40	.115	292	TEE	MODEL 979
6/0	2521	244	5	9½	11½	1.40	.12	292	TEE	MODELS 987A,987S,987, 987F,979
6/0	2321	243	5	9¼	11½	1.40	.125	292	TEE	MODELS 986A,987E
6/0	1721-1921	241	5	8½	10	1.40	.135	254	TEE	MODELS 986,988
8/0	7221	253	6	11½	13¾	1.50	.095	349	DB	MODELS 747,748
12/0	4128	246	3	9¾	14½	1.20	.125	368	TEE	MODEL 401
14/0	5021	249	4	10	11½	1.30	.11	292	DB	MODELS 980,982
18/0	2721	247	2	12½	11	1.10	.085	279	TEE	MODEL 989
21/0	7421	254	5	14	8½	1.40	.07	216	TONGUE	MODEL 750 - 17 JEWELS
21/0	2921	248	1	13½	10	1.00	.075	254	TEE	MODELS 997,995,995A,721
22/0	6221	251	5	14½	7¾	1.40	.065	197	DB	MODEL 911
FOR:	HAMPDEN									
18	1696	371	20	3	21¾	2.90	.21	552	TEE	
18	1696	370	20	2	21¾	2.90	.22	552	TEE	
16	2696	372	20	4	21¾	2.90	.19	552	TEE	MODEL 1890
16	5697	377	18	6	21½	2.65	.165	546	HOLE	
16	4697	376	18	5	21	2.65	.18	533	BRACE	
16	3696	375	18	4½	21	2.65	.185	533	TEE	MODEL 1902
16	3696	374	18	4	21	2.65	.19	533	TEE	MODEL 1902
16	3696	373	18	3½	21	2.65	.20	533	TEE	MODEL 1902
12	7696	384	9	7	18½	1.80	.15	470	TEE	MODEL 1910
12	7696	385	9	6	18½	1.80	.17	470	TEE	MODEL 1910
12	6696-7696	378	9	5	18½	1.80	.18	470	TEE	MODEL 1910
12	12696	379	5	5½	19	1.35	.175	483	TEE	
6	8696	380	9	6	16¼	1.80	.17	413	TEE	ALL JEWELS
3/0	9696	381	5	6½	13	1.40	.16	330	TEE	M.STARK-DIADEM
8/0	15696	382	3	8	8¼	1.20	.14	210	TEE	M.JANE-JOSEPHINE
11/0	11696	383	3	11	9-1/16	1.20	.10	230	TEE	ALL JEWELS

SIZE	CO.NO	NU VIGOR NUMBER	WIDTH	STR.	LENGTH	METRIC WIDTH	METRIC STR.	METRIC LENGTH	END	DESCRIPTION
FOR: HOWARD										
18	55	446	20	3	23½	2.90	.21	597	HOLE	
18	55	445	19	3	23½	2.80	.21	597	HOLE	
16	328	447	18	6	21½	2.70	.17	546	HOLE	
16	329	448	18	5	21	2.70	.18	533	TEE.	
12	552	449	10	7	19½	1.90	.15	495	HOLE	
12	553	450	9	5½	19	1.80	.175	483	TEE	
10	796	451	6	7	16	1.50	.15	406	TONGUE	
FOR: ILLINOIS										
18	47301	295	20	3½	21½	2.90	.20	546	TEE	OLD NO.53 1ST TO 6TH MODELS
18	47302	296	20	3	21½	2.90	.21	546	TEE	OLD NO.53 1ST TO 6TH MODELS
18	47303	297	20	2	21½	2.90	.22	546	TEE	OLD NO.53 1ST TO 6TH MODELS
16	47309	298	21	6¾	27	3.00	.155	686	MB	60 HOUR 13TH-14TH-15TH MODELS
16	47333	305	20	3½	20½	2.90	.20	521	TEE	OLD NO.124 4TH & 5TH MODELS - THICK BARREL
16	47314	299	18	5	20½	2.70	.18	521	DB	OLD NO.573 21-23 JEWELS SMALL BARREL
16	47315	300	18	4½	20½	2.70	.185	521	DB	OLD NO. 573 SMALL BARREL
16	47316	301	18	4	20½	2.70	.19	521	DB	OLD NO. 573 17-19 JEWELS SMALL BARREL
16	47317	302	18	3½	20½	2.80	.20	521	DB	OLD NO. 573 7-15 JEWELS SMALL BARREL
16	47326	303	18	6	22½	2.70	.17	572	MB	OLD NO. 1954 11TH & 12TH MODELS
16	47327	304	18	5½	22½	2.70	.175	572	MB	BUNN SPECIAL OLD NO. 1954 11TH & 12TH MODELS
16	47320	307	18	5	22½	2.70	.18	572	DB	OLD NO. 1770 LARGE BARREL 6TH TO 9TH MODELS
16	47321	308	18	4½	22½	2.70	.185	572	DB	OLD NO. 1770 LARGE BARREL 6TH TO 9TH MODELS
16	47334	306	16	3	20	2.50	.21	508	TEE	OLD NO. 365 1ST-2ND-3RD MODELS THIN BARREL
12&13	47336	309	5	6½	18½	1.34	.16	470	MB	OLD NO. 1845 EXTRA THIN 1ST TO 3RD MODELS
12&13	47337	310	5	6	18½	1.34	.17	470	MB	OLD NO. 1845 EXTRA THIN 1ST TO 3RD MODELS
12&13	47338	311	5	5	18½	1.34	.18	470	MB	OLD NO. 1845 EXTRA THIN 1ST TO 3RD MODELS
12	47349	314	11	7	18½	1.99	.15	470	MB	OLD NO. 1953 5TH & 6TH MODELS
12	47350	315	11	6½	18½	1.99	.16	470	MB	OLD NO. 1953 5TH & 6TH MODELS
12	47343	312	11	6	18½	1.99	.17	470	DB	OLD NO. 1236 1ST TO 4TH MODELS
12	47344	313	11	5	18½	1.99	.18	470	DB	OLD NO. 1236 GOING BARREL 1ST TO 4TH MODELS
6	47353	333	9	6½	14	1.80	.16	356	TEE	ALL JEWELS 1ST MODEL
0	47357	316	8	9¼	13	1.70	.125	330	TEE	OLD NO.981) 1ST TO 4TH
0	47358	317	8	9	13	1.70	.13	330	TEE	OLD NO.981) MODELS AND
0	47359	318	8	8½	13	1.70	.135	330	TEE	OLD NO.981) IMPROVED 4TH
6/0	47363	319	3	9¼	10½	1.18	.125	267	DB	OLD NO.1422 O.F.) 1ST TO
6/0	47364	320	3	9	10½	1.18	.13	267	DB	OLD NO.1422 O.F.) 3RD
6/0	47365	321	3	8	10½	1.18	.14	267	DB	OLD NO.1422 O.F.) MODELS.
6/0	47370	322	5	10	12½	1.41	.11	318	DB	OLD NO.1095 HTG) 4TH TO
6/0	47371	323	5	9¾	12½	1.41	.115	318	DB	OLD NO.1095 HTG) 6TH MODELS
12/0	47376	324	3	9½	14½	1.18	.12	368	DB	OLD NO. 358) 1ST
12/0	47377	325	3	9¼	14½	1.18	.125	368	DB	OLD NO. 358 ALL JLS) MODELS
18/0	47383	326	3	12	10	1.20	.09	254	DB	OLD NO. 2092) 1ST TO 5TH
18/0	47384	327	3	11½	10	1.20	.095	254	DB	OLD NO. 2092) MODELS 15
18/0	47385	328	3	11	10	1.20	.10	254	DB	OLD NO. 2092) JEWELS
18/0	47380	332	3	11	12	1.20	.10	305	TONGUE	OLD NO. 2092 1ST MODEL-HOOK IN BARREL
21/0	47387	329	1	13	8-3/10	1.00	.08	211	DB	)
21/0	47388	330	1	12¾	8-3/10	1.00	.0825	211	DB	) 1ST MODEL
21/0	47389	331	1	12½	8-3/10	1.00	.085	211	DB	)

SIZE	CO.NO.	NU VIGOR NUMBER	WIDTH	STR.	LENGTH	METRIC WIDTH	METRIC STR.	METRIC LENGTH	END	DESCRIPTION
FOR INGERSOLL RELIANCE										
16	1365	872	11	2	17½	2.00	.22	445	TEE	
16	2365	873	11	2	18½	2.10	.22	470	HOLE	
FOR: INGERSOL TRENTON										
16	365	802	15	3½	19	2.40	.20	483	TEE	
FOR: INGERSOL WATERBURY										
12	316	942	12	6	19½	2.10	.17	495	TONGUE	
FOR: NEW YORK STANDARD										
18	2189	585	20	1	20	2.90	.23	508	HOLE	
18	2190	586	20	1	20	2.90	.23	508	TEE	
16	1032	588	16	3½	21	2.50	.20	533	HOLE	
16	1321	655	15½	5	20	2.45	.18	508	TEE	
16	3196	590	15½	2	20½	2.45	.22	511	TEE	
16	3349	589	14	3	20½	2.30	.21	521	TEE	
16	1730	587	14	1	22½	2.30	.23	572	HOLE	
12	1322	656	11	5	19	2.00	.18	483	TEE	
12	4144	591	10	2	19	1.90	.22	483	TEE	
12	4282	593	9½	4	16	1.85	.19	406	TONGUE	
12	4284	592	9½	3½	18	1.85	.20	457	TONGUE	
10	7080	594	5¾	5¾	16¼	1.50	.168	413	TONGUE	
10	7080	595	5¾	4	16¼	1.50	.19	413	TONGUE	
6	5134	597	10	5	16	1.90	.18	406	TEE	
6	727	596	10	4½	16½	1.90	.185	419	HOLE	
0	6133	598	5½	7	15	1.45	.15	381	TEE	
3/0	1323	657	7	7	13	1.60	.15	330	TEE	
10/0	1324	658	2½	12	9½	1.15	.09	241	TEE	
FOR: ROCKFORD										
18	644	728	20	2	22	2.90	.22	559	TEE	
16	822	729	18	3½	20½	2.70	.20	521	TEE	
12	932	730	11	5½	18¾	2.00	.175	476	TEE	
6	544	731	12	5½	18½	2.10	.175	470	TEE	
0	1077	732	8	9	13¾	1.70	.13	349	TEE	
FOR: SETH THOMAS										
18	536	1073	24	3¾	21¼	3.30	.195	540	TEE	
18	141	1072	24	2	21	3.30	.22	533	TEE	
18	729	1074	24	1½	20	3.30	.22	508	TEE	
18	828	1075	20	2	20	2.90	.22	508	TEE	
16	2106	1076	14½	2	21	2.40	.22	533	TEE	
12	2521	1077	11	3½	21	2.00	.20	533	TEE	
6	1026	1078	10	3¾	14½	1.90	.195	362	TEE	
FOR: SOUTH BEND										
18	29528	517	21	4½	21½	2.97	.185	546	TEE	THICK
18	19528	516	21	3¾	21½	2.97	.195	546	TEE	THICK
18	69528	515	21	3	21½	2.97	.21	546	TEE	
16	47528	523	19	6	21-7/10	2.80	.17	551	TEE	THICK
16	67528	522	19	5½	21-7/10	2.80	.175	551	TEE	
16	37528	521	19	5	21-7/10	2.80	.18	551	TEE	
16	27528	520	19	4	21-7/10	2.80	.19	551	TEE	THICK
16	217528	519	17	5	20½	2.59	.18	521	TEE	
16	17528	518	17	3½	20½	2.59	.20	521	TEE	THICK

SIZE	CO.NO.	NU VIGOR NUMBER	WIDTH	STR.	LENGTH	METRIC WIDTH	METRIC STR.	METRIC LENGTH	END	DESCRIPTION
FOR:	SOUTH BEND CONTINUED									
12	35528	526	11	6	19	1.98	.17	483	TEE	
12	55528	525	11	5½	19	1.98	.175	483	TEE	ALL MODELS
12	25528	524	11	5	19	1.98	.18	483	TEE	
6	3528	527	10	4½	16½	1.85	.185	419	TEE	ALL MODELS
0	22528	529	7½	8½	13½	1.65	.135	343	TEE	
0	12528	528	7½	8	13½	1.65	.14	343	TEE	ALL MODELS
0	32528	530	6	8	13-1/6	1.50	.14	335	TEE	
FOR:	TRENTON									
16	567	1002	15	7½	17½	2.40	.215	445	TEE	
FOR:	WALTHAM									
8 DAY	2232	150	37	2	30	4.60	.22	762	HOLE	SIZE 37
8 DAY	2232	151	37	1	30	4.60	.23	762	HOLE	SIZE 37
18	2203	152	20	3	21	2.90	.21	533	TEE	MODELS 1877 & 1879 17-21 JLS
18	2203	153	20	2½	21	2.90	.215	533	TEE	MODELS 1877 & 1879 17-21 JLS
18	2203	154	20	2	21	2.90	.22	533	TEE	MODELS 1877 & 1879 15 JLS
18	2203	155	20	1½	21	2.90	.225	533	TEE	MODELS 1877 & 1879 7-15 JLS.
18	2205	156	21	3	21	3.00	.21	533	TEE	MODEL 1883 17-21 JEWELS)
18	2205	157	21	2½	21	3.00	.215	533	TEE	MODEL 1883 17-21 JEWELS)
18	2205	158	21	2	21	3.00	.22	533	TEE	MODEL 1883 17-21 JEWELS)
18	2205	159	21	1½	21	3.00	.225	533	TEE	MODEL 1883 7-15 JEWELS)
18	2222	160	23	6	25	3.20	.17	635	HOLE	MODEL 1892 7-15 JEWELS)
18	2222	161	23	5	25	3.20	.18	635	HOLE	MODEL 1892 21-23 JEWELS)
18	2222	162	23	4	25	3.20	.19	635	HOLE	MODEL 1892 17-19 JEWELS)
16	2218	164	19	4½	25	2.80	.185	635	HOLE	MODEL 1888 7 JEWELS
16	2218	165	19	4	25	2.80	.19	635	HOLE	MODEL 1888 7 JEWELS
16	2218	166	19	3½	25	2.80	.20	635	HOLE	MODEL 1888 7 JEWELS
16	2227	167	19	7	25	2.80	.15	635	HOLE	MODELS 1899-1908 21-23 JLS
16	2227	168	19	6½	25	2.80	.16	635	HOLE	MODELS 1899-1908 21-23 JLS
16	2227	169	19	6	25	2.80	.17	635	HOLE	MODELS 1899-1908 17-19 JLS
16	2227	170	19	5	25	2.80	.18	635	HOLE	MODELS 1899-1906 17-19 JLS
16	2227	171	19	4	25	2.80	.19	635	HOLE	MODELS 1899-1908 7-15 JLS.
16	2247	224A	17	6	21¼	2.60	.17	540	DB&H	MODEL 1945 R.B. 7 JEWELS
16	2208	163	14	2½	21	2.30	.215	533	TEE	MODEL 1872
14	2211	173	16	2	19	2.50	.22	483	TEE	MODEL 1884
14	2210	172	12	3	19	2.10	.21	483	TEE	MODEL 1874
12	2224A	183	12½	9	19¼	2.15	.13	489	HOLE	MODEL 1894 17-21 JEWELS
12	2224A	184	12½	8	19¼	2.15	.14	489	HOLE	MODEL 1894 7-15 JEWELS
12	2224A	185	12½	7	19¼	2.15	.15	489	HOLE	MODEL 1894 7-15 JEWELS
12	2224A	186	12½	6½	19¼	2.15	.16	489	HOLE	MODEL 1894 7 JEWELS
12	2224	182	12½	7	19¼	2.15	.15	489	HOOK	BUTTON END
12	2237	179	8	7	19¼	1.70	.15	489	HOLE	COL. B. MODEL 1924
12	2237	180	8	6½	19¼	1.70	.16	489	HOLE	COL. B. MODEL 1924
12	2237	181	8	6	19¼	1.70	.17	489	HOLE	COL. B. MODEL 1924
12	2234	174	4	9½	19	1.30	.12	483	HOLE	COL. A
12	2234	175	4	9	19	1.30	.13	483	HOLE	COL. A
12	2234	176	4	8	19	1.30	.14	483	HOLE	COL. A
12	2234	178	4	6½	19	1.30	.16	483	HOLE	COL. A
12	2234	177	4	5	19	1.30	.18	483	HOLE	COL. A
6X8	2215	187	10	3	16	1.90	.21	406	TEE	MODEL 1873
6X8	2215	188	10	2	16	1.90	.22	406	TEE	MODEL 1873
6	2219	191	12	8	16	2.10	.14	406	HOLE	MODEL 1890
6	2219	192	12	7	16	2.10	.15	406	HOLE	MODEL 1890
6	2219	193	12	6½	16	2.10	.16	406	HOLE	MODEL 1890
6	2217	190	10	5	16	1.90	.18	406	TEE	MODEL 1889
6	2217	189	10	4	16	1.90	.19	406	TEE	MODEL 1889
	2216	194	8	6	16	1.70	.17	406	TEE	MODELS 1882, 1887

SIZE	CO.NO.	NU VIGOR NUMBER	WIDTH	STR.	LENGTH	METRIC WIDTH	METRIC STR.	LENGTH	END	DESCRIPTION
FOR:	WALTHAM CONTINUED -									
0	2230	200	11¾	10	15	2.06	.11	381	HOLE	MODEL 1907
0	2230	201	11¾	9½	15	2.06	.12	381	HOLE	MODEL 1907
0	2230	202	11¾	9	15	2.06	.13	381	HOLE	MODEL 1907
0	2230	203	11¼	8	[illegible]	2.06	.14	381	HOLE	MODEL 1907
0	2228	197	8	10	15	1.70	.11	381	HOLE	MODEL 1900
0	2228	198	8	9½	15	1.70	.12	381	HOLE	MODEL 1900
0	2228	199	8	9	15	1.70	.13	381	HOLE	MODEL 1900
0	2220	195	6½	8	16	1.55	.14	406	HOLE	MODEL 1891
0	2220	196	6½	7	16	1.55	.15	406	HOLE	MODEL 1891
6/0	2248	2248	6	10	11½	1.50	.11	292	DB&H	MODEL 1945 R.B.
6/0	2226	204	6	10	13½	1.50	.11	343	HOLE	MODEL 1898 HTG & MODEL 1942
6/0	2226	205	6	9½	13½	1.50	.12	343	HOLE	MODEL 1898 HTG & MODEL 1942
6/0	2226	206	6	9	13½	1.50	.13	343	HOLE	MODEL 1898 HTG & MODEL 1942
6/0	2235	207	4	10	13½	1.30	.11	343	HOLE	MODEL 1912 J.S. SIZE 1912 O.F.
6/0	2235	208	4	9½	13½	1.30	.12	343	HOLE	MODEL 1912 J.S. SIZE 1912 O.F.
6/0	2235	209	4	9	13½	1.30	.13	343	HOLE	MODEL 1912 J.S. SIZE 1912 O.F.
10L	2229	210	6	12	10¼	1.50	.09	260	HOLE	
10L	2229	211	6	11	10¼	1.50	.10	260	HOLE	
10L	2229	212	6	10	10¼	1.50	.11	260	HOLE	
9L	2233	213	1½	11	10¼	1.08	.10	260	HOLE	
9L	2233	214	1½	10	10¼	1.08	.11	260	HOLE	
8¾L	2242	221	5	12	8¾	1.40	.09	222	HOLE	870 ROUND
7½L	2236	215	2	13	9	1.10	.08	229	HOLE	SAME AS 5¼L ROUND
750	2243	222	2	12	13	1.10	.095	330	HOLE	BARREL SHAPE 7½L
750B	2250	224C	2½	10½	12¼	1.15	.105	311	DB&H	7½L BARREL SHAPE R.B.
7¼L	2238	217	4	12	12¼	1.30	.09	311	HOLE	RECTANGULAR
7¼L	2238	216	4	11	12¼	1.30	.10	311	HOLE	RECTANGULAR
675	2249	224D	2½	15	8½	1.15	.06	216	TONGUE	R.B.
678	2251	224E	4	13½	9½	1.30	.075	241	DB&H	R.B. BARREL SHAPE
670	2244	224	2½	15	8	1.15	.06	203	HOLE	ROUND
6½L	2239	218	1½	11½	9½	1.05	.095	241	HOLE	SAME AS 450M
450	2241	223	1½	11½	10½	1.05	.095	267	HOLE	RECTANGULAR
4L	2240	220	2	12	8	1.10	.09	203	HOLE	400 RECTANGULAR
4L	2240	219	2	11	8	1.10	.10	203	HOLE	400 RECTANGULAR

ALLOY (UNBREAKABLE) MAINSPRINGS FOR CURRENT WRIST WATCHES

REGULAR

BESTFIT Stock No.	Dennison	Metric
4011C	0000 x 11 x 8½	.58 x .10
011H	0 x 11 x 10½	.90 x .10
012C	0 x 12 x 8½	.90 x .09
0595K	0½ x 9¾ x 11½	.95 x .115
195P	1 x 9½ x 13½	1.00 x .12
110H	1 x 10 x 10½	1.00 x .11
110P	1 x 10 x 13½	1.00 x .11
112E	1 x 12 x 9½	1.00 x .09
112R	1 x 12 x 14	1.00 x .09
15105P	1½ x 10½ x 13½	1.05 x .105
1513A	1½ x 13 x 7½	1.05 x .08
15135	1½ x 13½ x 6½	1.05 x .075
24V	2 x 4 x 16	1.10 x .19
28P	2 x 8 x 13½	1.10 x .14
295P	2 x 9½ x 13	1.10 x .12
210E	2 x 10 x 9½	1.10 x .11
210H	2 x 10 x 10½	1.10 x .11
211E	2 x 11 x 9½	1.10 x .10
211H	2 x 11 x 10½	1.10 x .10
211K	2 x 11 x 11½	1.10 x .10
211M	2 x 11 x 12½	1.10 x .10
212A	2 x 12 x 7½	1.10 x .09
212C	2 x 12 x 8½	1.10 x .09
212E	2 x 12 x 9½	1.10 x .09
213W	2 x 13 x 6½	1.10 x .08
213A	2 x 13 x 7½	1.10 x .08
213C	2 x 13 x 8½	1.10 x .08
213E	2 x 13 x 9½	1.10 x .08
214W	2 x 14 x 6½	1.10 x .07
214A	2 x 14 x 7½	1.10 x .07
214C	2 x 14 x 8½	1.10 x .07
258X	2½ x 8 x 18	1.15 x .14
2595P	2½ x 9½ x 13½	1.15 x .12
2510E	2½ x 10 x 9½	1.15 x .11
2510F	2½ x 10 x 10	1.15 x .11
2510H	2½ x 10 x 10½	1.15 x .11
2510P	2½ x 10 x 13½	1.15 x .11
2511E	2½ x 11 x 9½	1.15 x .10
2512F	2½ x 12 x 10	1.15 x .09
2514C	2½ x 14 x 8½	1.15 x .07
34Y	3 x 4 x 17	1.20 x .19
36Y	3 x 6 x 17	1.20 x .17
365Z	3 x 6½ x 22	1.20 x .16
38T	3 x 8 x 15½	1.20 x .14
38Z	3 x 8 x 23½	1.20 x .14
39M	3 x 9 x 12	1.20 x .13
310E	3 x 10 x 9½	1.20 x .11
310H	3 x 10 x 10½	1.20 x .11
310K	3 x 10 x 11½	1.20 x .11
3105F	3 x 10½ x 9¾	1.20 x .105
3105M	3 x 10½ x 12½	1.20 x .105
311C	3 x 11 x 8½	1.20 x .10
311E	3 x 11 x 9½	1.20 x .10
311H	3 x 11 x 10½	1.20 x .10
311K	3 x 11 x 11½	1.20 x .10
311N	3 x 11 x 13	1.20 x .10
312A	3 x 12 x 7½	1.20 x .09
312B	3 x 12 x 8	1.20 x .09
312C	3 x 12 x 8½	1.20 x .09
312E	3 x 12 x 9½	1.20 x .09
312H	3 x 12 x 10½	1.20 x .09
313A	3 x 13 x 7½	1.20 x .08
313B	3 x 13 x 8	1.20 x .08
313C	3 x 13 x 8½	1.20 x .08
313E	3 x 13 x 9½	1.20 x .08
313H	3 x 13 x 10½	1.20 x .08
314W	3 x 14 x 6½	1.20 x .07
314AA	3 x 14 x 7	1.20 x .07
314A	3 x 14 x 7½	1.20 x .07
314C	3 x 14 x 8½	1.20 x .07

REGULAR (Cont'd)

BESTFIT Stock No.	Dennison	Metric
314E	3 x 14 x 9½	1.20 x .07
315A	3 x 15 x 7½	1.20 x .06
315E	3 x 15 x 9½	1.20 x .06
WV100	3 x 15½ x 11½	1.20 x .055
359Z	3½ x 9 x 19½	1.25 x .13
3595K	3½ x 9½ x 11½	1.25 x .12
3595R	3½ x 9½ x 13	1.25 x .12
3510E	3½ x 10 x 9½	1.25 x .11
3510J	3½ x 10 x 11	1.25 x .11
3510T	3½ x 10 x 15½	1.25 x .11
3511E	3½ x 11 x 9½	1.25 x .10
3511H	3½ x 11 x 10½	1.25 x .10
3511R	3½ x 11 x 14	1.25 x .10
3512E	3½ x 12 x 9½	1.25 x .09
3512R	3½ x 12 x 18½	1.25 x .09
3513C	3½ x 13 x 8½	1.25 x .08
3513E	3½ x 13 x 9½	1.25 x .08
3514E	3½ x 14 x 9½	1.25 x .07
3515A	3½ x 15 x 7¾	1.25 x .06
46X	4 x 6 x 16¾	1.30 x .17
47X	4 x 7 x 16½	1.30 x .15
48T	4 x 8 x 15	1.30 x .14
485Z	4 x 8½ x 20	1.30 x .135
419P	4 x 9 x 13½	1.30 x .13
49T	4 x 9 x 15¼	1.30 x .13
494K	4 x 9½ x 11½	1.30 x .12
494P	4 x 9½ x 13¾	1.30 x .125
410E	4 x 10 x 9½	1.30 x .11
410H	4 x 10 x 10½	1.30 x .11
410K	4 x 10 x 11½	1.30 x .11
410M	4 x 10 x 12½	1.30 x .11
4105P	4 x 10½ x 11½	1.30 x .105
411C	4 x 11 x 8½	1.30 x .10
411E	4 x 11 x 9½	1.30 x .10
411H	4 x 11 x 10½	1.30 x .10
411K	4 x 11 x 11½	1.30 x .10
411M	4 x 11 x 12½	1.30 x .10
411P	4 x 11 x 13½	1.30 x .10
412C	4 x 12 x 8½	1.30 x .09
412E	4 x 12 x 9½	1.30 x .09
412H	4 x 12 x 10½	1.30 x .09
412K	4 x 12 x 11½	1.30 x .09
413A	4 x 13 x 7½	1.30 x .08
413C	4 x 13 x 8½	1.30 x .08
413E	4 x 13 x 9½	1.30 x .08
413H	4 x 13 x 10½	1.30 x .08
413M	4 x 13 x 12	1.30 x .08
414A	4 x 14 x 7½	1.30 x .07
414C	4 x 14 x 8½	1.30 x .07
414E	4 x 14 x 9½	1.30 x .07
414H	4 x 14 x 10½	1.20 x .07
415A	4 x 15 x 7	1.30 x .06
415C	4 x 15 x 8½	1.30 x .06
4565T	4½ x 6½ x 15	1.35 x .16
4575V	4½ x 7½ x 16	1.35 x .145
458R	4½ x 8 x 14½	1.35 x .14
459S	4½ x 9½ x 12¾	1.35 x .12
4595P	4½ x 9¾ x 13½	1.35 x .12
4513AA	4½ x 13 x 7	1.35 x .08
4513C	4½ x 13 x 8½	1.35 x .08
4513D	4½ x 13 x 9	1.35 x .08
4513E	4½ x 13 x 9½	1.35 x .08
4513F	4½ x 13 x 10	1.35 x .08
4513G	4½ x 13 x 10¼	1.35 x .08
4513H	4½ x 13 x 10½	1.35 x .08
4514C	4½ x 14 x 8½	1.35 x .07
4514H	4½ x 14 x 10½	1.35 x .07
45135AA	4½ x 14½ x 7	1.35 x .065
4515W	4½ x 15 x 6¼	1.35 x .06

REGULAR (Cont'd)

BESTFIT Stock No.	Dennison	Metric
54V	5 x 4 x 16½	1.40 x .19
55R	5 x 5 x 18½	1.40 x .18
565X	5 x 6½ x 19	1.40 x .16
57R	5 x 7 x 18½	1.40 x .15
58Z	5 x 8 x 22	1.40 x .14
595M	5 x 9½ x 12½	1.40 x .12
510E	5 x 10 x 9½	1.40 x .11
510H	5 x 10 x 10½	1.40 x .11
510K	5 x 10 x 11½	1.40 x .11
510M	5 x 10 x 12½	1.40 x .11
510P	5 x 10 x 13½	1.40 x .11
511E	5 x 11 x 9½	1.40 x .10
511H	5 x 11 x 10½	1.40 x .10
511K	5 x 11 x 11½	1.40 x .10
511M	5 x 11 x 12½	1.40 x .10
511P	5 x 11 x 13½	1.40 x .10
512C	5 x 12 8½	1.40 x .09
512E	5 x 12 x 9½	1.40 x .09
512H	5 x 12 x 10½	1.40 x .09
512K	5 x 12 x 11½	1.40 x .09
512M	5 x 12 x 12½	1.40 x .09
512P	5 x 12 x 13½	1.40 x .09
512S	5 x 12 x 14½	1.40 x .09
513C	5 x 13 x 8½	1.40 x .08
513E	5 x 13 x 9½	1.40 x .08
513H	5 x 13 x 10½	1.40 x .08
514A	5 x 14 x 7½	1.40 x .07
514C	5 x 14 x 8½	1.40 x .07
514E	5 x 14 x 9½	1.40 x .07
514K	5 x 14 x 11½	1.40 x .07
515A	5 x 15 x 7¼	1.40 x .06
515C	5 x 15 x 8½	1.40 x .06
5535R	5½ x 3½ x 14½	1.45 x .20
5510X	5½ x 10 x 19	1.45 x .11
WX98	5½ x 10 x 20	1.45 x .11
55105R	5½ x 10½ x 14½	1.45 x .105
5512E	5½ x 12 x 9½	1.45 x .09
5516W	5½ x 16 x 6½	1.45 x .05
65R	6 x 5 x 18½	1.50 x .18
65V	6 x 6 x 16	1.50 x .17
67P	6 x 7 x 13½	1.50 x .15
68N	6 x 8 x 13	1.50 x .14
68V	6 x 8 x 16	1.50 x .14
69M	6 x 9 x 12	1.50 x .13
69P	6 x 9 x 13½	1.50 x .13
695H	6 x 9½ x 10½	1.50 x .12
695M	6 x 9½ x 12½	1.50 x .12
WV101	6 x 9½ x 17	1.50 x .12
610E	6 x 10 x 9½	1.50 x .11
610H	6 x 10 x 10½	1.50 x .11
610K	6 x 10 x 11½	1.50 x .11
610M	6 x 10 x 12½	1.50 x .11
610P	6 x 10 x 13½	1.50 x .11
611E	6 x 11 x 9½	1.50 x .10
611H	6 x 11 x 10½	1.50 x .10
611K	6 x 11 x 11½	1.50 x .10
611M	6 x 11 x 12½	1.50 x .10
611P	6 x 11 x 13½	1.50 x .10
612C	6 x 12 x 8½	1.50 x .09
612E	6 x 12 x 9½	1.50 x .09
612H	6 x 12 x 10½	1.50 x .09
612K	6 x 12 x 11½	1.50 x .09
612M	6 x 12 12½	1.50 x .09
613C	6 x 13 x 8½	1.50 x .08
613E	6 x 13 x 9½	1.50 x .08
613H	6 x 13 x 10½	1.50 x .08
613K	6 x 13 x 11½	1.50 x .08
614A	6 x 14 x 7½	1.50 x .07
614E	6 x 14 x 9½	1.50 x .07
614H	6 x 14 x 10½	1.50 x .07
615A	6 x 15 x 7½	1.50 x .06
615C	6 x 15 x 8½	1.50 x .06
615E	6 x 15 x 9½	1.50 x .06
6511J	6½ x 11 x 11	1.55 x .10
6511S	6½ x 11 x 14⅛	1.55 x .10
65115	6½ x 11½ x 12¼	1.55 x .095
6513J	6½ x 13 x 11	1.55 x .08

REGULAR (Cont'd)

BESTFIT Stock No.	Dennison	Metric
6514C	6½ x 14 x 8½	1.55 x .07
6514F	6½ x 14 x 10	1.55 x .07
75R	7 x 5 x 18½	1.60 x .18
77V	7 x 7 x 16½	1.60 x .15
77Z	7 x 7 x 25½	1.60 x .15
78P	7 x 8 x 13½	1.60 x .14
785V	7 x 8½ x 16¾	1.60 x .135
79Y	7 x 9 x 17	1.60 x .13
710H	7 x 10 x 10½	1.60 x .11
710K	7 x 10 x 11½	1.60 x .11
710M	7 x 10 x 12½	1.60 x .11
710P	7 x 10 x 13½	1.60 x .11
7105J	7 x 10½ x 11	1.60 x .105
711E	7 x 11 x 9½	1.60 x .10
711H	7 x 11 x 10½	1.60 x .10
711K	7 x 11 x 11½	1.60 x .10
711M	7 x 11 x 12½	1.60 x .10
711P	7 x 11 x 13½	1.60 x .10
712C	7 x 12 x 8½	1.60 x .09
712E	7 x 12 x 9½	1.60 x .09
712H	7 x 12 x 10½	1.60 x .09
712K	7 x 12 x 11½	1.60 x .09
712M	7 x 12 x 12½	1.60 x .09
713C	7 x 13 x 8½	1.60 x .08
713D	7 x 13 x 9	1.60 x .08
713E	7 x 13 x 9½	1.60 x .08
713H	7 x 13 x 10½	1.60 x .08
713L	7 x 13 x 12	1.60 x .08
714C	7 x 14 x 8½	1.60 x .07
714E	7 x 14 x 9½	1.60 x .07
714H	7 x 14 x 10½	1.60 x .07
715E	7 x 15 x 9½	1.60 x .06
759Z	7½ x 9 x 28¾	1.65 x .13
83T	8 x 3 x 15½	1.70 x .21
835V	8 x 3½ x 16¼	1.70 x .20
84S	8 x 4 x 14½	1.70 x .19
86R	8 x 6 x 18½	1.70 x .17
865T	8 x 6½ x 15	1.70 x .16
WV96	8 x 9 x 15	1.70 x .13
89P	8 x 9½ x 13½	1.70 x .12
810H	8 x 10 x 10½	1.70 x .11
810N	8 x 10 x 13	1.70 x .11
811K	8 x 11 x 11½	1.70 x .10
811M	8 x 11 x 12½	1.70 x .10
811P	8 x 11 x 13½	1.70 x .10
812H	8 x 12 x 10½	1.70 x .09
812K	8 x 12 x 11½	1.70 x .09
812Z	8 x 12 x 28½	1.70 x .09
8512F	8½ x 12 x 9⅝	1.75 x .09
92R	9 x 2 x 18½	1.80 x .22
95X	9 x 5 x 19½	1.80 x .18
910K	9 x 10 x 11½	1.80 x .11
910N	9 x 10 x 13¾	1.80 x .11
911K	9 x 11 x 11½	1.80 x .10
911M	9 x 11 x 12½	1.80 x .10
911P	9 x 11 x 13½	1.80 x .10
912M	9 x 12 x 12½	1.80 x .09
9511H	9½ x 11 x 10½	1.85 x .10
WV97	9½ x 13½ x 12½	1.85 x .075
915C	9 x 15 x 8½	1.80 x .06
102X	10 x 2 x 19½	1.90 x .22
103X	10 x 3 x 19½	1.90 x .21
104X	10 x 4 x 19½	1.90 x .19
104Z	10 x 4 x 22	1.90 x .19
105U	10 x 5 x 21	1.90 x .18
1012L	10 x 12 x 12	1.90 x .09
113Z	11 x 3 x 21½	2.00 x .21
WV99	11 x 14 x 17½	2.00 x .07
115Z	11 x 5 x 20	2.00 x .18
122R	12 x 2 x 18½	2.10 x .22
126X	12 x 6 x 19½	2.10 x .17
134Z	13 x 4 x 20	2.20 x .19
136Z	13 x 6 x 23	2.20 x .17
143X	14 x 3 x 19½	2.30 x .21
164Z	16 x 4 x 20	2.50 x .19
165Z	16 x 5 x 20	2.50 x .18
183Z	18 x 3 x 23½	2.70 x .21
202R	20 x 8 x 18¾	2.90 x .22

AUTOMATIC WITH ATTACHED BRIDLES

BESTFIT Stock No.	Dennison	For
WA38	00½ x 14 x 7¾	Universal 24
WA2	00 x 14 x 8	LeCoultre 493
WA3	0½ x 11½ x 12½	Buren 1000, 1002, 1003
WA28	0½ x 15 x 8½	Omega 670
WA24	1 x 9½ x 12½	A. Schild 1716, 1717
WA11	1 x 12 x 13	Buren 1280
WA42	1½ x 11 x 12½	Movado 395
WA39	1½ x 14 x 9¼	Universal 25
WA62	2 x 8 x 17	LeCoultre 497
WA65	2 x 9¾ x 12½	Font 65
WA60	2 x 11½ x 12¼	Omega 28.10, 330
WA43	2½ x 9½ x 12½	A. Schild 1748
WA5	2½ x 9¾ x 12½	PUW 1260, 1261
WA51	2½ x 9¾ x 13½	Movado 531
WA6	2½ x 12 x 9½	Gruen 480
WA64	2½ x 12½ x 10½	LeCoultre 12A, 476, 481
WA88	2½ x 14 x 9½	Rolex 420
WA34	3 x 10½ x 10¾	Durowe 562, 565
WA33	3 x 10½ x 12½	Rolex 1030
WA32	3 x 10½ x 13	A. Schild 1580
WA35	3 x 11 x 12	A. Schild 1673, 1674
WA31	3 x 11 x 14	Omega 470
WA66	3 x 12 x 13	LeCoultre 812
WA29	3 x 13 x 14⅜	Bettlach 1575
WA27	3 x 16 x 8¾	Omega 455
WA9	3½ x 9½ x 14¼	Eta 2520, 2521
WA80	3½ x 11 x 10½	Tissot 28.1, 28-21
WA85	2½ x 12 x 13¼	IWC 85
WA59	4 x 10 x 11½	Kurth 28.45
WA86	4 x 11 x 11¾	Movado 115, 116, 118
WA8	4 x 11 x 13	Seiko Sportsmatic
WA87	4 x 12 x 9	Langendorf 1033
WA48	4 x 13 x 8¼	Eta 2365
WA30	4 x 13 x 9	ETA 2250
WA46	4 x 13 x 10	Felsa 700, 705
WA89	4 x 13 x 11¾	Universal 215
WA37	4 x 13½ x 7½	Eta 1216
WA47	4 x 13½ x 10½	Longines 19A
WA36	4 x 14 x 8¾	Tavannes 470
WA90	4 x 14 x 11	Kurth 19.45, 19.451
WA4	4 x 15 x 8½	A. Schild 1635
WA1	4½ x 9½ x 14½	Enicar 1124, 1145
WA16	4½ x 10 x 13½	Eta 2451, 2452
WA91	4½ x 10⅜ x 14³⁄₁₆	Movado 431A, 436, 438
WA13	4½ x 12 x 9¼	Mido 917, 917P
WA15	4½ x 13 x 8¾	A. Schild 1250
WA45	4½ x 13 x 10	Tavannes 420
WA92	4½ x 13½ x 11⅛	Rolex 520, 530
WA50	4½ x 14 x 8	Felsa 382
WA93	4½ x 14½ x 8½	Movado 165
WA19	5 x 11 x 13½	PUW 54
WA58	5 x 11 x 13¾	Movado 220, 221, 224
WA21	5 x 11½ x 12	Durowe 1162
WA18	5 x 12½ x 11	Longines 22A
WA75	5 x 12½ x 11	Rolex 520, 530
WA26	5 x 14 x 7½	Eta 2425, 2428
WA7	5 x 14 x 8½	Mido 707
WA95	5½ x 9 x 12⁹⁄₁₆	A. Schild 1590
WA40	5½ x 10 x 12½	Felsa 415, 690
WA41	5½ x 10 x 13¾	Felsa 410
WA49	5½ x 10 x 14¾	Eta 2375
WA44	5½ x 10½ x 13½	A. Schild 1712
WA96	5½ x 11 x 13⅝	Parrenin 1901
WA14	5½ x 11 x 10½	A. Schild 1336, 1361
WA12	5½ x 12½ x 9½	A. Schild 1320, 1323
WA23	6 x 10¾ x 10½	Eta 1256
WA25	6 x 11½ x 10¾	A. Schild 1302, 1315
WA17	6 x 14½ x 8½	A. Schild 1477
WA76	6½ x 10½ x 12¼	Rolex 720
WA10	7 x 13½ x 9	A. Schild 1171, 1173
WA20	7½ x 11 x 11½	A. Schild 1191, 1192
WA22	8½ x 12 x 11	A. Schild 1298

SPECIAL ENDS

BESTFIT Stock No.	Dennison	For	End
GL10	00 x12½x 8	Glycine	DB&H
WZ525	0 x12½x11	Zenith 525	DB&H
W195	0½x 5 x19½	IWC 95	DB&H
W190	0½x14 x 8½	IWC 90, 92	DB&H
WC4	1½x10½x13½	LeCoultre 11L0	DB&H
WL4	1½x12 x10	Longines 8L	TEE
W160	2 x10 x12¼	IWC 60	DB&H
W162	2 x12 x13	IWC 62	DB&H
W194	2 x14 x11	IWC 84, 94	DB&H
W176	2½x 9¾x11½	IWC 76, 86	DB&H
WV94	2½x10 x15	LeCoultre 489 Time	DB&H
WZ88	2½x13 x12	Zenith 88	DB&H
W151	2½x15½x 7½	IWC 51	DB&H
WT10	3 x 6¾x22¼	Wittnauer 17T	TEE
WL11	3 x11 x13½	Longines 23M	TEE
WL3	3 x14 x10	Longines 5L	TEE
357T	3½x 8 x15½	Ex Park 40	Spec. End
WT5	3½x11½x10½	Wittnauer 9W	TEE
WC2	4 x 8 x16½	LeCoultre 449	DB&H
WT8	4 x11 x12¾	Wittnauer 10TN	TEE
WC3	4 x11½x13½	LeCoultre 480	DB&H
413BS	4 x13 x 8	Era A-1000	Brac. End
WL1	4 x 5 x 7½	Longines 4LL	TEE
4510KS	4½x10 x11½	Kirowskie A-2000	DB&H
WL5	4½x13 x10	Longines 8LN	TEE
WC1	4½x15 x 9	LeCoultre 90L	DB&H
W183	5 x 9½x13	IWC 83	DB&H
WT3	5 x11 x14	Wittnauer 7TN	TEE
WL10	5 x12¼x11½	Longines 22L	TEE
WT2	5 x14 x 8½	Wittnauer 5S	TEE
W188	5½x 9¾x14	IWC 88	DB&H
WT9	5½x11 x11¾	Wittnauer 11ES	TEE
665Y	6 x 6½x17	Omega 140	DB&H
W189	6 x 9¾x14	IWC 89	DB&H
WL7	6 x11 x15½	Longines 9LT	TEE
WV402	6 x10 x18	Vulcain 402 w/Bridle	
WT7	6 x11½x13	Wittnauer 10T	TEE
WL12	6 x11½x14	Longines 23Z	TEE
WT4	6 x13 x11	Wittnauer 8T	TEE
L100	6 x15 x 7	Lip 100	DB&H
WZ124	6½x10½x14	Zenith 12.4	DB&H
WT6	7 x11 x11½	Wittnauer 10E	TEE
WL8	7 x11½x13½	Longines 10L	TEE
WL6	7 x11½x14	Longines 9L	TEE
WL9	8½x 9¾x15	Longines 12L	TEE
WV95	11 x14 x15½	LeCoultre 489 Alarm	DB&H
L135	13 x 6 x22½	Lip R40	DB&H
WZ193	18½x 4 x21¼	Zenith 193	DB&H

HOW TO FIND THE RIGHT MAINSPRING FOR AN OLD OR UNIDENTIFIED WATCH

Replacement mainsprings for Swiss and American watches are readily obtainable if you order as instructed in Lesson 4. The method given here is needed only if you have an old or unidentified movement or simply wish to verify that the spring in the watch is suitable. This procedure is furnished by the Watchmakers of Switzerland.

It is based on the table of thickness and length factors shown below. To get the required mainspring's correct dimensions, you multiply the barrel's inner radius by the factors in the table which apply. These factors assume that no space in the barrel is wasted between coils, because of hook and brace, or on account of that portion of the spring which is fixed to the barrel arbor. To allow for this wasted barrel space, the number of barrel revolutions must be adjusted as explained in the procedure below for using the table.

Barrel Revolutions	Thickness Factors	Length Factors
5	.025	53.09
5-1/4	.024	55.61
5-1/2	.024	56.01
5-3/4	.024	57.36
6	.023	58.79
6-1/4	.023	60.13
6-1/2	.023	61.62
6-3/4	.022	62.65
7	.022	64.26
7-1/2	.021	66.80
8	.020	69.40
9	.019	74.20
10	.018	79.10
11	.017	83.80
12	.017	88.40

PROCEDURE for Using the Table to Find the Spring's Dimensions:

1. Determine the number of hours in a barrel revolution. Find this by dividing the number of barrel teeth by the number of center pinion teeth. For example: A watch has a barrel with an inside diameter of 5.2 mm, a radius of 2.6 mm, and 84 teeth. The center pinion has 12 teeth. Divide 84 by 12 and you get 7 as the number of hours in one turn of the barrel.

(Continued)

2. Determine the number of barrel revolutions necessary. A watch should run for about 35 to 40 hours to give a safety margin large enough to assure that the watch will run at least 24 hours when fully wound. Let's take 35 hours as the power reserve for our example. Divide this power reserve by the number of hours in one turn of the barrel. Dividing 35 by 7 shows that 5 revolutions of the barrel are needed to make the watch run for 35 hours.

3. Adjust the number of barrel revolutions. To allow for the waste space previously mentioned, add 1 revolution if the number of turns arrived at in step 2 is 6 or below; add 1-1/2 above 6. For our example, the adjusted number of barrel revolutions is 5 plus 1 for a total of 6.

4. In the table, find the spring thickness and length factors for this adjusted number of revolutions. For 6 revolutions, the listed factors are .023 for thickness and 58.79 for length.

5. Multiply the barrel's inner radius by these thickness and length factors. Thus, .023 (thickness factor) times 2.6 mm (radius of barrel) gives .06 mm as the required thickness. And 58.79 mm (Length factor) times 2.6 mm (radius of barrel) equals 153 mm as the required length.

After you have found the thickness and length, you need only determine the proper height for the spring. You can do this easily by simply measuring the void space in the barrel and deducting, for safety, .05 mm for small movements, 1 mm for large ones, and 1 mm for clocks.

CHICAGO SCHOOL OF WATCHMAKING

Master Watchmaking

Test Questions — Lesson No. 7

Name: No.: Date:

Circle ONE correct answer unless told otherwise. SUBJECT: Selecting the Mainspring

1. Mainsprings are most accurately measured for width and strength by:

   Dennison gauge — Inch micrometer — Metric micrometer — Ligne gauge

2. To get the best results, what proportion of the area between the outside of the arbor and the inside shell of the barrel would be occupied by a mainspring with 11 coils?

   Two-thirds — One-half — One-third — One-fourth

3. How much should be occupied by one with 14 coils?

   Two-thirds — One-half — One-third — One-fourth

4. In figure 140, Lesson 6, would you say that the space occupied by the mainspring is:

   Too much — Far too much — About right — Not quite enough

5. The metric micrometer gives readings in:

   1/100 of a millimeter — 1/1000 of an inch — 64ths of an inch — 16ths of a ligne

6. In selecting a mainspring for an American watch, which one of the following is <u>NOT</u> necessary before removing the old mainspring from the barrel?

   See that it occupies the proper space — See that it has correct number of coils — See that the outside coil comes a trifle below the shoulder in barrel — Measure diameter of barrel

7. The style of tip shown in the Hamilton mainspring chart at No. 356 is:

   Hole end — Double brace and Hole end — Tongue end — T end

For the next three questions, write on the short lines below the correct reading for each metric micrometer shown:

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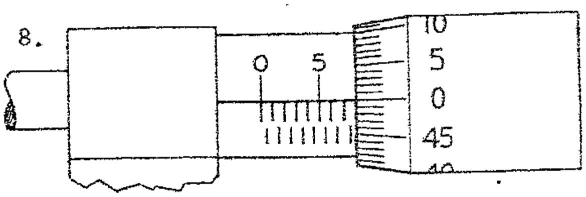

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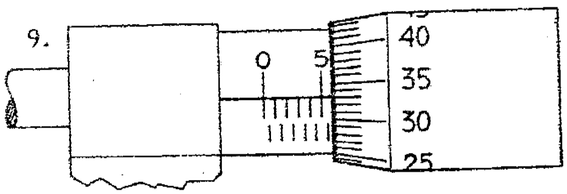

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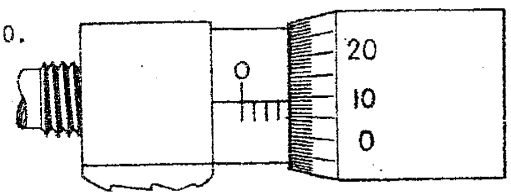


8. ____________________

9. ____________________

10. ____________________

- - Detach page or cut along this line - - - - and send to the School for grading- - -

Master WATCHMAKING

Lesson 8

ASSEMBLING WATCHES

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

INTRODUCTORY INFORMATION

Watch repairing today is nothing more than the orderly disassembly and assembly of a watch step by step, making positive that each part works as it should or is properly repaired. After each part of the watch is in good working order, and the watch is assembled, power applied, and regulation completed, the watch is ready for delivery to the customer.

In the lesson text, we have described and illustrated the procedure for disassembly and assembly of several movements. As there are a great variety of watches on the market today, we obviously cannot cover each one in every particular. Rather, we have chosen representative watches to show you the common basic principles. We have selected pocket watches because their large parts are easier to see and handle. However, once you understand the principles involved, you can apply them to other type watches, including smaller sizes, by allowing for minor variations. If you will keep this in mind, you will be able to use whatever type watches you have available for practice.

KEY POINTS OF LESSON ASSIGNMENTS 26, 27, 28:

- The different styles of studs in use.
- How to remove and replace the balance assembly.
- How to remove the dial.
- The parts of the dial train and how to remove and replace.
- How to remove the bridges.
- The parts of the train and their respective positions.
- How a full plate movement is assembled.

ASSIGNMENT NO. 26: Study Sections 205 through 209.

Study Questions:

1. How is the stud detached from the bridge in the Hamilton watch shown?
2. How is the stud detached from the bridge in the Waltham watch shown?
3. How is the stud detached from the bridge in the Elgin watch shown?

Recommended Practice:

Using an American watch, take the movement from case, let down power and disengage stud and hairspring from balance cock. See that you do not press stud down against arm of balance. Take off balance cock and then lift out balance. Repeat this operation until you can do it easily.

When it is not necessary to separate the balance from the balance cock in making repairs, you can save time by removing balance cock with balance and hairspring attached as described in Sec. 131 of Lesson 5. After you have mastered the sequence described above, practice taking out the balance cock, balance, and hairspring together.

ASSIGNMENT NO. 27: Study Sections 210 through 216.

1. How are the hands removed from a watch?
2. How is the dial removed? Are the dial screws completely removed or are they only released part way?
3. Do you understand the function of each part of the dial train?
4. When is the power let down?
5. What parts are removed before the barrel bridge can be removed?
6. Why should you examine wheels and pinions as you disassemble?
7. Where do you start to reassemble the movement?
8. How and why do you test the train?
9. What does the escapement do?
10. How is the balance replaced?
11. How is the cannon pinion replaced?
12. What precautions are necessary in replacing the dial?
13. How do you get the hands to "register correctly"?

Recommended Practice:

1. Disassemble and reassemble one of your practice movements. If your practice watch is not the same as the model shown in the lesson or covered in the Job Sheets at the end of Lesson 9, you may find it necessary to alter the procedure slightly, but the basic principles remain the same. It may help at first to make sketches of the parts as you disassemble to lessen the chance for error in assembly.

   Each watch has several different sizes of screws and it is important that you get them back in the right place. Until you get familiar with them, we suggest you put them back in the plate after you have taken off the part they were holding. After you learn their correct position, you can discontinue this practice.

2. If you find it necessary to remove any of the winding and setting parts, it would be best to read Lesson Manual 9 before going further.

3. After you've gone through the steps of disassembly and assembly a few times, practice until you can do this operation in about 45 minutes. Keep a record of your time on each trial and try to better your speed.

ASSIGNMENT NO. 28: Study Sections 217 through 218.

Is the procedure for assembly the same on a full plate movement as on a 3/4 plate or bridge model?

Recommended Practice:

If you have a full plate movement, practice disassembly and assembly until you can do it in one hour.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 8 and send in for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 8
Sections 205 to 218

Lesson 8 — Assembling Watches

Section 205

THE trains and escapements of modern watches, large or small, are much the same, and when you understand the mechanism and relation of the different parts in one you will have little difficulty in mastering others.

In demonstrating this first lesson on taking down and assembling a watch movement I have used a 16 size Elgin, three quarter plate model, shown in figure 169.

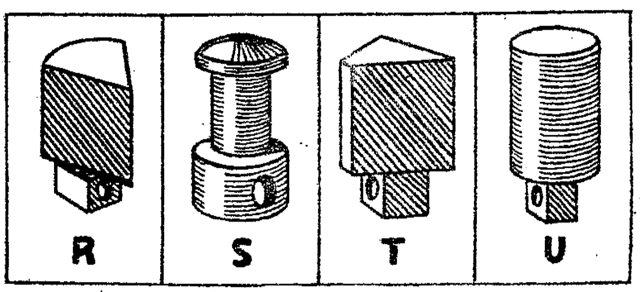
It is expected by this time that you will have no trouble taking the movement out of the case and that you realize the necessity of letting down the power before going further.

Sec. 206 — Balance, Hairspring and Hairspring Stud

The balance with hairspring is the most delicate part of a watch, and it is well to remove this first when taking a movement apart. The outer end of the hairspring is pinned into the stud which is held in the balance cock by means of a screw. In order to do this it is necessary to have the hairspring between the balance and the balance cock.

The earlier American watches were equipped with an "undersprung balance", that is the hairspring was under the balance — between it and the top plate — and the outer end of the hairspring was held in a heavy stud attached to the plate by means of a screw. (See figure 8 in lesson 1).

Do not get the idea that all modern hairspring studs are shaped alike or treated the same in taking down and assembling the movement with which they are connected. In figure 165 are drawings of four different styles of studs in common use. The one shown at R is the style found in the 16 size Elgin movement used with this lesson, S is the Hamilton type of stud described in the next section, T the Waltham model described in section 208 while U is the conventional round stud. A later type of round stud has one side flattened and is known as a D stud. Another style has a groove running lengthwise into which the stud screw sets, thus holding it in a fixed position. In movements fitted with these last three studs, the balance cock generally is lifted out with hairspring and balance attached as shown in figure 82 in lesson 5, and the stud is released from the cock after the whole assembly has been lifted away from the movement.

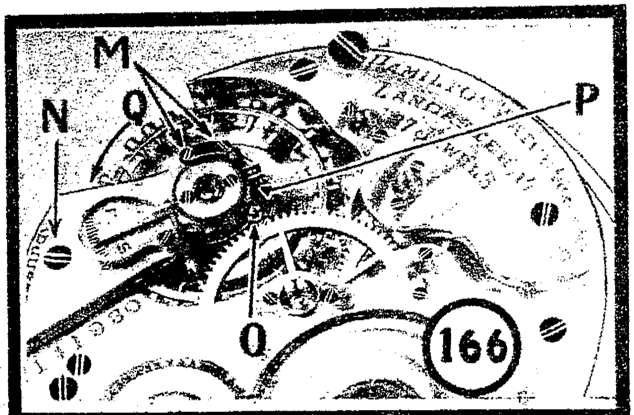


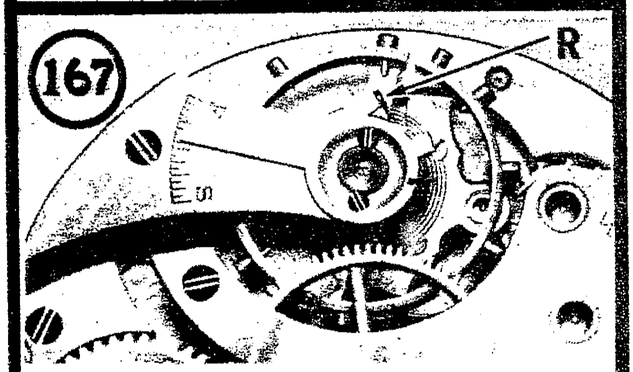
No. 165

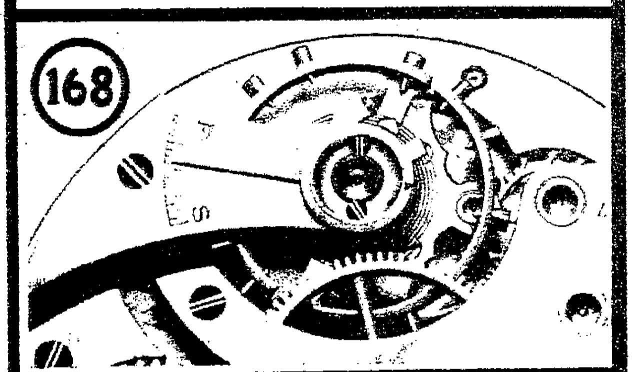
Sec. 207 — Hamilton Type of Stud.

With the Hamilton floating stud shown at S, figure 165, it is possible to remove and replace the balance with hairspring attached without danger of distorting the overcoil. To do this unscrew the two stud cap screws at M, figure 166, about one and a half turns before taking out the balance cock screw at N. Do not attempt to pick the stud from under the stud cap as this is liable to bend the hairspring at the curb pins, but after taking out the screw N, lift the balance cock with the balance suspended by the hairspring, up and away from the movement in order that the balance may not catch on the center wheel. By tilting the balance cock toward the stud side, the stud will fall out.

In replacing, pick up the balance by the arm or rim, using the tweezers, and place in position on the lower plate with the lower pivot in the balance jewel and the roller jewel or jewel pin in the slot of the fork. Move the balance around until the stud is outside the curb pins, set the balance cock in place, and turn







down the screw N, noting that the balance is free while doing this. Now the stud floats free on the outside of the curb pins at P as seen at O. Holding the movement in its movement holder in the left hand, with the forefinger of the same hand swing the balance around to the left in the direction of the arrow Q.

With your tweezers in the right hand, slip the upper shoulder of the stud under the cap with the overcoil of the hairspring on the outside of the curb pins. Slip the overcoil between the curb pins and allow the balance to swing back until the roller jewel is in the fork and the overcoil is free between the curb pins. Hold the balance in this position and tighten the two stud cap screws at M.

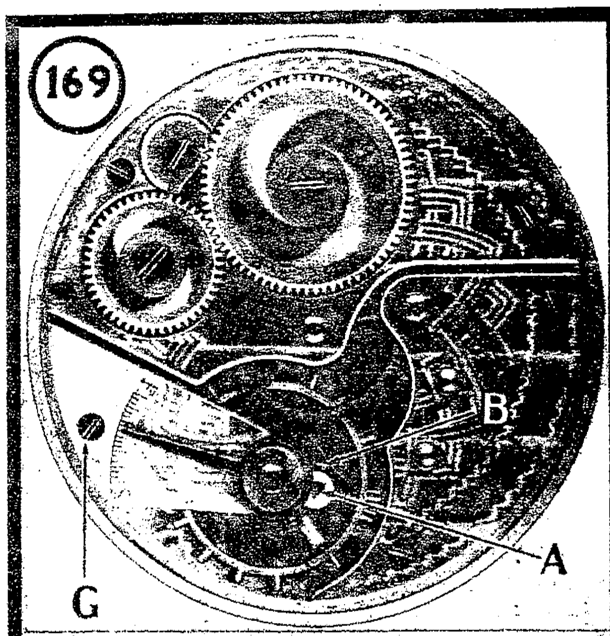
Sec. 208 — Waltham Hairspring Stud.

The Waltham stud, shown in figure 167 is triangular shaped and is released from the bridge before removing the balance cock screw. All that is necessary is to turn back the stud screw at R enough to allow the stud to be released, after which the balance cock screw is loosened and the bridge removed.

In replacing the balance with hairspring and stud attached, set the assembly in place with the stud floating between the curb pins and the stud screw, as shown in figure 168, using care to see that the roller jewel is in the slot in the fork before tightening down the balance cock screw. After doing this, hold the movement on edge and swing the stud into position, securing it there by means of the screw at R as in figure 167.

Sec. 209 - - Elgin Stud

The three cornered stud shown at A figure 169 is a typical Elgin style stud similar to R in



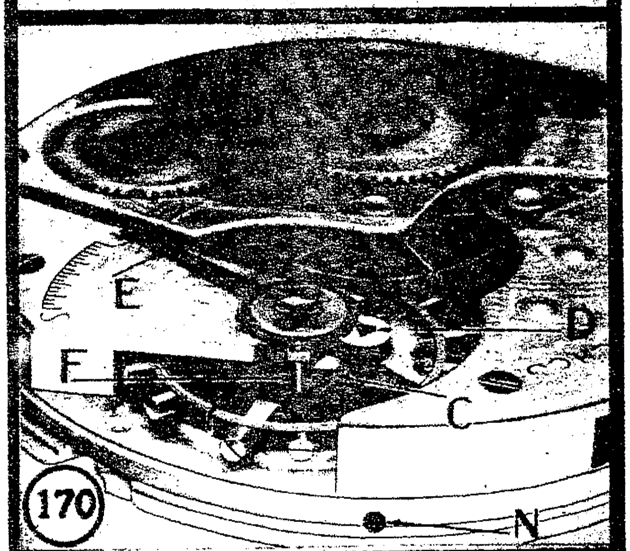
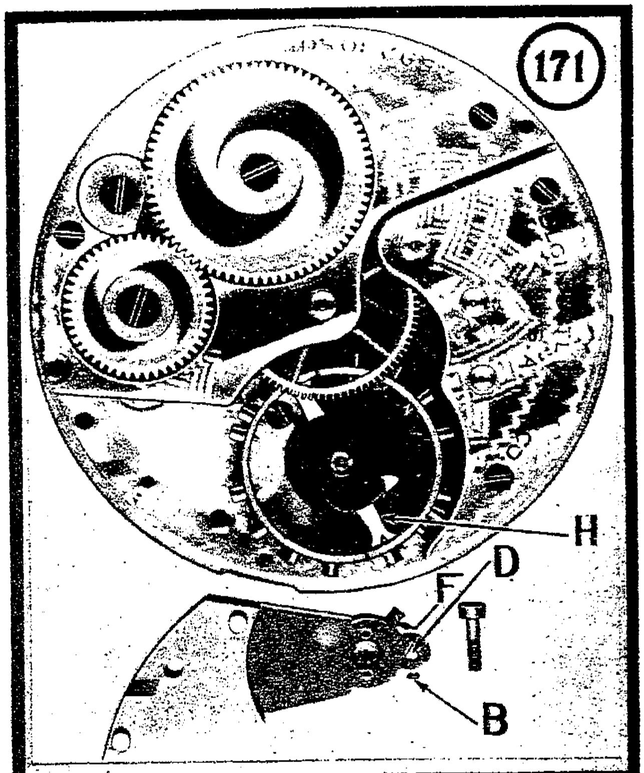


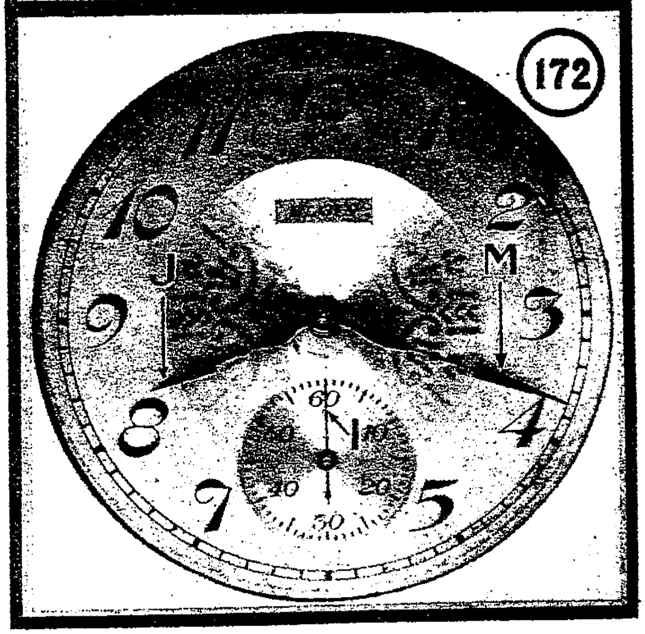
figure 165, and fits in a triangular shaped hole in the bridge being held in place by the stud screw at B. In taking the balance out, loosen this screw and carefully push the stud down until it is free of the bridge as shown in the enlarged view at figure 170 in which C is the stud after having been pushed free from the hole D in the cock. Here the regulator E has been pushed over far enough to give more room for the stud between the curb pins at F and the projecting end of the balance cock in which is located the stud hole D. Be sure and do this *before* you loosen the balance cock screw at G figure 169.

After freeing the stud, take out the balance cock screw, lift off the balance cock turning it over as shown in figure 171, and study it from the lower side. At F are the two curb pins commonly called the regulator pins. D is the hole for the hairspring stud and B the stud screw. Before proceeding further it is well to turn the stud screw in as far as it will go so there will be no danger of its being lost. The balance may now be lifted out and set to one side by grasping the arm at the point H using your tweezers in doing this. Be careful not to bend the lower pivot.

Although many watchmakers take the balance and balance cock out before loosening the stud screw as explained in Section 131 of Lesson 5, I have found that the average beginner runs less risk of distorting the hairspring when he follows the method just described in connection with this model of Elgin movement.

Having taken care of the balance, turn your movement over and set it in the movement rest, dial up, with hands attached as shown in figure 172. I is the second hand which revolves once a minute, M the minute hand which revolves once an hour and J the hour hand which makes one revolution in 12 hours.





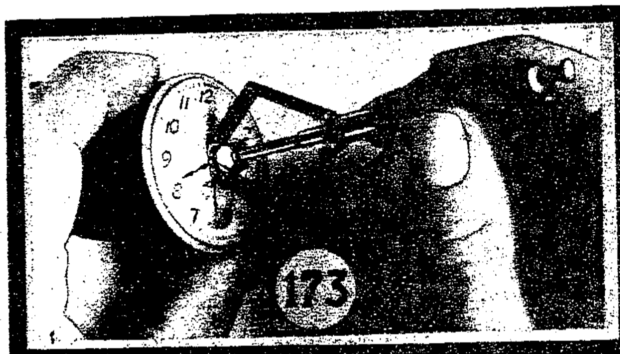
Sec. 210 — Removing the Hands

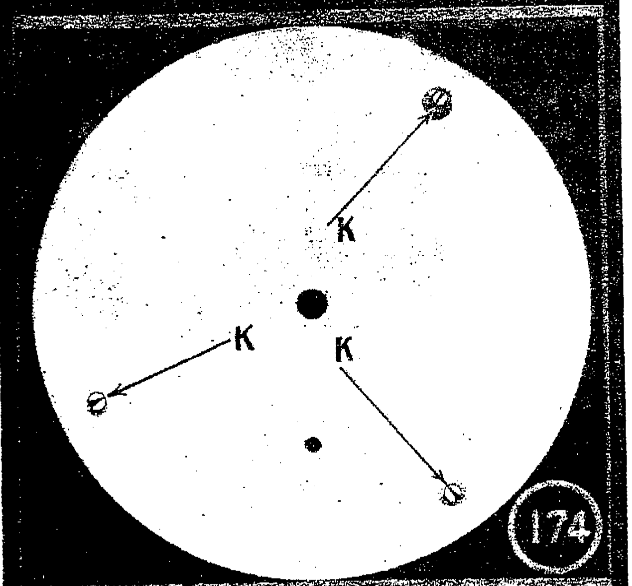
Use a hand remover to take off the hour and minute hands as shown in figure 173. Press on the top to spread the jaws and slip them under the hour hand at the center. Then by pressing down on the handle as shown here, the two hands will be pried off. It is well to slip a small sheet of celluloid between the hand remover and the dial to prevent scratching the dial.

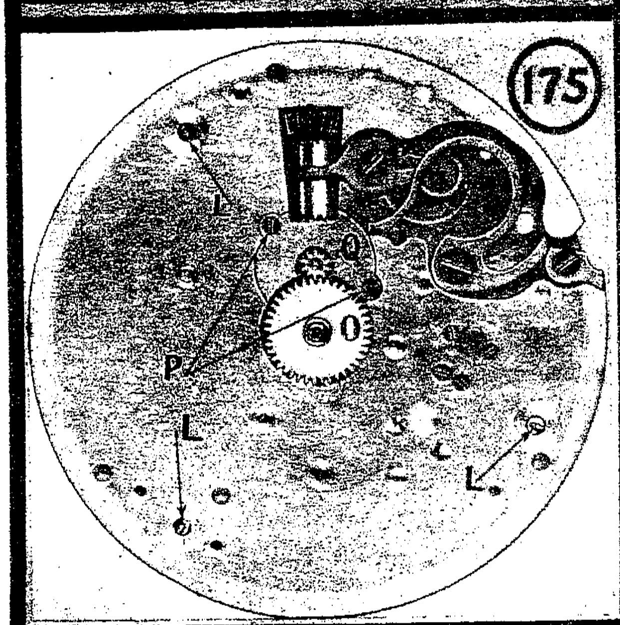
The second hand may be removed by using two thin bladed screw drivers, one under each side in the center, twisting the blades until the hand is released from its position on the 4th pinion. Here too it is well to slip a piece of celluloid between the screw driver blades and the dial.

The dial has three pins fastened to the back which fit into holes in the pillar plate and are held in place by means of small screws at the edge. These pins are the *Dial Feet* and the screws that hold them in place are *Dial Screws.* In figure 174 is shown the back of the dial with the dial feet indicated by the arrows K. At N in figure 170 is shown the location of one of the dial screws.

Locate the dial screws along the edge of the plate and with a screw driver that properly fits the head, turn each screw partly out, just enough to free the dial foot. With a fairly wide screw driver pry the dial up from the plate using great care not to injure it. Pry at two or three places, it being best to do this at the points where the dial feet are located. If the dial does not come off easily it may be that the dial







screws are not backed out far enough. Although the metal type of dial will stand more springing without injury than an enameled one, it must be handled with care to avoid scratching. In removing an enameled dial there is the danger of prying a little too hard, with a resulting crack in the enamel.

As soon as you take off the dial it is well to turn the dial screws in as far as they will go to prevent their dropping out and getting lost. The movement will now appear as in figure 175 with the tips of the three dial screws extending into the dial foot holes at L.

The hour wheel which carries the hour hand is shown at O. With your tweezers lift it off, take out the two screws at P and remove the *minute wheel clamp* at Q.

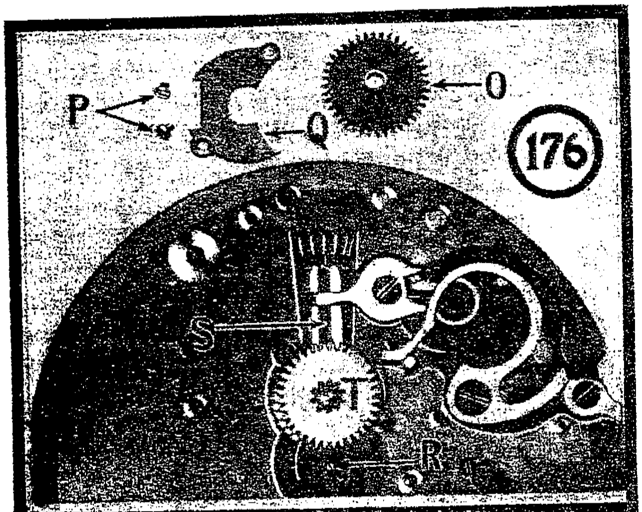
This part of your movement will now appear as at figure 176 with the hour wheel O, the minute wheel clamp Q and the two minute wheel clamp screws P along side. The minute hand is carried on the *cannon pinion* at R. This cannon pinion fits on the center staff with sufficient friction to carry the hands around with the center staff as it turns, yet free enough to be turned on the center staff when setting the watch, without bending any teeth.

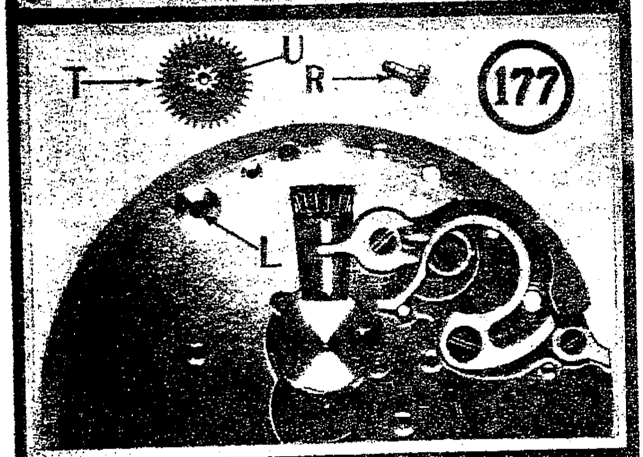
The clutch S, is in the setting position with its teeth engaging the teeth of the minute wheel T. In setting the watch the clutch is turned by means of the stem in the winding arbor and its power is transmitted through the minute wheel to the cannon pinion and minute hand.

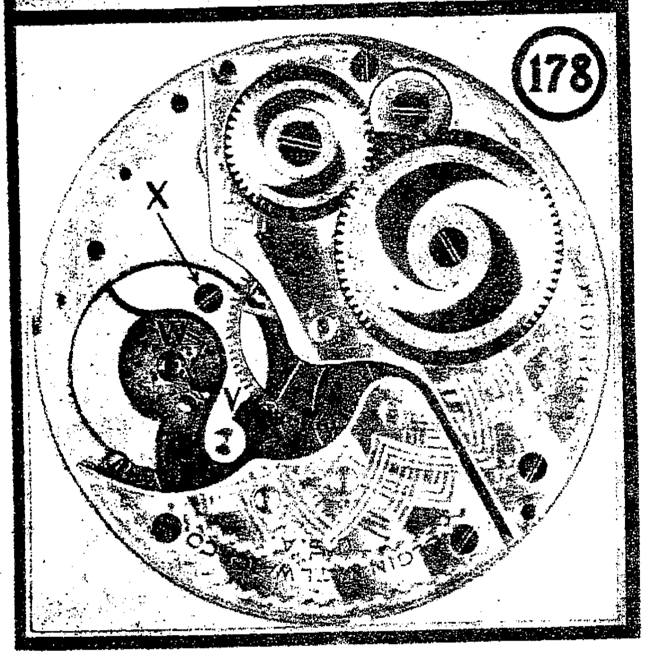
The cannon pinion may be removed by grasping it with a pair of strong tweezers and pulling straight out. If it is extra tight use a pair of brass lined pliers to remove it. The minute wheel is lifted out of its place and the movement from the dial side will appear as in figure 177. At T may be seen the minute wheel with the cannon pinion at R. The minute wheel has a small pinion attached at U, and it is this pinion that gears into the hour wheel as seen in figure 175.

Now return to the train side of the watch by turning it over and placing it on the other side of the movement rest.

The power having been let down, take out the *pallet fork* by removing the *pallet bridge screw* at X figure 178, and the *pallet bridge* V. In taking out any bridges from a movement see that none of the pivots is caught in a pivot hole as they are easily broken. Where a bridge is unusually tight it can be loosened by inserting the blade of a screw driver with a twist-







ing motion. Sometimes you will find a slot cut in the edge of the bridge for this purpose.

Before you remove the pallet fork, notice particularly how it is placed in the watch and replace it in the same position when assembling. If the model is one with a single roller the guard pin will set at a right angle to the fork and project upward. If a double roller, the guard dart will be below and parallel with the fork. The model shown here has a double roller and the guard dart at W is below the fork.

After removing the pallet bridge, the pallet fork with pallet arbor attached is easily lifted out, and the movement appears as in figure 179 with the pallet bridge at Y, the pallet fork and arbor, often abbreviated as the *P. F.* and *A.* at Z, and the pallet bridge screw at X. Viewing the pallet fork and arbor from the lower side at Z gives you an opportunity to see how the guard dart is attached at the slotted end of the fork.

The Train Bridge is now removed by taking out the screws at B and lifting the bridge out of its place as shown in figure 180, in which A is the Train Bridge and B the train bridge screws. The 3rd, 4th and escape wheels and pinions are now seen in their proper positions.

These may be lifted out, taking the escape wheel first, then the 4th wheel and finally the 3rd wheel. Notice that the 4th pinion has a long pivot on the lower end. This long pivot carries the second hand and cannot be removed from the movement until the second hand has been taken off.

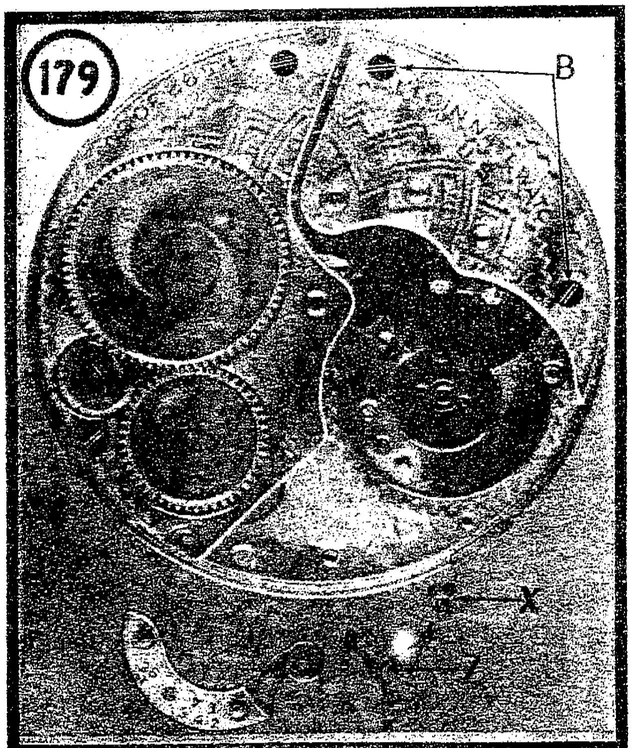
Now remove the barrel bridge by taking off the ratchet wheel at C, the crown wheel at D and then the Barrel Bridge screws. At this point you might have some difficulty in releasing the crown wheel screw at E. This screw has a *left hand thread* and in removing it should be turned to the *right.*

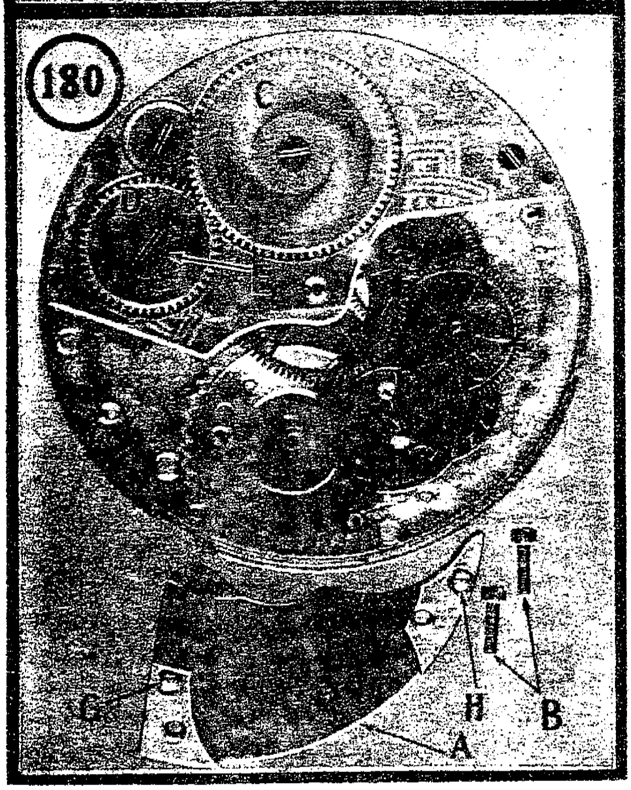
If in loosening a screw in the winding parts of any watch, it does not start as easily as you might expect, try twisting it the other way for you will frequently find such screws with left hand threads. Beginners often forget this and in attempting to force such a screw, use too much pressure and break the head leaving the threaded portion imbedded in the bridge.

Manufacturers differ sometimes as to the trade name of parts. The manufacturers of this movement list the wheel at D as the *main wheel* while others designate the first wheel shown at Q in figure 119, in lesson 6 as the *main wheel,* and the wheel which corresponds to this main wheel is called the *crown wheel* shown in figures 115, 128 and 131.

In these lessons I will give the technical and trade names which I have found to be most used among the members of the trade.

With the barrel bridge removed, the movement appears as in figure 181, the center wheel at E and the barrel at F. These may be lifted





out of their places and the plate will appear as in 182. This is a going barrel a d the cap being *down* we know by our rule of a former lesson that the mainspring coils to the left in the barrel. In this model is found also a safety pinion on the center staff.

At this point it is well to examine every wheel and pinion using your double loupe to see that there is no dirt in any of the teeth or leaves and that none of the teeth is bent. Should you find dirt in the leaves or teeth, *peg it out*. This is done by sharpening a piece of pegwood to a point much as you would a fine pointed pencil and rubbing this point back and forth wherever needed.

In this watch I found oil smeared over the plate from G to H figure 181, showing that whoever repaired it last used too much oil when reoiling. Too much oil does as much damage as too little oil although in this particular instance not much harm would result in the time keeping parts.

In this first attempt at taking down and assembling a watch I would advise you to take no more parts off the plate. The object of this lesson is to train you in manipulating such parts as constitute most of the time keeping portion of the watch. All the rest will be taken up in succeeding lessons and in a way I really believe will give a better insight into their workings than could be given now.

When assembling a watch movement use an assembling block and lay the lower plate in the recessed part as shown in figures 181, 182 and 183.

Sec. 211 — Study the Train

Before starting to reassemble this movement place the whole train upon the plate as shown in figure 183 and study it thoroughly. Notice that the leaves of the third pinion and escape pinion are above their wheels when assembled. So in placing them on the plate, first set the escape wheel and pinion in its proper place, next the third wheel and pinion and then the barrel. The leaves of the fourth and center pinions being below their respective wheels are set in last.

After they are placed, see that the teeth of each wheel come in proper contact with the leaves of the succeeding pinion, that is, the teeth in the barrel should be lined up with the leaves of the center pinion, the teeth of the center wheel with the leaves of the third pinion and so down to the escape pinion.

At first you may have some difficulty in telling the difference between the third and fourth wheel, but by noting that the fourth pinion has a long lower pivot which carries the second hand, you should have little trouble on that score. If a watch has no second hand you can tell the difference by examining the teeth and leaves. The teetn and leaves of the third wheel and pinion are somewhat coarser than those of the fourth wheel and pinion.

Sec. 212 — Assemble the Train

Start assembling the movement by placing the train on the plate *without* the barrel as this may be easily slipped into place after you have set the train bridge in position. Now place the train bridge with the two steady pins G and H in figure 180 directly over the holes J and K in figure 183.

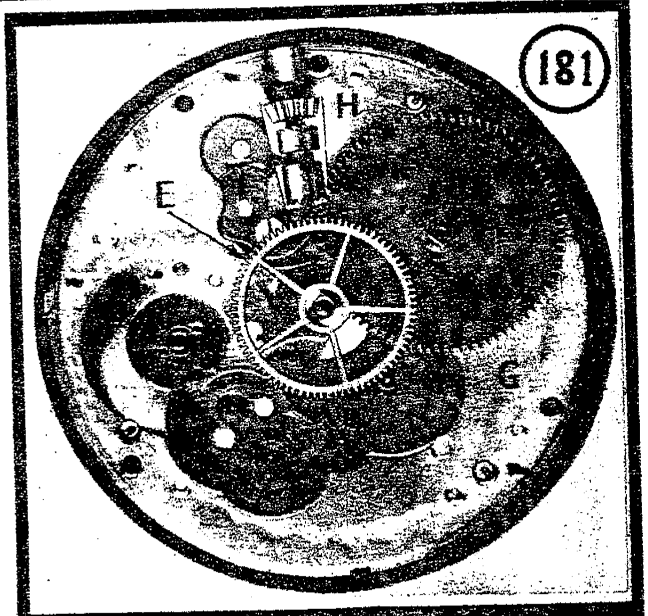
Take the movement holder and watch assembly in the left hand, holding the train bridge in its proper position as shown in figure 184 — using watch paper to protect from finger marks — and with a pair of fine pointed tweezers manipulate the upper pivot of each pinion into its proper pivot hole in the train bridge. At times you will find one of the upper pivots slightly longer than the others. If so fit the longest pivot first. Hold your work as close to the top of the bench as possible and do not put too much pressure on either the plates or the pinions. At first you will have a tendency to force the pivots into place but will soon learn that it is merely a matter of getting the pinions straight up and down and when the pivots are brought to the proper position very little effort is required to guide them into place.

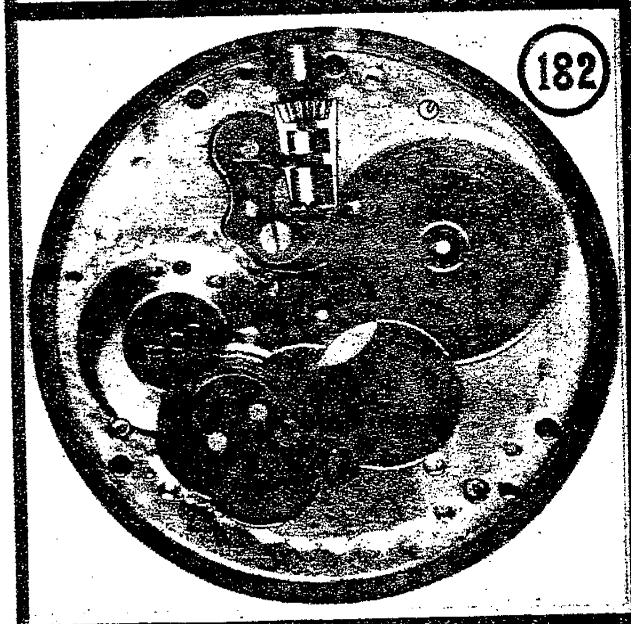
Still holding the bridge in place with the left hand, with the tweezers pick up one of the screws for the train bridge and set it in place, then with the proper size screw driver turn the screw down being careful to see that none of the pivots gets out of place. In the same way replace the other train bridge screw and then with your tweezers test each pinion by moving it up and down to see that it is perfectly free and has end shake.

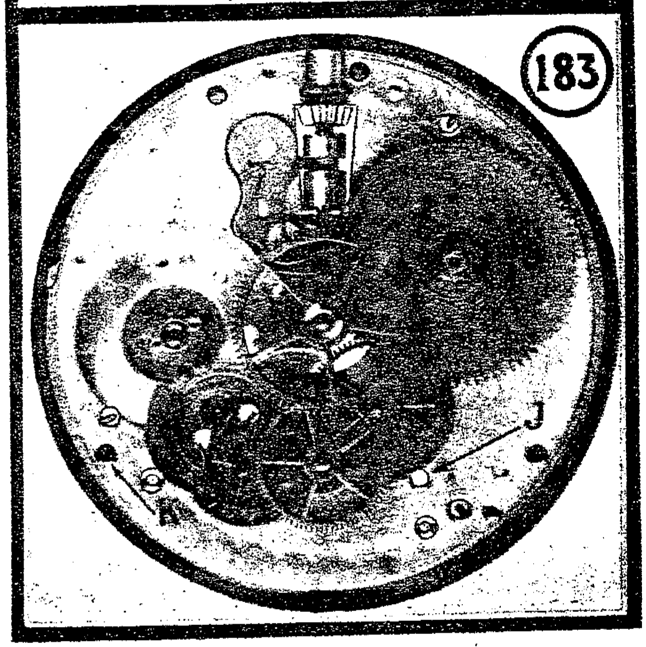
Slip the barrel under the center wheel with the square end of the arbor up as shown in figure 185 and replace the barrel bridge, fitting the upper pivots of the center staff and the barrel arbor in their proper holes. This bridge will usually fall right into place and you should experience no trouble here. Set the screws in the barrel bridge and your train is now assembled and should appear as in figure 186.

Although I am not asking you to oil this watch, I want to show you two places that many Watchmakers overlook. On this model it is well to place a small amount of clock oil on the raised ring under the ratchet wheel at M figure 186 and also on the one under the crown wheel at L. This often will make quite a difference in the amount of strength required in winding.

The crown wheel with washer is next put in place, being held by the crown wheel screw. Adjust the ratchet wheel with the square hole



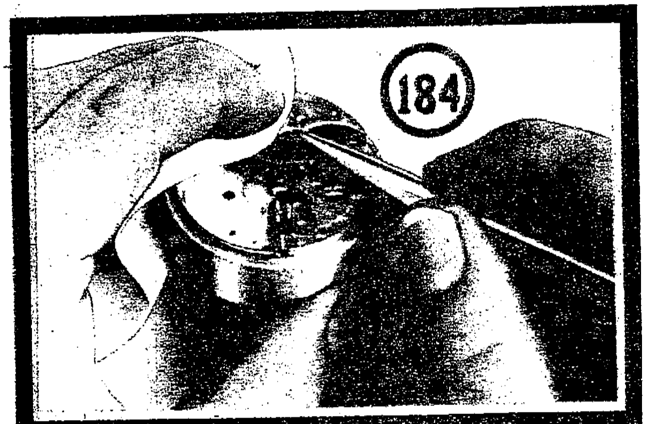


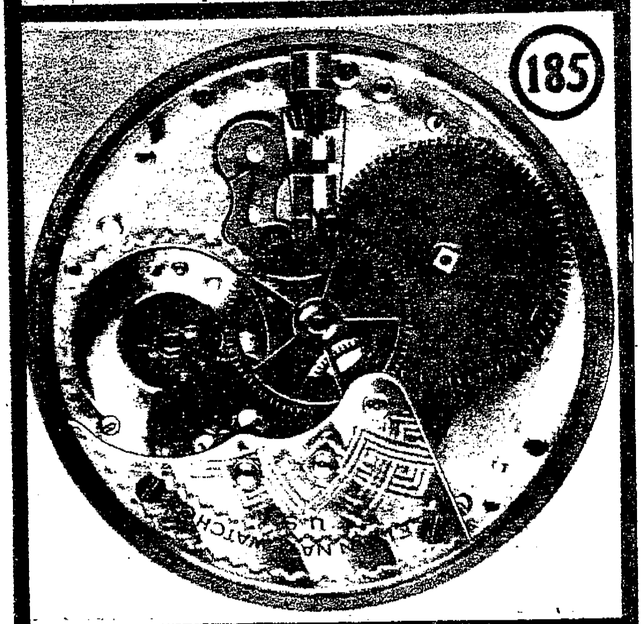


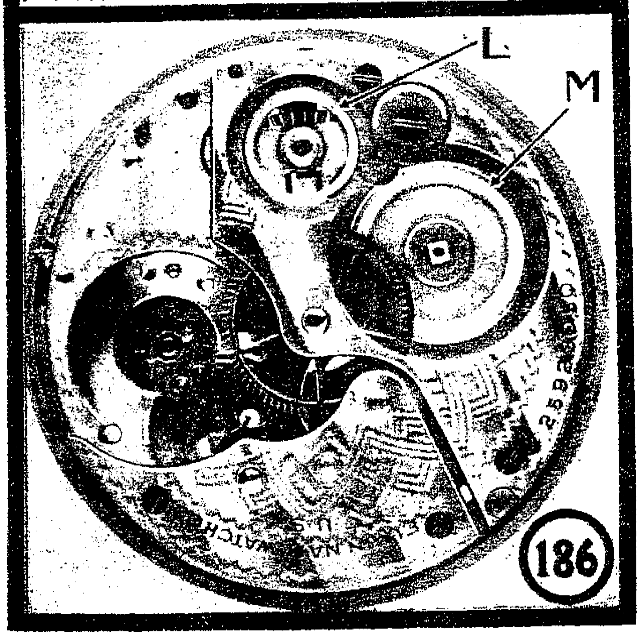
properly set over the square of the barrel arbor and secure with the ratchet wheel screw.

Sec. 213 — Test the Train

At this time you should test the freedom of your train. Take a bench key of proper size to fit the winding arbor, press in far enough to shift the parts to the winding position and give the key three or four turns. If everything is as it should be the wheels in the train will immediately start revolving with such rapidity that finally the momentum will carry them beyond a "state of rest" after which they will back up in the other direction or *recoil*. The recoil is gauged by watching the fourth wheel.







If your train runs down freely even though there is no recoil let it go at that, as in this example we are only practicing assembling and the lack of recoil might be caused by gummy oil, a set mainspring or some other cause which you will master later on.

The pallet fork is now set in place with the lower pivot of the pallet arbor in its proper pivot hole. Adjust the pallet bridge in position and if in dropping the bridge in place the upper pivot does not at once enter the pivot hole it is an easy matter to guide it into place with your tweezers.

Apply power to your train by giving the winding arbor three or four turns with your bench key. This will hold the fork over against one of the banking pins as shown at O in figure 188. If you now take the point of your tweezers and press the fork away from the banking pin it immediately should fly over to the other banking pin. Move the fork back and forth and study the action of the escape wheel teeth in giving these impulses to the fork.

Sec. 214 — Action of the Escapement

It is here that the power of the train is transmitted to the balance. The balance (wheel), hairspring and roller with the roller jewel are all fastened together on the balance staff and act as one piece. The slot in the fork strikes the roller jewel, throwing the balance around in a circular motion, but the hairspring, the outer end being fastened to the balance cock, resists this motion and finally brings the balance to a stop and immediately forces it to turn in the opposite direction.

As it returns to its original position the roller jewel enters the slot in the fork pushing it away from the banking pin just as you have done with your tweezers. At once the escape wheel tooth throws the fork in the other direction and the same thing occurs again. The slot in the fork strikes the roller jewel throwing the balance in the opposite direction only to be stopped and brought back by the hairspring and so it continues at the rate of 300 vibrations each minute.

Such is the action of the lever escapement and when you have mastered one you have made good progress toward mastering them all. As the watch comes from the factory the escapement has been adjusted to perform properly but often it is thrown out of order by inferior workmen and you are never sure that the escapement is correct until you have examined it. In later lessons we will take up the proper matching of the escapement in a thorough manner showing you how to test for errors and how to make the correct adjustments.

Sec. 215 — Replacing the Balance

In replacing the balance and balance cock, it is best to assemble these parts before placing in the watch. Lay the balance cock on the bench in an inverted position as shown in figure 171, first seeing that the stud screw at B is out far enough to allow the stud on the hairspring to enter the hole D without difficulty. *Do not* take this stud screw entirely out of the balance cock.

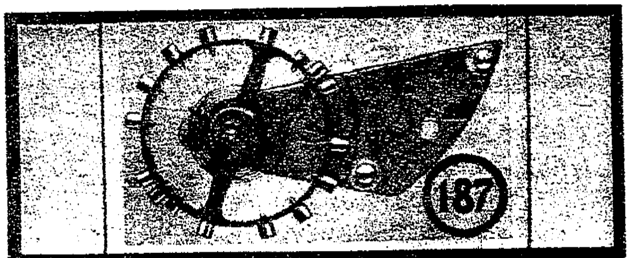
With the balance cock in this position lay the balance on top with the upper pivot of the staff in the jewel and the stud directly over the hole. See that the overcoil (the coil that is raised above the body of the hairspring) lies directly between the curb pins (regulator pins) and lightly press the stud into its place, using care not to hit the hairspring. Your hairspring should now lie level or parallel with the balance cock. Still holding it in this position set your stud screw by means of a small screw driver and your assembled balance and cock should appear as in figure 187.

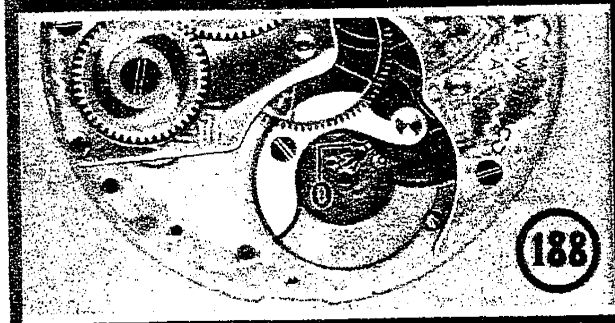
Now slip your tweezers under the balance cock as shown in figure 189 and turn it over, allowing the balance to hang suspended by the hairspring.

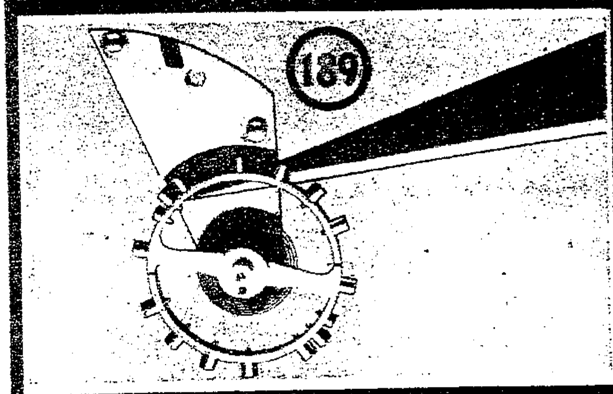
As you have already applied power to the train, the fork should be resting against one of the banking pins. If it is not resting against the one further from the edge of the plate, move it over to that position as shown at O, figure 188.

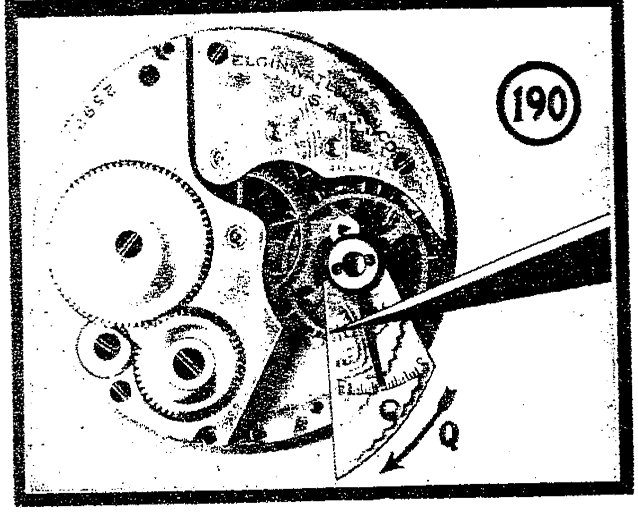
In replacing the balance in the watch be sure that the roller jewel will swing into the slot of the fork from the open side. If the jewel were to get outside the slot the watch could not run.

Do not attempt to set the balance bridge straight down into position but rather swing it in from the side. Holding it as shown in figure 190 slip the balance under the center wheel and then bring it down until the lower pivot of the staff is resting in the center of the lower jewel. Now your roller jewel is opposite the open side of the fork.



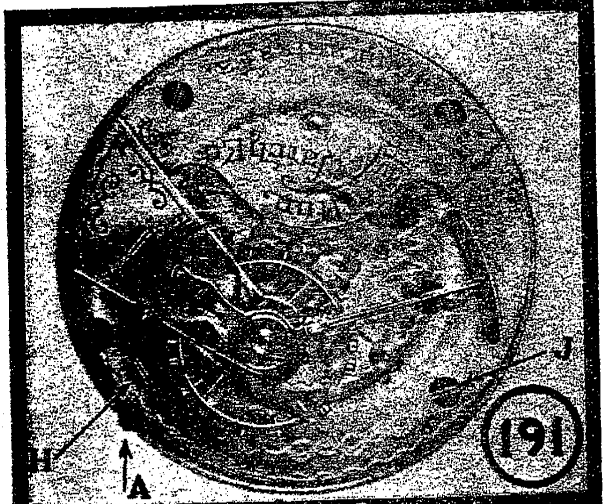


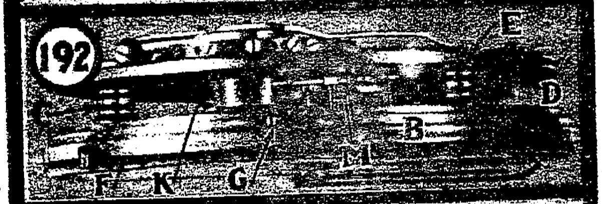


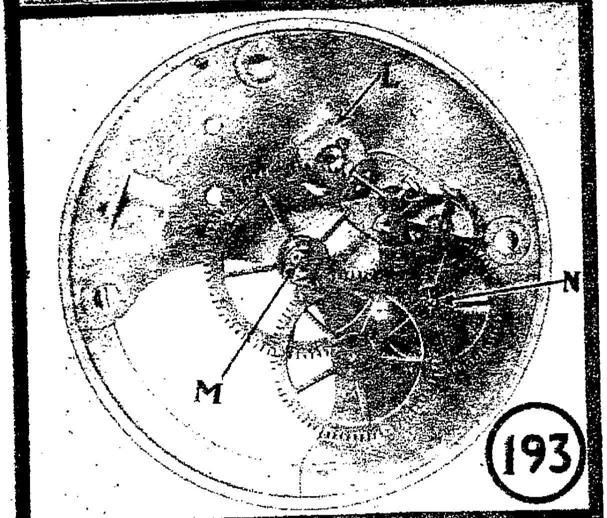


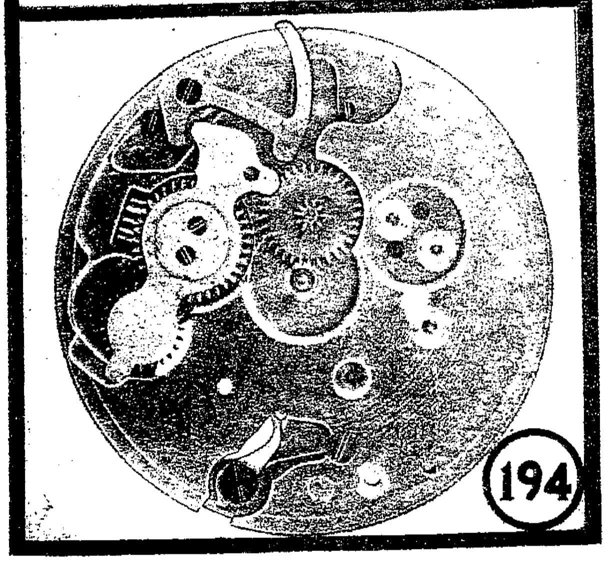
With the balance in this position twist the balance cock to the left as indicated by the arrow Q until the steady pins on the balance cock are directly over their holes in the lower plate. Lower into place, adjust the pivots in their jewels and see that the balance is free to turn in both directions. If everything seems O. K. set your balance cock screw and your watch should start right off.

In setting the balance cock in place you may at first get the roller jewel on the wrong side of the fork. If so do not attempt to force it over









to the other side, but lift up the entire assembly and try it again. After you have practiced this a few times it will make no difference which way the fork is banked. You can see from which direction the roller jewel must enter and manipulate the balance cock accordingly.

Sec. 216 — Replacing the Cannon Pinion

After satisfying yourself that your watch movement is functioning properly, turn it over on your movement rest and replace the cannon pinion. The cannon pinion should press down on the center staff with no difficulty by merely using a stiff pair of tweezers. In a higher jeweled watch where the pivot of the center staff fits in a jewel as in a 17 or 21 jeweled watch, it is well to support the lower end with a stump in order to prevent loosening or breaking the jewel.

Replace the minute wheel, its clamp and screws; set the hour wheel in place over the cannon pinion. See that the teeth and leaves are all in proper alignment, and then set the dial in place after backing out the dial screws.

If necessary to press a dial into place do so directly over the dial feet and thus avoid springing the dial. This applies especially to enameled dials as they crack or chip very easily. See that it is down far enough to rest on the plate all the way round, then set the dial screws to hold it in place.

Next press the hour hand in place on the hour wheel. The hour hand should be close enough to the dial to give room for the minute hand and yet not catch on the second hand. Adjust the hour hand parallel with the dial. In making the adjustment of the hands with a metal dial do not let your tweezers slip or drag as such dials show the slightest scratch.

Before placing the minute hand, turn the hour hand until it points exactly to some hour, 3 or 9 for example, then place the minute hand to point exactly at 12 and press it down on the cannon pinion. Placing the hands in this way at some exact hour causes them to "register correctly".

The second hand is now pressed on the long pivot of the fourth pinion which extends up to the center of the *second bit* in the dial.

After these are placed, use your bench key in the winding arbor with the parts in the setting position and turn the hands around the dial noting whether they clear each other at all points.

If the watch is now cased see that the minute hand does not rub on the glass.

Sec. 217 — Assembling a Full Plate Movement

One of the older types of watch movements, the full plate model, offers some difficulty to the beginner who attempts to take down and assemble it without instructions.

By a full plate model is meant one similar to the one shown in figure 81 in lesson 5 or figure 191 in this lesson. The trouble usually encountered by beginners is caused by not freeing the lower pallet arbor pivot from its jewel or pivot hole in the lower or pillar plate, before lifting off the top plate.

Figure 192 shows a side view of this movement looking at it in the direction of the arrow A, figure 191. The lower plate, B in figure 192 is called the pillar plate, and to it are attached the pillars, C and D, which support the top plate E. Here also may be seen the dial F and one of the dial screws G.

In taking this model apart, it is best first to remove the balance and balance cock. Next take off the barrel bridge and lift out the barrel. Take out the pillar screws, two of which are shown at H and J, figure 191, these screws extending through the top plate into the two pillars C and D figure 192. Now you are ready to lift off the top plate but in doing this you must be sure that the lower pivot of the pallet arbor is free.

At K in figure 192 is shown the potance and this is what causes most of the trouble in taking down or assembling this type of full plate movement. This potance is a support for the lower balance jewels, being attached to the top plate. Another view of the potance is at L figure 193. The end of the fork extends inside the potance, and in lifting the top plate the potance will catch on the end of the fork lifting it up and unless the lower pivot is freed from the lower pallet arbor jewel, break or bend that pivot or break the jewel.

All that is necessary in taking off the top plate is to so raise it that there is just room enough to permit the pivot on the lower end of the pallet arbor, M figure 192, to be lifted out of the jewel or pivot hole in the pillar plate by reaching in with the tweezers. After this the top plate may be lifted off without further trouble.

In assembling this style of movement many watchmakers set the wheels of the train in place on the pillar plate and then with the pallets and the escape wheel and pinion set in place on the top plate, tip the two plates together manipulating the pivots into the proper holes. The beginner will find it much more convenient to set up the train and pallets on the top plate, first setting the plate in one of the assembling blocks as shown in figure 193. Here the center wheel is partly cut away in order to show the pallets and how the end of the fork projects into the potance.

The pivots on the center staff at M and the fourth pinion N are much longer than the others and in lowering the pillar plate into the position shown in figure 194 the center staff is first fitted through the center jewel, the fourth pivot through the fourth jewel and finally the other pivots into their proper jewels. After all the pivots are in position the movement is turned over, while holding the plates, and the pillar screws are set in place. The balance of the movement is then assembled as has been described.

Sec. 218 — Be Careful

The main thing in watch repairing is to use care in all your work. Get into this habit and it soon becomes second nature to do your work as it should be done the first time over.

The inexperienced individual is inclined to use too much muscular energy at times. If a part does not readily go into place, he endeavors to force it. This is not necessary as these parts fit together with a precision that the average man is not used to and when lined up, go together with very little effort. If you come to a point where it seems you must clamp down hard in order to assemble a watch, examine closely and no doubt you will find something out of place.

The beginner generally thinks that the taking down and assembling of a watch is a very difficult thing to master, this being in line with the belief that a watch is such a complicated machine. In going through this lesson you must have realized that there are not a great number of difficulties to overcome nor are there as many parts to learn as most people suppose. Occasionally I have asked prospective students how many wheels they supposed were in the time-keeping part of the watch—how many in the train and have had them estimate all the way up to seventy-five and even one hundred.

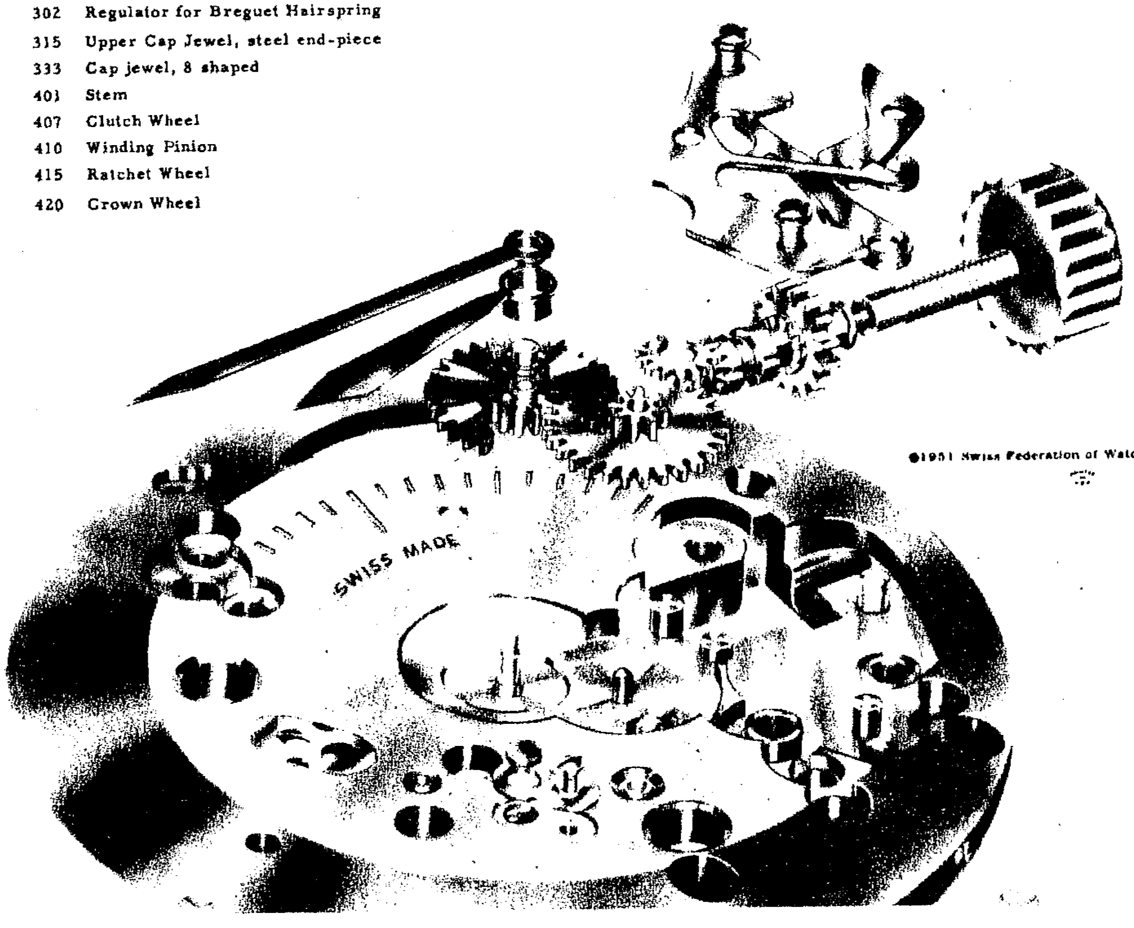
Do you realize that between the plate and bridges of this movement there are exactly six wheels including the barrel, escape wheel and balance. Yet when you have mastered and can replace each part connected with these wheels and their pinions and thoroughly understand the action of the escapement, you have mastered the majority of the repairs that come to the average Watchmaker.

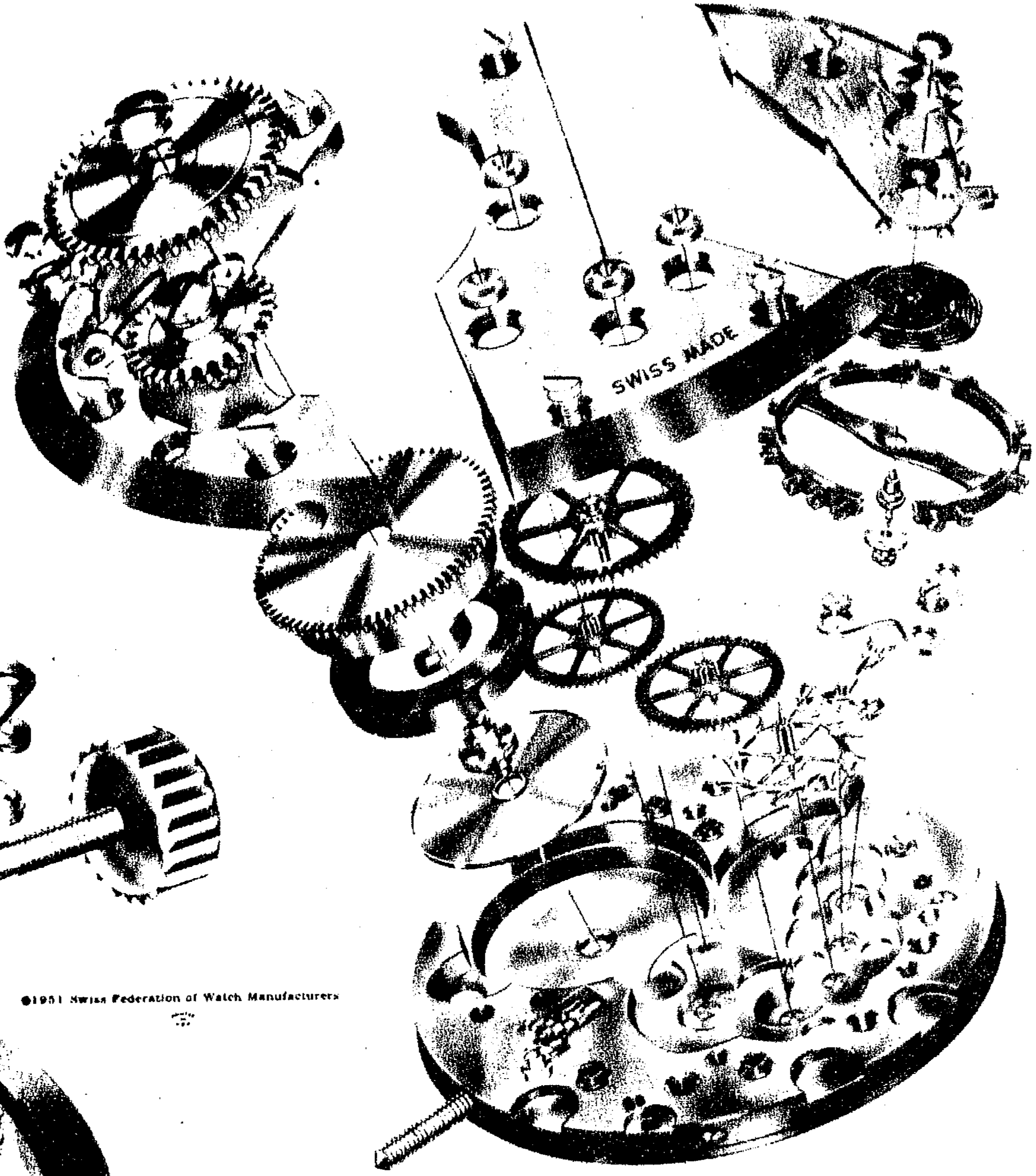
Behind the Dial of the Fine Swiss Watch

Official Swiss Parts Identification

NO.	NOMENCLATURE
100	Plate
105	Barrel Bridge
110	Train Wheel Bridge and Jewels
122	Balance cock for Breguet Hairspring
125	Pallet Clock and Jewel
185	Barrel Drum
190	Barrel Cover
195	Barrel Arbor
201	Center Wheel and Pinion
210	Third Wheel and Pinion
224	Fourth Wheel and Pinion with Second Hand Bit
240	Cannon-pinion (Steel)
260	Minute Wheel
302	Regulator for Breguet Hairspring
315	Upper Cap Jewel, steel end-piece
333	Cap jewel, 8 shaped
401	Stem
407	Clutch Wheel
410	Winding Pinion
415	Ratchet Wheel
420	Crown Wheel

NO.	NOMENCLATURE
425	Click
435	Yoke (Clutch lever)
440	Yoke Spring
443	Setting Lever (Detent)
445	Setting Lever Spring
450	Setting Wheel
703	Escape Wheel and Pinion with lower conical pivot
710	Jewelled Pallet Fork and staff
720	Pivoted Balance Wheel
723	Balance Staff
730	Roller with Jewel Pin
735	Breguet Hairspring, regulated, stud and collet
770	Mainspring





These exploded views of a fine Swiss watch are reproduced by courtesy of The Watchmakers of Switzerland Information Center Inc.

The WATCHMAKERS OF SWITZERLAND

CHECK YOURSELF

Progress Check 8A

A Self Test Review of Lesson 8

Study Sections 205 through 210 before answering these questions. Then see if you can answer them without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any, review the section on which the statement is based.

	Section Ref.
DIRECTIONS: This test will check how well you understand the meaning of what you read. Mark the one best choice for each statement in view of what the lesson manual tells you on that point.	
1. Understanding the mechanism of one movement makes it a. easier b. harder c. confusing to understand other models.	205
2. In taking apart a movement, you should first remove: a. winding mechanism b. balance with hairspring c. mainspring	206
3. The shape of the hairspring stud: a. helps you identify the make of watch b. makes a difference in disassembly c. makes no difference in disassembly	206
4. An advantage of a Hamilton floating stud is: a. it enables you to pick the stud from under the stud cap. b. it enables you to remove balance and hairspring without distorting the overcoil. c. it keeps the balance from catching on the center wheel.	207
5. The Waltham triangular stud should be removed: a. before the balance cock screw is removed. b. after the balance cock screw is removed. c. after the balance cock has been lifted out.	208
6. In removing the three cornered Elgin stud, it is recommended that you first: a. push the stud down free of the bridge. b. loosen the stud screw. c. loosen the balance cock screw.	209
7. In removing hands, you should: a. set hands at 8:20. b. pry off with celluloid. c. use a hand remover.	210

(Continued)

Progress Check 8A (continued) — Section Ref.

8. To remove the dial:
   a. Pry up the dial feet from the pillar plate.
   b. Loosen the dial screws and gently pry the dial up from the plate at points where dial feet are located.
   c. Pull the dial from the pillar plate. — 210

9. The cannon pinion is held in place by:
   a. clutch
   b. friction
   c. minute wheel clamp screws — 210

10. An extra tight cannon pinion should be removed with
   a. square nose pliers
   b. brass lined pliers
   c. round nose pliers — 210

11. To remove the pallet fork, first:
   a. pry off the pallet bridge.
   b. remove the guard dart.
   c. take out the pallet bridge screw. — 210

12. After the train bridge has been removed, take out these wheels in this order:
   a. 3rd, 4th and escape wheels.
   b. Escape wheel, 4th wheel, 3rd wheel.
   c. 4th wheel, 3rd wheel and escape wheel. — 210

13. The barrel bridge is removed by first:
   a. removing the crown wheel.
   b. removing the ratchet wheel.
   c. removing the barrel bridge screws. — 210

14. Watch screws have:
   a. right hand threads only.
   b. left hand threads only.
   c. either right or left hand threads. — 210

ANSWERS TO PROGRESS CHECK 8A:

1. a
2. b
3. b
4. b
5. a
6. b
7. c
8. b
9. b
10. b
11. c
12. b
13. b
14. c

CHECK YOURSELF

Progress Check 8B

A Self Test Review of Lesson 8

Study Sections 211 through 216. Then see if you can answer these questions without looking back. DO NOT SEND ANSWERS TO THE SCHOOL FOR GRADING. You'll find them at the end of this test. If you miss any questions, review the section on which the statement is based.

	Section Ref.
DIRECTIONS: This test will check how well you understand the meaning of what you read. Mark the one best choice for each statement in view of what the lesson manual tells you on that point.	
1. Before reassembly, it is a good precaution to lay out the train on the plate because: a. you can then assemble it as one unit. b. you can check the contact of teeth with leaves and the proper order and placement of wheels and pinions. c. you can oil it easily.	211
2. In fitting upper pinion pivots of unequal length in the train bridge, you should: a. fit the longest pivot first. b. fit the shortest pivot first. c. fit pivots straight up and down without regard for length.	212
3. The "recoil" of the train is judged by observing the a. escape wheel. b. center wheel. c. fourth wheel.	213
4. Power is transmitted from the train to the balance wheel by a. escape wheel teeth. b. pallet fork and roller jewel action. c. hairspring action.	214
5. In replacing the balance assembly, first a. turn out the stud screw. b. place the overcoil of hairspring between the curb pins. c. assemble the balance and balance cock.	215
6. The watch can run only if the roller jewel: a. can swing into the slot of the fork from the open side. b. is outside the slot. c. is centered in the fork.	215
7. The cannon pinion is replaced with: a. finger pressure. b. tweezers c. stump	216

(Continued)

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 8

Name: No.: Date:

Circle ONE correct answer unless otherwise directed. SUBJECT: Assembling Watches

1. The purpose of the hairspring stud is to:

Provide a means of regulating the watch	Fasten the hairspring to the balance wheel	Keep the coils of hairspring evenly spaced	Anchor the outside coil of the hairspring to the balance bridge

2. What part of a watch is most liable to be damaged when being disassembled by the beginner?

Stem and crown	The dial feet	Hour wheel	Balance with hairspring

3. To register correctly, the second hand in figure 172 should be:

As it is now and minute hand directly on any minute mark	At 15 and minute hand half way between marks	At 30 and minute hand at 3/4 to any minute mark	At 45 and minute hand at the minute mark

4. You are most liable to damage an enamel dial by: (Circle all correct answers.)

Wiping with a damp cloth	Prying too hard	Brushing	Dropping

5. You are most liable to damage a metal dial by:

Brushing	Blowing off lint with blower	Scratching or getting wet	Handling with watch paper

6. Why are dial feet necessary?

To keep the dial from pressing on the pillar plate	To hold the dial to the pillar plate	To keep the minute wheel from binding	To keep the hour wheel from binding

7. By comparison, the difference between the 3rd and 4th wheels and pinion is:

Entire 3rd wheel and pinion are made of steel	Entire 4th wheel and pinion are made of steel	Teeth and leaves of 3rd wheel and pinion are coarser than 4th wheel and pinion	3rd wheel has only three arms

8. The main differences between the 4th wheel and escape wheel are: (Circle all correct answers.)

Escape wheel has more teeth than 4th wheel	4th wheel has ordinary train wheel teeth	Escape wheel has differently shaped teeth	Escape wheel usually has 4 arms. 4th wheel has more.

9. By the "recoil" of the train we mean:

Testing the wheels for freedom	Reverse motion of the train after the momentum of the train has carried it beyond a state of rest	Reshaping the hairspring	Shaping the mainspring to the barrel

10. You start to assemble a full plate movement by:

Placing the balance in first	Placing the dial in first	Placing the train wheels and pallet in the upper plate	Placing the barrel in first

11. A hairspring stud is usually held in the bridge by:

A small screw	A pin	Friction	Snap fit

12. In disassembling a movement, you should first:

Remove barrel bridge	Remove pallet fork	Remove ratchet wheel	Let power down

Detach page or cut along this line — and send to the School for grading

Master WATCHMAKING

Lesson 9

WINDING AND SETTING MECHANISMS

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

9

INTRODUCTORY INFORMATION

The winding and setting mechanism in watches will vary in appearance, construction and operation, but the basic function is the same. Despite all the variation, there are only three main types: lever set, pendant set and detent. Your purpose in this lesson is to learn the workings of these types so you can confidently disassemble and assemble the winding and setting mechanism of any watch.

KEY POINTS OF LESSON ASSIGNMENTS 29, 30, 31, 32:

- The function of each part of the winding and setting mechanism.
- How the lever set mechanism works.
- How the pendant set mechanism works.
- The difference between the Swiss type setting and the American type setting.

ASSIGNMENT NO. 29: Study Sections 220 through 224.

Study Questions:

1. What advantages, if any, has a lever set mechanism over a pendant set?
2. How does the older type of lever set mechanism work?
3. How does the modern type of lever set mechanism work?

Recommended Practice:

1. Take a lever set movement, remove it from its case, let down the power, and remove hands and dial.

2. With the movement dial side up on the movement holder, study how the setting parts work.

3. Remove all setting parts found on dial side, including interset wheels, minute wheel, setting spring and clutch lever.

4. Turn the movement over on the movement holder and take off the barrel bridge or whatever is necessary to get at the setting parts on the train side.

5. Grasp the winding and setting clutch in the groove and lift out the winding pinion and clutch assembly and separate the parts of this assembly.

6. Place all winding parts from both sides of the movement in a jar or cup of degreasing solution. (See Lesson 10)

7. Pick up each piece with tweezers and after stirring in solution to remove oil, dry in clean cloth without lint. Place piece of watch paper on material tray and lay pieces on this as they are dried. Keep covered.

8. Replace parts in watch in reverse order in which you took them off. Place oil where clutch slides on winding arbor, at winding arbor bearing, on interset wheel bearings, in fact every place where there is any sliding or turning friction EXCEPT the minute wheel and hour wheel which should never be oiled.

ASSIGNMENT NO. 29 (continued:

9. Test winding and setting before replacing dial and hands. If O.K., replace these and recase movement.

10. To gain proficiency, make at least ten trials on this same movement before going on. Keep a record of your time and try to do better each time. Try to keep within 25 minutes at the most.

ASSIGNMENT NO. 30: Study Sections 225 through 229.

1. How does the pendant set mechanism differ from the lever set?
2. When timing a movement out of the case, is it necessary that the mechanism be in a winding or setting position?

Recommended Practice:

Try to obtain a mo ement of the type discussed in Section 226. Examine it carefully and try to see what each part does in the winding and setting mechanism. Then remove and replace setting parts as you did in the previous assignment. Repeat at least ten times and try to stay within 30 minutes time.

ASSIGNMENT NO. 31: Study Sections 230 through 232.

How does the Elgin set mechanism differ from the Waltham?

Recommended Practice:

Try to obtain or or more of the movements discussed in Sections 230-232. Study the setting mechanism and try to understand the job of each part. Then remove and replace the setting parts as you did before. Make at least ten trials and try to stay within 30 minutes.

ASSIGNMENT NO. 32: Study Sections 233 and 234.

1. What is the difference between the Swiss type and American type set mechanisms?
2. How are the setting parts of a Swiss movement used for identification?

Recommended Practice:

Obtain a Swiss watch and examine its winding and setting parts. Find out what each part does. Then remove and replace the winding and setting parts as you did with the other movements. Repeat this work at least ten times and try to stay under 30 minutes.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 9 and return to us for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 9
Sections 220 to 234

Lesson 9. — Winding and Setting Mechanisms.

Section *220* BEFORE having had a chance to handle the different models of watch movements, you may be somewhat confused when attempting to assemble the setting and winding parts.

It is a good plan to study the action and be sure you understand the office of each piece before taking any mechanism apart. If you come in contact with an unfamiliar type make a rough sketch showing just how the parts match with each other. There are not a great number of different types of winding and setting mechanisms and after you have had an opportunity to study them as they come to you for repairs, you will have little trouble in replacing any of the pieces and with practice can tell, when shown a setting part for an American watch, the factory from which it came and what its function is.

In the key wind watch, the winding and setting was performed on separate squares but in the stem wind and stem set movement both of these actions are accomplished by means of the one stem.

As shown in a previous lesson the sleeve in a pendant set case is liable to wear or become broken and allow the stem to slip from the winding to the setting position. Again one might neglect pressing the stem back after setting his watch, or even in handling it the stem could be brought out of the winding position, any of these preventing the proper performance of the hands in indicating the correct time.

While the convenience of the pendant set watch makes it more popular with the average person, the positive action of the lever set mechanism has been recognized as being better for Railroad Watches, consequently one of the requirements for a watch to pass Standard Railroad Inspection is that it be lever set.

Sec. 221 — An Older Type of Lever Set

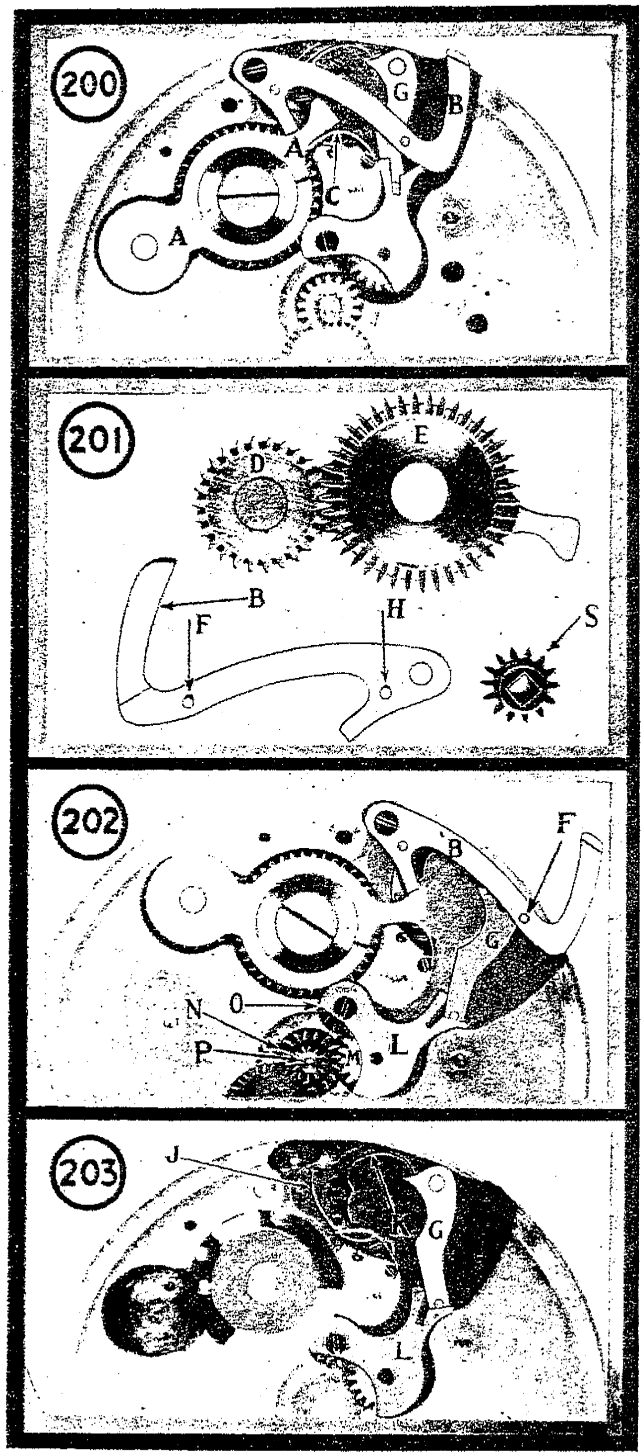
The principles of the winding and setting mechanisms are much the same in all watches, that is the stem turns the winding arbor which is connected with the ratchet wheel by a series of gears when winding, or with the cannon pinion when setting. The older forms of stem winding and setting mechanisms were quite complicated and not always as dependable in their action as the ones of today.

Figure 200 is a view of the dial side of an 18 size American made movement with the dial removed, showing one of the older types of lever setting mechanisms. The shifting of the parts from the winding to the setting position shown in figure 202 is accomplished by a series of levers and springs controlled by the setting lever B.

In figure 200 the mechanism is in the winding position with the lever B pushed in and the vibrating arm spring C pressing the vibrating arm A and this holds the interwind wheel which is underneath, against the ratchet wheel.

In figure 201 is shown the vibrating arm turned over to expose the interwind wheel at D and the crown wheel or main wind wheel at E. B is the setting lever also turned over showing the pins on the lower side, the setting cam G in figure 200 and 202 being controlled by pin F, while the setting lever spring J in figure 203, presses against the pin H, figure 201, and holds the setting lever firmly when in the winding position.

When the lever B is pulled out as shown in figure 202, the pin F slides along the edge of the setting cam G and allows it to shift to the position shown in figures 202 and 203 being forced over by the setting spring K, figure 203. In this position it so presses the setting bar L that the setting wheel M, figure 202, is engaged



with the wheel N which is attached to the cannon pinion P. Thus if the crown wheel is turned while in this position it engages the intermediate set wheel at O and this conveys the power from the setting wheel to the cannon pinion P which carries the minute hand.

In figure 204 is shown the other side of the plate with the winding bridge, ratchet wheel, click and click spring. This winding bridge may be removed by taking out the two screws R and S after which it will appear as in figure 205 with the bevel pinion in position at V. At S, figure 201, the bevel pinion standing on end shows the square hole into which the square of the winding stem fits. When this pinion is turned by means of the stem, the beveled leaves engage the teeth of the crown wheel and turn either the winding or setting, depending upon the position of the vibrating arm.

T in figure 204 shows where the interwind wheel engages the ratchet wheel when in the winding position.

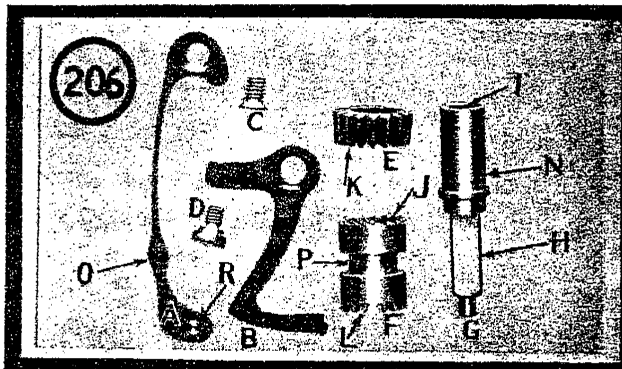
Sec. 222 — A Modern Type of Lever Setting

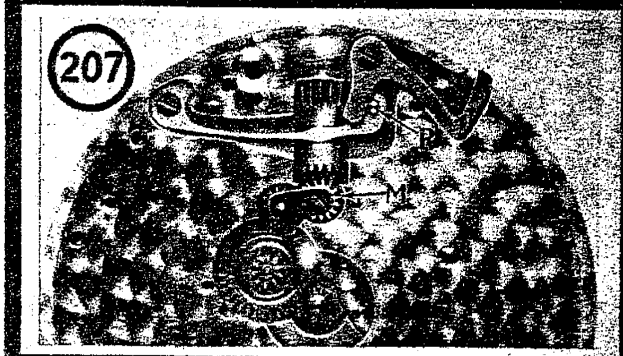
In the more modern type of watch the change from the setting to the winding is achieved by means of a sliding clutch. In figure 206 are shown the parts of a Hamilton type of lever setting mechanism. A is the clutch lever and spring, B the setting lever or shipper, E the winding pinion, F the clutch and G the winding arbor. The clutch F has a square hole running lengthwise through the center which fits over the square portion H of the winding arbor. The clutch slides freely on this square and is shifted back and forth by the clutch lever and spring A.

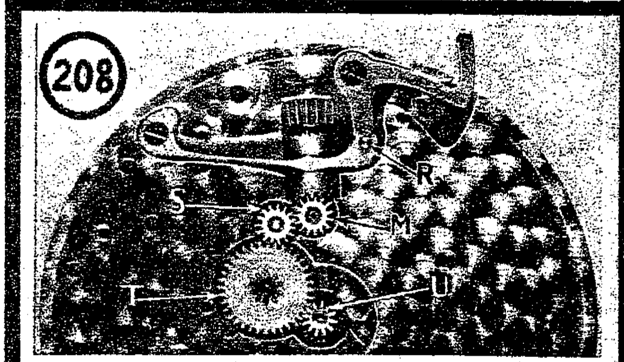
One end of the clutch has ratchet teeth at J to match the ratchet teeth in the lower side of the winding pinion at K, while the other end at L matches the teeth of the interset wheel at M in figure 207.

The winding pinion E has a hole through it which is fitted to turn freely on the round portion of the winding arbor at N. The thicker portion of the clutch lever and spring at O fits in the slot P of the clutch and when these parts are assembled and the setting lever is pressed into the winding position shown in figure 207, the tension of the clutch lever and spring holds the ratchet teeth of the clutch in contact with the ratchet teeth of the winding pinion.

When the setting lever is pulled out to the setting position the end of it is pressed against the pin R of the clutch lever and spring and forces it to the position shown in figure 208. This carries the clutch along the square portion of the winding arbor and the lower end is engaged with the teeth of the interset wheel M and this conveys the power through the setting wheel S and the minute wheel T to the cannon pinion U.





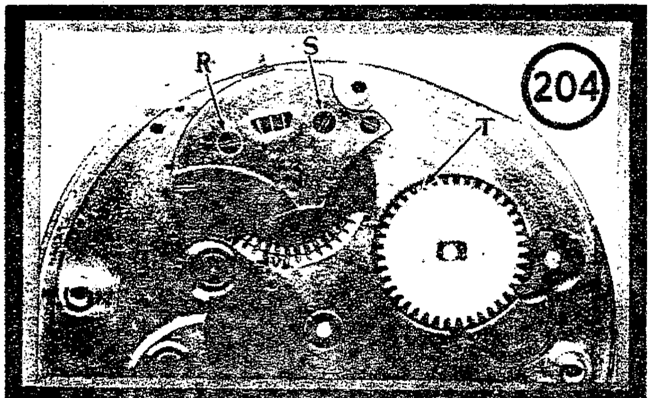


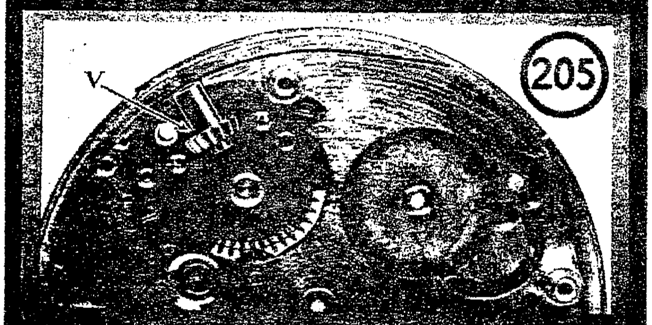
This action may be somewhat confusing at first but if you will remember that the power from the stem is conveyed by the winding arbor directly to the clutch and that the winding pinion does *not* turn except when engaged with the clutch, it may help you to recall how these parts should be placed.

In figure 209 is shown the other side of the plate when these parts are in the winding position and at figure 210 with the setting lever pulled out to the setting position. The clutch and winding pinion in 209 correspond to the position shown in 207, while 210 corresponds to 208. As may be seen in figure 209 the winding pinion is held in place on the winding arbor by the slot in the plate at V which prevents it from creeping away from the clutch and disengaging the teeth. When assembling these parts the clutch and winding pinion are placed on the winding arbor and then set in position on this side of the plate as shown in figure 209 and 210.

In figure 211 is shown the crown or winding wheel W and the ratchet wheel X, when the movement is assembled. At 212 is shown a side view of the crown wheel on which are two sets of teeth at right angles with each other, see Y and Z. When the clutch is engaged with the winding pinion and the winding arbor is turned by the stem — the winding arbor having a square hole shown at I in figure 206 into which the square of the stem fits — the leaves of the winding pinion shown at V in figure 209 are engaged with the lower teeth Z on the crown wheel and the upper teeth at Y are engaged with the ratchet wheel as shown in figure 211.

The clutch being held against the winding pinion by the tension of the clutch spring as in figure 207 and the teeth on each of these being ratchet shaped, when the winding arbor is turned backwards the ratchet teeth of the clutch rise and fall in the ratchet teeth of the winding pinion and make the familiar clicking or sound of the *backwind.* When the winding pinion is turned forward the clicking that is heard is caused by the rise and fall of the click at Q, figure 211, in the teeth of the ratchet wheel.



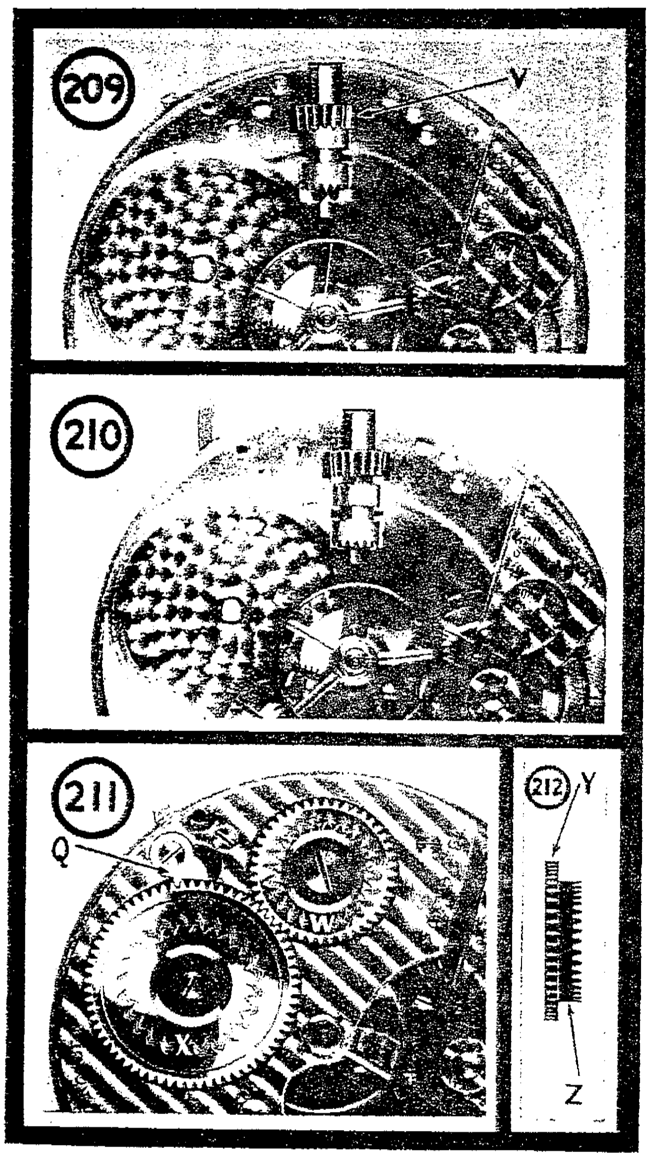


Sec. 223 — A Waltham Lever Set

Figure 214 shows another type of lever setting mechanism used on some models of the Waltham watch, with the setting lever at A and the shipper lever at B.

In figure 213, E is the winding pinion, F the clutch, G the winding arbor, H the setting wheel cap, I the setting wheel and J the winding arbor bearing. The end of the winding arbor at K fits into the hole of the winding arbor bearing at L.

On the shipper lever at C, figure 214, is a pin which projects on the under side and fits the slot in the clutch at O, figure 213. When the setting lever is shifted to the setting position the shipper lever is forced down and carries with it the clutch which engages the interset wheel under the setting cap at D, figure 215.



The winding arbor bearing is put in place from the movement side of the plate as shown at M in figure 216. The setting wheel is placed on its shoulder from the dial side and this assembly is held in place with the setting wheel cap screw N which screws through the setting wheel cap D, figure 215, into the winding arbor bearing M, figure 216.

Sec. 224 — Illinois Type of Lever Set

Figure 217 shows the setting arrangement of a high grade Illinois watch movement, the Bunn Special, in which A is the clutch lever, B the clutch lever spring, C the setting lever, and D the setting lever spring. One looped end of the setting lever spring is held by the screw at E while the other end fits over the pin on the lower side of the setting lever at F.

Figure 218 shows the position of these parts when the setting lever is shifted to the setting position and with the plate over the setting wheel removed.

The setting mechanism of the modern lever set watch is not complex in its action and after you understand the mechanical principles of the clutch and winding pinion in its relation to the crown wheel and setting wheel you should be able to re-assemble any of them.

Sec. 225 — Modern Pendant Setting Mechanisms

In some of the earlier models of Pendant set watches, before the use of the clutch, vibrating arms or yokes were used. These earlier forms were somewhat complicated but in all modern types you will find the mechanism much simplified and as in the case of the lever set, after you have once mastered the arrangements of the parts you should assemble easily either American or Swiss styles.

The use of the sliding clutch does away with the yoke and has been adopted by practically all watch manufacturers both in pendant and lever set movements.

Sec. 226 — Waltham Pendant Set

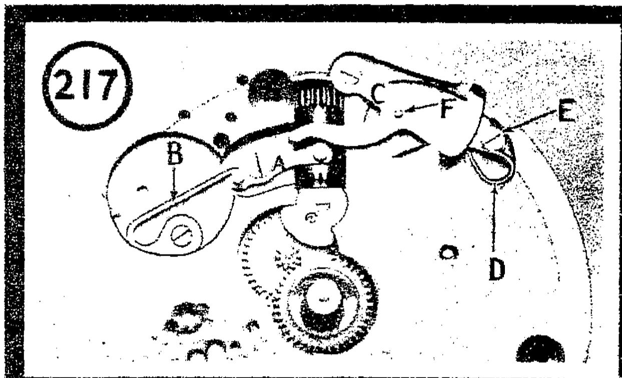
The Waltham pendant set mechanism shown here is used in connection with the stem and sleeve described in lesson 2.

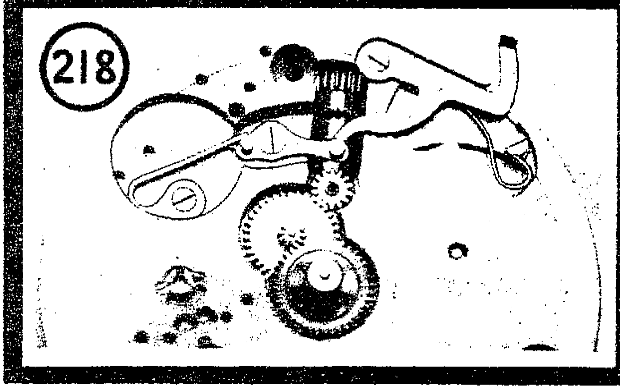
If you will compare the parts in figure 219 you will see that they are much the same as those used in the lever set in figure 213 with the addition of the plunger or push pin at R figure 219. In this photograph I have shown the other side of the winding arbor bearing to enable you to see the shoulder at S on which the setting wheel rests.

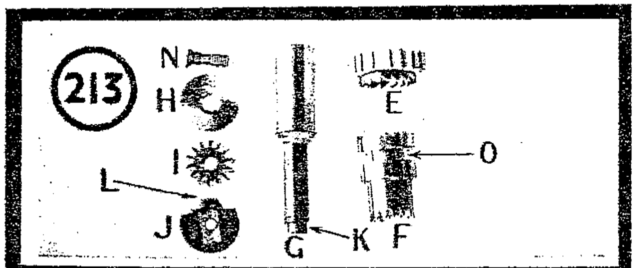
In examining the lever set watches we found that most of the mechanisms for changing the position of the clutch was on the dial side of the pillar plate while in this pendant set movement the majority of the parts are between this plate and the barrel bridge.

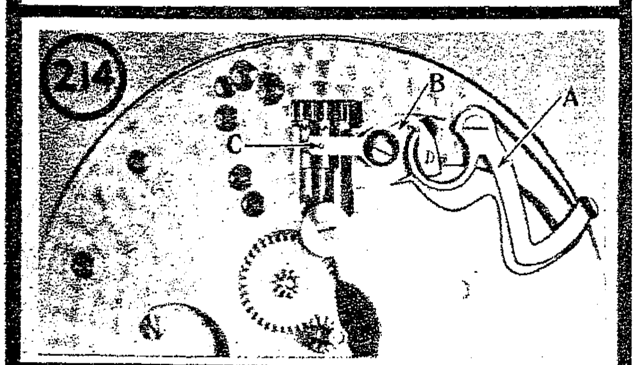
In figure 220 is shown the mechanism for shifting from the setting to winding in its position on the lower or pillar plate. These parts are held in place by the shipper cap shown at A and this cap is held by the screw B. By removing this screw and lifting off the cap the parts will appear as shown in figure 222. C is the shipper lever, D the shipper, while the triangular shaped spring shown at E is the shipper spring.

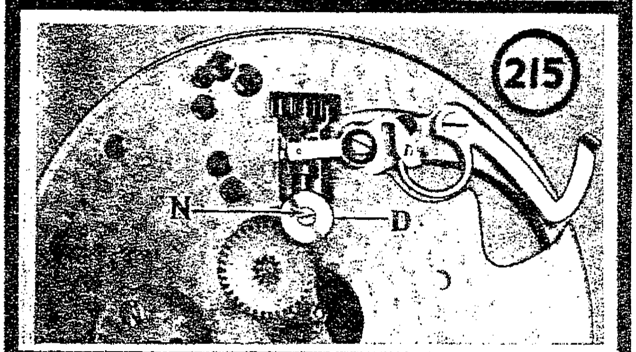
This shipper spring in some models is round as shown at F, figure 223, but its action is the same in either shape. The shipper performs the same office here that the clutch lever did in the lever set model in figure 214, that is it controls the position of the clutch.

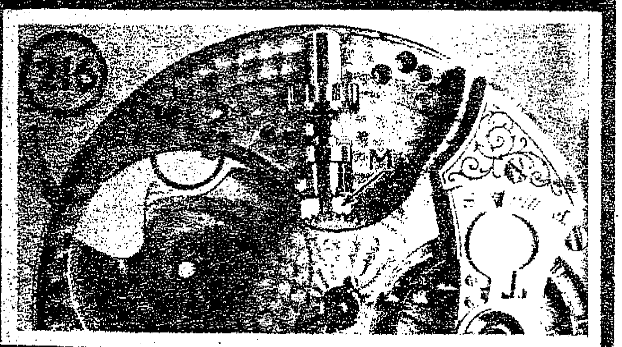










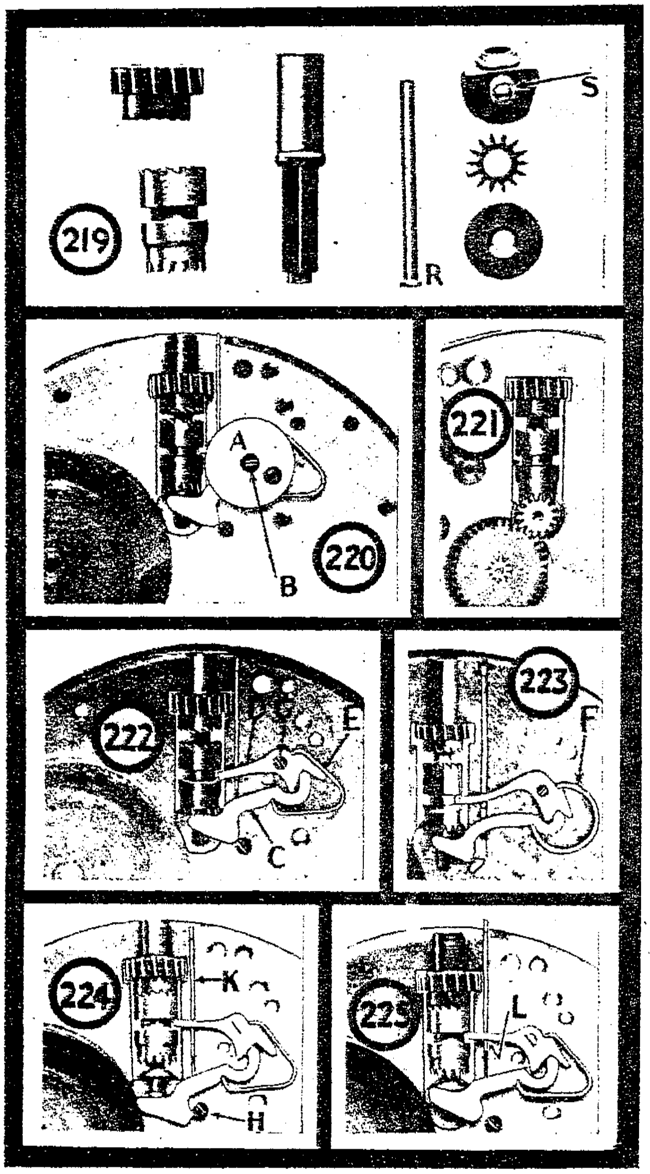


Sec. 227 — Setting Position

The position shown in figures 220 and 222, is the one that these parts will assume when the movement is out of the case or when the stem is pulled out to the setting position. The shipper D is pivoted on the screw G. The position of the shipper is controlled by the shipper lever C and the shipper spring E. As shown here the shipper spring presses the lever against the end of the shipper furthest from the clutch and the shipper being pivoted at G, the end which lies in the slot of the clutch is pressed downward carrying the clutch with it, until it engages the setting wheel, see figure 221.

Sec. 228 — Winding Position

When the stem in the pendant set case is pressed into the winding position by means of the crown and is held in that position by the sleeve as explained in Lesson 2, the plunger or push pin which extends through the winding arbor is pushed down to the position shown in 224 and the end of the plunger presses the shipper lever down past the stop screw H and forces the end of the shipper and with it the clutch upward into the winding position, that is with the ratchet teeth of the clutch in the ratchet teeth of the winding pinion. In taking down this mechanism it is not necessary to remove this screw it being left in the plate at all times even when cleaning the watch.



Care should be used to see that the shipper spring E or F does not spring away from you. In assembling it is well to place your shipper and shipper lever in position, then slip one end of the shipper spring in place and holding the two parts down hook the other end in its position. After doing this immediately replace the shipper cap and set the screw to hold it.

This mechanism is hard to assemble without instruction and the beginner usually is confused as to the position of the shipper and the shipper lever but anyone should be able to see the proper location of these parts by consulting these enlarged photographic studies.

Sec. 229 — When Timing Movement Outside the Case

When a lever set movement is out of the case the winding and setting will act as it would when in the case but this is different with a pendant set movement. The only thing that keeps the pendant set mechanism in winding position while in its case is the position of the stem, this in turn being held by the sleeve. When the movement is removed from the case this is released and the shipper spring through the shipper lever forces it to the pendant set position.

When the cannon pinion turns while in the setting position, it turns the minute wheel, setting wheel, clutch and winding arbor. If you will examine figure 221 you will see what I mean. When the cannon pinion is compelled to turn all these parts, its load is increased and unless it fits tighter than is necessary, is liable to slip on the center staff or if the cannon pinion is too tight it will slow down the motion or in some instances stop the watch.

Occasionally movements are allowed to run outside the case and unless there is some means of keeping the parts in the winding position this unnecessary friction will cause the watch to run at a different rate than when cased. For this reason pendant set watches have some method of throwing the parts into the winding position when outside the case.

In the Waltham movement shown here this is accomplished by means of the shipper bar at K in figure 224. The outer end extends to the edge of the plate where there is a notch in which to insert a screw driver or the tip of the tweezers and pull this shipper bar out which causes the hook on the other end at L to catch the shipper and shift it and the clutch to the winding position as shown in figure 225. As long as these parts are in this position the watch cannot be set from the winding arbor but will perform as it does when in the case with the stem pushed in.

It sometimes happens that you may neglect to press this shipper bar back to its proper position. For this reason it is well to always test the winding and setting with your bench key before recasing any movement.

Sec. 230 — Elgin Pendant Setting

Figure 227 shows part of the pillar plate from a 16 size Elgin movement with the winding and setting parts in place on the dial side. Figure 226 shows the other side of this same plate.

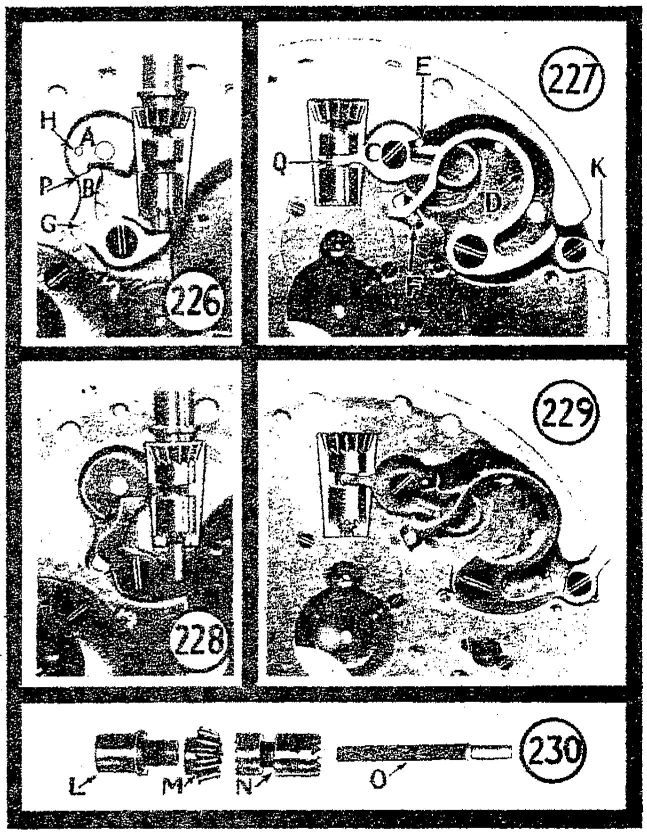
Here is a bevel or winding pinion together with a winding and setting clutch, much on the order of ones you have studied in previous sections, but controlled by a different plan.

The letters indicate the parts as follows:

A—Setting Cam
B—Setting Lever
C—Clutch Lever
D—Setting Spring
K—Setting Spring Cam

Figures 226 and 227 show the parts in the setting position. The setting spring D figure 227, presses the pin F down and this pin being attached to the setting lever B figure 226, at the point G, forces the setting lever over until the end at P pushes the setting cam A upward. At H on the setting cam is attached a pin which extends through the plate and may be seen at E figure 227. As the pin is pressed upward it forces the other end of the clutch lever at Q downward and this carries the winding and setting clutch into the setting position, gearing into the minute wheel as shown in figure 227.

When the stem is pressed into the movement, the winding arbor which also acts as a push pin, pressing down on the lower end of the

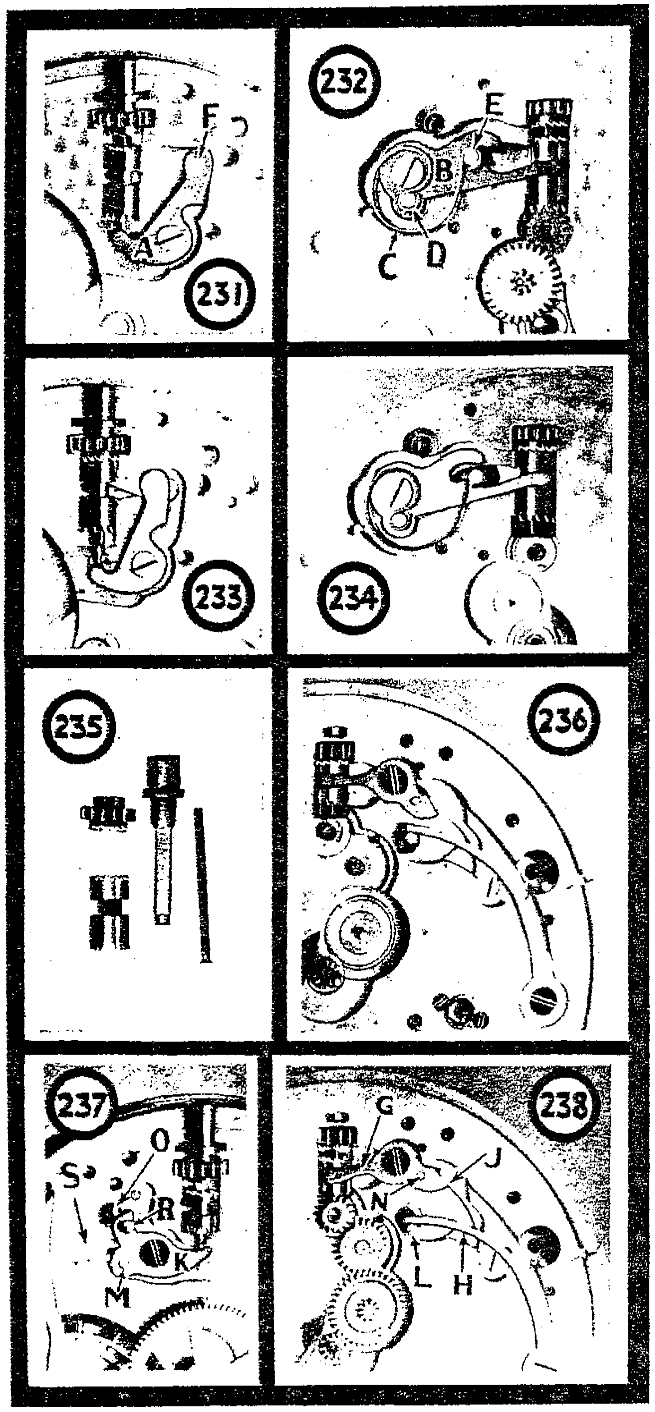


setting lever forces the setting cam over and this raises the end of the clutch lever and carries the winding and setting clutch into the winding position shown in figures 228 and 229.

At K figure 227 is the setting spring cam which serves the same purpose as the shipper bar on the movement described in Section 229. When the movement is in its case, the setting spring cam should be in the position shown in figure 227. If you wish to disengage the clutch from the minute wheel, in order to let the movement time outside the case, push the setting spring cam to the position shown in figure 229 and then with your bench key press the winding arbor to the winding position. The pressure of the setting spring on the pin F having been released by moving the setting spring cam, the parts will remain in this winding position. The setting spring cam may be changed from one position to the other without removing the dial. In casing this type of movement be sure to have the setting spring cam in the position shown in figure 227. If left projecting as in figure 229 it might be broken when pressing the movement into the case.

In figure 230 are shown the following:

L—Winding sleeve
M—Bevel Pinion or winding pinion
N—Winding and setting clutch



O—Winding arbor which also serves as a push pin.

In assembling these parts it is only necessary to line them up as shown in this photograph. The bevel pinion sets on the small shoulder of the winding sleeve, the square of the winding arbor goes through the winding and setting clutch extending into the winding sleeve. When assembled this unit will appear as in figures 226 and 228.

Sec. 231 — Illinois Pendant Set

Figures 231 to 235 show the setting parts of a 12 size Illinois movement not at all complicated and easy to understand. A, figure 231, is the locking lever, B figure 232 the clutch lever and C the clutch lever spring. As shown in figure 232 one end of the clutch lever spring is hooked over the pin at D on the clutch lever and the other end over the pin E which is on the upper end of the locking lever at F figure 231. This spring pulls the pin E into the slot of the clutch lever forcing the end which extends into the clutch, downward to the setting position as shown in figure 232.

When the push pin is forced down, it presses the locking lever over to the position shown in figure 233, thus forcing the pin on the other end past the shoulder in the slot of the clutch lever in figure 234, and this permits the clutch lever to spring upward into the winding position shown in figure 234.

In figure 235 are shown the parts with which you should be familiar by this time, the bevel pinion, the winding and setting clutch, the winding arbor and the pendant push pin. These parts are shown in the assembled unit in figures 231 and 233.

Sec. 232 — A Hamilton Pendant Set

Figures 236 to 238 show a type of Hamilton pendant set mechanism, simple and positive in action.

In figure 238:

G is the clutch lever

H the setting lever spring

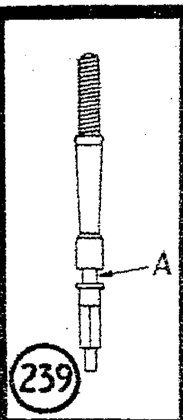
J the clutch lever spring.

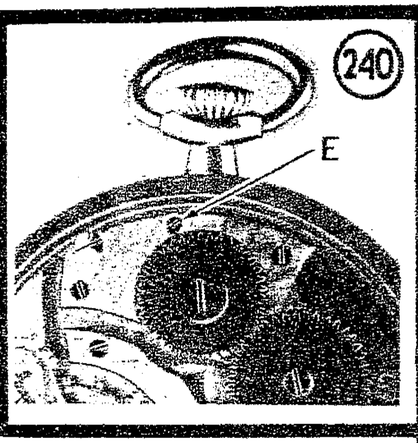
K in figure 237 the pendant set lever.

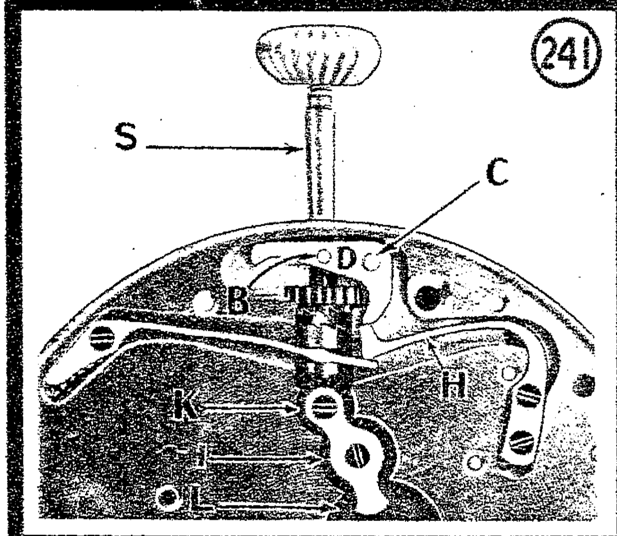
The pin at L figure 238 is fastened to the set lever at M figure 237 while the pin O figure 237 is fastened to the clutch lever at N figure 238. In the setting position the stronger setting lever spring H figure 238 forces the pin at L downward pressing that end of the set lever K figure 237 downward, the upper end pressing the pin at O upward and this presses the end of the clutch lever, which connects with the clutch, into the setting position shown in figure 238.

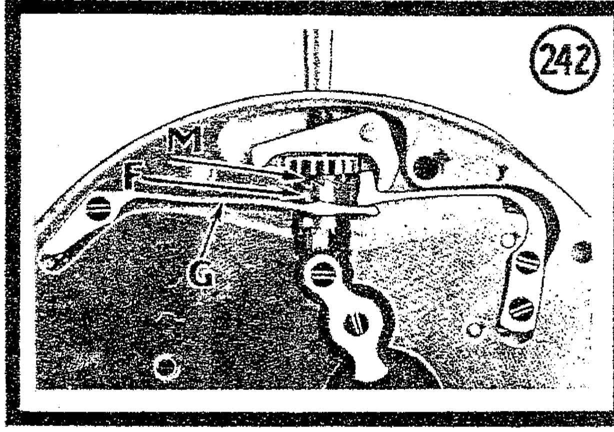
When the push pin is pressed down to the winding position by means of the stem, the pendant set lever K figure 237 is forced away from the pin O and this permits the weaker clutch lever spring at J figure 238 to press the end of the clutch lever and with it the winding and setting clutch into the winding position shown in figure 236.

In this movement will be found a cam fitting in the space at S, one side of which comes in contact with the pin R on the setting lever. This cam (not shown in the photograph) has a pin attached which extends up through the top plate terminating in a screw head and by inserting a screw driver in the slot of this head the cam may be turned to the left causing it to press against the pin R in the setting lever, figure 237 and forcing it into the winding position so the movement may run out of the case with the setting and winding parts in the same position as when in the case with the stem pushed in. The screw head which connects with this cam may be known by its color, it being dark blue while the bridge screws are bright finished. When the movement is replaced in the case be sure that the cam is so turned that the setting works properly.









Sec. 233 — A Different Type of Mechanism

The majority of Swiss pocket watches, some American models and practically all Swiss wrist and bracelet watches have a pendant set mechanism that does not require the use of a sleeve.

Figures 241 and 242 show enlarged views of the setting arrangement of a 12 size South Bend movement with the dial removed. This gives a good idea of the general principles of most pendant set mechanisms which do not depend upon a pendant sleeve.

In this model the setting lever D, figure 241, has a pin projecting from the lower side, the end of which may be seen at B and this pin fits in the slot of the stem at A figure 239. In the photograph in figure 241 the stem is shown at S, where it has been pulled out to the setting position carrying with it the setting lever.

In figure 242 the setting lever is shown in the normal position, that is with the stem pressed in. The winding and setting clutch F slides back and forth on the square of the winding arbor or stem and is controlled as to its position by the clutch spring G. When you pull on the stem it brings the setting lever to the position shown in figure 241 and the end of the setting lever forces the setting lever spring H down to the position shown here and it in turn presses down upon the clutch spring which carries the setting clutch downward until the lower end engages the teeth in the intermediate setting wheel at K, this in turn being connected to the cannon pinion by the larger intermediate setting wheel I and the minute wheel L.

When the crown and stem are pressed in, the setting lever slips off the set lever spring allowing it to resume its normal position as shown in figure 242, freeing the clutch spring which then forces the clutch to engage with the winding or bevel pinion M and this in turn winds the mainspring through the crown wheel and ratchet wheel on the other side of the movement, see figure 240.

In taking this type of movement from the case the screw at E figure 240 is turned to the left to loosen the setting lever D figure 241 and free the pin B from the slot in the stem. This is similar to the Swiss movement shown in figures 40, 43 and 44 in lesson 2, the screw at E, figure 240, extending down through the two plates and being threaded into the setting lever at C figure 241.

Sec. 234 — Examples of Swiss Setting Parts in Wrist Watches

In figure 243 are shown the setting parts of one type of setting mechanism as employed in a Swiss wrist watch. The part A is the setting lever or detent, B the yoke lever or clutch lever and C the yoke spring or clutch lever spring. This type of setting works on much the same principle as was described in section 233. When the stem is pushed in, the yoke lever holds the clutch in mesh with the winding pinion being held in that position by the spring C. When the stem is pulled out as in figure 244 it presses the end of the setting lever against the yoke lever which carries the clutch down until engaged with the intermediate set wheel and is locked in this position by the point on the yoke lever being held in the notch on the setting lever at E in figure 244.

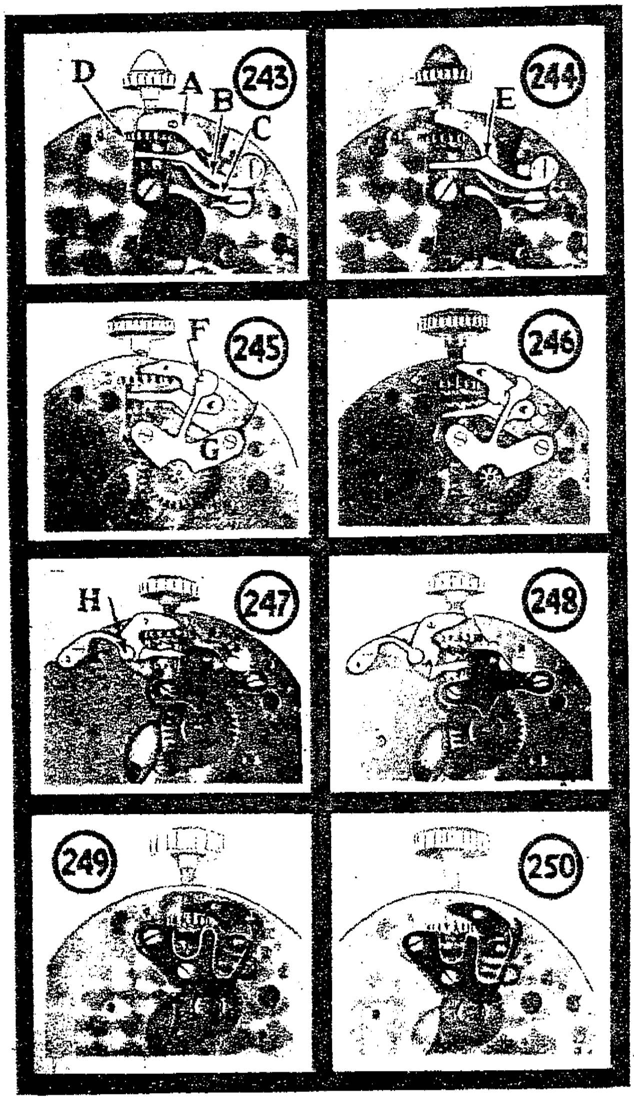


Figure 245 shows a Swiss type of setting and winding with a yoke bridge or setting wheel bridge, at G. Here the parts are locked into the winding position by means of the notch on the arm extending from the yoke bridge to the pin on the setting lever at F. When the stem is pulled out the lever is held in this setting position by the arm pressing against the pin as shown in figure 246.

In figures 247 and 248 is shown a different type of yoke bridge and here the setting lever works on the yoke lever from the left side and is locked in position by the pin on the end of the setting spring at H figure 247.

In figure 249 is another type of yoke bridge with the arm extending from the end to lock the setting lever in position much as the one does in figure 245. Figure 250 shows this same assembly in the setting position.

One of the systems of selecting material for Swiss watches is based largely upon the size of the movement and the shape of the parts I have been describing. Make yourself familiar with these three pieces, which are found in the great majority of Swiss wrist and bracelet watches and from the distinctive shape of which it is possible to identify the factory in which the watch was made.

1.—Setting lever or detent.

2.—Yoke lever or clutch lever.

3.—Setting wheel bridge or yoke bridge.

CHECK YOURSELF

Progress Check 9A

A Self Test Review of Lesson 9

Study Sections 220 through 224. Then see if you can answer these questions without looking back. DO NOT SEND ANSWERS TO THE SCHOOL FOR GRADING. You'll find them at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces. — Section Ref.

1. Pendant set watches are commonly used because of their ______________________________. — 220

2. Railroad watches use a ____________________ set mechanism. — 220

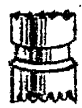
3. Although all winding and setting mechanisms are much the same in principle, the older forms were ______________________________ than modern types. — 221

4. The older type of lever set mechanisms discussed in this lesson makes use of a ______________________ arm and __________________ wheel. — 221

5. The modern type of lever setting mechanism uses a _______________ ________________________ and ____________________________ wheel. — 222

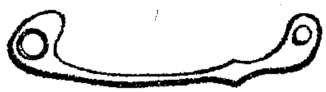
6. Identify these parts from a Hamilton lever set movement:

a. ____________________________



b. ______________________________

c. ____________________________



d. ______________________________ — Fig. 206

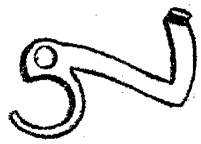
(Continued)

Progress Check 9A (continued):

	Section Ref.
7. Identify these parts from a Waltham lever movement:	Figs. 213-214
8. Identify these parts from the Illinois Bunn Special movement shown in this lesson:	Figs. 217-218

7. Identify these parts from a Waltham lever movement:

a. ______________________



b. ______________________

c. ______________________

d. ______________________

Figs. 213-214

8. Identify these parts from the Illinois Bunn Special movement shown in this lesson:

a. ______________________

b. ______________________

c. ______________________

Figs. 217-218

ANSWERS TO PROGRESS CHECK 9A:

1. convenience
2. lever
3. more complicated
4. vibrating
   interwind
5. sliding clutch
   interset
6. a. setting lever
   b. clutch
   c. winding arbor
   d. clutch lever
7. a. shipper lever
   b. setting lever
   c. clutch
   d. winding pinion
8. a. clutch lever
   b. setting lever
   c. clutch lever spring

CHECK YOURSELF

Progress Check 9B A Self Test Review of Lesson 9

Study Sections 225 through 234. Then see if you can answer these questions without looking back. DO NOT SEND ANSWERS TO THE SCHOOL FOR GRADING. You'll find them at the end of this test. If you miss any, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces. — Section Ref.

1. Both pendant and lever set movements of today use a ______________ ______________. 225

2. Either of these two springs  may be used for the same job in a Waltham pendant set movement. They are known as a ______ ______________ spring. 226

3. In the setting position of the Waltham pendant set mechanism shown in the lesson, the position of the shipper is controlled by the ______________ and the ______________. 227

4. In this same watch, the shipper presses down on the ______________ until it engages the ______________. 227

5. The Waltham pendant set mechanism shown in the lesson uses a ______________ to push down the shipper lever. 228

6. The shipper lever in turn forces the ______________ and ______________ up into the winding position. 228

7. To keep the pendant set mechanism in the winding position when out of the case, you pull out a ______________ on a Waltham or push up a ______________ on an Elgin. 229 230

8. The proper order for assembling these parts in an Elgin pendant setting is given in the column lettered __________.

a.	b.	c.
winding pinion	winding arbor	winding sleeve
winding sleeve	winding sleeve	winding pinion
winding and setting clutch	winding and setting clutch	winding and setting clutch
winding arbor	winding pinion	winding arbor

230

9. The locking lever on the Illinois pendant set shown in this lesson performs a function similar to the ______________ lever on a Waltham or the ______________ lever on an Elgin or Hamilton. 226 230 231 232

(Continued)

Progress Check 9B (continued): | Section Ref.

10. Match these alternate terms for these Swiss setting parts by placing the proper letter from column 2 in front of the corresponding term in column 1. | 234

Column 1:	Column 2:
____ setting lever	a. yoke bridge
____ clutch lever	b. detent
____ setting wheel bridge	c. yoke lever

==

ANSWERS TO PROGRESS CHECK 9B:

1. sliding clutch
2. shipper
3. shipper lever
   shipper spring
4. clutch
   setting wheel
5. plunger
6. shipper
   clutch
7. shipper bar
   setting spring cam
8. c
9. shipping
   setting
10. b
    c
    a

LESSON	8&9
DISASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L8&9-J1

HOW TO DISASSEMBLE A 12/s or 16/s ELGIN OPEN FACE

Tools, Equipment and Supplies:

Movement Holder Screwdriver Hand Remover Cannon Pinion Remover
Assembly Tweezer Mainspring Winder Jewel Pusher or substitute

PROCEDURE:	REFERENCE:
1. Remove movement from case and place in movement holder.	Lesson 1
2. Let down pow r.	Les. 5, Sec. 132
3. Loosen stud screw, remove balance cock and balance wheel.	Fig. 169
4. Remove hands, dial, hour wheel and cannon pinion.	Figs. 170-173-175-177
5. Remove minute wheel clamp and minute wheel.	Figs. 175-176
6. Remove clutch lever and setting spring.	Les. 9, Sec. 230
7. Turn movement over and remove pallet bridge and fork.	Figs. 178-179
8. Remove ratchet wheel and crown wheel.	Fig. 180
9. Remove train and barrel bridge.	
10. Remove train wheels and barrel.	
11. Remove barrel cap, arbor and mainspring.	
12. Lift out winding pinion and clutch assembly and separate the four parts of this assembly.	Les. 9, Sec. 230
13. Remove setting cam and setting lever.	Fig. 226
14. Remove balance cap jewels from balance cock and pillar plate. NOTE: Observe how these two jewel settings differ in size and appearance, so you will remember when replacing them which one belongs in the balance bridge and which one in the pillar plate.	Les. 10, Sec. 240; Les. 13

LESSON	8&9
ASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J2

HOW TO ASSEMBLE A 12/s or 16/s ELGIN OPEN FACE.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Assembly Tweezer   Mainspring Winder
Jewel Pusher or Substitute.

PROCEDURE: REFERENCE:

1. Place pillar plate on movement rest, dial side up.
2. Replace balance cap jewel.
3. Turn pillar plate over and replace setting lever and cam.
4. Assemble winding sleeve, winding pinion, clutch and winding arbor and put into place.
5. Place all train wheels on plate in this order: Fig. 183
   a. Escape wheel and pinion.
   b. 3rd wheel and pinion
   c. 4th wheel and pinion.
   d. Center wheel and pinion
6. Replace train bridge and screws. Fig. 184
7. Assemble mainspring, arbor and cap in barrel.
8. Replace barrel and bridge. Fig. 185
9. Replace crown wheel and screw. (Turn screw counter-clockwise to tighten.)
10. Replace ratchet wheel and screw.
11. Turn movement over and replace cannon pinion and minute wheel and clamp.
12. Replace clutch lever and setting spring.
13. Test winding and train. It should revolve freely.
14. Turn movement over and replace pallet fork and arbor and bridge.
15. Replace balance cap jewel and assemble balance and hairspring to balance bridge. Sec. 215
16. Replace balance bridge and wheel in movement.
17. Turn movement over and replace hour wheel, dial and hands. Lesson 11

LESSON	8&9
DISASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L8&9-J3

HOW TO DISASSEMBLE A 12/s or 16/s HUNTING MOVEMENT.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Hand Remover   Cannon Pinion Remover
Assembly Tweezer   Jewel Pusher or substitute.

PROCEDURE:	REFERENCE:
1. Place movement in movement holder and let down power.	Les. 5, Sec. 132
2. Loosen stud screw, remove balance cock.	Sec. 209
3. Remove balance wheel.	
4. Remove hands, dial, hour wheel and cannon pinion.	Sec. 210
5. Remove minute wheel clamp and minute wheel.	
6. Remove clutch lever and setting spring.	Sec. 230
7. Turn movement over and remove pallet bridge and fork.	Figs. 178-179 Fig.
8. Remove ratchet wheel and crown wheel.	Fig. 180
9. Remove train and barrel bridge.	
10. Remove train wheels and barrel.	
11. Remove barel cap, arbor and mainspring.	
12. Lift out winding pinion and clutch assembly and separate the four parts.	Sec. 230
13. Remove setting cam and setting lever.	
14. Remove cap jewels from pillar plate and balance cock.	Lessons 10 & 13

LESSON	8&9
ASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L8&9-J4

HOW TO ASSEMBLE A 12/s or 16/s ELGIN HUNTING MOVEMENT.

Tools, Equipment and Supplies:

Movement Holder, Screwdriver, Assembly Tweezer, Hand Remover
Mainspring Winder, Jewel Pusher or substitute

PROCEDURE:	REFERENCE:
1. Place pillar plate on movement rest, dial side up.	
2. Replace balance cap jewel.	
3. Turn plate over and replace setting lever and setting cam.	
4. Assemble winding sleeve, winding pinion, clutch and winding arbor and put in place.	
5. Place all train wheels on plate in this order: a. Escape wheel and pinion; b. 4th wheel and pinion; c. 3rd wheel and pinion; d. Center wheel and pinion	Sec. 212
6. Replace train bridge and screws.	Fig. 184
7. Assemble mainspring, arbor and cap in barrel.	
8. Replace barrel and bridge.	Figs. 185-186
9. Replace crown wheel and screw.	
10. Replace ratchet wheel and screw.	
11. Turn movement over and replace cannon pinion, minute wheel and clamp.	
12. Replace clutch lever and setting spring.	
13. Test winding and train. It should revolve freely.	
14. Turn movement over and replace pallet fork and arbor and bridge.	
15. Replace balance cap jewel and assemble balance and hairspring to balance bridge.	Sec. 215
16. Replace balance bridge and wheel in movement.	Fig. 190
17. Turn movement over and replace hour wheel, dial and hands.	Lesson 11

LESSON	8&9
DISASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J5

HOW TO DISASSEMBLE A 12/s or 16/s WALTHAM.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Hand Remover   Cannon Pinion Remover
Assembly Tweezer   Jewel Pusher or substitute

PROCEDURE: REFERENCE:

1. Place movement in movement holder and let down power.
2. Loosen stud screw and remove balance cock. Sec. 208
3. Turn movement over and remove hands and dial, hour wheel, cannon pinion and minute wheel.
4. Remove intermediate set wheel.
   NOTE: The bearing on which the intermediate set wheel is resting is also the bearing for push pin.
5. Turn movement over and remove pallet bridge and fork.
6. Remove ratchet wheel.
7. Remove crown wheel screw and crown wheel.
   NOTE: This is a right hand thread. Turn counterclockwise to release.
8. Remove train and barrel bridge.
9. Remove train wheels and barrel.
10. Remove barrel cap, arbor and mainspring.
11. Remove shipper cap, shipper spring, shipper lever, and shipper. Lesson 9 Secs. 226-227 228-229
12. Remove clutch and winding pinion assembly. Separate the five parts.
13. Remove balance cap jewels from pillar plate and balance cock. Les. 10-13

LESSON	8&9
ASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J6

HOW TO ASSEMBLE A 12/s or 16/s WALTHAM.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Assembly Tweezer   Mainspring Winder

PROCEDURE: REFERENCE:

1. Place pillar plate in movement holder, dial side up, and replace balance cap jewel.
2. Place pillar plate on movement rest, dial side down.
3. Assemble and replace the winding pinion and clutch assembly.
4. Replace shipper, shipper lever, shipper spring and cap.
5. Place all train wheels on plate in this order:

   a. Escape wheel and pinion.
   b. 4th wheel and pinion.
   c. 3rd wheel and pinion.
   d. Center wheel and pinion.

6. Replace train bridge and screws.
7. Assemble mainspring, arbor and cap in barrel.
8. Replace barrel and barrel bridge.
9. Replace crown wheel and screw. (Turn screw clockwise to tighten.)
10. Replace ratchet wheel and screw.
11. Test winding and train. It should revolve freely.
12. Replace pallet fork and arbor and bridge.
13. Replace balance wheel in movement. — Fig. 168
14. Replace balance cap jewel and put balance bridge in place.
15. With stud in place at proper height, tighten stud screw. — R in Fig. 167; Sec. 208
16. Replace intermediate setting wheel and cap.
17. Replace cannon pinion, minute wheel and hour wheel.
18. Replace dial and hands.

LESSON	8&9
DISASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J7

HOW TO DISASSEMBLE AN 18/s ELGIN.

Tools, Equipment and Supplies:

Movement Holder
Assembly Tweezer
Screwdriver
Hand Remover
Jewel Pusher or substitute.
Cannon Pinion Remover

PROCEDURE:	REFERENCE:
1. Place movement in movement holder.	
2. Loosen stud screw.	Lesson 5
3. Remove balance bridge and balance wheel.	Lesson 5
4. Let down power.	Lesson 5
5. Turn movement over and remove hands and dial.	
6. Remove hour wheel and cannon pinion.	
7. Remove minute wheel.	
8. Remove vibrating arm, crown wheel and intermediate winding and setting wheels.	Lesson 9, Sec. 221
9. Turn movement over and remove barrel bridge and barrel.	Lesson 5
10. Remove barrel cap, arbor and mainspring.	
11. Remove ratchet wheel.	
12. Remove plate bridge screws	Sec. 217
13. Turn movement over, holding upper bridge in place. Then lift lower plate up.	
14. Remove all train wheels and pallet fork and arbor from upper plate or train bridge.	
15. Remove balance cap jewels from potance and balance cock.	

LESSON	8&9
ASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J8

HOW TO ASSEMBLE AN 18/s OPEN FACE ELGIN.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Assembly Tweezer   Mainspring Winder

PROCEDURE: REFERENCE:

1. Replace balance cap jewels.
2. Set upper plate or train bridge in a movement holder, upside down. Sec. 217
3. Insert pallet fork and arbor in opening of potance. L in Fig. 193
4. Put escape wheel in proper jewel or hole, making sure that the escape wheel teeth line up with pallet stones.
5. Put fourth wheel in position with long pinion up.
6. Put center wheel in position with long pinion up.
7. Put third wheel in position.
8. Take pillar plate and lower it over train wheels. NOTE: The center pinion is the longest, so it should be first through. Then line up the fourth pinion in its proper jewel. Hold the pillar plate in place and line up the other three pinions in their proper jewels.
9. Holding pillar plate at edges, turn movement over and put in bridge screws.
10. Insert ratchet wheel. Be sure click is in position.
11. Assemble mainspring, arbor and cap in barrel.
12. Replace barrel and bridge.
13. Turn movement over and install cannon pinion and minute wheel.
14. Replace crown wheel, intermediate winding and setting wheel and vibrating arm.
15. Replace hour wheel, dial and hands.
16. Replace balance wheel and balance cock.

LESSON	8&9
DISASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J9

HOW TO DISASSEMBLE A SWISS AS 970.

Tools, Equipment and Materials:

Movement Holder   Screwdriver   Hand Remover   Cannon Pinion Remover
Assembly Tweezer

PROCEDURE:

1. Remove hands, dial, hour wheel and cannon pinion.
2. Turn movement over and loosen stud screw. NOTE: Do not push on stud.
3. Remove balance bridge and balance wheel. (Tilt movement holder on bench and jiggle as you lift balance bridge. Balance wheel should come free of movement.)
4. Turn bridge and wheel over and lay it flat on bench plate.
5. Holding bridge down firmly, select proper screwdriver and turn hairspring gate half way. NOTE: Gate may have a hole instead of a screwdriver slot. In that case, use a small pin to open regulator gate.
6. Turn bridge over and push on stud. Balance and hairspring should come free of bridge.
7. Let power down.
8. Remove pallet bridge and fork.
9. Remove train bridge.
10. Remove ratchet wheel and crown wheel. (Turn both screws clockwise to loosen.)
11. Remove barrel bridge and barrel.
12. Remove barrel cap, arbor and mainspring.
13. Remove train, starting with: a. Center wheel, b. 3rd wheel, c. 4th wheel, d. Escape wheel.
14. Remove two screws holding set bridge and carefully remove clutch lever and spring.
15. Remove minute wheel and intermediate wheel.
16. Remove all cap jewels.
17. Release set lever, pull out stem, remove clutch and winding pinion.

LESSON	8&9
ASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J10

HOW TO ASSEMBLE A SWISS AS 970.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Assembly Tweezer   Mainspring Winder

PROCEDURE:

1. Place pillar plate on movement holder.
2. Replace all cap jewels.
3. Place train wheels on plate in this order:
   a. Escape wheel
   b. 4th wheel
   c. 3rd wheel
   d. Center wheel
4. Replace train and escape wheel bridges.
5. Assemble mainspring, arbor and cap in barrel.
6. Replace barrel and bridge.
7. Replace crown and ratchet wheel.
8. Replace cannon pinion.
9. Replace winding pinion, stem, intermediate set wheel, minute wheel and set bridge.
10. Replace pallet fork and arbor and bridge.
11. Assemble balance wheel and hairspring to cock.
12. Holding bridge firmly, take screw driver and turn gate closed. Make sure that outer coil is in regulator pins.
13. Replace balance assembly in movement.
14. Replace hour wheel, dial and hands.

LESSON	8&9
DISASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J11

HOW TO DISASSEMBLE AN AS 1194 DIRECT DRIVE SWEEP SECOND.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Hand Remover   Cannon Pinion Remover
Assembly Tweezer

PROCEDURE:

1. Remove movement from case.
2. Remove hands and dial.
3. Remove hour wheel and cannon pinion.
4. Turn movement over and loosen stud screw. (NOTE: Do not push on stud.)
5. Remove balance bridge and balance wheel.
6. Turn bridge and wheel over and lay flat on bench plate.
7. Holding bridge down firmly, select proper screwdriver and turn hairspring gate a quarter turn in either direction.
8. Turn bridge over and push on stud. Balance should come free of bridge.
9. Let power down.
10. Remove pallet bridge and fork.
11. Remove train bridge.
12. Remove escape wheel, 4th (sweep) wheel and 3rd wheel.
13. Remove ratchet and crown wheel.
14. Remove barrel bridge and barrel.
15. Remove barrel cap, arbor and mainspring.
16. Remove center wheel bridge and center wheel.
17. Remove set bridge.
18. Remove minute wheel and intermediate set wheel.
19. Carefully remove clutch lever and spring.
20. Remove stem, clutch and winding pinion.
21. Remove all cap jewels.

LESSON	8&9
ASSEMBLY	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L8&9-J12

HOW TO ASSEMBLE AN AS 1194 DIRECT DRIVE SWEEP SECOND.

Tools, Equipment and Supplies:

Movement Holder   Screwdriver   Assembly Tweezer   Mainspring Winder

PROCEDURE:

1. Replace all cap jewels.
2. Replace center wheel and bridge.
3. Assemble mainspring, arbor and cap in barrel.
4. Replace barrel and bridge.
5. Replace crown and ratchet wheel.
6. Replace escape wheel, 3rd wheel and 4th (sweep) wheel.
7. Replace train bridge and screws. (Check for train recoil.)
8. Replace cannon pinion.
9. Replace clutch, winding pinion and stem.
10. Replace clutch lever and spring, intermediate set wheel and set bridge.
11. Replace pallet fork and arbor and bridge.
12. Assemble balance wheel and hairspring to cock.
13. Holding bridge, use screwdriver to close regulator gate. (Be sure outer coil of hairspring is in between regulator pins.)
14. Replace balance assembly in movement.
15. Replace hour wheel, dial and hands.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 9

Name: No.: Date:

Circle the correct answer: SUBJECT: Winding and Setting Mechanisms.

1. Why do railroad watches have a lever setting?

They are cheaper to construct	They are easier to wind and set	Lever set allows shorter pendant	Lever set has more positive action

2. How do modern types of lever set mechanisms differ from earlier types?

On older types stem could not be turned backward	Older type had differently shaped set lever	Modern types use a vibrating arm	Modern types use a sliding clutch

3. In the Hamilton set mechanism shown in figures 206, 207 and 208, when the set lever is in winding position, the clutch is in contact with the:

Interset wheel	Winding pinion	Minute wheel	Cannon pinion

4. In figures 206, 207 and 208, when the set lever is in setting position, the clutch is in contact with the:

Interset wheel	Winding pinion	Minute wheel	Cannon pinion

5. What is the purpose of the clutch lever?

To actuate the set lever	To move the clutch from winding to setting	To keep tension on the clutch lever spring	To hold the stem and crown in place

6. The power is usually conveyed from the clutch to the cannon pinion by which two wheels?

Hour wheel and minute wheel	Hour wheel and interset wheel	Interset wheel and minute wheel	Interwinding wheel and minute wheel

7. When timing a pendant set watch out of the case, you must:

Keep the setting mechanism in winding position	Have only 2 or 3 turns of power on mainspring	Tighten all case screws	Be sure it rests dial down

8. This is accomplished on a Waltham movement by means of a:

Setting spring cam	Setting lever	Vibrating arm	Shipper bar

9. This is accomplished on an Elgin movement by means of a:

Setting spring cam	Setting lever	Vibrating arm	Shipper bar

10. The South Bend set mechanism shown in figures 241 and 242 differs from the movements previously studied in that:

Setting is accomplished by pushing in on crown	Does not require a sleeve	Bezel must be removed to set watch	Hands will only set forward

11. In the common type of Swiss set mechanism, figures 245 to 250, the parts are locked into the wind or set position by means of the :

Setting spring	Set lever	Arm of yoke bridge	Clutch lever

Detach page or cut along this line — and send to the School for grading

Master WATCHMAKING

Lesson 10

CLEANING WATCHES

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

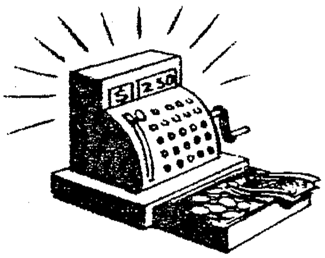
Printed in the United States of America

INTRODUCTORY INFORMATION

Many people, including some watchmakers, feel that cleaning a watch is a cure for all its ills. Along with this, they feel that the charge made for cleaning covers all ailments a watch may have. The fact is, cleaning by itself does not guarantee that a watch will be in running order afterward. Such a condition is possible only where a conscientious watchmaker has taken the pains and effort to put the watch in good order first, then clean it and bring it to time.

There is more to cleaning a watch than simply dunking it in several solutions. Many people do not understand this. Cleaning actually is but one phase of the work. The real task is to disassemble the watch, repair it, and put it back in running order. The skill and time this takes is actually what the customer is paying for, rather than just cleaning, which is only the washing off of the parts before their assembly.

It is well to make this clear to the customer at the outset, for many people have the idea a watch does not have to be taken apart for cleaning. This view is not accepted by any master watchmaker worthy of the name. Defects may exist which cleaning alone will not overcome. The only way the watchmaker can be sure a watch is in perfect order is by removing all of the parts, checking for defects, repairing, then cleaning, assembling, oiling, and bringing the watch to time. We again emphasize that cleaning is not a cure-all. The good watchmaker should explain this to his customers. He should not stress the cleaning aspect, but instead point out the work involved in the entire procedure. Unless the customer understands this, it is difficult to get proper pay for the work, particularly if additional repairs are needed.



A capable repairman should be able to take down a watch, clean it (if no repairs are involved) and reassemble in about 1 hour to 1 1/2 hours. Work of this nature will bring $6.50 to $9.50 on the average. Where repairs are needed (complete overhaul), more time is necessary (about 1 1/2 to 2 1/2 hours) and a higher return can be expected. A common charge in the cities for cleaning and overhaul is $10.00 to $25.00, depending on the type of watch and the work involved.

About this point in their studies, inexperienced students feel they know all that is necessary to handle any watch that comes their way. They think that by being able to take down a watch, clean it, and reassemble it, they are good enough to tackle any job that comes along. Granting they can do this much, and that some times this is sufficient if the watch is in perfect order, more often than not, other repair work is necessary. Unless the student can make all the necessary repairs before cleaning the watch, oiling and timing it, he is not qualified as a repairman. There is still much to be learned in this respect in the lessons ahead.

Lesson 10 will show you procedures to use in cleaning all parts of a watch. From this point on, you should clean watch parts in a professional way in your practice work. But you should also realize that knowing how to clean a watch is not the end of your training but just the beginning.

All the lessons of this course cover basic knowledge you should have. None of them should be skipped over or omitted. The order of lessons has been carefully planned to lead you as rapidly as possible to complete mastery of these fundamentals. Don't, therefore, get ahead of yourself. Learn each step thoroughly before going on. In this way, you will have full confidence in your ability when you have finished the course.

KEY POINTS OF LESSON ASSIGNMENTS 33, 34, 35, 36:

- Why watches should be cleaned.
- What parts should be checked.
- What cleaning solutions should be used.
- How to clean watches by hand.
- What jewels are removed and how to remove them.
- The procedure for cleaning.
- What parts are oiled and the correct way to oil them.
- The machine cleaning method.

ASSIGNMENT NO. 33: Review Lessons 1 through 9.

You should understand the following before attempting to clean watches:

1. The importance of having a good place to work.
2. How to remove and replace watches in their cases.
3. How to use screw drivers and tweezers.
4. How to replace the crown, stem, sleeve, and bow.
5. How to order Swiss type stems.
6. How to fit a watch crystal to a bezel.
7. How to read a millimeter gauge.
8. How to fit watch straps and cords.
9. The difference between an open face watch and a hunting face watch.
10. What is meant by the train, the wheels, and the pinions.
11. Sizes of watches.
12. How to identify watches and important factors in ordering materials.
13. Nomenclature and correlation.
14. What a going barrel is.
15. How to let down power.
16. How to remove and replace a mainspring in the barrel.
17. How to oil the mainspring properly.
18. How to use a mainspring winder.
19. How the motor barrel differs from the going barrel.
20. How to select a mainspring for watches.
21. The use of the metric micrometer.
22. Disassembly and assembly of watches.
23. Lever setting mechanisms.
24. Pendant setting mechanisms.
25. Swiss setting mechanisms.

ASSIGNMENT NO. 34: Study Sections 235 through 239.

Supplement to Section 236: Parts obviously defective need not be cleaned. You should replace them at once. Thus, upon reassembly, you will have at hand everything you need to complete the job.

ASSIGNMENT NO. 34 (Continued):

1. Why is it necessary to clean a watch?
2. Is it necessary to examine all the parts?
3. What is the common method of cleaning?
4. What is the modern method of cleaning?
5. What equipment and materials are needed for hand cleaning?

Recommended Practice:

Obtain the necessary jars and solutions and set up your cleaning equipment in preparation for cleaning watches.

ASSIGNMENT NO. 35: Study Sections 240 through 253.

1. Is it necessary to completely disassemble a movement for cleaning?
2. Is it necessary to remove cap jewels for cleaning?
3. How are the parts prepared for cleaning?
4. What is the procedure for cleaning?
5. How is the balance wheel cleaned?
6. How are small parts cleaned?
7. What is the procedure for assembly and oiling of the watch?

ASSIGNMENT NO. 36: Study Sections 254 through 259 and the Job Sheets at the back of the lesson.

1. How should a dial be cleaned?
2. How should a case be cleaned?
3. What other formula can be used for hand cleaning?
4. What are some reasons for using a watch cleaning machine?
5. How are watches cleaned when a machine is used?
6. What is the most recent method of machine cleaning?

Recommended Practice:

Examine the Job Sheets in the back of the lesson and select a cleaning method that meets your situation. Clean and oil a watch as outlined in this lesson. Repeat at least five times to gain proficiency. Try to better your speed each time.

You'll improve even faster if you can use a variety of watches. Clean both large and small watches in both American and Swiss makes. These movements need not all be cased nor do they necessarily have to be complete and in running order.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 10 and send in for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 10
Sections 235 to 259

CLEANING WATCHES

SEC. 235 — Necessity for Cleaning

One of the most common services which the watchmaker is called upon to perform is the cleaning of watches. The general repair of a watch is not complete until it has been cleaned thoroughly, oiled properly and brought to time. In a general overhaul the replacement of parts and the repairs necessary to put the watch in first class order must be done before the watch is cleaned. The actual cleaning does not require a great amount of skill provided you are able to take apart and reassemble a watch in a workmanlike manner. Every part must be absolutely clean and then kept that way until the movement is back in the case. Of course, this cannot be accomplished until the movement has been taken apart, including the winding and setting parts, and all cap jewels removed and cleaned before reassembling. The difference between the so-called "cheap" cleaning job and that done in a shop catering to better-class work most often is merely a difference in thoroughness.

As a general rule, a watch does not get dirty as we think of dirt on larger machinery. The modern watch case, if closed tightly, protects the movement against particles of dirt and lint, but in spite of the care manufacturers take to exclude dirt, dust is bound to penetrate into the movement one way or another. The particles of lint and dust work into the train and increase friction, eventually causing the watch to stop. When the oil becomes impregnated with dust, abrasive action follows and the highly polished surfaces of the pivots become roughened and, if left without cleaning and oiling, the pivots may be cut to such an extent as to ruin them. Rough pivots and gummy oil, or lack of oil, cause undue friction which, in turn, slow down the motion and change the rate of the watch.

When a watchmaker takes in a watch to be cleaned he frequently finds, upon taking it apart, that other repairs are necessary. If the watch belongs to a regular customer it is fair to suppose that unless it has met with an accident it is in good condition otherwise than the thickening of oil and accumulation of dirt. It is therefore good practice to make a thorough examination of the parts during the process of taking it apart, and a final examination after the parts have been thoroughly cleaned.

At this point the student is handicapped because of his inability to make all the necessary repairs. As he progresses with the lessons these repairs will be made. However, we will suggest a short form of examination for the student to follow.

SEC. 236 — Examination of Parts

Examine the case. See if it closes tightly, both front and back. Examine the crystal and run fresh cement in bezel if necessary. See if the case shows dents or other evidences of misuse. This may be an indication of the sort of treatment to which it has been subjected and is often a guide to the watchmaker in determining the cause of trouble. Check winding and setting before removing from the case. Frequently a watch winds or sets hard when in the case, due to faulty alignment of the movement with the pendant. If pendant set, check the winding and setting before removing from the case.

Remove movement from the case and make certain the case screws hold the movement firmly in place. Remove dust band. Check hands to see if they are fitted properly. The hour and minute hand should fit securely; the second hand just tight to be movable on the fourth pinion pivot without endangering the train or escapement. After the hands and dial have been removed, examine the dial wheels, including the cannon pinion, minute and hour wheels.

See that the hour wheel has sufficient sideshake to be free on the cannon pinion without rocking, and that the length of the pipe is just sufficient to be visible beneath the hand shoulder of the cannon pinion.

Examine the balance wheel. Stop it at the point of rest, then release it, allowing it to gradually come up to a motion. If the balance is out of true in the round it can be easily determined by looking directly down upon the balance. Look at the balance from the side to see if it is out of true in the flat.

Examine the hairspring in the same manner to detect errors in the round and flat. When a spring is true in the round there will be no appearance of jumping; the coils will appear to uniformly dilate and contract. The hairspring must be level and centered. These conditions and the method of correcting them will be taken up in future lessons.

Examine the escapement. Bring the roller jewel in perfect line with the balance staff and pallet arbor. This is the point of rest. Try the shake of the fork slot of the roller jewel. This is done by grasping the fork with a pair of fine pointed tweezers and carefully moving from side to side while holding the balance.

Remove the balance and examine the pivots on the balance staff. See that they are straight and have no grooves. Students often injure the ends of balance pivots by forcing the balance cock into place when the pivot is not in the jewel hole.

Make sure the roller jewel is securely set, perfectly upright, and is not chipped.

Let down the mainspring and remove the pallets. Examine the pallet stones for imperfections. Check the guard pin. Check the pivots on the pallet arbor. Examine each and every wheel and pinion as it is removed. Examine other parts as they are removed. When you are capable of making all repairs you will find that it pays to find and correct these repairs before cleaning a watch.

SEC. 237 — Cleaning Methods

There are many different methods used in cleaning watches. Before World War II the most common method involved the use of cyanide of potassium.

In this method of cleaning a watch, benzine or naptha was used to cut the old oil and grease. The parts were scrubbed in soap solution, then dipped into potassium cyanide solution to brighten the plates and wheels thoroughly. The parts then were rinsed in clean water, dipped into alcohol and dried in boxwood sawdust. As far as actual cleaning of the watch and parts are concerned, little improvement has been made over this process. But cyanide of potassium is such a deadly poison and must be handled so carefully that we strongly advise against its use at any time. Present day cleaning methods generally use prepared cleaning solutions sold by material houses in place of cyanide with equally satisfactory results.

When parts are dried in sawdust, much time and care must be used in brushing every particle of the sawdust from the parts lest a tiny piece be overlooked and eventually work its way into the train or escapement.

SEC. 238 — Cleaning by Hand

The system of hand cleaning we are now going to explain was recommended by several watch factories. It takes advantage of certain chemicals which do away with the need for using sawdust and which clean with less effort than the method just described. But you cannot skimp on the thoroughness of your work. **Every part must be cleaned.**

The original system used carbon tetrachloride in the first jar because of its excellent degreasing qualities and because it was also noninflammable. Unfortunately, carbon tetrachloride is also toxic if inhaled or if left on the skin for any length of time. As a result, the U.S. Food & Drug Administration in 1970 forbade its use in any household products and it is now virtually unobtainable.

Trichloroethylene has replaced carbon tetrachloride in home cleaning products. It works similarly but is flammable and less toxic. In the U.S.A., you will usually find it wherever household cleaning products are sold in drug stores and housewares departments of large department stores. You may find it under its own name or under such trade names as Carbona. If not obtainable, any high-grade degreasing agent will do.

SEC. 239 — Preparation for Cleaning

In your first attempt at cleaning a watch use a 12 or 16 size watch movement. In addition to the tools already used you will need the following:

- 7 Glass Jars (½ pint capacity) or Alcohol Cups
- 1 Bunch White Metal or Brass Wire
- Bench Block
- Blower
- Jewel Pusher
- Jewel Screw Drivers, Set of 3
- 1 Bottle of Watch Oil
- Gold Tipped Watch Oiler
- Oil Cup
- 1 Bunch Pegwood
- 1 Hard Watch Brush
- 1 Soft Watch Brush

For practice in cleaning watches any type of glass jar with a wide mouth and a cover will be suitable. Figure 10-1 illustrates ½ pint jar with a screw top which is very satisfactory.

Label jars from 1 to 7 and fill about 2/3 full of solution as follows: trichloroethylene in jar #1, denatured alcohol in jar #2, etc.:

No. 1 Trichloroethylene
2 Denatured Alcohol

FIG. 10-1

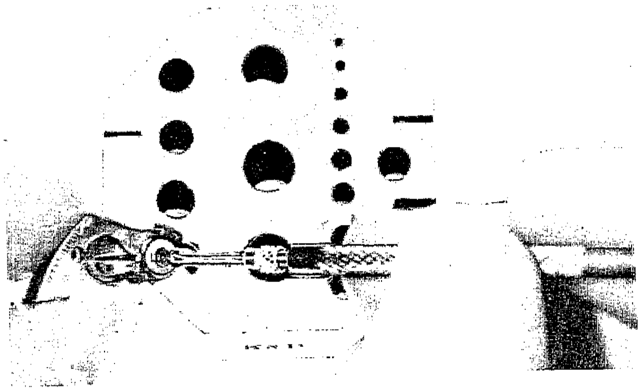


FIG. 10-2

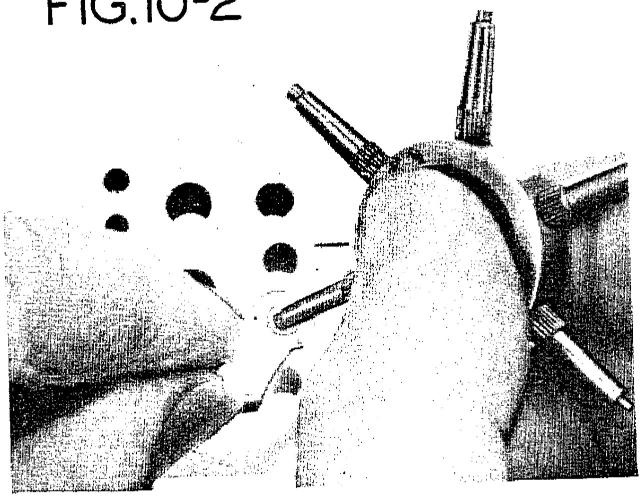


FIG. 10-3

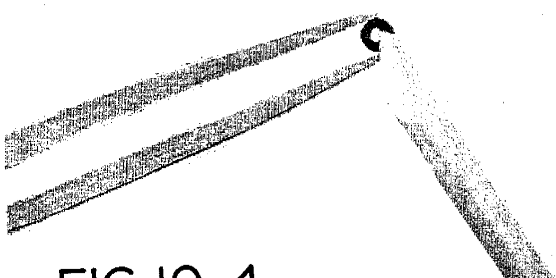


FIG. 10-4

3 Soap Solution (formula to follow)
4 Tap Water (change frequently)
5 Distilled Water
6 Denatured Alcohol
7 " "

The denatured alcohol used in jars #2, #6 and #7 should be of the highest quality. Avoid denatured alcohol that is yellow in color.

You can obtain suitable denatured alcohol by asking for shellac solvent in paint or hardware stores, where denatured alcohol is usually sold under various trade names.

For making soap solution used in jar #3 secure from your druggist:

2⅔ ozs. Tincture of Green Soap
28 ozs. Household Ammonia
1 gal. Distilled Water

From the gallon of distilled water remove one quart, add the tincture of green soap and ammonia to the remaining distilled water and refill with distilled water. This will give you one gallon of watch cleaning solution for use in cleaning watches manually.

SEC. 240 — Removing Balance and Cap Jewels

Let down the power and completely disassemble your practice movement as described in Lesson No. 8 and place the parts in a movement tray and cover. Keep the plates and wheel segregated. It is necessary to remove cap jewels. The cap jewels are found directly above and below the balance wheel and are the jewels upon which the ends of the balance pivot rotate. This is true in most 7, 15 and 17 jewel watches. In watches of 19 and 21 jewels you will usually find another pair of cap jewels at the end of the escape pinion or pallet arbor, but for your practice work we recommend using only 7, 15 and 17 jewel watches, having upper and lower balance cap jewels only.

Figure 10–2 illustrates removing 2 jewel screws that hold cap jewel in place in the balance cock. After removing jewel screws invert bridge over hole in bench block and push jewels out with jewel pusher as in figure 10–3. Be sure hole in bench block is larger than diameter of jewel settings. You will now find that you have two jewels in settings, one with a hole in it called the balance hole jewel and one without a hole called the cap jewel.

Sharpen one end of a piece of pegwood to a point and the other end to a chisel shape. Dip the pointed end of pegwood into the trichloroethylene and clean surface and hole of balance jewel. This will loosen the old oil. The same procedure should be repeated on the flat side of the cap jewel, figure 10–4, using the chisel shaped end of your pegwood. Replace balance jewel in setting in balance bridge, shoulder side down and replace jewel screws. Place cap jewel in material tray and remove the lower balance and cap jewel from pillar and clean in the same manner as the upper jewels. Keep cap jewels separate and remember which is the lower and which is the upper. The reason we replace the balance jewels in the balance cock and the pillar plate is to keep them from getting mixed.

SEC. 241 — Preparatory to Stringing

Examine closely every wheel and pinion and if you find pieces of dirt or rust in any of the teeth or pinion leaves, remove it by means of pegwood, figure 10–5. The gummed oil or pieces of dirt will come off easily enough but if there is rust between the leaves, mix a little Lap Powder with oil to the consistency of thick cream and apply this on the chisel shaped end of the pegwood rubbing back and forth until the rust is all removed. Dip each wheel into trichloroethylene (solution #1) and press the leaves of the pinion into pithwood to remove dirt and old oil. Examine carefully under a double loupe. Repeat if necessary.

SEC. 242 — Removing the Mainspring

Many watchmakers do not remove the mainspring from the barrel when cleaning a watch provided the oil seems clean and the mainspring is in good shape, but instead take off the cap and lift out the arbor and clean these two parts separately; then with a clean cloth or watch paper wipe off as much of the old oil as possible on the coils of the spring and inside of the barrel, and apply fresh oil. In this case the barrel should not be put into the solutions as described in the following instructions. However, it is difficult to tell whether the mainspring is set unless it is removed from the barrel and to do a master job of cleaning make it the rule rather than the exception to remove the mainspring.

SEC. 243 — Stringing the Parts

It is necessary to prepare at least three wires to string parts while they are in the different solutions. The illustration at figure 10–6 gives an idea of the form used. This is made from a piece of brass wire about 7/10 mm in diameter. Smaller sizes of wire are used for the small parts and for the train wheels, and the larger size wire for the heavier parts, such as the plates and the bridges.

On one of the wires which you have prepared, string all the bridges and plates including the pillar plates, barrel and train bridge, pallet bridge, barrel, large winding wheels and balance cock. Hook the end of

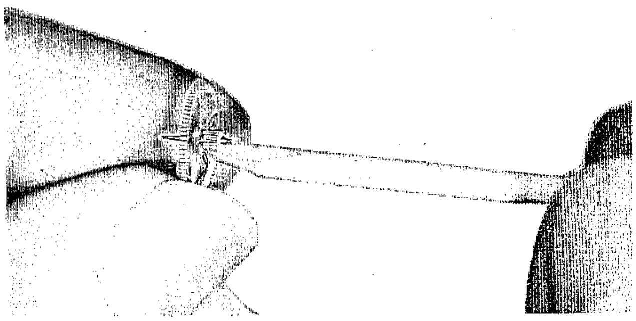


FIG. 10-5

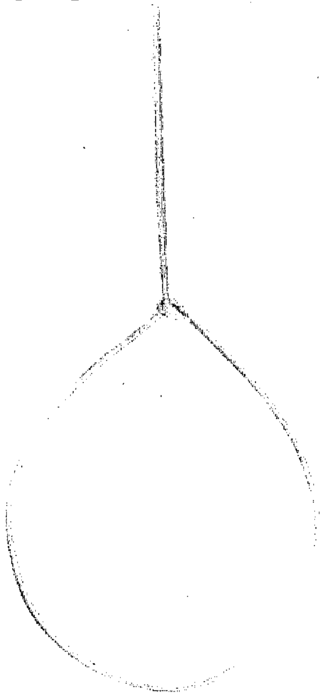


FIG. 10-6

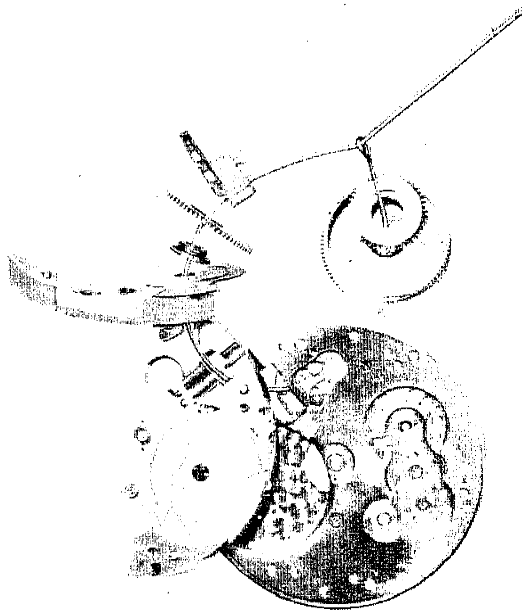


FIG. 10-7

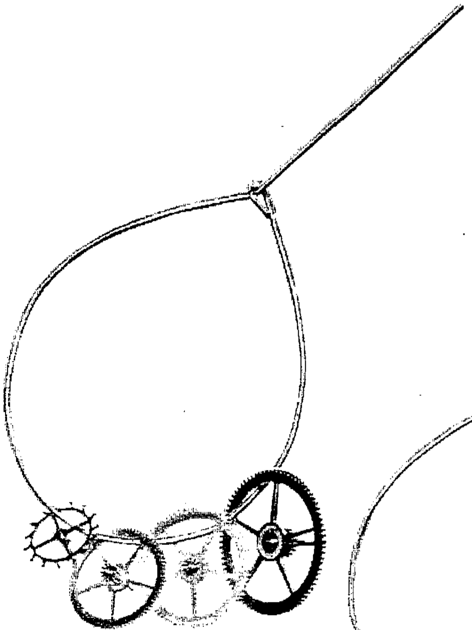


FIG.10-8

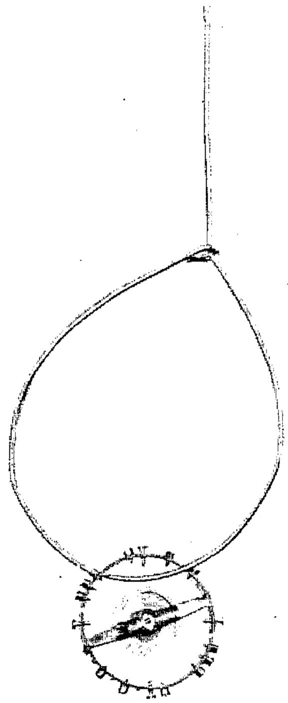


FIG.10-9

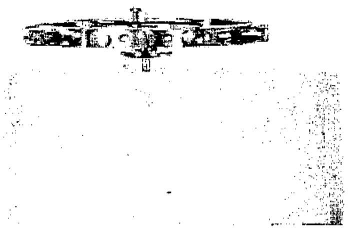


FIG.10-10

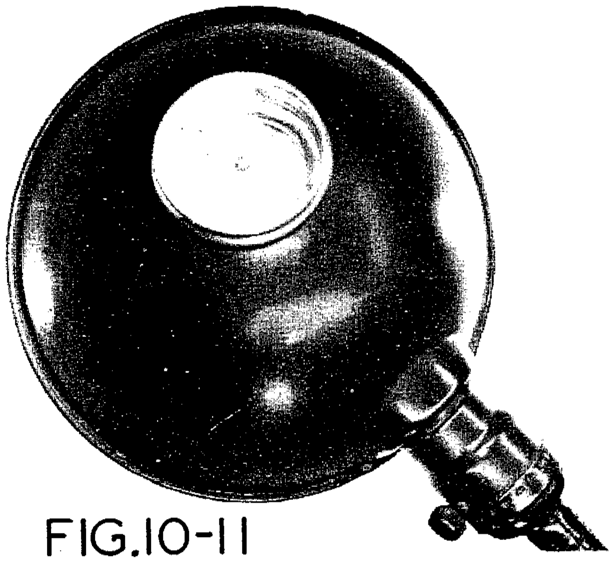


FIG.10-11

the stringing wire and lay to one side, figure 10–7. On another wire string all the wheels except the balance wheel and lay to one side, figure 10–8.

It is best to string the balance with hairspring attached on a separate wire, figure 10–9. Before stringing the balance press the pivot into a piece of pithwood, figure 10–10. Press the pithwood down to the roller on one end and to the hairspring collet on the other. This will remove surplus dirt and oil.

SEC. 244 — Procedure for Cleaning

Plates and Bridges (figure 10–7):

1. Dip into solution #1. Stir rapidly with a circular motion, reversing the direction about every five revolutions, for approximately twenty seconds.
2. Scrub parts thoroughly with the hard watch brush.
3. Repeat step one to rinse parts.
4. Remove and shake off as much solution as possible before placing in solution #2.
5. Stir rapidly in solution #2 for approximately ten seconds to remove trichloroethylene.
6. Dip in solution #3 and scrub thoroughly with hard watch brush.
7. Rinse in solution #4 for ten seconds.
8. Rinse in solution #5 for ten seconds.
9. Rinse in solution #6 for ten seconds.
10. Rinse in solution #7 for ten seconds.
11. Remove from solution #7 and shake parts back and forth for about 45 to 60 seconds or until parts are dry.

Now place parts in preheated pan which is fairly warm but not hot. Figure 10–11 illustrates an excellent warming pan which has been riveted on to the reflector of bench lamp. Place a piece of clean watch paper in pan before drying plates and wheels. After they are dry allow the parts to slide off the wire into a clean material tray or piece of watch paper and cover immediately with movement cover.

Train wheels and pinions (figure 10–8): Follow same procedure as in cleaning plates and bridges.

SEC. 245 — Cleaning Balance

Balance wheel (figure 10–9):

1. Dip in solution #1 and stir slowly with a circular motion for about ten seconds.
2. Rinse in solutions #2, #3, #4, #5, #6 and #7 for approximately five seconds for each solution.

Figure 10–12 illustrates the method used in removing the surplus solution from the balance wheel and hairspring with the blower. Hold the balance above a piece of pithwood. The upper balance pivot should be touching the pithwood. Carefully blow through the hairspring and balance wheel until dry. Place on watch paper in warming pan.

The pallet fork and arbor are cleaned by holding the fork in a pair of tweezers and swishing back and forth through solutions #1 and #2. Remove surplus solution by placing fork over pithwood and using blower as in figure 10–13. Press faces of pallet stones into pithwood, then brush carefully with soft watch brush. See that the faces of the pallet reflect light evenly. Be careful that the balance and the pallet fork are not left in any of the alcohol solutions for over five seconds as the alcohol will attack the shellac which keeps these jewels in place.

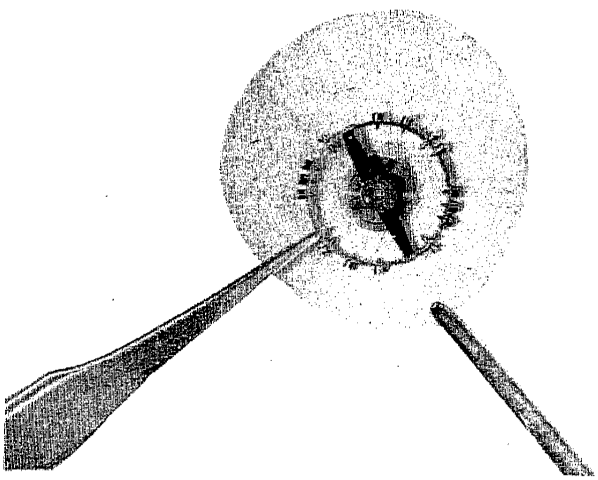


FIG.10-12

SEC. 246 — Cleaning Small Parts

To clean the screws and small parts which cannot be strung on wire, provide yourself with some sort of strainer. A tea strainer with fine mesh is suitable and prevents the small parts from falling through. Place all the small parts in the strainer and swish it back and forth in solution #1, lift out of the solution and let drain, then through solutions #2 to #7. Lift out and let drain. Invert strainer over a clean lintless cloth held in the palm of the hand allowing all the parts to fall into the cloth, figure 10–14. See that none are left in the strainer.

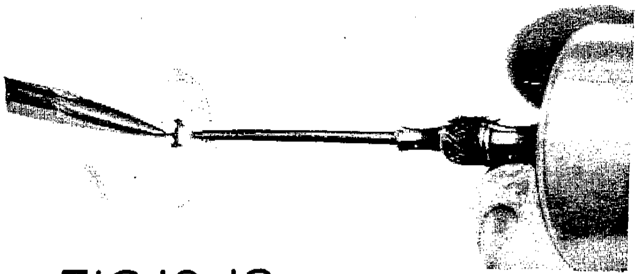


FIG.10-13

Catch up the corners of the cloth. Hold it closed at the top with one hand and with the other rub the parts against it until dry. Empty the contents carefully on to a piece of watch paper. Inspect. See that they are bright and clean. Should there be any particles of lint on any of the parts, brush with your soft brush, figure 10–15. Use blower if necessary.

SEC. 247 — Cleaning the Mainspring

Clean the mainspring by swishing it in solutions #1 and #2. Dry on a soft cloth. If the mainspring appears clean and you wish to remove the oil from its surface, it is possible to take a piece of watch paper and folding it over the end of the mainspring draw the spring through the paper, figure 10–16. Be careful not to straighten out the mainspring.

Self taught workmen clean poorly. Such work never gives satisfaction. Be satisfied only when you give your very best effort. Build up your reputation by doing good work and you never need to worry about being able to get plenty of watch work.

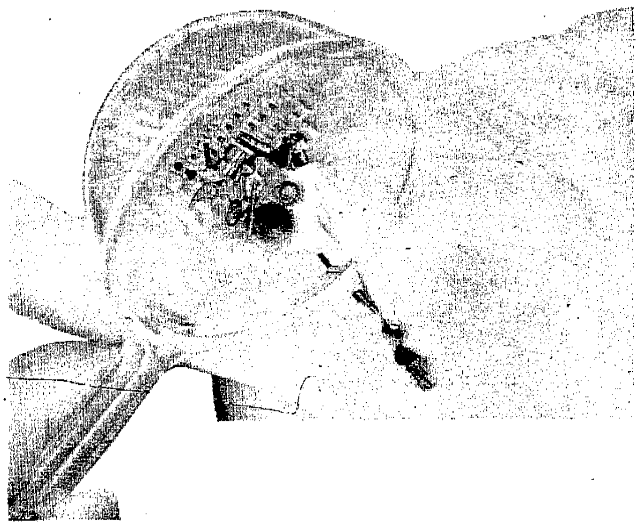


FIG.10-14

SEC. 248 — Oiling

In reassembling the watch, it is necessary to oil each bearing surface as we assemble and if you follow the instructions carefully, you will not skip any place that requires oil.

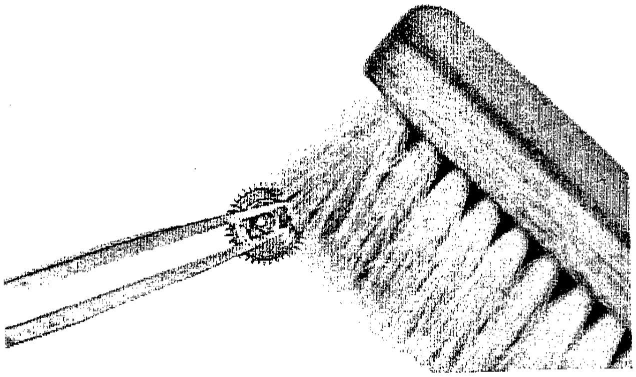


FIG.10-15

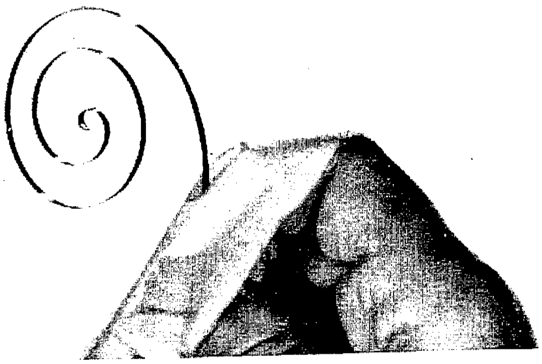


FIG.10-16

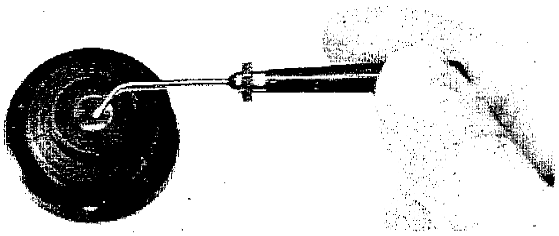


FIG.10-17

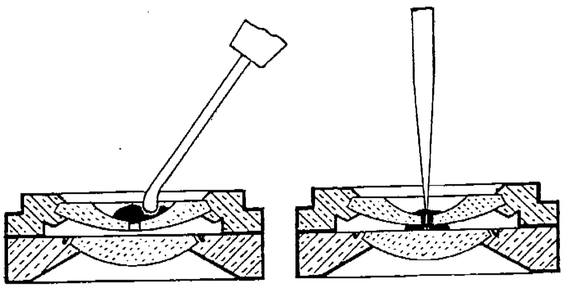


FIG.10-18

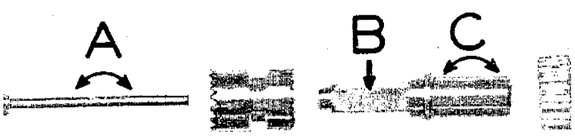


FIG.10-19

It is best to keep your watch oil in an oil cup, figure 10–17. Be certain to replace the cover whenever you are not using the oil. A medium sized drop of oil will oil several watches; consequently, it is only necessary to keep a small amount of oil in the oil cup. It is best to clean the oil cup every day and refill with fresh oil. It is necessary to oil the moving parts of a watch as you would any piece of machinery or wherever friction develops.

SEC. 249 — Oiling Balance Jewels

Replace all cap jewels before assembling the watch. Place a small amount of watch oil in the recess of the balance hole jewel, figure 10–18. Place a needle or a pointed steel wire, which has been dipped in watch oil, in the hole of the jewel. This will force the oil through the balance jewel and down to the cap jewel. When you remove your needle there should be no trace of oil left in the cup of the balance hole jewel. In watches that have cap jewels other than the balance cap jewels such as a 21 jewel watch, which has cap jewels on the upper and lower ends of the escape pinion and pallet fork, the same procedure is followed in cleaning and oiling these additional jewels.

SEC. 250 — Reassembling the Watch

Replace the mainspring and arbor in the barrel and oil as described in Lesson No. 5.

Figure 10–19 shows the winding pinion, winding arbor, clutch and setting plunger from right to left. In this particular style assembly a small amount of oil should be placed on the setting plunger at A. At B oil all four sides of the winding square, being very careful not to get an excess amount of oil on any side of the square. Actually you should not be able to see any oil on the square. Lightly oil the upper portion of winding arbor at C and assemble.

SEC. 251 — Procedure for Oiling Train

The lower plate or pillar plate shown in figure 10–20 should have a small amount of oil placed on the bearings for the winding and setting illustrated by Arrow A, and for the set lever illustrated by Arrow B. Place a small amount of oil on lower plate bearing which receives the barrel arbor, Arrow C.

Figure 10–21 illustrates the barrel and the winding pinion, clutch assembly and setting lever in place. Oil arbor at A and place small amount of oil in center jewel at C and on the upper and lower end of the winding arbor at B. Replace train wheels, train and barrel bridge and crown wheel as in figure 10–22. Place a small amount of oil at A and B, figure 10–22. Oil crown wheel at C. Replace click, ratchet wheel and crown wheels, figure 10–23; oil center wheel at A. 3rd wheel at B, 4th wheel at C and escape wheel at D. Place just enough oil in these jewels so that it will flow through the jewel and around the pivot similar to the darkened portion of figure 10–24.

SEC. 252 — Oiling from Dial Side

Turn movement dial side up, figure 10–25, and place small amount of oil on 2 or 3 teeth of the clutch as illustrated by Arrow A. Oil bearings for intermediate setting wheels at B. Some watches have only one intermediate setting wheel. Place small amount of oil at C for clutch lever. Do not oil arbor at D where minute wheel is placed. Previously we oiled the center jewel from the other side but you should check at this time to see if there is enough oil in the oil cup. If not, add to it, Arrow E. Replace cannon pinion and setting parts and place small amount of oil where friction occurs as indicated by Arrows A in figure 10–26. Oil lower 3rd wheel pinion at B, lower 4th wheel pivot at C and lower escape pivot at D.

SEC. 253 — Oiling Escape Wheel Teeth

After you have assembled and oiled your watch DO NOT use your blower where it might spread the oil.

With one of your bench keys wind watch three or four turns and observe the action of the train wheels. If it is in first class order, the train will run down, come to a complete stop, and the escape wheel will then reverse its direction, running backward for three or four turns. In high grade watches this action happens so fast that it is necessary to watch the 4th wheel instead of the escape wheel. This is usually an indication that the train of the watch and the winding mechanism are in good order, that is, up to this point. When you are satisfied that the train of the watch is in good order the next step is to oil 4 or 5 teeth of the escape wheel illustrated by Arrow A, figure 10–27. Be careful to oil only the face of the escape wheel teeth. A surplus of oil will collect dirt and dust. As the watch runs the teeth of the escape wheel will carry the oil to the locking and impulse faces of each pallet stone. Replace pallet fork, arbor and pallet bridge. Oil upper pivot as indicated by Arrow A in figure 10–28. Replace the balance and balance cock. See that the roller jewel enters the fork and that the balance is free and has the right amount of end-shake. CAUTION! DO NOT OIL THE ROLLER JEWEL OR PALLET STONES. Turn movement over. Replace minute and hour wheel and oil lower pallet arbor pivot as indicated by Arrow A, figure 10–29. Replace dial and hands.

Wind the movement four or five turns using one of your bench keys. The balance should start off immediately and take about one full turn.

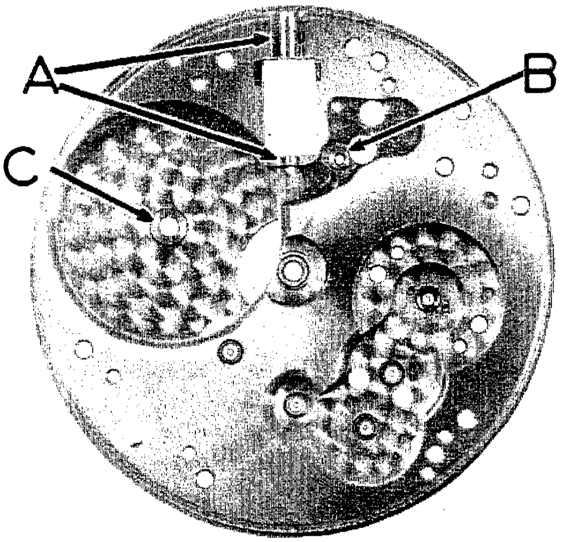


FIG.10-20

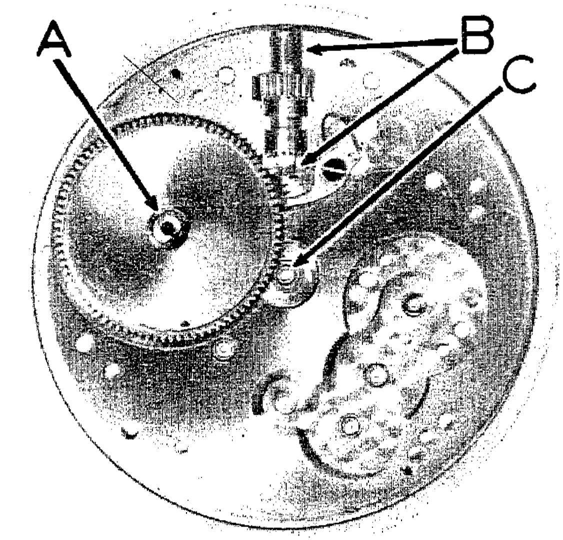


FIG.10-21

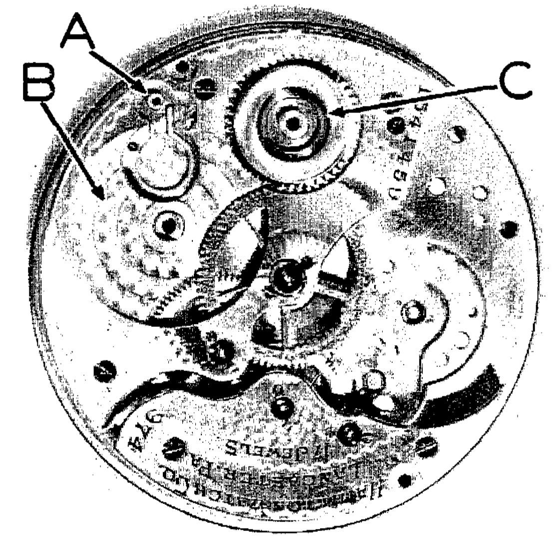


FIG.10-22

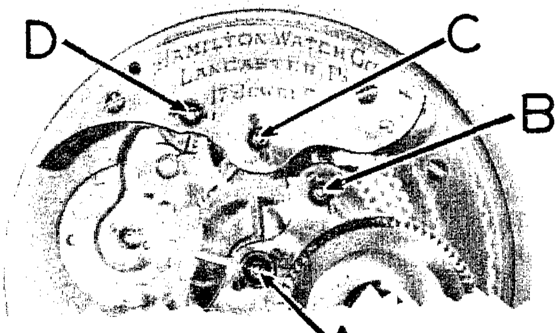


FIG.10-23

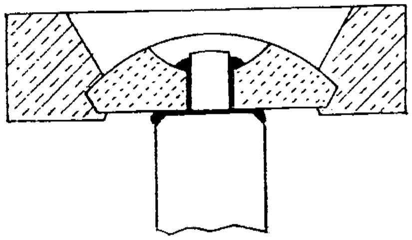


FIG.10-24

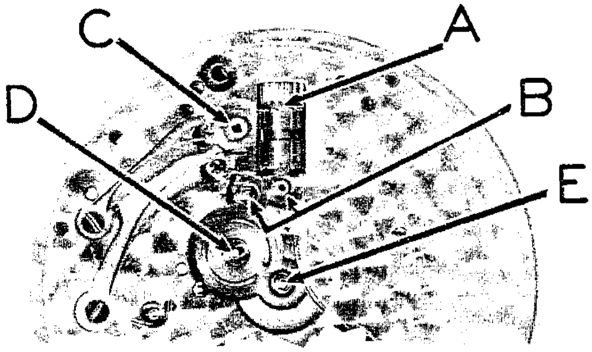


FIG.10-25

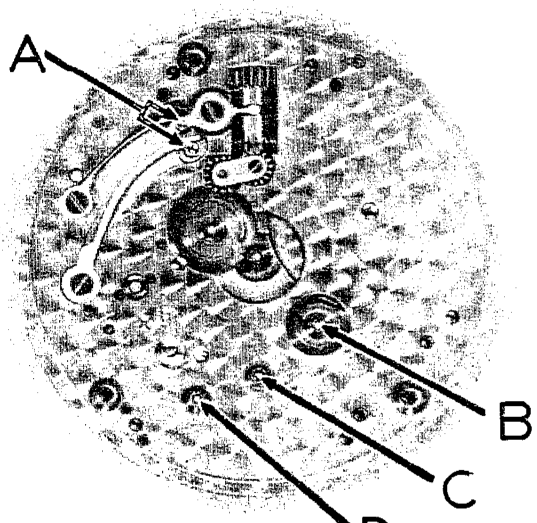


FIG.10-26

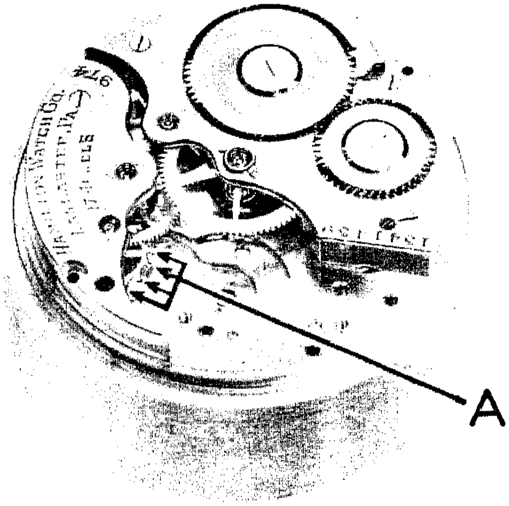


FIG.10-27

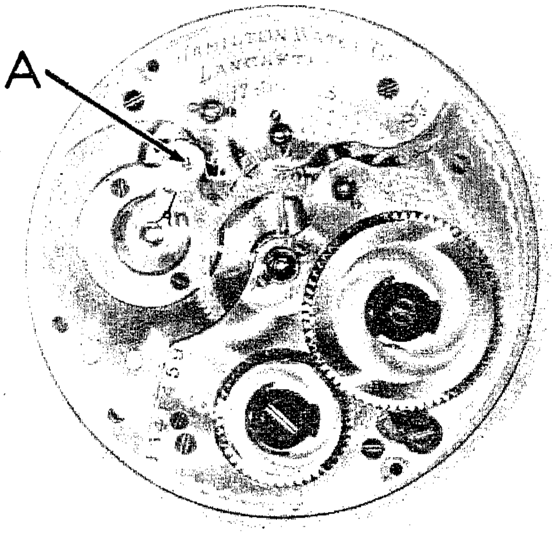


FIG.10-28

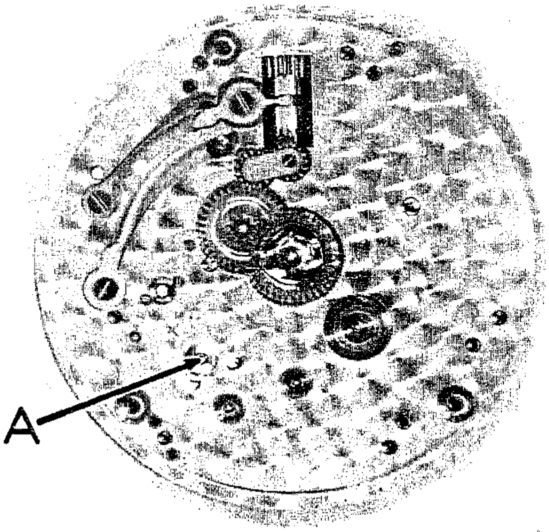


FIG.10-29

SEC. 254—Cleaning the Dial

There are two common types of dials—the enameled dial and the metal dial. The older style or white enameled dial is made of glass hard enamel baked on a copper base and can be cleaned in any solution used in cleaning watches. Unless very dirty, it is the common practice merely to clean any dirt or finger marks from this kind of dial with a dry clean cloth or even a piece of watchpaper. The figures on this dial are baked into the enamel and there is no danger of rubbing them off when cleaning.

In the better grades of metal dials the numerals are enamel and these dials may be cleaned by dipping in cleaning solutions.

Metal dials frequently are lacquered but in spite of this have a tendency to tarnish. The lacquer may come off in places leaving the dial with a blotched or streaked appearance. A cyanide dip will generally help in brightening a tarnished metal dial but great care must be used. Another method is by means of common baking soda, a small quantity mixed to the consistency of cream being placed on the dial with the finger and rubbed with a light circular motion. When the dial is sufficiently brightened, rinse with water and dry by patting with a soft cloth or place in warming pan.

Metal dials with painted numerals must be handled carefully lest the figures come off. They may be cleaned with prepared dial cleaner. Be careful about rubbing off the figures.

At first you may have difficulty in seeing whether a metal dial has enameled figures or not but after examining a few you should be able to tell at a glance. As a general rule the enameled figures lie flatter on the dial being flush with the metal or even a trifle below the surface while the other type shows the numerals on the metal as though painted or printed on top of the surface of the dial.

SEC. 255—Cleaning the Case

Whenever you clean and reoil a watch you should also clean the case. If the case has a polished finish and you have access to a polishing motor, it is well to repolish the case. This is about the only part of the watch your customer can see and he is liable to judge your ability by the outside appearance of the completed job. If you are not so equipped, polish as best you can by using a polishing cloth. To wash the case use a stiff brush with soap and ammonia and scrub thoroughly. Rinse in water to remove all traces of soap and then dry with a clean cloth. In spite of your utmost efforts there will be some water remaining around the stem and crown and perhaps the joints of the case. Dip the entire case in a cup of alcohol to remove the last trace of water and then dry again with the clean cloth. Last, heat the entire case pendant down over an alcohol lamp until it is as hot as your hand will bear and the excess alcohol will burn off.

If it is a pendant set case with sleeve, place a small amount of oil on the stem where it comes in contact with the sleeve as has been described in Lesson No. 2. Wash the bezel and glass, wiping dry, and see that there are no marks, streaks or lint left on the glass. Place the regulator in the center of the balance cock. See that the hands are adjusted properly. They should not come in contact with each other at any place. Replace movement in case. Check hands again. They must not touch the glass.

Wind and set the watch. Endeavor to set second hand with the second hand on a watch or clock which keeps correct time.

SEC. 256—Formulas for Cleaning Solutions

The following formulas are for your reference. Each of the ingredients may be ordered from your druggist. Be careful in handling the 29% solution of ammonia as it is highly concentrated. Keep from breathing the fumes and only order enough to make the desired, necessary amount of solution.

Solutions for Manual Cleaning Method

1 Part Tincture of Green Soap
3 Parts Ammonia (29% solution)
44 Parts Distilled Water

Solutions for Machine Cleaning Method

1 Part Tincture of Green Soap
2 Parts Ammonia (29% solution)
45 Parts Distilled Water

SEC. 257—Watch Cleaning Machine

The student will hear a great deal about watch cleaning machines. Today the most modern shops use cleaning machines and when used properly, have increased the profits of the repair department. When watch cleaning machines were introduced there were some claims that it was not necessary to take the watch apart in order to clean it. This brought a sincere condemnation from all expert watchmakers and for a while the machine was not accepted among the trade. However, as with everything that has merit, the machine was gradually accepted by qualified watchmakers who proceeded to experiment with it and the solutions necessary to make the machine produce excellent results. It remains a fact, however, that any machine in the hands of an indifferent workman will-not produce the best results.

There are many good machines on the market similar to those illustrated in this lesson.

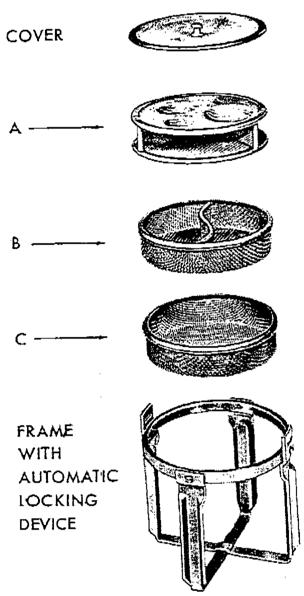
SEC. 258 — Machine Cleaning Method

The following is the commonly accepted procedure used with few variations with a machine using the 3 jar method and the prepared solutions furnished by the manufacturer of any particular machine.

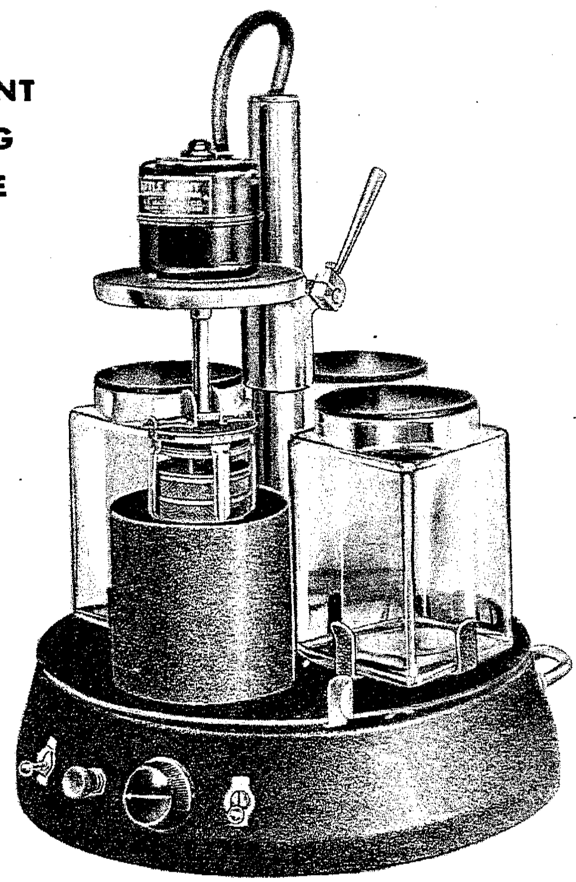
1. Take watch completely apart.
2. Make necessary repairs.
3. Brush greasy parts with prepared cleaning solution to remove old oil.
4. Place bridges, plates, barrel, etc., into the largest compartment, C-Fig 10-30.
5. Place all screws, levers, etc., which you know will not slip through holes in basket in separate compartment. B-Fig 10-30.
6. Place train wheels into separate compartment. A-Fig 10-30.
7. Place pallet fork and balance in separate compartment. A-Fig 10-30. (Do not put hairspring in cleaning machine. Clean separately.)
8. Place cover on basket and clamp basket in machine.
9. Run slowly in solution #1 for approximately 2 minutes. The speed can be controlled by the rheostat.
10. Spin off surplus solution in upper half of cleaning jar. Some machines have a separate jar for spinning off solutions.
11. Rinse in solution #2 for approximately 2 minutes.
12. Spin off surplus solution.
13. Repeat operations 11 and 12 with solution #3.
14. Place in heater compartment, spinning for 3 or 4 minutes, or until dry.
    Remove parts carefully and examine.

SEC. 259 — Superior Method of Machine Cleaning

The newest machine method of cleaning is with sound waves, known as ultrasonic cleaning. This method is considered particularly desirable for electric and electronic watches. Figure 10-33 shows a typical ultrasonic watch cleaning machine. It provides a more efficient cleaning method than a regular machine and requires only partial disassembly. The method will be discussed in detail in a later lesson (Modern Shop Methods).



LITTLE GIANT CLEANING MACHINE



Square jars prevent solution from excessive whirling and instead force it through the basket, which results in more thorough cleaning. Has three jars: One for cleaning solution, one for Rinse No. 2 and one for Rinse No. 3. Metal shielded compartment is a drier with an electric heater.

FIG. 10-30

L&R CLEANING MACHINES

FIG. 10-31 - MASTERMATIC

Uses three jars. One for watch cleaning solution No. 1, one for Rinse No. 2 and one for Rinse No. 3. Has a metal-shielded heating unit for drying parts. Comes with or without automatic reverse.

FIG. 10-32 - HEAVY DUTY

This machine is useful where greater production is needed. A special basket holds three separate complete movements. Uses three jars like the Mastermatic. Shielded heating unit.

FIG. 10-33 - CONSOLE ULTRASONIC

A typical ultrasonic cleaning machine. Has one cleaning jar, two rinsing jars and a drying chamber. Cleans three or more watches at one time. If you already have the machine shown in Figure 10-31, you can obtain an ultrasonic attachment for it.

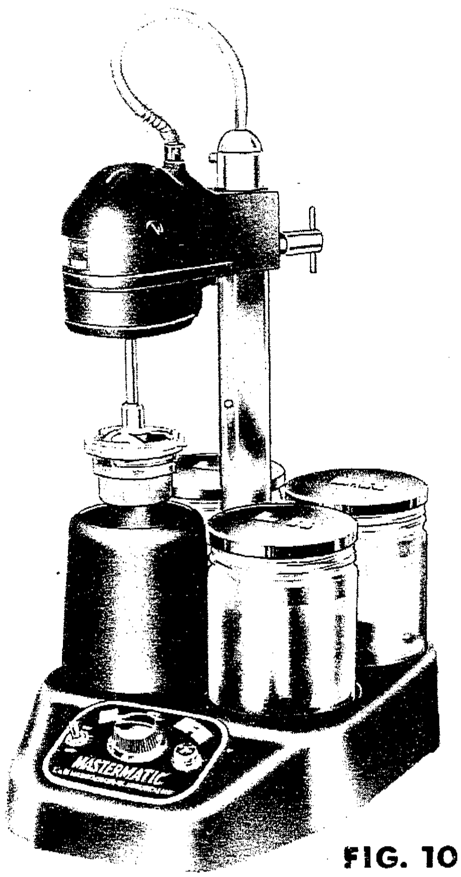


FIG. 10-31

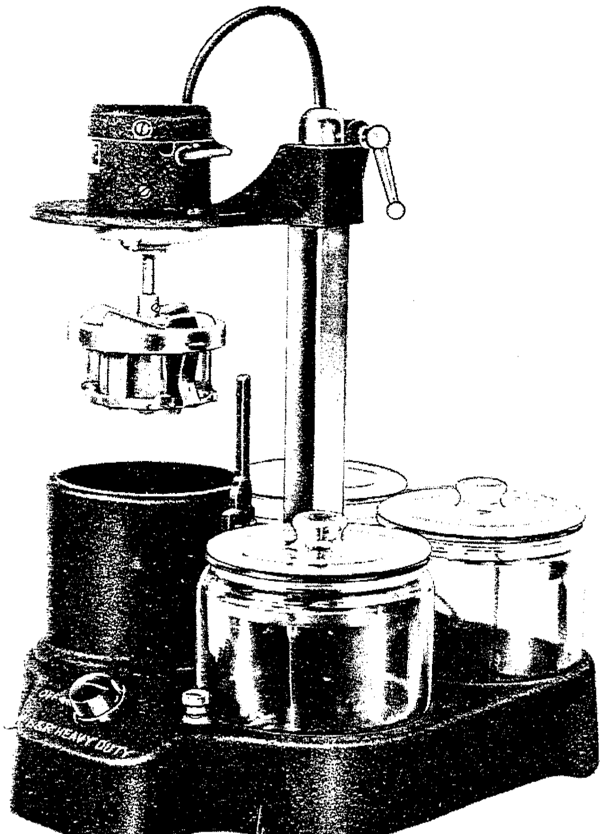


FIG. 10-32

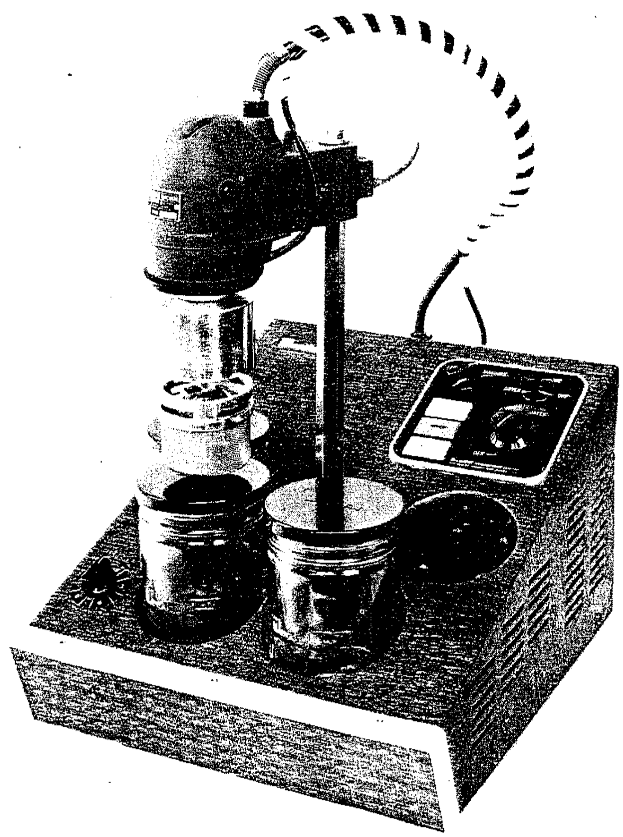


FIG. 10-33

CHECK YOURSELF

Progress Check 10A

A Self Test Review of Lesson 10

Study Sections 235 through 245. Then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. Watches need cleaning and oiling to counteract the excess ______ caused by dust, gummy oil, rough pivots, or lack of oil.	235
2. A thorough ______ is recommended while a watch is being prepared for cleaning.	235
3. Watch repairs should be made ______ cleaning.	236
4. Potassium cyanide is effective in brightening parts, but its use is not advised because it is ______.	237
5. If care is taken to brush out every particle, sawdust is as effective as any means for ______.	237
6. ______ jewels must be removed before the watch is cleaned.	240
7. Before stringing wheels, use ______ to remove dirt or rust from teeth or pinion leaves.	241
8. One reason why it is best to remove the mainspring from the barrel to clean it is because it is easier to tell if the mainspring is ______.	242
9. A part which is preferably strung on a wire by itself is the ______.	243
10. Pithwood is very helpful in cleaning dirt and old oil from ______ ______.	241 243
11. A ______ watch brush is used to scrub plates, bridges and wheels.	244
12. To insure thorough drying of large parts in hand cleaning, use of a ______ is recommended.	244
13. It is important not to leave balance and pallet fork in ______ longer than ______ seconds because it softens the ______ which holds the stones in place.	245

CHECK YOURSELF

Progress Check 10B

A Self Test Review of Lesson 10

Study Sections 246 through 259. Then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. Small parts are best cleaned in a ____________.	246
2. A ____________ watch brush is used to remove lint or dust particles which might settle on parts after cleaning.	245 246
3. If the mainspring appears clean and just the oil is to be removed, this can be done with ____________.	247
4. After the train and winding mechanism are replaced and properly oiled, test the ____________ of the train wheels by applying power with a bench key.	253
5. Enamel dials are usually cleaned with a ____________ ____________.	254
6. Metal dials may be brightened with ____________ or ____________ ____________.	254
7. Cases are cleaned with ____________ and ____________ and should usually be repolished after cleaning.	255
8. The principal advantage of machine cleaning over hand cleaning is ____________.	257
DIRECTIONS: Place an X in front of those parts which should be oiled in reassembling a watch:	
9. _____ cap jewels _____ mainspring _____ barrel arbor _____ pinions of the center wheel, 3rd wheel and 4th wheel. _____ pivots of the center wheel, 3rd wheel and 4th wheel. _____ teeth of the center wheel, 3rd wheel and 4th wheel. _____ escape wheel teeth _____ winding parts _____ dial train wheels _____ roller jewel _____ lower pallet arbor pivot _____ upper pallet arbor pivot _____ hairspring _____ pillar plate bearings	248 thru 253

LESSON	10
CLEANING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L10-J1

HOW TO CLEAN WATCHES BY HAND (7 JAR METHOD)

Tools, Equipment and Supplies:

- 7 glass jars, 1/2 pint capacity
- 1 bunch white metal or brass wire
- Bench block
- Blower
- Jewel Pusher or substitute
- Set of 3 Jewel Screw Drivers
- Movement Holder
- 1 bottle of Watch Oil
- Watch Oiler
- Oil Cup
- 1 bunch Pegwood
- 1 bunch Pithwood
- 1 Hard Watch Brush
- 1 Soft Watch Brush

Label the glass jars from 1 to 7 and fill with solutions as indicated in Sec. 239.

PROCEDURE:	REFERENCE:
1. Take movement from case and disassemble. Remove all cap jewels.	Sec. 240
2. Peg out all jewels and press all pivots in pithwood. With double loupe examine pinion leaves and wheel teeth for dirt or rust.	Sec. 241
3. Remove mainspring.	Sec. 242
4. Bend three wires into loops and string all bridges and large parts on one wire.	Sec. 243
5. On second wire, string all wheels except balance wheel.	
6. On third wire, place balance with hairspring attached.	
7. Scrub large parts in degreasing agent. (Trichloroethylene, the substitute for carbon tetrachloride, is sold under its own name and various trade names, such as Carbona, in drug stores and houseware sections of large department stores.)	Sec. 244
8. Rinse in denatured alcohol.	
9. Scrub in soap solution. (Use formula in Section 239.)	
10. Rinse in two separate jars of distilled or soft water, or one tap water and one distilled water.	
11. Rinse in two separate jars of denatured alcohol.	
12. Shake or blow off solution.	

(Continued)

JOB SHEET
L10-J1
Continued

PROCEDURE: (Continued) — REFERENCE:

13. Dry parts in warming pan lined with watch paper. (The use of boxwood sawdust for drying parts is not needed in this method.) — Sec. 244

14. Repeat the above procedure for the string of wheels.

15. Clean balance separately by stirring slowly in Jar #1 (degreasing agent) for about 10 seconds. Follow with a 5 second rinse in each of the other jars. Dry with a blower and place on watch paper in warming pan. — Sec. 245

16. Clean pallet fork and arbor with a quick dip (not over 5 seconds) in solutions #1 and #2. Dry with a blower and brush with soft watch brush. — Sec. 245

17. Place screws and remaining small parts in a strainer and swish through all the solutions in order. Lift out and drain, then turn parts out onto a clean lintless cloth. Dry with the cloth and empty onto watch paper. Use a blower if necessary and brush any lint with the soft watch brush. — Sec. 246

18. Clean the mainspring, if necessary, by swishing in solutions #1 and #2 and drying on a soft cloth. — Sec. 247

19. Assemble watch, putting train in first, then mainspring and cannon pinion. — Sections 250-251

20. Oil each bearing surface of watch as in Sections 248 through 252. Then check for train recoil. — Sections 248-253

21. Put in pallet fork and balance and oil four or five teeth on escape wheel. — Sec. 253

22. Check dial for finger prints and tarnish. — Sec. 254

23. Clean and polish case and recase watch. — Sec. 255

NOTE: If you prefer to use boxwood sawdust to dry parts as many workmen still do, several alternate methods are available to you:

HOW TO CLEAN BY HAND USING SOAP SOLUTION, ALCOHOL AND BOXWOOD SAWDUST

Tools, Equipment and Supplies: As before plus Boxwood sawdust and Shaker.

NOTE: Besides the formula in Section 239, another usable formula is: 1 pint of hot water, 1 tablespoon of Soilax or Spic and Span, and 2 ounces of household ammonia, if the product does not already contain ammonia.

PROCEDURE: REFERENCE:

1. Follow steps 1 through 12 of preceding method (Job Sheet L10-J1).

2. Dry parts in warm boxwood sawdust.

3. Sift sawdust through strainer; then remove all watch parts.

4. Brush each part with soft watch brush to remove all sawdust particles. Peg each jewel.

5. Clean balance and pallet fork and arbor as in steps 15 and 16 of previous method. These parts are easily damaged, so DO NOT put them in the sawdust shaker to dry. Instead, take a small material can, fill it with boxwood sawdust, and set these parts in it. Replace the lid and set the can aside for about five minutes while you work on something else. Then remove the parts and blow off any remaining sawdust with a blower.

6. Follow steps 17 through 23 on Job Sheet L10-J1. Secs. 246-255

ANOTHER METHOD OF CLEANING BY HAND USING SOAP, ALCOHOL AND BOX-WOOD SAWDUST. (Recommended by Omega Watch Company)

Tools, Equipment and Supplies:

Yellow Soap
Sulphuric Acid
Denatured Alcohol

Benzine
Boxwood Sawdust
Sawdust Shaker

Material Can
Tools as in previous methods

PROCEDURE:

1. Follow steps 1 through 6 of the 7-jar method. (Job Sheet L10-J1)

2. Make a soap water solution by combining a quart or so of hot water with 1/4 ounce of yellow soap (laundry soap, such as Fels-Naptha, etc.).

3. Heat this solution to the boiling point, then add 4 or 5 drops of sulphuric acid to clear the solution.

4. Dip parts to be cleaned in the boiling water. Leave from 3 to 10 minutes according to the size of parts and amount of dirt.

5. Rinse in denatured alcohol.

6. Dry in boxwood sawdust.

7. Clean the mainspring by sliding it through the tips of a tweezer that contains a piece of thin cloth to absorb the oil, Fig. A.

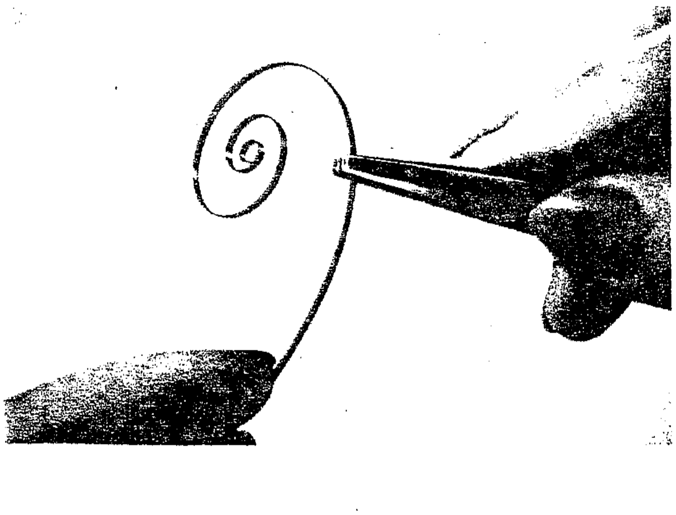


Fig. A

(Continued)

PROCEDURE: (Continued)

8. Clean the pallet fork and arbor, the roller jewel and balance pivots with pith-wood previously dipped into light benzine, Fig. B. If necessary, the pallet and balance may be quickly dipped into hot water for a few seconds (longer will soften the shellac that holds the pallet and roller jewels) and then rinsed in benzine. Dry in sawdust. (The material can procedure explained in the previous method is the easiest and safest way to do this.)

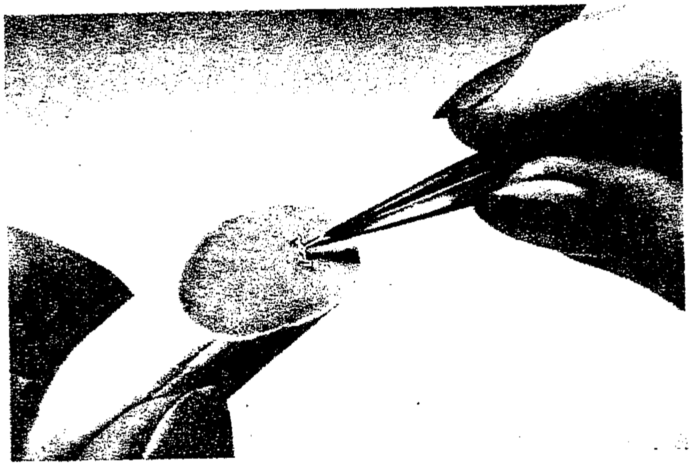


Fig. B

9. Assemble watch, putting train in first, then mainspring and cannon pinion.	Secs. 250-251
10. Oil each bearing surface of watch as in Sections 248 through 252. Then check for train recoil.	Secs. 248-253
11. Put in pallet fork and balance and oil four or five teeth on escape wheel.	Sec. 253
12. Check dial for finger prints and tarnish.	Sec. 254
13. Clean and polish case and recase watch.	Sec. 255

NOTE: The use of cyanide solution for cleaning watches is not recommended because it is such a deadly poison. If used, the solution is made by dissolving one ball of cyanide in a quart of lukewarm water. The parts can be scrubbed with stiff brush and strong laundry soap, given a soft water rinse, followed by a dip in cyanide solution (not over 10 seconds), rinsed again in soft water and alcohol and dried in boxwood sawdust as above. If you use cyanide, do not inhale its fumes or allow it to touch your skin.

HOW TO CLEAN BY HAND USING COMMERCIALLY PREPARED SOLUTIONS AND THREE JARS.

Tools, Equipment and Supplies:

3 glass jars, 1/2 pint capacity.
Commercial watch cleaning solution
Commercial rinse solution
Boxwood sawdust and shaker
Other tools and supplies listed for Job Sheet L10-J1

PROCEDURE:

1. Follow steps 1 through 6 of the 7 jar hand method. (Job Sheet L10-J1)
2. Place commercial cleaning solution in Jar #1. (This solution combines a degreasing agent with the cleaning agent.)
3. Fill jars #2 and #3 two thirds full of the commercial rinsing solution. (The rinse contains a brightening agent also.)
4. Dip the bridges and large parts into Jar #1 and scrub with a brush. Rinse in Jars #2 and #3 and dry in sawdust.
5. Dip the wheels into the first jar without scrubbing and rinse in Jars #2 and #3. Dry in sawdust.
6. Sift sawdust through strainer; then remove all watch parts.
7. Brush each part with soft brush to remove sawdust particles. Peg each jewel.
8. Clean screws and other small parts by dipping the strainer in all three solutions and drying in a lintless cloth as before.
9. Dip the mainspring, if cleaning is necessary, in all three solutions and wipe dry with one of the methods previously given.
10. The balance and pallet fork and arbor can be dipped into all three solutions without risk of loosening the jewels. Dry in boxwood sawdust in material can as previously explained.
11. Assemble as in steps 19 through 23 of the 7 jar hand cleaning method. (Job Sheet L10-J1)

HOW TO CLEAN WATCHES WITH A CLEANING MACHINE, USING COMMERCIALLY PREPARED SOLUTIONS.

Introductory Information:

Cleaning machines do not clean watches better than hand cleaning; they simply clean faster. They are most useful where speed and saving of time are important considerations. They can do an excellent job if the watch is carefully prepared and the machine properly operated.

Most machines have three cleaning jars, one jar for cleaning solution and two for rinse. Some machines have four jars and the extra jar may be used for throw off of surplus solutions or for an extra rinse. Most machines have a reversing means, which allows the basket to spin in both directions. Some machines reverse automatically; others manually. The basket may be reversed while in solution, but should not be reversed while spinning free of solution. Most machines have a drying well. Some use a heating unit and fan; others use just a heating unit. The basket is lowered over this heating unit and turned slowly to dry the parts. Some heating units have a timer; others have no timer and you must determine the proper drying time by trial and inspection of parts. The length of time in solutions will vary also with the make of cleaning solution, but instructions are usually printed on the containers. Fill jars with just enough solution to cover basket.

PROCEDURE: REFERENCE:

1. 1. Completely disassemble the watch, make repairs, and peg out all jewels to remove old oil. Secs. 257-258

2. Hand scrub excessively greasy plates or bridges with cleaning solution.

3. Distribute parts in cleaning basket and attach to cleaning machine.

4. Lower basket into cleaning solution, allow to soak about 30 seconds and then rotate basket for a period up to three minutes.

5. Raise basket just above level of cleaning solution and spin to throw off surplus solution.

6. Lower basket in first rinse and spin for a period of up to three minutes.

7. Spin off solution.

8. Lower basket into second rinse and spin for a period of up to three minutes.

9. Spin off surplus solution.

10. Lower basket into preheated heating well. Turn basket slowly for a period of three or four minutes.

11. Remove basket and place watch parts in movement tray.

12. Assemble the watch, applying oil as you go. Secs. 248-255

ANSWERS TO
PROGRESS CHECK 10A:

1. friction
2. examination of parts
3. before
4. poisonous
5. drying parts
6. cap
7. pegwood
8. set
9. balance with
   hairspring attached
10. pivots and pinions
11. hard
12. warming pan
13. alcohol
    five
    shellac

==

ANSWERS TO
PROGRESS CHECK 10B:

1. strainer
2. soft
3. watch paper
4. action
5. dry clean cloth
6. cyanide or
   baking soda
7. soap
   ammonia
8. speed
9. cap jewels
   mainspring
   barrel arbor
   pivots of the center wheel,
   3rd wheel and 4th wheel
   escape wheel teeth (4 or 5)
   winding parts
   lower pallet arbor pivot
   upper pallet arbor pivot
   pillar plate bearings

==

SUMMARY

1. Almost every repair job involves cleaning and re-oiling, so these procedures must be thoroughly learned. A good cleaning job is a "must" for successful repairing.

2. Repairs are best made before cleaning. As you disassemble the watch, you should check each part to be sure it is in working order. If not, you should repair or replace the part then. When you have finished cleaning and reassembling, the job should be practically done.

3. Watches can be cleaned just as well by hand or machine. Machines are helpful but not essential. Their big advantage is they save time and enable you to handle a volume of work. They do not clean any better than you can do by hand.

4. Cap jewels must always be removed for cleaning.

5. The balance and hairspring are cleaned separately from the other parts to avoid damaging them.

6. A common tendency is to put too much oil. It is better to put too little than too much. Use a needle or watch oiler to place the right amount of oil at the exact spot needed to reduce friction.

7. In this lesson you have learned various methods for cleaning watches. It should be apparent that cleaning a few watches for this assignment is not enough to make you truly proficient. This lesson is put here early in your course to insure that you will have cleaned enough watches to do it well by the time you are finished with your lessons. From now on, you are expected to clean and properly oil, where necessary, any work you send to the School for inspection.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — *Master Watchmaking* — *Lesson No. 10*

Name: ________________ No. ________ Date: ________________

Circle ONE correct answer unless otherwise directed. SUBJECT: Cleaning Watches

1. Cap jewels are removed before cleaning:

   So they can be oiled | So the hole jewel and face of cap jewel can be cleaned | To keep them from breaking | To polish the setting

2. The balance and pallet fork should not be left over 5 seconds in which solution:

   Trichloroethylene | Distilled water | Tap water | Alcohol

3. Which is the correct method of oiling the train jewels of a watch?

   Oil the pivots first, then assemble | Oil the jewels first, then assemble | After assembly, place oil in oil cup surrounding pivots | After assembly, oil under side of jewels

4. How many teeth of the escape wheel should be oiled?

   None | One | All | Four or five

5. After the balance and hairspring are taken from the last jar, how do you remove the excess solution?

   Shake it until dry | Fold in piece of watch paper | Hold with hairspring down on pith and use blower until dry | Place in warming pan and let it dry

6. When the pallet has been cleaned, how should you dry it?

   Use blower. Press stones into pithwood and brush | Place between two pieces of pith | Place in warming pan | Brush with soft brush

7. How should you clean the mainspring?

   Lay flat on bench and rub with folded watch paper | Swish in solutions #1 and #2 and dry on soft cloth or watch paper | Clean in all solutions except #3 and place in warming pan | Clean the same as plates of watch

8. It would be impossible to place cap jewels on both pivot ends of which wheel?

   Balance wheel | Escape wheel | Center wheel | 3rd wheel

9. Which part of the roller jewel is oiled?

   Face | Sides | End | None

10. When are cap and balance jewel assemblies oiled?

    As soon as they are removed from solution #3 | Before they are assembled | After they are assembled | They should not be oiled

11. At which point do you oil the minute wheel?

    It should not be oiled | On the bottom side | At the teeth in the circumference | Where it contacts the arbor or post

12. Which of the following should be done when cleaning the case? (Circle all correct answers.)

    Scrub with soap and ammonia | Rinse in water | Rinse in alcohol | Rinse in trichloroethylene

Detach page or cut along this line and send to the School for grading

Master WATCHMAKING

Lesson 11

TIMING, RATING AND REGULATION

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

65-11 REVISED 1961 PRINTED IN U.S.A.

KEY POINTS OF LESSON ASSIGNMENTS 37, 38, 39, 40:

- The differences between timing, rating and regulation.
- How to test for magnetism and how to demagnetize.
- Why watches lose time.
- How to adjust the cannon pinion.
- The purpose of the regulator and how to adjust regulator pins.
- Watch motion -- how to determine and test it.
- Why watches gain time.
- Why and how timing washers are used.
- What meantime screws are.
- Types of hands and how they are fitted.
- How to refill luminous hour and minute hands.

ASSIGNMENT NO. 37: Study Sections 260 through 263.

Study Questions:

1. What is the difference between timing, rating and regulating?
2. How is a watch tested for magnetism?
3. How is the demagnetizer used?
4. Is the compass demagnetized before using?

Recommended Practice:

1. Make the experiment in magnetism outlined in Section 262.
2. Test your watch movements for magnetism and demagnetize, if necessary.

ASSIGNMENT NO. 38: Study Sections 264 through 267.

1. What are some common causes of a watch losing?
2. How is the cannon pinion adjusted to fit properly?
3. What is the purpose of the regulator?
4. How should the regulator pins be adjusted?

Recommended Practice:

1. Check your watch movements for proper fit of cannon pinion. Tighten loose cannon pinions. Tap lightly and check frequently so as not to overdo the tightening.
2. Examine the regulator pins of your watch movements and see if adjustments are needed. Make necessary adjustments as described in Section 266.
3. Remove and replace one or both regulator pins from various sized movements. Use Job Sheet L11-J2 as a guide for this work.

ASSIGNMENT NO. 39: Study Sections 268 through 276.

1. What positions are used in testing motion?
2. How do you determine the proper motion?
3. What are some common causes of a watch gaining?
4. Is it necessary to make notes when regulating a watch?

ASSIGNMENT NO. 39 (continued):

5. What are timing washers used for?
6. What are meantime screws? What are they used for?
7. When and how are meantime screws changed?
8. Of what use is the undercutter?

Recommended Practice:

Practice timing as many watches as you can. Use Job Sheet L11-J1 as a guide.

ASSIGNMENT NO. 40: Study Sections 277 through 283.

1. What are the types of hands?
2. How is the hole in a hand closed?
3. How is the hole in a hand made larger?
4. How is the Swiss hand gauge used?
5. How are luminous hands refinished?

Recommended Practice:

1. Check the hands on your practice movements. Note the style. Are they fitted correctly? If not, make such adjustments as you can at this time.
2. Remove hands from your practice movements and replace them to register correctly. Adjust them for dial clearance and proper relationship to each other. Try to use various size movements for this practice.
3. Fit new hands if original hands are broken or missing. How will you order new hands?
4. Remove the luminous paste from a pair of hands and refinish.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 11 and send in for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 11

Sections 260 to 283

TIMING, RATING AND REGULATION

SEC. 260—Timing, Rating and Regulation

Timing, rating and regulation are three different subjects. Timing is the operation required to bring a watch to time after it has been repaired. Rating is the observation and comparison of the variation of the daily rate of a watch after adjusting. Regulation refers to the adjustment of a watch to its owner's personal routine and habits.

In all of our work the lessons call for practice on specific jobs. This lesson on timing does not include rating, adjusting and regulation. The lessons to follow will instruct you in many other repairs which you must learn before you can properly time, rate and adjust a watch. Your practice watch will not always keep correct time in all positions because of your inability to make repairs which are necessary. As you proceed with each of the following lessons, you will understand more clearly the preceding lesson. Master each lesson, strive to do each job a little better. Speed will come only from continued practice, so PRACTICE, PRACTICE, PRACTICE.

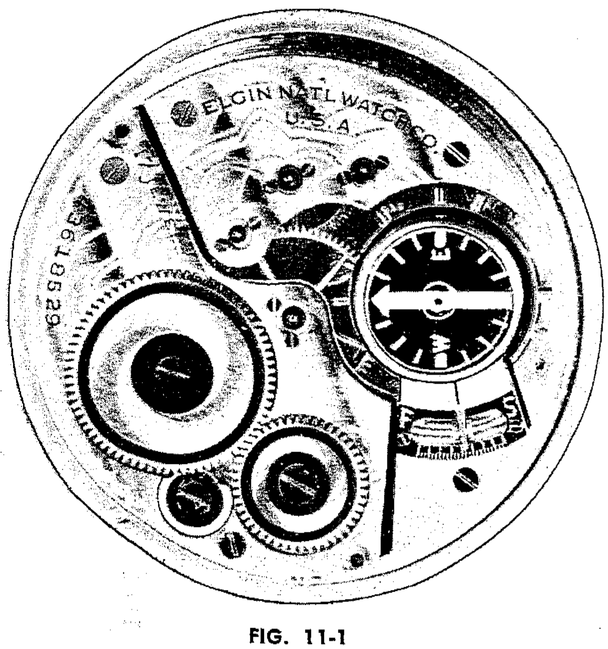


FIG. 11-1

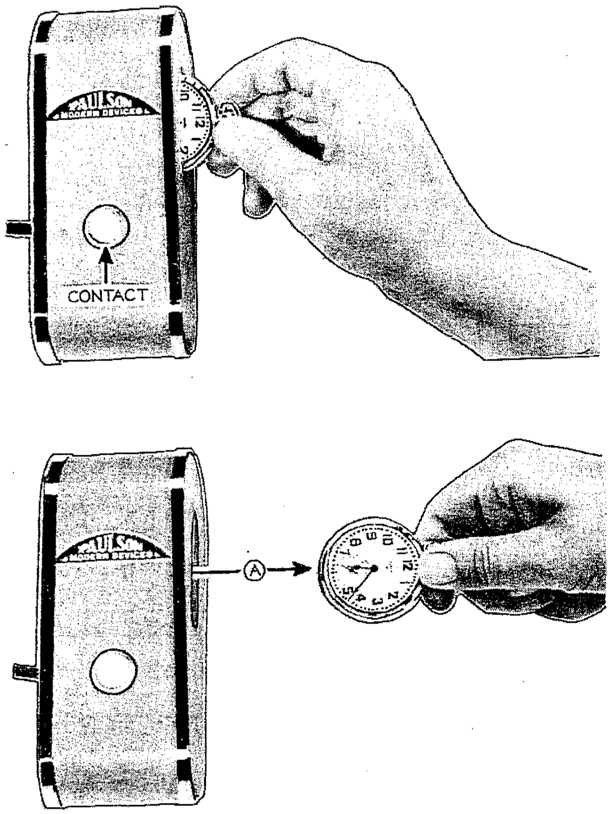


FIG. 11-2

SEC. 261—Testing for Magnetism

Before attempting to make any repairs on a watch it should be tested for magnetism. A quick test can be made when the balance is in motion by placing a small compass which has had the magnetism removed directly over the balance cock, figure 11–1. If the watch is magnetized, the needle on the compass will move quickly from side to side and, in some cases, twirl completely around.

To remove magnetism it is necessary to have a demagnetizer. Figure 11–2 illustrates the demagnetizer in use. This demagnetizer is for use on alternating current only. Hold watch carefully inside demagnetizer as in figure 11–2. Close contact and pull watch away slowly from the demagnetizer in direction of arrow A.

When at arm's length release contact. Test with compass. In some cases, it becomes necessary to take the watch apart and demagnetize each part separately. Make it a practice to test your watch for magnetism and demagnetize if necessary before doing any and all repairs. When a watch is magnetized you cannot bring it to time .

SEC. 262 — Experiment in Magnetism

Most watchmakers use a small magnetic compass to test for magnetism in watches. Before proceeding further with this lesson, let us make a simple experiment.

Material required: 1 Small Magnetic Compass
1 Demagnetizer
1 Piece Steel Rod

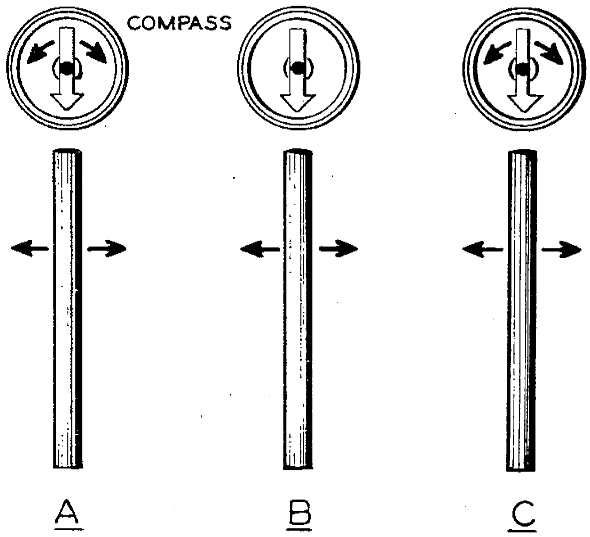


FIG. 11-3

Place your compass on bench, figure 11–3. Move the steel rod toward the compass directly in line with N (north) and, at the same time, move it from side to side as indicated by the arrows, diagram A. The closer the rod gets to the compass the greater the indicator will be agitated.

Now demagnetize the compass (figure 11–2), and repeat the operation, diagram B. This time the compass indicator will remain at rest.

Now magnetize the test rod by placing in demagnetizer, upper illustration of figure 11–2, and close contact. Release contact quickly WITHOUT REMOVING ROD from demagnetizer. The test rod will now be magnetized.

Repeat the previous operation, diagram C, and you will find the indicator of the compass again is agitated.

Suppose we substitute a watch for the test rod. Then in diagram A a watch containing steel parts can agitate the needle of a compass even though the watch is devoid of magnetism. However, in diagram B a watch containing steel parts cannot agitate the indicator of a compass if the watch is devoid of magnetism. But in diagram C a watch containing magnetism will agitate the compass needle even though the compass is devoid of magnetism.

From this test you can observe the fallacy of using a compass which contains a magnetic indicator. Any type of sensitive indicator devoid of magnetism would serve as well. Remember when you have demagnetized your compass it is no longer a compass. It becomes a testing device.

SEC. 263 — Types of Master Regulators

In order to be able to time watches it will be necessary for you to have a Master timepiece. With a radio you will have no difficulty hearing the time signal given on most stations at the half hour and hour. Some jewelers or watch repairmen have a master clock with a seconds beat pendulum. Some have chronometers, others use electric clocks that are controlled by a Master system or any of the above-mentioned devices. A 12, 16 or 18 size watch that is an excellent timekeeper will be suitable.

SEC. 264 — Some Causes of Watches Losing

In the timing of watches, there are a great many factors to be considered. If the watch to be regulated is in perfect order, timing, adjusting and regulation are not difficult.

Some of the most common faults causing watches to lose time are as follows: In pendant set pocket watches, if the sleeve is not adjusted correctly, it will allow the clutch to become engaged in setting position causing the watch to slow down or stop altogether (Lesson No. 2).

Be sure hands fit correctly. Check cannon pinion. If the cannon pinion is loose, your watch will lose erratically. This is a common fault and is easily overlooked by the beginner. Make the following test before removing hands. Test as shown in figure 11–4,

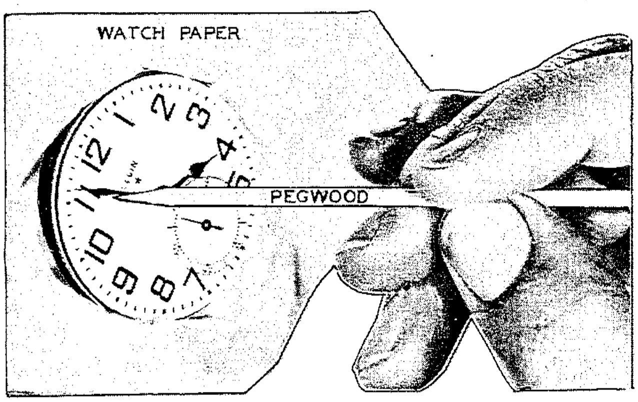


FIG. 11-4

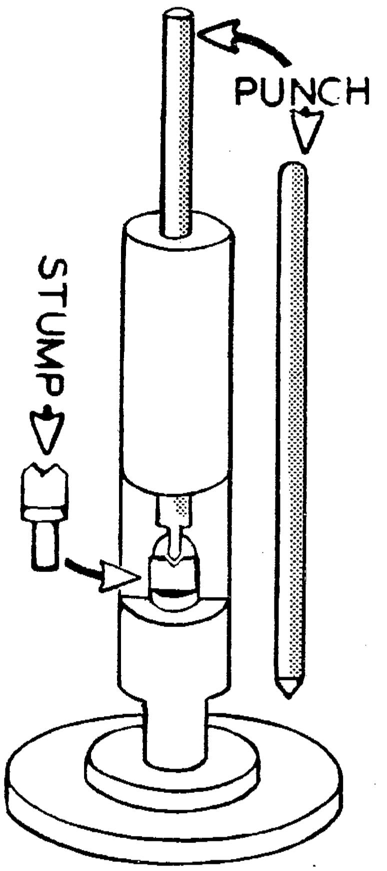


FIG. 11-5

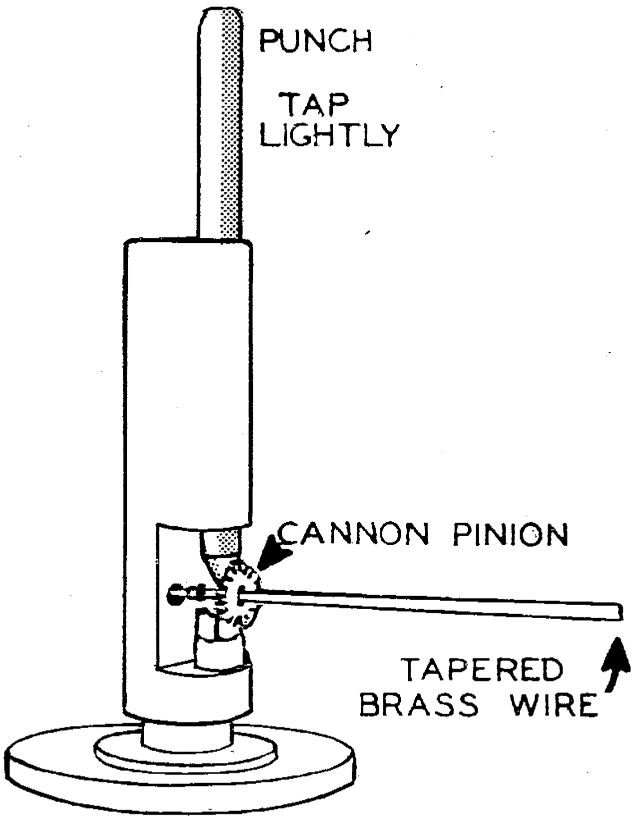


FIG. 11-6

moving minute hand from side to side. If cannon pinion is loose, the minute hand will move freely from side to side but if correct, you will meet with a little resistance. However, it cannot be too tight as it has to slip when setting parts are in the setting position but it must tight enough to turn with the center pinion. Figure 11–5 illustrates a cannon pinion tool used for tightening cannon pinions.

To tighten cannon pinion, place the small pointed punch in position and tap very lightly, figure 11–6. Use caution. A small tapered brass wire inserted into hole in cannon pinion will keep from crushing the pinion. A few light taps will bring better results than one heavy crushing blow.

Some watchmakers use a dull pair of cutting pliers as in figure 11–7.

FIG. 11-7

SEC. 265—The Regulator

Figure 11–8–A shows an Elgin balance cock with the regulator set in its correct position as it comes from the factory. The regulator contains two pins usually made of brass which fit over the outside coil of the hairspring. These pins control the length of the hairspring when the regulator is moved. In most American watches the regulator is snapped in place on the balance cock. In Swiss and American watches using a Swiss type of jewel assembly the regulator is held in place by the upper cap jewel. Moving the regulator toward F (fast) will make the watch run faster. Moving the regulator toward S (slow) will make the watch run slower. On some watches these letters will be A (advance) and R (retard).

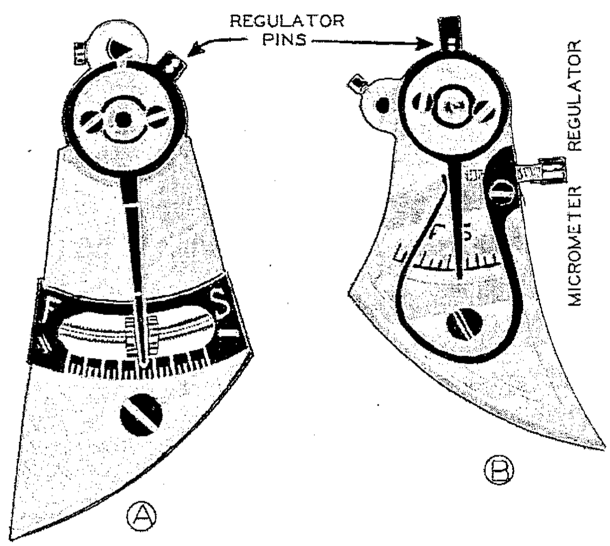


FIG. 11-8

Figure 11–8–B shows another type of regulator which has a micrometer screw that can be moved as much or as little as desired. It is found on better grade watches mostly of the quality used by railroad men. A full turn of the micrometer regulating screw makes a probable difference of from 10 to 25 seconds a day, depending on the make and size of the watch.

SEC. 266—The Regulator Pins

Check regulator pins. If they are too far apart, the watch will lose.

Figure 11–9 is a series of drawings illustrating their types and faults. The regulator pins at A are a common type used in American watches having a flat hairspring. The regulator pins at B, which are shorter, are used in both American and Swiss watches having an overcoil hairspring. The regulator pins at L are a common type of pin used in Swiss watches having a flat hairspring.

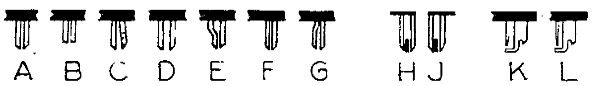


FIG. 11-9

Regulator pins illustrated at H show the proper relation between the outside coil of the hairspring (the heavy black line) and the pins when the balance is at rest. Actually the amount of space between the hairspring and each of the pins is hardly visible even with a double loupe.

If the balance is moved from its position at rest either to the right or left, this coil will rest against one of these pins, in this case the one on the left, diagram J. Now the amount of space between the hairspring and the regulator pin can be determined visually and should be just enough to insure freedom of movement.

Figure 11–9, diagram C, illustrates regulator pins which are too far apart and are brought back to the correct position by bending as illustrated by dotted line. Diagram D illustrates regulator pins which are too far apart and are corrected by adjusting in a manner similar to that shown in diagram E. Diagram F illustrates regulator pins which are too close together and are corrected by adjusting in a manner similar to that shown in diagram G.

SEC. 267—Purpose of Regulator

The purpose of the regulator, which includes the regulator pins, is to lengthen or shorten the hairspring. The actual length of the hairspring is from the stud to the hairspring collet. The length of the hairspring is controlled by the regulator pins in the following manner:

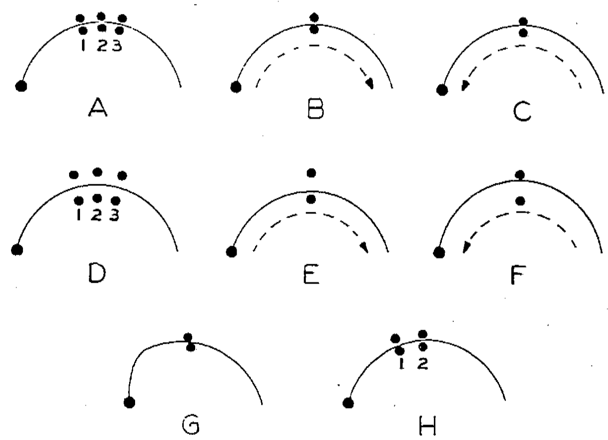


FIG. 11-10

Figure 11–10, diagram A, illustrates three sets of regulator pins (1–2–3). No. 2 represents the position of the regulator pins when the regulator is in the center of the F & S Scale and the balance is at rest. Notice that the hairspring does not touch either of the pins. Moving the regulator toward the "fast" No. 3 would shorten the hairspring and toward the "slow" No. 1 would lengthen the hairspring. Remember in these illustrations the balance is at rest and there is no change in the relation between the pins and the outer coil of the hairspring.

Now move the balance in the direction of the arrow in diagram B and the coil of the hairspring will move against the inside regulator pin. Move the balance in the direction of arrow in diagram C and coil will move against the outer regulator pin. Now as the balance swings back and forth the hairspring moves from one regulator pin to the other in this manner.

Diagram D illustrates three sets of regulator pins in the same position as those shown in A with the balance at rest, but the space between the regulator pins and the outside coil of the hairspring is excessive. In this case, the pins do not control the length of the hairspring as you can see, diagrams E and F. When the balance is moved in the direction of arrows E or F the outside coil of the hairspring does not come in contact with the pins; consequently, the regulator pins have no effect.

Diagram G illustrates regulator pins which are too close together and moving the regulator pins toward "slow" would cause it to bend in a manner similar to the illustration.

Diagram H illustrates what happens when the outside coil does not follow between the pins when the balance is at rest at illustrated in diagram A. In this case the pins at No. 2 are correct. Moving the regulator pins toward "slow" causes the inside regulator pin to contact the hairspring as shown at No. 1. Consequently, the watch may have a tendency to gain instead of lose as indicated on the scale.

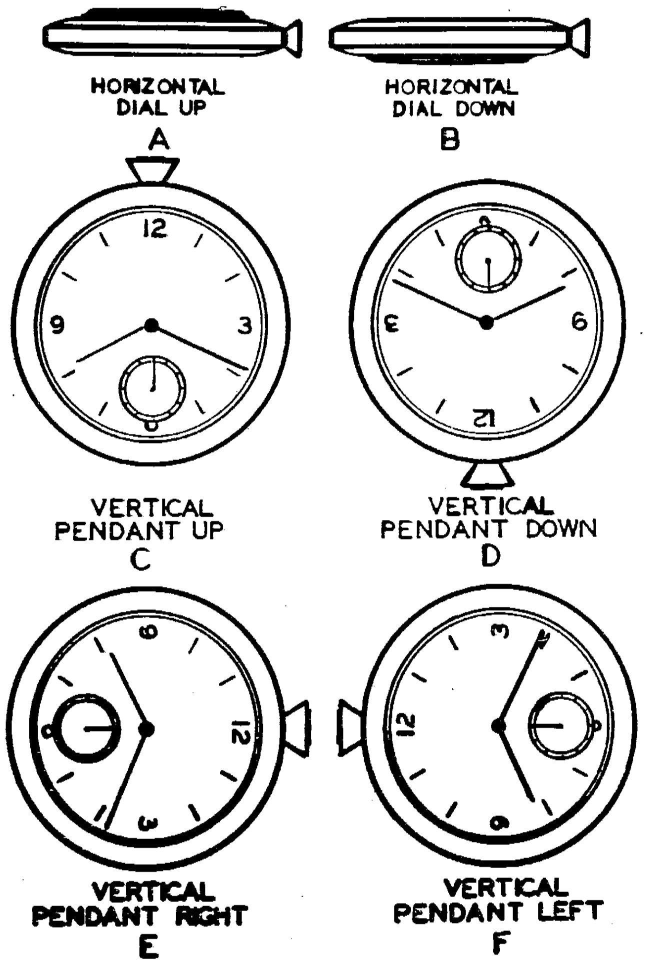


FIG. 11-11

SEC. 268—Positions Used in Testing Motion

Hold watch dial down and notice motion. A watch in good order should have oscillation of from 1¼ to 1½ turns in this position.

Figure 11–11 illustrates the following positions: A—dial up, B—dial down, C—pendant up, E—pendant right, F—pendant left. These are known as the five positions. The sixth position is pendant down—D. When you see and hear of a watch being adjusted to five positions it means A, B, C, E, and F. These adjustments are usually made at the factory and if the watchmaker uses genuine material and skillfully does his work, he will not have any trouble in getting his repair jobs to keep time.

SEC. 269—Determining Motion

Figure 11–12 is a drawing used to illustrate the method used to determine the motion of a balance. The balance wheel and arm at rest are shown by the heavy black lines.

If the balance and arm are moved from A to B, which is ⅛ of the circumference, and released, the balance will swing back in direction of line CD, and

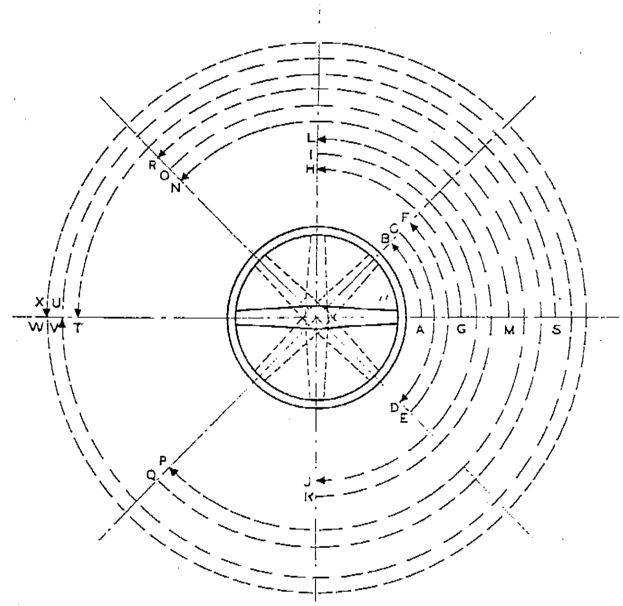


FIG. 11-12

back again from E to F, etc. The balance is then said to motion ¼ of a turn. If the balance moves from G to H and then back from I to J and then from K to L, etc., it will have a motion of ½ turn. M to N and O to P and Q to R illustrate ¾ of a turn. S to T and U to V and W to X, etc., illustrate one full turn.

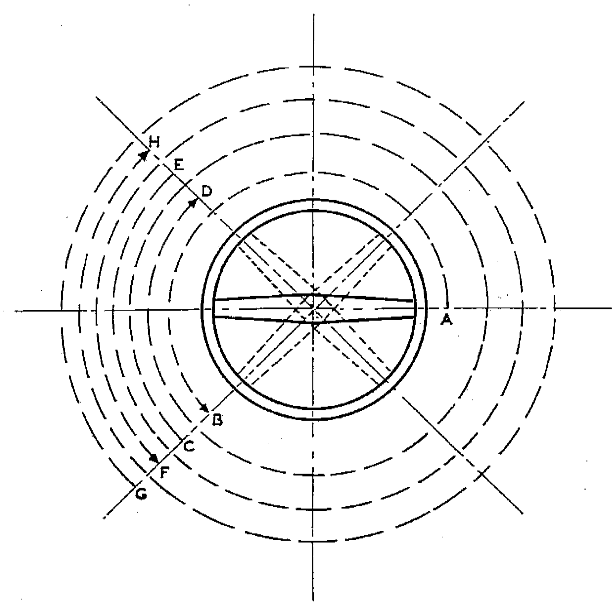


FIG. 11-13

Figure 11–13, A to B and C to D and E to F and G to H illustrate 1¼ turns. At 1½ turns the arms would appear to stop at positions illustrated by center lines.

SEC. 270—Testing Motion in Watch

In practice, stop the balance wheel completely using a bristle from a watch brush, release it and watch it swing back and forth until arms appear to meet at D and C and meet again at E and F. Now the balance has completed one full turn. If the watch is taking the correct motion, it will then appear to cross at E and F until it reaches the maximum swing, which will be from 1¼ to 1½ turns. Notice position of arms in relation to dotted line. This is after the wheel has made one full turn and arms appear to stop at G and H.

A watch should motion the same in position dial up and dial down. If it doesn't, it may be caused by several things among which the most common are dirt and old oil in jewels, burred pivots, hairspring out of level, loose hairspring stud and others. Before timing be certain the watch motions correctly.

After you are satisfied that the balance motions correctly dial up and dial down, test by letting the balance wheel fall toward the pallet fork. In this position a watch will have a tendency to slow down a trifle, not as much in pocket watches as in bracelet watches. However, it should not slow down more than ¼ of a turn.

SEC. 271—Some Common Causes of Watch Gaining

If a watch has an excessive rate of gain, the fault is generally found in the hairspring. However, there are cases when a balance screw may be loose and the screw will fall out. Check the balance wheel and ascertain if you have an equal number of screws on each side of the balance arms. If so, then check the hairspring. If the coils stick together, it may be from oil or magnetism. Check for magnetism. Clean balance and hairspring (Lesson 10) if coils of hairspring are oily.

At times a customer has jarred his watch in such a manner that the outside coil has become caught on the stud or between the regulator pins. Release carefully. The hairspring must be level and parallel to the arms of the balance wheel. The overcoil must pass through the regulator pins and must not touch the under side of the center wheel or balance bridge.

SEC. 272—Making Notes when Regulating

In timing a watch with a second hand set the second hand to coincide with second hand on your master timepiece. Set the minute and hour hands to correspond with hands on master timepiece. Make a note on back of watch tag or piece of paper the exact time the watch was set.

Figure 11–14 illustrates the notations made on the back of a watch tag. Following is an explanation: Monday, February 2, at 10 A.M., the watch was set. At 11 A.M. the watch had gained 5 seconds, entered on tag as +5. In 24 hours this watch would gain approximately 120 seconds (24×5) or two minutes. After making the necessary adjustment, the watch was reset and the ticket marked Reg. (regulate) and Set. At 1 P.M. the watch had gained two seconds, which is at the rate of 24 seconds per day $\frac{(24\times2)}{2}$. After making necessary adjustment the ticket was marked Reg. but it was not reset. At 6 P.M. it was still two seconds fast. Tuesday, February 3, at 9 A.M. it was 23 seconds slow which was at the rate of 40 seconds in 24 hours. Regulate and mark ticket Reg. At 6 P.M. watch was ten seconds slow showing a gain of 13 seconds in 9 hours or about 35 seconds per day. Watch was regulated again. Wednesday, February 4, 9 A.M. watch was 7 seconds slow showing a gain of 3 seconds in 15 hours. No regulation was made but watch was set.

Thursday, February 5–5 seconds fast in 24 hours

Friday, February 6–9 seconds fast in 48 hours

This watch now shows a slightly fast rate which is very desirable. Further regulation would be made from time to time if required.

In the case of a watch without a second hand, set accurately with a master timepiece watch every six hours or so at first. It sometimes takes three, four or five days to regulate accurately. This will explain the reason watchmakers take more time than customers anticipate for repairing.

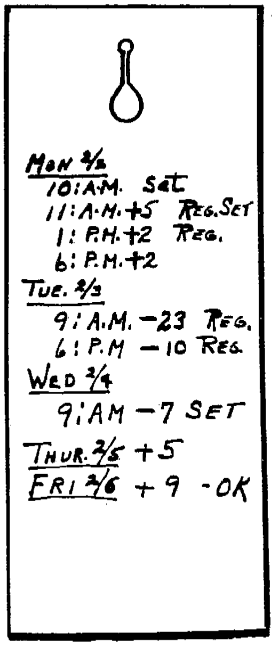


FIG. 11-14

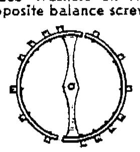
SEC. 273 — Hints on Timing Machines

Today in the larger shops the advent of the timing machine enables the watchmaker to time his watches more accurately and speedily than ever before. It is possible to take in a watch for repair and after bringing it to time return it to the customer the same day knowing that the watch will keep accurate time.

You will hear a great deal about time machines. Timing machines are electronic instruments used to test the rate of a watch in any position, enabling the repairman to predict the average rate of the watch to be timed as it will be when the owner carries it. The latest models translate the "tick" into a written record from which the watchmaker makes his observations. These machines are expensive for the beginner. However, the use of timing machines will be given in a later lesson.

TIMING WASHERS for AMERICAN and SWISS WATCHES

Place Washers on two opposite balance screws



Do not place Washers on meantime screws

26 0 to 18 Size

3¾ to 21 Ligne

Size and Rate Per 24 Hours Marked on Bottle

Number Order	American Sizes	Swiss Ligne Sizes	Rate Per 24 Hours
1	26/0-21/0-20/0	3¾ to 5½	20 Seconds
2	26/0-21/0-20/0	3¾ to 5½	40 Seconds
3	26/0-21/0-20/0	3¾ to 5½	1 Minute
4	26/0-21/0-20/0	3¾ to 5½	2 Minutes
5	26/0-21/0-20/0	3¾ to 5½	3 Minutes
6	26/0-21/0-20/0	3¾ to 5½	4 Minutes
7	18/0 to 6/0	6¾ to 9¾	20 Seconds
8	18/0 to 6/0	6¾ to 9¾	40 Seconds
9	18/0 to 6/0	6¾ to 9¾	1 Minute
10	18/0 to 6/0	6¾ to 9¾	2 Minutes
11	18/0 to 6/0	6¾ to 9¾	3 Minutes
12	18/0 to 6/0	6¾ to 9¾	4 Minutes
13	10/0-8/0-5/0	10½ to 11½	20 Seconds
14	10/0-8/0-5/0	10½ to 11½	40 Seconds
15	10/0-8/0-5/0	10½ to 11½	1 Minute
16	10/0-8/0-5/0	10½ to 11½	2 Minutes
17	10/0-8/0-5/0	10½ to 11½	3 Minutes
18	10/0-8/0-5/0	10½ to 11½	4 Minutes
19	4/0-3/0-0	12 to 13	20 Seconds
20	4/0-3/0-0	12 to 13	40 Seconds
21	4/0-3/0-0	12 to 13	1 Minute
22	4/0-3/0-0	12 to 13	2 Minutes
23	4/0-3/0-0	12 to 13	3 Minutes
24	4/0-3/0-0	12 to 13	4 Minutes
25	6-12	15 to 17	20 Seconds
26	6-12	15 to 17	40 Seconds
27	6-12	15 to 17	1 Minute
28	6-12	15 to 17	2 Minutes
29	6-12	15 to 17	3 Minutes
30	6-12	15 to 17	4 Minutes
31	16-18	19 to 21	20 Second
32	16-18	19 to 21	40 Second
33	16-18	19 to 21	1 Minute
34	16-18	19 to 21	2 Minute
35	16-18	19 to 21	3 Minute
36	16-18	19 to 21	4 Minute

FIG. 11-15

SEC. 274 — Use of Timing Washers

Example: Watch set at: 9:00 A.M. Set
Reading at: 10:00 A.M. 8 Sec. Fast
Watch is running approximately 192 seconds fast per 24 hours or a trifle over 3 minutes per day

The most common way of slowing this watch down is to use balance washers to add weight to the wheel. Figure 11–15 illustrates a chart from a cabinet of balance timing washers. On the chart is a list of the different sizes of washers contained in the bottles. If the watch is 18 size, we would add a pair of washers from bottle 35 as it is marked three minutes per day. This, in all probability, would bring the watch within the range covered by the regulator and we would then proceed to make the final adjustment with the regulator. However, these washers will act differently on different makes of watches. It might happen that the three minute washers would be too heavy, in which case exchange them for a lighter pair. These washers are obtainable for all sizes of watches. Place washers on screws nearest the balance arms, figure 11–16. Balance screws are best removed and replaced with a balance screw holder, figure 11–17.

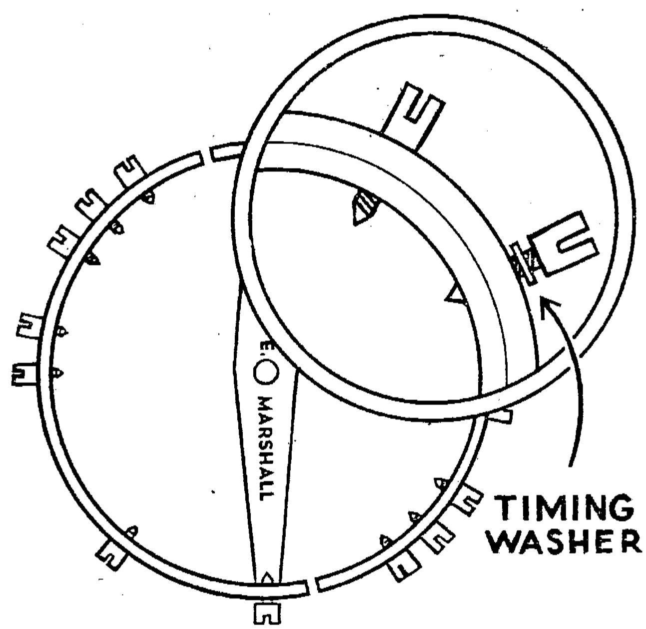


FIG. 11-16

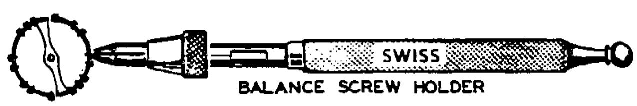


FIG. 11-17

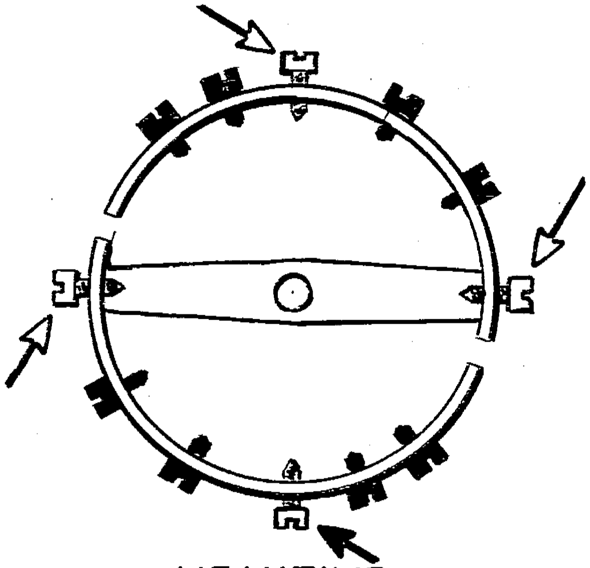


FIG. 11-18

SEC. 275—Meantime Screws

On some balance wheels you may notice one or two pairs of balance screws that are noticeably different from the majority of screws. The heads of the screws are shorter and the threaded portion is longer. These are called meantime screws and are a feature of the Waltham movement. Other watch manufacturers use them in their better grade of movement such as railroad watches and fine pocket watches. These are not found on the majority of Swiss made movements. Figure 11–18 illustrates a balance having 4 meantime screws. Do not change the position of these screws when making repairs on the balance. The position of these screws is changed only when the daily rate is adjusted. Moving a pair of screws toward the center will cause the watch to gain. Moving a pair of screws outward from the center will cause the watch to lose. Always move a pair of screws and move them an equal amount. Caution: Never add timing washers or use an undercutter on the meantime screws.

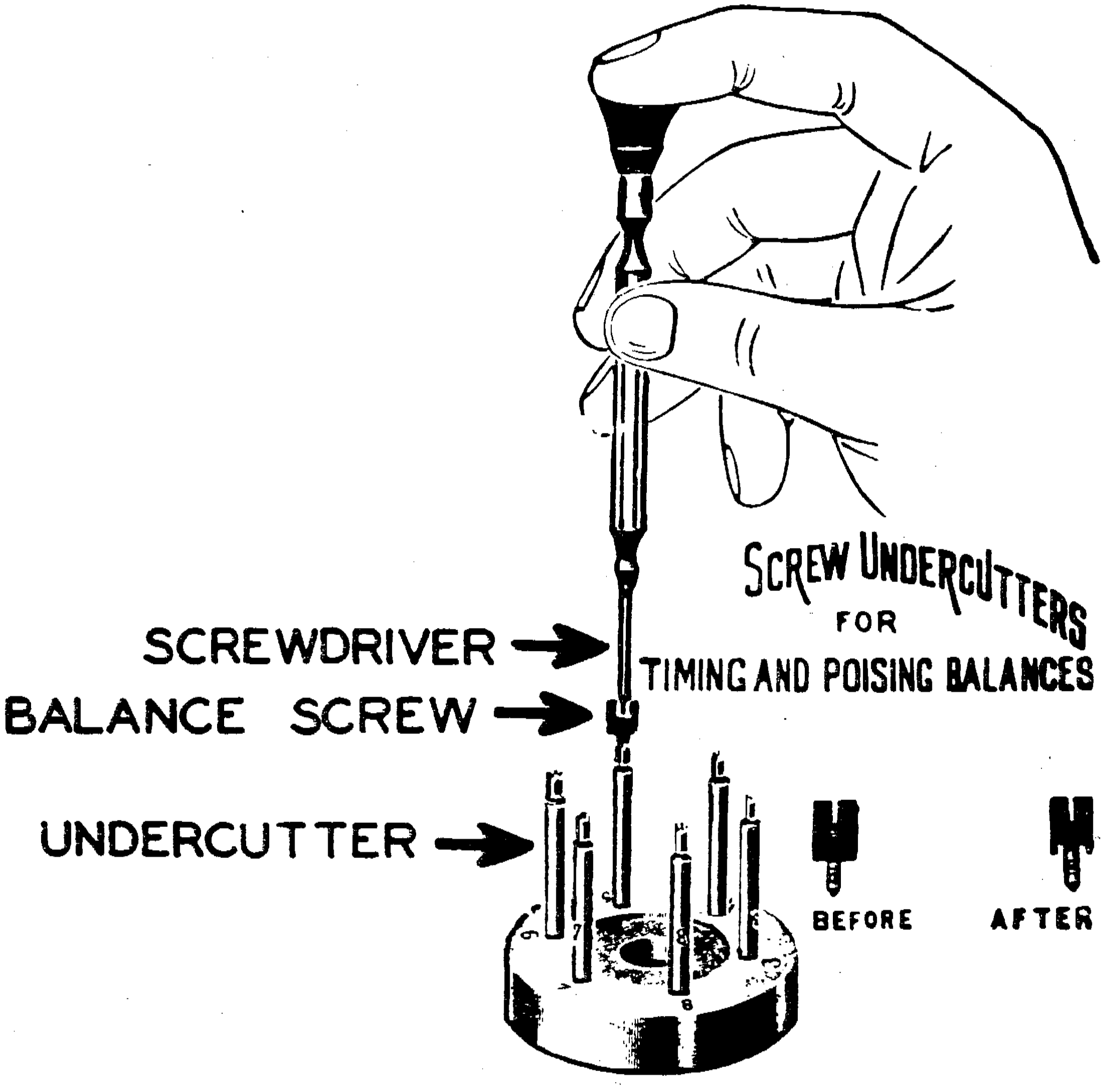


FIG. 11-19

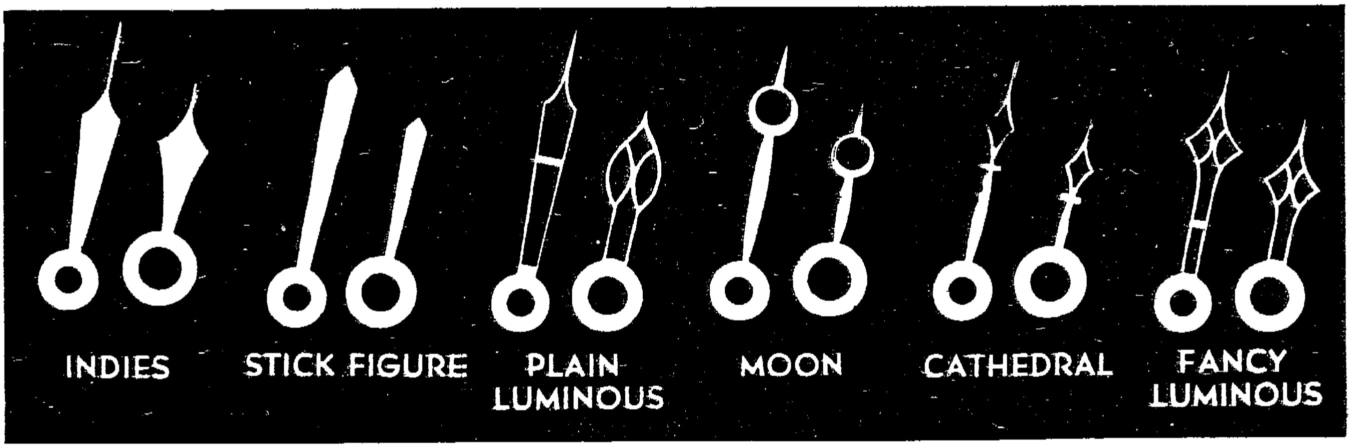


FIG. 11-20

SEC. 276—Use of Undercutter

When a watch runs too slowly—that is, it cannot be regulated by the regulator, it is usually brought to time by removing a little weight from a pair of balance screws. This is done by use of an undercutter, figure 11–19. The use of this tool will be explained thoroughly in lesson on Poising.

For practice on this lesson try timing as many different watches as you can. Do not be afraid to do it over and over. Get the habit of making notes (figure 11–14) when timing a watch. Do not trust to memory.

SEC. 277—Purpose and Types of Hands

It is necessary for you to understand at this time the purpose of the hands, the names of different style hands, and how to adjust and select hands. Inasmuch as you will not have all of the necessary tools at present, it isn't practical for you to replace hands on every watch that needs them. There will be times when you will need a lathe or a staking tool to do this job properly. You will acquire these tools as you progress with your training but it would not be practical for you to make a pipe for a second hand unless you had a lathe; and before you can make a pipe, you would have to have instruction in lathe work. However, the illustrations and the reading matter are for your information and reference work.

Hands are usually made from steel or brass; some are blued and some are gilded, others have luminous paint on them in order that they can be easily read at night. The average watch has three hands. They are the minute hand, which is the longest and which makes one revolution an hour, the hour hand which makes one revolution every twelve hours, and the second hand which makes one revolution a minute. The minute hand is fitted friction tight on the cannon pinion. The hour hand is fitted friction tight on the hour wheel. The second hand is fitted friction tight by means of a tube or pipe over the extended pivot of the fourth wheel.

In replacing hands for most American made watches the hands desired can be ordered by the name and size of watch; for example, 1 pair hands for Elgin 12 size. Figure 11–20 illustrates a variety of styles. It is best to send samples of broken hands or material when reordering.

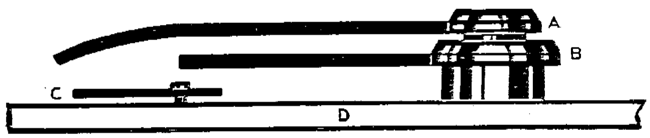


FIG. 11-21

SEC. 278—Relation of Hands

Figure 11-21 is a drawing showing the relation of the hands to each other and to the dial. A is the minute hand, B the hour hand, C the second hand and D is the dial. Notice that the second hand (C) comes very close to the dial surface. Be certain the second hand clears the dial. Sometimes a piece of lint or broken glass wedged between the hand and the dial will cause the watch to stop.

SEC. 279—The Second Hand

The second hand is replaced by pushing pipe over extended pivot of 4th pinion using the flat upper end of tweezers. This must be done carefully so as not to bend the 4th pinion. Figure 11–22 illustrates a pair of pliers used to hold a second hand. At A the second hand is held securely by the pipe and a small pivot broach is used to ream out the hole. Broach hole in the pipe carefully. The second hand should press on easily but securely. At B the hand is held by the pipe but with the end of the pliers. Closing the pliers will close the second hand pipe slightly.

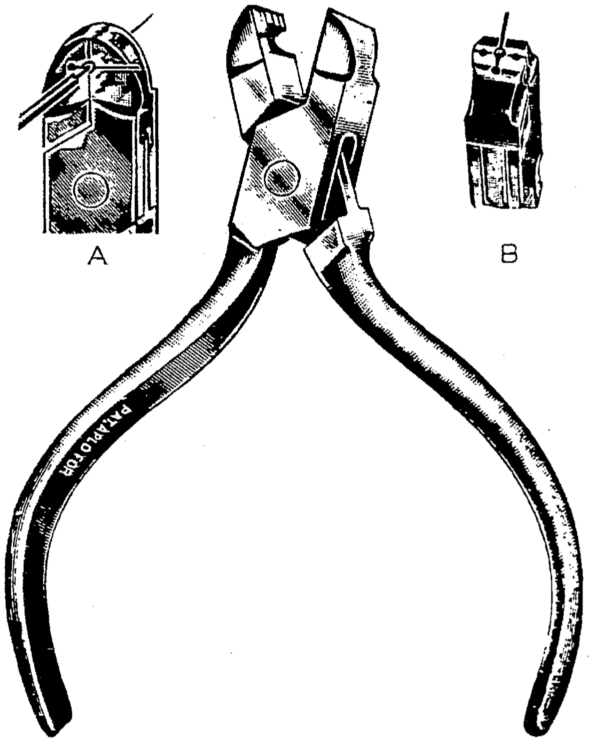


FIG. 11-22

SEC. 280 — The Hour Hand

The hour hand has a socket that fits snugly over the tube extending from the hour wheel and the top of the hand should be flush with the top of this tube and parallel to the dial, allowing for clearance between this hand and the second hand. This hand can be put in place by using tweezers, but the proper way is to use a hollow flat face staking tool punch. If a new hand fits too tightly, it can be opened by a cutting broach, figure 11–23. To close the socket, use a concave punch from staking set, figure 11–24.

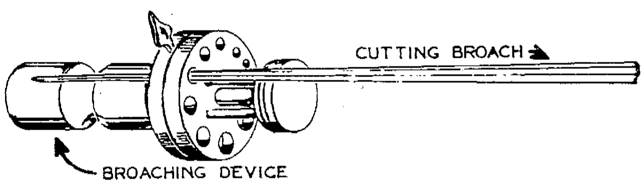


FIG. 11-23

SEC. 281 — The Minute Hand

The minute hand can be pressed on with tweezers but it is more practical to use a staking tool, figure 11–25, which has a stump at A upon which the lower end of the Center Pinion is resting. This prevents breaking the lower center jewel. Holes in minute hands are opened

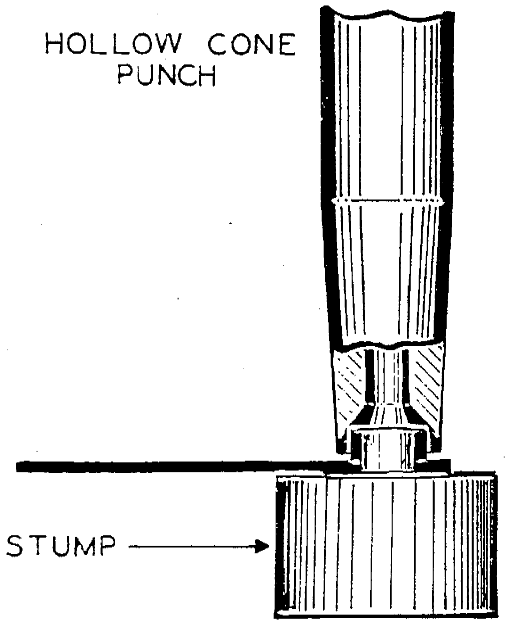


FIG. 11-24

with a broach, figure 11-23, and best closed with staking set using round faced punch, figure 11–26. In replacing hands be careful to see that hands register correctly. Set the pointer of the hour hand at 3. Set the pointer of the minute hand at 12 and replace. Your hands will then register correctly. When the minute hand is directly over any minute mark, the second hand should point to 60.

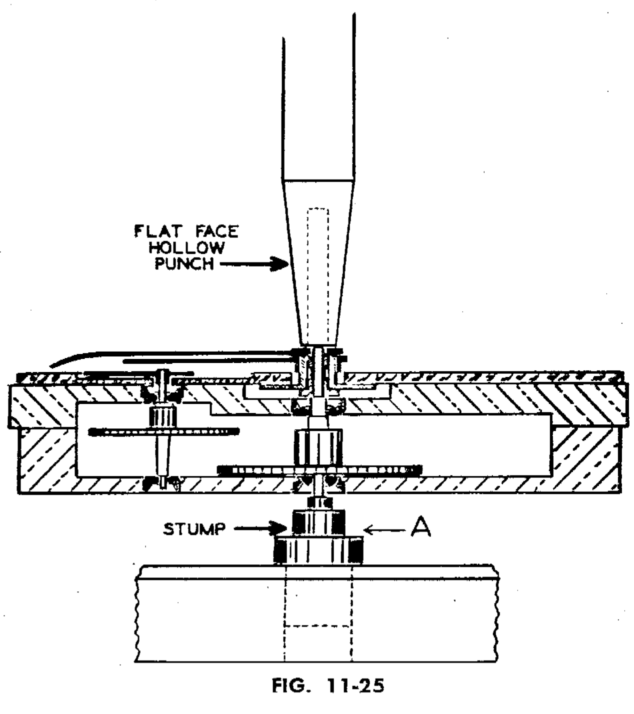


FIG. 11-25

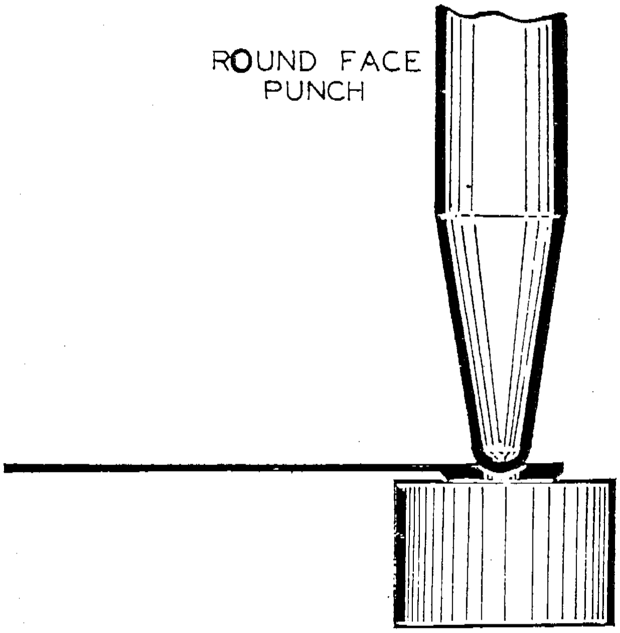


FIG. 11-26

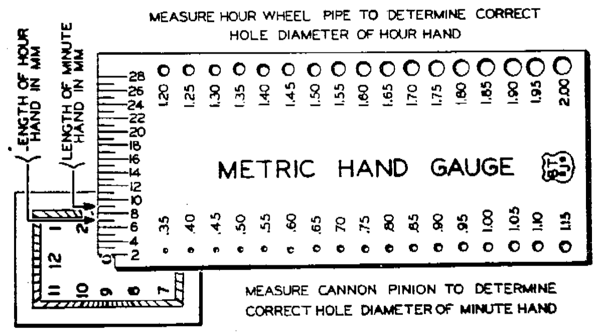


FIG. 11-27

SEC. 282—Swiss Hand Gauge

Figure 11–27, which is self-explanatory, illustrates a hand gauge for measuring Swiss type hands.

Swiss hands can then be ordered by dimensions:

Example: 1 Blue Minute Hand—Length 12 mm
hole .65 mm

SEC. 283—Refilling Luminous Hands

It is possible to refill luminous hour and minute hands using a kit similar to figure 11-28. Generally it contains two different shades to match the figures on dial. Heat spatula slightly and with a small amount of paint applied to hand, quickly move spatula backward and forward, figure 11–29, until paint flows freely on hand. If necessary, trim off excess paint with razor blade. Apply paint sparingly; an excessive amount will cause the hands to catch. A sweep second hand is fitted to a pinion making one revolution per minute. In watches of this type, the cannon pinion is hollow. These come in several colors and also with luminous paint. They are replaced best with a punch and stump, figure 11–25.

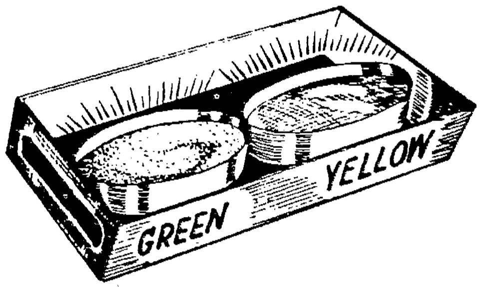


FIG. 11-28

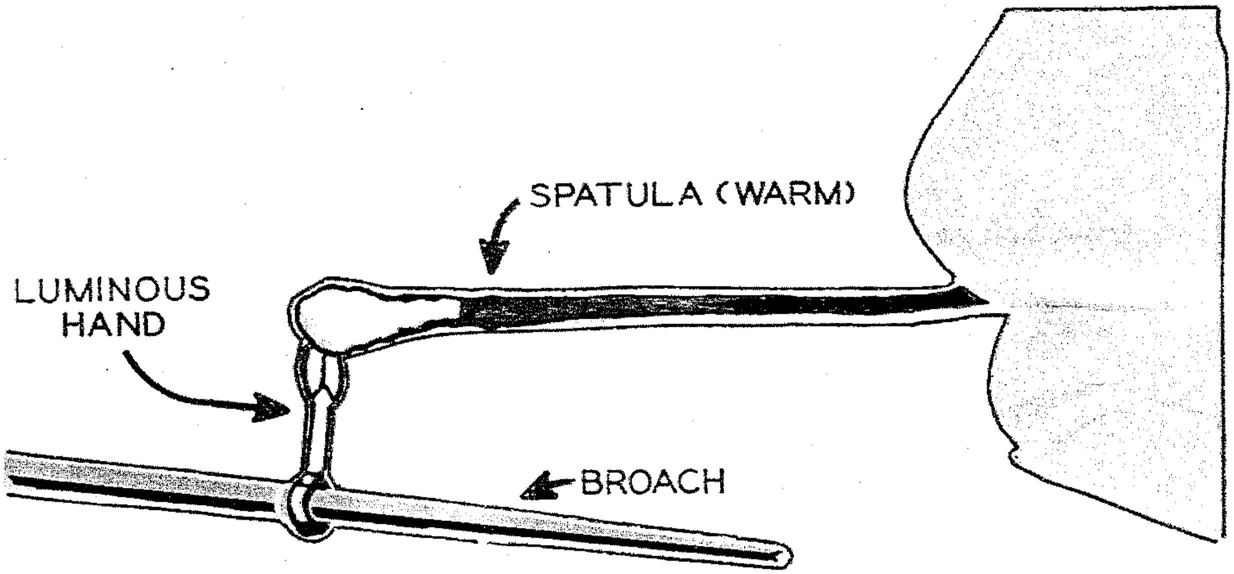


FIG. 11-29

CHECK YOURSELF

Progress Check 11A — A Self Test Review of Lesson 11

Study Sections 260 through 267. Then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. Bringing a watch to time after repairs have been made is called ______________.	260
2. Observing and comparing the daily gain or loss of a watch after adjusting is called ______________.	260
3. Adjusting a watch to the habits and routine of the wearer is known as ______________.	260
4. Magnetism is removed with a ______________.	261
5. Magnetism in a watch affects the ______________.	261
6. Before a magnetic compass is used to test for magnetism, it should be ______________.	262
7. For timing watches, it is necessary to have a ______________ ______________.	263
8. Either a ______________ or ______________ can be used to tighten a loose cannon pinion.	264
9. In most American watches, the regulator is ______________ on the balance cock, but in Swiss type jewel assemblies it is usually held in place by the ______________.	265
10. A watch will lose if the ______________ are too far apart.	266
11. The regulator controls the ______________ of the hairspring by changing the position of the regulator pins as the regulator is moved.	267

CHECK YOURSELF

Progress Check 11B — A Self Test Review of Lesson 11

Study Sections 268 through 283. Then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The five positions for testing motion in pocket watches are: a. ____________ b. ____________ c. ____________ d. ____________ e. ____________	268
2. The amount of swing of the balance is known as ____________.	269
3. The correct motion for a watch in Dial Up position is ____________ to ____________ turns.	270
4. Dial down motion should be the same as ____________.	270
5. If the hairspring is caught or has its coils stuck together, the watch will in all probability ____________.	271
6. Watches are preferably adjusted to a ____________ rate.	272
7. Two means used to slow down watches are ____________ and ____________.	274 275
8. A method for increasing the rate when the regulator does not answer the purpose is to remove weight from a pair of balance screws with ____________.	276
9. Hands on a watch should be fitted ____________.	277
10. The ____________ of hands should always be checked after replacement.	278
11. The second hand can be replaced with ____________.	279
12. The hour hand can be replaced with tweezers but a ____________ is preferable.	280
13. For replacing a minute hand, a ____________ is best.	281

ANSWERS TO PROGRESS CHECK 11A:

1. timing
2. rating
3. regulation
4. demagnetizer
5. timing
6. demagnetized
7. master timepiece
8. cannon pinion tool
   dull cutting pliers
9. snapped
   upper cap jewel
10. regulator pins
11. length

ANSWERS TO PROGRESS CHECK 11B:

1. a. dial up
   b. dial down
   c. pendant up
   d. pendant right
   e. pendant left
2. motion
3. 1-1/4 to 1-1/2
4. dial up
5. gain
6. slightly fast
7. timing washers
   meantime screws
8. undercutters
9. friction tight
10. clearance
11. tweezers
12. flat face hollow punch
13. flat face hollow punch

SUMMARY

1. Magnetism makes a watch run erratically and prevents proper timing. If present, it must be removed by means of a demagnetizer.

2. A loose cannon pinion is a frequent cause for watches losing time and should always be checked.

3. The regulator is a means for making watches run faster or slower. It does this by shortening or lengthening the hairspring. Regulators may snap in place or be held by the upper cap jewel.

4. Regulator pins which fit over the outside coil of the hairspring can throw a watch off if they are not set parallel and the right distance apart. They must always be checked.

5. A watch is said to have good motion when it swings about 1-1/4 to 1-1/2 turns.

6. Trouble in the hairspring is the main reason for watches gaining although there are other possibilities which must be checked.

7. Timing washers, meantime screws and undercutters are means for changing the weight of the balance wheel to make the watch run slower or faster.

8. Meantime screws are always moved in pairs. A pair means the two screws across from each other.

9. Never add timing washers to meantime screws or undercut them.

10. It is important to check the clearance of hands and to see that they fit neither too tightly nor too loosely.

11. A hand gauge is used to determine the hole size and length of missing Swiss hands.

12. Special kits are available to refinish luminous hands.

LESSON	11
TIMING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L11-J1

HOW TO TIME, RATE AND REGULATE A WATCH.

Tools, Equipment and Supplies:

Compass Demagnetizer Tweezers Pegwood Screwdrivers
Balance Screw Holder Undercutters Timing Washers

PROCEDURE:	REFERENCE:
1. Test for magnetism.	Sec. 261
2. Set regulator in center of index.	Sec. 265
3. Check regulator pins.	Sec. 266
4. Test motion.	Secs. 268-269-270
5. Set hands to coincide with master clock or time piece. Start recording rates, entering the time set.	Sec. 272
6. Check watch with master clock at a later time. (2 - 4 - 6 hour intervals are preferred.)	
7. Calculate the amount of time in seconds or minutes your watch has lost or gained, for a 24 hour period.	
8. Make a note of the loss or gain and the time of day.	
9. Make adjustments to compensate for loss or gain.	Secs. 267-274-275-276
10. Reset watch with master time piece.	
11. Repeat steps 5 - 6 - 7 - 8 - 9 until watch keeps satisfactory time.	

NOTE: Regulate pocket watches to gain about 5 seconds a day in pendant up position.

Regulate wrist watches to gain about 10-15 seconds a day in pendant down position.

Further timing adjustments may be needed to meet the needs of the wearer.

HOW TO REPLACE A REGULATOR PIN.

Tools, Equipment and Supplies:

Pin Vise   Needle   Bench Block   Abrasive Stone   Regulator Pins
Nippers or Bench Knife.

PROCEDURE:

A. 1. Remove regulator from balance bridge.

2. Push out old pin with fine needle in pin vise.
NOTE: As the pin is tapered, push it out from the bottom side of the regulator.

3. Support the regulator with the bench block and insert a new tapered pin from top side of regulator until the pin fits snugly.

4. With nippers or bench knife, cut off the large end about .1 mm above top of regulator. Smooth this end with a fine abrasive stone.

5. Force this short end in flush with the top of regulator.

6. Cut off the other end even with the remaining original pin and dress the end so it matches the original shape. (If both pins are replaced, dress ends into shape as in A, Figure 11-9.)
NOTE: If the second pin is a gate type pin (as in L, Figure 11-9), cut off the new pin so it is just slightly shorter than the foot of the gate.

7. Adjust the pins to make them parallel and the proper distance apart, Sec. 266.

8. Replace regulator and bridge in movement.

NOTE: There are no tools designed solely for adjustment of regulator pins. A small chisel shaped tool and a pair of tweezers can usually be used. The usual adjustments are spacing, bending to make parallel, and so on. To illustrate the technique used, refer to D and E, Figure 11-9. To make the left pin in D like the left pin in E, tilt the left pin in D away from the right pin, make the necessary bends in the left pin with a tweezers, and then tilt the pin back to the position shown in E.

B. GATE TYPE REGULATOR PINS (Shown at L in Figure 11-9.)

The purpose of this type of pin is to keep the hairspring from coming out from between the regulator pins. There is usually a slot for a screwdriver in the gate type so the pin can be turned a quarter turn in either direction when you want to release the hairspring. We recommend you replace the entire regulator rather than try to replace the gate type regulator pin.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — **Master Watchmaking** — *Lesson No. 11*

Name: No: Date:

Circle the correct answer: SUBJECT: Timing, Rating and Regulation

1. When removing magnetism from a watch, the contact is released:

After watch is pulled away to arm's length	Before putting watch inside demagnetizer	While watch is inside demagnetizer	When watch has been withdrawn about 2 feet from demagnetizer

2. In testing a watch for magnetism, use:

A steel rod	A timing machine	A demagnetizer	A compass

3. Which of the following will cause a watch to lose time? (Circle all correct answers)

Sleeve not adjusted properly causing clutch to engage in setting	Cannon pinion too tight	Loose cannon pinion	Loose hands

4. In the Swiss type of jewel assembly, the regulator is held in place:

By being snapped in place	By the lower cap jewel	By the upper cap jewel setting	By the hairspring stud screw

5. If the regulator pins are too far apart:

The watch is likely to gain	The watch may stop	The hairspring may become distorted when regulator is moved	The watch is likely to lose

6. If the regulator pins are too close together:

The watch may stop occasionally	The hairspring may become distorted when regulator is moved	The watch is likely to lose	They have no effect

7. The balance wheel in dial down position should have how many turns of oscillation?

1-1/4 to 1-1/2	3/4 to 1	1-1/2 to 2	1-1/2 to 1-3/4

8. If, from a state of rest, you move the balance a distance of 1/8 of its circumference and release it, the balance is then said to have how much motion?

1 turn	3/4 turn	1/2 turn	1/4 turn

9. If a watch gains excessively, the fault may be: (Circle all correct answers)

The hairspring	A balance screw may have come out	The hands are improperly adjusted	The hairspring coils may be stuck together

10. Meantime screws:

Are to be fitted with timing washers if the watch gains	Are to be undercut if the watch loses	Are always turned till the head touches the balance rim	Are never undercut or have washers added

11. The safest way to replace the minute hand is to use:

A staking tool	A pair of tweezers	A small brass hammer	A wide-bladed screwdriver

12. To make the hand fit the hour wheel post tighter, the hour hand socket may be closed with a:

Pair of smooth jawed pliers	Pair of strong tweezers	Hollow cone punch	Flat face punch

Cut along this line and send to the School for grading

Master Work Sheet

For use with Proficiency Exam No. 1 (Lessons 1 through 11)

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NOTE: This worksheet is based on an American watch, 12 size or 16 size. However, any watch can be used by allowing for minor variations in procedure, skipping those instructions which do not apply, and following the procedures for other movements given in your Job Sheets at the back of your lesson manuals.

1. TEST WINDING AND SETTING, paying close attention to adjustment of the stem and crown.

2. REMOVE MOVEMENT FROM CASE:

   a. Remove back and bezel. (Lesson 1)
   b. Note the make of case and kind of material (Karat gold, gold plate, stainless steel, etc.)
   c. Pull crown out into setting position.
   d. Select screwdriver of proper size and remove case screws. (Fig. 22). Use tweezers to lift out screws. Place in parts tray.
   e. Remove movement from case. (Fig. 25)

3. REPAIR AND CLEAN CROWN, STEM, SLEEVE AND BOW.

   a. Remove crown. Use flat pliers to hold stem while unscrewing crown. (Lesson 2)
   b. Notice position of sleeve in relation to top of pendant in order to replace sleeve with as few adjustments as possible.
   c. Select proper size sleeve wrench bit and remove sleeve.
   d. Push stem from sleeve and dip both in benzine, or, better still, in a non-inflammable drying solution. Wipe parts with clean cloth.
   e. Reassemble stem and sleeve. Place in parts tray.

4. CHECK CRYSTAL. See that it fits properly and is properly sealed. If present crystal requires cementing or replacement, do that at this time. (Lesson 3) Clean crystal.

5. CLEAN AND POLISH CASE AS FOLLOWS:

   a. Replace bezel and back and polish case, using a double polishing cloth.
   b. Wipe off any powder that may be left on case. (Sec. 37)
   c. Again remove bezel and back and wipe out inside of case.

6. REPLACE STEM, SLEEVE AND CROWN.

   a. Place drop of oil in oil cup. (Lesson 10)
   b. Remove the stem and sleeve from parts tray. Use tweezers to handle parts.
   c. Touch tip of oiler to oil in oil cup and transfer a small amount to slot in stem where sleeve rests when in winding position. (Lesson 2)
   d. Place stem and sleeve in pendant of case, adjusting as nearly as you can to proper position by means of the sleeve wrench. (Lesson 2)
   e. Replace crown on stem, screwing it down firmly while holding stem with pliers. (Lesson 2)

7. RECASE MOVEMENT AND ADJUST STEM AND SLEEVE.

   a. Pull out on crown so that stem is in setting position. (Lesson 1)
   b. Start movement in case by inserting end of stem in winding arbor and let movement slide into the proper place. (Lesson 1)
   c. Push in on crown so stem is in winding position.
   d. Replace case screws. Before tightening, be sure stem is properly aligned, will turn freely, and move from wind to set position. Then tighten screws and recheck. (Lesson 2)
   e. Test winding and setting and if you find that sleeve has not been adjusted to proper position, remove movement and make necessary adjustment. Replace movement and recheck. Follow this procedure until the stem and sleeve are functioning properly.

8. After adjustment of stem and sleeve is satisfactory, REMOVE MOVEMENT FROM CASE.

9. EXAMINE MOVEMENT and determine the following: (Lesson 4)

   a. Type of movement? (Full plate, 3/4 plate, bridge model, and so forth.)
   b. Make, model, size, number of jewels, hunting or open face?
   c. (If an American movement and you cannot find out the model, use serial number of movement.)

   b. Be sure you know what these terms refer to and where these parts are located in the watch: (Lesson 4)

   Dial screws, balance assembly, balance bridge screw, stud screw. Determine the type of regulator pins. (See Job Sheet L11-J2)in Lesson 11.) Locate each of the wheels in the time train, the pallet fork and arbor, crown wheel, ratchet wheel, barrel, and so forth.

10. CHECK FOR MAGNETISM. Demagnetize, if necessary. (Lesson 11)

11. Place movement in movement holder.

12. REMOVE BALANCE BRIDGE AND BALANCE ASSEMBLY.

   a. Disengage hairspring from regulator pins and separate stud from balance bridge. (Lessons 8-9-11)
   b. Screw stud screw back into place so it does not get misplaced.
   c. Examine regulator pins and make necessary adjustments or replace if necessary. (Note: You MUST replace one regulator pin as part of your Proficiency Examination. See Job Sheet L11-J2 for procedure.)

13. LET DOWN POWER FROM MAINSPRING. (Lesson 5)

14. CHECK AND REMOVE HANDS. (Lesson 8)

   a. Straighten bent hands, if any.
   b. Fit new hands, if needed. (Lesson 11)
   c. Check to see that cannon pinion has proper tension by pushing against minute hand with pegwood. (Lesson 11) If loose, correct in Step 15g.
   d. Remove hands.

15. REMOVE DIAL AND DIAL TRAIN.

a. Release dial screws and remove dial. Check condition of dial feet.
b. Screw dial screws back in place so they will not be misplaced.
c. Examine all winding and setting parts and determine their function and relationship. (Lesson 9)
d. Remove hour wheel. Check teeth in hour wheel.
e. Remove minute wheel. Check teeth in minute wheel.
f. Remove cannon pinion.
g. If you found cannon pinnion loose in 14c above, tighten with cannon pinion tightener, put back in place and check for correct fit. If correct, remove.
h. Remove crown and ratchet wheels. It is likely crown wheel screw will have a left thread. On some models, both crown and ratchet screws are left thread.

16. As you take off each screw, note its characteristics, as it is important to put each screw back in its proper place.

17. REMOVE PALLET BRIDGE AND PALLET FORK. (Lesson 8)

18. REMOVE BOTH BARREL AND TRAIN BRIDGES.

19. REMOVE BARREL AND TRAIN WHEELS.

a. Before doing so, notice how each is geared into the other. Study their position. (Lesson 8)
b. Remove train in this order:
   1. Center wheel, barrel, third wheel, fourth wheel, escape wheel. (Note: Some models require third wheel to be removed after the fourth wheel.)
   2. Place all parts in movement tray, except the barrel.

20. REMOVE BARREL CAP, ARBOR AND MAINSPRING. Determine if spring is correct for the watch, whether spring is set, and its general condition. Place all parts in parts tray.

21. If this is an American pendant set movement, it is likely part of the winding and setting mechanism is lying loose. Note the position of each part and study how it works before removing it. Separate parts and place in parts tray. Always use tweezers to handle parts. (Lesson 9)

22. Turn pillar plate over and examine the winding and setting parts on this side. Study their function and then remove. Place in parts tray.

23. Select proper size jewel screwdriver and REMOVE ALL CAP JEWELS.

a. Replace jewel screws in plates so they are not lost or misplaced during assembly. (Lesson 10)
b. Using pegwood, break up old oil and residue on both sides of jewel and the hole.

24. PRESS ALL PIVOTS IN PITHWOOD.

a. Examine wheels and pinions with double loupe for dirt or rust in pinions and wheel teeth.

b. Peg pinion leaves to remove dirt. Pegwood impregnated with diamantine is used to remove rust spots.

25. CLEAN AND DRY, using any approved method. (Lesson 10)

a. Inspect carefully. All parts should be clean and bright and jewels should be spotlessly clean.
b. Before reassembly, be sure all cleaning solution has evaporated and no particles of pith, pegwood, lint, dust, or sawdust (if used) remain on any part. Don't touch cleaned parts with fingers. Use tweezers or watch paper as appropriate.

26. REPLACE ALL CAP JEWELS AND JEWEL SCREWS. Be sure each jewel is in its correct position, as jewels in pillar (or lower) plate are often different from those in upper plates and bridges.

27. PLACE A SMALL DROP OF OIL IN OIL CUP OF BALANCE JEWEL. Insert an oil inserter in the hole of the balance jewel in order to allow the oil to flow into the hole between hole and cap jewel. (Lesson 10)

28. INSERT MAINSPRING IN BARREL, using mainspring winder.

a. Be sure spring is lying in correct position to engage with arbor. Be sure end of spring is anchored to barrel. (Lesson 5)
b. Examine and make necessary correction to inner coil of mainspring so it will engage the arbor properly and replace the arbor.
c. Place 4 or 5 large drops of oil on the mainspring.
d. Replace barrel cap. Be sure it is in proper position and well seated.
e. Oil arbor on each side where it passes through the barrel and cap.
f. Place barrel back in parts tray.

29. Place pillar plate in movement holder with time train side upward.

30. ASSEMBLE SETTING PARTS that fit on this side of pillar plate and put them in place. Using oiler, put small amount of oil on each bearing surface, or use special set mechanism lubricant, if you prefer. (Lesson 9)

31. PUT TRAIN WHEELS IN PLACE IN THIS ORDER:

Escape wheel, 4th wheel, 3rd wheel, 2nd wheel.
(Note: Some models may require a change in order of assembly of these wheels due to the way they overlap and engage with each other.)

32. PLACE TRAIN BRIDGE IN PLACE OVER WHEELS. Do not apply any pressure.

a. As this movement has been cleaned and should remain so, avoid getting finger prints on plates. Wrap your index finger in watch paper.
b. Lift movement and movement holder to eye level with your left hand, with your index finger (wrapped in watch paper) resting lightly on the train bridge.
c. With fine tweezers, reach into the train and carefully move upper pivot of each wheel into its respective jewel hole. No pressure should be applied to the bridge during this operation. Let just the weight of your finger hold it in place.
d. After pivots are all in place and the bridge is down against the pillar plate, make a final check of train by pressing down against the arm of the center wheel. When this is done, all wheels of the train should move freely.

33. Set the movement with movement holder back on work surface with your index finger still holding the train bridge.

    a. Insert one plate screw and screw it in part way.
    b. Check that all pivots are in place and train is free before tightening this screw.
    c. Replace the rest of the train bridge screws.

34. SET BARREL IN PLACE ON PILLAR PLATE.

35. REPLACE BARREL BRIDGE. As this may also be the bearing for one or more wheels in addition to the barrel, use same procedure in seating as you did for the train bridge.

    a. Again check freedom of the train. (Lesson 10)
    b. Oil point where arbor comes through barrel bridge.

36. REPLACE RATCHET WHEEL. Be sure square of arbor is properly fitted into square of ratchet wheel.

37. Oil bearing points where crown wheel will rest and REPLACE CROWN WHEEL.

38. OIL THE TRAIN.

    a. Place a small amount of oil in oil cup of each jewel on this side of train. Take care not to overoil. Take care to place oil in right spot and not smear it over the jewel or plate. Refer to illustrations in Lesson 10 to see how correct amount of oil will appear.
    b. Turn movement over. Place on perfectly clean work surface and proceed to oil train on dial side of pillar plate.
    c. Apply a very slight smear of oil to the pivot of the center wheel where cannon pinion will fit.

39. CAREFULLY PRESS CANNON PINION INTO PLACE with your tweezers. Support the other end of the center staff on a stump or other support as you do this. The cannon pinion must always be replaced before the minute wheel to prevent incorrect meshing from damaging the teeth of the minute wheel.

40. REPLACE WINDING AND SETTING PARTS ON DIAL SIDE OF PILLAR PLATE. Oil bearing surfaces lightly.

41. CHECK THE TRAIN RECOIL.

    a. Turn movement over. Wind the mainspring a few turns. The wheels should begin turning as soon as you start winding. Train should run rapidly until completely unwound and wheels should reverse (recoil) as the last bit of power runs down. This indicates a free train.
    b. For a thorough check, movement should be held in different positions and this test made in each position.
    c. This test is used to locate friction points in the train, such as bent pivots, cracked or broken jewels, lack of end shake, lack of oil, and so forth.
    d. Using a watch oiler, place a small amount of oil on the impulse face of four or five of the escape wheel teeth. This is to lubricate the contact between pallet stones and teeth. This method of oiling is preferred for beginners, as there is a tendency to overoil.

e. An alternate method of oiling is to place a small amount of oil on the impulse face of each pallet stone. This method is very exacting. The oil must be placed on the impulse face only.

42. REPLACE PALLET FORK AND PALLET BRIDGE.

Apply the least possible amount of oil to the pallet arbor pivots on both sides with a watch oiler.

43. REPLACE BALANCE BRIDGE AND BALANCE ASSEMBLY.

a. Using bench key, wind mainspring part way.
b. Lay balance bridge upside down on an elevated work surface such as a pithwood button. Hold the balance wheel upside down with tweezers and work the stud into place in the bridge, taking care that outside coil or overcoil of hairspring is in place between regulator pins. Hold bridge firmly without touching the balance wheel and tighten the stud screw.
c. If regulator has a gate type pin, turn this pin so as to lock the hairspring in between pins.
d. Turn balance assembly over and rest on watch paper in preparation for assembly in movement.
e. Movement should be in movement holder with position for balance assembly toward your right hand (reverse, if you are left handed), fork in position against the banking pin closest to center of movement.
f. Using tweezers, pick up balance assembly by the bridge with the balance wheel suspended below the bridge by the hairspring.
g. Hold in position so roller jewel is facing toward the center of the movement.
h. With your left hand, tilt the movement and holder and move balance wheel into position. (Tilting movement will allow balance to clear edge of train wheel.)
i. As balance is moved into place, slowly lower movement to level position and, with tweezers still gripping bridge, turn bridge in direction necessary to bring it to its final resting position. Lower bridge into position, taking care that spring is not hitting or resting over any of the train wheels. As bridge is brought to final position, the watch should begin running, showing the roller jewel is properly aligned to the fork slot and that pivots are free in jewels. Balance should continue to motion as you place bridge screw in place and tighten it.
j. Check to see that hairspring stud is at right position to support hairspring level in watch. If adjustment is necessary, loosen stud screw and raise or lower stud as needed. Tighten the stud screw.

44. CHECK TO DETERMINE THAT BALANCE MOTIONS EQUALLY WELL IN ALL POSITIONS.

a. Wind the mainspring fully.
b. Check to determine the amount of motion the balance is taking and see that same motion continues in dial up and dial down positions. Also in pendant up and pendant down positions. Ideal amount of motion is 1-1/4 to 1-1/2 turns. To recognize the amount of motion, you must first understand that the balance never makes a complete revolution. Rather, it turns first in one direction, then reverses and moves an equal distance in the opposite direction. The amount of motion is the total of both swings from one end to the other and back again.

45. Turn movement over and rest on clean surface, such as watch paper.

46. REPLACE HOUR WHEEL AND DIAL WASHER.

47. REPLACE DIAL AND HANDS.

   a. Loosen dial screws, put dial in place and tighten dial screws.
   b. Using watch paper, wipe dial free of any smudges or finger marks.
   c. Replace second hand, hour hand and minute hand. Be sure hands register the hour, minute and second properly and that each has clearance for free movement without hitting each other, the dial or the crystal.
   d. Check setting mechanism to see that hands will set properly.

48. ADJUST REGULATOR to center of index on the balance bridge as preliminary to bench timing the watch.

49. RECASE THE MOVEMENT:

   a. Check case to see that it is free of dirt and lint. Pull crown into setting position.
   b. Tilt movement so winding arbor engages with stem in case and allow movement to slide into position in case. If movement has any protruding pins or levers on edge of pillar plate, such as a setting cam or shipper lever bar, be sure they are in proper position and not binding.
   c. Press crown into winding position.
   d. Turn crown to see that it is engaged and properly aligned in arbor.
   e. With fingers covered with watch paper to prevent finger prints, hold movement in place and turn it over and insert case screws.
   f. Screw them in nearly tight and again check wind and set before tightening fully.
   g. Replace back and bezel.

50. SET HANDS TO CORRECT TIME. Use a source of time you consider quite accurate.

51. Now TIME YOUR WATCH. Make records and regulate as required. Time pocket watches in at least dial up, dial down and pendant up positions. Time wrist watches in at least dial up, dial down and crown down positions.

AVERAGE TIME LIMIT: While the actual time required for these procedures will vary somewhat with different movements, a proficient workman can usually complete these steps in one to one and a half hours. If you find yourself taking a longer time after you have learned these procedures, you need more practice to bring your work up to professional standards.

Master WATCHMAKING

Lesson 12

FACTORY SET TRAIN JEWELS

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

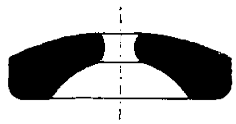
Printed in the United States of America

INTRODUCTORY INFORMATION

In previous lessons the part played by jewels in watches was briefly touched on. In the next three lessons you will study jewels in more detail with emphasis on their use and replacement.

Most jewels are used as bearings and these are of two main types: 1. bezel or burnished-in jewels, which have beveled edges, and 2. friction jewels, which have straight sides.

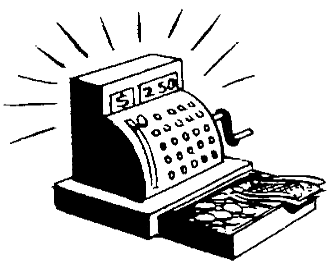
1. A Bezel or Burnished-in Jewel



2. A Friction Jewel

Before 1930, bearing jewels were of the first type. In Lessons 12 and 13 you will note a variety of settings have been devised for these jewels. Many of them are still in use. However, it is not always possible to get a replacement jewel setting because the manufacturer is now out of business. In such cases, you must make your own replacement setting, which requires considerable work, or do as the modern repairman does -- replace the jewel with a friction jewel or friction bushing and jewel.

Both watch manufacturers and repairmen now make extensive use of friction jewels because they have proved to be very serviceable and are much easier to install in plates or bridges. Friction jeweling will be discussed in detail in Lesson 14.



An average charge for replacing broken jewels is from $2.50 to $3.50. It is usual to add $1.00 to $1.50 more for center jewels.

The cost of jewels varies with the type: Train, balance hole and cap jewels in settings run from 50¢ up, depending on their quality and manufacturer. Friction jewels cost from 30¢ to 50¢.

Many material supply houses will fit friction jewels individually to plates or bridges as required where the repairman lacks friction jeweling equipment to do the job himself. A labor charge is added to the cost of the jewel for this service.

In setting jewels of any type, pay particular attention to which side of the plate or setting is used. The top side of a plate or setting is the side toward you as you look at a watch that has not been disassembled. The under side is the side nearest the wheels.

KEY POINTS OF LESSON ASSIGNMENTS 41, 42:

- Why jewels are used in a watch.
- The types of jewels.
- How to test sideshake and endshake.
- How to measure the hole in a jewel.
- Different types of train jewel settings.
- How to use a staking tool.
- How to burnish-in jewels.

ASSIGNMENT NO. 41: Study Sections 285 through 294. Read Sections 303 and 304.

Study Questions:

1. What is the purpose of jewels?
2. What types of jewels are used in the average watch?
3. Why is it important that there be endshake and sideshake in train jewels?
4. What determines the amount of sideshake?
5. How are jewel holes measured?

Recommended Practice:

1. Examine various watches for number, type and location of jewels.
2. Make the tests for sideshake and endshake suggested in Sections 291 and 292.

ASSIGNMENT NO. 42: Study Sections 295 through 302.
Read Tools and Materials of the Trade, pages 17 through 21.

1. What are the differences in the train jewel settings discussed in this assignment?
2. How is a train jewel setting held by screws replaced?
3. What is a staking tool? What are some of its uses?
4. What can you do if a replacement setting is not available?

Supplementary Information:

Sections 295 and 297: It is sometimes possible to get replacement settings for this type if the watch is of current manufacture. When ordering, you should give all measurements and also include old settings as a sample. If not available, make a new setting or replace it with a friction bushing and jewel. See Job Sheet L14-J4 for procedure.

Section 299: This type of setting is generally found in older watches and usually cannot be replaced with a factory replacement. It is necessary to either make a new setting or replace it with a friction bushing and jewel. See procedure in Job Sheet L14-J5.

Section 300: This type of setting is still being used, but it is not always possible to get a replacement setting. In such cases, the common practice is to friction jewel the old bushing (Sec. 335, Lesson 14). Also see Job Sheet L14-J6.

Section 301: This type of jewel is no longer in common use. It can be replaced with a friction jewel or a friction bushing and friction jewel. See procedure in Job Sheets L14-J4, L14-J6, L14-J7, and L14-J8.

Recommended Practice:

Remove and replace an upper train jewel and setting, preferably one held by screws. Follow this general procedure:

a. Let down power of mainspring.
b. Remove balance bridge and balance wheel and lay in safe place, bridge down and wheel up.
c. Remove pallet bridge and pallet.
d. Remove train bridge.
e. Remove setting from bridge and follow steps in Section 296.
f. Replace train jewel and assemble movement in this order: Train wheels and train bridge. Pallet and pallet bridge. Balance and balance bridge.

REQUIREMENT: Answer Test Questions for Lesson 12 and send in for grading.

FACTORY SET TRAIN JEWELS

SEC. 285

By now you should be well acquainted with the majority of terms used in watchmaking. Additional tools required in most cases will relate to the lesson at hand. From now on your course becomes more intense. We will present each lesson in a more concise form.

SEC. 286 — Purpose of the Jewels

The purpose of jewels in watches is a mystery to most people. They may be able to talk glibly of "17 jeweled" watches or perhaps of a full jeweled timepiece but, as a general rule, they have no idea where the jewels are located nor what purpose they serve.

SEC. 287 — Jewels as Bearings

Bearings for pivots in the earlier watches were holes drilled in the plates or bridges with metal bushings. Such is the method used for train pivots in some grades of movements manufactured today. Some of the modern watches use metal bushings which are fitted friction tight into the plates or bridges. These bushings can be easily replaced when the pivot holes are worn. When bushings are used, there is more friction and wear as compared with the modern bearings of stone or the so-called "jewels" of the watch. Occasionally students have added fourteen extra jewels to the train and escapement of a seven jeweled movement, thus making it into a twenty-one jeweled timepiece, and invariably were surprised to find that it was necessary to replace the original mainspring with a much weaker one in order to get the proper motion, this being due to the reduced amount of friction in the train and escapement.

Sapphires, rubies and garnets are the most common stones used to make jewels. Cap jewels in some of the older models of high grade watches and chronometers were made of diamond chips and while these are really diamonds, their intrinsic value is not as great as many are inclined to imagine although they serve the purpose as well as an expensive, brilliant cut diamond. Diamonds are not used in the average watch manufactured today.

For average purposes, synthetic sapphires and rubies make the best jewels for bearings in watches. Garnets are usually used in the cheaper grades of watch movements. It is not necessary that watchmakers attempt to manufacture their own jewels.

SEC. 288 — 7 Jeweled to 23 Jeweled Watches

Seven is the minimum number of jewels in most standard American watch movements. These jewels are as follows: one upper cap jewel, one upper balance hole jewel, one lower balance hole jewel, one lower cap jewel, two pallet stones and one jewel pin or roller jewel. A 15-jeweled watch has an additional four pairs of plate jewels, one each for the upper and lower pivot of the pallet arbor, one for each end of the third, fourth and escape pinions. These jewels are named according to the position they occupy. Thus we have the upper 3rd jewel, 4th jewel, upper escape jewel and upper pallet arbor jewel. On the pillar plate, the opposite jewels are the lower 3rd jewel, lower 4th jewel, lower escape jewel and lower pallet arbor jewel.

By adding an upper and lower center jewel, the total number of jewels is 17. A pair of cap jewels added to the ends of the pallet arbor or the escape pinion would make a total of 19 jewels. A pair of cap jewels added to both the pallet arbor and escape pinion will make a total of 21 jewels. A 23-jewel watch has an additional pair of jewels in the mainspring barrel or at the ends of the arbor (see Lesson 6).

In some watches, jewels are not always matched in pairs and it is quite common to find movements with 6, 9, 11, 16, 17 or 19 jewels. There are also other combinations with which you will become familiar as you progress with your repairing.

SEC. 289 — Types of Jewels

The following list of jewels are used in the average watch:

- Train jewels or plate jewels
- Balance hole jewels
- Balance cap jewels or end stones
- Pallet stones
- Roller jewel or jewel pin

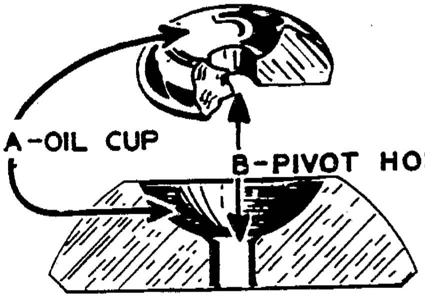


FIG. 12-1

SEC. 290—Train or Plate Jewels

Figure 12-1 illustrates a drawing of a train jewel with a section removed, and a cross-section of this same jewel. A is the oil cup; B is the pivot hole.

Figure 12-2 illustrates a square shoulder pivot used in conjunction with a train jewel. These square shoulder pivots are highly polished and must have sideshake and endshake in order that they may rotate freely.

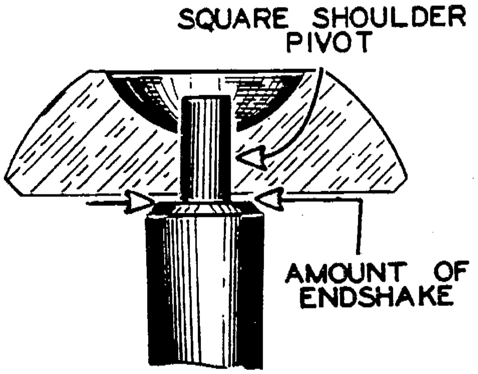


FIG. 12-2

SEC. 291—Sideshake

Sideshake is the freedom between the sides of the square shoulder pivot and the hole in the jewels. The amount of sideshake varies according to the diameter of the pivot. Example: The amount of sideshake in a pallet arbor is less than that in a center wheel. Sideshake is hardly perceptible. It is tested by grasping the pinion with tweezers and endeavoring to move it from side to side. It may be perceptible with your double loupe. In better grade watches, the sideshake can scarcely be seen or felt. If you find an excessive amount of sideshake, there is a possibility that the jewel is broken or that the pivot is cut.

SEC. 292—Endshake

Endshake is tested with the power off. Grasp the pinion with your tweezers and endeavor to move it up and down. This endshake is perceptible on all wheels and pinions including the balance. The space between the face of the train jewel and the shoulder on the pivot, figure 12-2, is the amount of endshake.

To get an idea of the proper amount of both endshake and sideshake, test as many wheels and pinions in different watches as possible.

SEC. 293—Measuring the Hole in a Jewel

Holes in train jewels or balance jewels can be measured by a jewel hole gauge. By slipping the fine needle point in the hole of the jewel and pressing the face of the jewel against the stop, the indicator will register the hole size on the index, figure 12-3. This reading is in hundredths of a mm. Diameters of pivots are measured with the metric micrometer.

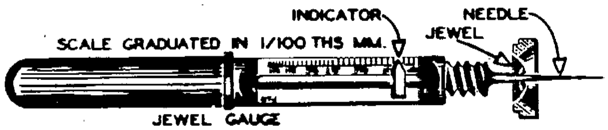


FIG. 12-3

SEC. 294—Determining the Amount of Sideshake by Measurements

Procedure:

1. Measure pivot with metric micrometer and mark down the reading.
2. To ascertain the size of hole in jewel which will allow the proper amount of sideshake with the pivot you have measured, refer to the following chart:

Diameter of Pivots in Hundredths of a mm.	Size of Hole in Hundredths of a mm.
.10 mm.	.11 mm.
.11 "	.12 "
.12 "	.13 "
.13 "	.14 "
.14 "	.16 "
.15 "	.17 "
.16 "	.18 "
.17 "	.19 "
.18 "	.20 "
.19 "	.21 "
.20 "	.22 "
.21 "	.23 "
.22 "	.24 "
.23 "	.25 "
.24 "	.26 "
.25 "	.27 "
.26 "	.28 "
.27 "	.29 "
.28 "	.30 "
.29 "	.31 "
.30 "	.32 "
.31 "	.33 "
.32 "	.34 "
.33 "	.35 "
.34 "	.36 "

.35	"	.37	"
.36	"	.38	"
.37	"	.39	"
.38	"	.40	"
.39	"	.41	"
.40	"	.42	"

SEC. 295—Train Jewels in Setting

Train jewels in American watches are usually set in metal bushings made of brass, oreide, or low carat gold. These settings are usually held in place by jewel screws. Figure 12-4 shows this type of setting: A is the plate, B is the setting, C is the train jewel and D the jewel screws.

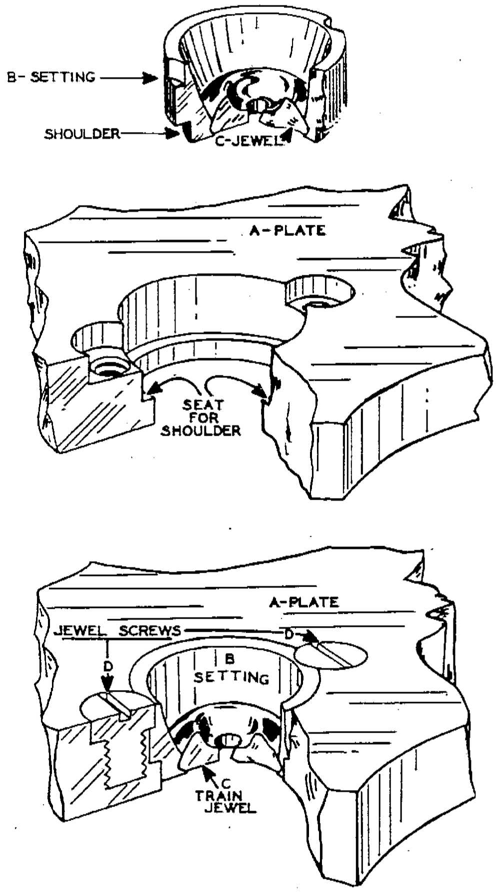


FIG. 12-4

SEC. 296—Replacing Factory Train Jewel

Replace a train jewel setting held by jewel screws as follows:

1. Remove jewel screws.
2. Place plate or bridge over hole in bench block. Be sure hole in bench block is slightly larger than the setting.
3. Force setting out with jewel pusher.
4. Measure pivot with micrometer.
5. Compare measurement with chart, Section 294.
6. Select the proper hole size.

In a shop, you would then select from your stock of material a jewel in a setting with the proper hole diameter which corresponds to the name and size of the watch for which the jewel replacement is to be made.

Without a stock of train jewels, you would order from your supply house as follows:

1 Train Jewel in setting
Name of Watch:
Size of Watch:
Description of jewel (whether upper or lower—center, third, fourth, escape or pallet):
Size of hole desired in hundredths of a mm.:
Send sample whenever possible.

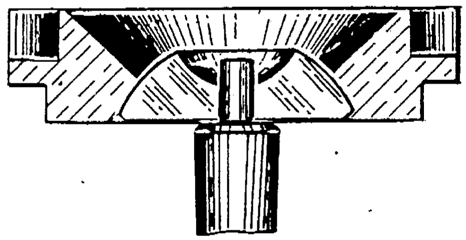


FIG. 12-5

When you have selected the proper jewel for replacement, be sure to test the jewel on the pivot before replacing in watch. The pivot in figure 12-5 fits a little snugly and, in all probability, would cause trouble.

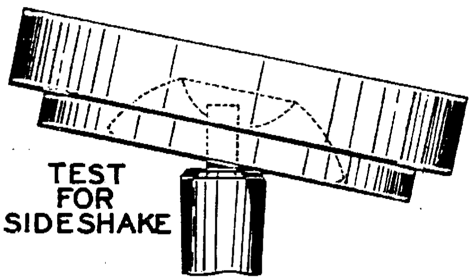


FIG. 12-6

In figure 12-6, the jewel setting is tipped. This shows a slight amount of freedom, which is actually sideshake, between the pivot and hole of the jewel.

The depth of the shoulder determines the amount of endshake and must therefore be correct.

Figure 12-7 illustrates a method of determining whether or not the shoulder on the new setting is exactly the same as the shoulder on the old setting. Figure 12-8 shows the old setting in comparison with one in which the shoulder is cut too deep. Figure 12-9 illustrates too shallow a shoulder. The only way a student could rectify these errors would be to return the setting to his supply house with complete instructions, thus enabling them to make the corrections. When you have progressed into your lathe work, you will learn how to correct a setting that does not conform to your requirements.

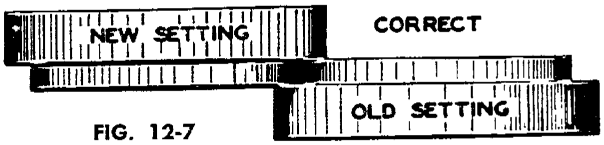


FIG. 12-7

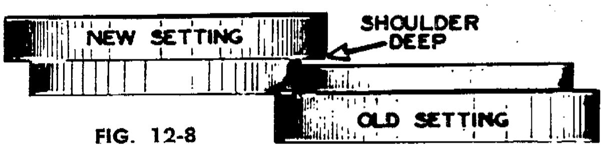


FIG. 12-8

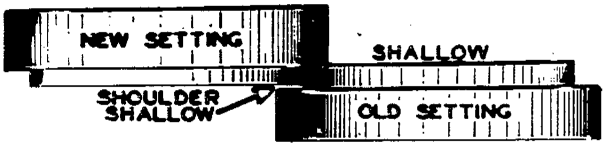


FIG. 12-9

SEC. 297—Raised Setting

Figure 12–10 shows sectional drawing of a train jewel set in a raised setting:

A—Plate
B—Setting
C—Jewel
D—Jewel Screws

Notice that the jewel screws are not set below the surface of the plate. A portion of the setting slightly

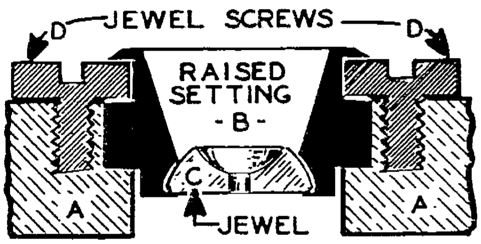


FIG. 12-10

larger than the diameter of the jewel screw is milled out. The portion of the jewel screw head which overlaps the setting keeps this setting in place.

SEC. 298—The Staking Tool

From now on your work will necessitate the use of a staking tool, not only for taking out and replacing jewels but for other jobs such as tightening roller tables, closing holes, endshaking of trains, closing pivot holes in non-jeweled watches, driving out staffs, pinions and arbors, staking balance train, wheels on pinions, driving on rollers, closing hour and minute hands, pressing on hairspring collets, indenting the safety pinion staffs, and many other jobs.

There are many manufacturers of staking tools. A staking tool is comprised of a frame similar to cross section figure 12–11 and an assortment of punches and stumps. Staking tools come with as few as 24 punches and 4 stumps and as many as 133 punches and 25 stumps. In the better grade staking tools the punches can be inverted through a hole in the die plate and used as a stump. This is a distinct advantage, and if possible, is the type of staking tool you should own. There are staking tools with a friction jewelling tool which can be readily attached. In modern shop work we recommend specific tools for specific purposes. In a later lesson you will be shown an excellent friction jewelling device which can be used for many jobs other than friction jewelling. In our opinion, it is a definite advantage to have these two tools as separate units.

As stated before, there are a number of staking tool punches and stumps but it is not necessary for you to learn the purpose of these in one lesson. In fact, the student acquires a more thorough knowledge of the staking tool by learning the use of the different punches and stumps in the regular order of his lessons.

The top of the frame, figure 12–11, is bored to receive any one of the punches and to hold that punch upright and at right angles to the hardened steel die. This die has a series of graduated holes drilled at such a distance from the center that it is possible to bring each hole directly under any punch that may be inserted in the punch guide. The die may be locked in

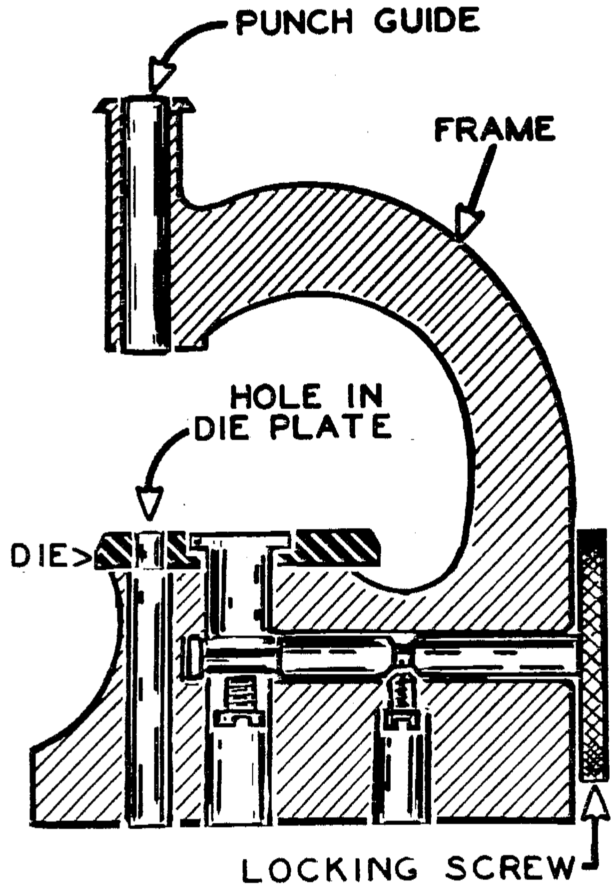


FIG. 12-11

position by means of the locking screw. On the upper part of the frame in the better grades of staking tools is a sustaining device which, with slight friction, holds the punch at any height.

With every staking tool there is a Centering Punch which is used solely for the centering of holes in the dieplate. Figure 12–12 shows the shape of the lower end of this punch and because the upper end is of a design found on none of the other punches, you should have no difficulty in identifying it. If you wish to center any particular hole, the die is unlocked by turning the locking screw and the die revolved until the hole desired is directly under the point of the centering punch. Now press the point of the centering punch firmly into the hole with the die still loose and while holding it there, lock in position with locking screw.

Do not use the centering punch for any other purpose as its needle-like point is easily ruined and rendered unfit for centering small holes.

The four shapes of punches used most are the flat face solid punch, round face solid punch, flat face hollow punch, and round face hollow punch. Figure 12–12 illustrates the following punches: A—centering punch, B—flat face solid punch, C—round face solid punch, D—flat face hollow punch, E—round face hollow punch and F—taper mouth closing punch. Examine your set and identify these punches. Notice there is a greater variety of punches B, C, D and E than of any other.

Having identified these punches, practice centering the different holes in your staking tool die.

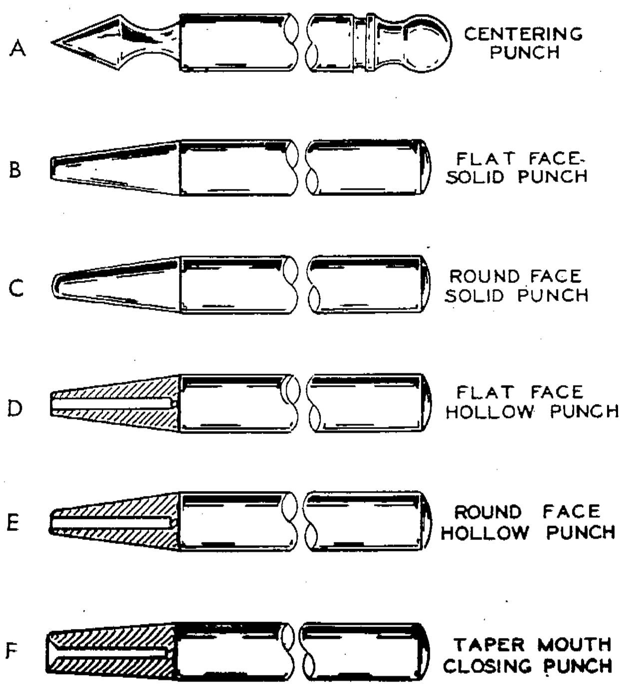


FIG. 12-12

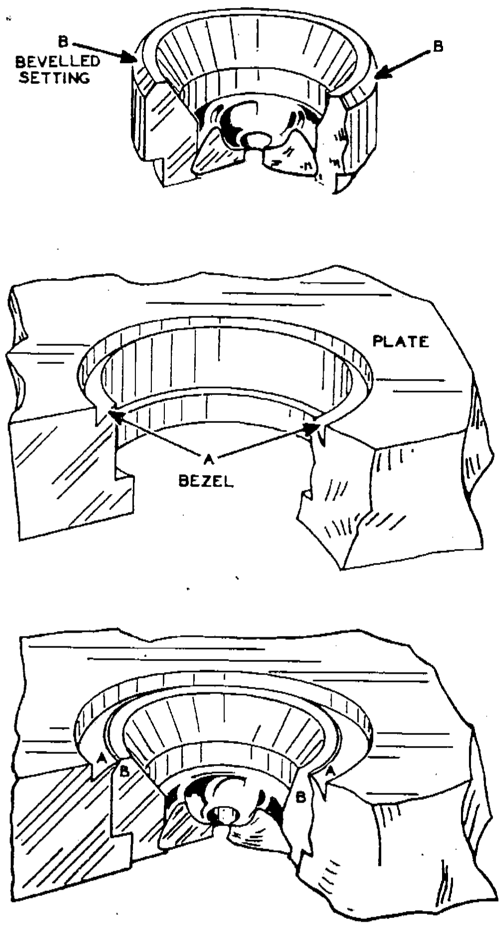


FIG. 12-13

SEC. 299—Another Type of Train Jewel Setting

The type of jewel setting shown in figure 12–13 is generally found in the pillar plate of some American watches and is held in its place in the plate without the use of jewel screws. The opening in the plate, instead of having recessed places for screws, has a bezel around the edge as shown at A. The upper edge of the jewel setting is beveled slightly, see B, figure 12–13. After the setting has been pressed into position in the plate, the bezel A is burnished tightly over the edge of the setting B thus holding it in place without the use of screws.

To remove a jewel setting just described, select a hole in the staking die that is somewhat larger than the full diameter of the jewel setting and center it using the centering punch. Select a flat faced solid punch, the face of which is smaller than the inner diameter of the jewel setting. Place the pillar plate over the hole in the die with the beveled side of the jewel toward the die. Bring the flat face of the punch down in contact with the jewel setting as shown in figure 12–14, adjusting the watch plate so the punch is in the center of the jewel setting. Hold the punch firmly against the setting and strike the upper end of the

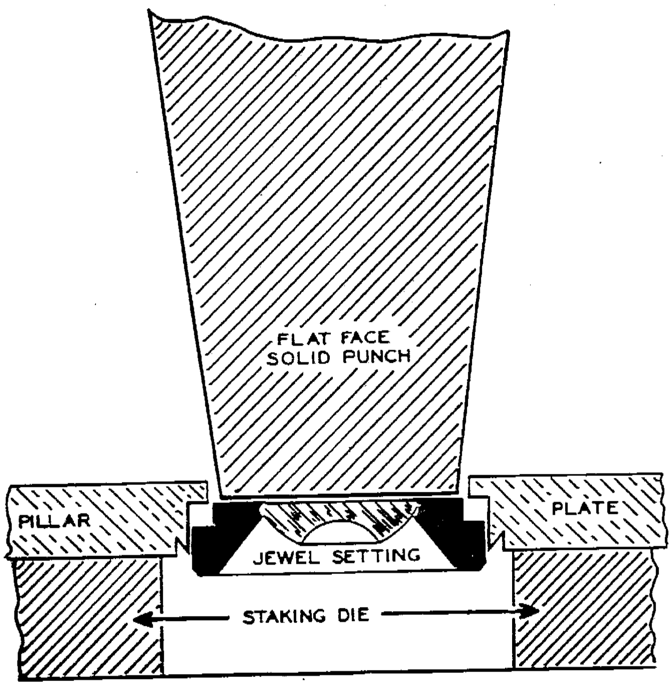


FIG. 12-14

punch a light sharp blow with a brass staking tool hammer. Do not strike too hard a blow and be sure that your punch is not large enough to bind in the opening in the plate as this may injure the shoulder. It is only necessary to drive the setting out of the plate and it is better to use a series of light blows than one heavy one. Never use a steel hammer on your punches. As the setting is driven out of the plate, it forces out the beveled edge of the opening to nearly its original shape.

To replace this type of train jewel setting, proceed as follows:

1. Measure pivot.
2. Compare measurement with chart, Section 294.
3. Select jewel from stock corresponding to name and size of watch.
4. Try pivot for sideshake (figure 12–6).
5. Measure diameter of setting and compare diameter with old setting, using micrometer.
6. Compare shoulders (figure 12–7).
7. Place pillar plate on staking die.
8. Press setting in place with flat face solid punch which is slightly smaller in diameter than the bezel (A–figure 12–15).
9. Select flat face solid punch slightly larger than the diameter of setting and tap slightly. This will force edge of bezel over jewel setting (B–figure 12–15).
10. Test jewel setting with pegwood. It must be tight.
11. It is good practice to run a burnisher around edge of bezel (figure 12–20).

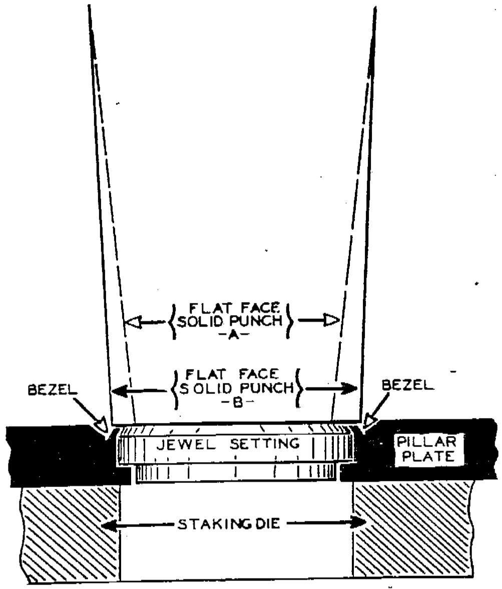


FIG. 12-15

SEC. 300 — Friction Train Jewel Setting

It has been the custom of a few watch manufacturers to make the bearings in the plates of their seven jeweled movements in the form of metal bushings which are pressed into openings in the plate and held in place by friction.

Much the same plan has been adopted in fitting jewels in some watches. Figure 12–16 shows a drawing of a friction train jewel setting of this type. Here the opening in the plate has no shoulder and the settings are of such diameter that they are held in place friction tight. The edges of the settings are usually beveled.

To replace a broken jewel and its setting, it is only necessary to drive out the old one using a flat face solid punch as illustrated in figure 12–16. The new setting is replaced from the inner side of the bridge or plate, the beveled edge serving as a guide while placing it in position. If there is too much endshake, the jewel can be driven in enough to make the correct amount.

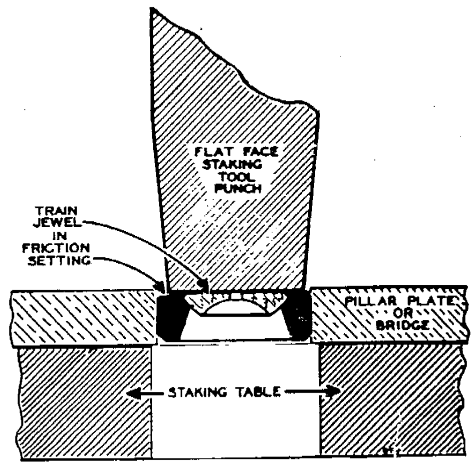


FIG. 12-16

If not enough endshake, drive the jewel a trifle toward the outside.

There are times when the plate or bridge will not rest solidly upon the staking die. If such is the case, a flat face stump can be placed in the largest hole in the die plate which has been previously centered. In this manner, the portion of the bridge or plate surrounding the jewel setting can be properly supported.

The cost of a complete assortment of train jewels in settings for all the different makes of watch movements is so great that only the largest shops attempt to carry them. It is best for the beginner to follow the plan adopted by the great majority of watchmakers and order such jewels as they are needed. Should a watch be brought to you for repairs and you find a broken lower 3rd jewel, order a new one specifying on your order the make and size of movement for which it is intended, which particular jewel it is and also be sure to send the old jewel setting together with the wheel and pinion on which the new one is to be fitted. In this way you will be able to secure a new jewel with correct sized hole, thickness and height.

Thus if you were to order a lower third jewel for a Hamilton 989:

"One only lower 3rd jewel Hamilton 989. Hole Diameter (24), sample enclosed."

In a future lesson on lathe work, you will be shown how with a small investment and at a considerable saving jewels in blank settings can be fitted to most style watches.

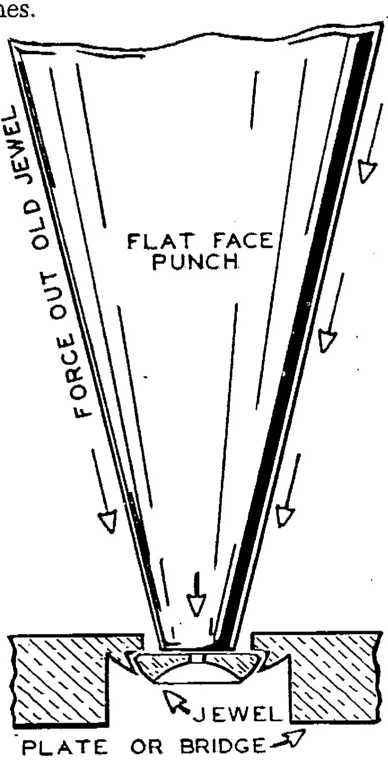


FIG. 12-17

SEC. 301—Jewels Set in the Plate

You will find in some watch movements, especially those made in Switzerland, jewels set directly in the bridge or plate without the use of bushings or settings, hence the name "plate jewel." In figure 12–17 is shown a cross section of a Swiss type of jewel set directly in the plate. The seat for the jewel is cut directly in the plate as shown in figure 12–17, then a bezel is cut around the opening in order to have a thin edge to burnish over the jewel. Force out a broken jewel with a flat face staking punch.

After the jewel has been pushed out of the seat the edges of the bezel in most cases must be opened a little further until they are straight up and down. This is done with a bezel opener. Bezel openers usually come in sets of three which will cover practically all sizes of jewel bezels found in Swiss wrist and bracelet watches and larger sizes of movements, figure 12–18.

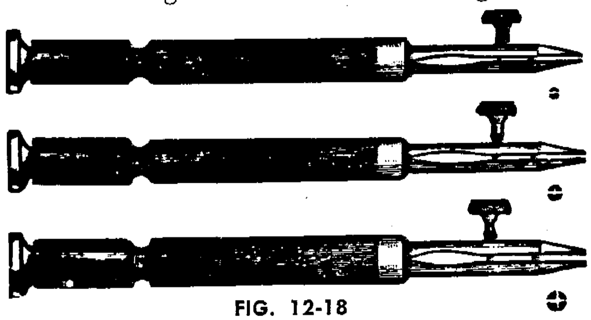


FIG. 12-18

In using the bezel opener, select one on which the jaws when closed will go easily into the old jewel seat and then gradually open the jaws by turning the screw, figure 12–19. Hold the opener much as you

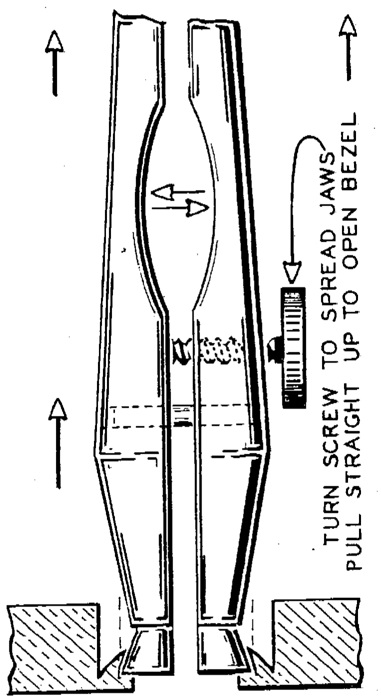


FIG. 12-19

would a screw driver and as the jaws come in contact with the bezel, twist it back and forth between the thumb and fingers keeping it as nearly upright as possible. As you do this, at the same time tightening the tension slightly by means of the screw, the bezel will gradually open until the sides of the seat are nearly straight.

Do not attempt to open the bezel by spreading the jaws of the bezel opener the full amount at one time but rather by applying a little tension after each trial. Be careful not to open the bezel too much. It is better to have the opening in the plate a trifle smaller at the bezel than at the bottom of the seat and then select a jewel than can be forced into the opening.

In selecting the jewel to fit this open bezel, there are three dimensions that must be taken into consideration: the diameter of hole to fit the pivot, the outside diameter to fit the seat in the plate, and the correct thickness which can be judged from the old jewel. As explained before, the pivots and holes in jewels are numbered by hundredths of a millimeter but the outside diameter is measured in tenths of a millimeter. If you have a selection of jewels all supposed to be of a certain outside diameter, you will find by using your micrometer that they may vary somewhat in sizes. Thus in a dozen No. 12 jewels, you will probably find sizes running from 1.15 to 1.25 mm. This gives you an opportunity to select a jewel to within a few hundredths of a millimeter of the size desired. A very convenient way of estimating the outside diameter of a jewel to fit the old seat is by means of your bezel opener. If you will insert the bezel opener and open the jaws until they will just fit without any sideshake in the jewel seat and then withdraw the bezel opener without changing the position of the jaws, it is easy to obtain the measurements in 100ths of a mm.

To replace a train jewel of this type proceed as follows:

1. Force out broken jewel with a flat face staking punch (figure 12–17). The bezel will be forced open to a certain extent.
2. Place bezel opener in seat of setting (figure 12–19).
3. Spread jaws of bezel opener carefully and pull straight out (figure 12–19).
4. Measure across jaws of bezel opener with micrometer. This measurement will be outside diameter of jewel.
5. Measure pivot and compare with chart, Sec. 294. This will be the hole diameter.
6. Select jewel from stock with corresponding outside diameter and hole diameter for replacement.
7. If not in stock, order from material house.

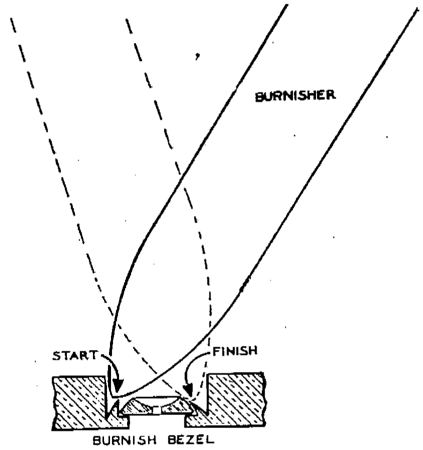


FIG. 12-20

8. Place train jewel in seat (figure 12–20).
9. Figure 12–20 illustrates a hard steel burnisher used to force bezel over jewel. The solid lines of burnisher illustrate the bezel at the start and the dotted lines illustrate the burnisher and the bezel which is now tight against the jewel.

In ordering a new jewel for the type of seat described in this section, it is best to send in the plate with the bezel opened together with the wheel and pinion for which it is intended. In this way a jewel of correct diameter to fit both the seat and the pivot can be furnished.

SEC. 302 — Swiss Watches

As already mentioned, it is very easy to select material for American watches if the sample of the old part is furnished together with the name of the manufacturer and the size of the watch. However, in ordering Swiss material it is necessary to have a little more definite information. There are literally thousands of names of Swiss watches on the market today, each importer perhaps having several different names although there are comparatively few different Swiss factories.

After the watchmaker has established a profitable repair business, it is well to have an assortment of unset jewels. They can be had with sized holes and assorted diameters and in the larger and more complete assortments with sized holes and sized diameters.

The replacing of broken jewels in timepieces is one of the paying services rendered by watchmakers and should be studied and practiced until you are thoroughly proficient in replacing any type with which you may come in contact. Do not be satisfied with merely getting the new jewel in the plate so the endshake is correct but with the appearance of having been secured in the bezel by means of a broken nail and a sledge hammer, but rather endeavor to have each job with a finish that stamps it as the work of a Master Watchmaker.

SUPPLEMENTARY INFORMATION

HOW WATCH JEWELS ARE MADE

Watch jewels are manufactured on specialized machines. Each machine performs just one operation. These sections will describe only the main operations in a long series.

SEC. 303-A Brief Background

Before 1700 watches had no jewels. Wheel pivots simply ran in brass holes in the plates. Then in 1704 Nicolas Fascio, a Swiss watchmaker living in London, invented and patented a method for drilling holes in gem stones and ushered in the jeweling system.

For the next 200 years, natural gem stones were used for watch jewels. Since the purpose of such jewels is to provide a smooth, hard surface and thereby lessen friction, rubies and sapphires were principally sought because they rank next to diamonds in hardness. These watch jewels were made by hand and watchmakers likewise made their replacement jewels by hand.

But natural gems vary in quality and availability. As the number of watches increased, it became evident that a more certain and less costly source of jewels was needed. Efforts in this direction began as early as 1837.

Manufacturers tried first to produce suitable rubies by fusing chips of natural ruby. These efforts were not satisfactory. Then in 1902, Auguste Verneuil, a Frenchman, devised a flame-fusion process for making rubies and sapphires synthetically, which gave birth to a whole new industry. The furnace used for this process bears Verneuil's name.

SEC. 303A - Materials Used in Modern Jewels

The material used for synthetic jewels is the same as is found in natural jewels. It is crystalized aluminum oxide, known as corundum. To produce this, alum is roasted in silica trays in a very hot furnace (1,000 degrees Centigrade) to form a feathery white powder.

Many kinds of stones can be obtained from this base by adding different coloring matter. Adding chromic oxide -- a metallic salt -- produces rubies. Titanium and iron are used for sapphires while cobalt and vanadium will produce emeralds. For many industrial uses, the white powder is left plain. Rubies are preferred for watch jewels because their red color makes them easier to see and to handle.

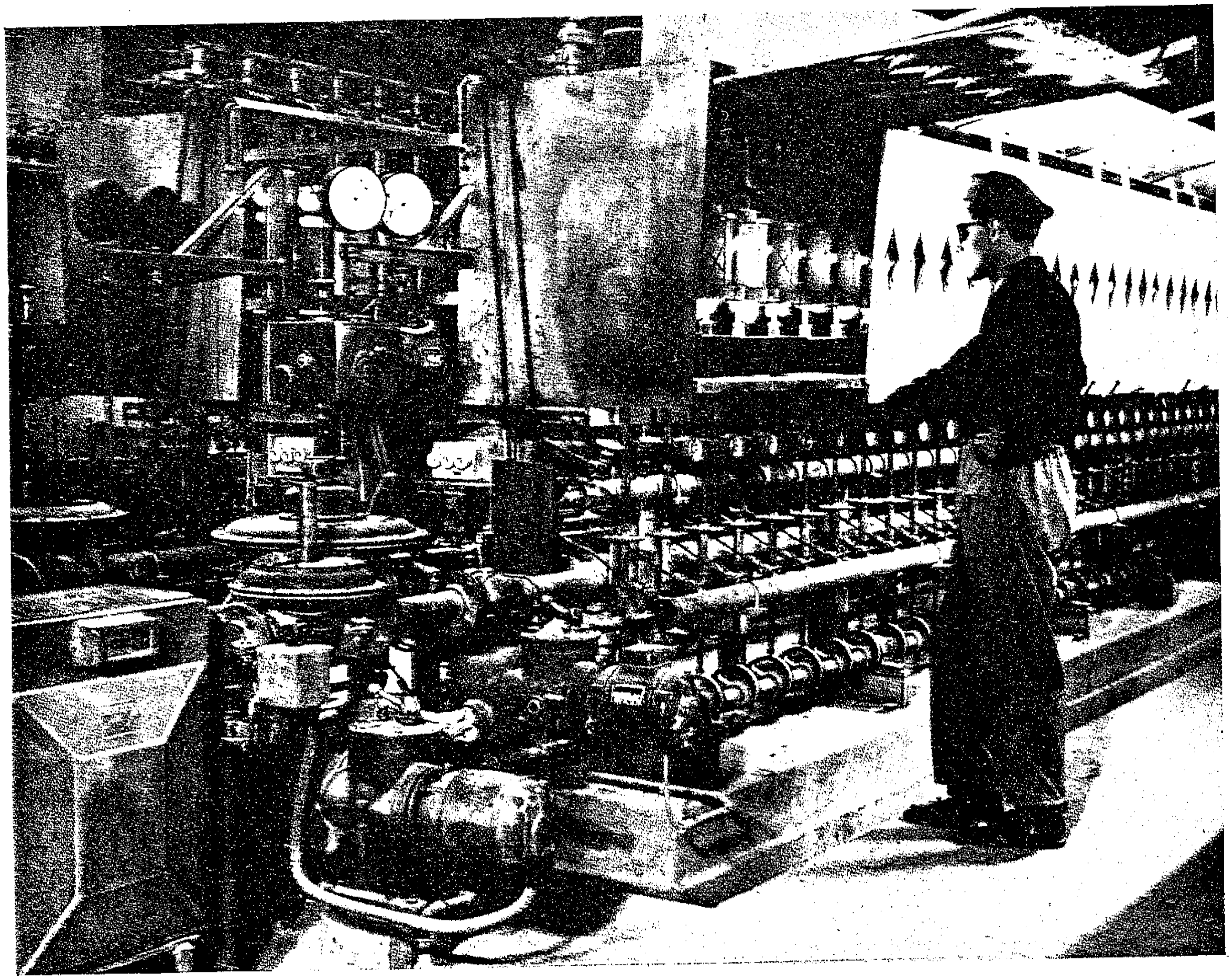


FIG. 12-21

SEC. 303B - Forming the Crystal in a Verneuil Furnace

The powdery oxide is poured slowly into a Verneuil furnace. (Figure 12-21 shows a battery of these at the Sadem factory in Switzerland.) The furnace has an oxyhydrogen flame of about 2,000 degrees Centigrade. As the powder passes through the flame, it fuses into drops. These fall onto and build up on a fireclay base or stick.

This continued action produces a mass shaped like a carrot, Fig. 12-22. The exact heat is important. The furnace technician watches through a door and raises or lowers the stick as necessary so the drop will cool a few degrees before the next one falls. In this way, a crystal is formed. The process takes several hours.

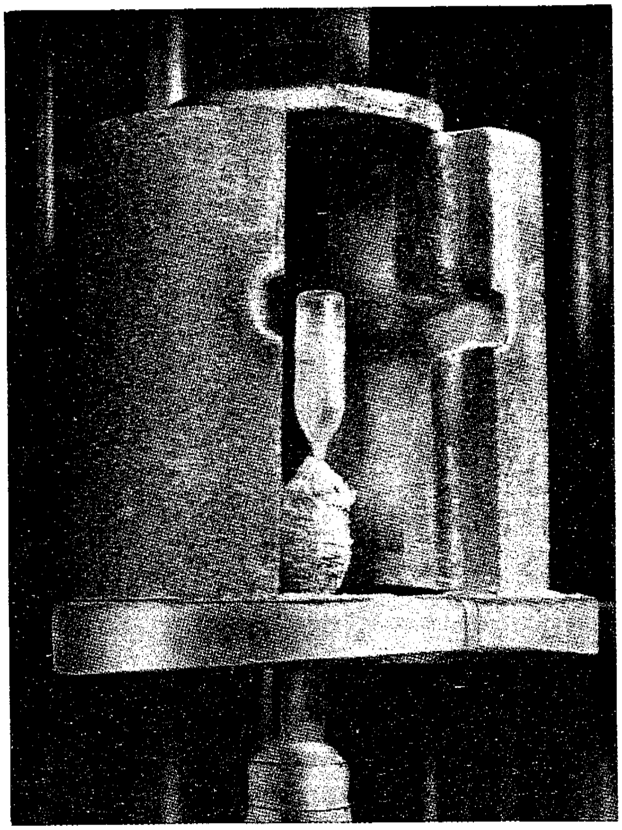


FIG. 12-22

The resultant mass is called a "boule". This is the French word for "ball" since the early boules were ball shaped. Now they are longer in shape and may weigh as much as 800 carats (a little over 5 ounces). Most are smaller, since there is a possibility of the boules developing strains inside and splitting when they weigh over 300 carats. A boule this size will be about two inches long and 3/4 of an inch in diameter. The average boule is about 1/2 inch in diameter, one to two inches long and weighs about 125 carats.

The boule is a single crystal, much more perfect than a natural crystal. It is more uniform, more free of flaws, more easily polished, and considerably cheaper in the quantities required for watches.

SEC. 303C - Value of Jewels

The average jewel costs only 2¢ to 25¢ to manufacture, so that individually jewels are inexpensive. In sum total, however, they represent considerable sums of money. It takes 900 kilos (2025 pounds or more than one ton) of aluminum oxide to make just 1 kilo (2.25 lbs.) of jewels. For jewels of the finest quality, 1 kilo represents a value of 3,000,000 Swiss francs (about $775,000 U.S. -- 1972 value).

SEC. 304-Steps in Watch Jewel Manufacture

The boules are cut into uniform slices with diamond charged copper saws. The slices in turn are cut into small squares. These squares are then turned into round discs on special machines. These discs are called "blanks".

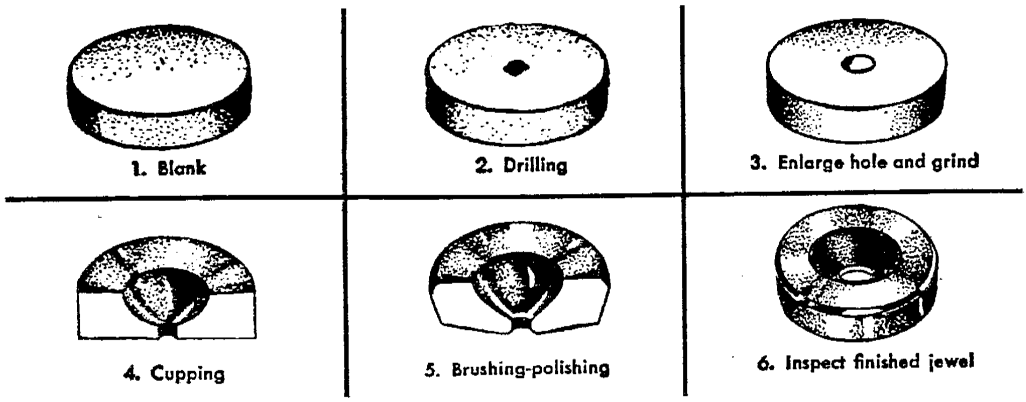
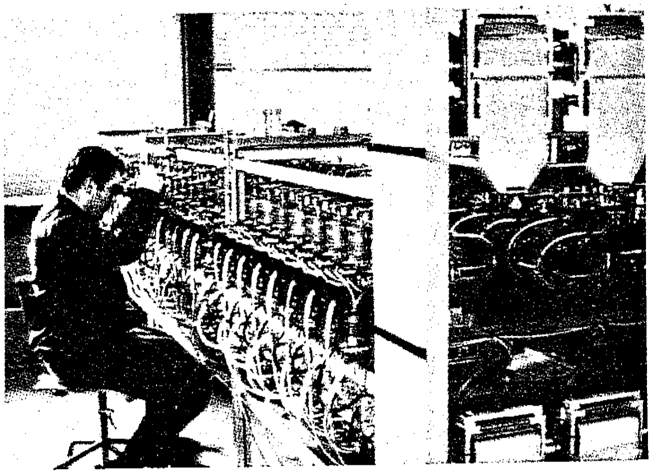
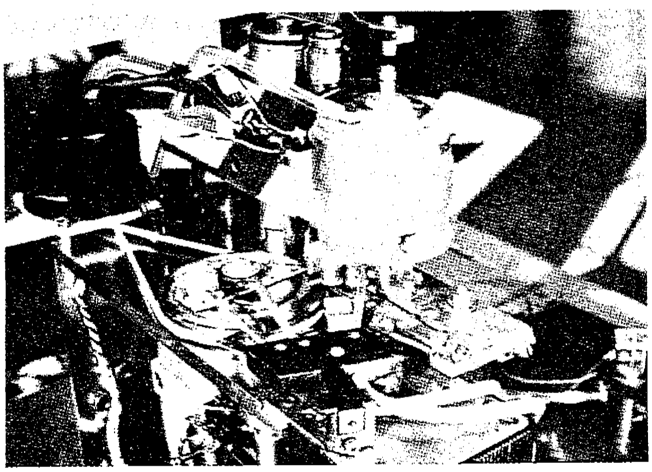


FIG. 12-23

This is the starting point for the actual manufacturing process, which in Switzerland takes place in special watch jewel factories. There are a number of these and all together they turn out over 700 million watch jewels each year (as of 1967). In the early days of manufacturing synthetic jewels, they were still produced by hand and a workman could turn out 200-250 a day. Now, thanks to automatic machinery, a workman can produce some 2500 each day -- ten times as much.



General view of an automatic drilling shop.
FIG. 12-24



Detail of an automatic drill.
FIG. 12-25

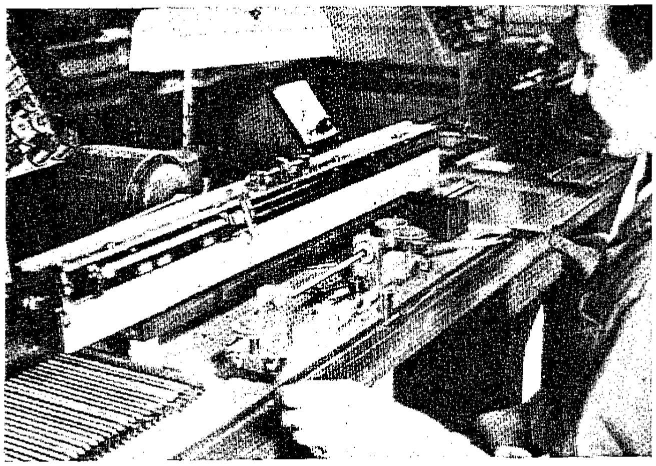
SEC. 304A - Drilling

The first manufacturing step is drilling. For this purpose, fine steel wire "bits" are charged with diamond powder and used to pierce the blank. At this step there is no attempt to obtain precise measurement. That comes later. For now, the purpose is just to get a hole through the blank. Drilling is normally done on automatic drilling machines, Figures 12-24 and 12-25.

After the first working model of the laser beam was accomplished in 1960 by an American named T. H. Maiman, research was begun to see if it was practical to make these holes with a laser beam. (The term Laser stands for Light Amplification by Stimulation of Energy Radiation.) Laboratory results were favorable and later in the decade several companies were formed in Switzerland to set up the process for large scale production. It is hoped in this way to speed up this step in the jewel making process.

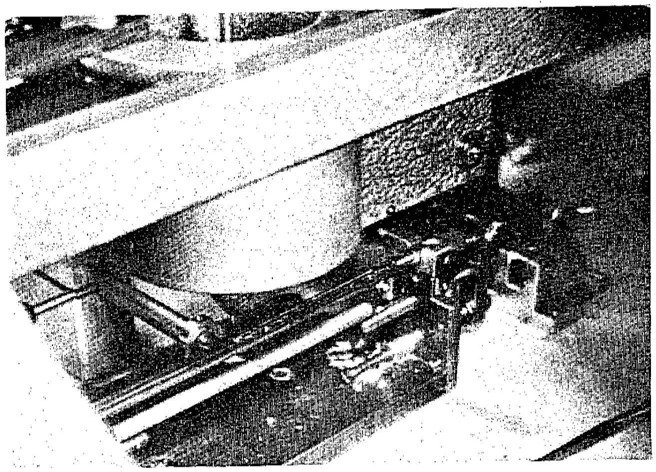
SEC. 304B - Enlarging

In the second step, the hole in the jewel is enlarged to the desired shape and surface finish. Unlike the initial drilling, this step requires exact measurements within



Machine for enlarging small holes.

FIG. 12-26



The gumming-up of an enlarging chain.

FIG. 12-27

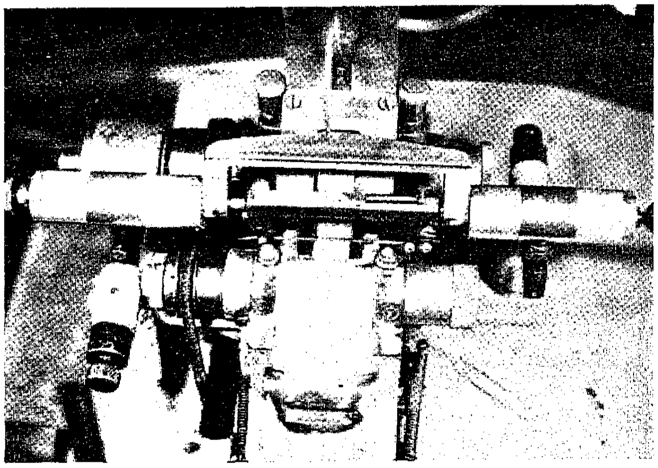
minute tolerances measured in microns. A micron is 1/1,000 of a millimeter. The average human hair is 50 microns in diameter. A micron is 1/50th of this or about 1/25,000 of an inch.

The enlarged hole must have perfectly polished surfaces to cut down friction to the lowest possible point. This demands a surface condition of the most exacting quality. In order to get this quality, the diamond powders used are carefully gra-dated to keep out oversize grains which might groove the desired finish.

Inspection of these surfaces is a most difficult task since the holes are only 1/10th of a millimeter on the average. The pointed instruments and gauges usually used in machining to give an impersonal surface check are useless in these tiny areas. They must be checked by eye. A light is therefore skimmed across the surface of the hole and the machining scratches are examined with a microscope and binoculars.

SEC. 304C - Turning

A third operation is turning. This provides the outer dimensions of the jewels. Cylindrical grinding accomplishes the job. The jewels are placed caterpillar fashion on metallic or synthetic wire the exact size of the hole and crushed diamond

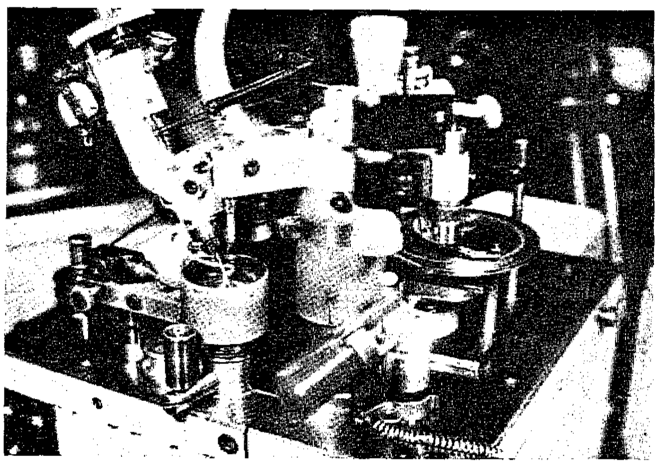


Detail of a turning machine.

FIG. 12-28

General view of a recessing shop.

FIG. 12-29



Detail of a recessing machine.

FIG. 12-30

is used on the grinding machine to shape the outer form of the jewel. It is vital that this outside edge be perfectly concentric with the hole in the center. In contrast to the hole, which is made as smooth as possible, the outer surface is more or less rough (depending upon the intended use for the jewel), so as to better hold it in place.

SEC. 304D - Forming the Oil Cup

The next process is to form a little recess or oil cup. This is done entirely on an automatic machine, Fig. 12-30. The turning tool is actually a very small grinding wheel about 1/2 mm. in diameter. This wheel, shaped like a lead pencil, turns at the rate of 30,000 revolutions per minute.

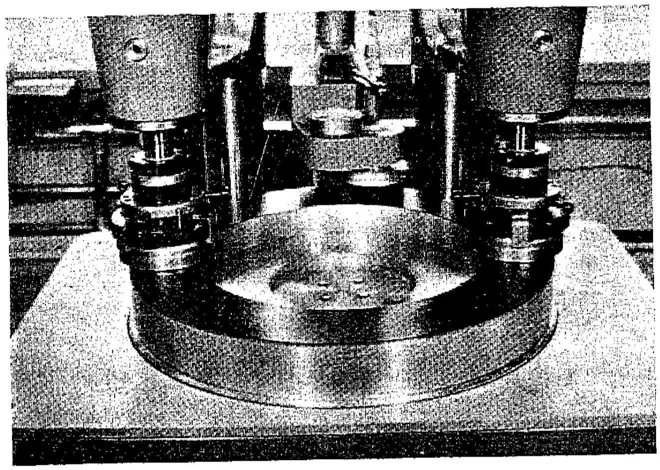
Lubrication is very important at this stage since it is necessary that the jewel be kept cool during the grinding process. Lubrication also serves to keep the wheel from becoming clogged with diamond paste. The preferred lubricant is vegetable oil mixed with other ingredients, although mineral oil is also used.

Most jewels have straight sides. In some it is desirable to slightly round the edges of the hole to produce an olive shaped jewel hole, which offers the least amount of friction.

SEC. 304E - Polishing

The jewels are now cemented onto plates for the polishing process. The first step in polishing is called brushing. The purpose of brushing is to form the rounded off angles, the domed surfaces and the various chamfers required by the type of jewel. A brush charged with diamond paste is used on the outside surface of the jewels as the plate holding them is turned in varying directions.

The second part of the polishing process is lapping, which is necessary to reduce the jewels to the desired thickness. Again, grinding wheels of various types are used for this purpose, Fig. 12-31.



Lapping machine for polishing the flat surfaces of the jewel.

FIG. 12-31

After each stage of these operations, the jewels are cleaned with a mixture of nitric and sulphuric acid, dipped into pure alcohol and dried.

In between the various operations the jewels must be continually inspected. Upon completion, the jewel is enlarged about 35 times and carefully examined to make sure it is perfect in every respect.

CHECK YOURSELF

Progress Check 12 — A Self Test Review of Lesson 12

After you have studied Sections 285 through 302, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. A ______________ mainspring is required when more jewels are added to the same size and model watch.	287
2. In an American 15 jewel watch the additional jewels will be found in the ______________.	288
3. One jewel which has no counterpart is the ______________ jewel.	288
4. Train jewels are also called ______________ jewels, while cap jewels are also called ______________.	289
5. The hollowed out portion of a jewel is called the ______________.	290
6. In order that train pivots may turn freely in the pivot holes, there must be ______________ and ______________.	290
7. Sideshake is the freedom between the sides of the ______________ ______________ and the ______________ in the jewel.	291
8. Endshake is the space between the ______________ of the train jewel and the ______________ on the pivot.	291
9. A ______________ is used to measure holes in train or balance jewels while a ______________ is used to measure pivot diameters.	293
10. The amount of sideshake varies with the ______________ of the pivot.	291 294
11. Train jewels in settings for American watches are usually held in place by ______________.	295
12. Besides identifying the movement when ordering replacement jewels, it is important to give the ______________ and ______________ of the jewel.	296
13. In a raised train jewel setting, the jewel screws are set ______________ the plate.	297
14. The principal parts of a staking tool are: a. ______________ b. ______________ c. ______________ d. ______________	298

Progress Check 12 (continued)

	Section Ref.
15. In addition to the centering punch which is common to all staking sets, the four most used punches are: a. ______ b. ______ c. ______ d. ______	298
16. A ______ hammer is used with the staking set.	299
17. Train jewel settings which do not use jewel screws are held either by a ______ or by ______.	299 300
18. Where a jewel is set directly in the plate or bridge without the use of bushings or settings, it is known as a ______ ______.	301

==

ANSWERS TO PROGRESS CHECK 12:

1. weaker
2. train
3. roller
4. plate
   end stones
5. oil cup
6. sideshake
   endshake
7. square shoulder pivot
   hole
8. face
   shoulder
9. jewel hole gauge
   metric micrometer
10. diameter
11. jewel screws
12. hole size
    description
13. above
14. frame
    punch guide
    die plate
    locking screw
15. flat face solid
    round face solid
    flat face hollow
    round face hollow
16. brass
17. bezel
    friction
18. plate jewel

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 12

Name: No.: Date:

Circle the correct answer or answers: SUBJECT: Factory Set Train Jewels

1. A 7 jewel and a 21 jewel watch of the same size and model will require:

   Different width of mainspring | Different strength of mainspring | Different width and strength of main-spring | The same main-spring

2. How many additional wheels have jeweled bearings in a 15 jeweled watch compared to a 7 jewel watch?

   Four | Three | Two | One

3. Which one of the following jewels is NOT used as a bearing for wheels?

   Pallet stone | Train jewel | Balance hole jewel | Cap jewel

4. The train wheels of a watch should have:

   Endshake only | Sideshake only | Both sideshake and endshake | Neither sideshake nor endshake

5. Sideshake is defined as:

   The freedom between the outside diameter of the pivot and the hole in the jewel | Difference between the outside diameter of the jewel and diameter of hole in jewel | The space between the face of the train jewel and the shoulder of the pivot | Freedom of the jewel in the setting or plate

6. Holes in train jewels are measured with:

   A millimeter gauge | A ligne gauge | A micrometer | A jewel hole gauge

7. In selecting a jewel for a replacement, which one of the following is NOT done until after the other three?

   Measure pivot with micrometer and select jewel | Test jewel on pivot for freedom or sideshake | See if shoulder on setting is same as on the old setting | Place jewel in plate of watch

8. The top of a staking tool frame is bored to receive the punches and hold them upright and at right angles to the:

   Frame | Die Plate | Locking Screw | Punch Guide

9. Some American watches have a train jewel setting in the pillar plate which is held in place without screws by means of a bezel burnished over the edge of setting. This type setting is removed when broken by:

   Loosening setting with a large screw driver | Using a brass hammer, punch and staking tool | Pushing out with a piece of pegwood | Pushing out with the jewel pusher

10. The friction jewel setting differs from the one described in question 9 in that: (Circle all correct answers)

    It has no shoulder | Endshake can be adjusted by driving in or out | It is held in place by a bezel | It is held in place by friction

11. In replacing a friction jewel, if bridge does not rest solidly on the staking die, you can:

    Press jewel in or out with a jewel pusher | Use a bench block | Use a flat face stump | Use a round face stump

12. In the Swiss type jewel set directly in the plate without use of settings or bushings, the jewel is held in place by

    Two jewel screws | One jewel screw | A bezel burnished over edge of jewel | Friction

Detach page or cut along this line — and send to the School for grading.

Master WATCHMAKING

Lesson 13

FACTORY BALANCE HOLE JEWELS AND ROLLER JEWELS

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

Printed in the United States of America

13

INTRODUCTORY INFORMATION

No doubt you have noticed by now that watch jewels have different shapes for their different uses. A curved jewel is commonly used for balance pivots, escape wheel pivots and pallet arbor pivots, although a flat, friction-type balance hole jewel may also be used. (See Section 333 in Lesson 14.)

The curved surface was designed to aid in oiling because oil (like other liquids) has a tendency to flow into a narrow space. A simple experiment will show you how this occurs. Take two pieces of flat glass and place two edges together but separate the opposite edges slightly. If you now insert a little oil between them, it will tend to run to where the edges come together. This action or physical phenomenon is called "capillary attraction" and is the means by which oil is held around the pivot end until the oil evaporates (about one year under normal conditions).

If the balance hole jewel and cap jewel are set too far apart, the capillary attraction is reduced and the oil is liable to be drawn away. Hence, it is important to adjust this space between the two stones so the bubble of oil can properly form around the pivot. The customary clearance is about 0.02mm (2/100). You were instructed in Lesson 10 on the method of oiling in which you insert a drop of oil in the oil cup of the hole jewel and force it down with a needle.

When the balance hole jewel is flat, some watchmakers apply a drop of oil to the cap jewel before it is screwed into place. (Some types have a groove to show the extent of the area to carry the oil, but if not, the oil is limited to a similar sized area.) After the balance jewel is in place, a drop of oil is applied as usual to the oil cup.

The types of balance hole and cap jewels and settings for American and Swiss watches described in this lesson have been in use for many years and are still in use. However, as was true for train jewels, it is not always possible to get replacement parts for the older watches whose manufacturer is out of business.

Of the different shapes of roller jewels illustrated in this lesson, only the D-shaped jewel is now in common use. In some modern Swiss watches, the roller jewel is friction fit in the roller.

KEY POINTS OF LESSON ASSIGNMENTS 43, 44, 45, 46:

- The difference between straight and olive hole balance jewels.
- The proper amount of sideshake for balance pivots.
- How to remove and replace the balance jewel assembly.
- How to order factory set balance and cap jewels.
- Balance jewel assemblies in Swiss watches.
- The purpose of the roller jewel.
- The different shapes of roller jewels.
- The different types of rollers.
- How to determine the proper size roller jewel to use.
- How to set a roller jewel.

ASSIGNMENT NO. 43: Study Sections 305 through 311.

Study Questions:

1. What is the difference between straight and olive hole balance jewels?
2. What is the relation of the balance and cap jewels to the pivots?
3. How much side shake is correct for balance pivots?
4. How is the balance assembly taken apart?
5. What information is needed to order a factory balance jewel?

Supplementary Information:

Section 307: The type jewel settings illustrated in Figures 13-5 and 13-6 are still in use on many models of American watches. Replacement parts are usually available.

Recommended Practice:

Remove the balance, cap and hole jewels from an American watch, preferably large size. Clean, examine and replace.

ASSIGNMENT NO. 44: Study Sections 312 through 313.

What is the difference between Swiss and American balance jewel assemblies?

Supplementary Information:

Section 312: This type of jewel and setting is still in common use. The cap jewel and setting can usually be replaced, except in older models. The balance hole jewel is a burnished-in type. You can replace it with a friction jewel set into the balance bridge.

Section 313: This type of setting is in common use. The balance hole jewel is a friction jewel set in a friction bushing. Equally common is a friction jewel set directly into the bridge without use of a bushing.

Recommended Practice:

Remove, examine, clean and replace the balance jewel assembly in a Swiss watch.

ASSIGNMENT NO. 45: Study Sections 314 through 316.

1. What stock jewel assortments are recommended?
2. How should small and delicate parts be wrapped for shipment?
3. How do the illustrated Hamilton and Illinois balance assemblies differ from other American assemblies?

Supplementary Information:

Section 315: This type of assembly is still used by the Hamilton Watch Company. It is generally possible to get replacement parts regardless of the age of the watch.

ASSIGNMENT NO. 46: Study Sections 317 through 325.

1. What is the purpose of the roller jewel?
2. What are the different shapes of roller jewels?
3. What are the types of roller tables?
4. Is the roller jewel set in the impulse roller or the safety roller?
5. How are roller jewels gauged?
6. What clearance is allowed between the roller and fork slot?
7. What preparations are made before setting a roller jewel?
8. What is the procedure for setting the roller jewel?
9. How is the roller jewel straightened, if set awry?
10. What is the correct length of the roller jewel?

Recommended Practice:

1. Make the tool illustrated in Figure 13-20.
2. Make the tool illustrated in Figures 13-24-1 and 13-24-2.
3. Remove the roller jewel from a practice watch. Clean the hole and the roller jewel and prepare the cement. Then replace the roller jewel. Be sure the roller jewel is set straight and cemented properly so it will not work loose. Clean off any excess cement from the roller jewel and roller table.

REQUIREMENT:

➧ Answer all Test Questions for Lesson 13 and return for grading.

MASTER WATCHMAKING
A Modern, Complete, Practical Course
CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Lesson 13
Sections 305 to 325

FACTORY BALANCE HOLE JEWELS AND ROLLER JEWELS

SEC. 305—Olive Hole Jewels

The train jewels shown in the previous lessons had holes through them, the walls of which were straight. In balance hole jewels, there are two types of holes; one type has straight walls

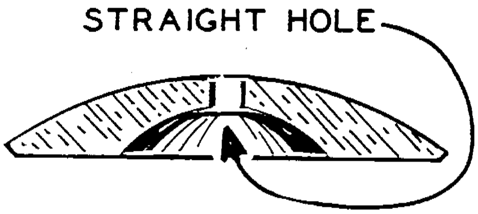


Fig. 13-1

as in the train jewels, figure 13-1, while the other has curved walls and is called an olive hole jewel, figure 13-2. The olive hole gives a smaller bearing surface without sacrificing

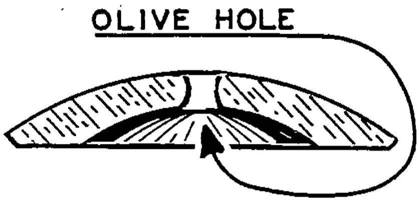


Fig. 13-2

strength and tnere is less adhesion of oil between the jewel hole and the pivot.

SEC. 306—Balance and Cap Jewel Assemblies

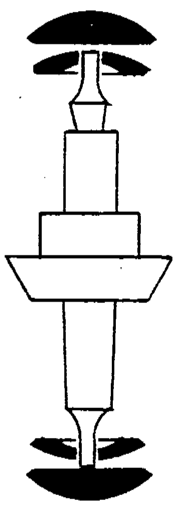


Fig. 13-3

Balance hole jewels are used in connection with cap jewels as bearings for pivots with conical shaped shoulders such as are found on the balance staff. Figure 13-3 is a drawing of cone pivots. In the lesson on train jewels you learned that the side and shoulder of the square shoulder pivot came in contact with the jewel. With a conical pivot, the cone is never in contact with the jewel. The bearing surfaces are at the end and side.

Balance hole jewels are used as bearings for all conical pivots. The name "balance hole jewel" applies to these jewels when they are used as bearings for the balance staff. However, the same type of jewel assembly is used in watches such as railroad

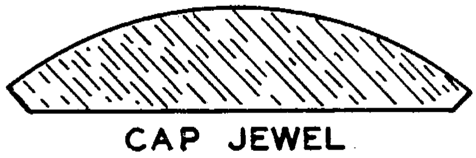


Fig. 13-4

watches where cap jewels are used on pallet and escape wheel assemblies.

The cap jewel, figure 13-4, known also as the end stone, differs from either the balance hole or train jewel in that it has no hole through it but is a plain, highly polished surface, which acts as a bearing for the end of the pivot. The pivot projects through the balance hole jewel and the only part of the pivot that comes in contact with the cap jewel is the end. The cap jewels, one of which is located at each end of the balance staff, determine the amount of endshake for that particular balance staff.

SEC. 307—Relation of Balance and Cap Jewels to Pivots

In figure 13-5 is shown the relation of the balance hole jewel D, balance cap jewel C, and the balance pivot. Here you can see that the pivot is held in its central position by the hole in the balance hole jewel and that it is kept from extending too far through that jewel by the cap jewel. In this assembly, each jewel is burnished in a setting and the two settings placed in one opening, the two lower jewels or foot jewels in the pillar plate and the upper jewels or cock jewels in the balance cock. The balance jewel assembly in American watches usually is a setting with a shoulder as shown in figure 13-6. The setting for the cap jewel, figure 13-6, generally has counterbored openings for the heads of the jewel screws. Figure 13-6 also shows the position that they occupy when fitted to the balance cock, C representing balance hole jewel in its setting, B the cap

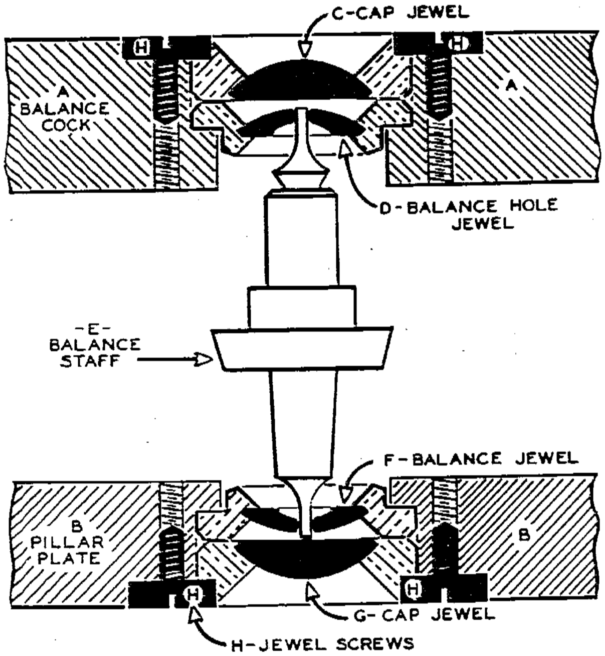


Fig. 13-5

jewel in its setting, D the jewel screws, and A a section of the balance cock.

SEC. 308—Chart to Determine Proper Sideshake

Measure balance pivot with your micrometer and use the following chart to obtain the proper freedom or sideshake:

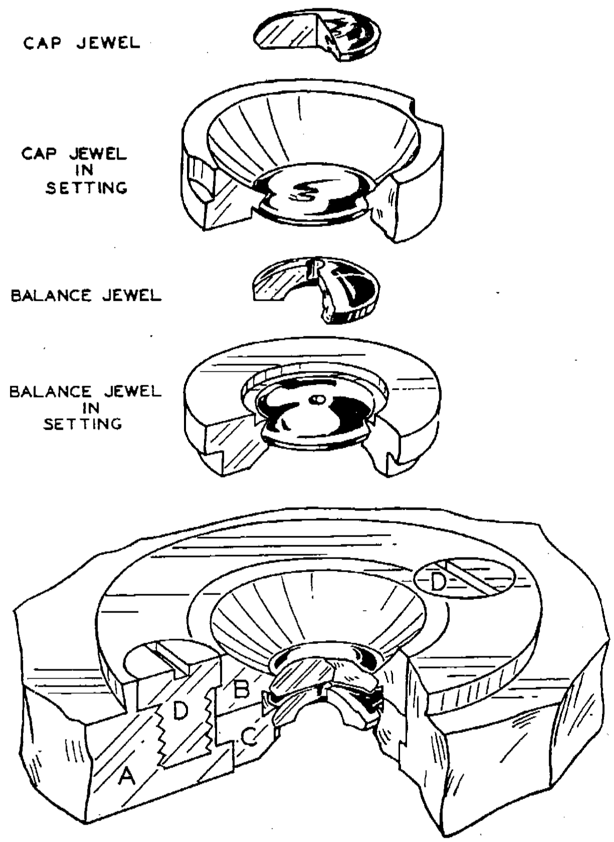
Pivot Measures in 100th of a mm	Use Jewel with Hole
.05	.06
.06	.07
.07	.08
.08	.09
.09	.10
.10	.11
.11	.12
.12	.13
.13	.14
.14	.15

Always test the jewel on pivot before replacing. Jewel holes may vary in size slightly. If a properly set balance jewel is placed over a correctly shaped balance pivot, the pivot should go through easily and extend through the jewel about the same distance as its own diameter. Should the pivot not extend through, it is liable to bind when the movement is in such a position that the pivot is running on the cap jewel.

SEC. 309—Removing Balance Jewel Assembly

The following procedure is used to remove American balance jewel assembly held in place by jewel screws:

1. Remove jewel screws.



A – Balance Cock
B – Cap Jewel In Setting
C – Balance Jewel In Setting
D – Jewel Screws

Fig. 13-6

2. Place cock or pillar plate over large hole in bench block.
3. Select proper size jewel pushers and force balance and cap jewel out.
4. Separate balance jewel from cap jewel.

With a sharp knife, cut off the end of a piece of pithwood to get a clean, flat surface and with this wipe off any dirt or oil that may be on the faces of the two jewels. When a watch has not been cleaned for a long time or when a poor grade of oil has been used, the surface of the jewels may be covered with gummed or dried oil which the pithwood will not remove easily. In such instances, scrape clean the face of the jewels with the end of a piece of pegwood cut to a chisel shape, and then clean with cleaning solution. Examine each jewel separately using a double eye glass to determine if they are cracked or broken, and whether or not the balance hole jewel is chipped around the hole. If cracked, broken or chipped, it should be replaced with a new jewel.

Sometimes the cap jewel may be found with a slight "pit" in the center of its flat surface where it has been in contact with the pivot.

If the cap jewel is cracked or "pitted", it also should be replaced.

Having examined the jewels to see that they are perfect, cleaned the surfaces and pegged out the hole in the balance hole jewel, you are now ready to replace them in the balance cock, but before doing so, be sure to test the balance hole jewel on the balance pivot to see that it fits correctly.

The main reason we insist that students practice upon better grades of watches, and those which have not been worked upon by incompetent workmen, is so that they may be able to acquaint themselves with the correct relations and fittings of the associated parts. If, at this time, you are working upon a watch that is in first class condition, you can obtain a very good idea of the proper relation of the balance hole jewels and the pivots by testing each hole jewel on the proper pivot.

SEC. 310—Replacing Balance and Cap Jewel Assembly

Your first step in replacing the jewels will be to insert the balance hole jewel in the opening in the balance cock and to press it down against the seat, using a jewel pusher. Having done this, press the cap jewel in place using care to see that the counterbores match on the jewels and balance cock. Press the cap jewel down firmly against the balance hole jewel and if it is the correct size, the flat surface of the cap jewel setting will be flush with the top of the opening in the balance cock. Insert the balance jewel screws and turn them down until tight. Be very careful and avoid getting any scratches or marks on the cap jewel setting. As you will observe, this setting is stripped and burnished on the top to a high polish. You should endeavor at all times to protect this fine finish.

Having replaced the jewels, you should now proceed to assemble the balance, making certain that there is the proper amount of endshake and that there is no noticeable sideshake on the balance staff.

In fitting a new balance hole jewel, try the pivot to see that the hole is of proper size and compare the shoulder height of the setting with the old one. If this shoulder is not the same as the old one, it will make a difference in the endshake. The new setting must be of the right diameter to insure its being neither too tight nor too loose. If the old cap jewel setting was of the right thickness, the new one should have the same measurements. A variation in this dimension will make no difference in endshake as long as it is pressed down firmly against the balance hole jewel setting, but if it is a flat setting, it will make a difference in appearance as the top surface should be flush with the balance cock. Should the countersinking at the end of the cap jewel setting be too deep, the balance screw heads may not hold it firmly in place and this loosening of the setting will cause trouble in timing or rating or might even stop the watch under certain conditions.

SEC. 311—Ordering Factory Jewels

To order a balance hole jewel from a material house, it is only necessary to remove both settings, measure the pivot with micrometer, and select or order a complete new jewel and setting, allowing the difference between hole and pivot size as listed in Section 308.

Example:

Pivot measure .11 mm

1-12s Elgin upper balance jewel hole .12

1-12s Elgin lower balance jewel hole .12

To replace cap simply select or order:

1-12s Elgin upper cap jewel

1-12s Elgin lower cap jewel

Always specify whether upper or lower balance or cap jewel when reordering. Lower jewels may not be of the same dimensions as the upper. Compare shoulders and thickness of settings.

SEC. 312—Balance Jewels in Swiss Watches

As you have already learned, the American manufacturers set their balance jewels in separate settings which fit openings in either the balance cock or pillar plate. In some Swiss watches, however, a slightly different method is used. The upper cap jewel setting is held in place by two jewel screws inserted from the *lower* side of the balance cock, extending through it and threaded

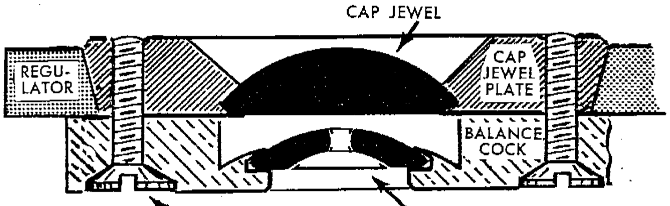


Fig. 13-7A

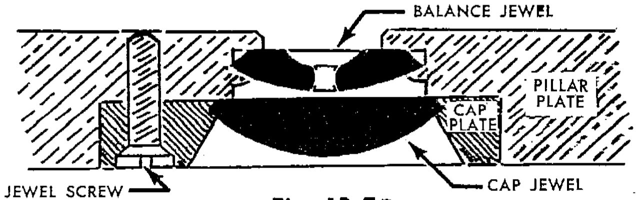


Fig. 13-7B

into the cap jewel plate. (Figure 13-7A) The lower cap jewel setting is held in place by just *one* jewel screw inserted through the cap jewel plate into the pillar plate. (Figure 13-7B) The balance jewels are burnished directly into the balance cock and pillar plate.

To replace the old jewels, force them out. Open the bezel with bezel opener. Select balance jewel of correct diameter and hole size. Replace and burnish. (Similar to Sec. 301, Lesson 12.) However, it is more practical nowadays to replace this burnished type with friction jewels.

The inverted position of the upper jewel screws sometimes causes confusion in reassembly for those accustomed to top side replacement as done on American movements. You can avoid a tendency to set these jewel screws in from the top by reassembly in this way: First, lay down the cap jewel plate upside down. Place the regulator over the cap. (The lower edge of the cap jewel plate is beveled to match the inside of the regulator.) Turn the balance cock upside down also and set it so the two screw holes are directly over the holes in the cap jewel plate. Finally, insert the screws from this side.

When the regulator is in place and the cap jewel plate tightened by the jewel screws, the regulator will be held securely because the overlapping top edge of the cap jewel plate acts as a wedge to hold the regulator.

SEC. 313—Swiss Friction Settings

Figure 13-8 illustrates the modern balance hole and cap jewel assembly used in Swiss watches. Here the cap jewel is held in place in the cap jewel plate by friction and the plate is held in place by two jewel screws set in from the under side. The balance hole jewel is held in the setting by friction and the setting is in turn a friction setting set in the cock or pillar plate. Replacing this type of jewel comes under friction jewelling.

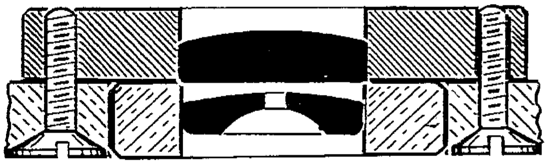


Fig. 13-8

You may find old Swiss watches in which the cap jewel is merely set under the cap without being held in place by the bezel. This naturally does not give the proper distance between the cap jewel and the balance hole jewel since the cap jewel then sets directly on the balance hole jewel and the oil has a tendency to spread away from the pivots.

SEC. 314—Balance and Cap Jewel Assortments

Most watchmakers carry assortments of balance hole and cap jewels to fit the more common American watches. In the better arranged assortments of balance hole jewels in settings each bottle or capsule contains jewels for a specified size of watch and with the assortment is an index showing these makes and sizes. Thus if you wish to replace the upper balance hole jewel of a 16 size Waltham watch, find on the index card the number of the bottle containing the upper balance hole jewel for a 16s Waltham movement. As explained in Sec. 308, if the pivot measures .10 mm, you should select a jewel with a .11 mm hole in order to get the proper amount of sideshake. The jewel selected will not necessarily fit exactly, and it must be tried on the pivot before placing in the watch.

It is not necessary to carry a large assortment of cap jewels as one bottle for each size is sufficient. Nor is it necessary to subdivide the sizes as one cap jewel will suffice regardless of the size of the pivot, provided the setting is of the correct diameter and thickness.

When ordering a single balance hole jewel, state the make and size of watch for which it is intended, whether a cock or foot jewel, and the size hole desired. Send in the old jewel with your order. If not sure of the hole size, send in the balance also. In shipping a balance or any small part of a watch by mail, to protect it in transit, always wrap it in watch paper and place it in a small metal box or container. If a cap jewel is ordered, give make and size of movement and whether cock or foot jewel and send in old jewel setting as a sample.

SEC. 315—Hamilton Balance Jewel Assembly

Figure 13-9 is a cross section of a Hamilton style balance jewel assembly. The balance jewel setting, which is a friction setting, holds the cap jewel in place. Remove and replace with staking tool or jewel pusher.

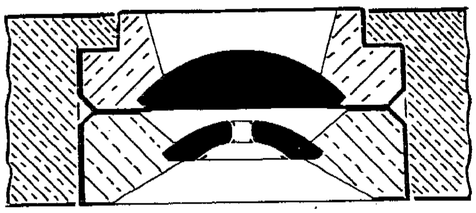


Fig. 13-9

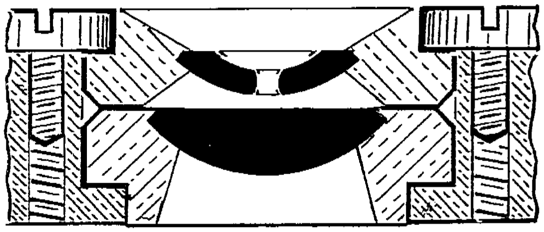


Fig. 13-10

SEC. 316—Illinois Balance Jewel Assembly

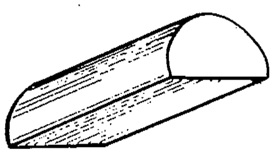
Figure 13-10 illustrates a type of balance and cap jewel setting found in some models of watches, namely, Illinois. The settings are removed and replaced by removing the jewel screws and removing the settings from the under side of the balance cock or pillar plate.

SEC. 317—Purpose of the Roller Jewel

The impulse from the fork is conveyed by means of the jewel pin, or roller jewel as it is more commonly known, and causes the balance to turn. It is sometimes referred to as the impulse pin. This pin or jewel is set in the roller table by means of shellac and the roller is driven on the lower tapered end of the balance staff friction tight. The roller table is made of steel or of softer metals such as nickel, oreide, etc. In some models of watches using a composition roller, the roller jewel is forced into place without the use of shellac or cement.

Roller jewels are made of garnet, sapphire, or ruby. Garnet roller jewels are softer and are broken more easily than ruby or sapphire jewels; the difference in cost is so slight that it is advisable to use the better quality of roller jewels for your repairs.

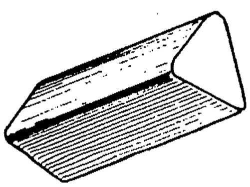
SEC. 318—Shapes of Roller Jewels



HALF ROUND OR -D- SHAPE

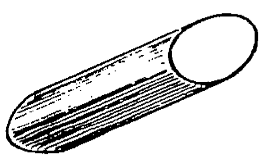
Fig. 13-11

There are several different shapes of roller jewels. The so-called half round is more the shape of a D, as shown in figure 13-11. This type of roller jewel is used in the majority of modern watches. Occasionally you may find watches with triangular shaped roller jewels as shown in figure 13-12. These are used in some of the higher grades of Swiss watches. Another type is the oval roller jewel illustrated in figure 13-13.



TRIANGULAR

Fig. 13-12

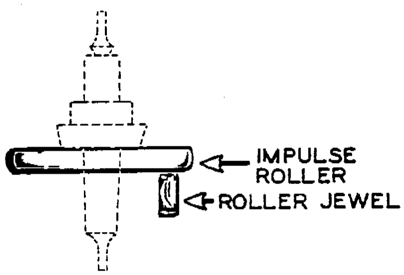


OVAL

Fig. 13-13

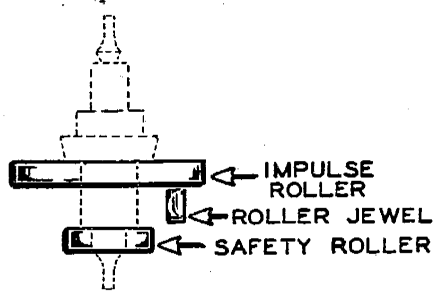
SEC. 319—Types of Roller Tables

There are three types of rollers or roller tables used in modern watches. Most of the older models of watches are equipped with the single roller as illustrated in figure 13-14, in front of which has been milled out a small section called the passing crescent. Another type, the two piece double roller, consists of two separate rollers. The larger one carries the roller jewel and is known as the impulse roller, while the smaller one contains the passing crescent and is called the safety or guard roller. The balance staff used with this type of double roller has two shoulders and each roller is fitted to its respective shoulder. In figure 13-15 the larger of the two rollers contains the roller jewel while the guard roller, which is below, contains the passing crescent. While the impulse roller is usually thought of as being circular in form, any other shape will perform as well provided it fulfills the function of carrying the roller jewel at the required distance from the balance staff and does not throw the balance out of poise. The most common form of double roller is called the combination roller, figure 13-16. Here the impulse roller



SINGLE ROLLER

Fig. 13-14



TWO PIECE DOUBLE ROLLER

Fig. 13-15

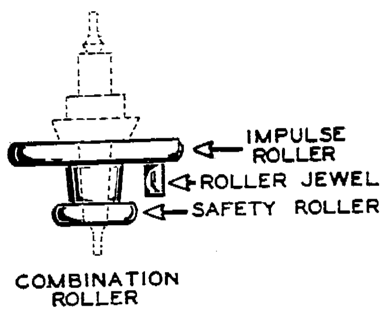


Fig. 13-16

and safety roller are permanently connected by means of a tube or pipe. They are held in place on the balance staff by friction and the staff requires only one seat similar to the one used with a single roller.

SEC. 320—Gauging Roller Jewels

Roller jewels are gauged in hundredths of a millimeter. Thus a roller jewel size 30 measures 30/100 mm across its greatest diameter.

The freedom or "shake" between the roller jewel and the slot in the fork should be approximately .015 to .02 mm. Formerly, it was customary to gauge the roller jewel by holding it with the tweezers and trying the freedom or shake by moving it back and forth in the slot of the fork. Many a jewel has been snapped out of the tweezers while doing this. A roller jewel gauge used in combination with an assortment of roller jewels in metric sizes has done away with this troublesome test and has made the selecting of the roller jewel a comparatively simple problem for any watchmaker to master. Figure 13-17 illustrates a roller jewel gauge which consists of a series of leaves somewhat on the order of a feeler gauge. Each leaf or feeler is stamped with a number which corresponds to the number of sizes used in the roller jewel

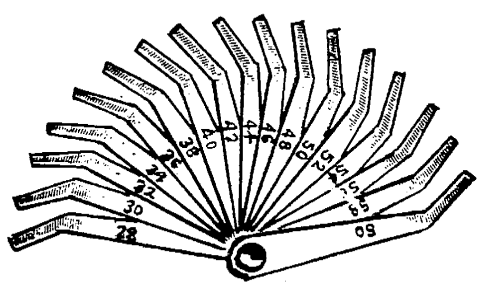


Fig. 13-17

assortment. With this instrument you can readily gauge the width of the slot in the fork, and allowing .01 to .02 mm for freedom or shake, arrive at the correct size of jewel to select from an assortment. It is not necessary to take the watch apart to do this; merely remove the balance cock and balance and select the gauge, the tip of which fits the slot in the fork without shake but yet is not tight enough to stick, figure 13-18. With this gauge it is not necessary to figure the amount of sideshake on the jewel; merely select a jewel approximately .02 mm smaller than the number on the particular

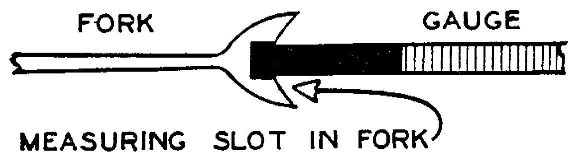


Fig. 13-18

gauge that fits the slot. Example: Gauge stamped 36, select jewel 34. It is advisable to try jewel in fork slot before setting. The following chart gives the most common sizes and their comparative sizes on the gauge:

Slot in fork measures	Use roller jewel
28	26
30	28
32	30
34	32
36	34
38	36
40	38
42	40
44	42
46	44
48	46
50	48

SEC. 321—Preparation For Setting Roller Jewel

A broken roller jewel is a frequent cause of stoppage in a watch and it is an easy matter for the master watchmaker to locate this trouble. Suppose a customer brings a watch to you for repairs. In your examination of the balance staff give the watch a slight circular twist to make the balance swing back and forth. Should you find that while the balance oscillates freely the fork does not move, you can feel justified in making an estimate for a new roller jewel. The jewel usually breaks flush with the roller table and it is an easy matter to press the remaining piece of jewel out of the roller with a pointed steel wire or needle.

Before replacing the new roller jewel, remove all old cement with a chisel-shaped piece of brass wire. Brass is used because it will not mar the surface of the roller yet it is harder than the cement. Figure 13-19 illustrates a tool which can be made from a piece of brass or nickel wire about 2 mm in diameter and approximately 35 mm long. Figure 13-20 is an enlarged view of this tool.

The hole into which the jewel is to be set should be cleaned with a piece of pegwood

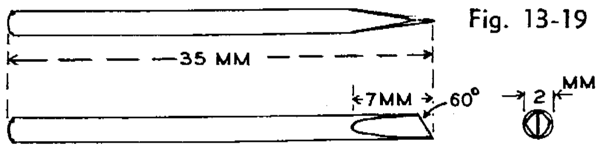


Fig. 13-19

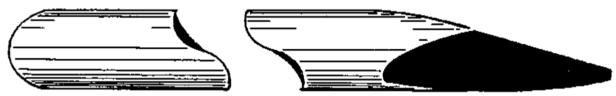


Fig. 13-20

sharpened to a long point. Twist the pegwood, which has been dipped in alcohol, around in the hole until all of the old cement has been removed. Select a jewel to fit the slot in the fork, and see that it is absolutely clean. Holding the jewel in a pair of tweezers, dip it in alcohol and press the jewel into pithwood. It is essential that the hole in the roller and the jewel be perfectly clean in order that the jewel can be set securely. The main cause of loose roller jewels is that the hole and jewel were not absolutely clean or the cement had been overheated.

SEC. 322—Preparing Cement

Practically all roller jewels are held in place by means of cement. Once in awhile you may find one set in a composition roller without cement. These jewels are pressed into position. Liquid cement is not recommended for setting roller jewels. You will find shredded shellac will serve the purpose better and if prepared properly, is more easily handled. Prepare as follows: Heat the end of a stick of lathe cement or shellac in the flame of an alcohol lamp, turning it over and over until the end becomes very soft. Be careful not to burn it. Grasp a small portion of the warmed cement with a pair of tweezers and pull it out into a string of cement. If you desire a thin string, pull it out rapidly and for a thicker string, pull it out more slowly. It is wise to prepare a number of these threads of shellac for future use. See figure 13-21.

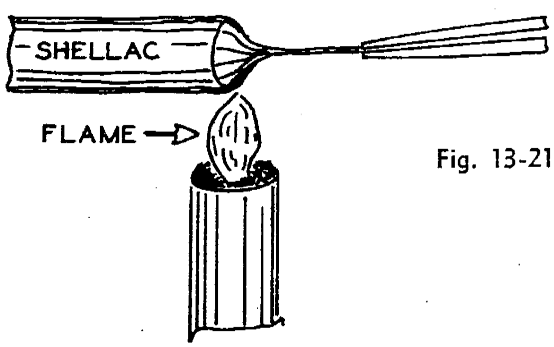


Fig. 13-21

SEC. 323—Setting the Roller Jewel

There are a number of tools on the market designed for use in setting a roller jewel. Some of these will work very well on one type of roller but not on another, or perhaps they will work all right on large sizes of watches but are not very satisfactory for bracelet watches. With other types it is necessary to remove the roller from the staff.

The combination tool shown in figure 13-22 will be found satisfactory for the average watch and can be used for either single or double rollers without removing the roller from the staff. The combination tool holds the roller table on the edge and conveys the heat applied from the alcohol lamp to the table and jewel while setting or adjusting.

To set a roller jewel, open the jaws of the tool, figure 13-22, by pressing the button at A and catch the roller between the grooved jaws B with the balance above the flat faces of the jaws. The hole which receives the roller jewel should be centered between the jaws and toward the open portion of the jaws. In replacing the jewel it will be necessary to turn the combination tool over. Apply heat to the extreme end of arm C with the flame of your alcohol lamp, and when hot enough to melt the cement, insert the end of a thread of cement into the hole in the roller until it is completely filled. After pulling the rest of the cement away, apply heat to arm C again until cement flows evenly in hole. While the cement is still warm, insert the previously selected and cleaned roller jewel into the hole with the tweezers, pressing it through the warm cement until the jewel is flush with the top of the roller table. Warm again and touch the end of cement

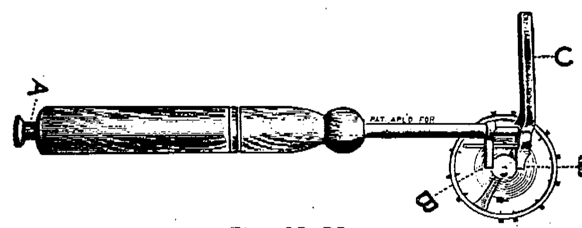


Fig. 13-22

thread to the top of the jewel until it melts over the end of jewel and roller table. Keeping the roller warm, grasp the roller jewel with the tweezers and move it up and down in order that the cement will completely surround the jewel in the hole. Remove and let cool and then with the tool illustrated in figure 13-19, remove all surplus cement from the face and sides of the jewel and also from roller table.

SEC. 324—Straightening Roller Jewel

The roller jewel must be so adjusted that the flat side forms a right angle with an imaginary line drawn from the center of the balance staff through the center of the roller jewel. If after setting the jewel you find the face at an incorrect angle, it can be adjusted by grasping the jewel with the tweezers and twisting it around to the angle desired, figure 13-23. In this case, the tweezers must be moved in the direction of arrow C to line A-B. Do not try to move jewel without preheating the roller table.

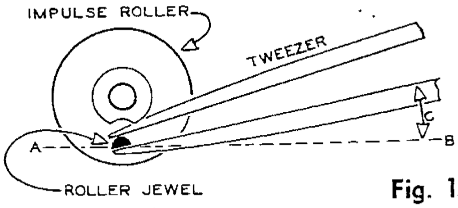


Fig. 13-23

The jewel, when viewed from the front and side, should form a right angle with the roller table. To straighten roller jewel file to the shape shown in figure 13-24-1 & 2 a piece of brass wire about 2 mm in diameter and mount

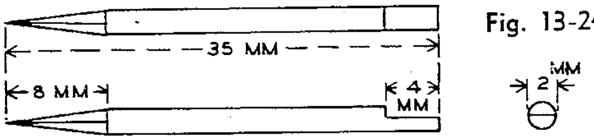


Fig. 13-24-1


Fig. 13-24-2

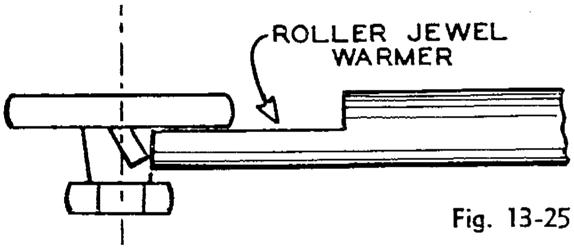
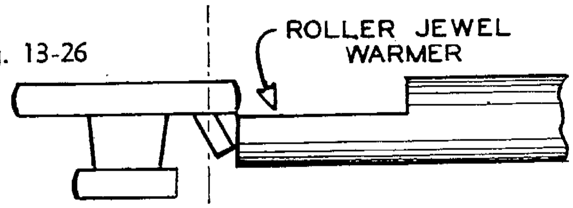


Fig. 13-25

it in a small handle. In using this handy tool, the end is heated with the alcohol lamp and pressed against the jewel as shown in figures 13-25 and 13-26. The heat applied need only be sufficient to soften the cement, after which it is an easy matter to press the jewel into an upright position. At first you may have a tendency to press too hard, pushing the jewel until it stands in the opposite direction. Repeat the operation until jewel is correctly positioned. After a little practice you will find the correct amount of pressure to apply. Care must be taken in applying heat to the roller in order to avoid burning the cement. When the cement becomes glossy and will spread, it will be of the correct temperature. Never heat the roller enough to cause it to discolor.

SEC. 325—Correct Length of Roller Jewel

The length of the roller jewel must be taken into consideration when selecting one for either the double or single roller. For a double roller, the jewel must be long enough to extend through the fork yet not long enough to come in contact with the guard dart. This can be judged by sighting across the guard roller. Figure 13-27 shows the length of the roller jewel. If the roller jewel extends down far enough to come in contact with the guard dart, the watch will stop. The roller jewel in a single roller must be long enough to extend through

Fig. 13-26


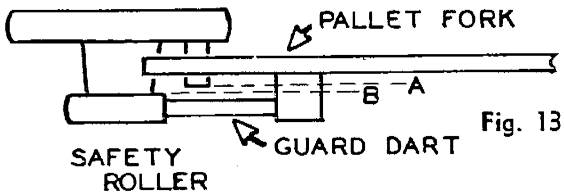
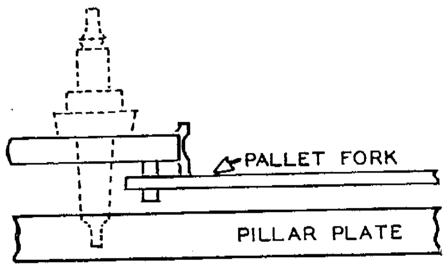


Fig. 13-27

Fig. 13-28


the fork, figure 13-28, but not long enough to rub on the balance jewel setting or plate.

Having set the jewel as directed in Section 323, its face square with the fork and perpendicular to the impulse roller, take hold of it with your tweezers while holding the balance in watch paper. Use your double loupe in examining the jewel to see that it is solidly set. Examine the edge of the roller table and the roller jewel to see if there is any cement other than that surrounding the jewel in the hole. If there is, scrape off all excess using the chisel-shaped brass wire. Examine and clean the passing crescent on all single rollers. Clean and brush carefully with soft brush. DO NOT USE OIL ON THE ROLLER JEWEL.

CHECK YOURSELF

Progress Check 13A | A Self Test Review of Lesson 13

After you have studied Sections 285 through 302, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. Two types of balance hole jewels are ________________ and ________________.	305
2. Balance hole jewels used with cap jewels are used as bearings for ________________ pivots.	306
3. Jewels without holes, which serve as bearings for ends of pivots, are known as ________________ jewels or ________________.	306
4. To provide proper sideshake, the difference between the size of the balance pivot and the side of the balance hole jewel should be ____________ mm.	308
5. In replacing the balance and cap jewel assembly, a good workman is careful to protect the ________________.	310
6. In fitting a new balance hole jewel, three points to check are the size of the ____________, the diameter of the ____________, and the height of the ________________ on the setting.	310
7. When ordering balance or cap jewels, you must specify ____________ or ____________ because the dimensions may vary.	311
8. In many Swiss watches, the jewel screws are screwed in from the ________________ side of the balance cock.	312
9. The modern Swiss balance hole and cap jewel are held in place by ________________.	313
10. To avoid having to order jewels for each repair, most watchmakers will stock ________________ of ________________.	314
11. In the Hamilton balance jewel assembly shown in the lesson, the ________________ setting holds the ________________ in place.	315
12. After a cap and balance jewel assembly has been taken out, any ________________ should be removed from the surfaces of the jewels.	309
13. Cap jewels which are pitted should be ________________.	309

CHECK YOURSELF

Progress Check 13B

A Self Test Review of Lesson 13

After you have studied Sections 317 through 325, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The ______________________ transfers the impulse from the fork to the balance wheel.	317
2. The roller jewel is usually held in place by ______________ but a few types are ______________________.	317
3. Of the various shapes of roller jewels, the __________ shape is most common.	318
4. The three types of roller tables are: a. ____________________________ b. ____________________________ c. ____________________________	319
5. Roller jewels are gauged in ______________ of a ______________.	320
6. Sideshake between the roller jewel and the slot in the fork is about ____________ mm.	320
7. A quick means for determining the proper roller jewel size is to use a ____________________________.	320
8. When setting a new roller jewel, the first step is to remove all traces of old ________________.	321
9. The preferred type of cement for setting roller jewels is ____________________.	322
10. The roller jewel must be set while the cement is ______________.	323
11. To straighten an out of line roller jewel, it is essential to first ________________________.	324
12. The roller jewel in a double roller table must clear the ________________________.	325

==

ANSWERS TO
PROGRESS CHECK 13A:

1. straight
   olive
2. conical
3. cap
   endstones
4. 1/100
5. finish
6. hole
   setting
   shoulder
7. upper
   lower
8. under
9. friction
10. assortments
    common sizes
11. balance jewel
    cap jewel
12. gummed or dried oil
13. replaced

==

ANSWERS TO
PROGRESS CHECK 13B:

1. roller jewel
2. shellac
   friction fit
3. D or half round
4. single roller
   combination roller
   two piece double roller
5. hundredths
   millimeter
6. .02 (2/100)
7. roller jewel gauge
8. cement
9. shredded shellac
10. warm
11. soften the cement
12. guard dart

HOW TO REMOVE AND REPLACE A "D" SHAPE ROLLER JEWEL IN A SINGLE ROLLER.

Tools, Equipment and Supplies:

Combination Tool	Chisel-shape Brass Wire	Roller Jewel Gauge
Hairspring Remover	Roller Jewel Warmer	Tweezers
Alcohol Lamp	Jewel Cement (Shellac)	

PROCEDURE:	REFERENCE:
1. Remove balance assembly from movement.	Lessons 5 & 8
2. Remove hairspring. (Optional)	Lesson 15 Sec. 352
3. Grip roller in jaws of combination tool. Heat tool over alcohol lamp. Remove roller jewel when cement softens.	Fig. 13-22
4. Remove balance assembly from combination tool and allow to cool.	Sec. 323
5. Clean roller of all cement and foreign matter with chisel-shape brass wire.	Sec. 321
6. Select replacement jewel.	Sec. 320
7. Grip roller in jaws of combination tool, reheat, and apply cement to jewel hole.	Sec. 323
AN ALTERNATE METHOD: Insert roller jewel in roller before applying cement.	
8. While cement is still soft, set roller jewel in roller.	Sec. 323
9. Reheat and move jewel up and down in hole to surround the jewel with cement.	Sec. 323
10. Examine closely to see that jewel is well cemented.	
11. If jewel is not firmly set and upright, reheat and straighten.	Sec. 324
12. Remove from combination tool, let cool, and clean off any surplus shellac with the chisel-shape brass wire.	Sec. 321 Sec. 323

LESSON	13
JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L13-J2

HOW TO REMOVE AND REPLACE A "D" SHAPE ROLLER JEWEL IN A DOUBLE ROLLER.

Tools, Equipment and Supplies:

Combination Tool	Chisel-shape Brass Wire	Roller Jewel Gauge
Hairspring Remover	Roller Jewel Warmer	Tweezers
Alcohol Lamp	Jewel Cement (Shellac)	

PROCEDURE:	REFERENCE:
1. Remove balance assembly from movement.	Lessons 5 & 8
2. Remove hairspring. (Optional)	Sec. 352
3. Grip roller in jaws of combination tool. Heat tool over alcohol lamp. Remove roller jewel when cement softens.	Fig. 13-22
4. Remove balance assembly from combination tool and allow to cool.	Sec. 323
5. Clean roller of all cement and foreign matter with chisel-shape brass wire.	Sec. 321
6. Select replacement jewel.	Sec. 320
7. Grip roller in jaws of combination tool, reheat, and apply cement to jewel hole.	Sec. 323
AN ALTERNATE METHOD: Insert roller jewel in roller before applying cement.	
8. While cement is still soft, set roller jewel in roller.	Sec. 323
9. Reheat and move jewel up and down in hole to surround the jewel with cement.	Sec. 323
10. Adjust roller jewel so as to be just above passing crescent.	Sec. 325
11. Examine closely to see that jewel is firmly cemented.	
12. If jewel is not firmly set and upright, reheat and straighten.	Sec. 324
13. Remove from combination tool, let cool, and clean off any surplus shellac with the chisel-shape brass wire.	Sec. 321 Sec. 323

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 13

Name: No: Date:

Circle the correct answer (or answers): SUBJECT: Factory Balance Hole Jewels and Roller Jewels.

1. One of the advantages of the olive hole jewel is that it:

Has a smaller bearing surface	Is cheaper to manufacture	Is less apt to break	Is easier to replace

2. Cap jewels are sometimes known as:

Jewel pins	Impulse jewels	End stones	Center jewels

3. The balance pivot is held in its central position by:

The jewel screws	The cap jewel	The balance cock	The hole in the balance jewel

4. The end shake of the balance staff is determined by:

The size of the hole in the balance jewels	The diameter of the cap jewels	The location of the balance hole jewels	The location of the cap jewels

5. To obtain the proper sideshake or freedom, a balance pivot measuring 10/100th of a millimeter would require a balance jewel with what size hole?

.10 mm	.11 mm	.12 mm	.13 mm

6. When fitting a new balance hole jewel and setting in an American watch you should make sure of at least three things before replacing the setting in the balance cock. Circle the three which are necessary, assuming that the old jewel and setting were correct:

Height of shoulder of setting must be same as old one	Hole must be of proper size	Diameter of setting must be same as old one	Jewel itself must be same diameter as old one

7. Which of the following shape roller jewels are described in this lesson?

Half Round	Triangular	Square	Oval

8. Roller jewels are gauged in:

Hundredths of a millimeter	Tenths of a millimeter	Thousandths of an inch	Sixteenths of a ligne

9. If the slot in the fork measured 40 with a roller jewel gauge, you would select a roller jewel measuring:

36	38	40	42

10. In order to set a roller jewel securely, you must:

Heat cement very hot	Use liquid cement	Be sure jewel fits tightly in hole in roller	Have hole in roller and the jewel absolutely clean

11. With a double roller, the roller jewel must:

Be exactly even with the bottom of the fork	Extend through the fork and just touch the guard dart	Extend about two-thirds of the way through the fork	Extend through the fork but not touch the guard dart

12. After setting the roller jewel, which of the following should be done? (Circle all correct answers)

Oil the roller jewel	Use double loupe and take hold with tweezer to see it is solidly set	See that it is perpendicular to the impulse roller	Examine roller table and jewel to see if there is any excess cement

Detach page or cut along this line and send to the School for grading.

CHICAGO SCHOOL OF WATCHMAKING 310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Student Consultation Sheet

Date ____________ Student No. ____________

Lesson No. ______

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Name	
Address	
City State Zip Code	

Please check ( ) if you have CHANGED YOUR ADDRESS.

ASK YOUR QUESTIONS HERE...

WE'LL ANSWER HERE...

INSTRUCTOR: Return an unused sheet with each used one.

(If necessary, use other side.)

ach page or cut on line and use this sheet if you have questions on the course.

Master
WATCHMAKING

Lesson 14

FRICTION JEWELING

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

INTRODUCTORY INFORMATION

The development of friction jeweling was an important step forward in present day watchmaking. It enables manufacturers to produce watches of simpler construction at less cost and more accurate performance. It helps the repairman by making watches easier to repair. This lesson should be given careful study, as watchmakers now use friction jeweling extensively in replacing other types of jewels.

There are three basic types of friction jewels: Train, Balance and Cap. Both the procedure and preparation for setting will vary according to the type of jewel and the type of setting or plate into which it is being fitted. Reaming of the hole in the plate or setting is done from the side in which the jewel will be fitted.

Train jewels are set perfectly flat from the <u>under side</u> of the plate or setting at a depth that will allow proper endshake for the pivot. The hole, likewise, is reamed from this same side before the jewel is set.

Balance jewels are set from the <u>top</u> of the plate or setting and the hole is reamed from the top side. The oil cup side of the jewel should be down and the hole at perfect right angles to the bridge. The necessary space between the balance hole jewel and the cap jewel is set by adjustment of the balance hole jewel only. The hole jewel is set slightly below the surface of the bridge or plate. The depth below the surface should be approximately .02 mm (2/100) and should be not more than a distance equal to half the diameter of the balance pivot.

Cap jewels should be set perfectly flat and flush with the <u>under</u> surface of the setting as it sits in the watch. The hole is reamed from the under side also.

The plate or setting being reamed should be on a solid base and be perfectly flat so the hole is reamed straight. Some reamers will not turn true but will sway from side to side as they are used. In this event, the plate or setting must be allowed to sway with the reamer so the hole will not be larger than the size of the reamer. The burr raised by the reamer on the surface edge of the plate or setting should be removed with a deburring tool before setting jewel.

Detailed procedures for replacing friction jewels or replacing out-moded settings with friction jewels will be found in your Shop Training -Job Guides for Lesson 14.

KEY POINTS OF LESSON ASSIGNMENTS 47, 48, 49:

- The purpose of friction jeweling.
- The different types of friction jeweling tools.
- Types of friction jewels.
- Friction jewel assortments.
- How to replace a friction jewel.
- How friction jeweling attachments are used.
- How to identify shock protector devices.
- How to disassemble and assemble shock protector devices.

ASSIGNMENT NO. 47: Study Sections 330 through 332.

Study Questions:

1. What is the purpose of friction jeweling?
2. How does the size of the hole compare with the size of the friction jewel?
3. What types of friction jeweling tools are available?

ASSIGNMENT NO. 48: Study Sections 333 through 343.

1. What kinds of friction jewels are there?
2. What is the procedure for replacing a friction train jewel?
3. Of what use is the face plate?
4. With what type of jewel is a pump pusher used?
5. What are some other uses for a friction jeweling tool?
6. What kind of pushers are used for convex jewels?
7. What can you do if you can't get a friction jewel large enough or of the correct diameter?
8. How does the size of the pusher used to replace a friction cap jewel compare with the jewel to be used? Why?

Recommended Practice:

Replace a friction train, balance and cap jewel in a watch. For procedure, see Job Guide Sheets L14-J1, L14-J2, L14-J3.

ASSIGNMENT NO. 49: Study Sections 344 through 346 and the Supplementary Information herein.

Three systems for protecting the balance staff pivots against shock are in use. The first and most common type is called a «floating bearing», Fig. A. In this, the cap and balance jewels move or give a little when the balance pivot receives a sudden shock and then return to their original positions. These devices protect the pivots no matter what direction the shock comes from, Figs. B, C and D. Note in these illustrations how the force of the impact is taken by the shank of the pivot or the staff itself instead of the delicate pivot end.

Fig. A
Floating bearing.
Palier flottant.

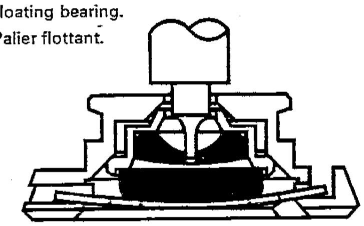


Fig. B
Radial shock.
Choc radial.

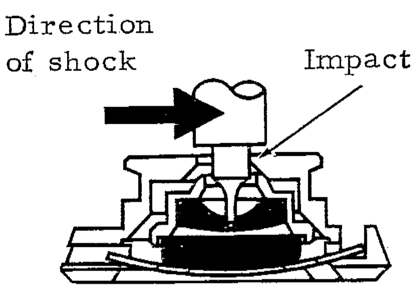


Fig. C
Oblique shock.
Choc oblique.

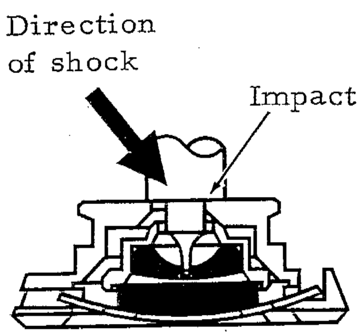
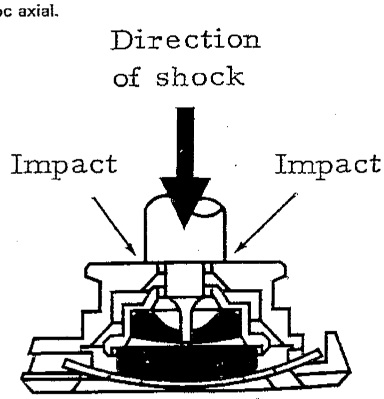


Fig. D
Axial shock.
Choc axial.



ASSIGNMENT NO. 49 (Continued):

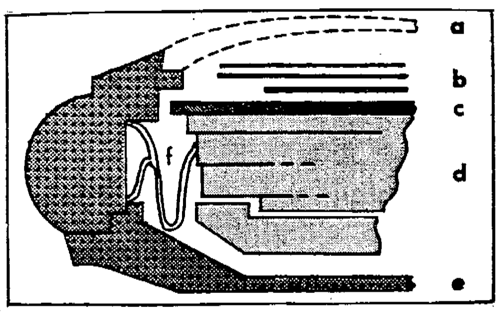
There are dozens of variations of this type with new ones appearing from time to time. Many hundreds have been patented but never reached the market. Incabloc and KIF are two of the most widely used and you should give them particular attention. Some of the many devices are illustrated in the following pages and further described in the Job Sheets for Lesson 14. The main requirement in all of them is that the balance hole jewel be free to move. Formerly you could identify this type just by the shape of the spring. Now the many variations in use make identification more difficult and we include a set of charts (Section 346) to assist you in this.

The second shock absorber system uses what is called a "floating balance". This is a specially designed balance whose rim is suspended from the balance by one or more flexible arms. Again, many patents have been taken out on this principle, but not many are in use because of the delicacy of the balance. This system uses regular fixed type jewels. The Wyler Incaflex and Elgin Dura-Balance are representative of this type and are the ones you are most likely to meet. These two are covered in the lessons on balance wheels, which follow.

Besides the very delicate pivots, other parts of the watch can suffer also from shock. Crystals get broken, hands get bent, a barrel cover can pop open, dial feet can bend or break, the hairspring can be thrown out of center, the movement itself can be displaced as can the index. In a self-winding watch, the oscillating weight can be disturbed and the rotor axis broken.

As a result, a third system was devised to try to protect the entire movement. Instead of the usual enlarging rim to hold the movement in the case, a device is used to suspend or "float" the entire movement and to absorb any shocks received. The Certina DS System uses a plastic ring for this purpose. Another recent one, the Oltrashock System, Fig. E below, uses a metal ring with flexible, spider-like legs. This kind of protective system can be teamed up with one of the regular shock absorber systems to give double protection. However, this third system is relatively little used.

Fig. E.
Oltrashock
System



In sketch at left, letter references are as follows:
a — Crystal
b — Hands
c — Dial
d — Movement
e — Case
f — Shock absorbing ring

COMBINED JEWEL SETTINGS

On many modern watches you will find some combined jewel settings used on the train wheels instead of regular jewel settings. Sometimes they are also used on the balance where shock protection is not desired. Even though these settings are included in the charts in Section 346, they are not in fact shock protective devices. The hole jewel is friction fit into the assembly and is not free to move in event of shock. They look like a shock absorbing device because the cap jewel is held in place with a spring. Some of these springs are removable and are re-

ASSIGNMENT NO. 49 (Continued):

leased by turning with a tweezers. Others are hinged and are lifted up to release the cap jewel for cleaning. The cap is lifted out with tweezers in all cases.

The purpose of these combined settings is to keep the cap jewel exactly parallel to the hole jewel and at a fixed distance that insures the proper amount of oil is used. The Duofix (Job Sheet L14-J12) used in Swiss watches and the Diafix found in Japanese (Seiko) watches are typical of these. (See Job Sheet L14-J19.)

Study Questions:

1. What does an Incabloc jewel assembly consist of?
2. How is it removed for cleaning?
3. In what ways is the Incabloc similar to or different from other shock absorbing devices?
4. What are the principal variations in shock protective devices now in use?

Recommended Practice:

When you have access to a watch with a shock protective device, remove, clean and replace it. Refer to your Job Sheets for procedures.

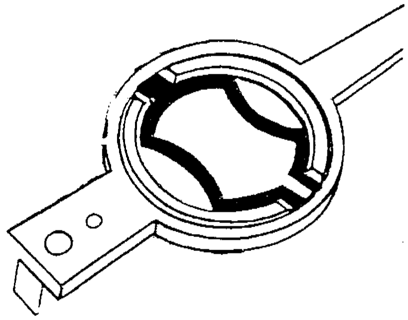
REQUIREMENT:

➧ Answer the Test Questions for Lesson 14 and send in for grading.

SUPPLEMENTARY INFORMATION

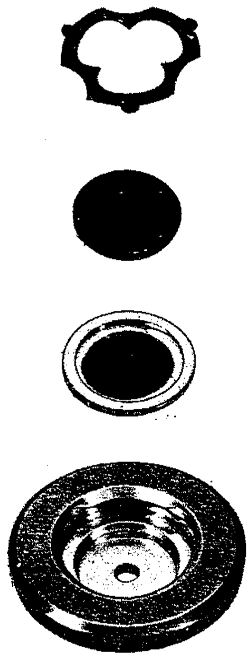
INCABLOC

In this country, the Incabloc is the most common of all the shock absorbing devices. It is readily identified by its lyre-shaped spring, which presses the cap jewel against the balance jewel setting. The jewels and bushing then move as one piece up or down or sideways according to the direction of the shock received by the balance pivots. See Section 344 and Job Sheet L14-J9 for details of disassembly and assembly.



KIF 370

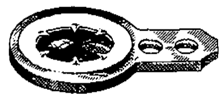
This device is similar in principle to the Incabloc. The retaining spring for the cap jewel differs in design, however, in that it has three outer projections or ears which enable it to be locked into position in a groove in the support. It also has three inner projections which apply pressure to the cap jewel. The base or main body of this assembly is friction fit into the plate or bridge. The balance hole jewel is friction fit into an inner setting which has an upper groove on which the cap jewel simply rests. The retaining spring holds the cap jewel in place. For disassembly and assembly, see Job Sheet L14-J13.



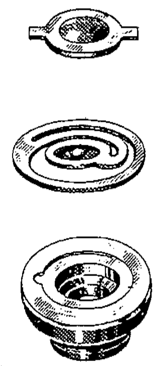
SHOCK RESIST

The Shock Resist differs from the two assemblies just described in that there is no contact between the cap jewel and the balance hole jewel or the spring which surrounds it. Each jewel moves independently according to the nature of the shock.

The cap jewel is burnished into its own spring with spring prongs on top of the jewel acting as shock absorbers and permitting the cap jewel to shift.

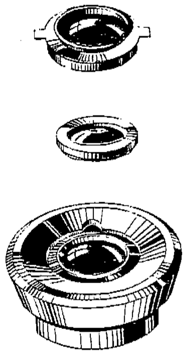


The friction balance hole jewel fits into a spiral spring setting which is held in place in the base of the assembly by a C-shaped retaining ring. The balance jewel assembly is friction fit into the bridge or plate. The balance jewel need not be taken out for cleaning, but can be cleaned with the plate or bridge. For disassembly and assembly, see Job Sheet L14-J10.



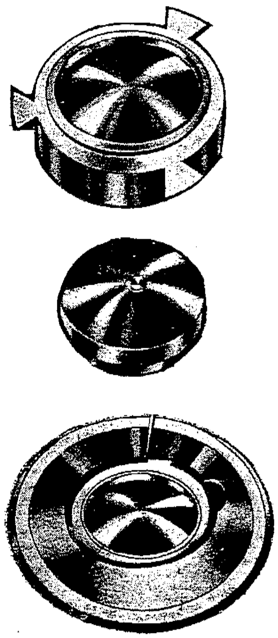
SUPER SHOCK RESIST

The main difference in this assembly from the Shock Resist is that the cap jewel is friction fit into a setting which has two protruding tips which serve both to lock the endstone in place and act as shock absorbers. The balance hole jewel is mounted as in the regular Shock Resist. For details of disassembly and assembly, see Job Sheet L14-J11.



MONOREX

Similar to the above in that the cap jewel is friction fit into a setting which has two protruding prongs to lock the cap and balance jewels into the base and serve as shock absorbers. The body of the assembly is friction fit to the balance bridge and plate and should not be removed for normal cleaning and service. The balance jewel is friction fit into a tapered setting. For disassembly and assembly, see Job Sheet L14-J16.



RUBY SHOCK

The base of this assembly is friction fit into the plate or bridge. The balance hole jewel is not mounted in a setting, but simply rests on a beveled inner surface of the base. The cap jewel is mounted in a setting which has three protruding spring prongs. These lock under the top lip of the base and hold the jewels in place but allow them to shift under shock. For disassembly and assembly, see Job Sheet L14-J17.

Important!

Most shock resist parts are made in several diameters to fit various sized movements. When ordering replacement parts, send the broken part as a sample.

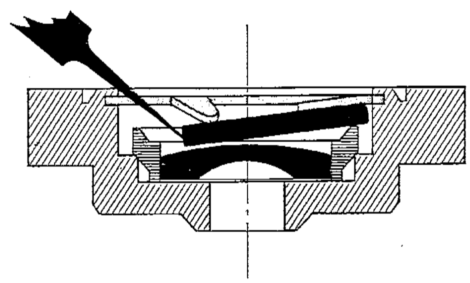
SUPPLEMENTARY INFORMATION (Continued)

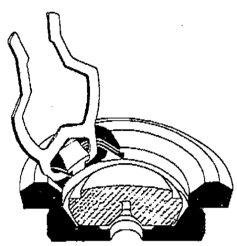
There are many reasons for the great variety of anti-shock devices. Competition, imitation of established successful devices, the urge to be different, development of new materials, changes in watch design and manufacture, the search for lower manufacturing costs, for improved installation of jewel settings, for ways to make servicing easier for the repairman -- these are just a few of the spurs to new shock protective devices.

This constant search and change create fashions in shock devices as in other things. What is popular now may not be used a few years from now. Shock Resist, for example, was popular 20 years ago, particularly in Benrus watches. Now it is no longer used. Some of the devices shown in Sec. 346 are already obsolete and no longer manufactured. What this means for you as a repairman is that you cannot always get an exact replacement for a less popular device should you need one. Fortunately, there are enough devices with similar characteristics that this is not a real problem other than knowing what is available.

To illustrate the changes manufacturers seek, let's look at a few recent developments. Here are two designed to make servicing easier:

First is a new model of a French shock absorber introduced in 1971. It is called AntiCHOC 106. When cleaning is needed, the watchmaker simply pushes the cap jewel into the position shown instead of taking the assembly apart. This not only saves time, but eliminates the danger of losing some of the tiny parts. After cleaning, the repairman uses tweezers to restore the cap jewel to its normal position.



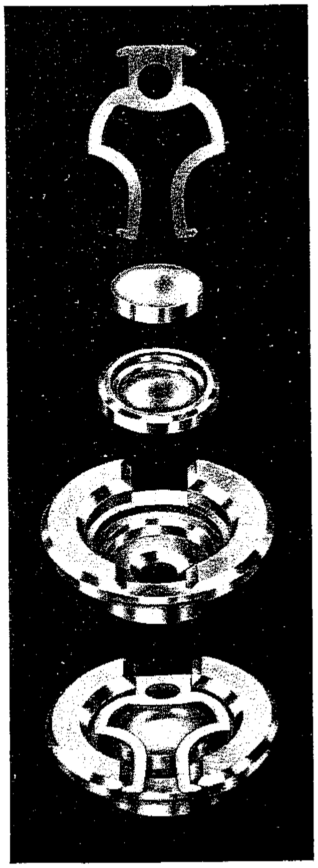


The second device is from KIF Parechoc, a Swiss concern, and uses a new material to obtain a one-piece, self-lubricating setting. This shock absorber is called LUBROKIF. The setting is made from an absolutely stable, temperature-resistant synthetic which, it is claimed, eliminates the need for lubrication with no risk of wear.

Most jewel setting manufacturers make more than one shock absorber device in order to have a quality setting for high grade watches and an inexpensive one for cheaper movements. On the next page we show a typical "family" of shock absorbers. These are by Erismann-Schinz SA, a Swiss firm which makes the Monorex already discussed. As is true of all our illustrations, we show them for information only and are not implying any endorsement. But these handsome illustrations clearly show how the shock device changes form according to its intended use. This group covers the full range of watch manufacture from expensive high grade watches down to inexpensive pin lever movements.

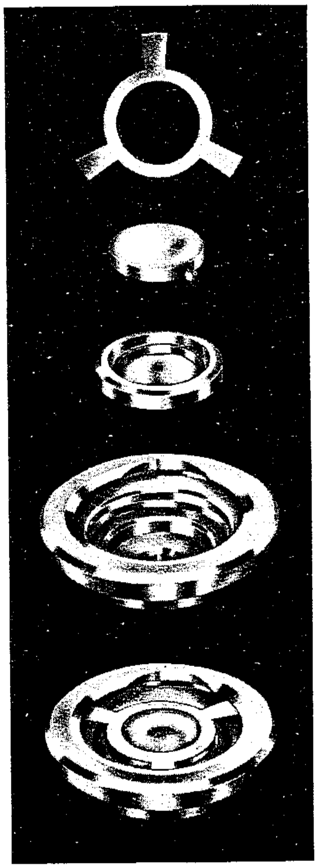
SUPPLEMENTARY INFORMATION (Continued)

This family of shock absorbers is intended to give the watch manufacturer a choice of device that best suits the quality of the watch and its production cost.



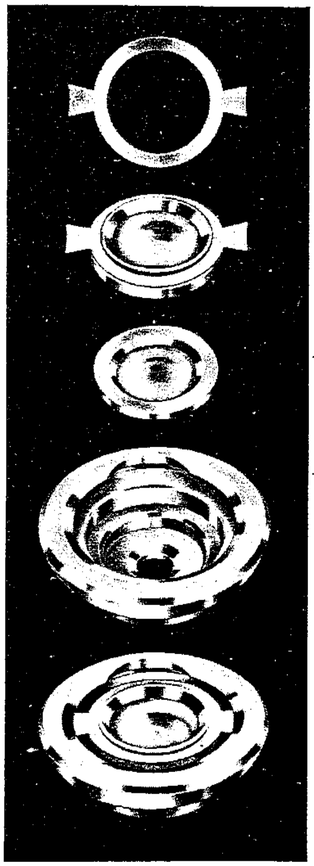
Starshock

The endstone spring with its three contact points ensures rapid, accurate recentring. The Starshock is the ideal shock-absorber for watches of high precision or with high-frequency oscillators.



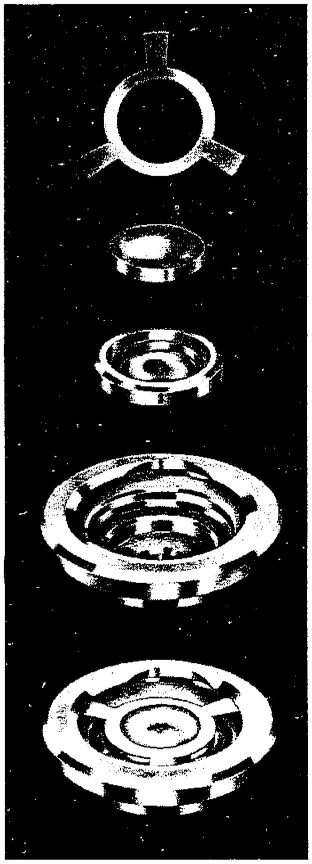
Trishock

This offers all the advantages of the Starshock, except for the fact that the spring has three arms. It is circular in shape and touches the entire surface of the endstone, insuring perfect centring. Economically priced.



Monorex

Its design is similar to that of the Trishock, but its circular spring has two arms. The process of driving in and removing the system is both reliable and simple.



Simrex

This shock-absorber is specially designed for Roskopf and pin-lever watches. In addition to its technical qualities, it is very reasonably priced. It is available with metal endpieces or ruby endstones.

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Lesson 14

Sections 330 to 346

FRICTION JEWELLING

SEC. 330 — Purpose of Friction Jewelling

One of the few but great improvements in modern watch repairing has been the advent of FRICTION JEWELLING. The friction jewel serves the same purpose as jewels in setting or those burnished directly into the plates or bridges, and the addition of a good friction jewelling tool is extremely profitable to the watchmaker who desires to speed up his work in an efficient manner. Proper use of the friction jewelling tool will bring real pleasure to many tasks which before took up a great deal of time, and, of course, will build up the profits of the repair department.

There are a great many times in the watchmaker's career when the profit he should have earned from repairing a watch has been turned into a loss due to his failure to accurately estimate and charge for repairs. In estimating repairs, we know that an accurate estimate can be made if the watchmaker will take the watch completely apart and check each part thoroughly to see what repairs are needed. However it is not always practical to estimate a watch in this manner due to the time involved. Consequently, there are times when we find that the watch we have taken in for a cleaning job or for a broken balance staff also has a cracked or broken jewel which must be replaced if we are to turn out first class work. Possibly the jewel may be set directly into the plate or bridge, or the watch may be one for which it is hard to obtain material. Formerly this would require a great deal more work than we had bargained for, but as we have already made the customer a price on the basis of returning his or her watch in first class condition, it is up to the repair man to make the additional repairs at his expense. It is better to do these jobs and not mention the fact to the customer. You will be rewarded by having a satisfied customer.

In the previous lesson the proper method of replacing jewels set in friction setting was explained. Our only concern when replacing a jewel of that type was the diameter of the hole in the jewel, and the outside diameter of the setting.

The method of friction jewelling about to be described deals primarily with the outside diameter of the jewel and the inside diameter of the hole in the setting. Of course the hole in the jewel must be the proper size to fit the pivot. In friction jewelling the outside diameter of the jewel must be greater than the inside diameter of the hole which is to receive it. This difference usually is 1/100 of a millimeter.

SEC. 331 — Types Of Friction Jewelling Tools

The most complete and precise friction jewelling tool at the present time is illustrated in figure 14-1. It is a precision tool for replacing jewels in watches and has additional accessories for straightening balance pivots, replacing hands, and setting pallet arbors in position.

The holes in the pivot straightening tool are accurately calibrated to ¼ of 1/100 of a mm. The pushers, anvils, and reamers are accurate to 1/100 mm. However, this tool will serve the watch repair man better if he knows the principles of jewel replacement. More of this will be taken up in the lessons on lathe work.

Following is a list of the contents included in the tool case, figure 14-1:

- 1 Friction jewelling tool
- 12 Flat pushers
- 5 Anvils
- 11 Concave pushers
- 15 Reamers

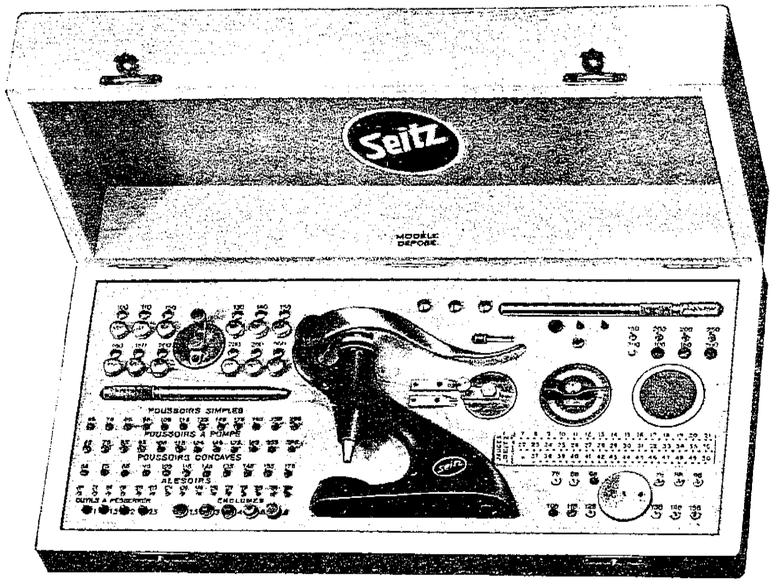


Fig. 14-1

12 Pump pushers
Tools for setting the pallet arbor.
4 Round face hole reducing or closing punches
Face plate with 3 clamps
12 chucks and holders for holding brass settings
Assortment of brass settings
12 Centering points
5 Pushers and 3 anvils for replacing watch hands
3 Chucks with handle
Tool for straightening pivots
Pivot gauge
Centering pump pusher
Grinding stone

Figure 14-2 is the standard outfit which combined with an assortment of friction jewels, will satisfactorily serve the average watchmaker for all general repairs.

Figure 14-3 illustrates a fine friction jewelling tool which is furnished and used with a staking tool set.

SEC. 332 — Description of Arbor Press and Cutters

Figure 14-4 illustrates a friction jewelling tool which is more or less a small arbor press. The hole in the base or die plate is made to receive the anvils. The lever is easily removable when using the reaming tool, figure 14-5. The micrometrical nut at the top of frame is easily read and allows the workman to make precision adjustments when setting a jewel. The handle, figure 14-6, is so made that the pushers can be quickly changed. Figure 14-7 illustrates the base into which the many important pushers, reamers, and anvils are placed, as follows:

Top row—12 flat pushers
2nd row—12 centering pump pushers
3rd row—11 concave pushers
4th row—15 reamers
5th row—Anvils, hole closing punches

The handle which holds the reamers is con-

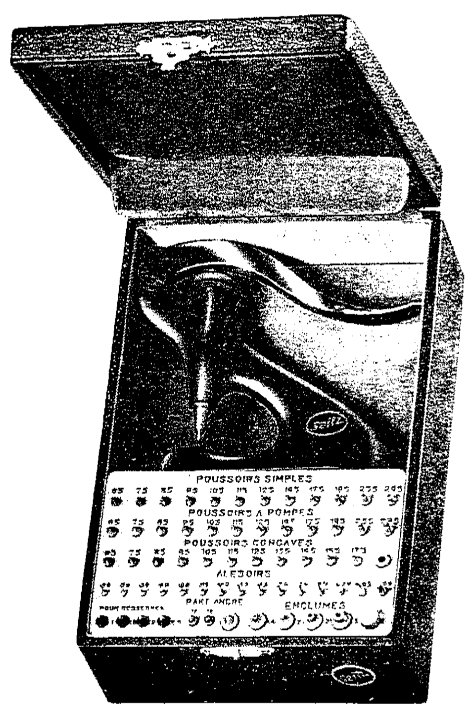


Fig. 14-2

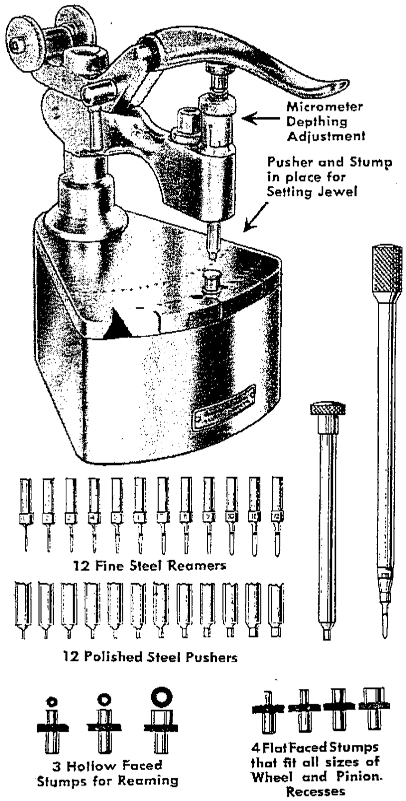


Fig. 14-3

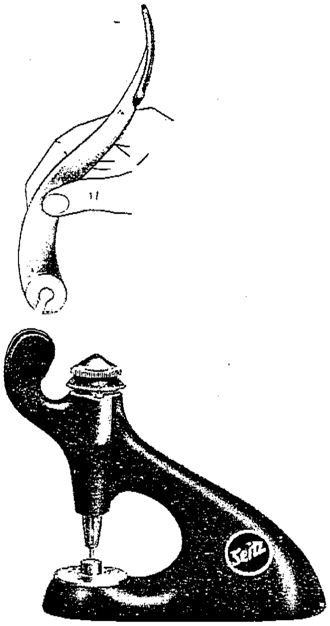


Fig. 14-5

Fig. 14-6

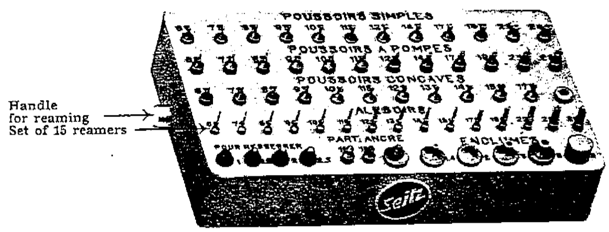


Fig. 14-7

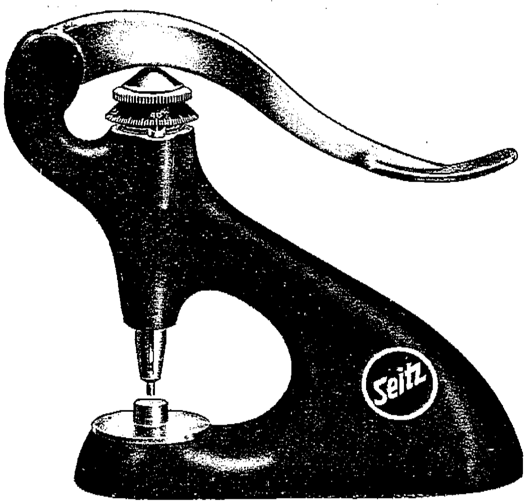


Fig. 14-4

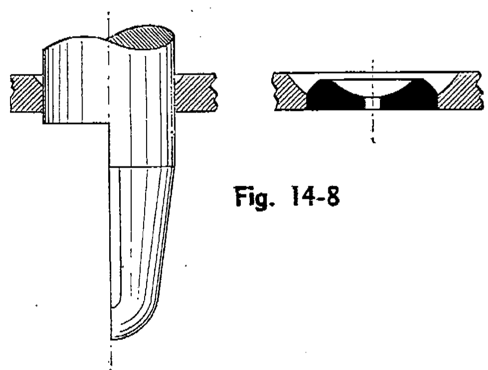


Fig. 14-8

tained in the side of the block. The reamer or smoothing broach is a half-round, tapered cutter which, when used in a plate or bridge, opens a hole to the exact hundredth of a millimeter as stamped on the reamer. The watchmaker uses a jewel which is 1/100 of a mm. larger than the diameter of the reamer. The jewel is then forced into the opening with the proper pusher.

Figure 14-8 is an enlarged view of a reamer showing the completed work of reaming the hole in a plate. The other illustration in figure 14-8 shows the opening after the jewel has been set in place.

SEC. 333 — Types of Friction Jewels

Figure 14-9 illustrates the various types of friction jewels used with a friction jewelling tool. The friction jewel at A is a convex balance jewel with an olive hole. The friction jewel at B is a flat jewel similar to a train jewel which can be used as a balance jewel in some current models of watches. On smaller types of Swiss watches however, it is primarily used as a train jewel for the pivots on the pallet arbor or the escape pinion. The olive hole helps to reduce friction. The friction jewel at C is the regular flat, straight hole train or plate jewel. The friction jewel at D, which is the same shape as the train jewel but has a large hole is used for the center arbor. At E is shown a common type of friction cap jewel.

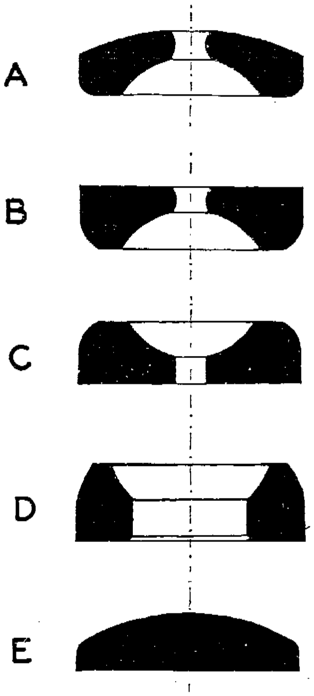


Fig. 14-9

SEC. 334 — Description of Assortments.

Chart Showing a Complete Assortment of Balance Jewels

Diameters of jewels in hundredths of mm.

	70	80	90	100	110	120	130	140	150	160	180
7	70	80	90	100	110	120	x	x	x	x	x
8	70	80	90	100	110	120	130	140	150	x	x
9	70	80	90	100	110	120	130	140	150	x	x
10	70	80	90	100	110	120	130	140	150	x	x
11	70	80	90	100	110	120	130	140	150	x	x
12	70	80	90	100	110	120	130	140	150	160	180
13	x	x	90	100	110	120	130	140	150	160	180
14	x	x	90	100	110	120	130	140	150	160	180
15	x	x	90	100	110	120	130	140	150	160	180
16	x	x	x	100	110	120	130	140	150	160	180

Fig. 14-10

The above chart, figure 14-10, is a sample of a complete assortment of friction balance jewels with olive holes. The numbers in the first column reading from top to bottom (7, 8, 9, etc.) represent the size of the hole in the jewel. The figures opposite each of these hole sizes represent the outside diameters of the jewels. The average watchmaker does not usually carry as complete an assortment as this and they may be purchased in many different assortments. Train jewels and center jewels are catalogued similarly. Cap jewels are catalogued by outside diameters only, as they are without holes.

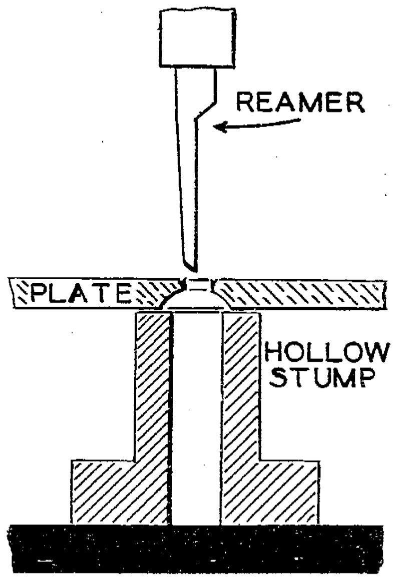


Fig. 14-11

SEC. 335 — Procedure for Replacing Friction Train Jewel

1. Remove broken or cracked jewel from setting. This can be done easily by punching out the jewel from the plate or setting with a pusher that is slightly smaller.
2. Select a reamer that will enlarge the present hole slightly and place this reamer in the holder, figure 14-11.
3. Select the smallest hollow stump that will accommodate the reamer and place in the base of the frame.
4. Hold plate or bridge over hollow stump, figure 14-11.
5. Run reamer **completely through** the plate or bridge. Figure 14-12. These reamers are self-centering and cut slowly.
6. After drilling completely through the plate or bridge, remove reamer and carefully examine hole using a double loupe. If all of the old bezel has been removed the hole will appear bright and shiny.

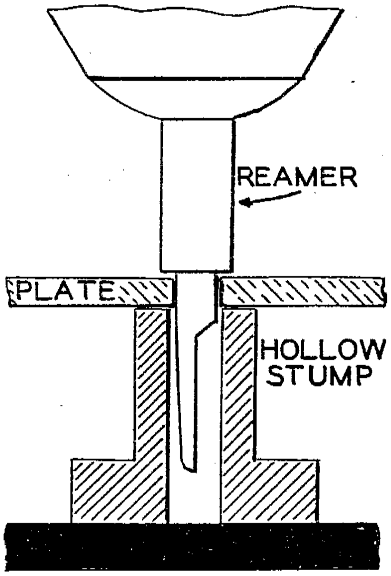


Fig. 14-12

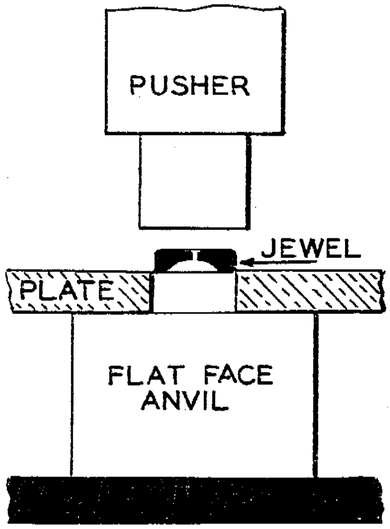


Fig. 14-13

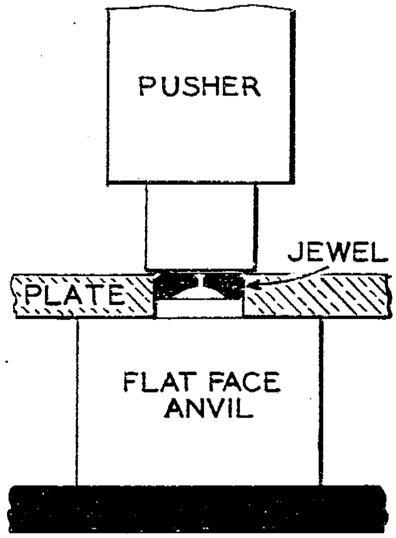


Fig. 14-14

7. If any of the old seat remains, repeat the above operation using the next larger size reamer.
8. Select a train jewel that corresponds to the diameter of the reamer.
   Example: Reamer measures 1.29 mm; use jewel with diameter 130 mm.
   Reamer measures .99 mm; use jewel with diameter 1.00 mm.
   The difference of 1/100 mm allows for friction fitting.
9. Select flat face stump upon which to place bridge or plate. If plate is recessed be certain that the stump selected is small enough in diameter to fit into recess.
10. Select pusher slightly larger than the reamed-out hole, and place in frame.
11. Place plate or bridge on flat-face stump, with the inside of the plate facing up.
12. Holding the pusher flush against the plate, adjust micrometer nut so that it is impossible to push lever any lower. Release lever.
13. Place jewel in reamed-out hole, oil cup down, figure 14-13.
14. Press on lever gently until the face of the pusher comes in contact with the jewel, increasing the pressure slowly until the jewel has been forced into the hole. The pusher should now be flush with the plate and the jewel securely in place, figure 14-14. Release lever and remove plate.
15. Test for end-shake. If more end-shake is required jewel can be pressed below the surface with a pusher slightly smaller than jewel diameter. This amount can be controlled by micrometer nut.

SEC. 336 — Face Plate

Plates and bridges can usually be held with fingers when reaming. If it is desirable to replace the friction jewel in an old setting, make the replacement with the setting in the plate or bridge. The face plate illustrated in figure 14-15 can be used when it is impractical to hold the bridge or setting with the fingers. This face plate will hold small bridges such as the pallet bridge illustrated and comes with additional clamps for holding settings, etc. Since face plate is very light, it will follow the reamer when working, thus avoiding a hole which will not be true. It can also be used when replacing jewels as it holds the bridge or setting securely, enabling the workman to center it easily under the pusher.

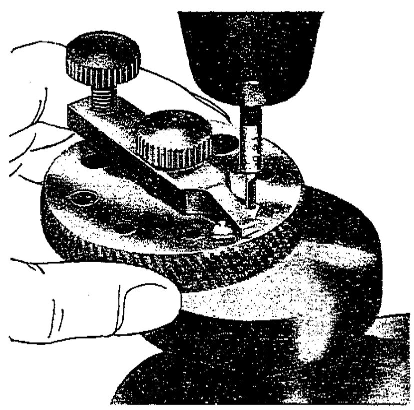


Fig. 14-15

SEC. 337 — Pump Center Pushers

The pushers used to replace the jewel just described are flat face pushers. Another type of pusher is illustrated in figure 14-17. These are pump center pushers and the face of the pusher is hollowed, thus allowing the workman to center the pusher and press into place both flat and convex jewels.

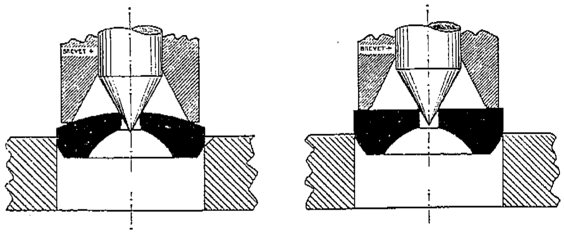


Fig. 14-17

Keep your pushers in first class condition. There are times, especially after constant use, when the faces of the pushers should be reground to prevent breakage of jewels. In order to regrind the face of the centering pump pusher it must be taken apart. Figure 14-18 illustrates a cross section of a centering pump pusher. Press lightly on the top at A with a screwdriver in order to compress the spring, and make a one quarter turn to release the spring and pump. Let us repeat again that it is impossible for a man to do good work with poor tools.

Fig. 14-19

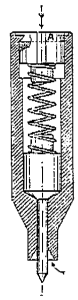


Fig. 14-18

SEC. 338 — "SEITZ" Grinding Stone.

Figure 14-19 illustrates a specially selected stone set into a metal plate. It is used to grind the surfaces of the pushers and anvils flat when the surfaces have become marred or distorted. Figure 14-20 illustrates the correct method used to regrind these articles. Place the pusher to be reground into the handle and press upon the grinding stone. Hold securely and move grinding stone back and forth as shown by the arrow. For regrinding the faces of anvils there is included a small bushing which fits into the handle.

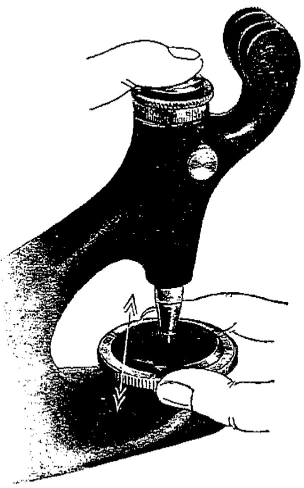


Fig. 14-20

SEC. 339 — Uprighting

Figure 14-21 illustrates a centering pump pusher used to upright a plate or bridge which has a defective hole. The pillar plate is placed on the base of the jewelling tool in such a manner that the jewel in the pillar plate fits directly over the pump center. With the defective upper plate or bridge screwed in place, ream out carefully just enough to correct the defective hole and replace jewel.

SEC. 340 — Hole Reducing Punches

Figure 14-22 illustrates the use of the hole reducing punches found in some friction jewelling tools. In some cases these punches can be used to avoid replacing a jewel which is only loose in the setting, not broken. However, it usually is to the watchmaker's advantage to replace loose jewels with jewels which fit properly.

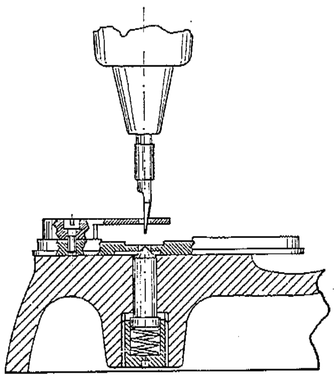


Fig. 14-21

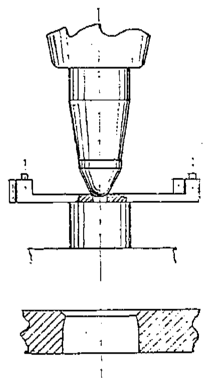


Fig. 14-22

SEC. 341 — Pushers Used With Convex Jewels

Plate and center jewels are replaced in the plate or bridge from the inside. Balance jewels are replaced from the outside of balance bridge or pillar plate. However, the balance jewel must be set slightly below the surface of the bridge plate or setting. This distance below the surface and the reasons were explained in a previous lesson.

Figure 14-23 illustrates the type of pushers used to replace **Convex** balance jewels. This type of pusher will lessen the breakage caused by using a flat pusher. It should be slightly smaller than the diameter of the jewel to be replaced, as this will allow the pusher to go below the surface of the plate or bridge without damaging the edges of the jewel setting. The depth the balance jewel is to be set is controlled by the micrometer nut at the top of the friction jewelling tool. Replacing a friction jewel in a plate or bridge which previously contained a friction jewel does not always require that the hole be reamed out again. Instead a reamer of the correct diameter can be placed in the hole and used as a gauge to select the proper size of friction jewel. Example: If a reamer measuring 1.09 mm fits the hole from which the old jewel has been removed a jewel with a diameter of 1.10 mm would be used for replacement. Always check endshake.

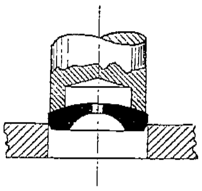


Fig. 14-23

SEC. 342 — Friction Brass Settings

There are times when the watch repair man does not have a friction jewel of large enough diameter to replace a broken jewel. This is often the case with old model watches in which the manufacturer took pride in the large jewels displayed in the plates. For this type of jewel replacement and others where it is impractical or impossible to find a jewel of the correct diameter, brass settings are obtainable in assorted diameters large enough to be set into the plates. These settings come with gauged diameters in metric measurements the same as do the friction jewels, and are set the same as a friction jewel. This provides a new setting into which we can now proceed to fit a friction jewel. Thus you will have a friction jewel set into a setting which in turn is set friction tight into the plate or bridge.

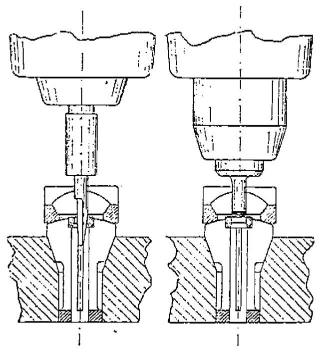
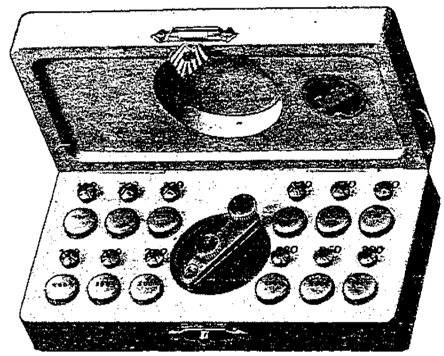


Fig. 14-24

Figure 14-24 illustrates the method of holding a setting of this type in a small chuck for reaming. Choose the brass setting of the desired diameter, place in chuck, place chuck in holder and place clamp over chuck. Small settings must not be tightened too much as they can easily be forced out of shape. Ream out the setting and press jewel into place. Then proceed to replace brass setting in plate or bridge. Figure 14-25 illustrates a set of these chucks complete with the clamp to hold the settings. This type of holder will follow the movement of the reamer, avoiding an off center hole.

Fig. 14-25



SEC. 343 — Friction Cap Jewels

Cap jewels can be readily replaced as the outside diameter of the cap jewel is the only measurement to be considered. They are replaced by using a pusher slightly larger in diameter than the diameter of the jewel selected, which will set the jewel flush with the setting.

SEC. 344 — Incabloc

Incabloc is a self-contained Mechano-Flexible Combined Bearing which protects the pivots. Incabloc maintains the two pivots of the balance staff securely in their accustomed positions, but permits them to shift under the influence of a shock coming from any direction. Immediately after such a shock the Incabloc spring causes the balance to automatically resume its original position. In figure 14-26, A is the block bed

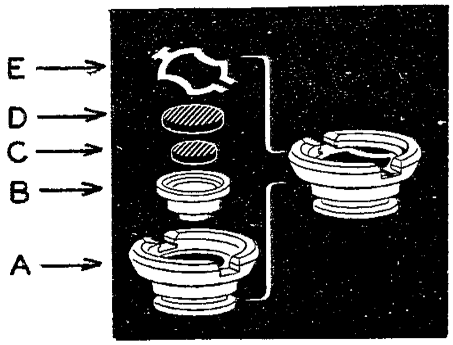


Fig. 14-26

into which the bed or setting for the balance hole and cap jewel is fitted. B is the bed, C the balance hole jewel, D the cap jewel and E the Incabloc spring, which exercises an even and calculated pressure. The block is held in place in the balance cock by a small U-shaped spring. In replacing the balance or cap jewels in the block or cleaning the jewels, it is not necessary to remove the block. Press the open end of the Incabloc spring away from block, figure 14-27, thus releasing one side of the spring. Release opposite side in like manner. Lift up spring carefully noting that it swings up and away from the jewel as on a hinge. It is not necessary to remove the spring any further. You will now have access to the cap jewel which can be readily removed, exposing the balance jewel in setting. A small tool, which will enable the workman to release the Incabloc spring without damage, can be made from a piece of mainspring ground to a long tapered point and mounted in a piece of pegwood. When cleaning a watch these jewels should be put to one side and cleaned separately keeping in mind their respective places in order that they may be replaced in their proper positions. Oil the same as any ordinary balance and cap jewel combinations.

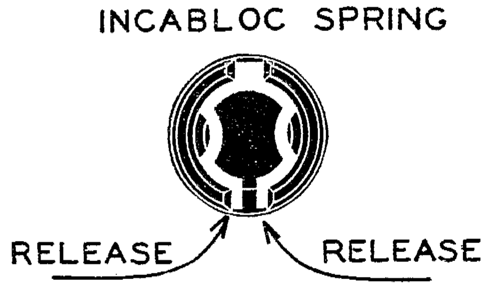


Fig. 14-27

Figure 14-28 illustrates Incabloc assemblies.

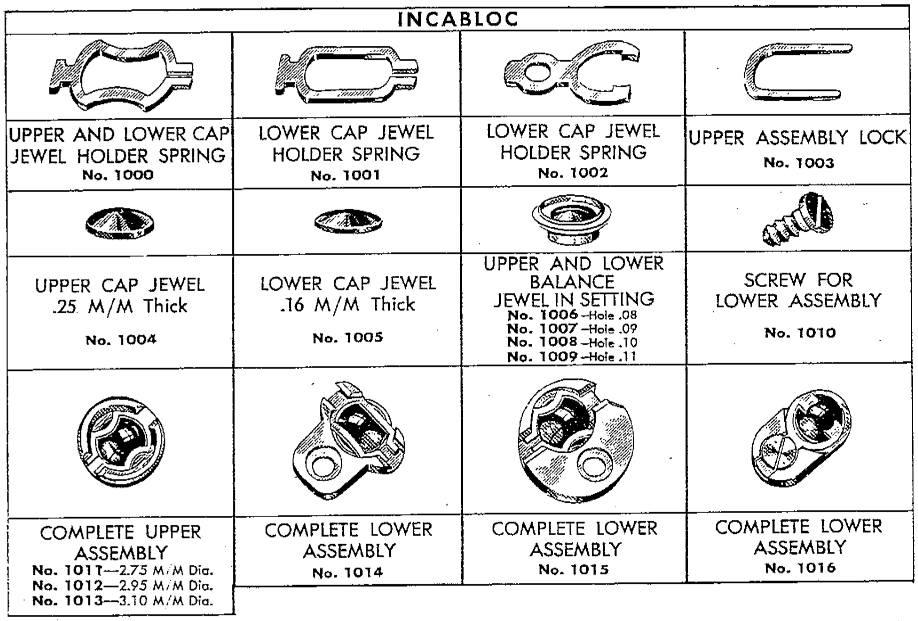
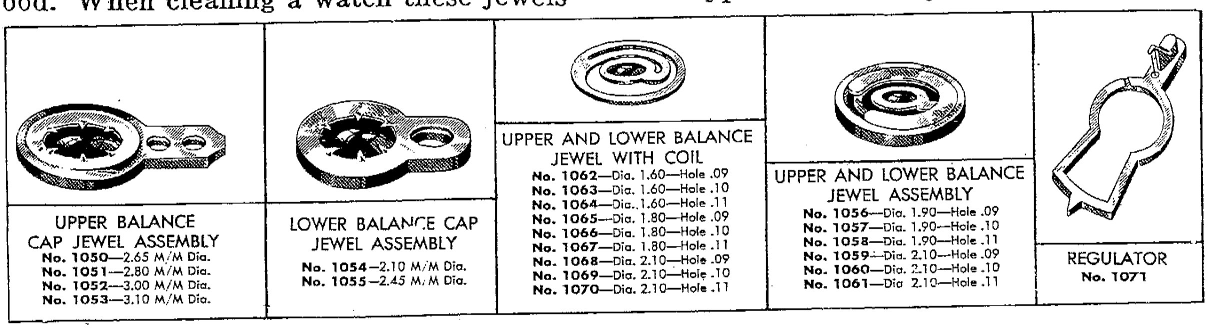


Fig. 14-28 Courtesy C. & E. Marshall Co.

SEC. 345 — Shock-Resist

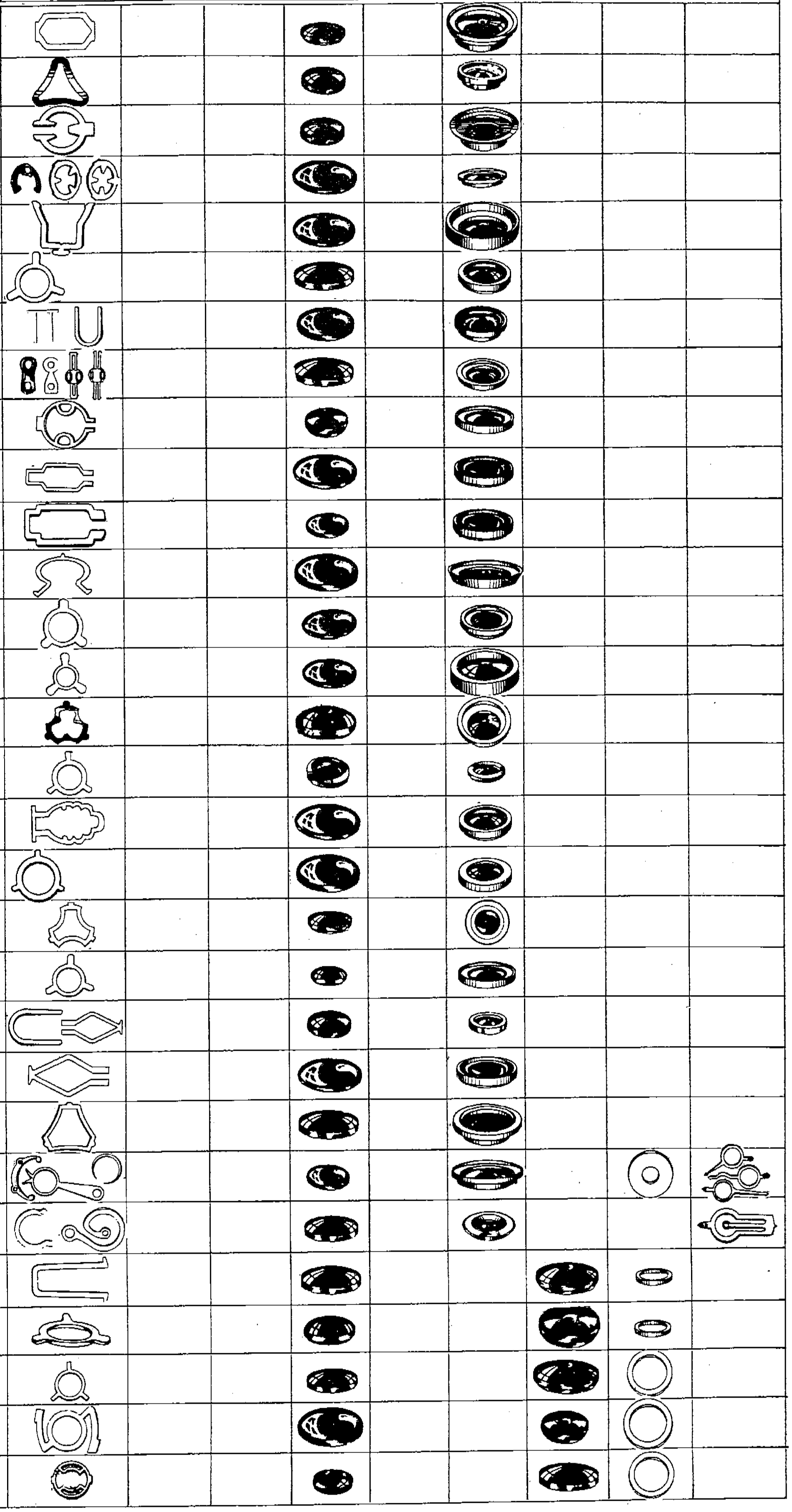
Figure 14-29 illustrates "Shock-Resist" material. These illustrations will be self-explanatory when you come across watches equipped with this type of balance jewel assembly.

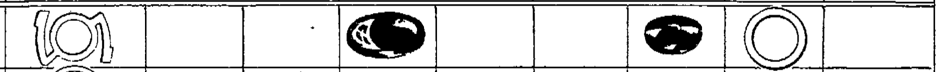
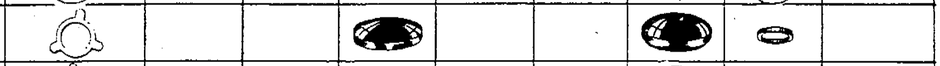
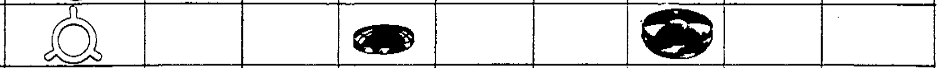
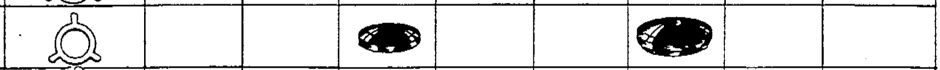
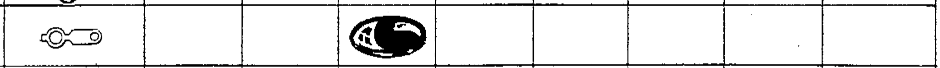
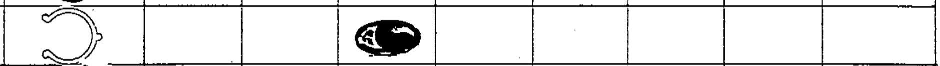
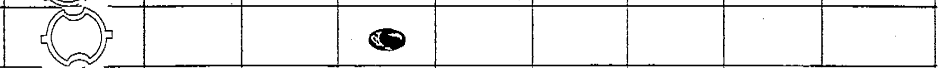
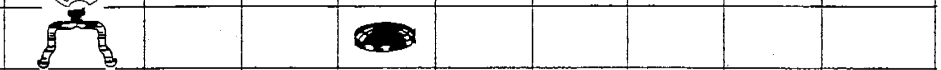
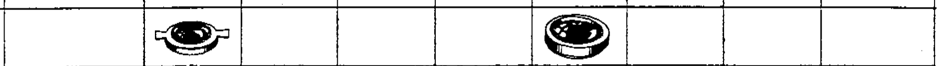
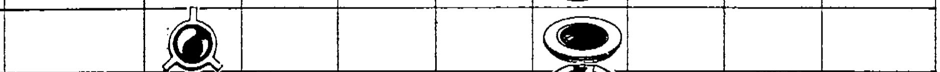
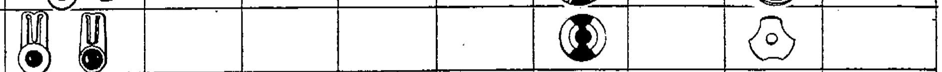
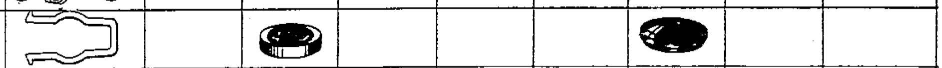
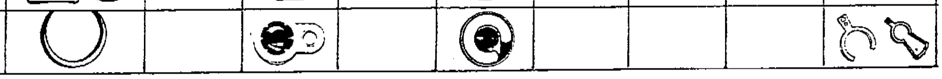


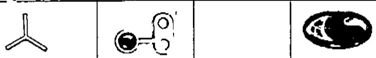
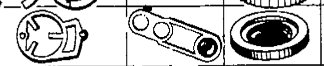
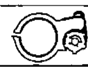
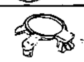
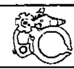
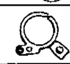
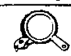
Courtesy C. & E. Marshall Co.

Fig. 14-29

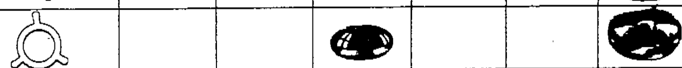
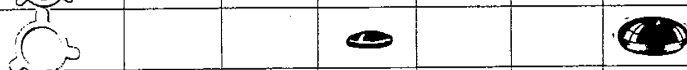
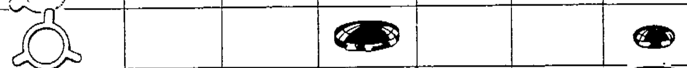
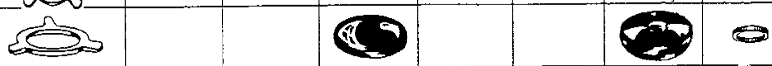
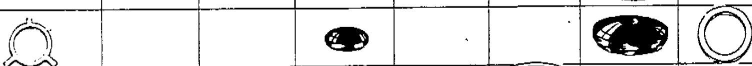
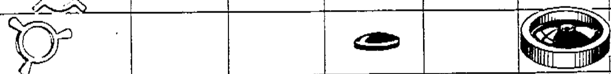
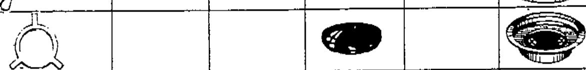
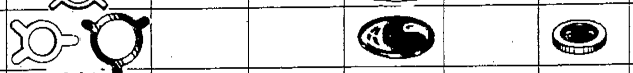
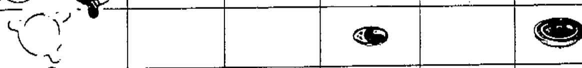
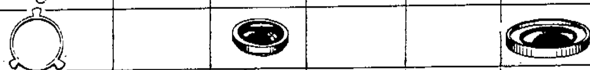
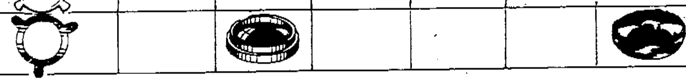
SHOCK	Country of Origin		1 Spring	2 Cap Jewel & Spring	3 Cap Jewel & Setting	4 Cap Jewel	5 Bal JL and Spring	6 Bal JL and Setting	7 Balance Jewel	8 Ring	9 Regulating Device
DIAC	SWISS										
RESOMATIC	SWISS										
EMO ANTICHOC	SWISS										
VIBRAX 160E	SWISS										
DUOFIX	SWISS										
TRISHOCK	SWISS										
ANTICHOC 102	FRANCE										
ANTICHOC 51	FRANCE										
SHOCK STABIL	SWISS										
DUROBLOC	GERMANY										
DUROSWING	GERMANY										
FORSTER NEW	GERMANY										
HERCULES NEW	GERMANY										
JUNGHANS	GERMANY										
KIF 190-TRIOR P	GERMANY										
PROTAX	GERMANY										
RUFASUPER	GERMANY										
UNISAFE	GERMANY										
DIASHOCK	JAPAN										
ERA	RUSSIA										
KIROWSKIE	RUSSIA										
VOSTOK	RUSSIA										
BILDINGMAIER	GERMANY										
CYMAFLEX K	SWISS										
HERCULES OLD	GERMANY										
ANTICHOC MT	FRANCE										
MICROFLEX	FRANCE										
CONTRACHOC-MAUTHE	GERMANY										
NEUTRO SHOCK	JAPAN										
MEDAFLEX	SWISS										



SHOCK	Country of Origin		1 Spring	2 Cap Jewel & Spring	3 Cap Jewel & Setting	4 Cap Jewel	5 Bal JL and Spring	6 Bal JL and Setting	7 Balance Jewel	8 Ring	9 Regulating Device
NEUTRO SHOCK	SWISS										
RUBY NEUTRO SHOCK	SWISS										
MASTER SHOCK	SWISS										
UWERSI-VUFE	GERMANY										
FARR-INTEX	GERMANY										
KIENZLE	GERMANY										
ULTRABLOC	GERMANY										
FORSTER A	GERMANY										
FORSTER B	GERMANY										
INTERCO-BIGALU	GERMANY										
DIAFIX	JAPAN										
R CAP	JAPAN										
FIXMOBILE	SWISS										
PROTEC-GENERAL 75	SWISS										
MONOREX-DUROCHOC	GERMANY										
UNICHOC	GERMANY										
GIROCAP	SWISS										
SIMREX PIN LEVER	SWISS										
MONOREX 53	SWISS										
OKAYFIX	SWISS										
RUBY SHOCK	SWISS										
ETERNA E	SWISS										
ETERNA H	SWISS										
ETERNA L	SWISS										
SUPER ANTICHOC MT	FRANCE										
RUFAREX COMBILAGER	GERMANY										
CORTEBERT SPIROFIX	SWISS										
ETERNA T	SWISS										
ETERNA U	SWISS										
SHOCK RESIST	SWISS										

SHOCK NAME	Country of Origin		1 Spring	2 Cap Jewel & Spring	3 Cap Jewel & Setting	4 Cap Jewel	5 Bal JL and Spring	6 Bal JL and Setting	7 Balance Jewel	8 Ring	9 Regulating Device
PHENIX VIBROCHOC	SWISS										
PROTEC-GENERAL 82	SWISS										
PROTEC-GENERAL 90	SWISS										
LUBRIFIX	SWISS										
SUPER SHOCK RESIST	SWISS										
CYMA OLD	SWISS										
PROTEC-GENERAL 836	SWISS										
LIENGME SHOCK STOP	SWISS										
CIMIER LAPANOUSE	SWISS										
ORIS	SWISS										
INCASTAR	SWISS										
SPIROTOR	SWISS										
TRIOSTAT	SWISS										
FONTO	SWISS										
SANDOFIX	SWISS										

The most difficult Shock Devices to identify are those which use springs with 3 arms. To permit you to more easily identify these, we have regrouped all these springs below so that, by scanning carefully, you will be able to select the proper shock. In addition to this listing, each spring is shown under its specific grouping.

SHOCK NAME	Country of Origin		1 Spring	2 Cap Jewel & Spring	3 Cap Jewel & Setting	4 Cap Jewel	5 Bal JL and Spring	6 Bal JL and Setting	7 Balance Jewel	8 Ring	9 Regulating Device
KIENZLE	GERMANY										
FARR INTEX	GERMANY										
UWERSI VUFE	GERMANY										
ERA	RUSSIA										
ULTRABLOC	GERMANY										
MICROFLEX	FRANCE										
CONTRASHOC-MAUTHE	GERMANY										
JUNGHANS	GERMANY										
HERCULES NEW	GERMANY										
UNISAFE	GERMANY										
DIP RESOMATIC-BRAC	SWISS										
TRISHOCK	SWISS										
PROTAX	GERMANY										
RUFAREX COMBILAGER	GERMANY										

CHECK YOURSELF

Progress Check 14 — A Self Test Review of Lesson 14

After you have studied Sections 330 through 345, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The outside diameter of the friction jewel must be __________ larger than the inside diameter of the hole which is to receive it.	330
2. A __________ is needed to replace friction jewels.	331
3. Balance jewels are catalogued by __________ size and __________.	334
4. Cap jewels are catalogued by __________ only.	334
5. When necessary to ream a hole for replacing a friction jewel, a __________ supporting stump is used, while a __________ supporting stump is used when the jewel is being pushed into place.	335
6. The purpose of the face plate is to hold __________ or __________ which cannot be held with the fingers.	336
7. A pump center pusher can be used for both __________ and __________ jewels.	337
8. To keep pushers and anvils in good condition, they must occasionally be __________.	337 338
9. Straightening a defective hole is called __________.	339
10. If a jewel is merely loose but not broken, a __________ punch can be used to avoid replacing the jewel.	340
11. Plate and center jewels are replaced in the plate or bridge from the __________.	341
12. Balance hole jewels are replaced from the __________ of the balance bridge or pillar plate.	341
13. If a friction jewel of the correct diameter is not obtainable, it is possible to use a __________ into which a friction jewel of available size can be set.	342

(Continued)

Progress Check 14 (Continued) | Section Ref.

14. In replacing friction cap jewels, only the ______________________ need be considered.	343
15. The purpose of Incabloc, Shock-Resist and other similar devices is to ____.	344 345

ANSWERS TO
PROGRESS CHECK 14:

1. 1/100 mm
2. friction jeweling tool
3. hole
outside diameter
4. outside diameter
5. hollow
flat face
6. small bridges
settings
7. flat
convex
8. reground
9. uprighting
10. hole reducing
11. inside
12. outside
13. friction brass setting
14. outside diameter
15. protect the
balance pivots

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J1

HOW TO REPLACE A FRICTION TRAIN JEWEL IN A WATCH.

Tools, Equipment and Supplies:

Friction Jeweling Tool Screw Drivers Tweezers Eye Loupe Micrometer
Friction Train Jewels

PROCEDURE:	REFERENCE:
1. Push out the broken or cracked jewel.	Step 1 of Sec. 335
2. Examine the hole carefully to see if it can be used as is.	
NOTE: If the hole in the plate or bridge needs to be enlarged, ream from the inside.	Steps 2 thru 7, Sec. 335
3. Select replacement jewel. Cracked, chipped or broken friction train jewels can usually be replaced with new jewels of the same diameter unless the hole is damaged.	Step 8, Sec. 335. Lesson 12, Sec. 294.
4. Select flat stump and pusher.	Steps 9 & 10, Sec. 335
5. Place the plate or bridge with lower side up on the stump and lower the pusher until it just touches the plate. Set the micrometer stop.	Steps 11 & 12, Sec. 335
6. With tweezers, place the jewel in the hole, oil cup side down.	Step 13
7. Press the lever to push jewel in flush with plate.	Step 14
8. Remove plate and replace wheel and pinion. Check endshake. Correct if necessary.	Step 15

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L14-J2

HOW TO REPLACE A FRICTION BALANCE JEWEL.

Tools, Equipment and Supplies:

Friction Jeweling Tool   Screw Drivers   Tweezers   Eye Loupe   Micrometer
Friction Balance Jewels

PROCEDURE:	REFERENCE:
1. Remove broken or cracked jewel from balance cock or lower plate.	Step 1 of Sec. 335
2. Examine hole to see if it can be used as is.	
NOTE: If hole in plate or bridge needs to be enlarged, ream out from top or outside of balance bridge or pillar plate.	Sec. 341 Steps 2 thru 7, Sec. 335
3. Select replacement jewel.	Sec. 341 and Lesson 13, Sec. 308
4. Select flat stump to support plate or balance cock with top or outside face up.	Step 9 of Sec. 335
5. Select a pusher slightly larger than diameter of jewel.	
6. With tweezers, place jewel in hole, oil cup down and press jewel flush with surface of plate or bridge.	
7. Now it is necessary to set the jewel slightly below the surface of the plate or bridge to provide proper capillary action for the oil, as explained in Lesson 13. Replace the pusher you just used with one slightly smaller than the jewel. Support the bridge or plate and lower the pusher until its face just touches the jewel and rests lightly on it. Adjust the micrometer stop against the lever of the jeweling tool and then back off the micrometer stop about .02 mm or the amount of depth you desire. Press jewel in to this amount.	Sec. 341
8. Check endshake. If you have gone too deep or the jewel is not level, turn the plate or bridge over and push the jewel out part way. Then turn the plate or bridge back again and push the jewel to the desired depth.	

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J3

HOW TO REPLACE A FRICTION CAP JEWEL.

Tools, Equipment and Supplies:

Friction Jeweling Tool Screw Drivers Tweezers Eye Loupe Micrometer
Friction Cap Jewels

Introductory Information:

Cracked, chipped or broken friction cap jewels can generally be replaced with new jewels of the same diameter.

Most upper cap jewels are in steel settings. Where setting is steel, replace both setting and jewel. Do not attempt to ream a steel setting as it will damage reamer.

PROCEDURE:	REFERENCE:
1. Remove broken or cracked jewel from setting.	Step 1 of Sec. 335
2. Examine hole to see if it can be used as is.	
NOTE: If hole needs to be enlarged, place setting in face plate, with the under side or inside surface up. Ream from this side.	Sec. 336 Steps 2 thru 7, Sec. 335
3. Select replacement jewel.	Sec. 343
4. Select flat stump and pusher slightly larger than the diameter of jewel.	Steps 9 & 10, Sec. 335
5. Support setting with under side or inside surface up on stump and lower pusher by pressing lever so pusher just touches setting. Set micrometer stop.	
6. With tweezers, place cap jewel over hole in setting and press jewel in exactly flush with surface of setting.	Sec. 343

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L14-J4

HOW TO REPLACE A FRICTION TRAIN JEWEL IN A SETTING HELD IN PLACE BY JEWEL SCREWS. (Section 296, Lesson 12)

Tools, Equipment and Supplies:

Friction Jeweling Tool   Screw Drivers   Tweezers   Eye Loupe   Micrometer
Friction Train Jewels

Introductory Information:

Friction jewels can be successfully used as replacements in many watches originally designed for other types of jewel setting. The principles for inserting friction train jewels are the same regardless of the original type of setting. (See Job Sheet L14-J1.) In replacing this type, however, do not remove the setting itself from plate or bridge.

PROCEDURE:	REFERENCE:
1. Press out damaged jewel with pusher slightly smaller than the jewel. Press toward the bezel side. Support plate on hollow stump.	
2. Using progressively larger reamers, ream the hole until jewel seat and bezel have been cut away completely, leaving a smooth hole with straight walls.	Steps 2 thru 7, Sec. 335
3. Select replacement jewel.	Step 8 of Sec. 335 Lesson 12, Sec. 294
4. Press into setting and adjust depth for correct endshake.	

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J5

HOW TO REPLACE WITH A FRICTION JEWEL A TRAIN JEWEL IN A SETTING BURNISHED INTO THE PLATE. (See Sec. 299, Fig. 12-13.)

Tools, Equipment and Supplies:

Friction Jeweling Tool Screw Drivers Tweezers Eye Loupe Micrometer
Friction Train Jewels

Introductory Information:

Inserting a friction jewel into a setting burnished into the plate requires careful workmanship in order not to loosen the setting in the plate. If the setting becomes loose in the plate, remove setting and follow procedure in Job Sheet L14-J6.

PROCEDURE: REFERENCE:

1. Support setting on hollow stump.
2. Remove broken jewel.
3. Using progressively larger reamers, ream the hole until burnished edge which held jewel and the jewel seat have both been cut away, leaving a smooth-walled hole.
4. Select replacement jewel.
5. Select flat stump and pusher.
6. Support plate or bridge on stump and press in jewel.
7. Replace wheel and pinion and check endshake.

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J6

HOW TO INSERT A FRICTION BUSHING AND JEWEL.

Tools, Equipment and Supplies:

Friction Jeweling Tool, Friction Jewels, Friction Bushings, Tweezers, Eye Loupe, Micrometer

Introductory Information:

When a jewel of extra large diameter is required, it may be necessary to use a friction bushing into which a friction jewel is set. Holes in bushings do not come in a large variety of sizes but may be reamed to size of jewel you need. Bushings should be no thicker than thickness of plate or bridge.

PROCEDURE:	REFERENCE:
1. Remove damaged jewel or setting from bridge or plate.	
2. Using successively larger reamers, ream the hole until the jewel seat is removed, leaving a straight-walled hole.	
3. Select bushing with diameter .01 mm larger than hole reamed with the thickness slightly less than thickness of plate (to allow for depth adjustment) and with hole nearest to the size jewel you wish to set.	
4. If bushing requires reaming for the jewel, place in face plate or chuck and ream.	Sec. 336 Sec. 342
5. Select jewel.	
6. Set friction jewel in bushing.	
7. Press bushing into plate or bridge.	
8. Check for endshake.	

LESSON	14
FRICTION JEWELING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J7

HOW TO REPLACE A BURNISHED IN BALANCE JEWEL WITH A FRICTION JEWEL.

Tools, Equipment and Supplies:

Friction Jeweling Tool   Friction Balance Jewels   Tweezers   Eye Loupe

Introductory Information:

Some watches still in use have balance jewels burnished into the balance cock or plate. When these need replacement, it is best to use a friction balance jewel.

PROCEDURE:

1. Push out damaged jewel with a pusher slightly smaller than the jewel. Push toward the burnished side of the plate while supporting plate on hollow stump.

2. Using progressively larger reamers, ream the hole until both the burnish and jewel seat have been cut away, leaving a smooth-walled hole.

3. Select jewel.

4. Using a pusher slightly larger than diameter of the jewel, press jewel into bridge from the top.

5. Select pusher slightly smaller than jewel and press jewel into position slightly below the surface.

   NOTE: There should be a space of about .02 mm between the balance hole and cap jewel to provide proper capillary action for the oil, as explained in Lesson 13. The adjustment for this space is made by setting the balance hole jewel only slightly below the surface of the bridge or plate. This depth can be controlled when setting the jewel with the micrometer depth adjustment on the friction jeweling tool. First use a pusher slightly larger than the diameter of the jewel and press it flush with the surface of the bridge or plate. Then replace the pusher with one slightly smaller than the jewel. Support the bridge in place and lower the pusher until its face just touches the jewel and rests lightly on it. Now adjust the micrometer stop against the lever of the jeweling tool and then back off the micrometer stop approximately .02 mm or the amount of depth you desire. Press jewel in to this amount.

HOW TO REPLACE A BURNISHED IN CAP JEWEL WITH A FRICTION JEWEL.

Tools, Equipment and Supplies:

Friction Jeweling Tool   Friction Cap Jewels   Eye Loupe   Tweezers
Screw Drivers   Micrometer

Introductory Information:

Many watches still in use have cap jewels burnished in the cap jewel setting. If setting is of soft metal, this type of jewel can be replaced with a friction cap jewel. If setting is of steel, both setting and jewel should be replaced.

PROCEDURE:	REFERENCE:
1. Push out damaged jewel with pusher slightly smaller than the jewel. Push toward the burnished side. Setting should rest on flat hollow stump.	
2. Place setting in face plate bottom side up.	Sec. 336
3. Using progressively larger reamers, ream hole until jewel seat and burnish are removed.	
4. Select jewel. (.01 mm larger than hole in setting.)	
5. With a flat pusher, press jewel into setting from the under side of the setting flush with the bottom surface.	Sec. 343

HOW TO DISASSEMBLE AND ASSEMBLE AN INCABLOC SHOCK PROTECTOR DEVICE.

Tools, Equipment and Supplies:

Fine Tweezers

PROCEDURE: REFERENCE:

1. Release the open end of the Incablock spring or lyre-shaped spring with a fine tweezers or needle. Release one prong of spring at a time. — Lesson 14, Fig. 14-27

2. When both prongs are released, lift end of spring. (The other solid end is fastened to act as a hinge.)

3. Lift out the cap and balance jewel assembly.

4. Separate cap jewel from setting or bushing.

   NOTE: Sometimes when the oil is dry, the cap jewel may stick in the recessed top of the setting. The cap jewel can be separated with any of the following methods:

   a. Dip entire setting in alcohol.

   b. Hold setting slightly above work surface with tweezers and push oil inserter through the hole in the balance jewel.

   c. Hold setting in tweezers and press the cap jewel against the gummed surface of Scotch tape. Lifting the setting leaves the cap jewel on tape. The balance jewel remains in place.

5. Clean cap jewel and balance hole jewel with setting and allow to dry.

6. Oil Incabloc assembly. Use either of these methods:

   a. Hold balance jewel setting on work surface with tweezers and apply a small amount of oil to the jewel hole from the rounded side of the jewel. Place cap jewel in place in the setting.

   b. Hold cap jewel flat side up on work surface and apply a small amount of oil in center of the cap jewel. Then

(Continued)

without dipping oiler in oil cup, apply remaining oil on oiler to the hole jewel. Leave cap jewel in position on work surface and place setting and balance jewel on top of cap jewel.

7. Replace cap and balance jewel assembly in bridge or plate.

   a. Incabloc spring should be open to allow setting to move into place in block bed. Put setting in place.

   b. Hinge spring down to top of setting and lock each prong of spring into place with fine tweezers or needle.

POINTS TO REMEMBER:

1. Spring ends must be fastened.

2. The upper cap jewel is always thicker than the lower cap jewel.

3. The block bed in which the jewel setting is resting should be free of dirt and burrs.

4. When ordering a staff for a movement fitted with an Incabloc, be sure to specify "Incabloc" because the staff used with this type of setting is different from the regular ones.

5. Most shock resist parts are made in several diameters to fit various sized movements. When ordering replacement parts, send the broken part as a sample.

HOW TO DISASSEMBLE AND ASSEMBLE A SHOCK-RESIST PROTECTOR DEVICE.

Tools, Equipment and Supplies:

Tweezers   Screwdriver

PROCEDURE: REFERENCE:

NOTE: Cap jewel setting on balance bridge is generally held by screw from under side of bridge.

1. Remove balance assembly from movement. Sec. 345

2. Remove screws holding the cap jewel setting.

3. Clean jewels the same as any other type of jewel.

4. Place cap jewel setting on work surface with flat side of jewel up. Hold with tweezers while you apply a drop of oil to center of cap jewel.

5. Turn setting over with tweezers and place on bridge or plate. Take care to place setting exactly in right position so as not to smear the oil on the jewel. Replace cap jewel screws.

NOTE: Most shock resist parts are made in several diameters to fit various sized movements. When ordering replacement parts, send the broken part as a sample.

LESSON	14
SUPER SHOCK-RESIST	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J11

HOW TO DISASSEMBLE AND ASSEMBLE A SUPER-SHOCK-RESIST PROTECTOR DEVICE.

Tools, Equipment and Supplies:

Tweezers.

NOTE: See Assignment Sheet, Lesson 14, for information.

PROCEDURE:

1. Remove cap and hole jewel and setting.

   a. Using tip of tweezers, move one tip of the cap jewel setting to the cut out notch.

   b. Lift the disengaged tip with tweezers and lift out cap jewel and setting.

   c. With tweezers, lift out the balance jewel and setting.

2. Clean jewels the same as any other type of jewel.

3. Replace balance jewel and setting in the base of the assembly.

4. Place cap jewel flat side up on work surface and hold with tweezers as you apply a drop of oil in the center of the cap jewel.

5. Turn cap jewel setting over with tweezers and place in base of setting with one protruding tip engaged and the other in line with cut out notch.

6. Use tweezers to push tip down and turn either right or left a quarter turn to lock the cap jewel setting in place.

NOTE: Most shock resist parts are made in several diameters to fit various sized movements. When ordering replacement parts, send the broken part as a sample.

LESSON	14
DUOFIX	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L14-J12

HOW TO DISASSEMBLE AND ASSEMBLE A DUOFIX COMBINED JEWEL SETTING.

Important

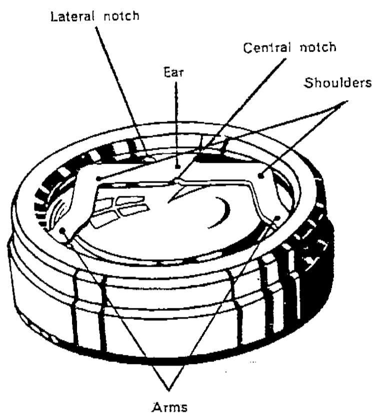
Do not attempt to disengage **the arms** of the key when dismounting the DUOFIX.

Tools, Equipment and Supplies:

Tweezers

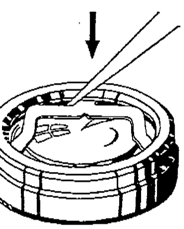
Introductory Information:

Study the illustration at the right to learn the terms used in the explanation below. At first glance, the key or holder spring might seem to be similar to the Incabloc and you might assume it is disassembled in the same way. Note, however, that you disengage the key at the end rather than the two arms as you do on the Incabloc.



PROCEDURE:

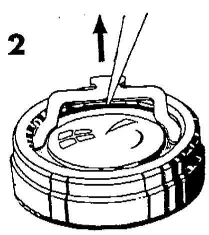
1



1

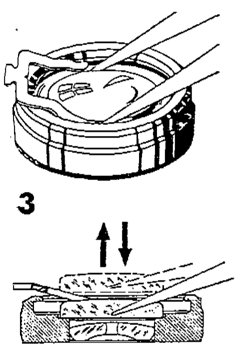
To disassemble the DUOFIX, use a sharp pointed tool in the notch beside the ear and disengage the ear from the block by a backwards movement.

2



2

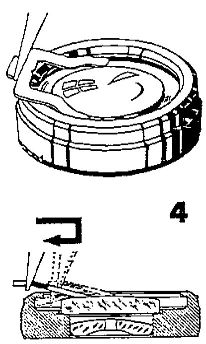
Engage the point of the tool into the central notch opposite the ear and slide the key outwards to release the cap jewel.



3

3

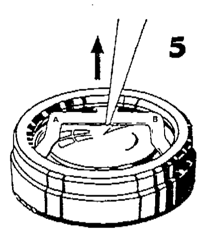
The cap jewel can be removed and replaced with tweezers. Cap jewel and jewel hole are easily cleaned.



4

4

To re-assemble, engage the tool point into the notch beside the ear and push the key slightly inwards under the perimeter of the block.



5

5

Bring the key to its locking position by pushing at the central notch. The ear will then slide under into groove in the block and the two shoulders A & B will touch the block wall.

Information supplied by Parechoc S.A.; Le Sentier, Switzerland

LESSON	14
KIF 370	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J13

HOW TO DISASSEMBLE AND ASSEMBLE A KIF 370 SHOCK PROTECTOR DEVICE.

Tools, Equipment and Supplies:

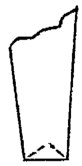
Tweezers Pegwood

NOTE: See Assignment Sheet, lesson 14, for information.

PROCEDURE:

1. Remove cap and hole jewel.

   a. Cut end of pegwood slightly smaller than diameter of retaining spring.

   b. Cut a concave cone in end of pegwood. This hollowed center will clear the curved cap jewel and allow pressure on the outer edge of the retaining spring.

   c. Press end of pegwood on retaining spring and turn until the three protruding tips of the spring are in line with notches on inner edge of base. Lift out spring.

   d. Turn bridge or plate over and setting containing balance hole and cap jewel will fall out.

   e. Separate cap jewel from setting by either dipping setting in alcohol or pressing cap jewel onto Scotch tape.

2. Clean and oil jewel assembly.

   a. Clean as any other type of jewel.

   b. Assemble as follows: Place cap jewel with flat side up on work surface and place balance hole jewel and setting on top of cap jewel.

   c. As the balance hole jewel is mounted with oil cup exposed, oil in the regular manner; that is, place oil in oil cup and use oil inserter. Hold setting in place on work surface with tweezers while oiling.

3. Place balance hole and cap jewel assembly in plate or bridge.

   a. Place jewel assembly in place in base.

   b. Place retaining spring in place with protruding tips of spring in spaces provided.

   c. Using concave end of pegwood, press downward and turn spring 1/6th turn in either direction to lock spring in place.

LESSON	14
KIF FLECTOR	

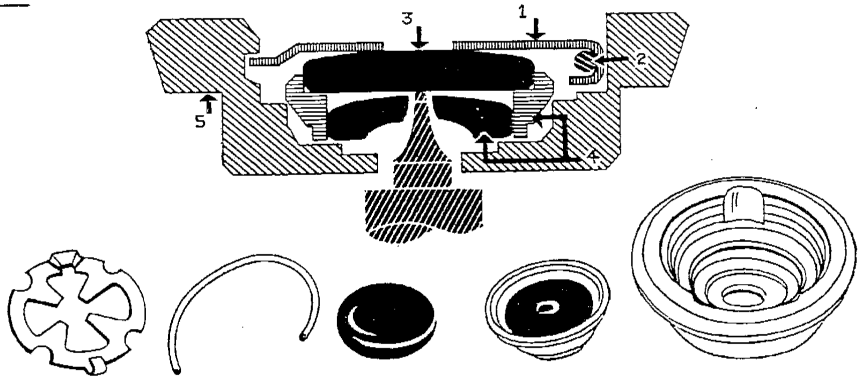
Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L14-J14

HOW TO DISASSEMBLE AND ASSEMBLE A KIF FLECTOR SHOCK PROTECTOR DEVICE.

COMPONENT PARTS



1. Spring 2. Hinge Ring 3. Cap Jewel 4. Jeweled Setting 5. Holder

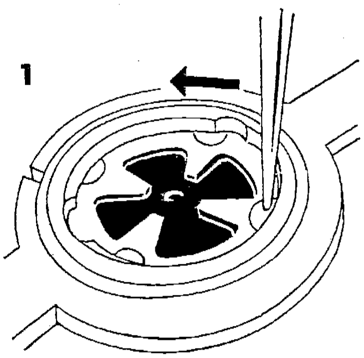
Tools, Equipment and Supplies:

Tweezers

Introductory Information:

This model Kif is hinged so it opens and handles more easily.

1



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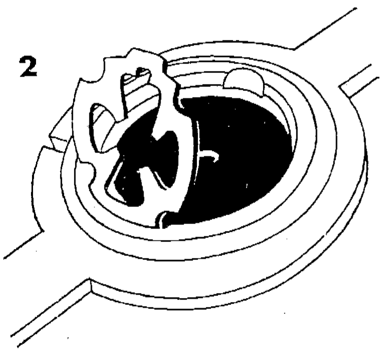

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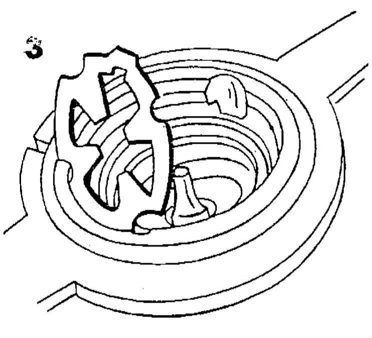


PROCEDURE:

1. Place a tweezer point in the spring notch and turn the spring slightly in the direction of arrow. This opens the spring.

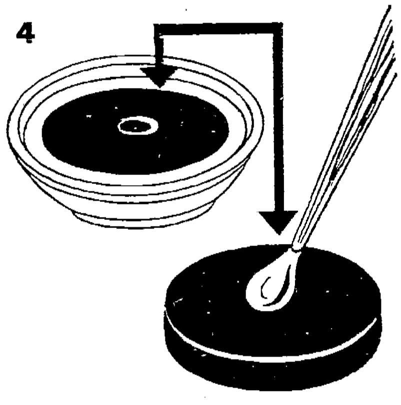
2. Lift out jeweled setting and cap jewel. Separate these two and clean like any other jewels.

3. Clean the exposed balance staff pivot.

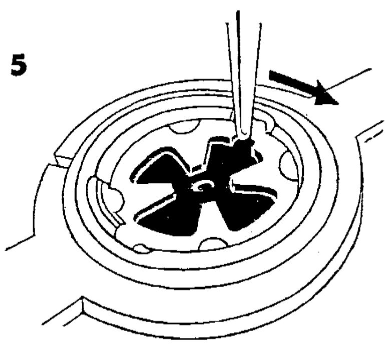
4. Place a drop of oil on the cap jewel and replace it in the jeweled setting.

5. Replace setting in holder. Lower spring and, with tweezer in notch, turn it in direction of arrow to fasten spring.

4



5



LESSON	14
KIF FLECTOR SPRING	

Master Watchmaking

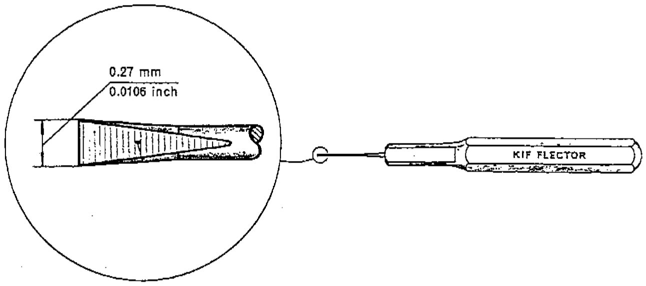
CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J15

HOW TO REPLACE A KIF FLECTOR SPRING.

Tools, Equipment and Supplies:



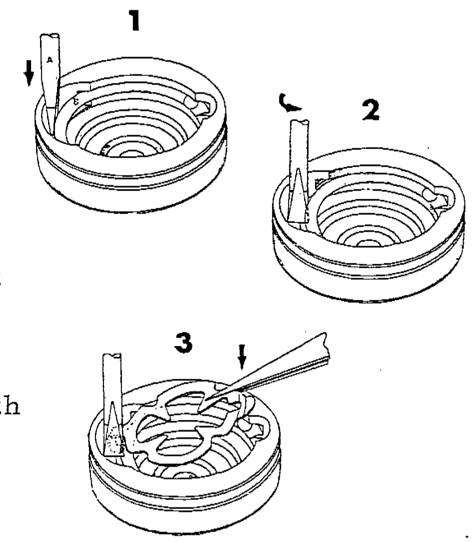
Kif Flector Tool (shown at right) or substitute (see below).

Tweezers   Replacement Spring

Introductory Information:

Once in a while the retaining spring will break and have to be replaced. When that happens, the procedure is as follows:

PROCEDURE:

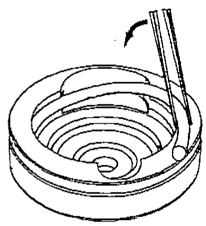


1. Insert the special tool A behind the hinge ring B.

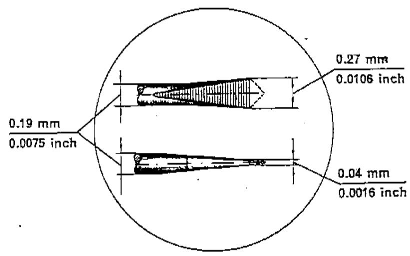
2. Turn tool A a quarter turn in either direction to push the hinge ring toward center. (NOTE: The spring usually breaks at the hinge. If still intact there, or if a piece remains, it can now be lifted out.)

3. To insert the new retaining spring, pick it up with tweezers and hook the hinge end under the hinge ring. Then pull out the special tool by lifting straight up. The spring is now in place.

NOTE: If necessary at any time to put in a new hinge ring, fasten it in place by inserting one arm first and then the other in the groove of the unit.



NOTE: If the special tool is not available, a "blue oiler" can be adapted for use by removing the front portion indicated by dotted lines in this illustration. Dimensions should be as shown.



HOW TO DISASSEMBLE AND ASSEMBLE A MONOREX SHOCK PROTECTOR DEVICE.

Tools, Equipment and Supplies:

Tweezers

NOTE: See Assignment Sheet, Lesson 14, for information.

PROCEDURE:

1. Remove cap jewel setting.

   a. Use tip of tweezers to turn the cap jewel assembly by pushing against one of the prongs in line with the slot.

   b. Raise the disengaged tip with tweezers and lift out the cap jewel setting.

   c. Lift out the balance hole jewel setting with tweezers.

2. Clean jewels just like any other type of jewel.

3. Replace balance jewel setting in base of assembly.

4. Place cap jewel flat side up on work surface and hold with tweezers while you apply a drop of oil in the center of the cap jewel.

5. Turn cap jewel setting over with tweezers and place setting in base with one prong engaged and the other in line with cut out notch.

6. Push tip down with tweezers and turn either right or left a quarter turn to lock cap jewel setting in place.

NOTE: Most shock resist parts are made in several diameters to fit various sized movements. When ordering replacement parts, send the broken part as a sample.

LESSON	14
RUBY SHOCK	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L14-J17

HOW TO DISASSEMBLE AND ASSEMBLE A RUBY-SHOCK SHOCK PROTECTOR DEVICE.

Tools, Equipment and Supplies:

Tweezers

NOTE: See Assignment Sheet, Lesson 14, for information.

PROCEDURE:

1. Using tip of tweezers against spring prong, turn cap jewel setting until two of the tips have disengaged from the setting. Lift out setting.

2. Turn plate or bridge over and balance jewel will fall out.

3. Clean jewels the same as any other type.

4. Place balance jewel in base of assembly.

5. With cap jewel resting on work surface and bottom of cap jewel up, place a drop of oil on face of cap jewel.

6. With tweezers, turn cap jewel setting over and place in base with one prong engaged and another in line with slot.

7. Press prong into slot with tweezers and turn setting until all three prongs are engaged.

NOTE: Most shock resist parts are made in several diameters to fit various sized movements. When ordering replacement parts, send the broken part as a sample.

HOW TO DISASSEMBLE AND ASSEMBLE A DIASHOCK SHOCK PROTECTOR DEVICE.

Tools, Equipment and Supplies:

Tweezers   Oil

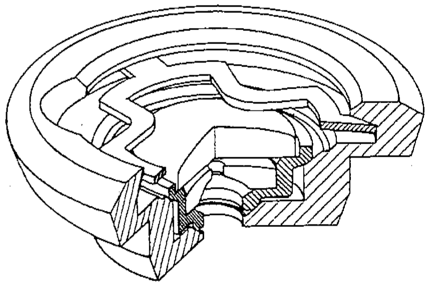


Fig. 1

PROCEDURE:

1. To remove the spring, turn it gently with a tweezers as shown in Fig. 2.
2. Lift out the cap jewel and jeweled setting.
3. Separate these two and clean as any other jewel.
4. Place a drop of oil on the cap jewel and replace it in the jeweled setting. (See illustration 4 on Job Sheet L14-J14, KIF Flector.)
5. Replace the spring by fitting and turning its three hooks one by one into the notch of the frame.

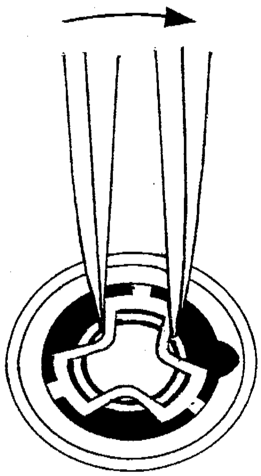


Fig. 2

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

HOW TO DISASSEMBLE AND ASSEMBLE A DIAFIX COMBINED JEWEL SETTING

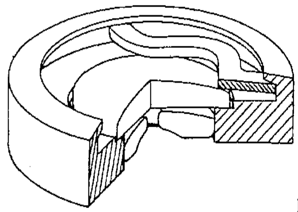


Fig. 1

Tools, Equipment and Supplies:

Tweezers Oil

PROCEDURE: (Men's watches)

1. Slide the spring down with tweezers to free the head of the spring, Fig. 2.

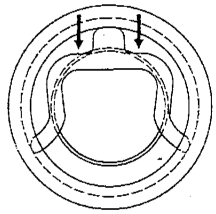


Fig. 2

2. Move the spring forward to free the cap jewel, which you then lift out, Fig. 3.

3. The train jewel assembly is friction fit into the train bridge. Before cleaning, it is advisable to relock the spring so it is not lost or damaged during the cleaning process.

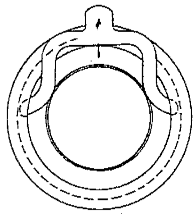


Fig. 3

4. To reassemble, unlock the spring, insert the cap jewel and relock the spring.

5. Oil the assembly from the oil cup side. Be sure the oil enters the hole as in Sec. 249, Lesson 10.

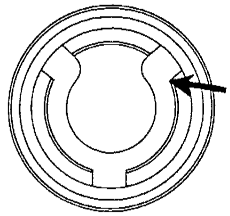


Fig. 4

PROCEDURE: (Women's watches)

1. Release the spring by pushing in on each leg in turn with tweezers, Figs. 4 and 5. Slide the head of the spring out, Fig. 6. Set spring aside.

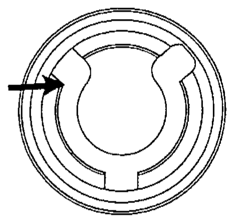


Fig. 5

2. Remove cap jewel with tweezers and set aside. Both spring and cap jewel are so small that it is best not to place them in the cleaning basket. Clean separately.

3. Reassemble in reverse order and oil as for men's watches.

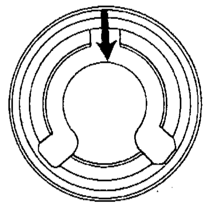


Fig. 6

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 14

Name: No. Date:

Circle ONE correct answer: SUBJECT: Friction Jeweling

1. Frequently a broken or cracked jewel is overlooked when estimating the charge for watch repairs. It is better in this case to:

Hold the job and make a new estimate to the customer	Turn the repair job out with the broken jewel	Replace the broken jewel and do not mention it to the customer	Replace the jewel and add the cost to the next repair job

2. In friction jeweling, the diameter of the jewel is larger than the diameter of the hole which is to receive it: How much is this difference?

1/4 of 1/100 of a mm	2/100 of a mm	1/100 of a mm	5/100 of a mm

3. By which dimensions are friction cap jewels catalogued?

Thickness and outside diameters	Thickness only	Outside and inside diameters	Outside diameter

4. When replacing friction train jewels, the end shake of the wheel and pinion can be adjusted and controlled by means of:

The micrometer nut	The thickness of the jewel	The correct hole size of jewel	The correct diameter of pusher

5. The face plate described in this lesson is used for:

Adjusting end shake	Setting cap jewels flush with settings	Holding small bridges and settings	Holding pillar plates

6. The friction balance jewel, like other types of balance jewels, must be set in the bridge, plate or setting:

With the top of jewel just above the surface	Slightly below the surface	Exactly half way through	Exactly even with the surface

7. If you ream a plate jewel setting with a reamer measuring 1.79 in diameter, what diameter jewel should you select?

1.79	1.80	1.90	2.80

8. Cap jewels are always set:

Flush with the surface of the setting	Exactly half way through the setting	Slightly above the surface of the setting	Slightly below the surface of the setting

9. The Incabloc jewels described in this lesson are held into the assemblies by:

Springs	Friction	Screws	Taper pins

10. Incabloc jewels are set into a flexible bearing to:

Make them more easily assembled	Increase the ease of adjusting end shake	Eliminate loss of jewel screws	Permit them to shift under the influence of shock

11. The upper cap jewel in the Incabloc assembly is:

Flat on both sides in contrast to the lower cap jewel	The same thickness as the lower cap jewel	Thinner than the lower cap jewel	Thicker than the lower cap jewel

12. Only one of the lists below names the jewels in the same order as they are arranged in the envelopes on the sample card, starting with the top envelope. Circle the one correct list:

Balance hole jewel Roller jewel Train jewel Pallet stone Cap jewel	Train jewel Pallet stone Balance hole jewel Roller jewel Cap jewel	Train jewel Roller jewel Balance hole jewel Pallet stone Cap jewel	Cap jewel Pallet stone Balance hole jewel Roller jewel Train jewel

Detach page or cut along this line — and send to the School for grading

Job Inspection Request

CHICAGO SCHOOL OF WATCHMAKING
310 LINCOLN AVENUE, FOX RIVER GROVE, ILLINOIS

Detach page or cut on line and use this sheet — when you need help on your shop work.

Use this Request whenever you need help or have questions on the practical work. Use a Student Consultation Sheet for all other questions or service.

Student number ____________ Date ____________

Name	
Address	
City State Zip Code	

IDENTIFY the work you are sending in for inspection:

____

____

____

( ) Enclosed
( ) Sent separately

When sending in work for inspection, be sure to pack it carefully to prevent damage in the mails. Surround your watches with crumpled papers. Insure valuable movements or other items of value.

To CHIEF INSTRUCTOR
Chicago School of Watchmaking

I am working on lesson number ______. Please tell me what to do about this:

(Tell briefly what work you did and where you had trouble with it.)

( ) PLEASE RETURN BY INSURED MAIL. ( ) DO NOT RETURN BY INSURED MAIL.

ENCLOSED ______¢ INSURANCE FEE

● INSTRUCTOR NOTE: Please send a new Request Sheet back with this one.

Master WATCHMAKING

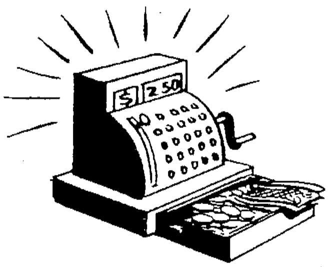
Lesson 15

REPLACING FACTORY BALANCE STAFFS

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

INTRODUCTORY INFORMATION

The importance of knowing how to properly replace a balance staff cannot be over emphasized. This is one of the most common repairs a watch repairman has to make. Balance pivots are very small and are made of hardened and tempered steel. They break easily when the watch is dropped or jarred severely.



Although balance staffs cost only 70¢ to $1.60, the repairman receives $6.00 to $9.95 as an average return for his work in replacing them. As a thorough job (including truing and poising the balance wheel and cleaning the balance and cap jewels) takes only about 45 minutes, this kind of repair is well worth while.

There are several types of balance staffs in use. You should learn to recognize each type because different procedures are used in replacing each type.

This lesson teaches the basic principles for removing and replacing the most common types of balance staffs. Even so, you may find yourself unable to replace the staff in all watches at this time. This is because the balance staff must be exactly correct in all dimensions. Sometimes a factory balance staff must be altered slightly even though it is supposed to be the right size. Most of these alterations are on the balance pivots. Such work is done on the lathe. You should not expect to be able to replace every balance staff, therefore, until after you have mastered lathe work and can make any necessary correction.

KEY POINTS OF LESSON ASSIGNMENTS 50, 51, 52:

- Why you should learn proper methods of replacing a staff.
- Types of balance staffs.
- The right way to remove a hairspring.
- How to remove a roller.
- How to remove the balance staff.
- How to check and compare the new staff with the old to assure a correct fit.
- How to use the staking tool in replacing staffs, rollers and hairsprings.
- Friction type staffs.

ASSIGNMENT NO. 50: Study Sections 350 and 351.
Read Tools and Materials of the Trade, page 22.

Study Questions:

1. What is genuine watch material?
2. In what ways and why do balance staffs vary?
3. How can you test for a broken balance staff?

ASSIGNMENT NO. 51: Study Sections 352, 353 and 353A (at end of lesson).

1. What is the approved method for removing the hairspring?
2. What are the approved methods for removing the roller?

Recommended:

Make the hairspring removing tools illustrated in Fig. 15-3. Use short pieces of old mainspring. If desired, handles can be made from pegwood about 25 mm long. Cement each tool into its handle.

ASSIGNMENT NO. 52: Study Sections 354 through 359.

1. How is the balance staff removed from the wheel?
2. What is the difference between the Waltham friction staff and the riveted staff?
3. What can be done if pivots are bent?
4. What is the nomenclature of the ordinary type of balance staff?
5. Why is it necessary to match the new staff with the old?
6. What should be checked before riveting a staff to the wheel?
7. How is the staff riveted to the wheel?
8. How is the roller replaced?
9. How is a friction staff replaced?

Recommended Practice:

1. Using your practice wheels and staffs, rivet the staffs to the wheel according to the instructions in Section 357.

2. Remove a single roller from a balance wheel, staff and roller assembly, according to Section 353. Replace roller according to Section 358. Be sure the roller jewel is at a 90° angle to an imaginary line through length of balance arm.

3. Remove and replace a combination roller from a balance wheel, staff and roller assembly, following instructions in Sections 353 and 358. Check that the roller jewel is at a 90° angle to the arm of the balance.

4. Remove and replace a two-piece double roller from a balance wheel, staff and roller assembly according to Sections 353 and 358.

REQUIREMENT:

➧ Answer all Test Questions for Lesson 15 and send in for grading.

SUMMING UP

The practical work in this lesson is only the first step in replacing a balance staff. To complete the job, the wheel must be trued in the flat and round and also be poised. These phases of the work will be taken up in Lessons 16 and 17.

REPLACING FACTORY BALANCE STAFFS

SEC. 350—The Balance Staff

The balance staff is sometimes referred to as the balance arbor. It is usually made of tempered steel. The balance wheel is attached to the balance staff and the pivots of the staff rotate in the balance jewel assemblies previously described.

Replacing a balance staff properly, together with the truing and poising of the balance wheel, affords an opportunity for the watchmaker to demonstrate his ability as a master workman. It is in this part of the watch that the unskilled workman most often delights in giving horrible examples of "botchwork." While you may come in contact with some of the "botchmaker's" art at other points—such as attempting to splice a mainspring in the center—it is in and around the balance and balance staff that such a person seems to delight in showing the **improper** methods of making repairs. In a great many instances, these errors have been made by using material that did not fit. Perhaps an attempt was made to substitute another make of balance staff. If the staff was too long or too short the balance cock was bent up or down. If the hub of the staff was too small for the balance, soft solder was used to fill in the gap. If the hole in the roller appeared to be too large for the balance staff it was remedied by using glue or cement to hold the roller in place. If the collet shoulder was too small the collet was pinched together, throwing the hairspring out of true and giving a poor holding for the collet. If the hole in the jewels appeared to be too small the pivot was ground or filed by hand until it entered the jewel hole. If the hairspring was too strong for the balance it was weighted down with an excess of washers or soft solder. These examples are not suppositions, but are actual cases as well as many other examples of what an ingenious "botchmaker" will do (when compelled to figure out a method to make repairs) when it would have been much easier to do the work properly in the first place, without danger of placing the watch in such condition that it could not run or be timed properly until practically rebuilt by a master watchmaker. Over a period of years there have been a great many attempts made to prevent poor quality watch repairing. Some states have licensing laws which are set up to protect the public against these practices. However, the one way to be certain that the public is adequately protected is by properly educating the watchmaker to make repairs correctly. The educator can only show the student the correct procedure. The student must practice until he is proficient; and at this time let me remind you again that proficiency can only be accomplished by practice. Do not attempt to make repairs on watches other than those you have for practice work. It is surprising what liberties some people will take with another person's watch rather than admit, even to themselves, that they do not know how to correct a very minor defect.

This lesson is difficult, not because the work is hard to understand but because to do balance staff work properly, you will also require instruction in truing and poising the balance. If a factory balance staff has a pivot that requires polishing or needs to be reduced slightly in diameter, it must be done on a watchmaker's lathe. There are times when the collet shoulder, balance shoulder, or roller table post require slight alterations, and these also require a watchmaker's lathe to complete properly. The purpose of this lesson is to teach you to replace a staff even though you have not had the instruction on lathe work. You must understand this part of staff replacement in order to understand when and how to make alterations with a lathe. This lesson is comparable to learning the letters of the alphabet. After you have mastered the alphabet you learn to combine these letters with each other to form simple words. Then as your education advances your vocabulary increases and you can read or write with ease words which would be difficult if it were not for the proper procedure used to teach you the elementary principles of reading and writing.

SEC. 351—Types of Balance Staffs

Genuine factory staffs are, as a rule, accurately made and easily replaced. When we refer to any piece of watch material as being genuine we mean it was made by the factory which made the watch originally for the particular model of watch in which it is being placed. Any other material, although it would fit properly, is referred to as imitation material. Use genuine material whenever posible. Take your time. Remember the pivots on balance staffs are only two to three times as thick as a human hair and being made of tempered steel can be broken easily.

The dimensions of balance staffs vary for different models even in the same size and make of movement. One of the older American factories, now out of business, had eight models all of the same size, each using a balance staff of different dimensions. This is usually due to a change or refinement in the model. For this reason it is well for the beginner to note the general types of balance staffs used in the different makes and sizes of watches which he handles. Some hubs you will observe are thicker than others or are cut on a different angle. On still others the collet shoulders may vary in diameter for the same models or different models of the same size. In selecting a replacement for a broken staff you must be able to judge which particular number of an assortment is the one required. The final proof of your correct selection is if all parts fit properly and when replaced in the watch, there is the correct amount of sideshake and endshake.

When a watch comes to you for repairs it should always be tested to see if the balance staff is broken. Grasp the arm of the balance wheel with tweezers and endeavor to move it from side to side as in testing for sideshake. If the lower end of the staff can be moved from side to side and also up and down, the chances are that the lower pivot is broken although it may act in much the same manner if the lower jewel is broken. The same test is used for the upper pivot. Often when a watch receives a jar or a fall hard enough to break the balance staff, one or more of the balance jewels may be broken also, so do not rely on such a superficial examination. Only by removing the balance and examining the pivots and jewels with a double loupe can the watchmaker make a fair and intelligent estimate.

SEC. 352—Removing Hairspring

1. Remove the balance with hairspring from the watch
2. Remove hairspring

The hairspring is attached to the balance by means of a collet. The collet is a small circular split brass collar into which the inner end of the hairspring is pinned. The hole through the center of the collet is enough smaller in diameter than the collet shoulder on the staff that it will hold securely when forced into place, usually with a staking punch.

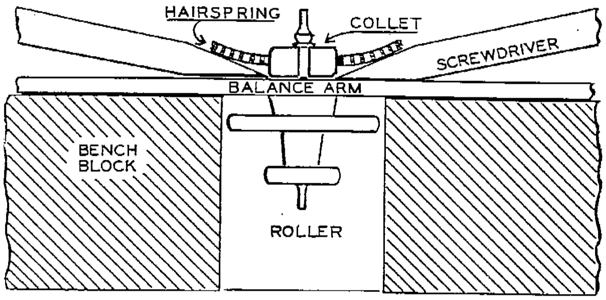


Fig. 15-1

Figure 15-1 illustrates the method of using two screwdrivers to remove the hairspring and collet. However, this method is dangerous as a slip of the screwdriver may cause irreparable damage to the hairspring. Figure 15-2 illustrates the method used in removing the collet by means of a small tool which can be made from a piece of mainspring. The arrow at A represents the twist given the tool in order to spread the collet enough to release the tension, and the arrow at B describes the turning of the collet around the collet shoulder, at the same time pulling slowly upward. The balance is held between the thumb and middle finger left hand while the right hand manipulates the tool. If the tool should slip, it would not be in position to damage the hairspring. Figure 15-3 illus-

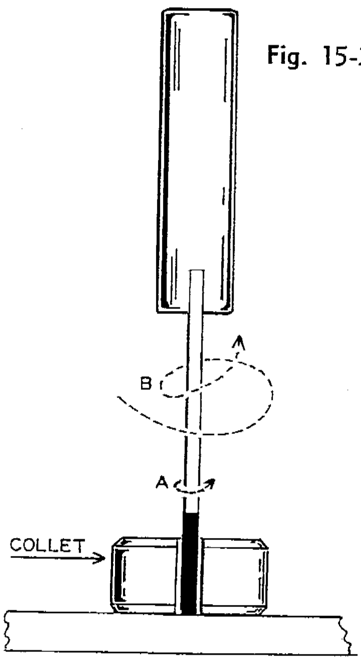
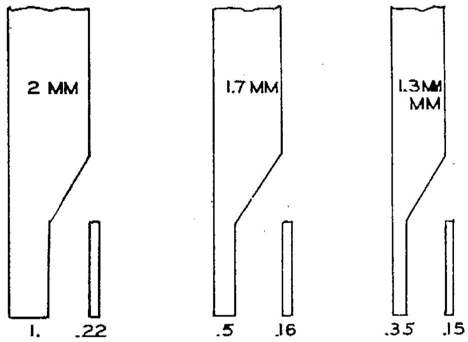


Fig. 15-2

Fig. 15-3



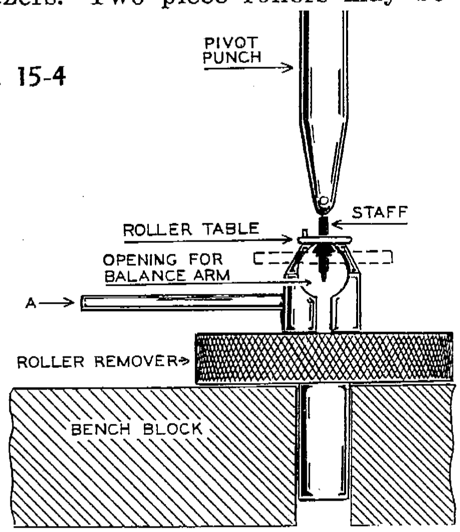
HAIRSPRING REMOVING TOOLS
MATERIAL--MAINSPRINGS
APPROXIMATE DIMENSIONS IN MM.

trates the dimensions of three of these tools which can be made from pieces of mainsprings, the thickness of which is given. As a mainspring is made from tempered steel, it is best to grind the material with a small grinding wheel or an oilstone.

SEC. 353—Removing the Roller Table

In the lesson on setting roller jewels, the three most common types of roller tables were described. There are many types of roller removers on the market, but the Rex roller remover described hereafter will do the job in most cases. Figure 15-4 illustrates the procedure. The roller remover is placed in the die plate of the staking tool or on a bench block. Holding the knurled edge of the roller remover between the thumb and forefinger, open the jaws of the tool by means of the small handle at A. Place the inverted balance over the jaws of the roller remover with the arm of the balance through the opening of the jaws. Carefully tighten the jaws until the roller table is in the position shown. Place the pivot punch, which is furnished with the tool, over the pivot and tap lightly with a brass hammer. This will loosen the roller table enough to be removed with the tweezers. Two piece rollers may be removed by the same method. However, the impulse roller will loosen first and will move up against the safety roller. Another light tap will loosen the safety roller, after which both rollers may be removed.

Fig. 15-4



SEC. 354—Removing the Balance Staff

Many watchmakers make a practice of driving out the balance staff without undercutting. This is done by placing the hub of the balance in a hole large enough to receive it without binding in the die plate of the staking tool, and after centering, punching it out with a pivot punch. This is poor practice and the work of inefficient workmen, for since the staff is made of tempered steel and the upper edge of the balance shoulder is riveted over the arm of the balance, this method has a tendency to enlarge the hole in the arm. In time the arm will be bent to such an extent that it will be difficult to true.

For all practical purposes, a balance staff can be removed from the wheel using a balance staff remover; however, the best method requires the use of the watchmaker's lathe. It will be beneficial to the student if we explain this method now and to demonstrate its value.

Figure 15-5 illustrates a balance staff with the roller removed but still riveted to the balance wheel. The staff in turn is held in a lathe chuck, the latter not illustrated. The staff, which is solid black, shows that portion which is left after part of the hub has been cut away. The dotted lines indicate the hub before it was cut away. Notice that it has been cut below the balance shoulder which is indicated by the dotted line. As you can see, this leaves a very thin rim over the balance arm. Figure 15-6 illustrates the method used to remove the remaining metal. The graver is sharpened to a long point and the cut is started at

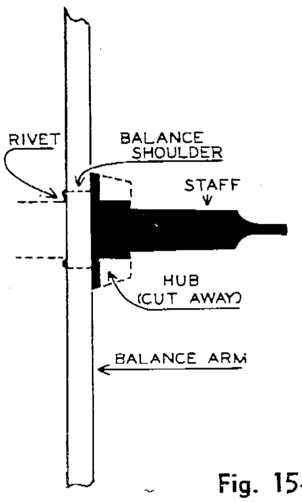


Fig. 15-5

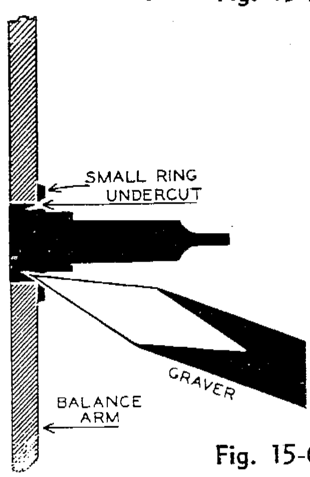


Fig. 15-6

the base of the previous cut. The instant the cutting edge of the graver reaches the balance arm the remaining metal will separate from the staff in the form of a small ring. The wheel can be ready removed over the roller post. As soon as the student has access to a watchmaker's lathe, he should use this method, as it is without a doubt the safest.

Figure 15-7 illustrates a staff remover which is used in conjunction with a staking tool. Remove staff as follows:

1. Select a hole in the die plate of the staking tool large enough to admit the hub of the staff. Make certain the hub does not fit too tightly; it must have a little side play.
2. Center hole selected with center punch.
3. Place balance and staff over hole in die plate.
4. Place staff remover over the arms of the balance and slip punch over upper end of balance staff.
5. Tighten knurled nut so that the balance arm will be held securely in place.
6. Strike punch A sharply with a brass hammer until the slight gap at C is closed. The staff will now be free of the balance arm.
7. Release nut and remove staff remover. The old staff should fall through the staking block. The methods described pertain to the removal of balance staffs which have a riveted edge to hold the balance wheel securely in place.

The most common type of friction staff is used in some models of Waltham watches. It is quickly recognizable by the supposed hub of the balance staff which, if blue, is not part of the balance staff; moreover, the staff is a friction staff. The blued hub is riveted to the arm of the balance wheel and the staff is removed as in figure 15-8. It is an easy matter to remove the old staff and replace it without disturbing the truth or poise of the balance wheel.

1. Select hole in die plate, which will support the blue hub, yet one which is large enough to permit the friction staff to fall through.
2. Center hole and lock die plate in place.
3. Select pivot or cone shape punch and place over staff.
4. A few slight taps with a brass hammer will drive the staff out.

Another type of friction balance staff is found in the 992 Elinvar Hamilton watch. Figure 15-9 illustrates this staff which, when assembled, looks similar to the one piece 16s double roller staff. Therefore, a groove, A, figure 15-9, has been added as a mark of identification. The

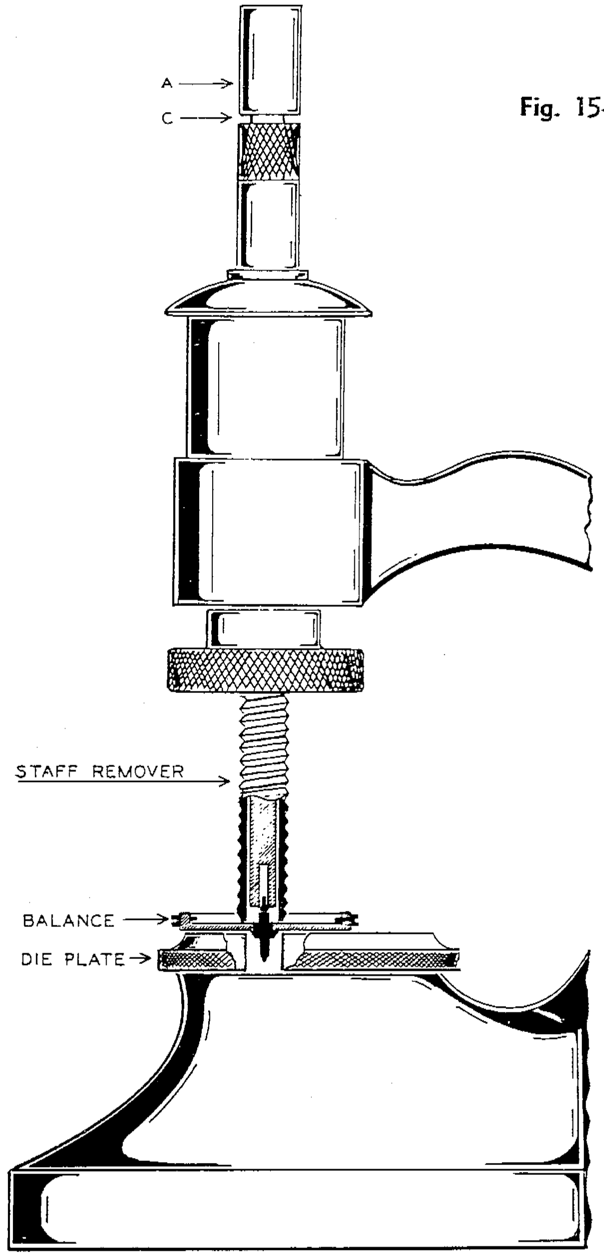


Fig. 15-7

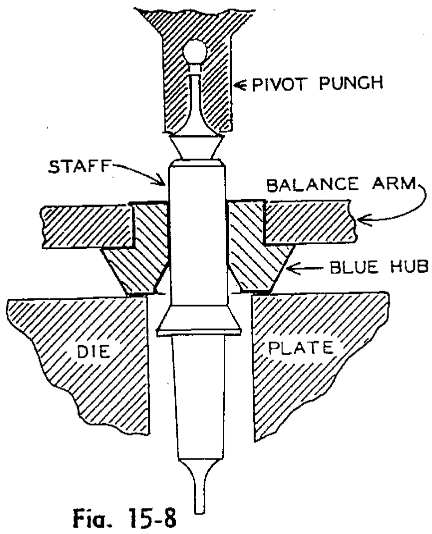


Fig. 15-8

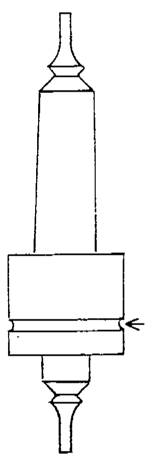


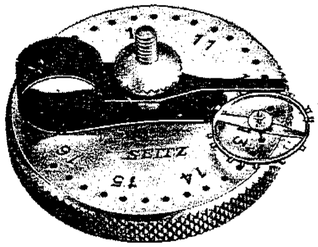
Fig. 15-9

procedure used in removing this type of balance staff is the same as the procedure used in removing the Waltham friction staff.

SEC. 355—Pivot Straightening

Many watchmakers endeavor to straighten pivots when they are bent rather than replace the staff. At times it is possible to straighten a pivot which is only slightly bent by placing it in a watchmaker's lathe and spinning true with the aid of a special pivot straightening tweezer. Figure 15-10 illustrates a pivot straightening

Fig. 15-10



device which is a part of the friction jewelling tool described in the previous lesson. The tool is a round metal plate set with 33 jewels from .08 mm to .16 mm, each hole ¼ of 100th larger than the preceding hole diameter. To straighten a bent pivot proceed as follows:

Example: Bent Pivot—diameter .10 mm

1. Place bent pivot in a hole of larger diameter, perhaps 12 or 13, according to the curve of the bent pivot.
2. Turn the balance carefully with a brush and press lightly on the high side of the balance with a piece of pegwood.
3. Repeat the above operation, each time placing the balance pivot in the next smaller hole until you reach hole 10. The moveable guide is used as an indicator and must not touch the rim of the balance.
4. The pivot should be polished in the lathe at this point.

If upon examination of the balance staff the pivot appears to be cut, the jewel is probably broken or cracked. After replacing the jewel, it is possible in some cases to regrind and polish the pivot satisfactorily. but in most cases it is better to treat a staff which has a cut pivot exactly as you would treat one with a broken pivot. When in doubt, put in a new staff; it is the mark of a fine workman.

Occasionally you will find a pivot which has become riveted on the end due to a jar or fall forcing the pivot directly against the cap jewel. When this occurs it is difficult to remove the pivot from the balance jewel and in some cases it is necessary to remove the cap jewel if possible and stone off the rivet with an oilstone slip. This will in all probability save breaking the hole jewel, but will require a new staff. Figure 15-11 gives the nomenclature of the ordinary balance staff. Throughout your career the proper names and dimensions of the parts of the staff will be referred to frequently.

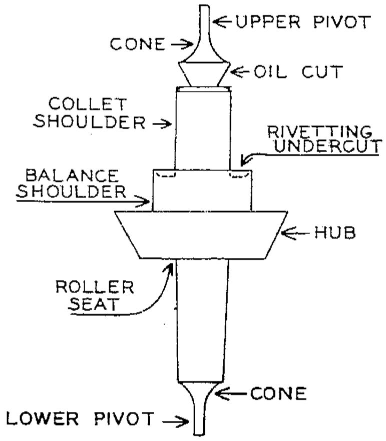


Fig. 15-11

SEC. 356—Matching the Balance Staff

In selecting a new balance staff for a watch it is necessary to know the make, size, and model and then match the staff accordingly. As stated previously, there may be several different models of watches in the same size of the same make. For instance, we may have a 16 size watch which requires a staff with a short hub and another model which may require a long hub, or we may have one with a large collet shoulder and another with a small collet shoulder. You will soon become familiar with the different models and eventually you will recognize the most common numbers by looking at the staff.

After you have selected a staff which you believe to be the correct model, make the following comparisons:

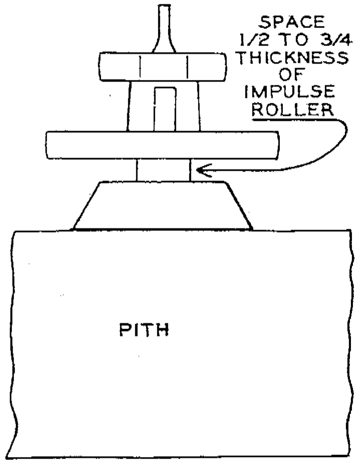


Fig. 15-12

1. Lay the old and new staff side by side and examine under a double loupe.
2. Test roller in position on roller post, figure 15-12. Roller should slip over post until the space between the hub and the impulse roller is approximately ½ to ¾ the thickness of the roller table.
3. Set balance in place on the balance seat. It should fit snugly without any side play. The shoulder should extend high enough above the arm of the balance to be riveted securely, figure 15-13.

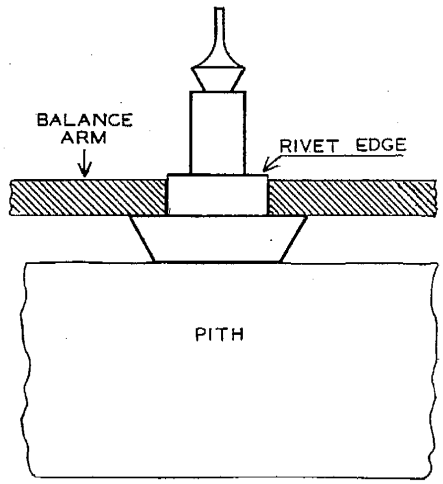


Fig. 15-13

4. Measure the collet shoulder of the old staff with your micrometer and compare with the diameter of the collet shoulder of the new staff. Measurements should be identical.
5. The length of the new staff should be identical with the one to be replaced. Allow about 0.25 mm for each broken pivot.
6. Compare pivot diameters by measuring with the micrometer.
7. Figure 15-14 illustrates another way to test the pivots for size. This test and all of the previous tests should be made before riveting the staff to the wheel. The pivot should enter the hole in the jewel and tip approximately 5 degrees to either side to allow the proper amount of sideshake. If the pivot is too large it will not tip from side to side and if it tips too far over, the pivot is too small for the hole in the jewel.
8. Place staff in lower jewel and replace balance cock. Test for endshake.
9. It is necessary at times to remove the cap jewels and ascertain if the pivot extends through the balance jewel far enough to reach the cap jewel without the cone of the pivot binding in the oilcup. A balance pivot

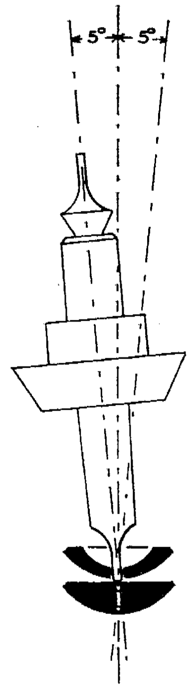


Fig. 15-14

should extend above the upper surface of the balance jewel approximately its own diameter.

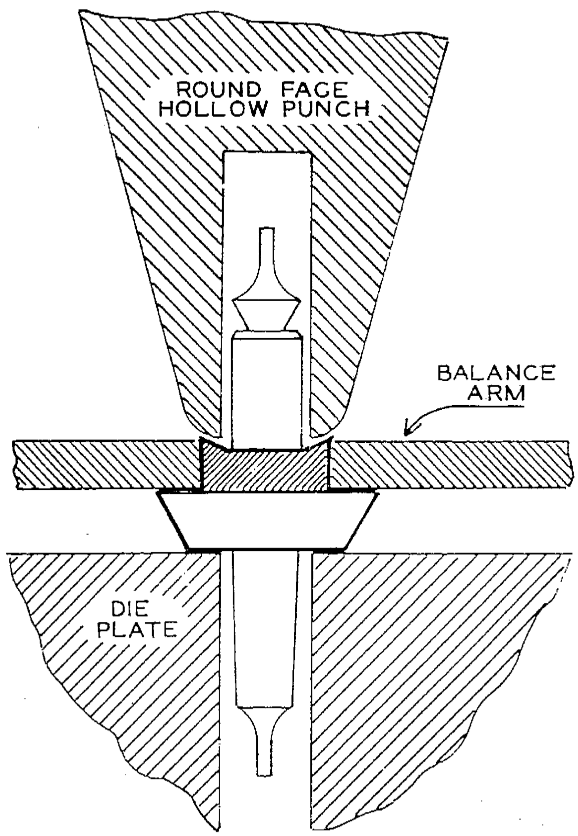


Fig. 15-15

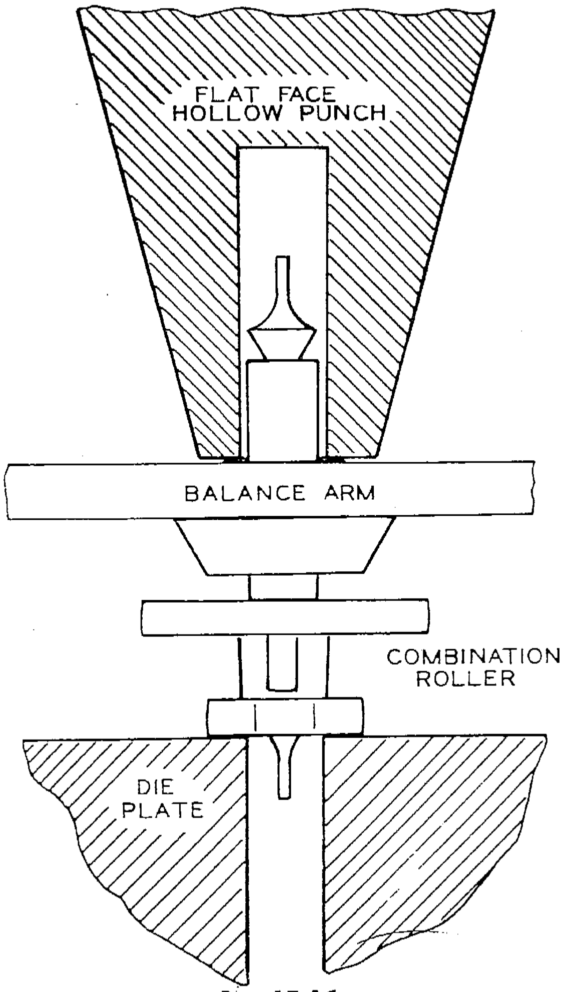


Fig. 15-16

SEC. 357—Riveting the Staff

Replacing a riveted balance staff is not a hard job, but each operation must be carefully executed, and the proper holes in the dieplate of the staking tool, together with the proper punches must be carefully selected.

1. Select hole in die plate which is slightly larger than the roller post.
2. Center this hole with centering punch.
3. Select a round face hollow punch and a flat face hollow punch which will slip over the collet shoulder freely. The round face hollow punch is used to spread the rivet and the flat face hollow punch will smooth and finish the previous operation. Figure 15-15 illustrates the staff in position in the die plate, the arm in position on the balance shoulder, and the round face hollow punch in position for riveting.
4. Tap the punch repeatedly with a brass hammer, at the same time turning the balance wheel slowly with the left forefinger. Do not use a crushing blow with the hammer. Many quick, light strokes of the hammer will do a better job.
5. Test by placing the thumb on the end of the riveting punch and exert as much downward pressure as possible. Try twisting the balance wheel around the staff. If no resistance is encountered the chances are that more riveting will be required. Rivet until secure, finishing with flat face hollow punch. This will require only several light taps with the brass hammer.

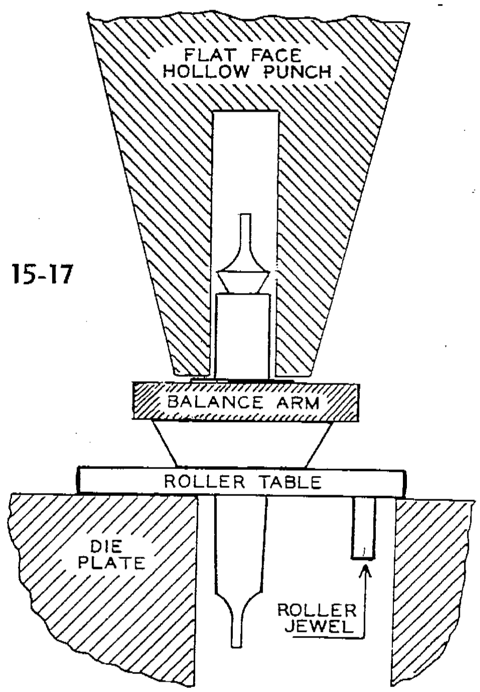
SEC. 358—Replacing the Roller

If the roller to be replaced is a combination roller, the previous operation requiring the use of the flat face hollow punch is repeated with the combination roller in place, figure 15-16. The roller jewel is usually placed at right angles to the arm of the balance wheel.

In replacing a single roller or the impulse roller from a two piece double roller proceed as follows:

1. Loosen die plate.
2. Select hole in die plate large enough to accommodate the roller jewel and the roller post when the roller is in place. The roller jewel should be placed at right angles to the balance arm.
3. Place flat face hollow punch in staking tool and carefully manipulate the staff and roller until they are directly under the punch. When you are certain that neither the staff or roller jewel will be damaged, tap punch with brass hammer until roller is tight against the seat, figure 15-17.

Fig. 15-17



SEC. 359—Replacing Friction Staffs

In selecting a friction staff, the same procedure is followed as in selecting a rivet type staff except that the post which enters the hub must just start into the opening in the hub. The difference must be made up by staking the staff in place.

1. Select a hollow stump which will allow the collet post of the staff to enter without binding.
2. Center stump with centering punch.
3. Drive staff into position using a round face hollow punch which fits freely over the roller post, figure 15-18.
4. Replace roller table as previously described.

It is not possible for the student to make the proper test of the balance wheel and staff in the movement at this time because we have not as yet covered the truing of the balance in the flat.

Always make the following tests before replacing the hairspring:

1. Test endshake.
2. Balance wheel must clear pallet bridge, Dial Down.
3. Balance wheel must clear balance bridge and center wheel, Dial Up.

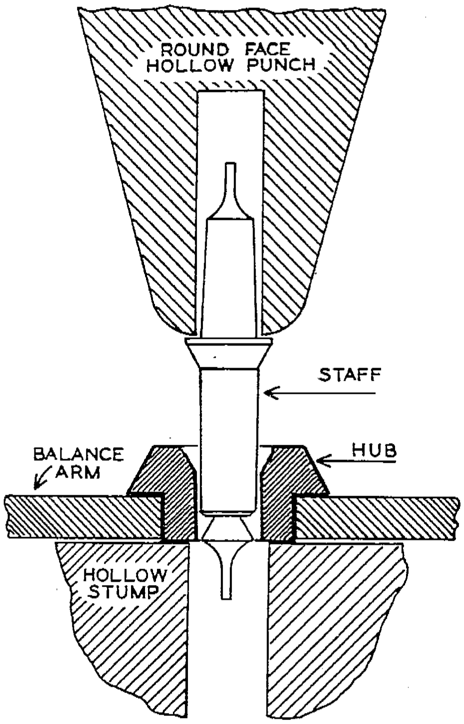


Fig. 15-18

4. Roller clears top of pallet fork, Dial Down.
5. With double roller, roller jewel must clear guard pin, Dial Down.

It is necessary to complete the next lesson on truing and poising before we can complete a satisfactory staff job.

SUPPLEMENTARY INFORMATION

SEC. 353A—Removing the Roller Table

The Rex style roller remover shown in figure 15-4 is fine for balance staffs with a thick hub, which are found in American pocket watches. But for Swiss make pocket watches, which have staffs with a thin hub, and for all wrist watches you should use a remover of the type shown here, figure 15-19.

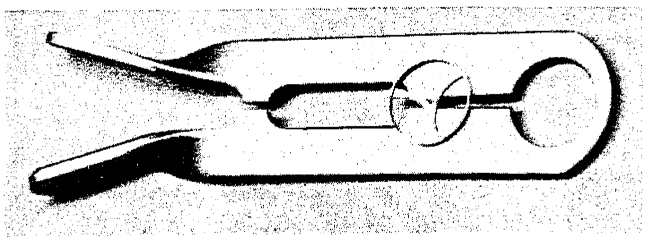


Fig. 15-19

For use, place this remover on your bench plate, slide the roller table under the jaws and move the balance wheel into the slot until snug. Squeeze the jaws with your fingers to loosen the roller. These jaws have a slight taper on the side not shown which forces the roller from the staff as you squeeze the jaws together. By keeping this tapered side down, you avoid having a roller table shoot up and away from you as can sometimes happen if you use the tool with the tapered side up.

Figure 15-19 also shows a 3 arm screwless balance, which will be discussed in the next lesson.

CHECK YOURSELF

Progress Check 15 — A Self Test Review of Lesson 15

Study Sections 350 through 359. Then see if you can answer these questions without looking back. DO NOT SEND THIS TEST TO THE SCHOOL FOR GRADING. You'll find answers at the end of the quiz. If you miss a question, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces. — Section Ref.

1. Material made by the factory which originally made the watch is called ______________ material. — 351

2. An indication that you have selected the correct balance staff is when the ______________ fit properly after you have replaced the staff in the watch and there is the right amount of ______________ and ______________. — 351

3. Before you replace the staff, you must remove the ______________. — 352

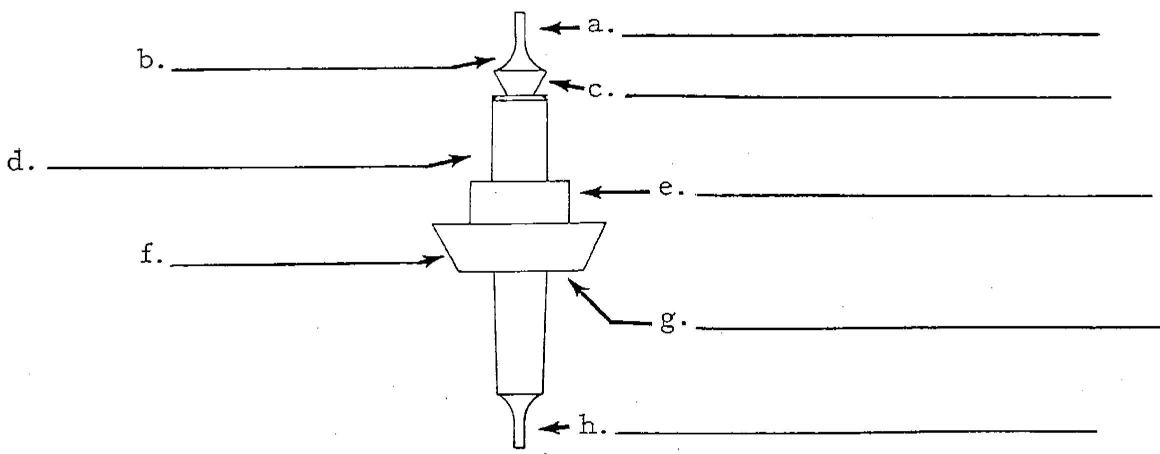
4. The roller table is removed with a ______________. — 353

5. There are several ways to remove the balance staff, but the one considered best is to ______________ the hub on a lathe. — 354

6. Two types of balance staffs are ______________ and ______________. — 354

7. A slightly bent pivot can be straightened in a ______________, but a cut pivot should be ______________. — 355

8. Identify the indicated parts of a balance staff:



355

(Continued)

Progress Check 15 (Continued)

	Section Ref.
9. What checks should be made when matching a balance staff?	356
a. ________________	
b. ________________	
c. ________________	
d. ________________	
e. ________________	
f. ________________	
g. ________________	
10. In riveting a staff, the rivet is spread with a ____________ face hollow punch while a ____________ face hollow punch is used to smooth and finish the operation.	357
11. The roller is replaced with a ____________ face hollow punch.	358
12. In replacing a friction staff, the staff is driven into position in the hub with a ____________ face hollow punch.	359

==

ANSWERS TO
PROGRESS CHECK 15:

1. genuine
2. parts
   endshake
   sideshake
3. hairspring
4. roller remover
5. undercut
6. riveted
   friction fit
7. lathe
   replaced
8. a. upper pivot
   b. cone
   c. oil cut
   d. collet shoulder
   e. balance shoulder
   f. hub
   g. roller seat
   h. lower pivot
9. a. Compare old staff with new.
   b. Check roller on roller post.
   c. Check balance on balance seat.
   d. Measure collet shoulder
   e. Check length of staff.
   f. Check diameter of pivots with micrometer.
   g. Test endshake.
10. round
    flat
11. flat
12. round

HOW TO REMOVE A RIVETED TYPE BALANCE STAFF.

Tools, Equipment and Supplies:

Staking Tool	Roller Remover	* Staff Remover	*Depending on which method is used.
Brass Hammer	Hairspring Remover	* Lathe	
Tweezers		* Graver	

PROCEDURE: REFERENCE:

1. Remove balance cock and balance assembly. — Lesson 8
2. Remove the hairspring, using hairspring remover. — Sec. 352
3. Remove the roller with a roller remover. — Sec. 353
4. Remove staff from wheel, using one of the methods below. — Sec. 354

NOTE: When removing a staff, either the rivet or the hub should be cut away in preference to driving out the staff with a staff remover and staking tool without undercutting. This is to avoid spreading the hole by driving the enlarged part of the rivet through it, as explained in Sec. 354. You must be aware of this possibility if you choose the third of the three procedures given below.

A. HOW TO CUT AWAY THE HUB OF THE STAFF. (Preferred method) — Sec. 354

1. Draw temper to a light blue. — Les. 27- Sec. 464

   NOTE: If the hub of a balance staff is too hard to cut with a regular graver, it should be softened before being cut on the lathe. This is done by heating the staff to a light blue without heating the wheel or arms of the wheel. A good method is to place a brass rod, into which you have drilled a hole, over the end of the staff and then heat the brass rod. This will transmit the heat to the steel. (Fig. 31-73, in Lesson 31, illustrates a similar procedure.)

2. Chuck up staff on collet seat.
3. Cut away hub of staff. — Fig. 15-5 & 15-6
4. Select flat face stump with hole slightly larger than riveted shoulder of staff and place stump in staking frame. Center to frame.

(Please turn over)

REFERENCE:

5. Place wheel, bottom side up, on the stump.

6. Using staff removing punch, tap gently to remove staff.

B. HOW TO CUT AWAY THE RIVET OF THE STAFF.
(Alternate method)

1. Draw temper to a light blue. (See note under A1 above.) — Les. 27 - Sec. 464

2. Chuck up staff on roller seat.

3. Cut away the rivet with a graver sharpened to a long, slender taper.

4. Place wheel on die plate of staking frame with hub in hole that is slightly larger than the hub.

5. Fit staff remover and punch in staking frame. Tap gently to drive out staff. — Fig. 15-7

C. HOW TO DRIVE OUT STAFF USING A STAFF REMOVER AND STAKING TOOL.

1. Place wheel on die plate with hub in hole slightly larger than hub of staff. — Fig. 15-7

2. Fit staff remover and punch in staking frame and tap gently to drive out staff.

3. Examine wheel carefully to see if hole has spread. The best indication of this is a burr formed around the hole on the bottom side of the wheel. The hole cannot be closed, but the burr can be smoothed out by laying wheel, bottom side down, on a flat, solid stump, and tapping gently with flat face solid punch of a size larger than the hole in the wheel. If the burr is not removed, there is a good chance you will be unable to true the balance wheel after staffing.

NOTE: Job Sheets L17-J1 through L17-J3 have the complete procedure for removing and replacing staffs. These Job Sheets are in Lesson Manual 17.

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

HOW TO REMOVE A BALANCE STAFF WITH SULPHURIC ACID.

Tools, Equipment and Supplies:

Glass Jar with ground glass cover, or wide mouth bottle with rubber stopper.
Sulphuric Acid (either chemically or commercially pure).
Distilled Water (Both water and acid can usually be obtained at your drug store.)
Small brass or copper wire.
Small magnet.

Introductory Information:

Where time is not important, there is a rather slow but simple and effective method for removing a staff without damage to the wheel. Many modern watches use balance wheels which contain no steel. In such instances, the steel staff can be dissolved out with a solution of sulphuric acid and water. It takes 4 to 10 hours' time, depending upon the strength of the solution. The balance wheel remains unchanged by this process.

The solution must be handled very carefully as sulphuric acid is dangerous and the fumes have a tendency to rust other steel tools or items which are nearby. The solution should be kept in a glass or porcelain container in a safe place. Should you spill any of the solution, ordinary baking soda will neutralize it.

PROCEDURE:

1. Place four parts of cold distilled water in the container.

2. Slowly pour one part of sulphuric acid into the water.

   Example: 2 ounces of distilled water. (4 parts)
   1/2 ounce of sulphuric acid. (1 part)

3. Remove hairspring.

4. Remove roller table.

5. Test balance wheel with a small magnet. If wheel rim or arm is not attracted by the magnet, it is safe to use this method. (Note: Do not touch the staff with the magnet. The staff is steel and will be attracted by the magnet.)

6. String balance on small brass or copper wire.

(Please turn over)

7. Immerse balance in solution and replace cover over wire. The wire will keep cover loose enough to allow fumes to escape.

8. When the staff is dissolved, remove balance wheel from the solution and rinse thoroughly under running water.

9. Dry balance wheel.

NOTE: Store the solution in a cool, safe place. It can be re-used until it starts to discolor the balance wheel.

When you finally throw out the acid solution, use plenty of water to flush it away.

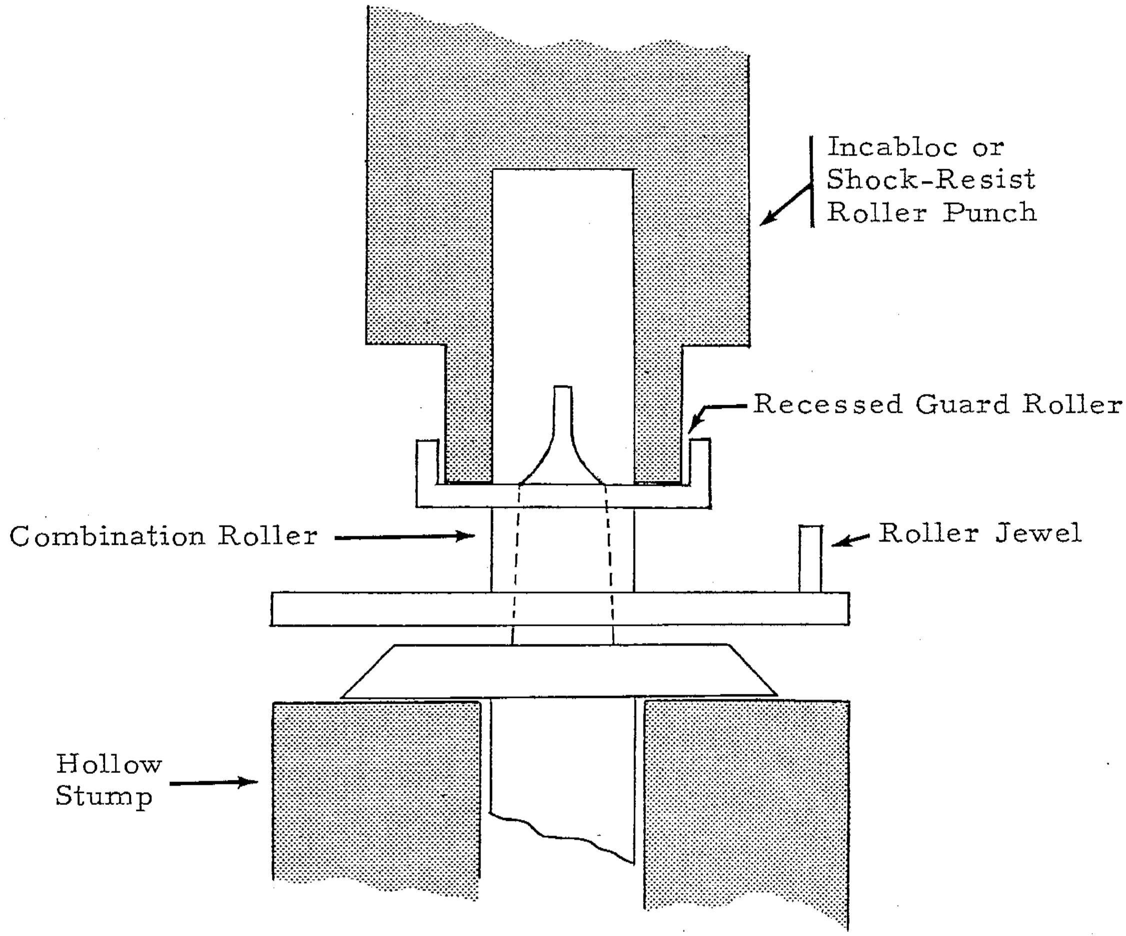
HOW TO REPLACE AN INCABLOC OR SHOCK-RESIST ROLLER WITH RECESSED GUARD ROLLER.

Tools, Equipment and Supplies:

Staking Set	Special Incabloc or Shock-Resist Punch
Hollow Stump	Brass Hammer

PROCEDURE:

1. Place balance wheel over hollow stump with roller shoulder up.
2. Place roller table on staff, with roller jewel at right angles to the balance arm.
3. Set punch in recess of guard roller and press or tap into place.



CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 15

Name: No.: Date:

Circle ONE correct answer: SUBJECT: Replacing Factory Balance Staffs

1. The term "genuine" balance staff or other piece of watch material means:

Made by the factory which made the watch	Made by hand to fit the watch being re-paired	Foreign made ma-terial made to fit American watches	Oversize staff or material which must be fitted

2. In removing a balance staff, the first step after removing the balance assembly from the move-ment is to:

Remove the roller table	Remove the hair-spring	Drive out the staff	Cut away the hub of staff

3. In removing a friction balance staff:

The roller need not be removed	The hub is driven out of the balance arm with the staff	The hub is cut away	The staff is driven out of the hub, which remains in the balance arm

4. In removing the hairspring, the safest method is to use:

Blade of bench knife	A hairspring remover	One screw driver	Two screw drivers

5. The roller table is removed:

After staff is removed from the balance	Before removing the hairspring	With a roller remover	By pulling off with tweezers

6. The Waltham balance assembly, using a friction staff may be recognized:

By the short hub	By the long hub	By the blued hub	By the shape of the roller table

7. Some Hamilton watches use another type of friction balance staff which may be recognized:

By the blued staff	By its use with a blued roller	By the shape of the pivots	By the grooved staff

8. The usual type of balance staff, which is riveted into the balance wheel, has a riveting undercut:

At the top of the balance shoulder	At the top of the hub	Below the oil cut	On the roller seat

9. In selecting a new balance staff for a watch, the roller post should be of such size that the space between the hub of staff and the impulse roller should be how many thicknesses of the impulse roller?

2 to 3	3/4 to 1	1/8 to 1/4	1/2 to 3/4

10. The collet shoulder of the new staff should be tested by:

Placing the hair-spring collet on the collet shoulder	Comparing it with shoulder on old staff, using a double loupe	Measuring it with a micrometer	Measuring it with a millimeter gauge

11. In testing a balance staff pivot for side shake in the balance and cap jewel assembly, the balance staff should tip from center to side approximately:

10 degrees	7-1/2 degrees	5 degrees	2 degrees

12. In replacing a single roller or the impulse roller from a two-piece double roller, proceed by:

Placing roller on stump with hole slightly larger than roller post	Placing roller over hole in die plate large enough to accomodate the roller jewel and roller post	Placing collet seat in hole in die plate and driving roller on with flat face hollow punch	Placing balance arm on stump with hole large enough to ac-comodate collet seat

-Detach page or cut along this line — and send to the School for grading.-

CHICAGO SCHOOL OF WATCHMAKING 310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Student Consultation Sheet

Date ________________ Student No. ________________

Lesson No. ________

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Name	
Address	
City State Zip Code	

Please check ( ) if you have CHANGED YOUR ADDRESS.

Cut along this line and use this sheet if you have questions on the course.

ASK YOUR QUESTIONS HERE...

(If necessary, use other side.)

WE'LL ANSWER HERE...

INSTRUCTOR: Return an unused sheet with each used one.

Master WATCHMAKING

Lesson 16

TRUING BALANCE WHEELS

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

16

INTRODUCTORY INFORMATION

As previously stated, replacing a balance staff involves three operations: fitting, truing and poising. In the last lesson you fitted the staff to the wheel. In this lesson you will learn how to true the wheel in the flat and round in order that the wheel will run freely in the watch. This is very exacting work and you will require lots of practice to do it well. We feel you will perform this practice work more wholeheartedly if you understand why it is so important. Section 360 of the lesson text will tell you.

KEY POINTS OF LESSON ASSIGNMENTS 53, 54:

- The purpose of truing.
- Types of balance wheels.
- Truing calipers and how they are used.
- How to true balance wheels in flat and round.
- The screwless balance.
- The Wyler Incaflex balance.

ASSIGNMENT NO. 53: Study Sections 360 through 363.

Study Questions:

1. What is the purpose of truing?
2. What is meant by truing in the flat? In the round?
3. What are the types of balance wheels?
4. What are the types of truing calipers?
5. What purpose do balance screws serve?

ASSIGNMENT NO. 54: Study Sections 364 through 365B.

1. How is the indicator set for checking the wheel in the flat?
2. Are bends in the rim of the wheel made with fingers or wrench?
3. What is used to make bends in balance arms?
4. How is the indicator set for checking the wheel in the round?
5. What are the advantages of a screwless balance?
6. How does the Wyler Incaflex balance differ from other types?

Recommended Practice:

True balance wheels in the flat and round until you are proficient. When setting the indicator, be sure it is parallel and as close to the rim as possible without hitting so as to allow a fine line of light between rim and indicator.

Begin by truing the wheel in the flat and then true in the round. After truing in the round, check again to see that the wheel is still true in the flat. If not, make corrections. Then check the round again. Keep making corrections for flat and round alternately until no error exists.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 16 and return for grading.

CHECK YOURSELF

Progress Check 16 — A Self Test Review of Lesson 16

Study Sections 360 through 365. Then see if you can answer these questions without looking back. DO NOT SEND THIS TEST TO THE SCHOOL FOR GRADING. You'll find answers at the end of the quiz. If you miss a question, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. A balance wheel must be true in the flat so it will ______________ ______________.	360
2. The balance wheel must be true in the round as well as in the flat so it can be properly ______________.	360
3. A bi-metallic wheel with a cut in the rim toward the end is known as a ______________.	361
4. A one piece balance wheel which is not cut is called a ______________ balance and is frequently used with a ______________ staff.	361
5. While it is being trued, the balance wheel is held in a ______________ ______________.	362
6. The position of balance screws should not be changed because they are so placed for ______________.	363
7. A missing balance screw will not affect ______________ but will affect ______________ and ______________.	363
8. Rim bends in the flat are made with ______________.	364
9. Bends on the balance arm are done with a ______________.	364
10. The starting point for truing in either flat or round is where the ______________ and ______________ are joined.	364 365

ANSWERS TO PROGRESS CHECK 16:

1. turn freely
2. poised
3. compensating balance
4. solid
   friction
5. truing caliper
6. temperature adjustment
7. truing
   poising
   timing
8. fingers
9. wrench
10. rim
    arm

TRUING BALANCE WHEELS

SEC. 360—Purpose of Truing

The truing and poising of the balance wheel are very closely related. Truing a balance wheel generally requires a great deal of practice. Your ability to true and poise a balance wheel has a tremendous bearing upon the results you will attain in adjusting and bringing a watch to time. The balance wheel must be true in the flat in order that it may rotate freely between the pallet bridge and the balance cock. The rim must have clearance between the pallet bridge and the center wheel. A balance wheel which is slightly out of true in the flat can be the cause of the watch stopping in certain positions.

A wheel must be true in the round and flat before it can be poised properly. It is impossible for a watch to keep accurate time in the various positions if the wheel is out of poise. Many times the question is asked, "Is it better to have the wheel true or poised?" The two are so closely related that it must be said that a wheel should be trued as nearly perfect as possible and then poised.

Truing in the flat is the adjustment required to have the rim of the balance wheel rotate in the same plane. The wheel is in the flat position when we look across the rim of the wheel.

Truing in the round is the adjustment required to have the rim of the balance concentric with the balance pivots. The wheel is in the round position when we look directly down on the wheel. Poising is the adjustment required to bring the balance wheel to the state of being balanced.

SEC. 361—Types of Balance Wheels

Figure 16-1 illustrates a bi-metallic balance wheel which has an inner rim of steel and an outer rim of brass. This type is now found only in older watches. When the rim is cut toward the end, it is known as a compensating balance.

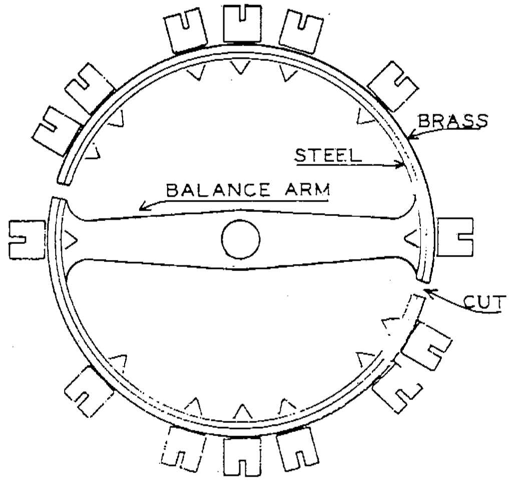


Fig. 16-1

Figure 16-2 is an illustration of a monometallic balance wheel, which came into use after 1920 when compensating hairsprings were introduced. The rim of this type wheel is **NOT** cut. It is usually referred to as a **SOLID** balance wheel. Watches with this balance also use a friction staff. The watchmaker seldom has to true this type of wheel for it rarely gets

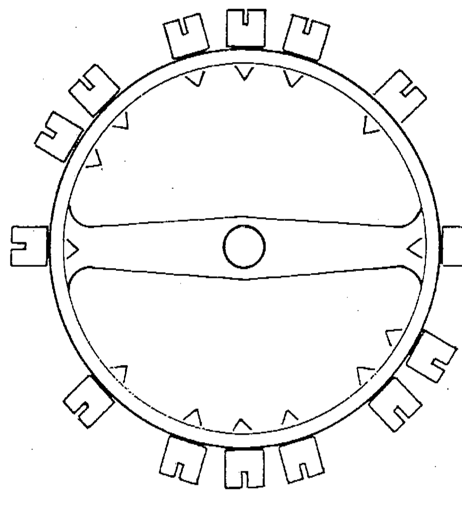


Fig. 16-2

out of true if properly handled. It is practically impossible to true this type of balance in the round. Truing in the flat can be accomplished if the workman is careful and understands thoroughly the principles of truing.

SEC. 362—The Truing Caliper

Figure 16-3 illustrates a parallel jaw truing caliper in which the center screw is used to open and close the jaws of the caliper. When the balance staff and wheel are in place the jaws can be adjusted to hold the wheel in position without any further attention from the workman. This is probably the most popular of all truing calipers. The chief disadvantage is the fact that the screw must be loosened each time the balance is removed.

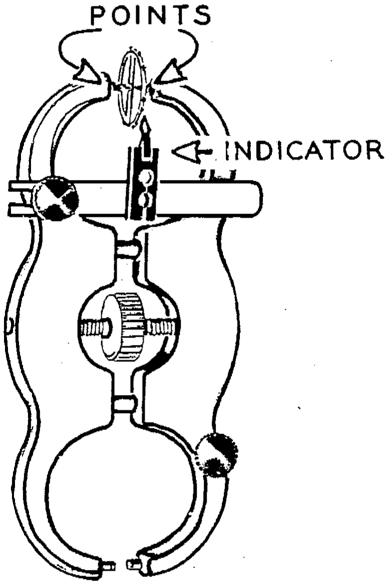


Fig. 16-3

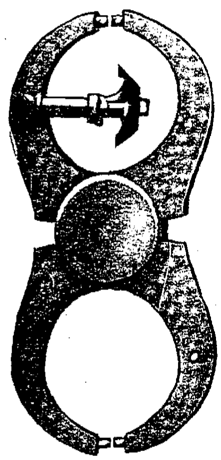


Fig. 16-4

The caliper shown in figure 16-4 does not have a center screw to keep the jaws closed on the cones of the balance pivots, and the workman must therefore exert enough pressure to keep the jaws closed while making any adjustments on the rim of the wheel. The indicator is a little more flexible than in some types because it is swung in a ball and socket.

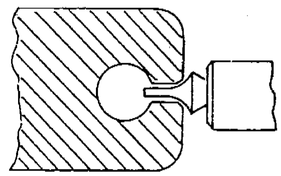


Fig. 16-5

Figure 16-5 illustrates an enlarged view of a point in the jaws of a truing caliper. Notice that the pivot does not come in contact with the point when the jaws are closed. The cone of the pivot rides on the countersink which is designed to receive it, and in this manner adjustments can be made on the rim of the wheel without damaging the pivots.

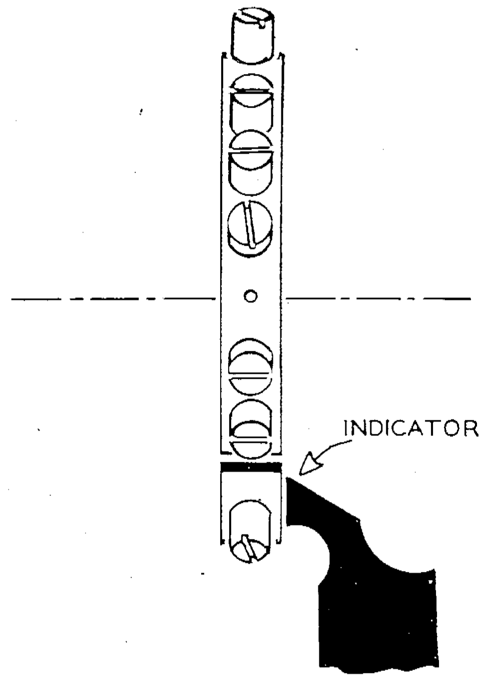


Fig. 16-6

Set the indicator in the position shown in figure 16-6 when truing in the flat. Figure 16-7 illustrates the indicator in the correct position when truing in the round.

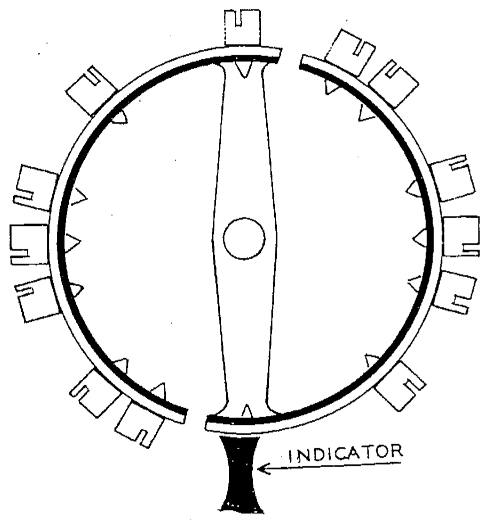


Fig. 16-7

SEC. 363—The Balance Screws

In figure 16-8, the balance screws set in the rim are lettered A, B, C, D, E, F, and G. Notice that set directly opposite each one of these screws on the other half of the rim is a corresponding screw. Example: A-1 is opposite A. B-2 is opposite B, etc. These screws give the balance the proper weight and have been placed in their respective locations by the factory for temperature adjustment. **Do not change their position.** If upon examination of a wheel you should find an unequal number of screws, for instance seven on one side and six on the other, it would be necessary to equalize the number by adding one. The absence of screws does not interfere with truing a balance but will hinder any attempts made to poise the balance or bring the watch to time.

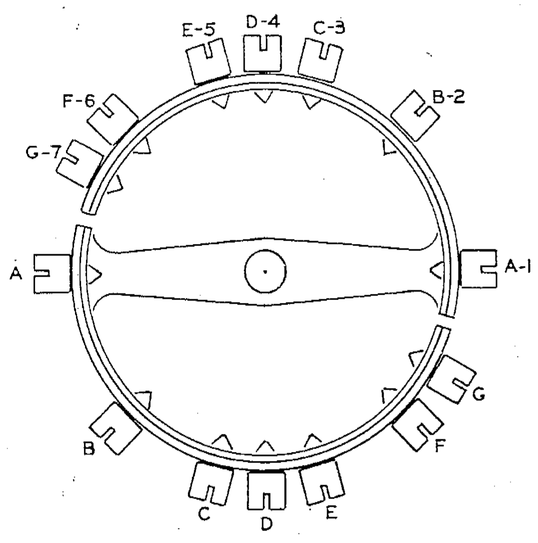


Fig. 16-8

SEC. 364—Truing in the Flat

If the balance wheel was true before replacing a balance staff and you have done your work carefully, you will find very little truing to be done; however, there are a great many times when in overhauling a watch for the first time you will find the balance out of true. Although another workman may not have the ability to true the balance wheel properly, you are not excused for doing the same. Check every balance for true and poise. The results you obtain when bringing a watch to time will depend upon the wheel being trued and poised. Use large balance wheels for practice work.

The following instructions are used in conjunction with the illustrations shown. These illustrations are for the purpose of demonstrat-

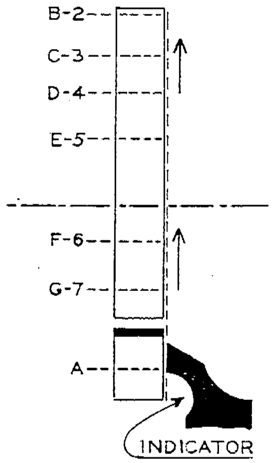


Fig. 16-9

ing the procedure used when truing a balance wheel in the flat. Very few wheels will be out of true as badly as the one shown. The letters A, B, A1, B2, etc., correspond to the centers of the balance screws and their positions on the rim of the wheel as illustrated in figure 16-8.

1. Place wheel in caliper and set the indicator, figure 16-9.
2. Keep indicator as close to the rim as possible.
3. Keep edge of indicator parallel with rim of wheel.
4. The starting point is where the arm joins the wheel.
5. True each half separately.
6. After each bend or alteration, return to starting point.
7. Move wheel in direction of arrow, figure 16-9, until the distance between the rim of wheel and the indicator increases or decreases. For our purpose we will say this distance has increased.

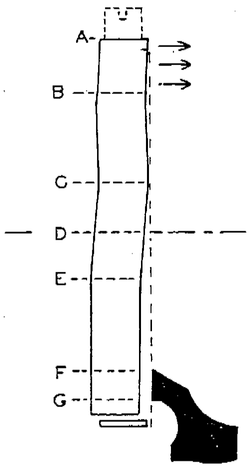


Fig. 16-10

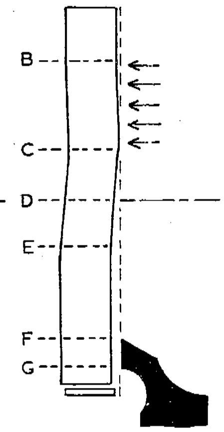


Fig. 16-11

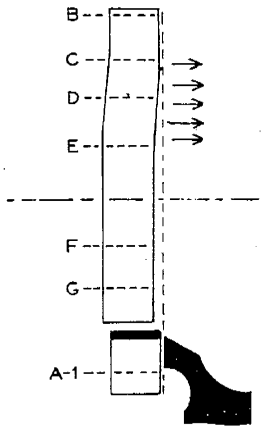


Fig. 16-12

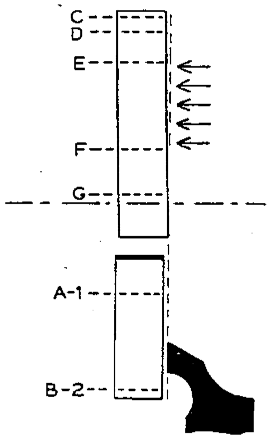


Fig. 16-13

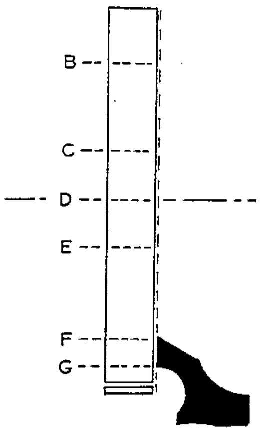


Fig. 16-14

8. Figure 16-10 illustrates this variation between the points A and B. The vertical dotted line is the path of the indicator.
9. Bending the rim of the wheel in the direction of the arrows between A and B will correct this section of the rim. Do not attempt to make any other corrections on the rim until this section is parallel to the indicator.
10. The section between B and C, figure 16-11, has moved toward the indicator. (Always return to starting position after each bend.) This section may be brought parallel to the indicator by bending at B in direction of arrows.
11. Return to starting point and check.
12. Section C to E, figure 16-12, has moved away from the indicator and must be bent at C in the direction of the arrows.
13. Return to starting point and check.
14. The section from E to the end of the rim has moved toward the indicator and must be bent back in the direction of the arrows, figure 16-13. This half of the wheel rim is now perfectly true in the flat and will appear as in figure 16-14.

This example is used to show some of the typical bends required when truing a balance in the flat. The average wheel requires very little bending. Usually one or two slight bends are sufficient to true the rim in the flat; however, remember after each bend to return the rim of the balance to the starting point. (4). At times you will have to adjust your indicator after each bend and also after returning the rim to its first position. To make the bends, place the rim of the balance between the thumb and second finger of the right hand. The caliper must be held firmly in the left hand. When making a bend, pressure must be exerted by the left hand in order to keep the jaws closed upon the cones of the pivots. Figure 16-15 illustrates the position of the thumb and finger when making a bend in the flat to the left. Notice that the thumb is slightly lower than the finger. The pressure is exerted by the thumb, the finger acting as the fulcrum. When making a bend to

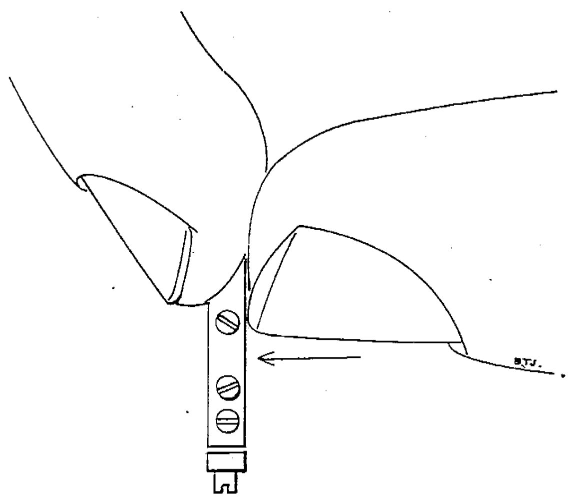


Fig. 16-15

the right the finger is lower than the thumb and the pressure is exerted by the finger, the thumb acting as the fulcrum.

When half of the wheel rim is true in the flat proceed to true the other half as follows:

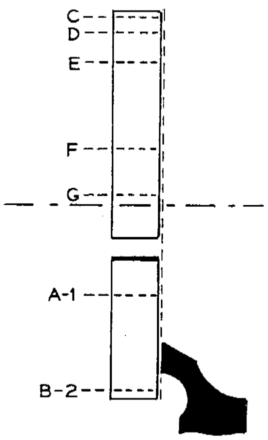


Fig. 16-16

Set indicator at A and turn rim half-way around. A-1 will be the starting point of the second operation, figure 16-16. The distance between the indicator and the rim of the wheel at A-1 should be the same as the distance between the wheel rim and A. If this distance is the same, proceed to true this half of the rim. If the arm of the balance requires bending, use

Fig. 16-17

the wrench illustrated in figure 16-17. Figure 16-18 illustrates the method of using this wrench. Place slot in wrench over arm and move in direction of arrows. It is not usually necessary to remove the wheel from the caliper when using the wrench in the flat. After both

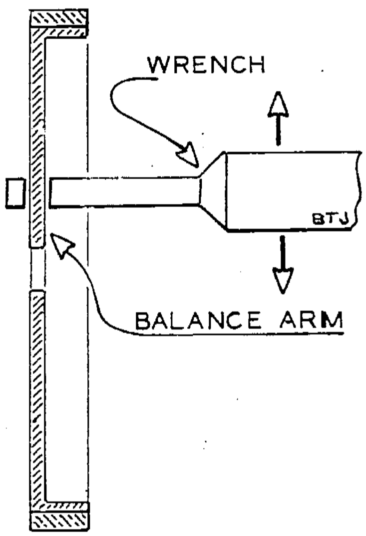


Fig. 16-18

sections of the balance have been trued, release the pressure of the left hand slightly and with the forefinger of the right hand, spin the wheel. If you have followed instructions carefully there should not be any variation of light between the indicator and the rim of the wheel. The wheel will then be TRUE IN THE FLAT.

SEC. 365—Truing in the Round

Truing a balance wheel in the round is similar to truing in the flat except that you will be unable to use your fingers when making the bends in the rim. The wrench illustrated in figure 16-18 is used primarily for this purpose.

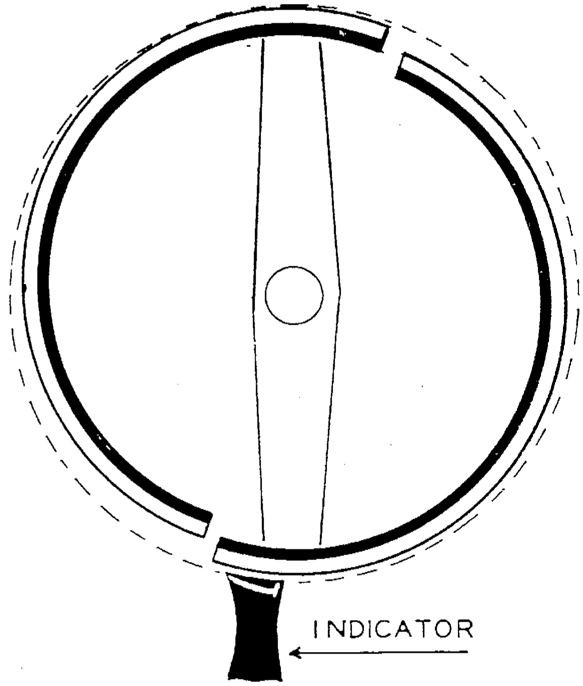


Fig. 16-19

Figure 16-19 is an illustration with both sections bent in. The dotted line indicates the path of the indicator.

1. Set indicator at point where the rim is joined by the arm. Indicator must follow curve of the rim.
2. Turn wheel slowly with forefinger of right hand while holding caliper in left hand. As the arm moves away from indicator the rim moves toward the indicator.
3. Place wrench over rim and bend in direction of arrow, being certain that you are applying pressure with the left hand, figure 16-20. Hold wrench lightly and be certain not to disturb the flat.
4. Bend rim in until it is the same distance

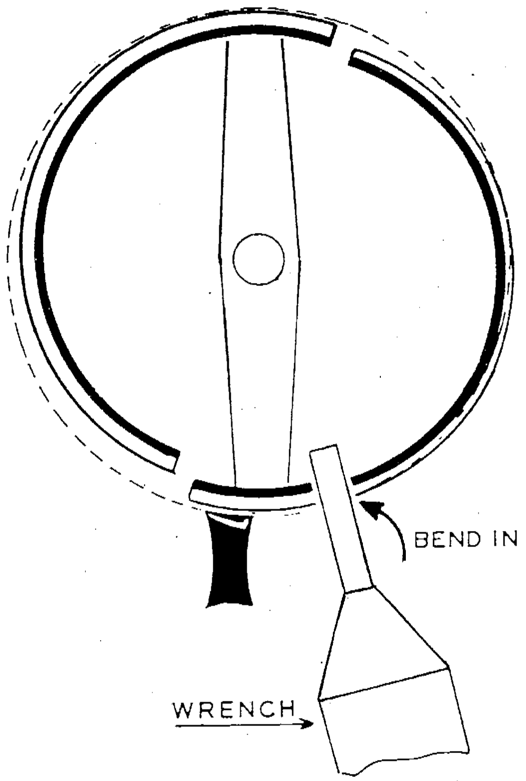


Fig. 16-20

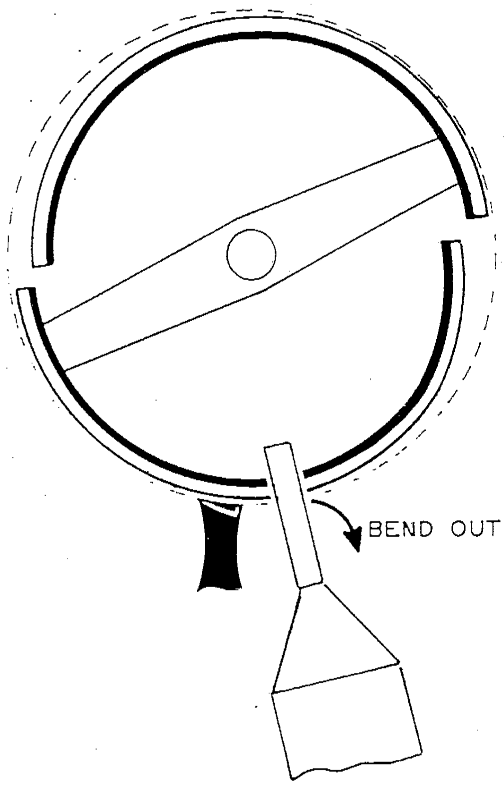


Fig. 16-21

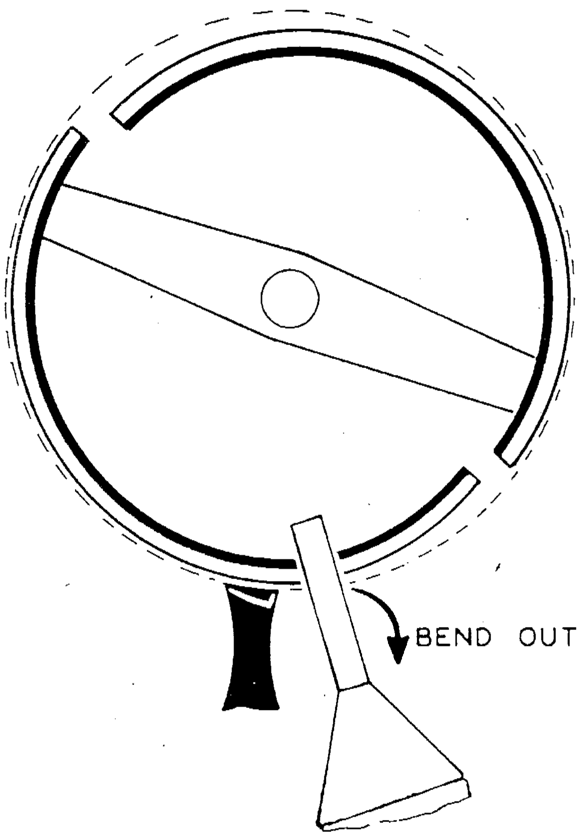


Fig. 16-22

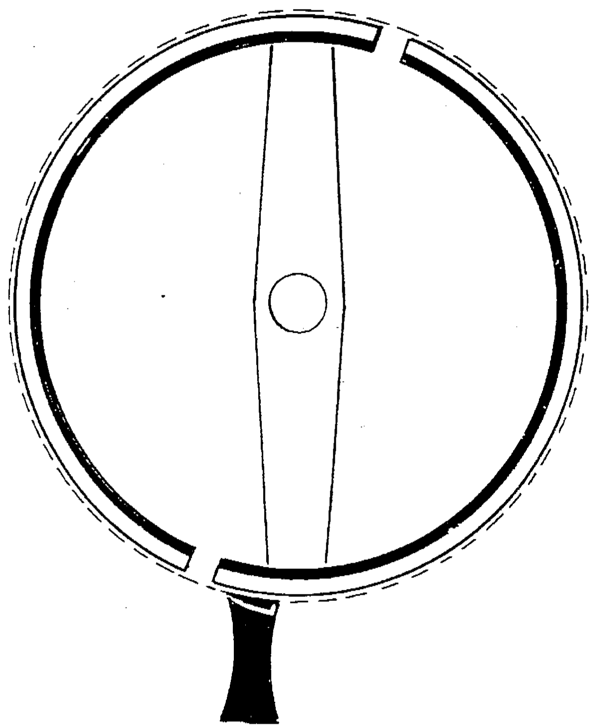


Fig. 16-23

as the starting point from the indicator.

5. Return to starting point, checking carefully the distance between the rim and the indicator. When certain that this section is correct proceed with the next section.

In figure 16-21 the rim of the balance wheel is true to point covered by the wrench. However, it must be bent out as illustrated by arrow. After bending it out check and proceed to next section.

The last section is bent out of true as in figure 16-22. When this half of the rim is true in the round, proceed to true the other half in the same manner. Spin the wheel as you did when checking the flat and the rim should not show any waves of light, figure 16-23.

Figure 16-24 illustrates the method used to true the rim of a balance wheel when one balance arm is shorter then the other. Make the first bend as close to the arm as possible and then proceed to true the rest of the rim as before. Now recheck in the flat. In your first attempts at truing wheels, you will in all probability have to check and recheck the round and flat several times before attaining perfection.

You will find that no matter how long you do watch repair work, there is a certain thrill that always accompanies a job that is well done.

You will soon be able to recognize quickly a balance that is out of true when it is in the watch. After truing the balance, test it in the watch as explained in this section. There may be times when it is necessary to raise or lower the arms slightly in order that the wheel will have the proper clearance. If your wheel seems to run true in the caliper but not in the watch, examine the pivots closely to see if they are

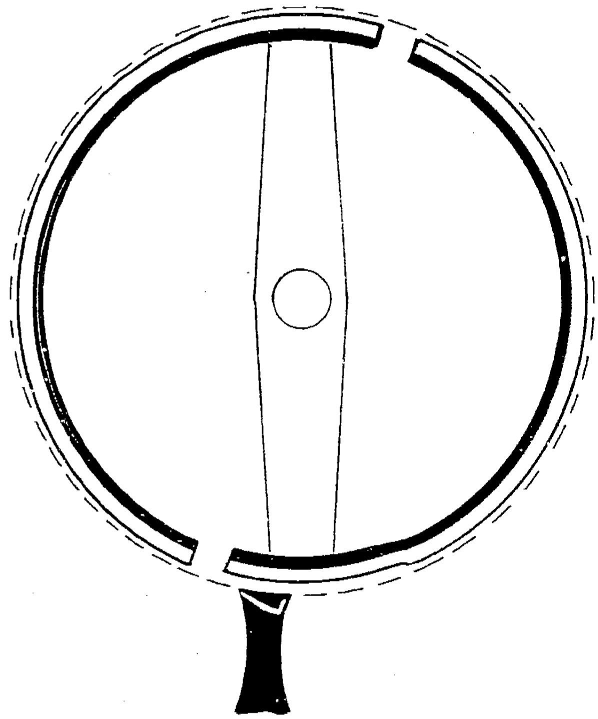


Fig. 16-24

bent. This may have happened if you relaxed the grip on your caliper while you were making a corrective bend. Mastery of truing and poising requires a great deal of practice; therefore, it is wise to obtain as many balance wheels as possible and practice at every opportunity.

As previously stated, the solid balance wheel, if handled properly, seldom gets out of true. However, when this type of wheel is out of true in the flat, it usually can be corrected by raising or lowering the arms slightly. When making bends of this type it is better to remove the wheel from the caliper so as not to bend or break the pivots.

SUPPLEMENTARY INFORMATION

SEC. 365A—The Screwless Balance

The solid balance wheel with screws, which replaced the bi-metallic balance, is itself being replaced by the screwless balance wheel.

About 90% of the Swiss watches currently being made use a screwless balance, figure 16-25. Some types have three or four arms, figure 16-26 and figure 15-19 in Lesson 15.

By eliminating the screws, the balance can be made stronger and larger without changing the overall balance size, figure 16-25. Its weight can be reduced about 10%, which lowers friction. Air resistance is also reduced, giving a better balance motion. Screwless balances are easier to clean and less likely to attract watch stopping lint or hairs.

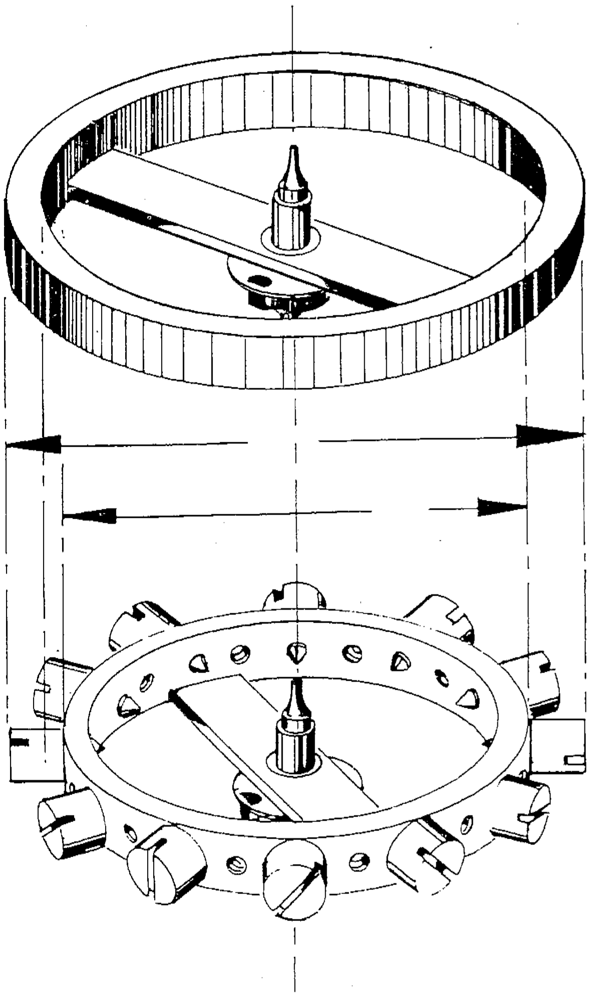


Fig. 16-25

The increase in the size of balance made possible by the elimination of screws is illustrated above. The comparison also shows how the effective weight of the balance is shifted outward; the mass of the balance is concentrated in the solid rim.

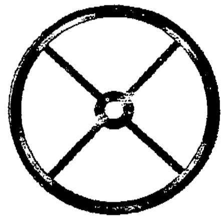


Fig. 16-26

If you remove the staff carefully when it needs changing, you should not have to true or poise the screwless balance. If necessary, it is trued in the flat in the same way as a split wheel. However, many of the 3 and 4 arm wheels are too small for your fingers to make the bend. Figure 16-27 shows that you can use a pair of H tweezers to spring the rim of the wheel.

When you find a high spot on the rim, hold the lower tongue of the tweezers under hub of staff and squeeze down on tweezers. This will support the small riveting edge of the staff so it won't break and will spring the high spot of the rim back into true.

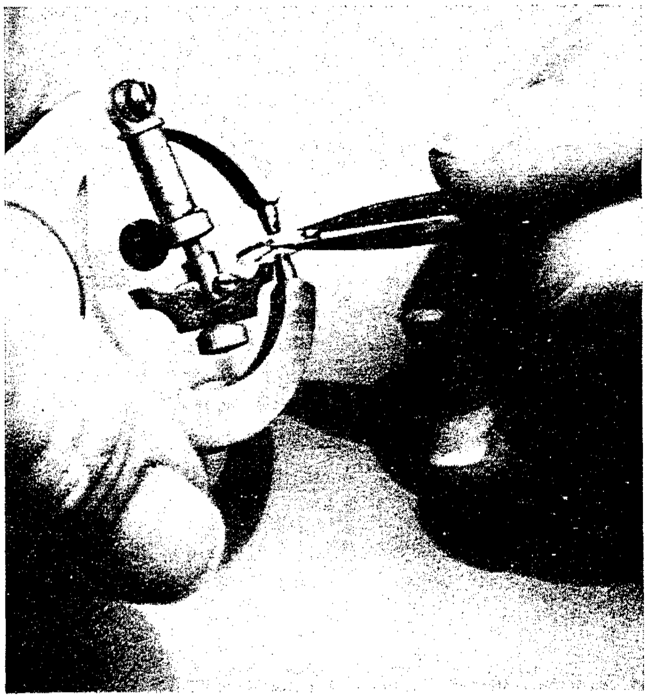


Fig. 16-27

Be careful when ordering staffs for screwless balances as they are not always interchangeable with staffs for balances with screws in watches of the same caliber. The height of the riveting points and the fitting diameters often differ.

Poising will be considered in the next lesson.

SEC. 365B—THE WYLER INCAFLEX BALANCE WHEEL

The Wyler Incaflex Balance Wheel is identical to the ordinary solid rim beryllium balance wheel except in one important respect—the arms, instead of being straight, are curved to provide flexibility. (Fig. 16-28)

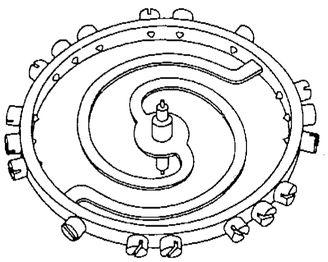


Fig. 16-28

Why the flexible arms?—Let us suppose that the watch is jarred or dropped and that it falls on its side,—the position most likely to break the balance pivots. The mass of the balance wheel moving in the direction of the fall is suddenly stopped. Because of the flexible design between rim and staff, the wheel will flex and move out of its regular shape. This flexing action absorbs the instantaneous shock that usually shatters the balance pivot. As soon as this happens, the balance rim comes in contact with the retainer ring which acts as a stop. The balance then snaps back to its original position and continues its original motion. The force of the fall has been "absorbed." In a watch having an ordinary balance wheel the full shock would have been transmitted directly to the balance pivots themselves with resultant damage.

How about the varied shock-resistant devices, ideas and systems that are being used in other makes? The answer is that some of them, no doubt, do absorb shock to some extent. But how about the watchmaker?—when the watch has to be cleaned. He may have to contend with jewels that fly away or fall out of the basket, springs that break off from the balance cock or plate, locking devices that may or may not hold—also jewels that may shift their position with each jar. The use of standard Jewels in the Incaflex system eliminates these problems, provides better jewel lubrication for longer wear and at the same time permits minimum friction for accurate time in smaller calibres.

However, even with an Incaflex Balance, it does happen occasionally that a staff will break. Here again we have provided a balance wheel which allows for staff replacement without difficulty. A broken staff need not be turned off on a lathe as it is easily punched out with a standard staff remover.

When replacing a staff (with a genuine one) use a flat faced hollow punch. DO NOT use a round faced riveting punch as it will distort the balance. Always check tightness of staff before replacing the roller. The sketches show the simplicity in the handling of the Wyler Incaflex Balance Wheel.

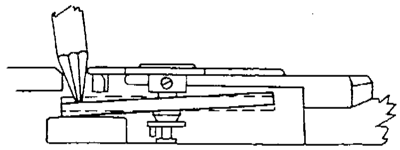


Fig. 16-29

If the wheel is in the watch and the rim is pressed down with a pegwood, it will be found to bend to an amazing degree. (Fig.16-29) If the pegwood is released, the rim snaps right back to its original position. The same effect is achieved when the incaflex wheel is pressed to one side in the horizontal plane. (Fig. 16-30)

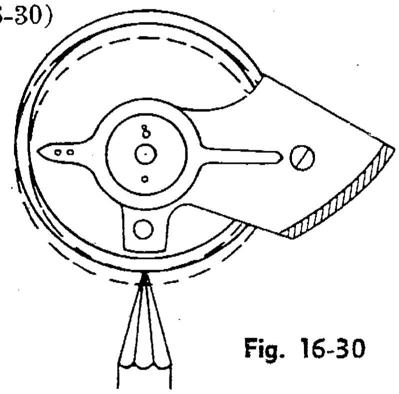


Fig. 16-30

The pallet bridge (Fig. 16-31) is specially constructed. It is part of a retainer ring which circles the balance around most of its orbit. The retainer ring provides the safety which prevents the incaflex wheel from moving excessively out of its orbit and it prevents the breakage of the balance staff.

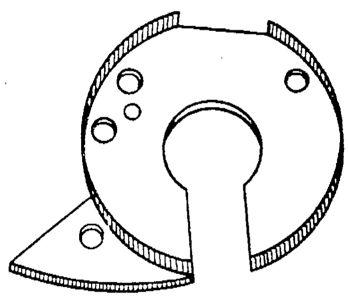


Fig. 16-31

Cut-outs are provided in the retainer ring (Fig.

16-31) so all the actions of the wheel can be observed properly. When the retainer ring does not circle the incaflex wheel in its entirety, the natural construction of the watch provides the necessary guard. An example of this is the vertical wall of the balance bridge and plate, which is sufficient protection on some models. (Fig. 16-32)

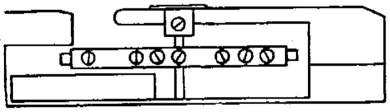


Fig. 16-32

Removing Rollers

Because of the curved arms of the balance wheel, some roller removers are not handy. Any tool is practical which holds the roller in place between the roller table and the safety roller, and allows the staff to be pushed through. (Fig. 16-33)

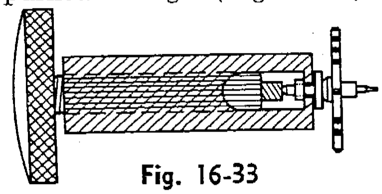
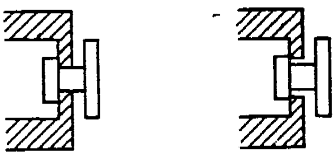


Fig. 16-33

Care must be taken to use the smallest available slot of the roller remover in order to avoid making burrs on the safety roller.



Correct Incorrect

Fig. 16-34

TRUING

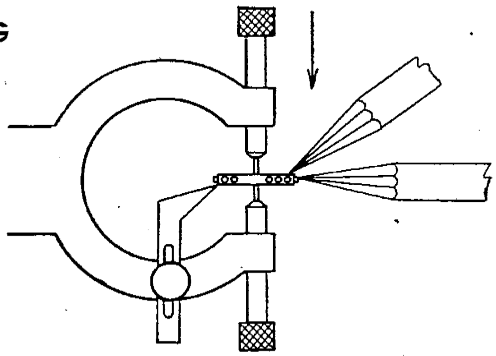


Fig. 16-35

Truing of incaflex wheels is more easily accomplished than on the ordinary balances, as no actual bending is necessary. The wheel is "pushed" into "flat" and "round" in its entirety with a finger or a pegwood. (Fig. 16-35) If, as in the illustration (above), the caliper shows up a high point, the wheel is simply pushed down vertically by pressing a pegwood gently against the rim in a downward direction. Or, if the wheel is out of round, it is pushed across in a horizontal direction. (Fig. 16-30)

Screwless Balance Wheels

As a compensating factor, every Wyler incaflex watch with a screwless balance wheel has a special regulator and moveable stud combination. This feature provides beat correction without disassembly of the balance and permits a wide latitude of regulation of from four minutes minus to six minutes plus.

Job Inspection Request

CHICAGO SCHOOL OF WATCHMAKING
310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Cut along this line - - - and send to the School with your work. -

Send this sheet and your practical work if you would like your instructor to inspect your preliminary practice work before you start on Proficiency Examination No. 2.. Please refer to the Master Work Sheet in this lesson manual. 16.

Student number ______________ Date ______________

Name	
Address	
City State Zip Code	

Chief Instructor
Chicago School of Watchmaking

Please examine the items I have checked below:

( ) Tool for removing excess cement from rollers and jewels. (Lesson 13, Section 321, Fig. 13-20.)

INSTRUCTOR COMMENT: ______________________________

____

____

( ) Tool for straightening roller jewel. (Lesson 13, Sec. 324, Figures 13-24-1 and 13-24-2.)

INSTRUCTOR COMMENT: ______________________________

____

____

( ) Set of three hairspring removing tools. (Lesson 15, Sec. 352, Fig. 15-3.)

INSTRUCTOR COMMENT: ______________________________

____

____

(Please turn over)

( ) Two practice balance wheels into which you have riveted staffs and which you have trued and poised:

Wheel A _____ Staked correctly.
_____ Staked incorrectly.
_____ Arm of balance not down against hub.
_____ Not riveted firmly.
_____ Wheel true.
_____ Wheel not true _____ in flat _____ in round.
_____ Pivots _____ OK _____ bent _____ broken.
_____ Wheel poised.
_____ Wheel not poised.

REMARKS: ____

____

____

Wheel B: _____ Staked correctly.
_____ Staked incorrectly.
_____ Arm of balance not down against hub.
_____ Not riveted firmly.
_____ Wheel true.
_____ Wheel not true _____ in flat _____ in round.
_____ Pivots _____ OK _____ bent _____ broken.
_____ Wheel poised.
_____ Wheel not poised.

REMARKS: ____

____

____

CHICAGO SCHOOL OF WATCHMAKING

Proficiency Exam No. 2

A test of your Master Watchmaking Shop Skills.

Student number ________________ Date ________________

Name	
Address	
City State Zip Code	

This examination covers the practical work for:

Lessons 12 through 17

You may send in this examination any time after you have completed study of the lessons above up to 3 years from your date of enrollment.

YOUR GRADE: ____________

Certificate Awarded: ____________

PURPOSE OF THIS EXAMINATION: To test your job skills and ability to do the practical work covered in the lessons included in this examination. It is not compulsory, but if completed satisfactorily will count toward your Diploma requirements.

STUDENTS WHO ATTAIN A SCORE OF 75 or better on this examination will be awarded a special Certificate of Proficiency for Jeweling and Staffing.

TO GUIDE YOU in the procedures, a Master Work Sheet is furnished for this examination. Do the work in the order given in the Master Work Sheet rather than as listed below.

YOU WILL NEED FOR THIS EXAMINATION:

One American movement, 15 or more jewels, preferably 12s or 16s.
One Swiss movement without a shock protective device and with 15 or more jewels and preferably 10 1/2 or 11 1/2 lignes.
One 7 jewel American movement, preferably 6s, 12s, or 16s.
(These watches should be clean and in running order.)

A. IDENTIFY THE AMERICAN MOVEMENT (15 or more jewels):

Make ________________ Size ________ No. of Jewels ____________
Model or Movement No.: ________________ Description of Case (if any): ____________

WORK REQUIRED:		Possible Score:	Points lost for errors:	Your Score:
1. Remove, examine, clean and replace the upper and lower balance hole and cap jewels.				
____ Cleaned, oiled and replaced correctly.		2		
____ Too much oil.	(-1)		____	
____ Cap jewel upside down	(-2)		____	____

(Please turn over)

Cut along this line and send -- to the School with your work for grading.

		Possible Score:	Points lost for errors:	Your Score:
2. Remove and replace the roller jewel.				
____ Roller jewel set correctly.		5		
____ Excess cement.	(-1)		____	
____ Tilted.	(-2)		____	
____ Loose.	(-2)		____	____

3. Remove a train jewel setting. Replace the jewel with a friction jewel and replace the setting. Indicate which jewel you replaced:

____	____	____	____
Hole size	Outside diameter	Upper or lower	Position 3rd, 4th wheel, etc.

		Possible Score:	Points lost for errors:	Your Score:
____ Set correctly.		8		
____ Tilted.	(-2)		____	
____ Too deep.	(-2)		____	
____ Not deep enough.	(-2)		____	
____ Upside down.	(-4)		____	____
4. Fit a factory staff to this watch.		30		
____ Staked correctly.				
____ Staked incorrectly.	(-5)		____	
____ Arm of balance not down against hub.				
____ Not riveted firmly.				
____ Wheel true.				
____ Wheel not true in flat.	(-5)		____	
____ Wheel not true in round.	(- 5)		____	
____ Pivots OK.				
____ Pivots bent.	(-5)		____	
____ Pivots broken.	(-5)		____	
____ Wheel poised.			____	
____ Wheel not poised.	(-5)		____	____

Remarks: ____

____

B. IDENTIFY THE SWISS MOVEMENT (15 or more jewels):

Make ____________________ Size _____ No. of Jewels ______
Model or Caliber No.: ______________ Description of Case (if any): ______________

5. Remove upper balance hole jewel and replace with a friction balance jewel.

		Possible Score:	Points lost for errors:	Your Score:
____ Set correctly.		8		
____ Tilted.	(-2)		____	
____ Too deep.	(-2)		____	
____ Not deep enough.	(-2)		____	
____ Upside down.	(-4)		____	____

(Continued on next page)

		Possible Score:	Points lost for errors:	Your Score:
6. Remove lower cap jewel from setting and replace with friction cap jewel.				
____ Set correctly.		5		
____ Tilted.	(-1)		____	
____ Too deep.	(-1)		____	
____ Not deep enough.	(-1)		____	
____ Upside down.	(-2)		____	____
7. Remove and replace the roller jewel.				
____ Set correctly.		5		
____ Excess cement.	(-1)		____	
____ Tilted.	(-2)		____	
____ Loose.	(-2)		____	____
8. Fit a factory staff to this movement.		30		
____ Staked correctly.				
____ Staked incorrectly.	(-5)		____	
____ Arm of balance not down against hub.				
____ Not riveted firmly.				
____ Wheel true.				
____ Wheel not true in flat.	(-5)		____	
____ Wheel not true in round.	(-5)		____	
____ Pivots OK.				
____ Pivots bent.	(-5)		____	
____ Pivots broken.	(-5)		____	
____ Wheel poised.				
____ Wheel not poised.	(-5)		____	____

Remarks: ______________________________

____

____

C. ON THE AMERICAN 7 JEWEL MOVEMENT:

		Possible Score:	Points lost for errors:	Your Score:
9. Close all pivot holes and adjust for proper side-shake and endshake.				
____ Closed correctly and properly adjusted.		5		
____ Not enough ____ sideshake ____ endshake.	(-2)		____	
____ Too much ____ sideshake ____ endshake.	(-2)		____	____
10. Remove and replace the pallet arbor.				
Height of pallet on arbor:				
____ Correct.		2		
____ Too high.	(-2)		____	
____ Too low.	(-2)		____	
Damaged parts: ______________________	(-1)		____	____

- - - Cut along this line and send to the - - - School with your work for grading. - - -

Master Work Sheet

For use with Proficiency Exam No. 2 (Lessons 12 through 17)

****

IF YOU HAVE NOT ALREADY DONE SO, DO THE FOLLOWING BEFORE YOU START THE PROFICIENCY EXAM ITSELF:

1. Make the tool illustrated in Fig. 13-20, Section 321.

2. Make the tool illustrated in Figs 13-24-1 and 13-24-2, Section 324.

3. Make a set of three hairspring removing tools as illustrated in Fig. 15-3, Sec. 352.

4. Stake staffs in practice wheels. (See Lesson 15 and the Job Sheets in Lessons 15 and 17. Follow steps 12 through 18 on Job Sheet L17-J2.)

5. True practice balance wheels. (See Lesson 16)

6. Poise practice balance wheels. (See Lesson 17)

When you are satisfied with your work above, begin the exam:

USE AN AMERICAN WATCH, preferably 12 or 16 size, 15 or more jewels.

1. Fit a factory staff to this watch, using the procedure outlined on Job Sheets L17-J1 or L17-J2 in this order:

   a. Follow steps 1 through 25 on the Job Sheet.
   b. Remove and replace the roller jewel. (Lesson 13, Sections 320 through 325.)

      NOTE: Replacement of the roller jewel is being done here for this exam because it is convenient and must be done before the wheel is poised. The job could have been done earlier or separately as is usual in repairing.

   c. Follow steps 26 through 30 on the Job Sheet.
   d. Disassemble the movement.
   e. Remove one of the train jewel settings.
   f. Remove jewel from setting and replace with a friction jewel. (See Lessons 12 and 14 Assignment Sheets and the Job Sheets in Lesson 14.)
   g. Replace jewel setting.

2. As watch submitted should be clean, finish disassembly and clean the movement. (Lesson 10 and Job Sheets for Lesson 10.)

3. Reassemble the watch, oil, and regulate.

(Continued)

Master Work Sheet for Proficiency Exam No. 2

USE A SWISS MOVEMENT, preferably about 10 1/2 or 11 1/2 lignes, 15J or more:

4. Fit a factory staff to this watch, using the procedure outlined in Job Sheet L17-J2 in this order:

   a. Follow steps 1 and 2 on the Job Sheet.
   b. Step 3: Remove the upper balance hole jewel and replace with a friction jewel. (See Lesson 13 and the Job Sheets in Lesson 14.)
   c. Step 3: Remove the lower cap jewel from its setting and replace with a friction jewel.
   d. Follow steps 4 through 25 of the Job Sheet. (L17-J2)
   e. Remove and replace the roller jewel. (Lesson 13, Sections 320 through 325.)
   f. Follow steps 26 through 30 on the guide sheet.

5. As watch submitted should be clean, complete disassembly and clean the movement. (Lesson 10 and the Job Sheets in Lesson 10.)

6. Reassemble the watch, oil and regulate.

USE AN AMERICAN 7 JEWEL MOVEMENT, preferably 6, 12 or 16 size:

7. Completely disassemble the movement.

8. Reassemble each wheel and pallet fork individually in movement and check for proper endshake and sideshake. (Lesson 17, Section 372)

9. Close each pivot hole and refit to each pivot as outlined in Job Sheet L17-J6.

10. Remove and replace the pallet arbor. (Lesson 17, Sec. 375 and Job Sheets L17-J4 or L17-J5, depending upon the type of arbor.

11. Clean and oil the movement, reassemble and regulate.

-Detach page or cut along this line- - and send to the School for grading.-

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 16

Name: No.: Date:

Circle the correct answer: SUBJECT: Truing Balance Wheels

1. The main purpose of truing and poising balance wheels is:

Truing for good appearance of balance. Poising to reduce wear of pivots.	To be able to properly adjust and bring all watches to time	To bring a gaining watch to time	To bring a losing watch to time

2. The compensating balance with the cut rim has:

An outer rim of brass and an inner rim of steel	An outer rim of steel and an inner rim of brass	The entire rim made of brass	The entire rim made of steel

3. The points in the jaws of the truing caliper come in contact with:

The sides of the pivots	The ends of the pivots	The oil cut or back cut of pivot	The cones of the pivots

4. The balance screws in a compensating balance have been placed in their respective positions by the factory:

To make the work of truing easier	For purpose of appearance	For purposes of poising	For temperature adjustment

5. In truing a balance wheel in the flat, place the indicator:

Inside the rim of wheel	Outside the circumference of the wheel	About 2 to 2-1/2 mm from the rim	Edge of indicator close to rim and parallel to it

6. In truing in the flat, the starting point is:

Where the half rim ends at the cut	Where the arm joins the wheel	At the middle of each half rim	At any point of the wheel

7. In truing a small screwless balance in the flat, the bends are most easily made with:

Thumb and finger	Smooth-jawed pliers	Strong tweezers	Two flat surfaces

8. In truing a cut-rim wheel in the round, it is best to start by putting the indicator:

At the free end of the rim	At any point on the rim	Where the rim is joined by the arm	About 1/3 of the distance from free end to arm

9. What precaution should you take to avoid damaging pivots when truing any type of wheel in flat or round?

Exert pressure on jaws of caliper to keep jaws closed on cones of pivots	Keep balance staff pivots loosely in calipers at all times	Bend very lightly so as not to put strain on pivots	Use a truing wrench only

10. If your balance wheel seems to run true in the caliper but not in the watch, it is likely that:

The wheel is not true in the flat	The wheel is not true in the round	The pivots are bent	The wheel cannot be trued

11. A solid balance wheel is trued in the round:

By the same method as the cut balance	Practically impossible to true it	By using a truing wrench	By removing from caliper for each bend

12. When one balance arm is shorter than the other it may be trued by:

Truing each rim in the radius of its own arm	Truing both halves of the rim to the radius of the long arm	Putting in a new balance staff and then truing	Practically impossible to improve it

Master WATCHMAKING

Lesson 17

POISING BALANCE WHEELS

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

17

INTRODUCTORY INFORMATION

Poising a balance wheel is the next important step. Poising is the even distribution of weight on the wheel. The screws need not be evenly spaced on the rim but they must be in opposite pairs. Assuming a wheel is the correct weight when taken from a watch but in need of poising, the task would be to poise the wheel without changing the weight. This is done by removing weight from the heavy side and adding a like amount to the light side. This takes good judgment, which can be acquired with practice.

The type of poising tool used is unimportant, except that the jaws must be parallel, polished and kept clean. The tool should have adjustable legs in order to level on the working surface.

KEY POINTS OF LESSON ASSIGNMENTS 55, 56:

- What is meant by poising.
- Types of poising tools.
- How to poise a balance wheel.
- How to remove or add weight to a balance screw.
- How to use an undercutter.
- How to use a Swiss type balance screw cutter.
- How to repair a worn pivot hole.
- How to order wheels and pinions.
- How to fit a pallet arbor.

ASSIGNMENT NO. 55: Study Sections 366 through 370 and 369A (Follows Sec. 375)
Read Tools and Materials of the Trade, page 23.

Study Questions:

1. What is the purpose of the poising tool?
2. What part of the pivot should rest on the jaws of the poising tool?
3. How is weight removed from balance screws? (See Lesson 11, Sec. 276)
4. How is weight added to balance screws? (See Lesson 11, Sec. 274, Figs. 11-16 and 11-17.)
5. When is a wheel in poise?
6. What observations should be made before poising the balance?
7. Is the weight of meantime screws ever altered? (See Sec. 275, Lesson 11, Figs. 11-18 and 11-19)
8. What is the Swiss type balance screw cutter?
9. How is a screwless balance wheel poised?

Supplementary Information for Section 368: Do not grip screws in balance screw holder so hard as to mar the polished surfaces. When removing balance screws, loosen them with a regular watch screw driver. After undercutting or adding weight, start them into place with a balance screw holder and tighten with a regular watch screw driver.

ASSIGNMENT NO. 55 (Continued)

Recommended Practice:

Clean the jaws of the poising tool. Be sure they are highly polished and free of oil. Poise balance wheels until you can do it well.

NOTE: Before poising, you should first be sure the wheel is true, the pivots are straight and polished, and the wheel is not magnetized. Clean pivots of staff in wheel to be poised and jaws of the poising tool with pithwood. If any dust, particles of metal or lint are on the wheel, clean entire wheel in watch cleaning solutions before pressing pivots into pithwood.

On all wheels other than practice wheels, the roller table and jewel should be on the staff.

ASSIGNMENT NO. 56: Study Sections 371 through 375.
Review Lesson 4, Section 119, and Tools and Materials of the Trade, pages 34 to 40.

1. How can you avoid breakage and errors in making repairs?
2. How is a worn pivot hole repaired?
3. What tools are used to close a pivot hole in a plate?
4. How would you order a new wheel and pinion?
5. How is a pallet arbor replaced?

Recommended Practice:

1. Remove a friction fitted pinion from a train wheel. Replace it, using a staking tool for both operations.

2. Close a worn pivot hole. Broach to fit pivot. Assemble wheel and plates or plate and bridge and try for freedom and endshake.

3. Remove and replace a pallet arbor of friction type and one of the threaded type.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 17 and return for grading.

MASTER WATCHMAKING

A Modern, Complete, Practical Course

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

Lesson 17

Sections 366 to 375

POISING BALANCE WHEELS

SEC. 366 — Definition of Poising

Poising a balance wheel is the art of obtaining perfect balance.. Too many watchmakers are apt to feel that it is not necessary to check the poise on every wheel. On inexpensive watches where the factory is not too careful about poising balance wheels, it is hard for a watchmaker to bring these wheels into poise. However, in the better grade watches the wheels are poised before the watch is brought to time and if carefully handled by good repair men, these wheels will remain in poise. A watch will not keep accurate time unless the wheel is poised, and immediately after checking the wheel to see if it is true, it should be tested for poise. A balance wheel cannot be poised if it is magnetized and a magnetized balance wheel will act as if it were out of poise. Lesson 11 explains magnetism, and by now you should be in the habit of testing each watch for magnetism.

In poising a balance wheel, remember that the pivots must be perfectly true, the wheel must be true in the flat and in the round and must be free of magnetism. The wheel is poised with the roller table in place, the roller jewel must be set and all excess cement removed, and the wheel and the jaws of the poising tool must be clean. Use pithwood to clean both.

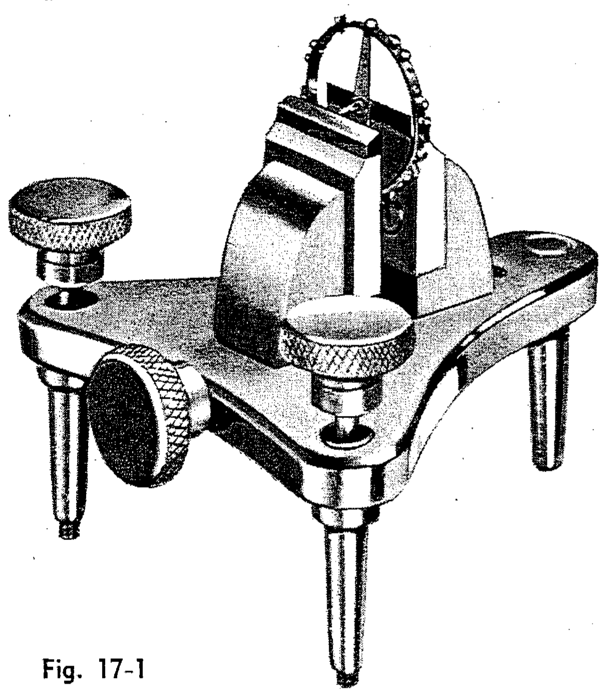


Fig. 17-1

SEC. 367 — The Poising Tool

There are many types of poising tools on the market. One of the most popular models is shown in figure 17-1. Two of the legs are on screws and are used to insure perfect level at all times. The jaws are of synthetic ruby with a high polish. Some poising tools are equipped with a spirit level. Steel jaw poising tools will serve the purpose well but the jaws must be kept at a knife edge and highly polished.

SEC. 368 — Poising the Balance Wheel

1. The balance wheel is set between the jaws of the poising tool with the pivots (not the cones) resting on the polished, knife-like edges of the poising tool, figure 17-2.

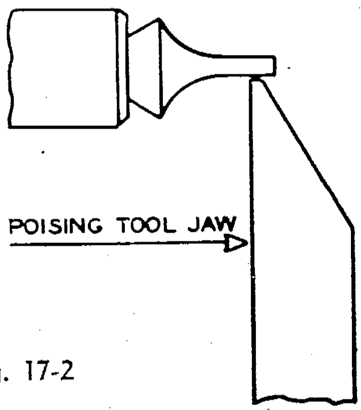


Fig. 17-2

2. Carefully turn balance wheel with pegwood and release.
3. If the wheel is out of poise the heavy side will be at the lowest point on the rim B, figure 17-3.
4. Removing weight from the balance screw located at this point will tend to bring the wheel into poise.

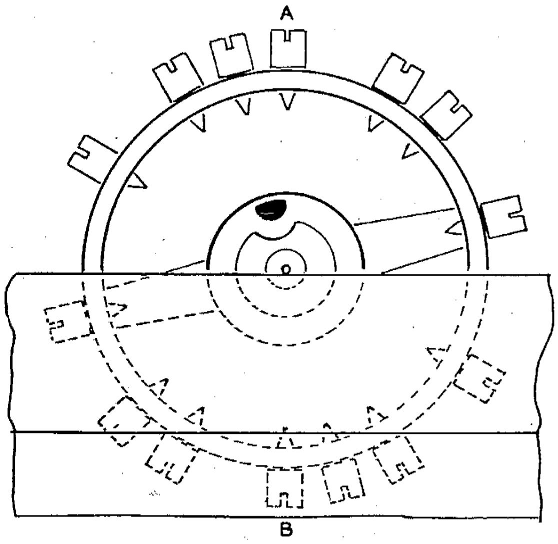


Fig. 17-3

5. Adding weight to the screw A opposite the heavy side A, figure 17-3, will obtain the same result.
6. It is best to add a little weight to the light side and remove a little from the heavy side.

To remove weight, use balance screw undercutter, having hole in the center to allow the threaded portion of the balance screw to enter (figure 11-19, Lesson 11).

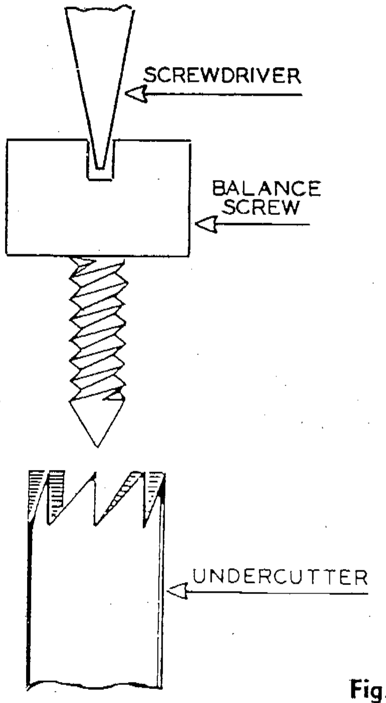


Fig. 17-4

Figure 17-4 illustrates the screw in place over the undercutter. Notice that the undercutter is smaller in diameter than the head of the screw. Turning the screw with a screwdriver will remove a slight amount of metal, depending upon

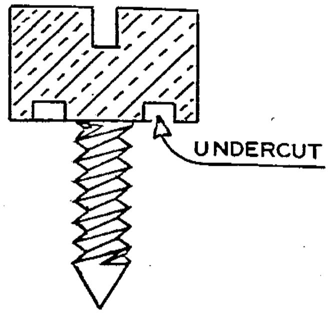


Fig. 17-5

how many revolutions the screw is turned. Do not use too much pressure. Figure 17-5 illustrates a balance screw that has been undercut.

The undercutter mounted in a lathe and the screw held in a balance screw holder is the most satisfactory method of all but is another method that cannot be used without a lathe. The first method works as well but is a little slower.

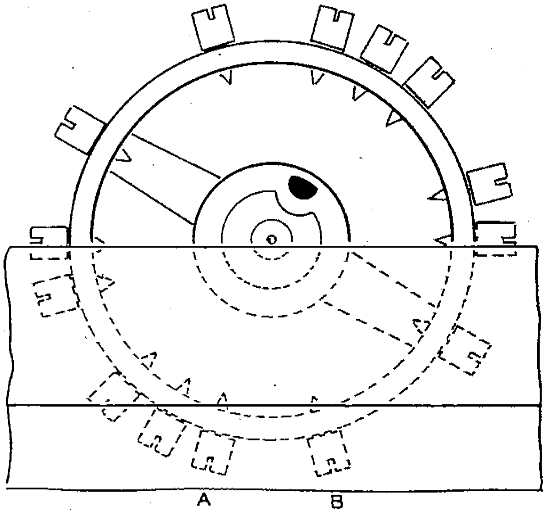


Fig. 17-6

Figure 17-6 illustrates a balance which has come to rest with the heavy side between the screws A and B. In such a case we would remove a little weight from each of the screws A and B with the undercutter.

Light weight timing washers may be added if it is desirable to add weight in order to bring the wheel into poise. In this connection, in our lesson on lathe work we will illustrate the procedure used in making punches for any size balance screw which will in turn allow us to make washers from brass, copper or in some cases gold and platinum. These punches will also serve us well in making special timing washers.

Remove weight from and add weight to the balance wheel carefully as it is very easy to get the wheel out of true. When the balance wheel

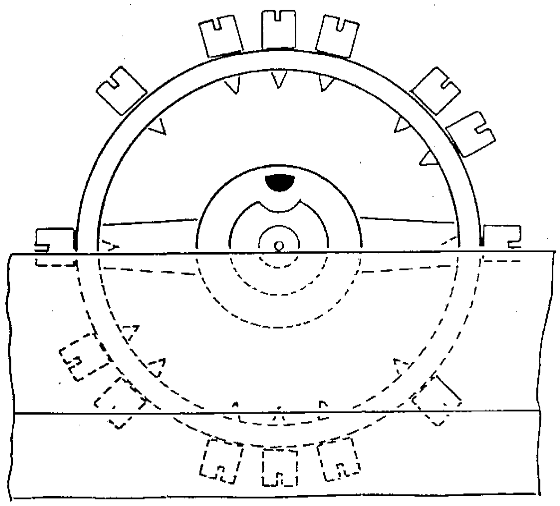


Fig. 17-7

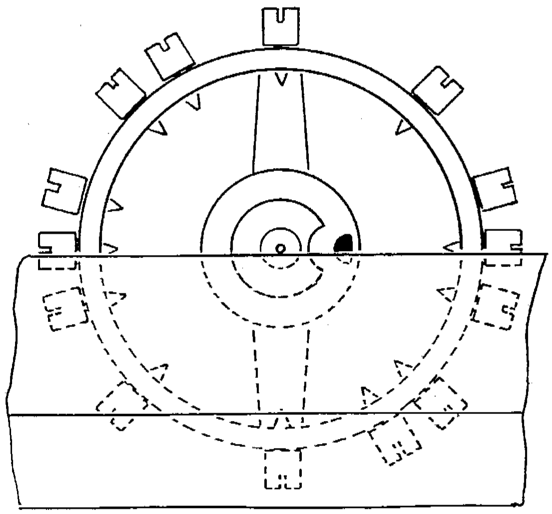


Fig. 17-8

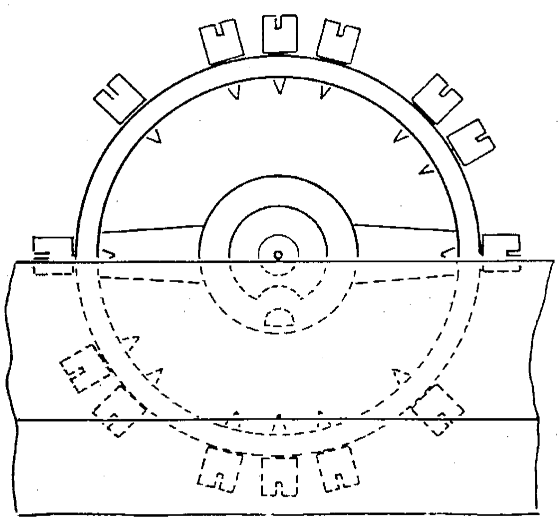


Fig. 17-9

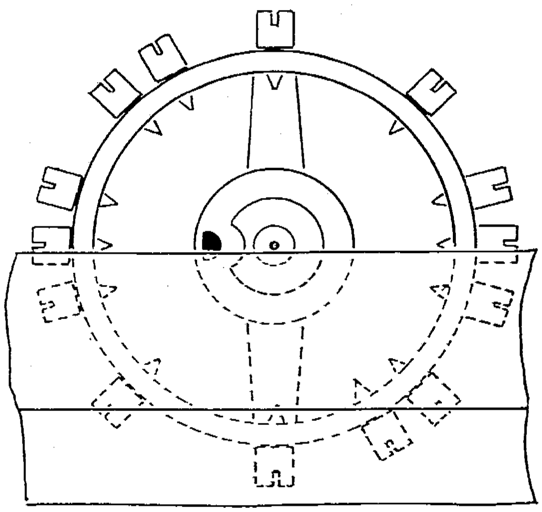


Fig. 17-10

will remain at any position on the jaws of the poising tool, it will be in poise. Try four positions by using the roller jewel as a guide. Figure 17-7 illustrates the roller jewel in a vertical position. Turn the roller jewel a quarter turn to the right, figure 17-8. Turn the roller jewel another quarter turn to the right, figure 17-9, and once more, figure 17-10. Tap poising tool lightly when the wheel is in each of the above positions. If it remains in each of the positions described the wheel will be in poise.

SEC. 369 — Some Observations to Make Before Poising a Balance

In making repairs on watches, it is an excellent idea to make certain notes as follows:

Notice position of regulator before removing balance from the movement. If the regulator is as far toward the F (fast) as possible we would assume this watch has a tendency to run slow. In this case, when poising the wheel it would be better to remove more weight from the balance than we add. Just the opposite is true if the regulator is toward the slow side. In this case it would be reasonable to assume that more weight should be added than removed when poising the balance wheel.

When a balance wheel is ready to be trued in the round and the ends of the balance rim are slightly toward the center, the weight which is contained in the balance rim will be moved away from the center. This will cause the watch to run slower. After the wheel has been trued properly it would in all probability be wiser to remove weight from the balance when poising the balance.

If the rims of the balance had to be trued toward the center it would be wise to add weight to the balance wheel when poising, as truing the ends of the balance rim toward the center moves the weight toward the center, thus causing the watch to gain.

These conditions must be observed carefully when making repairs and the more careful you are with your observations the easier it will be for you to bring your watch to time.

If your watch runs slow after you have trued and poised the balance wheel and the regulator is in the center, it is possible to speed it up by removing an equal amount of weight from a pair of balance screws which are directly across from each other. If the watch runs fast with the regulator in the center, a pair of washers of equal size and weight added to opposite pairs of screws will increase the weight of the balance wheel and cause the watch to slow down. (Lesson 11).

When poising the balance wheel, do not add to or remove weight from the meantime screws, but instead make any required adjustment on the balance screws on either side.

To poise a monometallic balance use the same method as is used to poise the regular balance wheel. However, in watches using this type of balance, you will find that the wheel is seldom out of poise if the staff has been properly replaced. If your wheel is out of poise, be sure to check the pivots carefully to see that they are perfectly true and have a high polish.

SEC. 370 — Swiss Type Balance Screw Cutter

Figure 17-11 illustrates a balance screw cutter which will cut the balance screw without having to remove the screw from the balance wheel. These come in sets of six and are recommended for bringing ordinary Swiss type balances to poise or for timing.

Use as follows:

1. Select collar which fits over balance screw

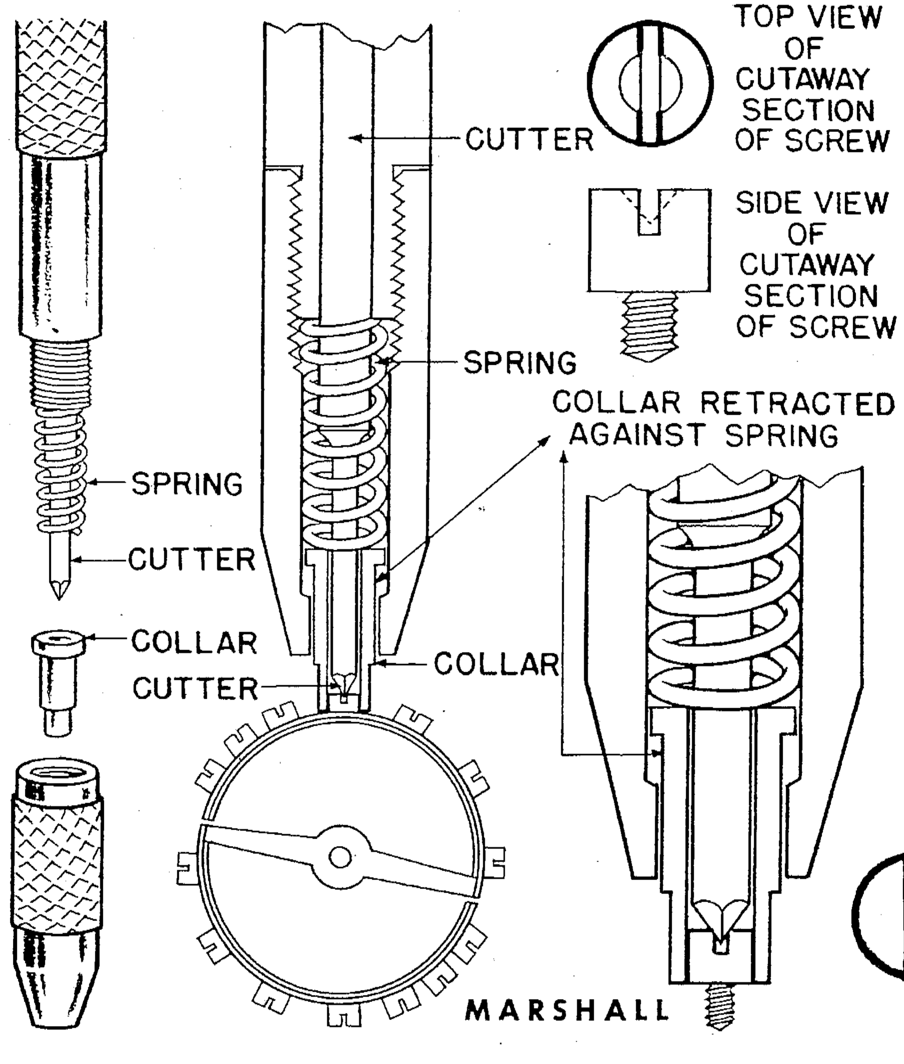


Fig. 17-11

to hold it in position . . . the collar retracts against the spring and automatically centers the cutter.
2. Turn handle as you would a screwdriver. The three bladed cutter countersinks (hollows out) the center of the top of the screw.
3. Remove cutter and test.

SEC. 371 — Train Wheels and Pinions

The wheel and pinions of a watch do not need replacing very often. The pivots are sturdy and it takes a hard knock to break the train pivots. There are times when a student will accidentally break a train pivot; this usually happens when too much force is exerted in assembling the watch. If a train wheel and pivot will not slip into place easily, check carefully to see if you might have overlooked interference at some point. There may be times when it seems as though the wheel and pinion do not fit properly. But REMEMBER that if it fit properly before you took it apart it should go back in easily. Any time you are in doubt, remove all wheels in the train and try the wheel and pinion you are having trouble with, in the watch by itself. This holds true for every operation in watchmaking, wheels and pinions, balance staffs, jewels, winding and setting parts. Try each part separately until you are positive that each and every part is functioning correctly. When you are certain that each part works smoothly, proceed with the next operation.

There are many occasions in which the student will have trouble when making repairs. For example: On certain Swiss watches in which the lower escape pivot is capped, the screw which holds the cap jewel in place can be interchanged with the lower balance cap jewel screw. However, the balance cap jewel screw is slightly longer, and if replaced as the escape cap jewel screw it may protrude enough to cause interference with the escape wheel. This example and many others cannot be considered part of your course as they are primarily due to carelessness or lack of experience. Your ability to locate these difficulties will mean the difference between an expert and a "botchmaker." Ability is determined by the skill in locating trouble quickly and making the necessary repairs.

Figure 17-12 is an illustration of a badly worn square shoulder pivot which should be replaced. Before replacing, however, ascertain the condition of the jewel, as it is possible that a cracked or broken jewel has caused the excessive wear. Or it may have been cut by accumulated dirt

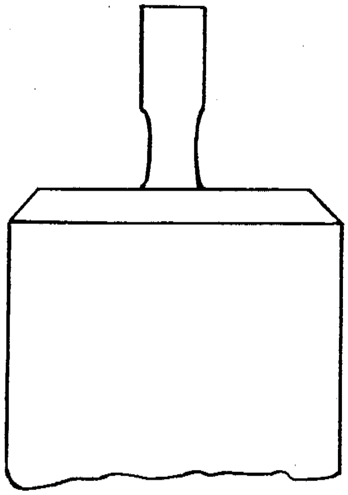


Fig. 17-12

and grime mixed with the old oil. If the jewel is cracked or broken, replace it before attempting to replace the wheel and pinion. In cases where the pivot turns directly into the plate or bushing, it will be necessary to close the pivot hole slightly.

SEC. 372 — Repairing a Worn Pivot Hole

In watches that do not have jewels for bearings the pivots of the train wheel pinions turn directly in the plates or metal bushings and we may find the pivot holes have become worn. This is especially true in watches that have been in use for a good many years. Excessive wear is easily determined by testing for sideshake and if the sideshake is noticeable, it is evident that the pivot hole is too large, figure A-17-13. For a thorough test, examine each wheel and pinion separately, testing for excessive sideshake.

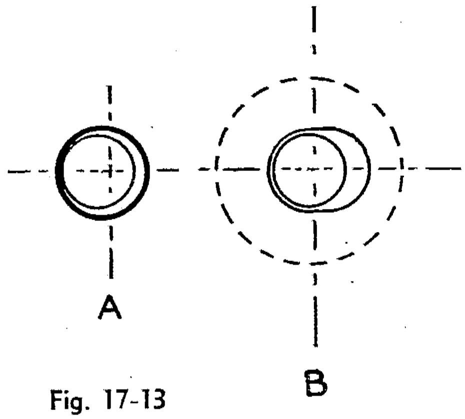


Fig. 17-13

Whenever a watch is taken apart it should be carefully examined to see if any such condition exists. Not all pivot holes that are worn can be satisfactorily closed. Figure B-17-13 shows a pivot hole that is worn so badly that it would be wasted effort to attempt to close it so that it would function properly. The recommended procedure in such a case would be to ream out the old pivot hole with a cutting broach large enough to accept a friction jewel. The large dotted circle in figure B-17-13 represents this hole. This bearing can now be put in first class order easily and quickly by fitting a friction jewel to the opening. If the pivot needs to be polished or replaced this must be done before fitting the friction jewel in order that you may select the proper size pivot hole in the jewel. Before friction jewelling came within reach of the watchmaker, it was necessary to "plug" the plate or bridge with a brass bushing and then drill a pivot hole of the correct size in the bushing. This, of course, has to be done on a watchmaker's lathe and, in some cases, necessitates the use of a face plate to "upright" the bridge or plate.

SEC. 373 — Closing Hole In Plate or Bridge

To close a pivot hole in a plate or bridge, select a flat face staking tool stump that will cover the bearing surface of the hole to be closed, figure 17-14. Select a small round face solid punch that will fit inside the oil cup. Tap the punch lightly until the hole is closed enough that the pivot will not enter it. Select a small pivot broach (a small reamer) that will enter the hole, and carefully open hole by rolling the broach back and forth between your thumb and forefinger. Do this from both sides until pivot fits correctly.

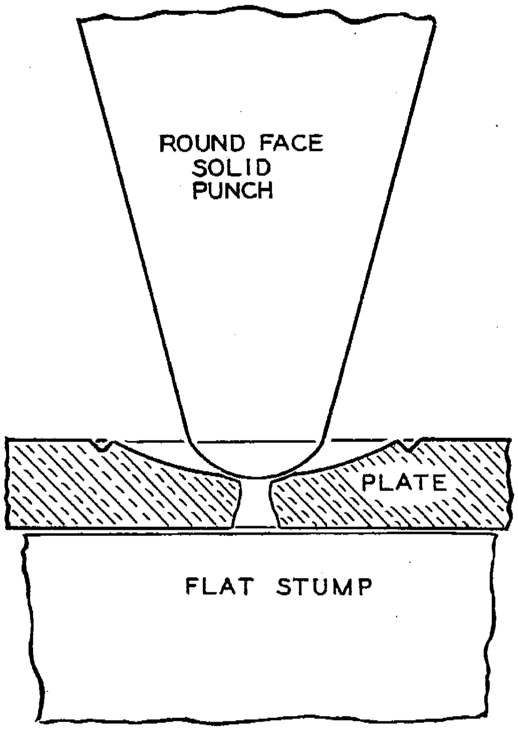


Fig. 17-14

SEC. 374—Ordering Wheels and Pinions

In replacing a worn wheel and pinion in a Swiss watch, it is usually necessary to order the wheel and pinion complete as the wheels are staked on at the factory. This assures the watchmaker of an accurate fit. When replacing a wheel and pinion, carefully try pivot in jewel bearing to determine if pivot fits properly. If the wheel and pinion are from the factory that made the watch, it will usually fit correctly. If the pivot fits a little snugly, it will have to be ground down slightly and repolished. However, that is another job that will have to wait until we reach lathe work.

In most American watches the wheel and pinions can be purchased separately and are of a friction fit. Figure 17-15 illustrates the method used to remove this type of pinion from the wheel. The wheel is placed over a hole in the die plate large enough to receive the pinion leaves. A flat face hollow punch is then used to force out the pinion. The pinion is replaced by reversing the above procedure, figure 17-16.

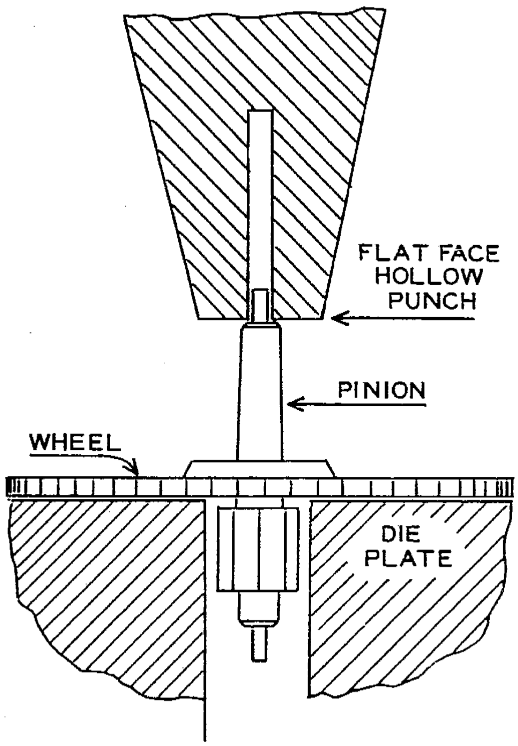


Fig. 17-15

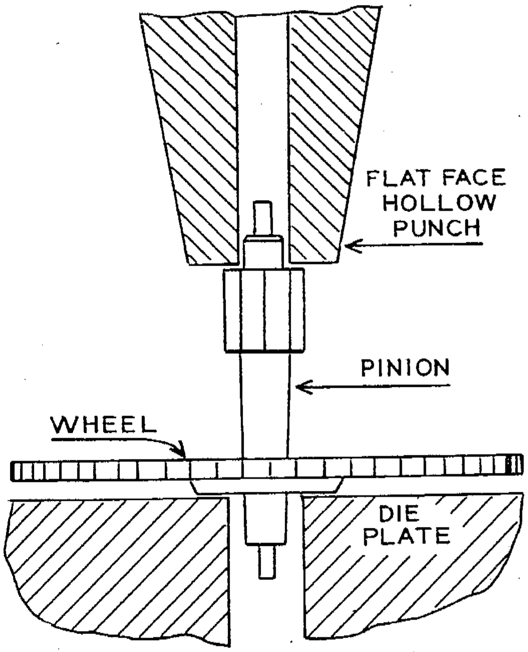


Fig. 17-16

Let us assume that the one we have ordered is the correct size. For practice, take one of your practice watches and remove the pinion from the wheel and then replace it.

When ordering, give the name of the part, describe name of watch and size.

Example: 1 Elgin 16 size 4th Pinion (Enclose sample if possible).

Figure 17-17 illustrates a round face hollow

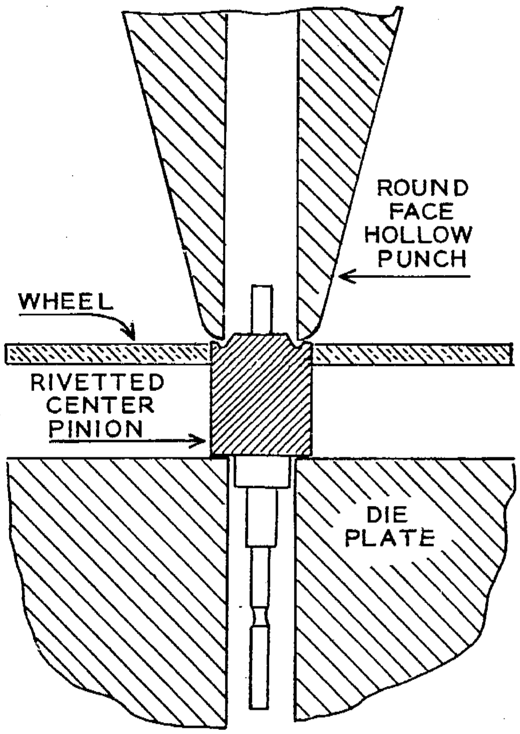


Fig. 17-17

punch used to rivet a center pinion to the center wheel. This procedure, with little variance, is used to tighten wheels which have become loose on other pinions of the rivet type.

SEC. 375 — Fitting Pallet Arbors

It is not often that a watchmaker is called upon to replace pallet arbors. They are rarely broken except through the misfortune of the repair man when replacing a pallet fork and arbor. They are one of the smallest and most delicate parts of a watch and difficult to handle.

The pallet arbors have either square shoulder or conical pivots and are usually very short. Some are threaded while others are friction fit, figure 17-18.

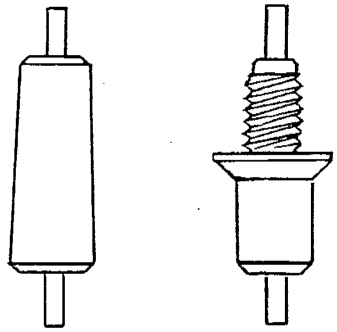


Fig. 17-18

In selecting a new pallet arbor, it is necessary to determine the type—a friction fit or screw type. The screw type can be removed easily by grasping arbor with a small pin vise and turning it out. Before replacing, be sure the lower pivot fits the lower jewel hole correctly and the upper pivot fits the upper jewel hole with proper sideshake.

Place pallet arbor in lower jewel. Put on pallet bridge and test for endshake. It is necessary to have endshake as previously explained in our lessons on jewels and staffs. If everything is now correct, replace arbor in fork. Here we have to mention the lathe again, this time as an excellent way of removing and replacing a pallet arbor in place of a pin vise. In the friction type they may be replaced with a staking tool using a small pivot punch or the tools furnished with the friction jewelling tool previously described. In doing work with a pallet fork and arbor, it cannot be stressed too much at this time that a student must use extreme care in handling each part. Be very careful not to bend the guard pin or loosen the pallet stones. As previously stated, it isn't often that these parts get out of order unless through carelessness of the workman.

More and more you will begin to realize the importance of lathe work. A regular watchmaker's lathe with a few more attachments than that of the average watchmaker's would enable you to manufacture a watch. It would hardly be profitable, but you should see by now that the student needs lathe work in order to become an expert. On the everyday job a lathe is required. Possibly you will only use it two or three times a day, maybe not at all, but it is impractical to think you can be without it; a pivot needs polishing, a jewel hole is out of upright, a balance shoulder must be undercut to stake balance properly. It is indispensable for cutting down roller seat, making tools, balance staff, setting jewels, etc. However, before you do lathe work it is to your advantage to become acquainted with the parts of the watch, their functions and failures. The next series of lessons concerns hairsprings followed by lessons on the escapement. These lessons will require a great deal of concentrated study and practice. There is very little practical work but with the experience gained in these lessons and the following lessons on lathe work your ability to repair watches will grow by leaps and bounds depending of course on the amount of watch repair you do. It is to your benefit to constantly review the previous lessons at every available opportunity.

SUPPLEMENTARY INFORMATION

SEC. 369A—Poising a Screwless Balance

A screwless balance likewise seldom needs poising. If it should be necessary, proceed as follows:

Locate the heavy spot and place the wheel on a bench block with the lower side of the wheel up. Use a small pivot drill set into a pin vise to start a hole in the rim. Check poise again. If this spot is still heavy, drill the hole a little deeper. Do not use a stone or file. Work carefully since you cannot add any weight.

If you have any extra hairspring at the stud, you can repin it to adjust the rate. If there is no extra amount of hairspring, you'll have to obtain a new spring vibrated to the wheel and bridge. (See Lesson 20.)

ANSWERS TO PROGRESS CHECK 17:

1. magnetism
2. level
3. weight
   balance screws
4. timing washers
5. balance screws
6. add
7. remove the screw
8. try each part separately
9. worn
10. friction jewels
11. pivot broach
12. friction fit
13. as a complete unit
14. threaded or screw type
    friction fit

CHECK YOURSELF

Progress Check 17 — A Self Test Review of Lesson 17

Study Sections 366 through 375. Then see if you can answer these questions without looking back. DO NOT SEND THIS TEST TO THE SCHOOL FOR GRADING. You'll find answers on the previous page. If you miss a question, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. Before a balance wheel can be poised, the watch must be free of ____________.	366
2. The poising tool must be perfectly ____________.	367
3. An out of poise balance wheel is adjusted by altering the ____________ of the ____________.	368
4. When it is desired to add weight, ____________ may be used.	369
5. If a watch has meantime screws, adjustments for poising should be made on the ____________ on either side.	369
6. If the regulator on a watch is toward the "slow" side, it is better to ____________ weight in poising.	369
7. An advantage of the Swiss type balance screw cutter is that it makes it unnecessary to ____________ from the balance wheel.	370
8. Anytime you have trouble in assembly, it is best to ____________.	371
9. If sideshake is excessive, it is likely the pivot hole is ____________.	372
10. Worn pivot holes are often repaired nowadays with ____________.	372
11. In closing a pivot hole in the regular way, the hole is first closed enough that the pivot cannot enter. It is then reamed with a ____________ until the pivot fits correctly.	373
12. Wheels and pinions for American watches can usually be purchased separately and are joined by a ____________.	374
13. Wheels and pinions for Swiss watches must ordinarily be ordered ____________.	374
14. The two types of pallet arbor are ____________ and ____________.	375

HOW TO REPLACE A RIVET TYPE BALANCE STAFF IN A WATCH HAVING A SINGLE ROLLER.

Tools, Equipment and Supplies:

Staking Tool	Roller Remover	*Staff Remover	*Depending on which staff removing method is used.
Brass Hammer	Hairspring Remover	*Lathe	
Tweezers	Balance Screwholder	*Graver	
Truing Caliper	Set of Undercutters	Poising Tool	
Eye Loupe	Screw Drivers	Timing Washers	

PROCEDURE:	REFERENCE:
1. Remove the balance cock and balance assembly.	Lesson 8
2. Remove balance and cap jewels.	Les. 10 - Sec. 240
3. If balance hole or cap jewels are cracked or damaged, replace. Make certain upper and lower jewels have same size hole.	
4. Clean and replace balance hole and cap jewels.	
5. Remove hairspring.	Sec. 352
6. Remove roller from balance assembly with roller remover.	Sec. 353
NOTE: Mark rim of wheel opposite position of roller jewel with colored pencil so roller can be replaced in same position. Mark is easily removed with cleaning solution.	
7. Remove staff from wheel.	Job Sheet L15-J1
8. Select replacement staff.	Les. 4 - Sec. 119 Les. 15 - Sec. 356
9. Place the staff only in movement with bridge in place and check endshake and sideshake.	Sec. 356
10. Remove staff from movement.	
11. Check wheel and roller on staff to see that they will fit correctly. Check collet seat diameter.	
12. Select and align a hole in the die plate of staking tool that will accommodate roller seat and give proper support to the bottom of the hub of the staff.	Sec. 357

(Continued)

PROCEDURE:	REFERENCE:
13. With staff in die plate, set balance wheel in place. Be sure wheel is firmly seated against the hub. If not firmly seated, use a flat face hole punch with a larger hole than the one in the wheel and press wheel down against the hub.	
14. Select round face hole punch in size that will go down over collet seat with the least amount of clearance.	Fig. 15-15
15. Turn the punch slowly as you tap it to spread the rivet.	
16. Select flat face hole punch with same size hole.	Fig. 15-16
17. Turn the punch slowly as you tap it to rivet the staff.	
18. Check to see that staff is firmly riveted.	
19. True the wheel in flat and round.	Lesson 16
20. Place balance wheel in movement. Pallet bridge and balance bridge should be in place.	
21. Check endshake and free motion of wheel.	
NOTE: A good test is to start the wheel turning slowly in either dial up or dial down position. The wheel should revolve freely and gradually slow down at the same rate in both positions. If the wheel is not free in either or both positions, check the following to find out what is wrong:	
a. Magnetism. b. Pivot bent, rough, burred, etc. c. Clearance of rim between center wheel and pallet bridge. d. Balance jewels dirty, cracked, chipped, or loose. e. Endshake. f. Balance screws out too far or timing washers rubbing. g. Wheel out of true. h. Jewel screws not tight.	Lessons 10 - 11 - 13 14 - 30 - 31 and Aids in Estimating and Repairing booklet.
22. Make any necessary correction to obtain free motion.	
23. Set roller on roller seat with roller jewel aligned with mark you previously made on rim.	
24. Select a hole in the die plate that will accommodate the staff and roller jewel.	Fig. 15-17

(Continued on next page)

PROCEDURE:	REFERENCE:
25. Use the same flat face hole punch you used in riveting and with pressure or a light tap drive the roller into place against the bottom of hub.	
26. Poise the balance wheel.	Lesson 17
NOTE: On some balance wheels, the manufacturer may have inserted either one or two pairs of meantime screws. You can recognize them by their longer screw shank compared to the other screws and by the fact they are usually not screwed all the way in to the rim of the wheel. THESE SCREWS ARE NEVER USED IN POISING nor should their weight be altered by adding or taking away weight from them.	Sec. 369
27. Recheck Step 19 and make any necessary adjustments.	
28. Recheck Step 26 and make any necessary adjustments.	
NOTE: If either the truth or poise of wheel is incorrect, you may have to correct both. A wheel that is out of true in the round will be out of poise when trued.	
29. Replace balance in movement with pallet fork and bridge in place and balance bridge in place. Check the fork and roller action and make the necessary adjustments.	Lessons 13 21 - 22 - 26
30. Replace hairspring. Check that it is true, centered, has overcoil (if any) properly formed, and so on. Put in beat.	Lessons 20 and 26
31. Oil balance jewels.	Lesson 10
32. Replace balance assembly and bridge and check for proper motion.	Lesson 11

LESSON	17
Balance Staff	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L17-J2

HOW TO REPLACE A RIVET TYPE BALANCE STAFF IN A WATCH WHICH HAS A COMBINATION DOUBLE ROLLER.

Tools, Equipment and Supplies:

Staking Tool	Roller Remover	*Staff Remover	*Depending on which staff removing method is used.
Brass Hammer	Hairspring Remover	*Lathe	
Tweezers	Balance Screw Holder	*Graver	
Truing Caliper	Set of Undercutters	Screw Drivers	
Eye Loupe	Timing Washers	Poising Tool	

PROCEDURE:	REFERENCE:
1. Remove the balance cock and balance assembly.	Lesson 8
2. Remove balance and cap jewels.	Les. 10 - Sec. 240
3. If balance hole or cap jewels are cracked or damaged, replace. Make certain upper and lower jewels have same size hole.	
4. Clean and replace balance hole and cap jewels.	
5. Remove hairspring.	Sec. 352
6. Remove roller from balance assembly with roller remover.	Sec. 353
7. NOTE: Mark rim of wheel opposite position of roller jewel with colored pencil so roller can be replaced in same position. Mark is easily removed with cleaning solution.	
7. Remove staff from wheel.	Job Sheet L15-J1
8. Select replacement staff.	Les. 4 - Sec. 119 Les. 15 - Sec. 356
9. Place the staff only in movement with bridge in place and check endshake and sideshake.	Sec. 356
10. Remove staff from movement.	
11. Check wheel and roller on staff to see that they will fit correctly. Check collet seat diameter.	
12. Select and align a hole in the die plate of staking tool that will accommodate roller seat and give proper support to the bottom of the hub of the staff.	Sec. 357

(Continued)

PROCEDURE: REFERENCE:

13. With staff in die plate, set balance wheel in place. Be sure wheel is firmly seated against the hub. If not firmly seated, use a flat face hole punch with a larger hole than the one in the wheel and press wheel down against the hub.

14. Select round face hole punch in size that will go down over collet seat with the least amount of clearance. — Fig. 15-15

15. Turn the punch slowly as you tap it to spread the rivet.

16. Select flat face hole punch with same size hole. — Fig. 15-16

17. Turn the punch slowly as you tap it to rivet the staff.

18. Check to see that staff is firmly riveted.

19. True the wheel in flat and round. — Lesson 16

20. Place balance wheel in movement. Pallet bridge and balance bridge should be in place.

21. Check endshake and free motion of wheel.

    NOTE: A good test is to start the wheel turning slowly in either dial up or dial down position. The wheel should revolve freely and gradually slow down at the same rate in both positions. If the wheel is not free in either or both positions, check the following to find out what is wrong:

    a. Magnetism.
    b. Pivot bent, rough, burred, etc.
    c. Clearance of rim between center wheel and pallet bridge.
    d. Balance jewels dirty, cracked, chipped, or loose.
    e. Endshake.
    f. Balance screws out too far or timing washers rubbing.
    g. Wheel out of true.
    h. Jewel screws not tight.

    — Lessons 10 - 11 - 13, 14 - 30 - 31 and Aids in Estimating and Repairing booklet.

22. Make any necessary correction to obtain free motion.

23. Set roller on roller seat with roller jewel aligned with mark you previously made on rim.

(Continued)

PROCEDURE:	REFERENCE:
24. Select a hole in the die plate that will accommodate the staff and properly support the bottom of the combination roller.	Fig. 15-16
25. Use the same flat face hole punch you used in riveting and with pressure or a light tap drive the roller into place against the bottom of hub.	
26. Poise the balance wheel.	Lesson 17
NOTE: Meantime screws, if present, are NEVER USED IN POISING.	
27. Recheck Step 19 and make any necessary adjustments.	
28. Recheck Step 26 and make any necessary adjustments.	
NOTE: If either the truth or poise of wheel is incorrect, you may have to correct both. A wheel that is out of true in the round will be out of poise when trued.	
29. Replace balance in movement with pallet fork and bridge and balance bridge in place. Check the fork and roller action and make any needed adjustments.	Lessons 13 21 - 22 - 26
30. Replace hairspring. Check that it is true, centered, has overcoil (if any) properly formed, and so on. Put in beat.	Lessons 20 and 26
31. Oil balance jewels.	Lesson 10
32. Replace balance assembly and bridge and check for proper motion.	Lesson 11

LESSON	17
Balance Staff	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L17-J2A

HOW TO REPLACE A RIVET STYLE STAFF IN A WATCH THAT HAS A SCREW-LESS STYLE BALANCE WHEEL:

Swiss - Two, three or four arm screwless balances (Solid balances)
Wyler Incaflex style (Flexible arm balance)

Tools, Equipment and Supplies:

Brass Hammer	Truing Caliper	Poising Tool
Tweezers	Roller Remover (Fig. 15-19)	Hairspring Remover
Screwdrivers	Staff Remover	Pithwood
Eye loupe		

PROCEDURE:	REFERENCE:
1. Remove balance bridge and wheel from movement.	
2. Open regulator gate and loosen stud screw. Remove balance from bridge.	
3. Check and clean upper and lower balance hole and cap jewels. If shock style jewels, see Sec. 344, Lesson 14.	
4. Remove hairspring. (Mark rim of wheel with colored pencil or scratch a small mark where stud is.)	
5. Remove roller table with roller remover. (Mark underside of wheel rim where roller jewel is.)	Les. 15 - Fig. 15-19
6. Remove broken staff with a staff remover.	Job Sheet L15-J1-C
7. Select replacement staff. Be sure you check balance seat, roller seat and collet seat with old staff.	
8. Place staff in lower hole jewel and fit upper bridge. Check for correct endshake.	
9. Remove staff from movement and place in pithwood. Select a flat face punch with hole that fits over collet seat. Fit balance wheel on wheel seat and place in die plate. NOTE: A round face punch should NOT be used on this type wheel as it may damage the soft arms.	
10. Rivet staff with flat face punch, turning wheel as you tap the punch.	
11. Check wheel in calipers and true if out of true in flat.	Les. 16 - Sec. 365A

(Continued)

PROCEDURE:	REFERENCE:
12. Replace roller table. (Be sure you line up roller jewel with mark you made under balance rim.)	
13. Poise wheel.	Sec. 369A
14. Replace hairspring. (Line up stud with mark you made.)	
15. Replace balance to bridge and fit in movement.	
16. Check beat and motion.	Lessons 11 & 26
17. Time watch.	Lessons 11 & 26

HOW TO REPLACE AN ELGIN DURABALANCE STAFF

Introductory Information

The Elgin DuraBalance is another form of flexible arm balance. Like the Wyler balance, it is intended to provide shock protection for the staff. It has no regulator pin and uses a regulating lever (C) with a pair of timing weights (D) for regulation. The regulating range is 15 minutes, from $7\frac{1}{2}$ plus to $7\frac{1}{2}$ minus. For standard yellow gold color weights, the index marks (G) on the balance rim mark off about 90 seconds. Heavier or lighter weights are available to extend the range five minutes faster or six minutes slower. However, it is not often necessary to change weights for this purpose.

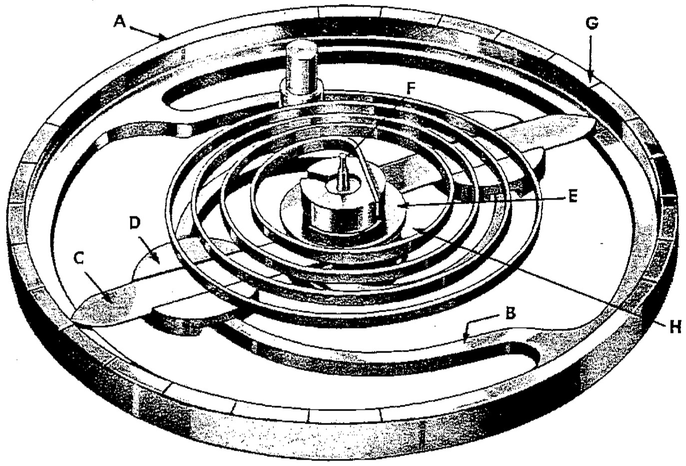


FIGURE 1—PERSPECTIVE OF BALANCE ASSEMBLY

This style wheel is used on Elgin Grades 730 and 830. Formerly, Elgin had an exchange service for the entire assembly as well as the balance complete. This service has now been discontinued and the watch repairman must now staff the wheel himself. Balance wheels, staffs, hairsprings, and weights are all still available.

Tools, Equipment and Supplies:

Staking Tool
Brass Hammer
Tweezer
Eye Loupe
Roller Remover
(Fig. 15-19)
Screwdrivers
Staff Remover
Poising Tool

PROCEDURE:

1. Remove balance bridge and wheel.

2. Loosen stud screw and push out stud.

3. Remove hairspring. (Mark where stud is.)

4. Mark where roller jewel is and remove roller table.

5. Look at regulating lever and see how it works with the weights in place. Moving it clockwise will speed up the watch, while counterclockwise slows it. Notice how the weights are fitted on the balance arm and held in place by the regulating lever.

6. Fit balance on staking tool die plate so the hub of staff fits in hole with little play.

(Continued)

JOB SHEET
L17-J2B
Continued

PROCEDURE:

7. Attach staff remover and line it up. Tighten the remover down on the balance lightly. Do not tighten it so much that it bends the regulating lever. Tap staff out. These staffs have an undercut, so they will break out without damaging the wheel.

8. Remove staff remover and look for the holding washer, regulating lever, two weights, and a friction washer. (See drawing below.)

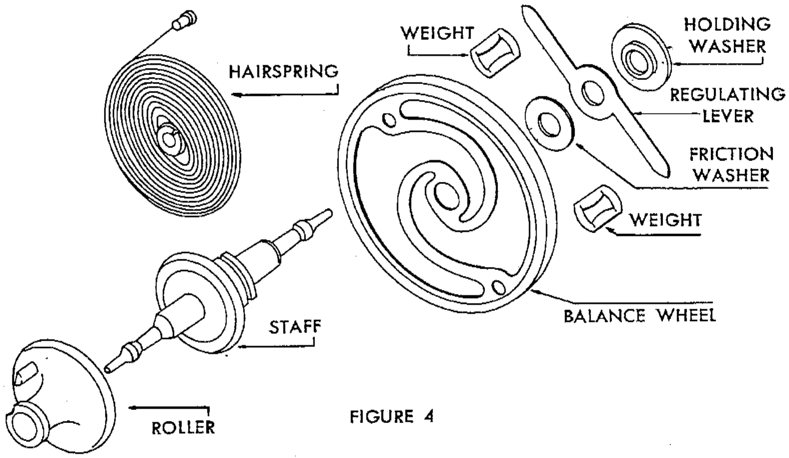


FIGURE 4

9. Select new staff and check it with old sample to be sure it is the same. Check for endshake and clean hole jewels.

10. Fit wheel on staff in pithwood and select a round face punch that fits the rivet edge.

11. Stake wheel to staff with round punch and flat face punch.

12. Replace roller table and be sure the roller jewel is lined up with mark on rim.

13. True wheel and poise.

14. Fit friction washer on collet seat. Place weights on balance arms and fit regulating lever above friction washer. (The weights will lie on the balance arm as you do this.)

15. Fit holding washer on the collet seat and press down with a flat face punch. This washer will hold the weights in place. You should now be able to turn the regulating lever with a little pressure.

16. Press hairspring down and the collet will also help to hold the regulating lever.

17. Fit balance complete to the balance bridge and replace them in the watch.

18. To regulate, hold balance arm (B in Fig. 1), and with tweezer move regulating lever clockwise or counterclockwise as needed.

HOW TO REPLACE A WALTHAM FRICTION TYPE BALANCE STAFF.

Tools, Equipment and Supplies:

Staking Tool	Tweezers	Hairspring Remover
Brass Hammer	Roller Remover	Screw Drivers
Truing Caliper	Balance Screw Holder	Poising Tool
Eye Loupe	Set of Undercutters	Timing Washers

PROCEDURE:	REFERENCE:
1. Remove balance assembly from movement.	Lesson 8
2. Remove balance and cap jewels.	Les. 10 - Sec. 240
3. Select replacement if either balance hole or cap jewels are damaged.	
4. Clean and replace balance hole and cap jewels.	
5. Remove hairspring.	Sec. 352
6. Mark underside of rim with colored pencil to indicate position of roller jewel.	
7. Remove roller from balance assembly with roller remover.	Sec. 353
8. Select and align hole in die plate of staking tool that will support the bottom of the hub but allow clearance for the shoulder on the staff as it is driven out of the hub.	Sec. 354 Fig. 15-8
9. NOTE: Some staking tools are equipped with special stumps for use in removing and replacing a Waltham friction staff. See the special manual, Tools and Materials of the Trade.	
9. Carefully drive out the balance staff with a cross hole staff removing punch.	
10. Select the replacement staff.	Les. 4 - Sec. 119 Les. 15 - Sec. 356
11. Fit staff in movement with bridge in place and check endshake and sideshake.	Sec. 356
12. Take staff out of the movement.	
13. Check wheel and roller on staff to see that they will fit correctly.	

(Continued)

PROCEDURE: REFERENCE:

14. Select flat face stump with hole in size that will accommodate collet seat of staff and support arms of wheel. Sec. 359

15. Place stump in staking tool and center hole of stump with centering punch.

16. Rest wheel up side down on stump. Sec. 359

17. Place collet seat end of staff in hub of wheel. Sec. 359

18. Select round face hole punch in size that will just clear the roller post. Sec. 359

19. Tap punch until staff is firmly seated.

20. True the wheel in flat and round. Lesson 16

21. Place balance wheel in movement with pallet bridge and balance bridge in place.

22. Check endshake and free motion of wheel.

    NOTE: A good test is to start the wheel turning slowly in either dial up or dial down position. The wheel should revolve freely and gradually slow down at the same rate in both positions. If the wheel is not free in either or both positions, check the following to find out what is wrong:

    a. Magnetism.
    b. Pivot bent, rough, burred, etc.
    c. Clearance of rim between center wheel and pallet bridge.
    d. Balance jewels dirty, cracked, chipped, or loose.
    e. Endshake incorrect.
    f. Balance screws out too far or timing washers rubbing.
    g. Wheel out of true.
    h. Jewel screws not tight.

    Lessons 10 - 11 - 13 14 - 30 - 31 and Aids in Estimating and Repairing Booklet.

23. Make any necessary corrections to obtain free motion.

24. Set roller on roller seat with roller jewel aligned with mark you previously made on rim.

(Continued)

JOB SHEET
L17-J3 Continued

PROCEDURE:	REFERENCE:
25. Select a hole in the die plate that will accommodate the staff and roller jewel and support the roller.	Sec. 358 Fig. 15-17
NOTE: For double roller, see Figure 15-16.	
26. Use the flat face hole punch you used in riveting and with pressure or a light tap drive the roller into place against the bottom of hub.	
27. Poise the balance wheel.	Lesson 17
NOTE: If present, NEVER USE MEANTIME SCREWS IN POISING.	
28. Recheck Step 20. Make necessary adjustment.	
29. Recheck Step 26. Make necessary adjustment.	
NOTE: If either the truth or poise of wheel is incorrect, you may have to correct both. A wheel that is out of true in the round will be out of poise when trued.	
30. Replace balance in movement with pallet fork and bridge and balance bridge in place. Check the fork and roller action and make any needed adjustments.	Lessons 13 21- 22 - 26
31. Replace and check hairspring. Put in beat.	Lessons 20 and 26
32. Oil balance jewels.	Lesson 10
33. Replace balance and bridge in movement and check for proper motion.	Lesson 11

HOW TO REMOVE AND REPLACE A SCREW TYPE PALLET ARBOR.

Tools, Equipment and Supplies:

Pin Vise

PROCEDURE: REFERENCE:

1. Grip the bottom of the arbor in either a pin vise or in a lathe chuck. Sec. 375

2. Unscrew the pallet arbor counterclockwise.

3. Select replacement arbor and determine that pivot size and endshake are correct.

4. Place arbor in either a pin vise or lathe chuck and screw fork onto arbor clockwise.

   NOTE: The pallet fork is delicate and precision adjusted. It is important not to bend the fork or shift the pallet stones while removing or replacing the pallet arbor. To hold down the chance of this happening, grip or support the fork as close as possible to the arbor.

5. Replace pallet fork in movement. Check endshake.

HOW TO REMOVE AND REPLACE A FRICTION TYPE PALLET ARBOR.

Tools, Equipment and Supplies:

Staking Tool   Brass Hammer

PROCEDURE   REFERENCE:

1. Place the pallet up side down and properly supported on the staking tool. Use a flat face hole punch with a hole that will just fit over the lower pivot and tap gently to drive out friction pallet arbor. Sec. 375

   NOTE: If arbor is still snug in fork after driving it level with the fork, it will be necessary to use a punch with a smaller end diameter than the arbor to tap it all the way out.

2. Select replacement arbor.

3. Place arbor in movement with bridge in place to determine if end shake is correct.

   NOTE: The friction pallet arbor may or may not be tapered. If it is, the tapered end is the end that goes farthest through the pallet fork and should be on the bottom side of it.

4. Place pallet fork on a stump in staking tool which will support the fork properly while allowing the arbor to be driven through the fork without interference.

5. Select a flat face hole punch with a hole of correct size to accommodate the pivot and give proper support to the pivot shoulder.

   NOTE: The arbor is very tiny and hard to handle compared to other parts, so use care when putting it into the fork. We suggest putting a very light touch of oil or beeswax on the face of the punch. This will cause the pallet arbor to stick to the punch and make it easier to align and insert the arbor.

6. If the pallet arbor is tapered, the small end should be put into the fork from the top. If it is not tapered, either end may be inserted in the fork. Tap the arbor into the approximate position that the old arbor had.

(Continued)

PROCEDURE:

7. Place the pallet fork in the movement with the escape wheel and balance in place.

8. Check the alignment of the pallet stones with the escape wheel teeth and fork with roller.

9. Make necessary adjustment to height of fork.

HOW TO CLOSE A WORN PIVOT HOLE IN A BUSHING.

Tools, Equipment and Supplies:

Staking Tool. Pivot Broaches.

PROCEDURE: REFERENCE:

1. Set train bridge on a stump in die plate of staking tool. Be sure stump is right size to support bushing. Sec. 372 Sec. 373

2. Select a round face solid punch in a size slightly smaller than the oil cup depression of bushing.

3. With the bushing supported on the stump and the round face solid punch in oil cup side of bushing, tap gently.

   NOTE: It will take practice to close a hole just the right amount. Work carefully and check frequently. When you find the pivot just barely starts into the hole, you have closed it enough. This method does not allow for sideshake, so you must then open the pivot hole slightly to allow for this. Two types of broaches are used to open and polish the hole. Cutting broaches enlarge the hole. Round broaches will polish it.

4. Use a cutting broach to carefully open the pivot hole to a size that will just accommodate the pivot.

5. Use the round broach to polish the pivot hole.

6. Replace bridge in movement with only the one wheel in place. Before tightening screws, see if you have enough endshake. In closing the hole, you may have reduced the endshake. In that event, remove the bridge and support it up side down on the die plate of the staking tool. With a flat solid punch, tap bushing gently to obtain desired endshake. After you correct for endshake, you may find you have to broach and polish the pivot hole again.

7. Recheck with wheel in place. Make any necessary adjustments until you have proper hole size and endshake.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — *Master Watchmaking* — *Lesson No. 17*

Name: No.: Date:

Circle the correct answer:

SUBJECT: Poising Balance Wheels

1. The balance wheel should always be tested for poise:

If the watch runs fast	If the watch runs slow	If the watch times erratically in different positions	Immediately after checking to see if it is true

2. If a balance wheel is magnetized, it will:

Continue rolling on the jaws of the poising tool	Act as if it were out of poise	Usually come to rest with arm vertical	Usually come to rest with arm horizontal

3. The balance wheel will be in poise when it will:

Roll with equal momentum in either direction on jaws of poising tool	Remain at any position on the jaws of the poising tool	Stop with arm vertical	Stop with arm horizontal

4. If you notice the regulator of a watch is as far toward "fast" as possible, it is better to poise the balance by:

Adding weight only	Adding a little more weight than you remove	Removing more weight than you add	Putting as much weight on the light side as you remove from the heavy side

5. The proper method of poising balance wheels which have two (2) or four (4) meantime screws is to:

Screw them out on the light side of the wheel and in on the heavy side	Adjust the balance screws on either side of the meantime screws	Add weight only, never undercut	Add weight or undercut them as necessary

6. In case of a pivot hole in the plate or bridge of a watch which is too large to be closed successfully, the best procedure is to:

Fit new plate or bridge	Use a pinion with a larger pivot	Ream out the old pivot hole and fit a friction jewel	Plug the plate or bridge with brass and drill a new pivot hole

7. In closing a pivot hole in a plate or bridge, the proper punch to use is a:

Solid round face	Solid flat face	Hollow round face	Hollow flat face

8. In fitting a friction pallet arbor, the tool usually used is a:

Staking tool or friction jeweling attachments	Bench block and hammer	Pliers	Pinvise

9. In fitting a threaded pallet arbor, what is the first operation performed?

Hold arbor with pinvise and screw into place	Screw arbor into pallet, put into place, and replace pallet bridge	Put into place and test for end shake	Try fit of each pivot separately in its respective jewel

10. Which one of these conditions is <u>NOT</u> necessary to poise a balance wheel?

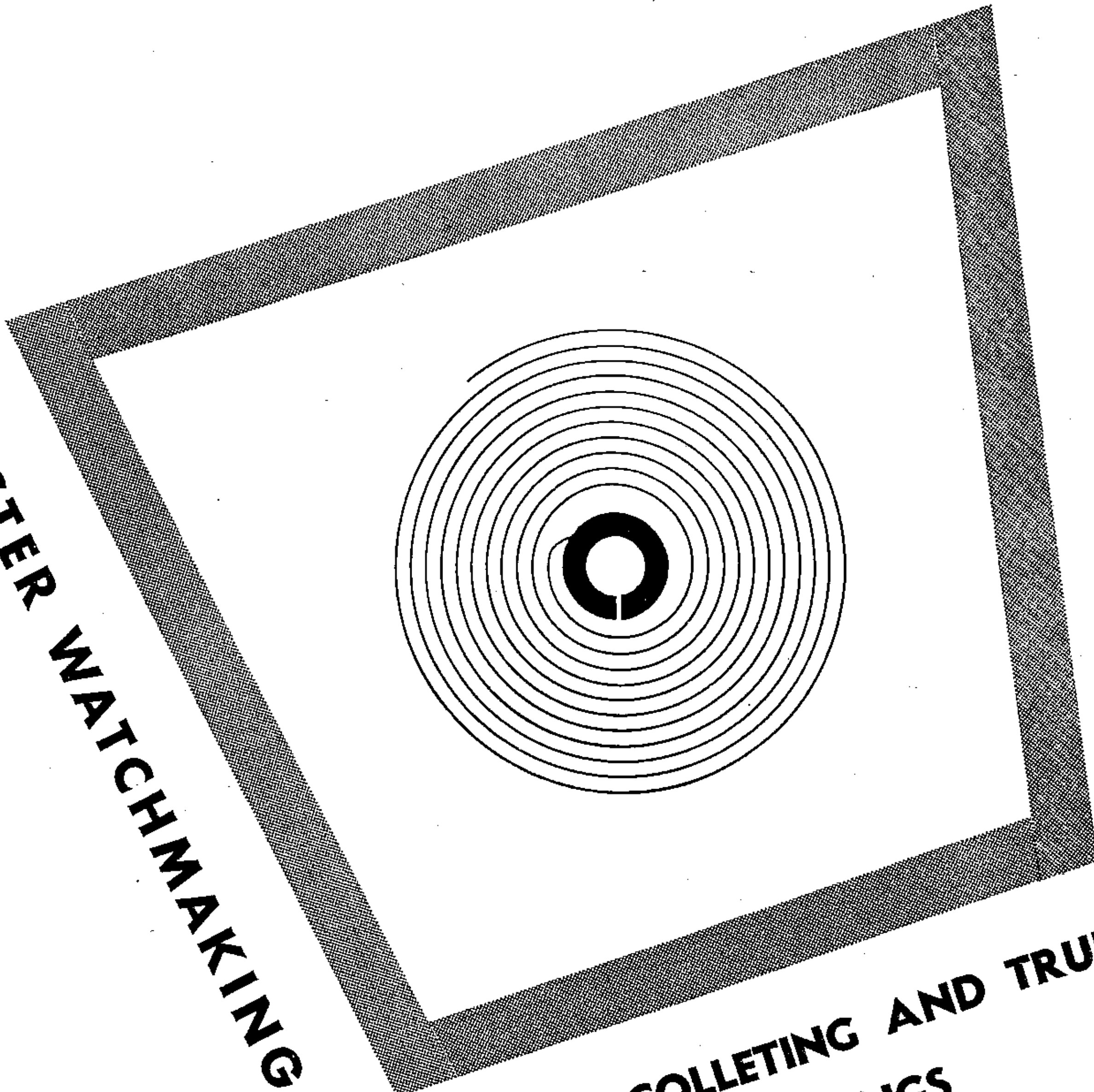
Wheel must be free of magnetism	Wheel must be true in flat and round	Pivots must be true and polished	Balance screws must be spaced at regular intervals

11. If a train wheel and pinion that fit properly before you took it apart does not seem to fit properly when reassembled, what is the best thing to do?

Oil the pivot	Reverse the cap and jewel screws	Try it separately in the watch	Force it in place

Detach page or cut along this line — and send to the School for grading

MASTER WATCHMAKING



LESSON 18 – COLLETING AND TRUING HAIRSPRINGS

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America
18

INTRODUCTORY INFORMATION

Most of the watches you work on will need some adjustment of the hairspring. The adjustment needed may be very slight, but it takes only a slight fault to cause a watch to stop or to keep erratic time. You must learn to see and correct such errors. How well you can do this can make the difference between a fine repair job and a poor one.

A hairspring seldom gets distorted by itself. It is more likely to be thrown off by careless handling by the repairman during disassembly, cleaning or refitting. The beginner especially can expect to make a good many errors of this kind at the start. By learning and using good procedures for handling the hairspring, many mistakes will be avoided, which is far easier than trying to correct them. But if errors do occur, you must know how to correct them and be able to do so.

There are no cut and dried procedures for making corrections. These lessons will cover mainly general principles and methods which you must adapt to the particular situation you find in the watch. First, you must train your eye to detect the fault. Then you must analyze the fault to see how best to correct it. Finally, you must train your hand to make corrections with as few motions as possible. You cannot work on a hairspring indefinitely. There is a limit to what the metal will stand. Unless you can make the correction quickly, you'll have to discard the spring as it will be useless in the movement.

Although we can tell you what to do, you must yourself train your hand to do it. This is best done by actually making adjustments. It will be well worth your time for a while to spend a few minutes every day on hairspring corrections. You need only a few tools -- eye loupe, tweezers and the like. Such practice will quickly rid you of any feeling of timidity about working on hairsprings, even though you will undoubtedly find the work challenging and a real test of your skill as a repairman.

KEY POINTS OF LESSON ASSIGNMENTS 57, 58, 59, 60.

- Kinds of hairsprings.
- How hairsprings are made.
- The purpose of the hairspring.
- What Isochronism is.
- How to collet a hairspring.
- How to true hairsprings in the flat.
- How to true hairsprings in the round.
- How to locate and correct bends in the body of the spring.

ASSIGNMENT NO. 57: Study Sections 376 through 378.

Study Questions:

1. Why are there two types of hairsprings?
2. How are hairsprings made?
3. What is the purpose of the hairspring in the watch?
4. What is meant by Isochronism?

ASSIGNMENT NO. 57 (Continued):

Recommended Practice:

Conduct an experiment in isochronism as given in the lesson. You may use any fairly heavy object suspended by a string.

ASSIGNMENT NO. 58: Study Sections 379 and 380.

1. When is colleting necessary?
2. What is used to fasten the hairspring in the collet?
3. How is the collet held while working on it?
4. How is the inner coil broken out?
5. What tools are used to form the tongue of the hairspring?
6. What procedure is used to pin the collet?
7. How is the excess pin removed?
8. Where are adjustments made when leveling or truing hairspring in the flat?

Recommended Practice:

Collet a number of your practice hairsprings. Follow procedure on Job Sheet L18-J1. Level each one as in Job Sheet L18-J2.

ASSIGNMENT NO. 59: Study Section 381 through 381.2.

1. What is the object of truing hairsprings in the round?
2. Where are adjustments made when centering the collet?
3. How can you check the hairspring for truth in flat and round?
4. How can you center the collet with the hairspring on the balance?

Recommended Practice:

True in the round the hairsprings you have just colleted. (See Job Sheet L18-J3.) Recheck the flat when truing in the round, as you may have moved the spring out of flat. Make any required adjustment and alternate checking round and flat until no error exists. Make final check and adjustments with hairspring on balance wheel and the wheel in your truing calipers.

ASSIGNMENT NO. 60: Study Section 382.

1. What tools are used to correct bends in the body of the hairspring?
2. How is this work done?

Recommended Practice:

1. Grasp one of the coils in the body of the hairspring with a tweezer and bend the coil in or out with another tweezer or taper pin so the spiral spacing is uneven. Correct the bend you have made. (See Job Sheet L18-J4.) Repeat until you can do it easily.

2. Use two pair of tweezers and tilt part of the hairspring out of level. Correct this. (See Job Sheet L18-J5.) Repeat until you gain proficiency.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 18 and send in for grading.

SEC. 376—Introduction to the Hairspring

The hairspring is such a fascinating part of the watch that many articles have been written about it. However, in these lessons we're going to limit our study to the actual operations needed to check and repair the hairspring furnished with the watch rather than delve into theoretical discussion.

The watchmaker is concerned with only two types of hairsprings: the flat, figure 18-1, and the overcoil, figure 18-2. There are other types of formed hairsprings, but they are not in general use and we will not discuss them.

We'll talk first about the flat hairspring and learn how to true it and collet it, if need be. Then we'll talk about the overcoil hairspring, which has its outer coil raised over the others and formed in across the top of them. Finally, we'll show how the hairspring is fitted to the watch and checked therein so it will run true and make the watch perform correctly.

The flat hairspring was the first kind made and the overcoil came later to get a hairspring with better timekeeping qualities. The overcoil thus was considered the superior form of spring. Until recently, it was found on most of the better grade watches. Now the trend is toward smaller, thinner watches in which there is not enough room for the overcoil. As a result, flat hairsprings are now commonly found in quality movements. They have proved quite satisfactory even though they do not permit as fine adjustment as in watches where an overcoil is used.

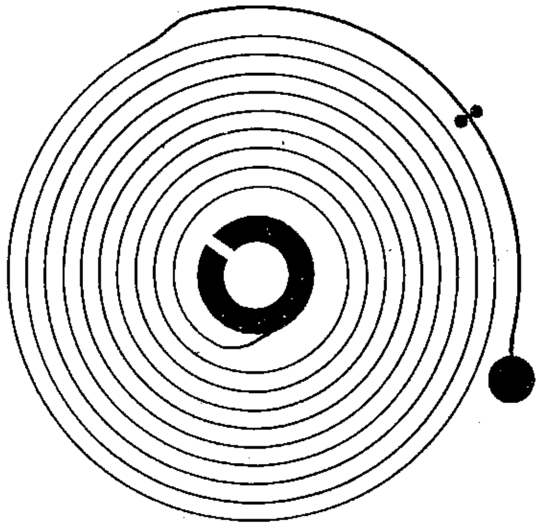


Fig. 18-1

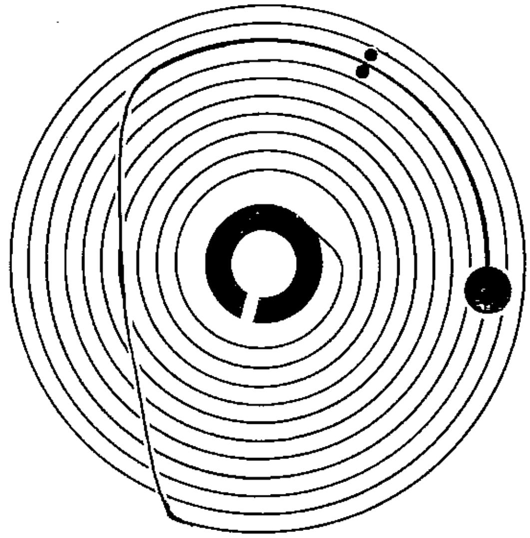


Fig. 18-2

The overcoil hairspring is known also as the Breguet hairspring in honor of its inventor, Abraham-Louis Breguet (1747-1823), a renowned Swiss watchmaker who settled in Paris.

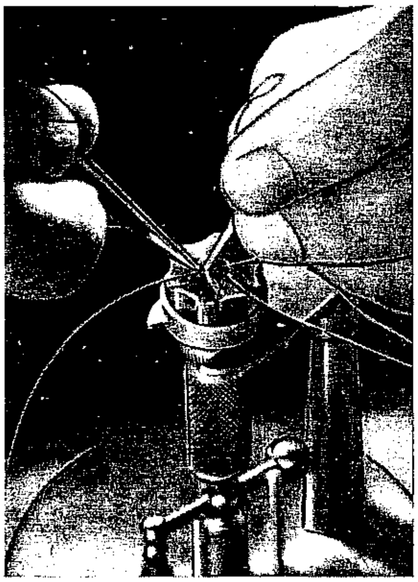
SEC. 376.1 -- How Hairsprings Are Made

The modern watchmaker no longer makes his own hairsprings as he once did. This job has been taken over by large manufacturers. You can be glad they have for it is very exacting work.

The wire used must be drawn and rolled to extremely fine dimensions to get a spring of proper strength. For example, a difference of 1/10,000 inch in an 18s hairspring makes a difference in time of six minutes an hour.

The ribbon-like wire is wound into a hollow forming tool, figure 18-3, which curls it into a flat spiral form. Several pieces of wire are wound into the same barrel-like box. This determines the spacing between the coils of the spring. For instance, if three springs are wound together, the space between coils will be twice the thickness of the spring. If four springs are used, the spacing will be three times the thickness of the spring. After being wound, the springs are heated so they will hold their shape and have the right amount of "spring" or elasticity.

Hairsprings are formed in a tool like this, then heat treated, colleted and studded.



Hamilton Watch Co.

Fig. 18-3

Hairsprings originally were made only of steel. But steel hairsprings are subject to temperature changes, magnetism and rust. This led to development of non-magnetic springs by use of other metals or combinations of metals called alloys. As many as six to eight metals are combined to form the wire from which modern springs are made.

Dr. Charles Guillaume, 1920 Nobel Prize winner in physics, was the first to develop a practical alloy which led to present day non-magnetic springs. Around the turn of the century, he invented a nickel alloy which was non-magnetic, non-rusting and little affected by temperature changes. He called it "Invar" from the first part of the word "invariable". Invar was quickly adopted for mono-metallic balance wheels, but was still too soft, too easily bent out of shape and not elastic enough for hairsprings.

Some years later, Dr. Guillaume invented Elinvar, a 36% nickel alloy, harder than Invar. He took this name from the two words "elasticity invariable". This alloy came to be widely used for hairsprings, and earned Dr. Guillaume the Nobel Prize.

Since then manufacturers have experimented with other alloys and have come up with some of higher nickel content. Ni-Span "C", with a nickel content of 42% is typical of these.

Beryllium, one of our lightest metals, is also used for hairsprings when alloyed with iron, copper, cobalt, or other metals. The result is harder than Elinvar, but other properties are about the same. Nivarox is one trade name for a beryllium alloy hairspring.

SEC. 377—Purpose of the Hairspring

Dr. Robert Hooke (English, 1635-1703) reportedly invented the hairspring in 1658. However, he did not patent or use his spring until much later. Meanwhile, Christian Huygens (Dutch, 1629-1695) introduced a hairspring in 1675 ahead of Hooke. As a result, Huygens is usually credited with the invention.

It was Dr. Hooke, however, who gave us the principle "Ut tensio, sic vis;" that is, "As is the tension, so is the power." This became known as Hookes' Law. This is the principle of the hairspring and is why it is used as a governor for the watch. Now how does it do it?

Let's take a balance in perfect beat and start it moving from the line of centers. "Line of centers" means this: When a watch is in beat, the roller jewel at rest is on a line drawn from the center of the balance staff to the center of the pallet arbor, figure 18-4.

As the escape wheel turns, it sends an impulse to the balance which moves the balance a short way off the center line. This movement winds up or tenses the hairspring. This tension then pulls the balance back across the line of centers to an equal distance on the other side. But as the balance is going to this point, it gets another impulse from the escapement, which sends the balance farther around than before. This action builds up until the balance is swinging back and forth as far as it can go.

Because the impulses from the escapement continue, you might think that the balance wheel would in time turn all the way around. It does not. Why not? Simply because it meets more and more frictions or resistances which act together to limit its swing.

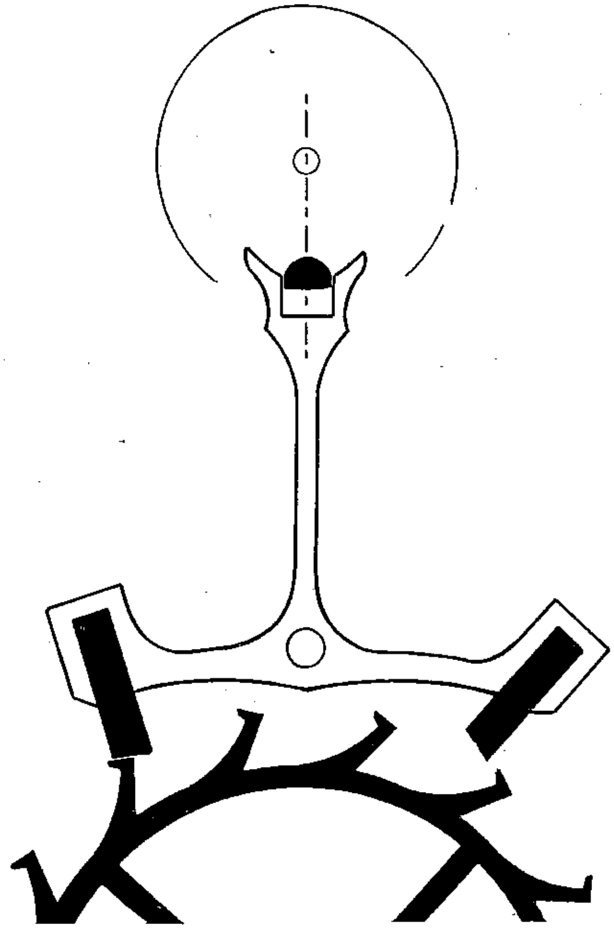


Fig. 18-4

Some of these resistances come from the jewel pin hitting the fork and the escape tooth striking the pallet stone. The balance pivots in their jewels cause more friction. The greatest resistance is from air pressure acting on the rim of the balance and its screws.

When the point is reached where these various frictions are stronger than the force of the impulse, the balance pauses. Then the power built up by the tension of the hairspring reverses the motion of the balance and sends it back an equal distance in the other direction.

You already know the power for the impulses comes from the mainspring as it unwinds. As the mainspring runs down, the impulses lose force. This slowly cuts down the distance the balance turns. When the watch finally runs down, the balance stops. But the watch is not supposed to gain or lose in spite of this change in force.

The purpose of the hairspring, therefore, is to keep the balance wheel turning at the same rate whether it is making a long swing, or high arc, as it is called, or a short swing, or low arc. This constant rate is called "isochronism."

SEC. 378—Isochronism

The term "Isochronism" comes from Greek and means "equality of time." For instance, we say the beats of a pendulum are isochronal. This simply means the pendulum of a clock oscillates (swings back and forth) in regular periods of time according to its length. In a watch, the balance wheel does likewise according to the diameter and weight of the balance together with the length and strength of the hairspring.

Let's try a little experiment so you will better understand what isochroniism means.

Fasten a light weight cord or linen thread as high above the floor as you can. A ceiling fixture is ideal for this. At the bottom end of the cord, about six inches from the floor, tie a small weight, such as a 12 size or 16 size watch case. Use a watch with a second hand to time the vibrations. (It is easier to count vibrations than oscillations. A vibration is a swing in one direction from one side to the other. An oscillation is two vibrations; that is, from one side to the other and back again to the starting side.)

1. With the weight at rest, carefully pull it back about six inches and then release it as shown in figure 18-5.

2. Count the exact number of times the pendulum swings back and forth for 60 seconds. Make a note of the total number of vibrations.

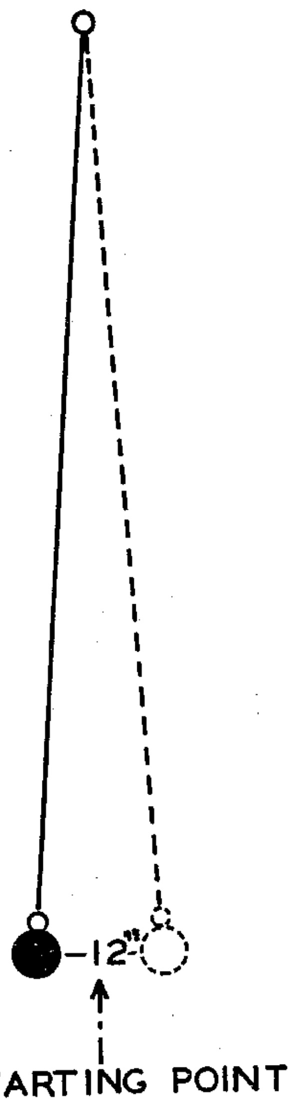


Fig. 18-5

3. Repeat steps 1 and 2 again, but this time pull the pendulum back about 36 inches or more, figure 18-6.

4. Compare results. You should find they are the same. From this experiment you can readily see that the time required for the pendulum to swing through the short arc of twelve inches, figure 18-5, and the long arc of seventy two inches, figure 18-6, is theoretically the same. In practice, however, you would have to consider the resistance of the air and in watches

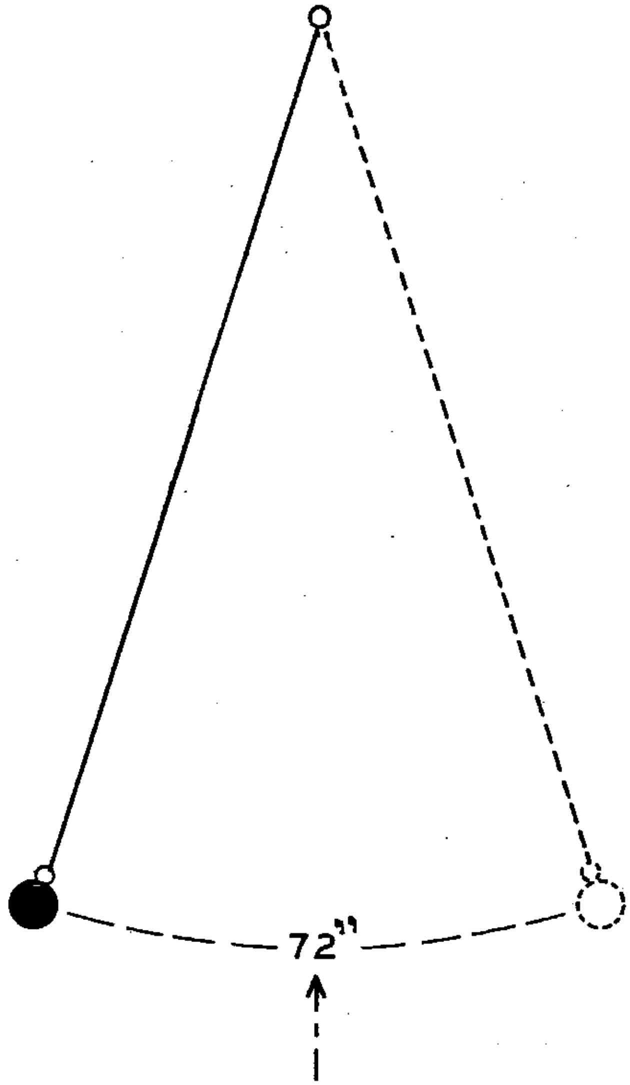


Fig. 18-6

the friction of pivots and other frictions already mentioned.

The accuracy of a watch depends on how well you can get the same rate or nearly the same rate whether the balance and hairspring are making a long arc or a short arc. The longest arc is found when the mainspring is fully wound. The arcs get shorter as the mainspring unwinds.

That is why it is important to use a hairspring that is correct for the watch and one that is free from errors as will be discussed later.

SEC. 379—Colleting the Hairspring

Your first hairspring work will be colleting. Colleting a hairspring means to fasten the inner coil of the hairspring to a small brass collar, figure 18-7. This collar in turn is fastened friction tight on the balance staff.

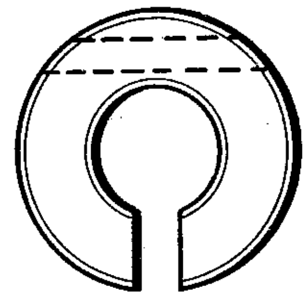


Fig. 18-7

This is an operation the modern repairman doesn't do as often as he used to. Nowadays, new hairsprings come already colleted and are selected to fit the collet shoulder properly. But you will still have a certain amount of colleting to do.

At times you may have to replace a cracked collet. This happens when a careless repairman has tried to force the collet over a collet shoulder which is too large for it.

Occasionally, a hairspring breaks at the collet and can be re-colleted.

Colleting is obviously necessary when you are fitting an uncolleted spring, such as your practice hairsprings.

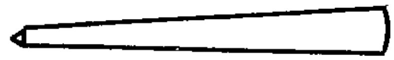
When you are working on high grade watches, it is considered better practice to use the original collet, if possible, provided it fits properly and is not damaged.

Note the collet has a small hole in it, as indicated by the dashed lines in figure 18-7. This hole may be opposite the slot or alongside of it. The hole is to receive the inner end of the hairspring.

It is important to note the location of this pinning hole in the collet. If you look at the collet from the side, you will see this pinning hole is not usually centered between top and bottom. In fitting a flat hairspring, the hole should be closer to the top. In fitting an overcoil hairspring, the hole should be closer to the bottom to provide room for the overcoil, which will be discussed in the next lesson.

If you are replacing a damaged collet, be sure the new one matches the original. Check that it is the correct height and size to fit the collet seat and has the pinning hole in the same position.

A small tapered brass pin, shown in figure 18-8, is used to fasten the hairspring in the collet. You can buy them from a supply house under the name of hairspring stud pins. These pins are also used to fasten the outer coil of the hairspring to the stud.



STUD PIN

Fig. 18-8

Sometimes you may want to make your own stud pin or a tapered pin of similar design. You can easily do this as illustrated in figure 18-9.

Cut a notch with a file in the edge of a small block of wood, preferably hardwood. This cut should be deepest toward the front and taper up the block, depending on the length of taper desired.

Insert a small piece of brass wire of small diameter in a pin vise and lay the wire in the notch of the hardwood block. Now roll the pin vise with the fingers of one hand while you move the file lightly back and forth with your other hand, over the brass wire until the pin is formed.

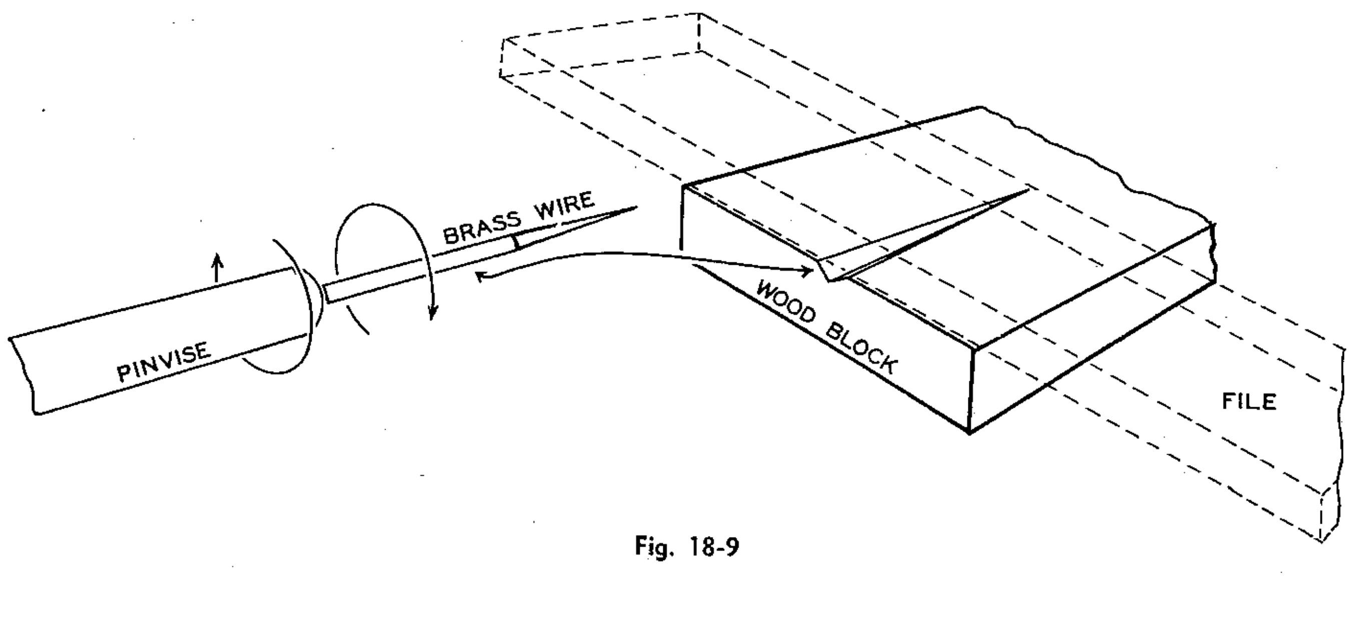


Fig. 18-9

When pinning the hairspring to the collet or working on the collet, hold it on a tempered and tapered steel pin or broach. Slip the collet onto the taper pin or broach and press the collet down firmly with a pair of tweezers laid on top of it and astride the taper pin, figure 18-10.

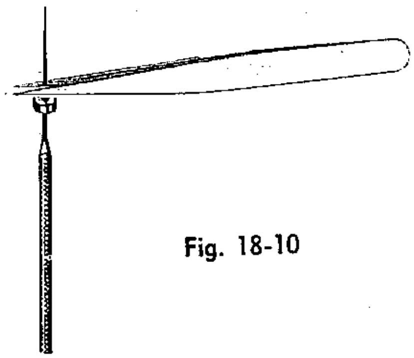


Fig. 18-10

Clean out the pinning hole with a small broach, figure 18-11, and try the brass pin in the hole before you start to pin the hairspring. It should go through the collet as shown in figure 18-12.

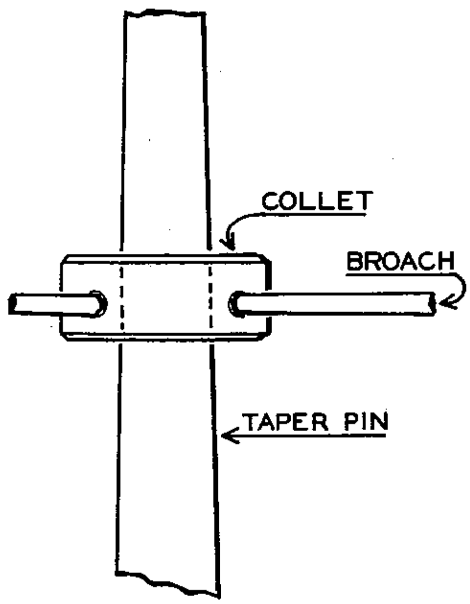


Fig. 18-11

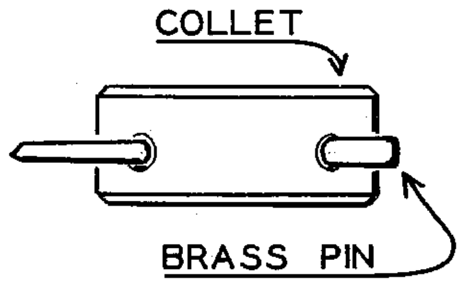


Fig. 18-12

In the illustrations which follow in this lesson and later ones, we will use these symbols to represent the tools you will use for the work:

= FINE POINTED HAIRSPRING TWEEZER

o TAPER PIN

OVERCOILING TWEEZER

Fig. 18-13

SEC. 379.1 -- Breaking Out the Inner Coil

The first step in actual colleting is to make room for the collet in the center of the hairspring. You do this by breaking out one or more of the inner coils according to the size collet and hairspring you are using. The easiest way to determine how much room you need is to place the collet over the center of the hairspring, as shown in figure 18-14. Break the coil at a point about the width of one coil from the collet. In the illustration, this point is where the dotted line changes to a solid one. This will allow enough space for the collet after the tongue is formed.

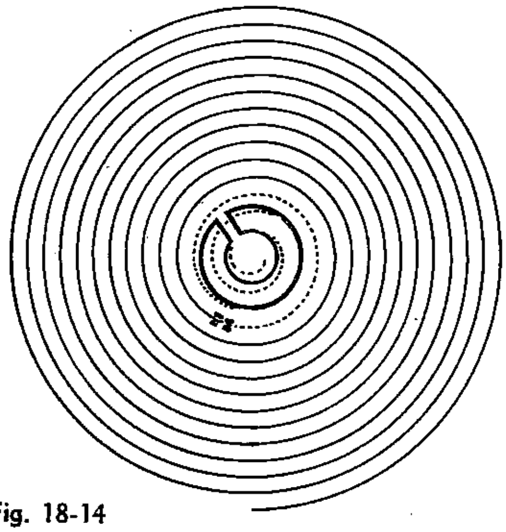


Fig. 18-14

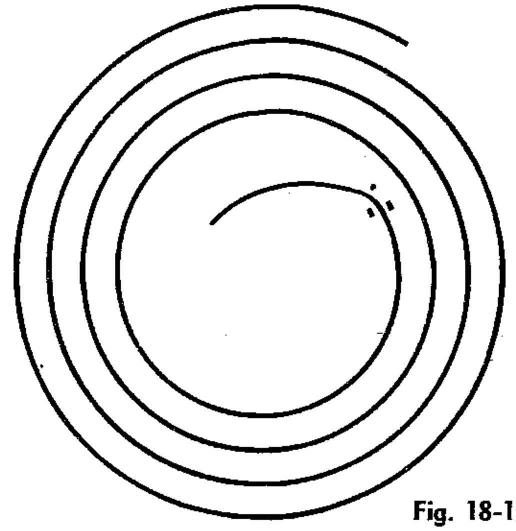


Fig. 18-15

Use two pairs of fine pointed tweezers with the points held close together and straight up to break off the inner portion. It is important not to distort the rest of the spring as you do this. To avoid such a mishap, hold the main part of the spring firmly with one tweezer and use the innermost tweezer to snap off the small portion.

SEC. 379.2 -- Forming the Tongue

Now form the tongue, which should be only as long as the hole in the collet. When the pin is pushed in to hold the hairspring in place, the tongue will slide into the collet hole as far as the bend. Any extra length would make it stick out on the other side, which is not desirable.

To form the tongue, lay the spring on your bench. Hold the coil as shown in figure 18-15 with a pair of hairspring tweezers and bend the end toward center with a taper pin or second pair of tweezers.

Now straighten the bent portion to conform to the hole in the collet. Hold the hairspring with a tweezers at the elbow of the bend. Slide a second pair of tweezers along the spring from the elbow to the end with a pinch-pull stroke. This should straighten the end piece.

SEC. 379.3 -- Pinning the Collet

Your next step is to pin the collet. Place the collet on a taper pin or broach, figure 18-10, and hold it upright. The top of the collet should be up and the entrance hole facing you. Grasp the hairspring with tweezers at the elbow and pick up the spring. Bring it down over the taper pin until the tongue of the hairspring is in line with the hole in the collet and insert the tongue into the hole, 18-16.

In order to keep the hairspring level at this point, support the hairspring with your forefinger until the brass pin is in place.

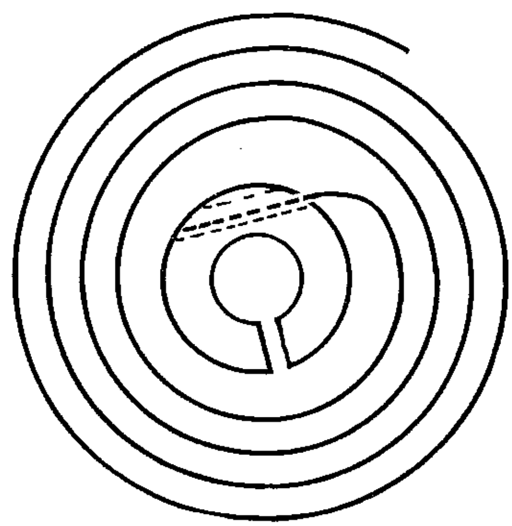


Fig. 18-16

Pick up the brass pin by grasping it with a tweezers at the thick end. Insert the small end of the pin in the hole from the same side as you inserted the tongue. Push in the pin until it holds the spring firmly enough that the hairspring cannot fall out and extends above the body of the spring on the far side, figure 18-17.

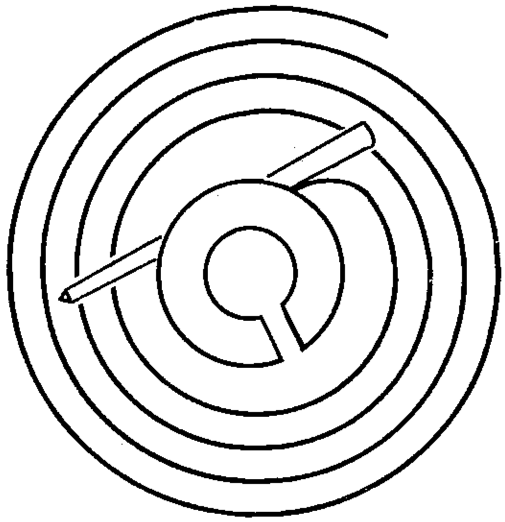


Fig. 18-17

Now hold the taper pin or broach so you are looking at the hairspring from the side. Turn the taper pin or broach slowly and check that the inner coil of the hairspring is parallel to the top and bottom of the collet and at right angles to the center of the taper pin or broach, as shown in figure 18-18.

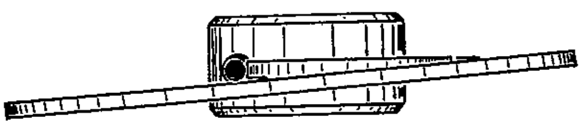


Fig. 18-18

Note in this illustration the body of the hairspring is held below the hole in the collet by the pin but the inner coil is parallel with the upper edge of the collet. After the pin is cut off, the body of the spring will move up into the same plane as the inner coil. If you have pinned the hairspring properly, it will not need truing in the flat.

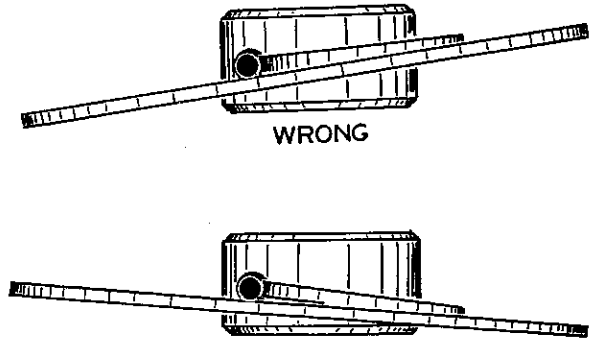


Fig. 18-19

It is very likely, however, that your first efforts may look like either figure 18-19A or 18-19B. In the first case, lower the inner coil with the point of a tweezer. In the second case, raise the inner coil with the inner flat side of a tweezer point under the coil. This leveling at the collet will be discussed further in the section on truing in the flat.

SEC. 379.4 -- Tightening the Pin and Cutting Off the Excess

When you are satisfied your work thus far is correct, you are ready to tighten the pin and cut off the excess.

To tighten the pin, you force it into place with a pair of heavy tweezers as shown in figure 18-20.

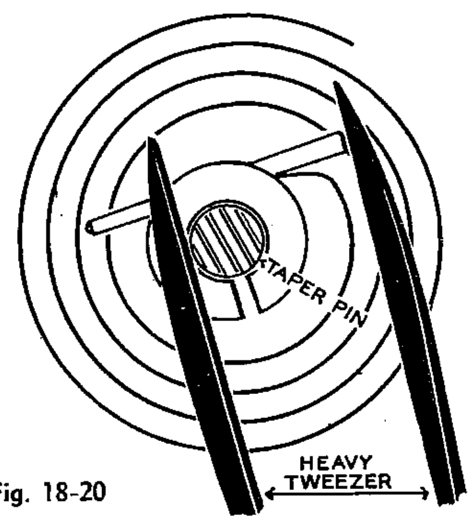


Fig. 18-20

There are various methods for removing the excess pin and you may use whichever you prefer. Whatever one you use, take care not to make a slip and ruin the work.

One of the oldest methods is to use a small sharp knife or heavy razor blade. If done carefully, it assures a clean job with no danger of any of the pin left protruding.

Hold the collet in place on the taper pin and work the end of the knife blade across the pin in a sawing manner. Use only the very tip of the blade. Cut the pin off tangent to the collet, as shown in figure 18-21. When the pin is cut almost through, remove the remaining portion by bending with tweezers.

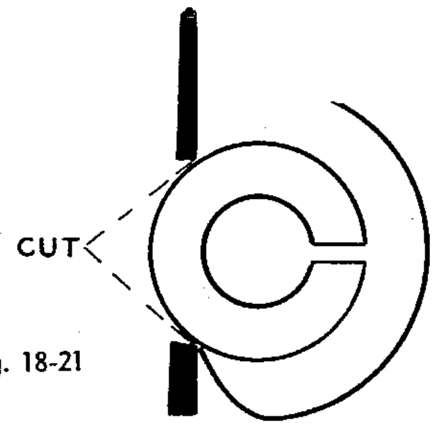


Fig. 18-21

Figure 18-22 shows why only the tip of the blade is used. Any further lowering of the blade would endanger the body of the hairspring.

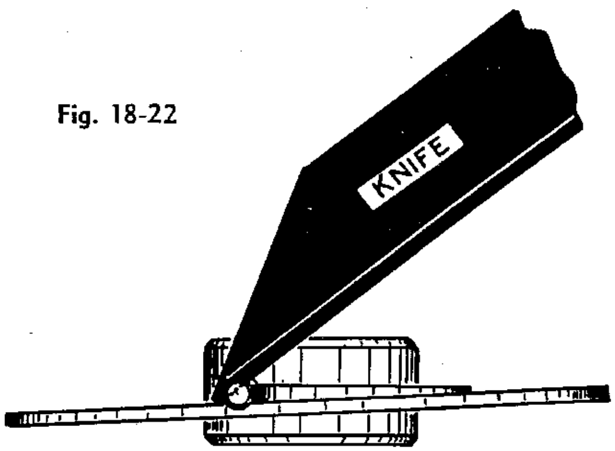


Fig. 18-22

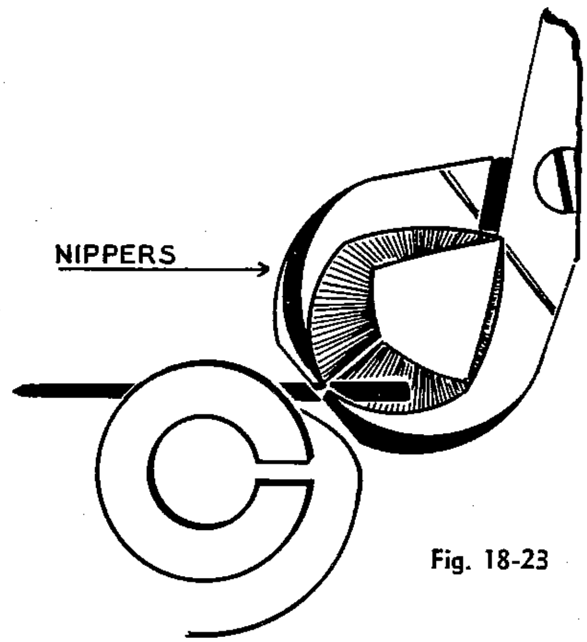


Fig. 18-23

Figure 18-23 shows another method for cutting off the pin. Cut off the large end with the nippers before you push the pin into place. Then cut off the thinner end by placing the nippers as close as possible to the collet, so that none of the pin is left sticking out. These nippers should not be used for any purpose other than cutting small brass pins, as the jaws are especially ground for this purpose.

Still another method for breaking off the pin is to break off both ends by making a 90 degree bend with a pliers after the pin has been tightened. To use this method, you must first score the pin at each end of the collet hole at the time you try the pin in the hole before you start to collet the hairspring. To break off the pin after it is firmly fastened, hold the brass pin with pliers and turn the taper pin a quarter turn. When breaking off the larger end, be sure to turn the taper pin in a direction which will not unpin the hairspring.

Any of the foregoing methods can also be used to pin the outside coil of the hairspring to the stud.

SEC. 380—Truing Hairsprings in the Flat

The average watch coming in for repair needs only minor adjustments for flat and round. The repairman ordinarily makes these corrections with the hairspring on the balance. But if the hairspring is badly out of adjustment, it should be removed from the balance, corrected, and then replaced on the balance for the final check. This must also be done when the balance arm gets in the way of a needed correction.

All that is usually necessary to true a hairspring in the flat is to bring the inner coil level with the collet. Only rarely, and then usually as the result of an accident will any of the outer coils be raised above or dropped below the rest of the hairspring. (This condition will be treated later.)

A hairspring that is level will be parallel with both top or bottom of the collet. If it is, the hairspring will run true in the flat when on the balance or at most need only a slight adjustment to bring it parallel to the arm of the balance wheel when the collet is tight against the bottom of the staff.

The procedure for truing in the flat or leveling is the same, whether it is done on a taper pin or broach, which is easier for the beginner, or with the balance removed from the watch and held in a truing caliper, as the experienced repairman does it.

The main thing to keep in mind is that all action takes place at the pinning point. The pinning point is where the inner coil of the hairspring enters the hole in the collet. Think of this pinning point as being much like a hinge on a counter which is raised to let someone through and then lowered. Your adjustments to raise or lower the inner coil should be swung off this point where the hairspring is fastened or hinged to the collet. All that is necessary is to use the inside of one point of a tweezer or the end of a needle to raise the low point of a coil which drops down from the pinning point or to press down the high point of an inner coil which rises from the collet.

As indicated, it is easier to make corrections on a taper pin or broach. Slip the collet of the hairspring over either of these and press it down firmly with a pair of tweezers placed over the top of the collet.

Figure 18-24 shows the collet in place. The dot-dashed line through the center of the drawing shows the correct position of the inner coil in relation to the top or bottom of the collet. The dashed lines show the inner coil out of level in both high and low positions.

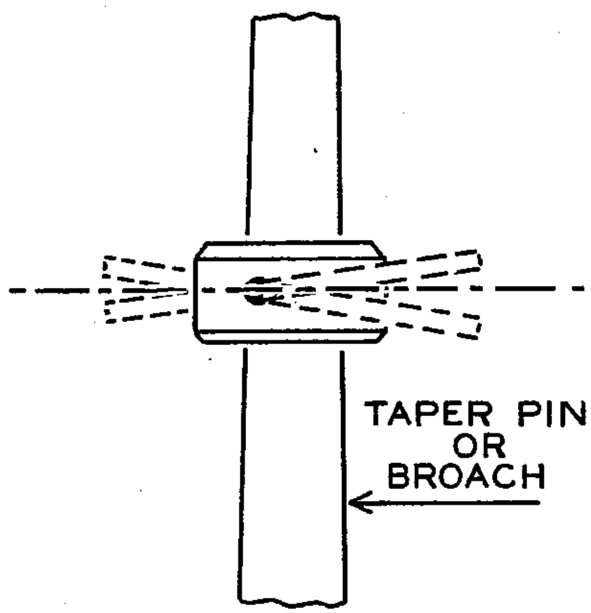


Fig. 18-24

Figure 18-25 shows the center coil above the line of level and it should be lowered as indicated by the arrow. Hold the taper pin firmly in your fingers. Place the inside of one tweezer point about halfway between the high point and the pinning point and press down on top of the inner coil until the coil is level.

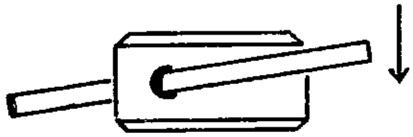


Fig. 18-25

Figure 18-26 shows the center coil below the line of level. The arrow indicates you must move the coil up. Place the inside of the tweezer point under the inner coil to lift it up to level.

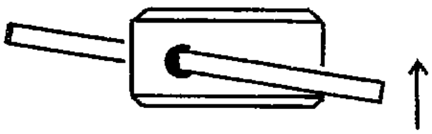


Fig. 18-26

The exact spot where you apply pressure may vary with the location of the high or low point, but should never be more than a half turn from the pinning point.

It is quite possible you may have to repeat these operations several times. Until you are experienced, you will probably apply more pressure than is needed and go beyond the leveling point.

Check your work by looking at the taper pin from the side and turning it a quarter turn at a time to see if the hairspring is level with the top of the collet all the way around.

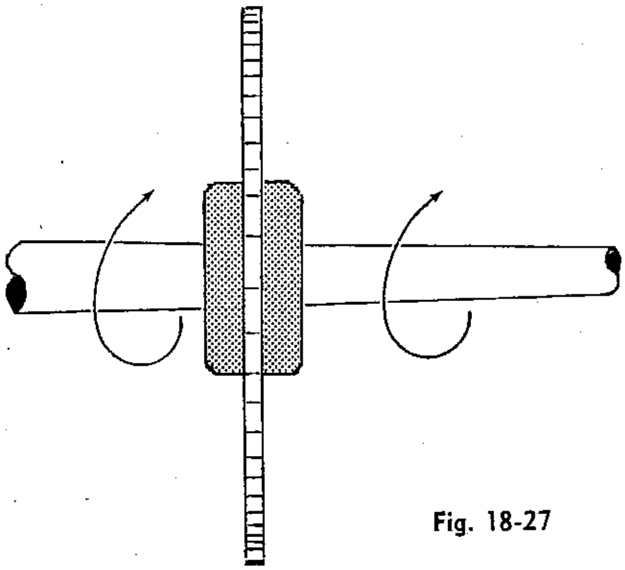


Fig. 18-27

Then hold the taper pin horizontally and rotate it with your fingers, figure 18-27. If the spring is out of flat, it will appear to wobble from side to side. This check is especially desirable when you use a hairspring with the stud attached. The weight of the stud will be down and will not interfere with your observation.

The final examination and any remaining adjustments should be made with the hairspring on the balance wheel and the balance wheel held in a truing caliper. Release the jaws of the caliper slightly so the balance will turn freely. Look over the rim of the balance wheel toward the collet and watch the first few inner coils. Now spin the balance wheel slowly and see if you notice any wobbling motions which would indicate the hairspring is out of flat.

If any minor adjustment is needed, make it by pressing down or lifting up with the inside of a tweezer point as you did when making corrections on the taper pin.

Truing in the flat is only one step in truing a hairspring. The spring may also be out of true in the round and that is our next consideration.

SEC. 381—Truing Hairsprings in the Round

A hairspring is said to be true in the round when all of its coils are evenly spaced and the collet is at the center of the spiral. Corrections made to achieve this condition are therefore called "truing in the round." Centering the collet is the main operation in truing in the round. Errors in spacing of the outer coils are less common and will be treated separately under the heading "Locating and Correcting Bends."

Before you can center the collet it is necessary to know what this means.

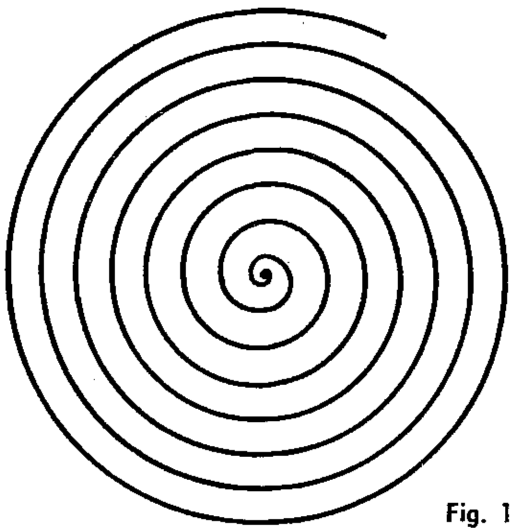


Fig. 18-28

A hairspring is a true spiral. If the coils were continued to center, it would look as shown in figure 18-28. The space between each coil is the same until you get to the innermost coil. At this point the space gradually gets less and less until it reaches the center. Note particularly that this center of the spiral is not an equal distance from any part of the spring as it would be if it were the center of a circle.

Centering the collet means to place the collet center and the spiral center at the same spot, as indicated by arrow A, figure 18-29. Any variation of these

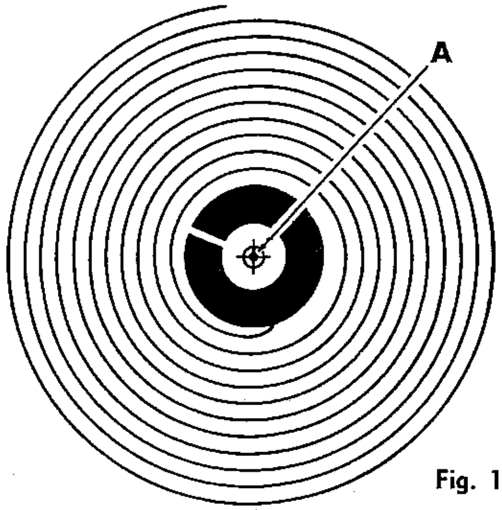


Fig. 18-29

two centers will cause the hairspring to be out of true.

In these illustrations we are using a cross in a circle to indicate the center of the spiral and a black dot to show the center of the collet. In an actual hairspring, you must visualize the spiral center because the inner coils are removed to make room for the collet.

Figure 18-30 illustrates the center of the hairspring at A and the center of the collet at B. These two centers must be made to coincide before the hairspring will be true. When colleting a hairspring, enough center coils must be broken out so the collet can be brought over the center of the spiral.

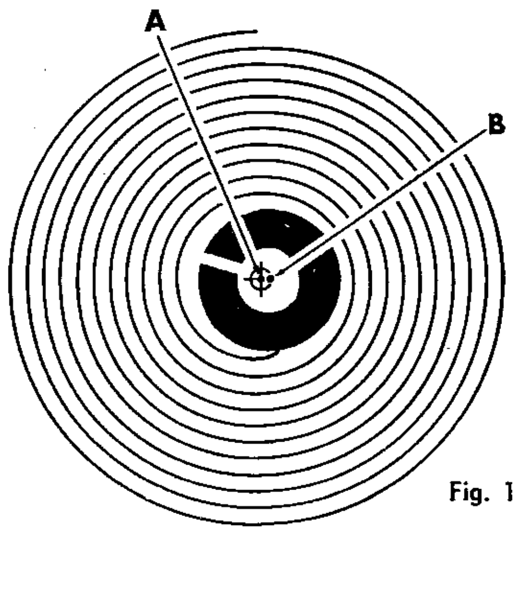


Fig. 18-30

Suppose you break out too many center coils when colleting? How will this affect these centers? Figure 18-31 shows an enlarged view of the collet and inner coils and indicates these two centers will not be affected in any way. The centers marking and the dotted line from the outer coil shows the hairspring can still be trued even if all the coils in between are taken out. However, it is harder to true a spring when too many coils are removed, so it is best to take out only what is actually needed when colleting. Some space around the collet must always be provided in order to center the collet, but no more is needed than was indicated before in figure 18-14.

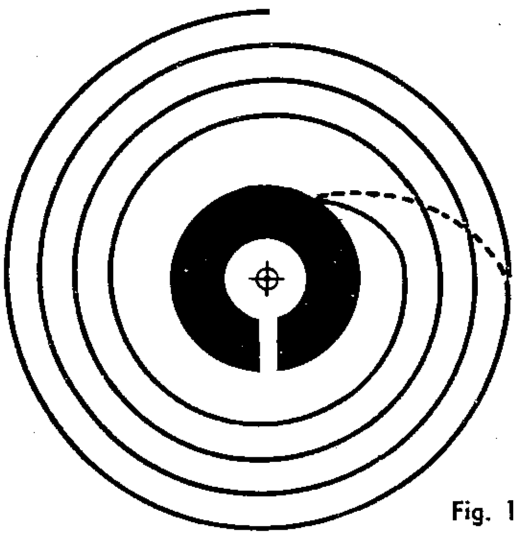


Fig. 18-31

As mentioned before, most repairmen make all corrections for flat and round with the hairspring on the balance. After you gain experience, you probably will do likewise. But if you are new at this, you'll find it easier, especially when truing in the round, to make corrections with the hairspring off the balance wheel and leave only minor adjustments for when the spring is on the balance.

For working with the hairspring removed from the balance, you will need a small piece of glass, figure 18-32. Ground glass is best, but clear glass will also do. Rest the glass on a

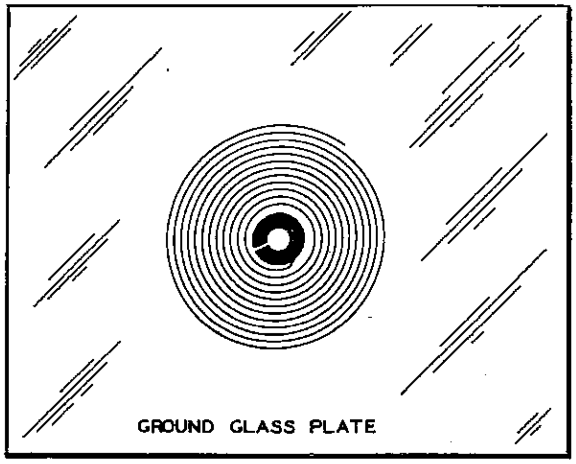


Fig. 18-32

movement holder or other support so as to raise it above your work surface at least 1/4 inch. This will drop out the shadows and permit you to see each coil clearly as you look down on it.

Before you start to center the collet check that the hairspring is level to the collet. If the hairspring is out of level, the collet or coils of the hairspring may not lie flat on the working surface.

Also, each time you make a correction to center the collet, recheck that the hairspring is still level. If it is out ever so slightly, level it again. Then recheck the round again and continue. In this way, when the collet is centered, the hairspring will also be level and ready to be put on the balance for the finishing touches.

SEC. 381.1 -- Centering the Collet

To start centering the collet, lay the hairspring on your glass working surface. With an eye loupe, preferably a double loupe, look directly down over the center of the hairspring and observe the location of the collet.

This first look should tell you if the collet is centered or not in the opening. The hairspring should look like figure 18-29. Notice there how the space between collet and hairspring gradually gets wider from the pinning point as it makes a full turn around the collet.

If the collet is not centered, you must see what correction is needed. Very likely you will note too much space on one side and not enough space on the other.

It may help you to visualize the correction you need if you think of the inside coil as an apparent circle with the collet placed in the center of the circle. (In doing this, do not consider the slight bend of the inside coil where it is pinned to the collet.)

All the corrections needed to center the collet are made as close to the collet as possible near the pinning point and never beyond the first quarter turn of the inner coil.

A fine pointed hairspring tweezer and a taper pin with a needle like point are the tools most commonly used to make alterations to center the collet. Use the best hairspring tweezers available in all your hairspring work and keep the points protected when not in use. Instead of a taper pin you may prefer to mount a needle in a small handle and use it to work in and around the coils.

Now let's consider some out of center conditions and see how they can be corrected. Figures 18-33 through 18-38 are typical of what you may encounter.

Each illustration shows the tools used to make the correction. The cross indicates the center of the hairspring. A black dot in the collet indicates the center of the collet. A hollow center dot or a like dot with an arrow attached indicates a taper pin or needle and two short lines indicate a hairspring tweezer.

When centering on glass, you must either hold the hairspring and move the collet or hold the collet and move the spring. The first way is easier since it lets you see what you are doing and we recommend it. But you must grasp the hairspring firmly with the tweezer near the elbow while you use the taper pin to move the collet in the direction you want it to go. You cannot simply push the collet without holding the spring firmly.

Fig. 18-33

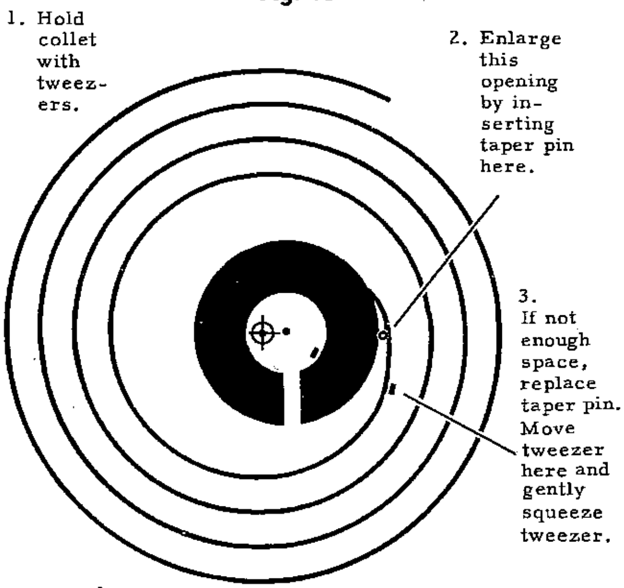


Figure 18-33 is typical of a hairspring which has just been colleted. Notice there is no elbow at the pinning point. This is because in colleting the tongue of the hairspring was forced into the hole up to the bend at the time the pin was pushed into place.

We must have an elbow to center the collet. The elbow acts as a hinge on which we can swing the collet when working on glass or swing the hairspring when truing on the balance wheel.

The simplest way to correct figure 18-33 is to hold the collet firmly against the glass working surface with your tweezer while you gently insert a taper pin between the inner coil and the collet as close as possible to the pinning point. This will enlarge the opening.

If the elbow is not large enough, replace the taper pin at the pinning point and place the tweezers as shown in figure 18-33, with one point inside the collet and the other outside the inner coil. Gently squeeze the tweezer points together and the coil will bend around the taper pin, which acts as a fulcrum.

If these actions have still not centered the collet, hold the hairspring near the pinning point with a tweezer and push the collet toward the wide side with the taper pin to equalize the spacing as in figure 18-31.

If you made too large an elbow, as in figure 18-34, use just the tweezers, placed as in the illustration and carefully close the points until you have the spacing you want.

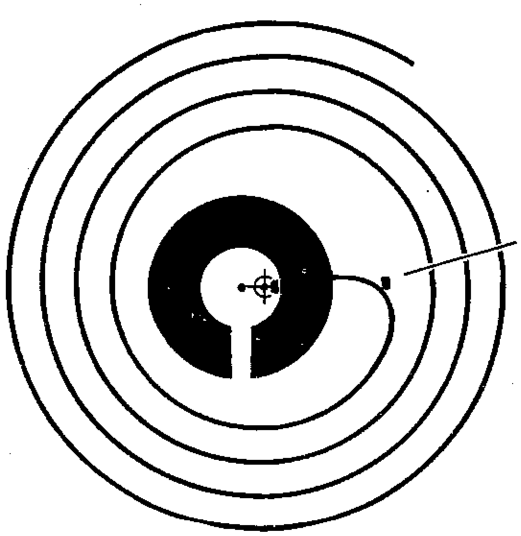


Fig. 18-34

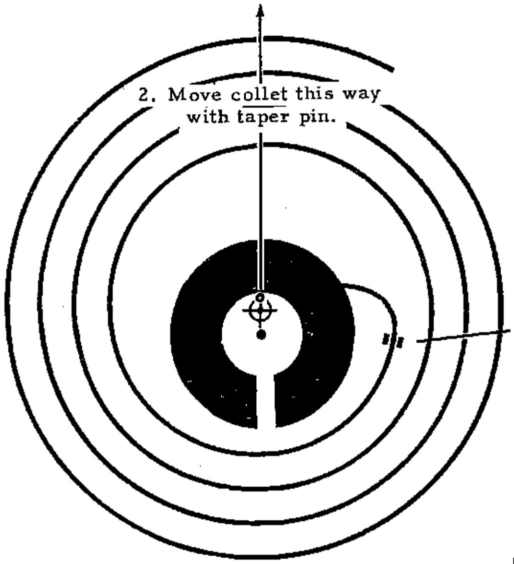


Fig. 18-35

In figure 18-35, place the tweezer as shown to hold the hairspring, and push the collet in the direction of the arrow with a taper pin.

In figure 18-36, hold the hairspring at the elbow with tweezers and push the collet with a taper pin in the direction of the arrow. If the collet should go slightly left of the theoretical center, closing the elbow with tweezers, as in figure 18-34, will probably bring the collet back where it belongs.

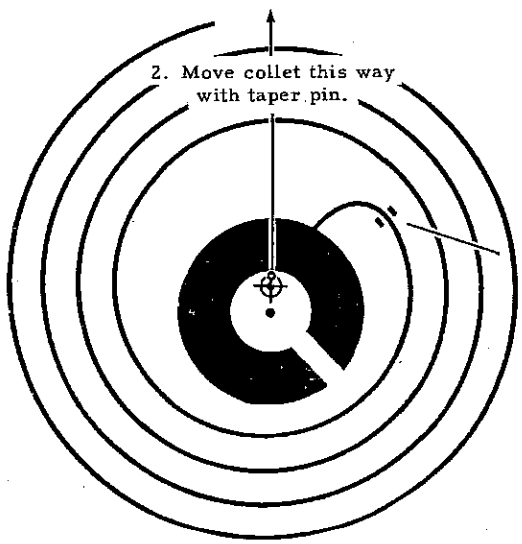


Fig. 18-36

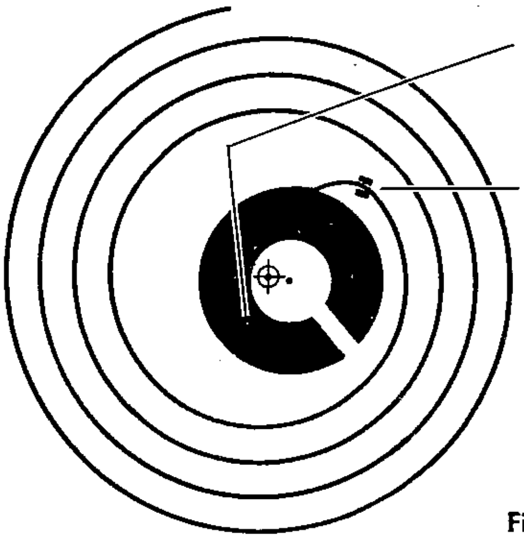


Fig. 18-37

In figure 18-37, hold the collet against the glass with your taper pin. Place the tweezer as shown and close it gently. This flattening of the curve should shift the collet center and the hairspring center to the same spot.

In figure 18-38, hold the hairspring with the tweezer as shown and push the collet in the direction of the arrow with the taper pin.

After centering the collet, check the hairspring to see that it is still true in the flat. Correct as necessary. Then recheck the round. Continue checking back and forth in this way until no further corrections are needed.

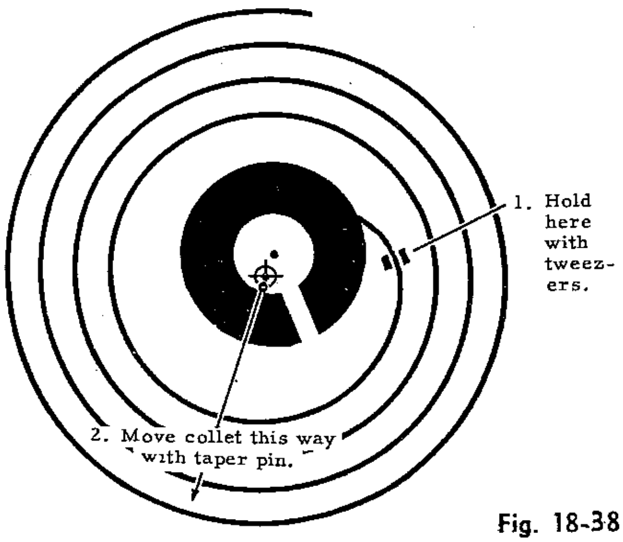


Fig. 18-38

The final test for truth in both flat and round is made with the hairspring on the balance and the wheel held in a truing caliper.

Replace the hairspring on the balance with a staking tool. Select a hole in the die plate that the roller will cover. Figure 18-39 shows a single roller set in the die plate of the staking block. Figure 18-40 illustrates a double roller in position over the die plate.

Lay the hairspring and collet on the balance staff and use a flat face hollow punch to press the collet firmly down onto the collet seat. In actual repairing, you must also put the watch in beat, as will be discussed in a later lesson.

Some repairmen use a bench block instead of a staking tool and press the collet on the staff with a tweezer in the manner indicated in Figure 18-10.

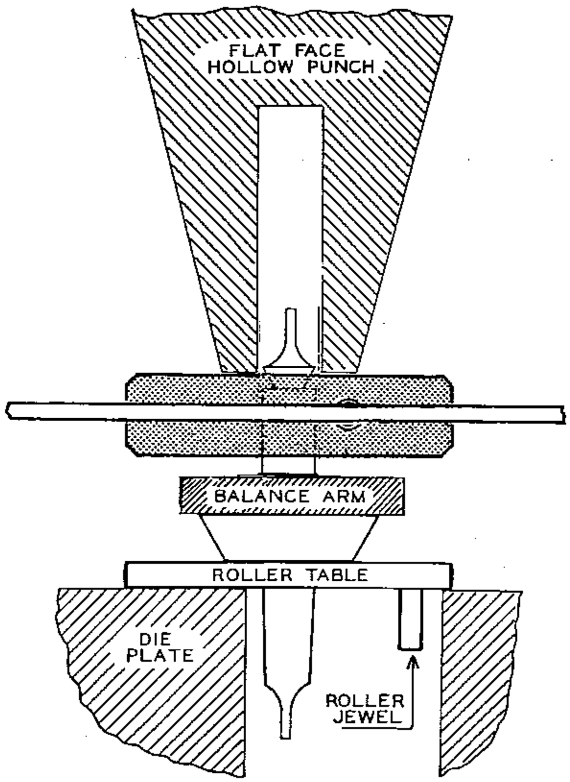


Fig. 18-39

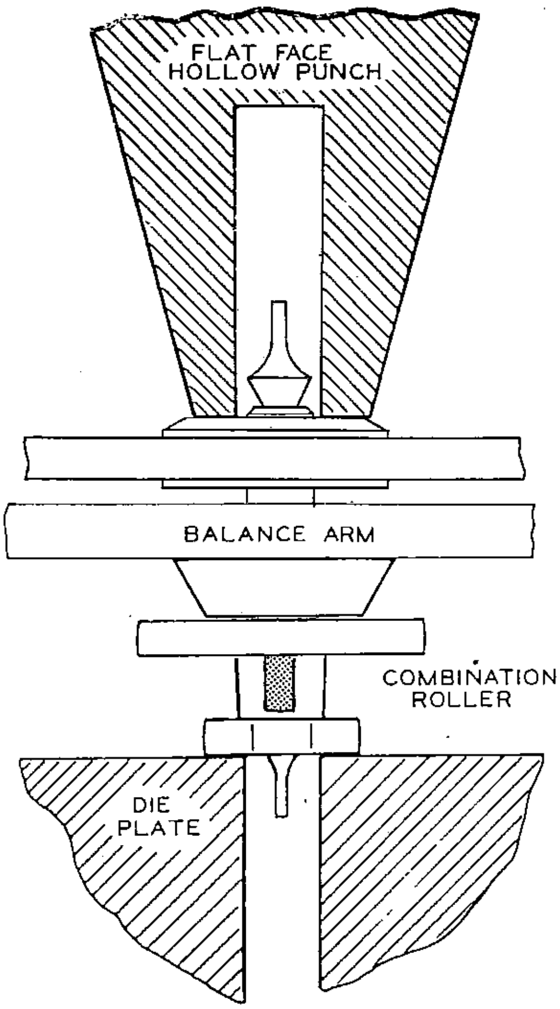


Fig. 18-40

You cannot observe directly from the side when the balance is in the truing caliper. The rim of the balance blocks your view. You must look over the rim toward the center coils and the collet. Release the jaws of the caliper slightly so the balance will turn freely. Brush the wheel with your forefinger to turn it slowly. Watch the first four or five inner coils.

As the balance turns, watch the pattern of light across the coils of the hairspring. If the coils seem to wobble up and down, the hairspring is not true in the flat. Make the necessary corrections as you learned earlier.

When the hairspring is true in the flat, hold the caliper so you are looking straight down on the hairspring. Spin the wheel slowly again. If the inner coils move smoothly away from or toward the collet, the spring is true in the round. If they seem to jump or bunch up toward or away from the collet, the spring is not true in the round and must be corrected.

If the hairspring is true in the flat and free of any errors in the outer coils, you can also use the indicator of the caliper to help you check on whether the collet is properly centered.

Set the indicator directly over a coil of the hairspring in the position shown in figure 18-41.

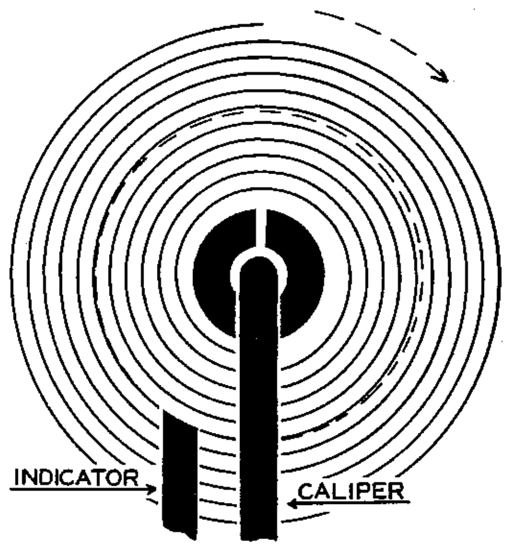


Fig. 18-41

Turn the balance 1/4 turn and the indicator should seem to have moved 1/4 the distance between coils, figure 18-42.

Turn the balance another 1/4 turn and the indicator should appear to have moved halfway between the coils, figure 18-43.

Another 1/4 turn and the indicator should appear to have moved 3/4 of the distance between coils, figure 18-44.

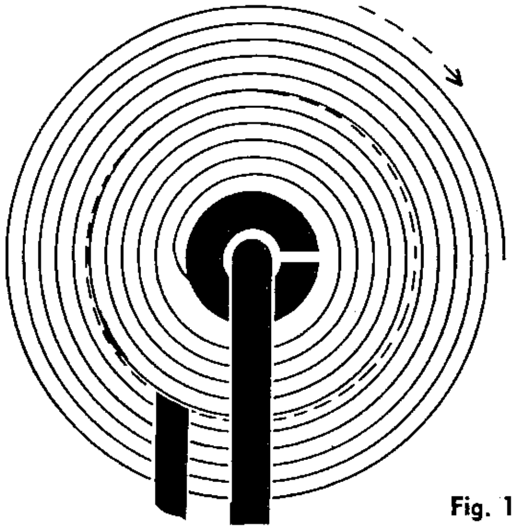


Fig. 18-42

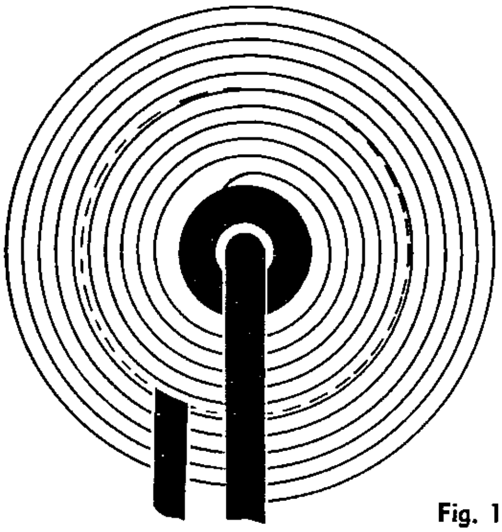


Fig. 18-43

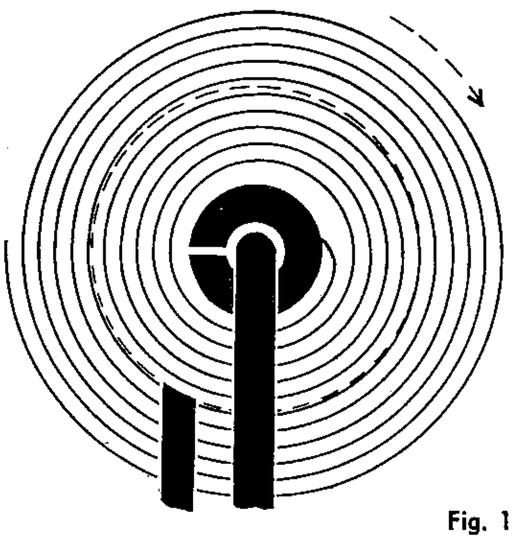


Fig. 18-44

After the last 1/4 turn, the indicator should be back where it started from. If it is, then the center of the collet and the center of the hairspring are properly matched up.

If the indicator appears to jump to another coil at any point, the collet is off center on that side. Make the necessary correction and recheck until no error appears.

SEC. 381.2 -- Centering the Collet on the Balance

After you've gained some experience with hairsprings, you may prefer to center the collet with the hairspring on the balance. You can readily do so if you provide a rest to keep the lower pivot from being broken.

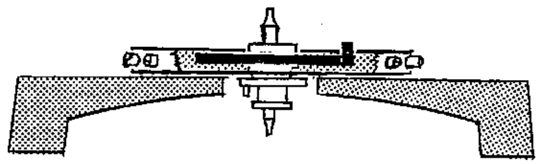


Fig. 18-45

Figure 18-45 shows a simple and practicable rest devised by Swiss watchmakers. It consists of a round, flat top crystal, about one inch across, with a hole about 1/8th of an inch drilled in its center. The balance arms rest on the crystal and the roller and lower pivot extend down through the hole.

Use the same tools you've been using to make corrections: a fine-pointed hairspring tweezer and a taper pin with a needle-like point. Hold the balance wheel when making corrections.

Just as before, all your corrections to center the collet will be made in the first quarter of the inner coil near the collet. It is merely a question of making the turn at the elbow smaller or larger as needed to get proper spacing.

As you make your adjustments, note carefully how the space is being altered. Remember that decreasing the space between collet and inner coil on one side will enlarge it on the other side. Similarly, adding more space on one side will lessen it on the other.

Remember, also, the collet now is fixed to the staff and cannot be moved to make corrections as when working on glass. For the most part, you get your result by grasping the inner coil close to the elbow and swinging the inner coil toward or away from the collet with the elbow acting as a hinge. No matter how you do it, avoid twisting the inner coil as you adjust the spacing.

If you need more space at the elbow, the easiest way to get it is to insert a taper pin between the inner coil and the collet and move it slightly toward the pinning point.

If you have too much space at the elbow and want to close it up and open up the other side, place one point of your tweezer outside the bend where it starts toward the collet and the other point in back of the staff. A slight pressure on the tweezer will force the coil back toward the collet.

Where the elbow is correct but the space farther out needs to be changed, grasp the spring as close as possible to the elbow and hold the tweezer upright. Grip the tweezer firmly and turn it slightly toward or away from the collet as needed for the correction.

Sometimes more than one bend may be needed to close a large space or enlarge a very narrow one. And sometimes a bend each way -- one out from the collet and one back toward the collet is required to get the proper result. Instead of two separate bends, experienced truers can pull the coil away from the collet and make the bend back toward the collet in one motion.

SEC. 382—Locating and Correcting Bends

As mentioned earlier, one or more outer coils may be thrown out of round or flat once in a while as a result of an accident. Before you can correct such errors, you must know how to find them.

This work should also be done on raised glass so you can see the coils clearly. To find the coil which is bent, always begin from the collet and follow around coil by coil until you come to a place where the spacing starts to vary. This is the point of error.

Hold the spring with your tweezers at this point and correct the error by pushing the coil in or out to the correct spacing. Here's an example to show how you do this:

Figure 18-46 shows a hairspring with two bends in it. Where there is more than one bend, as here, always locate and correct the one closest to the collet first and then go on to correct the other. You can do this work

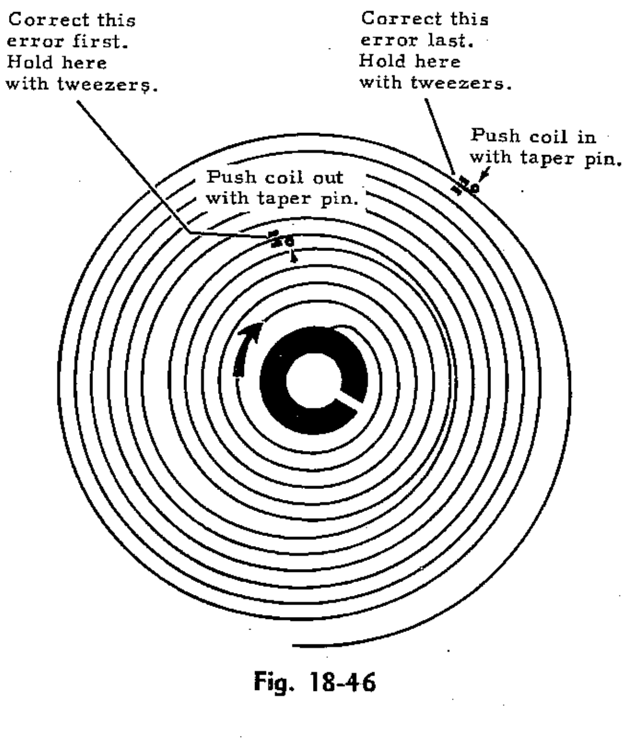


Fig. 18-46

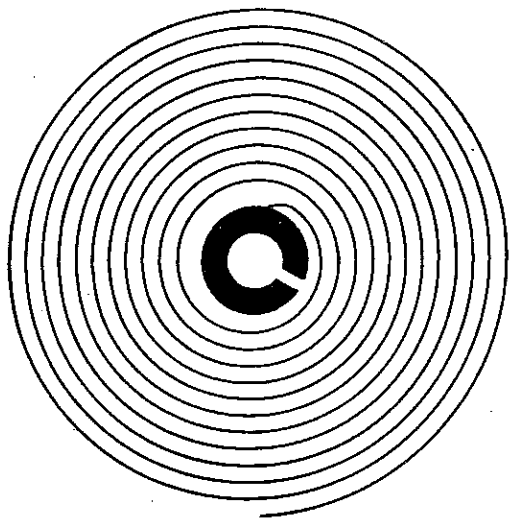


Fig. 18-47

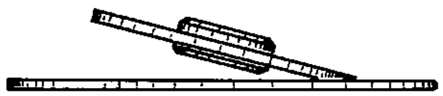


Fig. 18-48

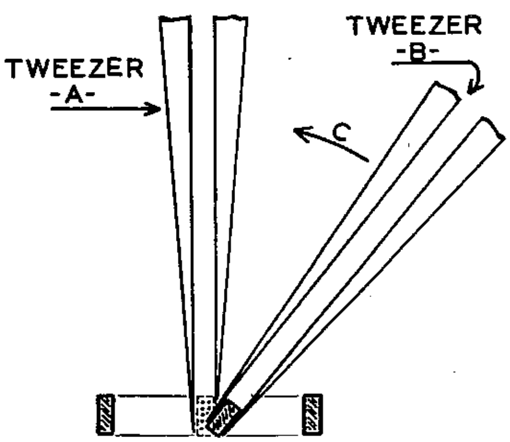


Fig. 18-49

in several ways, but we'll use the hair-spring tweezer and pointed steel taper pin we've been using.

Hold them both vertically at the point of error. Hold the spring with the tweezers and push out the coil with the taper pin until the spiral is again even. Use a stroking motion of the pin away from the tweezers to coax the spring back into place. If you push hard, you may make a sharp bend which you don't want.

After you have corrected the inner error, continue on around the coils until you come to the second place that needs correction. In figure 18-46 this is on the outer coil. Place your tweezer and taper pin as shown and carefully bend the coil in toward center. When you have the coils of the hairspring spaced as in figure 18-47, the hairspring is again a perfect spiral.

Sometimes you will get an out of flat condition as in figure 18-48. Here a few center coils and collet are higher than the rest of the hairspring.

Lay the hairspring on your glass plate and locate the error as you did before. Start from the collet and trace around the coils until you find the place where the coils is bent out of shape.

Figure 18-49 is a cross section of this condition. It shows three coils of a hairspring with the center one as the one which is twisted or bent. To correct this, grasp the part of the coil which is still straight and flat with a tweezer (tweezer A in figure 18-49). Then place a second tweezer alongside the first and right on the bend (tweezer B). Hold the hairspring firmly with tweezer A while you tilt up tweezer B in the direction of the arrow. This will straighten up the coil and lower the high ones back into the same plane as the rest.

CHECK YOURSELF

Progress Check 18A — A Self Test Review of Lesson 18

After you have studied Sections 376 through 379, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you miss any questions, review the sections on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The two types of hairsprings are ______________ and ______________.	376
2. The purpose of the Breguet hairspring is to get ______________________________.	376
3. When hairsprings are made, the spacing between coils is obtained by winding several ______________ in the same container.	376
4. The disadvantages of steel hairsprings are ______________________________.	376
5. The purpose of the hairspring is to govern the ______________________________.	377
6. "Equal time" is the definition of ______________.	378
7. The collet is used to fasten the hairspring to the ______________________________.	379
8. The hairspring is fastened to the collet with a ______________.	379
9. The steel pin used during colleting is called a ______________.	379
10. Before pinning the hairspring, the pinning hole should be ______________.	379

ANSWERS TO PROGRESS CHECK 18A:

1. flat overcoil
2. better timekeeping qualities
3. springs
4. temperature changes magnetism rust
5. balance wheel
6. isochronism
7. balance staff
8. stud pin
9. taper pin
10. cleaned or broached

CHECK YOURSELF

PROGRESS CHECK 18B — A Self Test Review of Lesson 18

After you have studied Sections 379.1 through 382, see if you can answer these questions without looking back. DO NOT SEND ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you miss any questions, review the sections on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The first step in colleting is to ____________________.	379.1
2. The tongue of the inner coil should be no longer than the ____________________.	379.2
3. The stud pin is tightened with ____________________.	379.4
4. In cutting off the stud pin after it is in place, the __________ of the knife is used in a __________ manner.	379.4
5. Stud pins may also be cut off with ____________________.	379.4
6. Adjustments for flat and round are ordinarily made with the hairspring on the ____________________.	380
7. Truing in the flat requires that the inner coil be level with the ____________________.	380
8. When the coils are evenly spaced and the center of the hairspring matches the center of the collet, the hairspring is said to be ____________________.	381
9. Corrections to center the collet are made in the __________ of the inner coil.	381.1
10. To locate a bend in the outer coil, start from the ____________________.	382

===

ANSWERS TO PROGRESS CHECK 18B:

1. break out the inner coil.
2. hole in the collet
3. heavy tweezers
4. tip
   sawing
5. nippers
6. balance
7. collet
8. true in the round
9. first quarter
10. collet

LESSON	18
COLLETING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L18-J1

HOW TO COLLET A HAIRSPRING.

Tools, Equipment and Supplies:

Eye Loupe	Two Pair of Hairspring Tweezers	Broaches
Bench Knife	Steel Taper Pin	Hairsprings
Collets	Hairspring Stud Pins	

PROCEDURE:	REFERENCE:
1. Place collet firmly on tapered steel taper pin or broach.	Fig. 18-10
2. Clean out the pinning hole with a small broach.	Fig. 18-11
3. Try the stud pin in the pinning hole of collet.	Fig. 18-12
4. Break out one or more of the center coils as needed for the collet.	Fig. 18-14 Sec. 379.1
5. Form tongue to same length as hole in collet.	Fig. 18-15 Sec. 379.2
6. Hold taper pin in one hand. With other hand, place tweezer at bend of elbow of inner coil and pick up hairspring. Insert tongue in pinning hole.	Fig. 18-16
7. Insert a brass stud pin small end first into the pinning hole and push it in until it holds the spring firmly and extends above the body of spring on far side.	Fig. 18-17
8. Hold taper pin so you are looking at hairspring from side. Turn taper pin slowly and check that inner coil is parallel with top and bottom of collet.	Fig. 18-18
9. When you are sure your work is correct to this point, tighten pin fully and cut off excess.	Figs. 18-20 18-21 18-22 18-23
10. To remove the collet from taper pin, turn taper pin so its point rests on your work surface. Place tweezer points above and astride collet and slide tweezers down taper pin until hairspring and collet touch work surface. Remove tweezers and lift out taper pin.	

HOW TO TRUE A HAIRSPRING IN THE FLAT (Level at the collet).

Tools, Equipment and Supplies:

Hairspring Tweezers
Colleted Hairsprings
Eye Loupe
Truing Caliper
Taper Pin

PROCEDURE:	REFERENCE:
1. Place hairspring on taper pin, pressing collet down firmly.	Fig. 18-10
2. Hold taper pin so hairspring is vertical and you are looking at it from the side. This eliminates sag in the spring and enables you to tell more easily if hairspring is out of true.	Fig. 18-27
3. Rotate taper pin slowly. If spring seems to wobble, it is not true.	
4. Locate high or low point.	Fig. 18-25 Fig. 18-26
5. Turn taper pin so hairspring is horizontal. Use the inside of one tweezer point to press down or lift up the inner coil as needed to make the hairspring coil and collet parallel to each other. Make corrections at the high or low point if it is within a half turn from the elbow. Otherwise, make corrections between the high or low point and the elbow so the change always takes place at the elbow.	

LESSON	18
HAIRSPRING TRUING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L18-J3

HOW TO TRUE A HAIRSPRING IN THE ROUND (Center the collet).

Tools, Equipment and Supplies:

Colleted Hairsprings · Hairspring Tweezers · Flat Glass · Eye Loupe
Steel Taper Pin · Truing Calipers

PROCEDURE:	REFERENCE:
1. Place hairspring, leveled in flat, on small piece of glass. Raise the glass above the working surface about 1/4 inch to drop out shadows.	Sec. 381
2. Look straight down on the spring. Your aim is to have the collet center match the center of the spiral (Figure 18-29) and the elbow formed so the spiral of the inner coil gradually gets wider from the collet to the first full coil.	Fig. 18-29
3. Look for two things: a. Is there enough space or too much space at the elbow? b. Does the space around the collet look about like that in Figure 18-29?	
4. If the elbow is too close to collet, hold collet firmly against the glass and insert a taper pin at pinning point between collet and coil. This should force out the coil enough to form an elbow. You want the elbow out far enough that you can use it as a hinge when making corrections to center the collet.	Fig. 18-33
5. If the elbow is still not large enough, replace the taper pin and place one point of the tweezer inside the collet and the other point on the outside of the inner coil. Squeeze the tweezer points together gently, using the taper pin as a fulcrum to form a larger elbow.	
6. If the elbow is too far out, reverse the above without the taper pin. That is, put one tweezer point inside the collet, the other outside the inner coil at the elbow and squeeze gently to close up the bend at the elbow.	Sec. 381.1
7. If the elbow is about right but the collet is still off center, hold the inner coil with your tweezer at the point of correction and swing the inner coil in or out with another tweezer or taper pin as needed to obtain the proper spacing. Make all corrections in the first 1/4 coil as close to the elbow as possible.	

(Continued)

PROCEDURE: | REFERENCE:

8. When your hairspring looks like Figure 18-29, recheck that it still is level, as you may have moved it out of flat while adjusting the round. Make corrections as needed; then recheck the round again.

9. Continue to check flat and round alternately until you have the hairspring as perfect as you can get it.

10. Place hairspring on balance wheel and examine in truing caliper for both flat and round. View both from same position; that is, looking over the rim of balance toward the inner coils. If the hairspring seems to wobble, it is out of flat or level. If it moves jerkily, it is out of round. To determine the exact point of error, use the indicator on the truing caliper as explained in Section 381.1. Sec. 381.1

11. Any needed minor adjustments can be made on the balance in much the same way as in steps 4, 5, 6, and 7 above. Sec. 381.2

LESSON	18
HAIRSPRING TRUING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L18-J4

HOW TO CORRECT A BEND IN AN OUTER COIL.

Tools, Equipment and Supplies:

Hairspring Tweezers   Taper Pin   Flat Glass

PROCEDURE:

REFERENCE:

Sec. 382
Fig. 18-46

1. Start at collet and trace around coils until you come to a place where spacing starts to vary.

2. Grasp this point with a hairspring tweezer held straight up and down.

3. With a taper pin placed just beyond the tweezers, stroke the coil gently to push it in or out as required to even the spacing.

   Note: A second tweezer may be used instead of the taper pin to bend the coil in or out. However, do not put the tweezer tight against the other one or you may shear off the spring when you bend it.

4. Hold the first tweezer in place until you are sure you have made enough correction. Otherwise, you may lose your place, as the error will be less apparent.

5. If there is another bend, as in figure 18-46, correct the one closest to the collet first; then use the same method to correct the outermost error.

LESSON	18
HAIRSPRING TRUING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L18-J5

HOW TO CORRECT AN OUTER COIL WHICH IS OUT OF FLAT.

Tools, Equipment and Supplies:

Hairspring Tweezers

PROCEDURE: REFERENCE:

1. Start from the collet and follow around the coils until you arrive at the high or low point. — Sec. 382

2. Place one tweezer alongside this point on the part of the coil which is still correct. Grip coil firmly with tweezer which should be straight up and down.

3. Place a second tweezer on the bent portion alongside the first tweezer. Grip coil with second tweezer and tilt tweezer in or out as needed to lower or raise the out of level coils.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions | Master Watchmaking | Lesson No. 18

Name: No.: Date:

SUBJECT: Colleting and Truing Hairsprings GRADE: ____________

DIRECTIONS: In the following statements, select the ONE BEST answer and place the letter of that answer on the short line in front of the question number.

____ 1. The overcoil hairspring was invented by:
- A. Abraham-Louis Breguet
- B. Dr. Robert Hooke
- C. Christian Huygens
- D. Dr. Charles Guillaume

____ 2. When a watch is in beat, the roller jewel at rest is on a line drawn from the center of the balance staff to:
- A. The center of the 4th wheel.
- B. The center pinion of the watch.
- C. The center of the pallet arbor.
- D. The center of the receiving pallet jewel.

____ 3. The experiment with the weight and string teaches:
- A. The time required for the short arc of a pendulum is the same as for a long arc.
- B. The time required for the short arc is less than for a long arc.
- C. The time required for the short arc is greater than for a long arc.
- D. The time required depends on the weight of the pendulum.

____ 4. Removal of too many center coils from a hairspring:
- A. Does not make it impossible to true in the round.
- B. Does make it impossible to true in the round.
- C. Can be corrected by using a larger collet.
- D. Renders the spring more liable to damage or distortion.

____ 5. How long should the tongue of the hairspring be in relation to the hole in the collet?
- A. One fourth the length of the hole.
- B. One third the length of the hole.
- C. Slightly longer than the hole.
- D. Same length as the hole.

____ 6. In pinning the hairspring to the collet:
- A. Force pin in as far as it will go; then bend spring parallel to top or bottom of collet.
- B. Make certain inner coil is parallel with top or bottom of collet before forcing pin into place.
- C. Cut off pin before inserting into collet.
- D. Use a pin that is of a size that will be tight as soon as the point enters the collet.

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(Please turn over)

____ 7. The nippers illustrated in this lesson:
A. Are used to cut off the inner coils to make room for the collet.
B. Are used to snip off unneeded outer coils.
C. Should not be used for any other purpose than cutting small brass pins.
D. May be used for many other purposes than colleting work.

____ 8. When truing a hairspring in the flat, the bending must take place:
A. Throughout all the coils of the spring.
B. In the elbow near the collet.
C. In the outside coils of the spring.
D. In the inside coils of the spring.

____ 9. When the centers of the collet and hairspring exactly coincide, the hairspring is:
A. Practically true in the flat.
B. Practically true in the round.
C. Slightly out of true in the round.
D. Slightly out of true in flat and round.

____10. Truing a hairspring in the round is accomplished:
A. By making adjustments throughout the body of the spring.
B. By correctly bending the first three inside coils.
C. By working as necessary on the entire inside coil.
D. By never working beyond the first quarter coil.

____11. In truing hairsprings in the round, the tools usually used to make the corrective bends are:
A. Two thick pointed tweezers.
B. One wide pointed and one fine pointed tweezer.
C. A wide pointed tweezer and a taper pin.
D. A fine pointed tweezer and a taper pin.

____ 12. When starting to check the truth of a hairspring in the round, place the indicator of the truing caliper:
A. One quarter of a space between coils.
B. At exactly half the space between two coils.
C. At the end of the outside coil of spring.
D. Directly over a coil.

____13. When locating bends in the body of a hairspring, the correct method is to:
A. Start at the outside coil.
B. Start where the coils are widely spaced.
C. Start at the center of the hairspring and follow a coil.
D. Start where the space between the coils is the smallest.

____ 14. When correcting a hairspring which has a few of the center coils and the collet raised above the body of the hairspring, the work should be done:
A. On glass, with two pairs of tweezers.
B. On glass, with two needles.
C. In the truing caliper.
D. On the taper pin.

(Continued on next page)

Name: Student number

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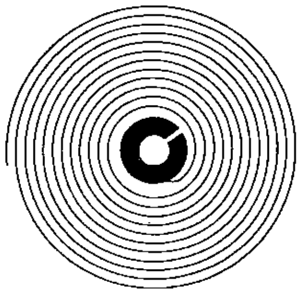
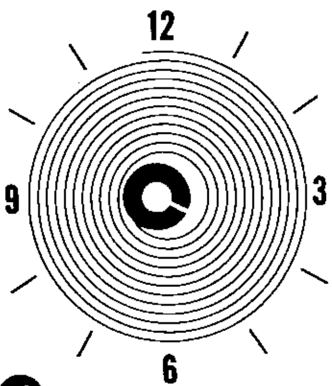
SECOND REQUIREMENT: Centering the Collet.

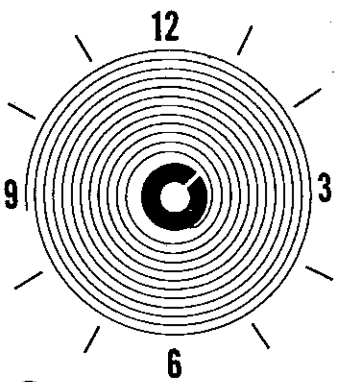


The hairspring shown at the left has the collet correctly centered. In the next three illustrations are shown three collets which are off center. What correction is needed and how is it best made? You are making this correction with the hairspring on a glass work surface. Place the letter of the answer you select on the short line in front of the question number.



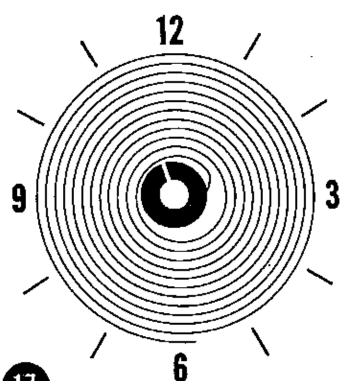
15

____ 15. A. Grasp the inner coil of the hairspring at 6 o'clock with tweezers held vertically. Hold firmly and with a taper pin in hold of collet, move collet toward 1 o'clock.
B. Grasp the inner coil of the hairspring at 6 o'clock with tweezers held vertically. Hold firmly and with taper pin in the hole of the collet about 4 o'clock, move the collet toward 3 o'clock.
C. Place a small taper pin in the hold of the collet and push the collet toward 3 o'clock.
D. Grasp the inner coil of the spring at 12 o'clock with tweezers held vertically and push the collet toward 6 o'clock with a taper pin.



16

____ 16. A. Grasp inner coil with tweezers held vertically at 4 o'clock. Hold firmly. Insert taper pin in hole of collet and move toward 9 o'clock.
B. Grasp inner coil with tweezers held vertically at 4 o'clock. Hold firmly. Insert taper pin in hole of collet and move collet toward 12 o'clock.
C. Insert a taper pin in the hole of collet and push collet toward 8 o'clock.
D. Insert a taper pin between the collet and inner coil at 4 o'clock. This will move collet toward 9 o'clock.

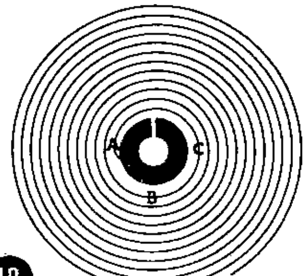


17

____ 17. A. Grasp the inner coil with tweezers held vertically at 2 o'clock and turn tweezers away from collet toward 3 o'clock.
B. Grasp the inner coil of the hairspring with tweezers held vertically at 12 o'clock. Hold firmly and with a taper pin in the hole of the collet, push the collet toward 6 o'clock.
C. Hold tweezer vertically with one point on elbow of inner coil at about 2 o'clock and the other point in hole of collet. Close tweezers gently to move collet toward 4 o'clock.
D. Insert a taper pin in the hole of the collet and push the collet toward 4 o'clock.

(Please turn over)

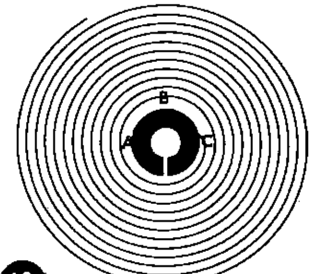
THIRD REQUIREMENT: Truing in the flat (Leveling)



18

The two hairsprings shown in the next two illustrations are out of level. The springs are shown from both top and side to show the relationship of the pinning point in the collet to the high or low point. You are to make these corrections with the collet firmly pressed on a taper pin. What correction is needed and how is it best made? Place your answer in front of the question number as before.

____ 18. A. Press down the inside coil at A with needle or tweezer point.
B. Press down the inside coil at B with needle or tweezer point.
C. Grasp the inside coil at C with tweezers and tilt toward the collet.
D. Lift the inner coil at C with a needle or tweezer point.

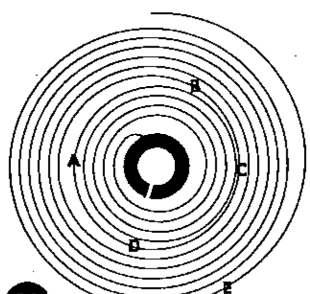


19

____ 19. A. Grasp the inner coil with tweezers at A and tilt away from the collet.
B. Press down the inside coil at A with needle or tweezer point.
C. Press down the inner coil at B with needle or tweezer point.
D. Lift the inner coil at C with needle or tweezer point.

FOURTH REQUIREMENT: Truing the spiral of the hairspring.

The spring at the left has one or more distortions in its coils. What correction or corrections are needed and how are they best made? When corrected, the hairspring should look like the one below at left.



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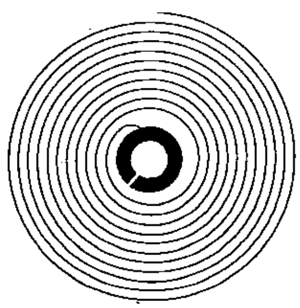


____ 20. A. Grasp the spring at A with a tweezer held vertically and bend the coil away from the collet with a second tweezer or taper pin just beyond A. Then grasp the spring at E and move the outer coil in toward the collet with a second tweezer or taper pin just to the right of E.
B. Grasp the spring at C with tweezers held vertically and bend the coil away from the collet with a second tweezers. Then hold the coil at B and swing coil toward collet with second tweezers.
C. Grasp the spring at D with a tweezer held vertically and move the coil outward with a taper pin to the right of D. Then grasp the spring at C and move the coil away from the collet with a taper pin.
D. Grasp the spring at D with a tweezer held vertically and move the coil outward with a taper pin to the right of D. Then grasp the spring at E and move the outer coil in toward the collet with a taper pin to the right of E.

CHICAGO SCHOOL OF WATCHMAKING   310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Student Consultation Sheet

Date ______________ Student No. ______________

Lesson No. ______

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Name	
Address	
City State Zip Code	

Please check ( ) if you have CHANGED YOUR ADDRESS.

ASK YOUR QUESTIONS HERE...

(If necessary, use other side.)

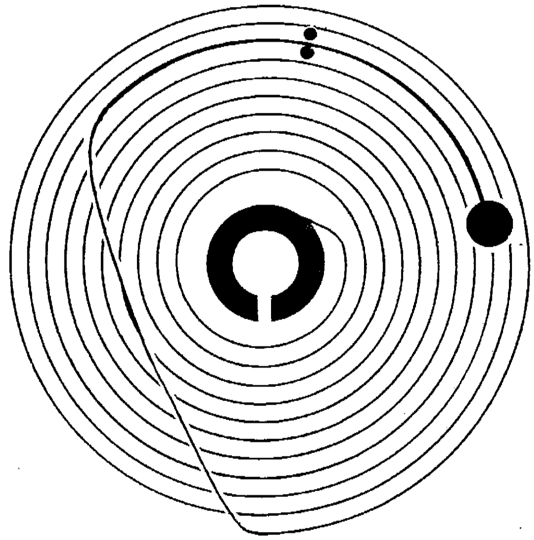
WE'LL ANSWER HERE...

INSTRUCTOR: Return an unused sheet with each used one.

Cut along this line and use this sheet if you have questions on the course.

Student Consultation Sheet

MASTER WATCHMAKING



LESSON 19 – THE OVERCOIL HAIRSPRING

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

19

INTRODUCTORY INFORMATION

In this lesson you will learn to form an overcoil hairspring. This type of work, like other hairspring work, takes lots of practice but is very necessary. As a watch repairman, you will many times have to make minor adjustments or, in some cases, to reshape the overcoil to put it back in its original shape.

KEY POINTS OF LESSON ASSIGNMENTS 61, 62:

- Types of overcoils.
- Methods used to raise overcoils.
- How to form a gradual bend overcoil.
- How to form a knee bend overcoil.

ASSIGNMENT NO. 61: Study Sections 383 and 384.

Study Questions:

1. How do overcoils differ in shape?
2. In what respect are all overcoils alike?
3. Why must you shape the final portion of the overcoil to follow a particular coil or space between coils?
4. What methods are used to raise overcoils?

ASSIGNMENT NO. 62: Study Sections 385 and 386.

1. What tools are used to raise and form an overcoil?
2. How is the overcoil raised above the body of the spring?
3. What determines the height of the overcoil?
4. After the overcoil is raised and leveled to the proper height, what has to be done next?

Recommended Practice:

1. Form an overcoil on a practice hairspring, using Fig. 19-4 as a pattern and Job Sheet L19-J1 as a guide. For this practice work make the regulation arc follow the third coil from the outside.

2. Next select other style overcoils from illustrations 19-1 through 19-8 for your additional practice. Use the same procedure and have the regulation arc follow the third coil.

3. Now try your hand at the knee bend overcoiling procedure, using Job Sheet L19-J2 as a guide. You'll find the experience you gain here particularly helpful in leveling an overcoil in actual repairing. Use the same patterns as you did for the gradual bend.

ASSIGNMENT NO. 62 (Continued)

Recommended Practice:

If necessary, you can re-use your practice springs for the knee bend method by breaking off the gradual bend overcoils you previously made.

After you have tried both methods of forming an overcoil, you can see which one works best for you.

REQUIREMENT:

Answer the Test Questions for Lesson 19 and send in for grading.

SEC. 383—Types of Overcoils

There are hundreds of shapes of overcoils resulting from many people's efforts to get a spring isochronally perfect. Many articles and books have been written which discuss the whys and wherefores of these many patterns. An experienced watchmaker can easily identify many of these shapes as coming from a particular factory.

Knowing where the shapes come from is not too important. You will learn this without effort as you work with more watches. What is important is being able to handle every type of overcoil. Our purpose in this lesson is simply to teach you to form and adjust an overcoil hairspring no matter who made it in the first place. You have only two methods to learn in this lesson. With them you can make any type of overcoil. In actual repairing, you will probably find yourself using just a few basic types or minor variations of them.

You will not always be forming a new overcoil. Many times you will simply be reshaping an overcoil which has been accidentally bent or one which is not of proper height or improperly centered. But if you can form an overcoil, you can easily correct one.

Figures 19-1 through 19-8 show a few of the many forms and shapes an overcoil may take. Not all are found in the modern watch. Several of these shapes, figures 19-4, 19-7 and 19-8, are more or less basic patterns of overcoil in use today.

No matter what shape of overcoil is used, one section is just about the same in all. This is the part just before the stud. This section must pass through the regulator pins in the watch. The regulator pins are at a fixed distance from the balance hole jewel. When the pins move, they can move only in a circular path. So this section of the spring which moves between the pins must always be a part or arc of a circle. For this reason, it is usually called the regulator arc or regulator circle. Note in figures 19-1 through 19-8 how much alike this section is. Its shape stays the same no matter which coil it follows, where the stud is, or how long or what shape the section raised over the body of the spring actually is.

The overcoils in these illustrations all lie in one direction. This is only for illustration. They may lie in the opposite direction as well. The actual direction is set by the location of the stud and regulator pins on the balance cock.

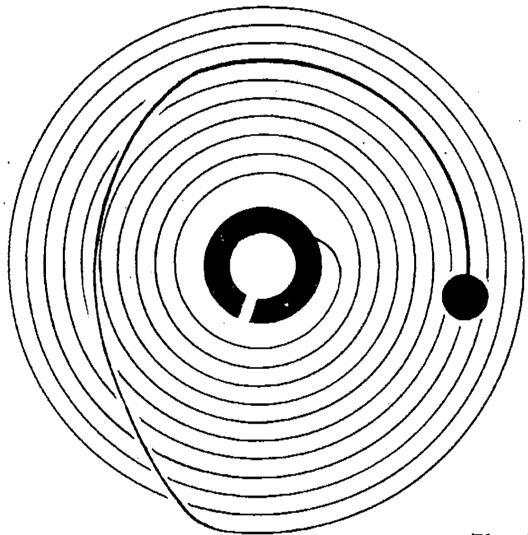


Fig. 19-1

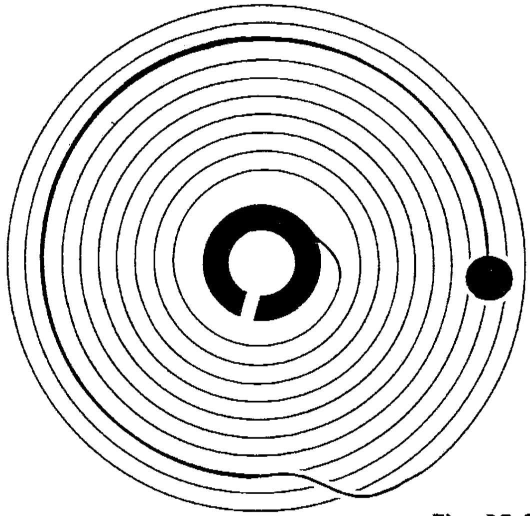


Fig. 19-2

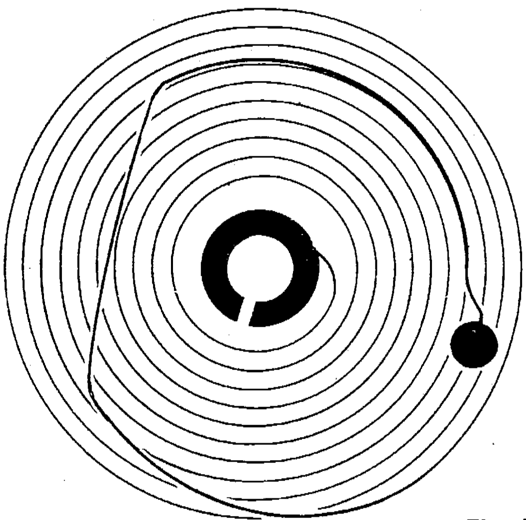


Fig. 19-3

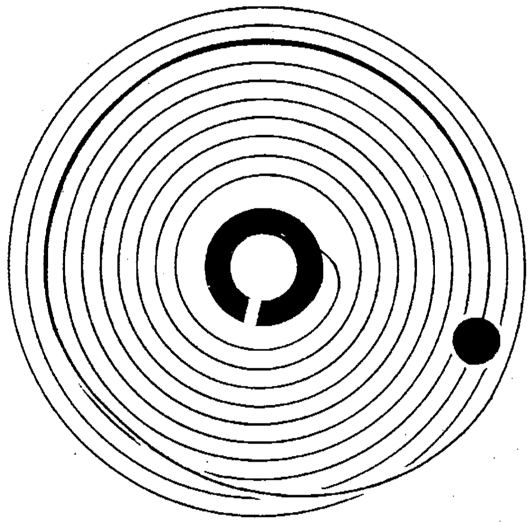


Fig. 19-4

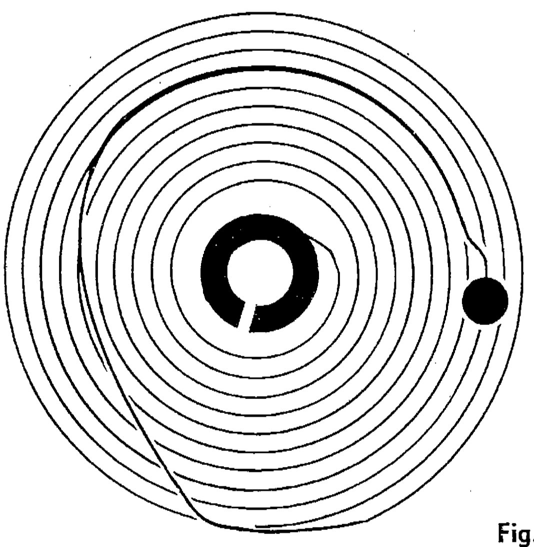


Fig. 19-5

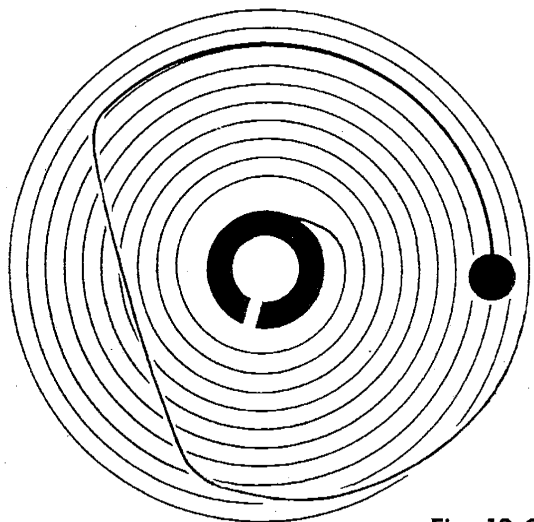


Fig. 19-6

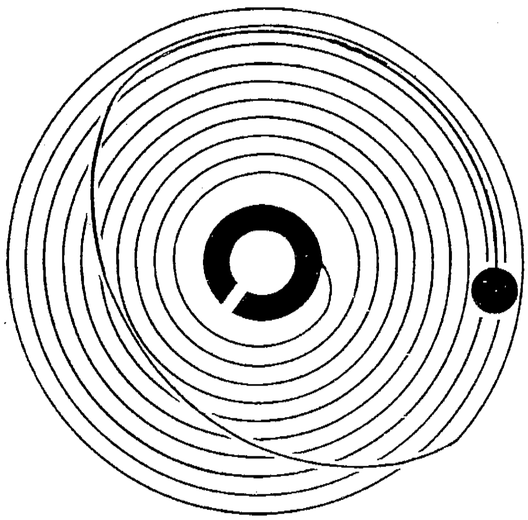


Fig. 19-7

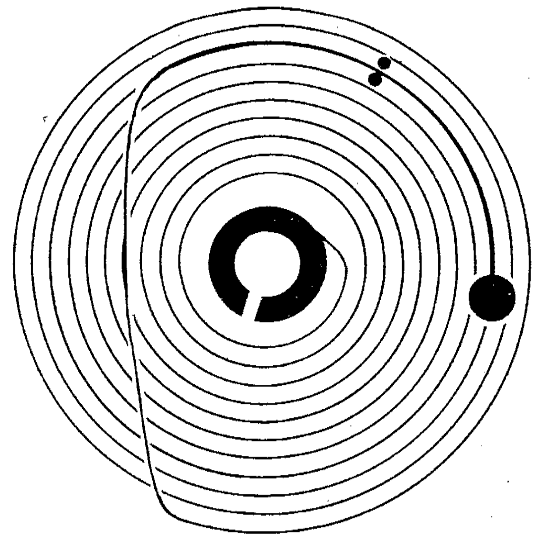


Fig. 19-8

SEC. 384— Methods of Raising the Overcoil

Two methods are used to raise the overcoil. One is the gradual bend overcoil shown in figure 19-9. The other is the knee bend overcoil shown in figure 19-10.

Both types are of about equal merit so far as timekeeping qualities go. However, the knee bend is preferred by many watchmakers who find it easier and quicker to make than the gradual bend. In this lesson, you'll learn to form both types. Then you can decide for yourself which one you like best.

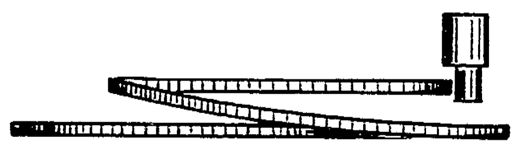


Fig. 19-9

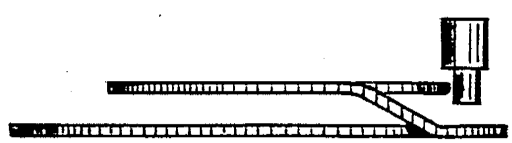


Fig. 19-10

SEC. 385—Forming the Gradual Bend Overcoil

The first step is to raise the overcoil. Begin by laying the hairspring on a flat surface. The glass plate used in truing is fine for this purpose also.

Now grasp the outer coil with two fine pointed tweezers placed side by side as shown in figures 19-11 and 19-12. Figure 19-11 shows the hairspring from the side while figure 19-12 shows a top view. Place the tweezers about 7/8ths of the distance from the end of the outside coil at point X in figure 19-12. Hold them straight up and down as shown in figure 19-11.

Tilt the hairspring upward by tipping the tweezer nearest the end (tweezer A) away from the spring as shown by the arrow in figure 19-12. At the same time hold tweezer B firmly in position. This action will raise point Y, which is directly across from your tweezers, figure 19-12. In figure 19-11, point Y is the place marked "Next Bend".

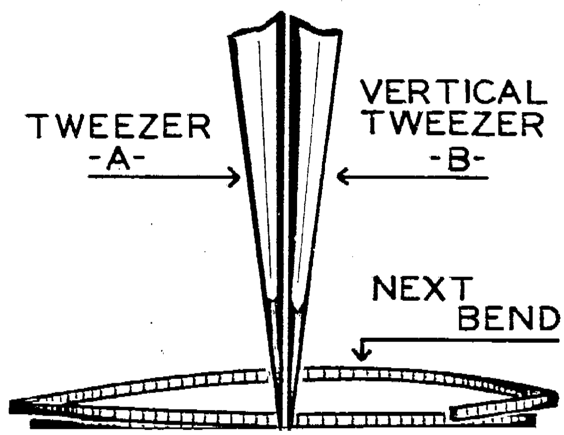


Fig. 19-11

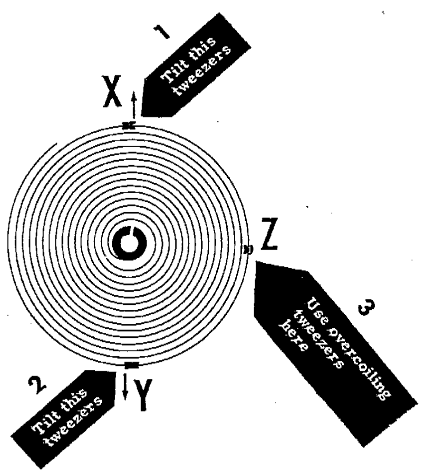


Fig. 19-12

When you believe you have raised point Y to the correct height, release the tweezer you tilted (tweezer A). DO NOT RELEASE TWEEZER B until you are sure the overcoil is at the right height at point Y. By not releasing tweezer B until the coil is at the right height, it is easy to raise or lower the coil as necessary.

Pick up the hairspring with tweezer B and see if the coil is the correct height at point Y. This distance should be 2 to 3 times the width of the hairspring wire as shown in figure 19-13.

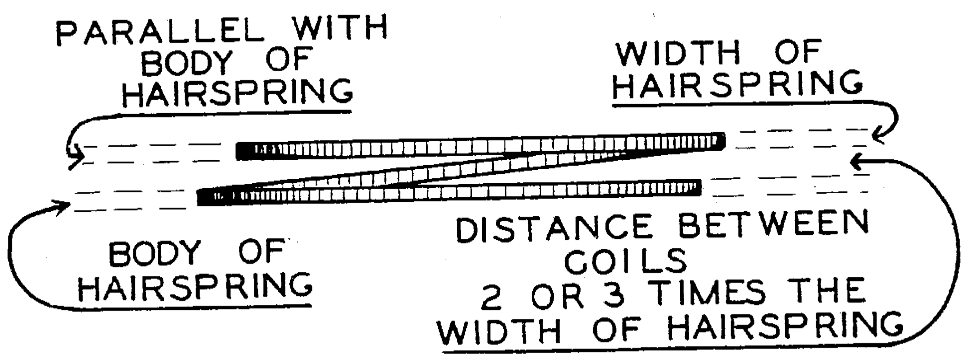


Fig. 19-13

In actual repairing, the distance between the overcoil and the body of the hairspring is set by the space between the balance cock and the arm of the balance wheel, as well as by the location of the inner coil pinning hole in the collet.

If you find you do not have the coil at the right height, return the spring to the glass. Replace tweezer A and with it bend the hairspring up or down as necessary to raise or lower the coil at point Y.

After you have obtained the correct height, you must level the remaining part of the overcoil. Release both pairs of tweezers and move them to point Y, figure 19-12. (See also "Next Bend", figure 19-11.) With the two tweezers held straight up at Y, tilt again the tweezer nearest the outer end as indicated by the arrow in figure 19-12, so as to level the overcoil from point Y to the end. Always keep one tweezer in place until your work is completed at this point.

The next step is to form the overcoil itself. This is usually done with overcoiling tweezers. These tweezers come with points of different curves. Generally, an overcoiling tweezer No. 10-1 or 10-0 will handle the average repair job.

The way to use the overcoiling tweezer is to place it directly over the point of bend as shown in figure 19-14. The upper illustration shows the coil of the spring (line AB) before it is bent while line AC is the position this section of coil will be in after it is bent at O. In the lower drawing, figure 19-14, the bend has been completed. The overcoiling tweezer is still centered directly over the point indicated by the arrow at O in the top drawing.

In figure 19-15, you can see the result of using too much pressure on the overcoiling tweezer. The coil has gone to D instead of stopping at C.

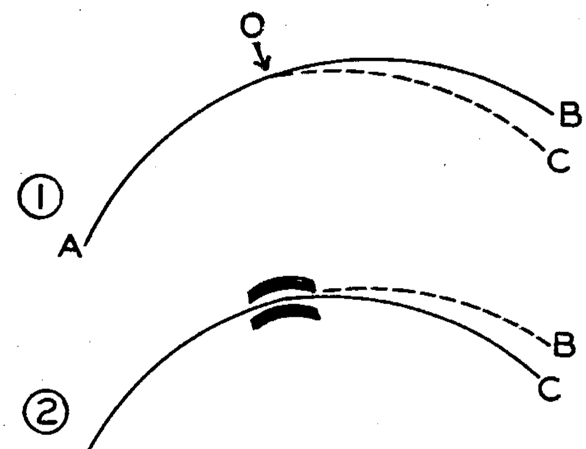


Fig. 19-14

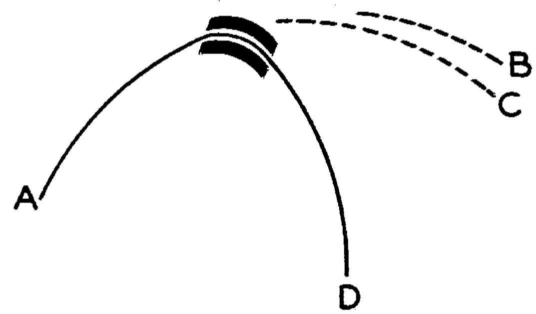


Fig. 19-15

Figure 19-16 shows how you can correct this situation and bring line AD back to the position for which it was originally intended.(AC). Simply reverse the overcoiling tweezer as illustrated.

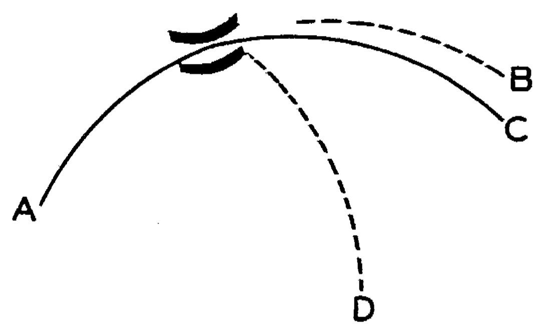


Fig. 19-16

Instead of overcoiling tweezers, some repairmen form the overcoil with one tweezer and a taper pin in the same way you made corrections in truing the outer coils in the previous lesson.

If you use this method, hold the spring with the tweezer at the point of bend and use the taper pin to push the spring toward its center to form the curve you want. You can curve only a small portion at one time, so you must move your tweezer along and repeat this action several times to get the entire section in a circular shape.

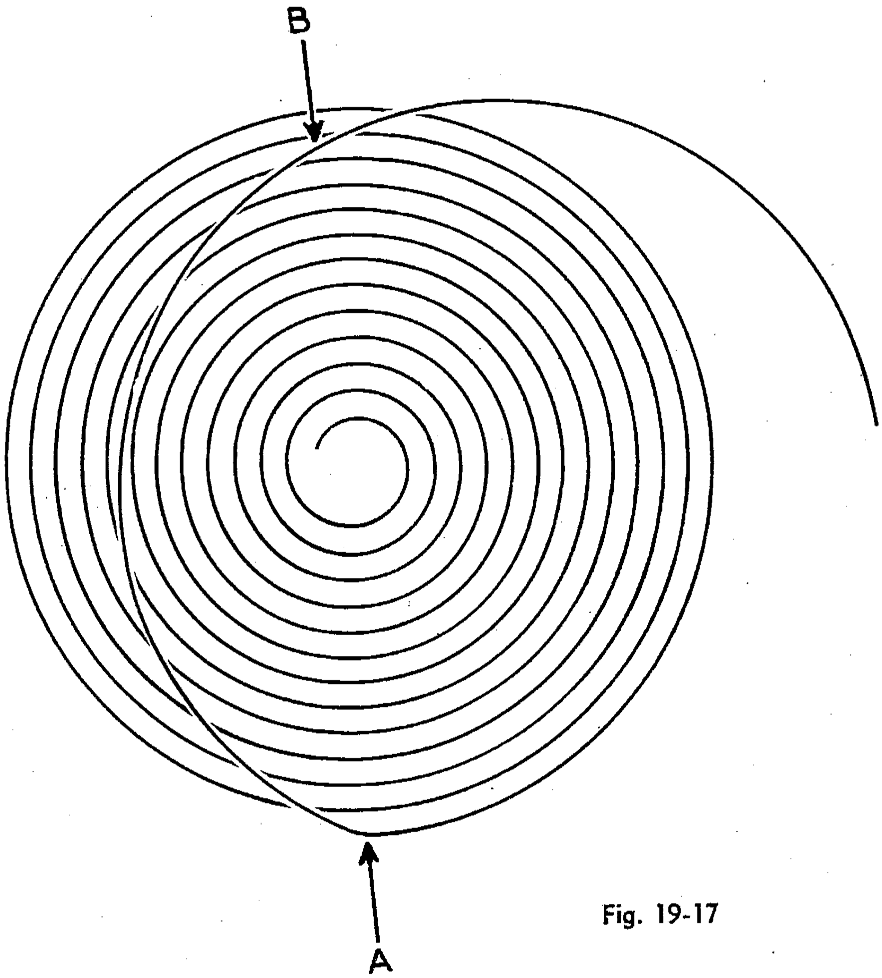


Fig. 19-17

In forming the overcoil, make the first bend at a point where you are sure the overcoil will clear the body of the hairspring. In figure 19-17 this is A. In figure 19-12 this point is at Z.

Grasp the hairspring lightly with overcoiling tweezers at point A. Press the ends of the tweezer together carefully and bend the outside coil in over the body of the spring according to whatever pattern you are following.

Where a second bend is needed, its location will be fixed by the location of the regulator pins when the hairspring is centered over the balance cock, because the final portion of the overcoil (the regulator arc) must move freely between the pins. This will be covered more fully in the next lesson. For your practice, you may use any coil in the body of the hairspring and form the remaining portion to follow the coil selected. The second or third coil from the outside are good ones to use. In this example, we're going to have the overcoil follow between the second and third coils, so the second bend in this case will be at B in figure 19-17.

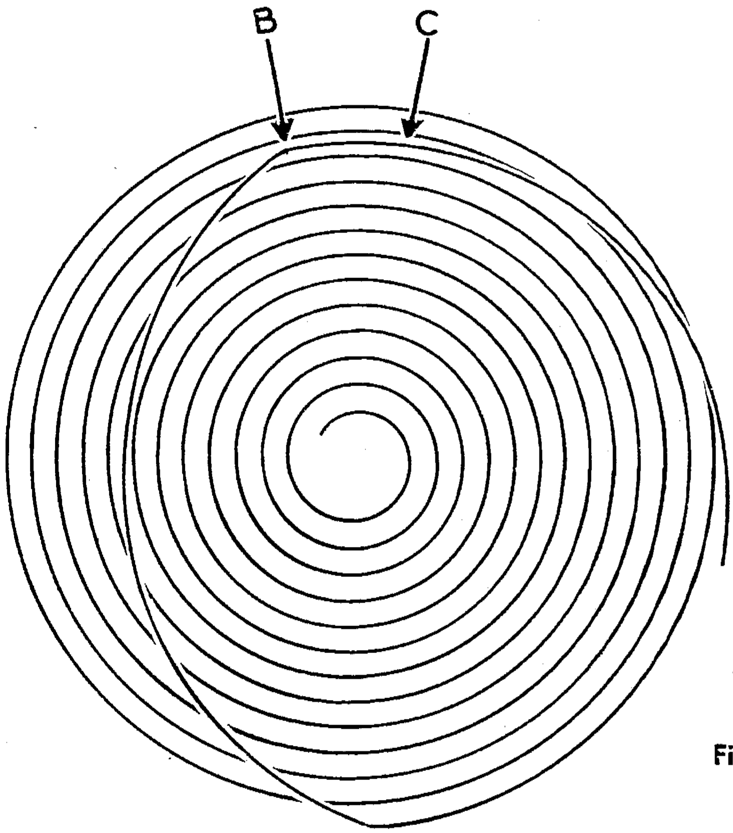


Fig. 19-18

After making this bend, the overcoil will appear as shown in figure 19-18. Move now to point C and continue shaping the overcoil until it appears as in figure 19-19. When forming the overcoil in the round, be sure to look directly down on it each time you make an examination.

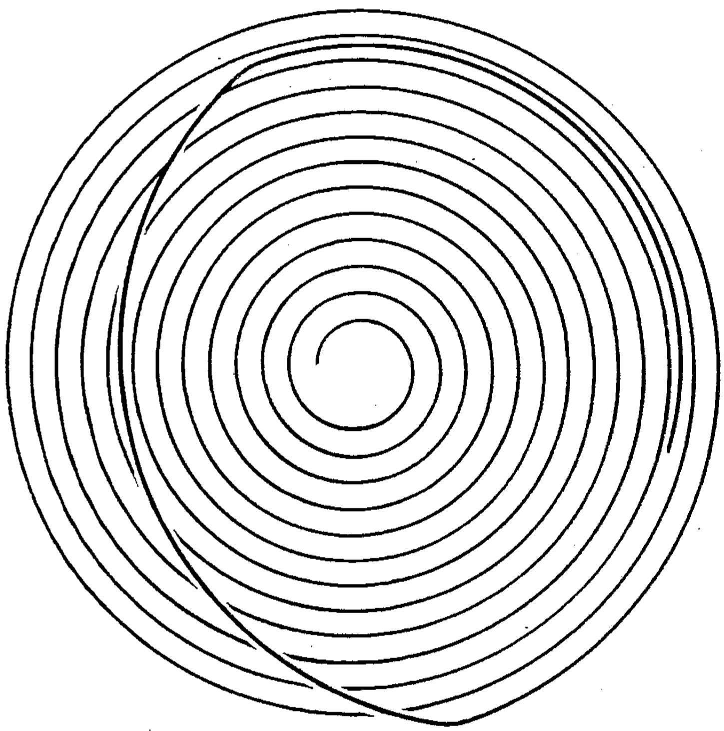


Fig. 19-19

After you have completed the overcoil, check to see that it is level. It must be parallel with the body of the spring as shown in figure 19-13.

Sometimes it may look like figure 19-20. To correct this, grasp the overcoil at its high point C with two pair of hair-spring tweezers. Tilt one as you did in raising the overcoil until section BC is level. Doing this will raise section AB higher than you want as shown in figure 19-21. Lower this section to the correct height by placing two tweezers at B and tilt the outermost one toward the spring until section AB is level.

An alternate and somewhat easier method is to grasp the spring at B with an H tweezer and push down on point A with a taper pin or piece of pegwood.

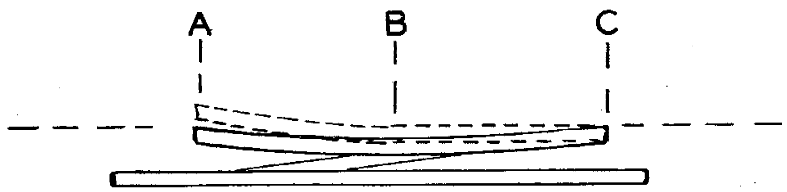


Fig. 19-20

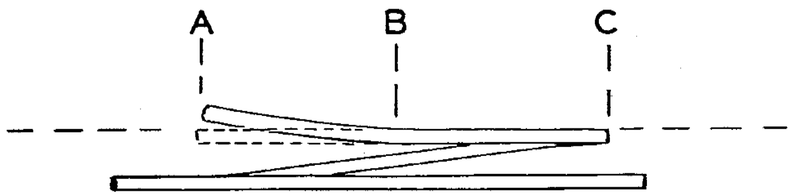


Fig. 19-21

SEC. 386—Forming the Knee Bend Overcoil

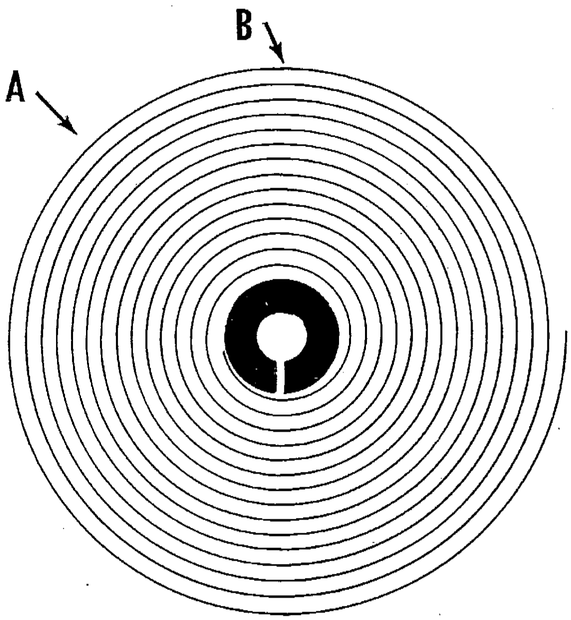


Fig. 19-22

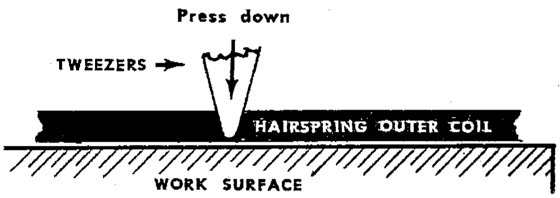


Fig. 19-23

Fig. 19-24

Some repairmen use a special tool to form the knee bend. However, you can do the job just as well with an ordinary #H Dumont tweezer. This is a short tweezer with thick points.

Place the hairspring on a piece of soft wood or linoleum. Grasp the spring at point A, figure 19-22, with the #H tweezer. Point A should be 5/8ths of a turn away from the end of the spring. If you are fitting this spring to a watch, point A should be 5/8ths of a turn from the stud.

Hold hairspring firmly in tweezer as you press tips of tweezer down into the soft wood block or linoleum, figure 19-23. (If the spring slips in tweezer, round the tweezer points slightly.) The result is illustrated in figure 19-24.

Turn the spring over. Let the raised portion of the overcoil overhang the work surface, figure 19-25. Move your tweezer to point B, figure 19-22. On a practice spring, this point is about 1/8th of a turn beyond point A where you made your first bend. If you are fitting this hairspring to a watch, the height of overcoil you want determines the distance between the bend at point A and point B. Press the tips of the tweezer into the work surface. The result of this bend is shown in figure 19-26.

Now level the overcoil as necessary. Grasp the hairspring firmly at bend A, figure 19-26, with a tweezer. Lift or press down on the overcoil as required with a piece of pegwood, taper pin or similar tool, figure 19-27.

Form the overcoil in over the body of the spring. Follow the desired coil or space between coils just as you did when making the gradual bend overcoil. Use overcoiling tweezers or a regular hairspring tweezer and taper pin, as you prefer.

Recheck to see that overcoil is of right height, level with the body of spring and smoothly formed to follow over the proper space or coil.

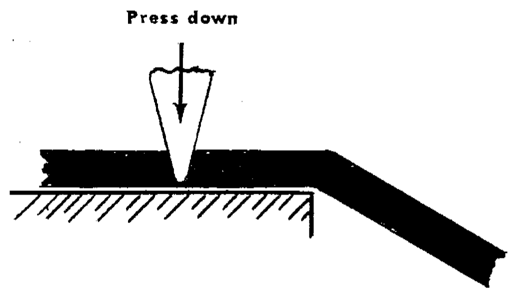


Fig. 19-25

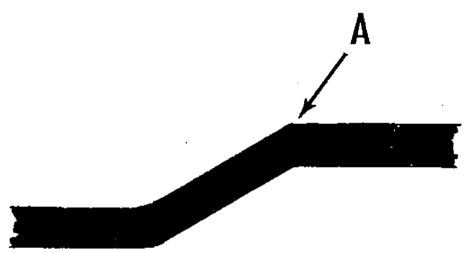


Fig. 19-26

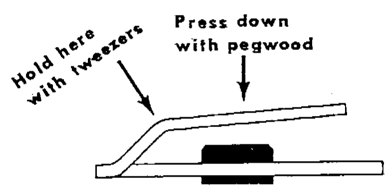
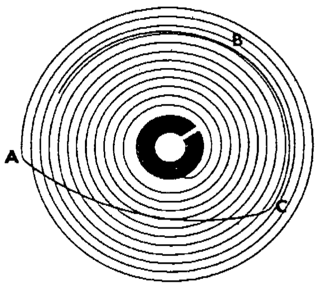


Fig. 19-27

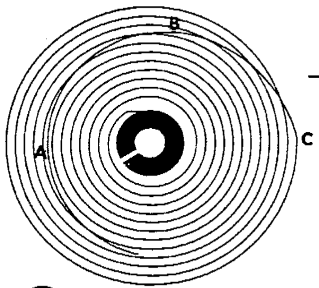
SECOND REQUIREMENT: Correcting Bends in the Overcoil.

In the next two questions, assume the two overcoils shown were intended to follow between the third and fourth coils. Since they do not, what correction is needed? Place the letter of the answer you select on the short line in front of the question number.



6

____ 6. A. Grasp overcoil at A and bend overcoil toward center with taper pin or second tweezers.
B. Grasp with tweezers at B and with taper pin or second tweezers bend overcoil away from center.
C. Grasp with tweezers at C and with taper pin or second tweezers, bend overcoil away from center.
D. Grasp with tweezers at C and bend overcoil toward center with taper pin or second tweezers; then grasp at B and bend overcoil away from center in like manner.

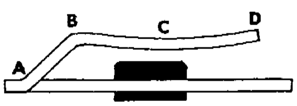


7

____ 7. A. Grasp overcoil with tweezers at A and bend overcoil away from center.
B. Grasp overcoil with tweezers at B and with taper pin or second tweezers bend overcoil outward.
C. Grasp with tweezers at C and with taper pin or second tweezers, bend overcoil outward.
D. Grasp with tweezers at C and bend overcoil away from center; then grasp at B and bend toward center.

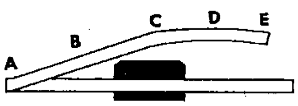
THIRD REQUIREMENT: Leveling the overcoil with body of spring.

In the next three questions, these side views indicate overcoils not level and parallel to the body of the spring. What correction is needed? Place the letter of the answer you select on the short line in front of the question number.



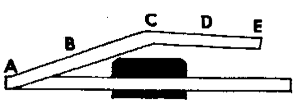
8

____ 8. A. Hold at A with tweezers while you press down at B; then hold at B and press down at C with pegwood.
B. Hold at B with tweezers and press down on D with pegwood.
C. Hold at C with tweezers and press down on D with pegwood.
D. Hold at B with tweezers while you lift at C with tweezers; then hold at C while you press down D with pegwood.



9

____ 9. A. Hold at C with tweezers and press down D with pegwood.
B. Hold C with tweezers while you lower D with pegwood; then hold D and raise E with tweezers.
C. Hold at A and raise at B with tweezers; then reshape bend at C.
D. Lift up at A with tweezers, press down at C with pegwood; then lift at E.



10

____ 10. A. Hold at C and lift up at E.
B. Hold at A and lift up at E.
C. Hold at A and raise at B with tweezers; then hold at C with tweezers and press down at E.
D. Lift at A with tweezers; then press down at C.

-- -Detach page or cut along this line- - - - - and send to the School for grading.- -

CHICAGO SCHOOL OF WATCHMAKING

Test Questions **Master Watchmaking** *Lesson No. 19*

Name: ______________________ No.: ______________ Date ______________

SUBJECT: The Overcoil Hairspring GRADE: ____________

DIRECTIONS: In the following statements, select the ONE BEST answer and place the letter of that answer on the short line in front of the question number.

_____ 1. The overcoils in this lesson are all alike in one respect:

A. The raised portion is formed the same in all.
B. All follow a space instead of a coil.
C. All have the overcoil following the same coil, counting from outside of body.
D. The section of spring which lies between the pins is primarily the same.

_____ 2. In raising a gradual bend overcoil, the two hairspring tweezers are placed close together about how far from the end of the outside coil?

A. One full coil.
B. 7/8th of the distance.
C. 3/4th of the distance.
D. 5/8th of the distance.

_____ 3. In actual repairing, the distance between the body and overcoil of the hairspring is determined by:

A. Space equal to 1 or 2 times the width of the hairspring coil.
B. Space equal to 2 or 3 times the width of the hairspring coil.
C. Space equal to 3 or 4 times the width of the hairspring coil.
D. Space between balance cock and arm of balance wheel.

_____ 4. When forming the overcoil of a hairspring, the most important thing is to be sure:

A. The first bend is sharp.
B. The first bend is gradual.
C. The overcoil will clear the body of hairspring.
D. The overcoil is close to body of hairspring.

_____ 5. When forming a knee bend overcoil, how far from the end of the outside coil do you make the first bend?

A. 5/8th of the distance.
B. 3/4th of the distance.
C. 7/8th of the distance.
D. One full coil.

(Please turn over)

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

HOW TO FORM A KNEE BEND OVERCOIL.

Tools, Equipment and Supplies:

#H Dumont Tweezer
Eye Loupe
Overcoiling Tweezer
Pegwood or Taper Pin
Supply of Hairsprings
Soft Wood Block

PROCEDURE:	REFERENCE:
1. Place the hairspring on a piece of soft wood or linoleum.	Sec. 386
2. Grasp the spring with tweezer about 5/8ths of a turn from the outer end.	Fig. 19-22
3. Hold hairspring firmly with tweezer as you press tips of tweezer down into soft wood block or linoleum.	Fig. 19-23
4. Turn the spring over and let the raised portion overhang the work surface.	
5. Move your tweezer about 1/8th of a turn from the first bend and again press down with tips of tweezer.	Fig. 19-25
6. Level the overcoil. Grasp the hairspring firmly with a tweezer at the first bend you made. Press down or lift up on the overcoil as required with a piece of pegwood or a taper pin.	Fig. 19-27
7. Form the overcoil over body of hairspring with overcoiling tweezer or taper pin and tweezer to follow a selected coil or space between coils.	
8. Check for proper height, level, and follow over proper space or coil.	

HOW TO FORM A GRADUAL BEND OVERCOIL.

Tools, Equipment and Supplies:

2 Fine Pointed Hairspring Tweezers	Flat Glass	Eye Loupe
Overcoiling Tweezer	Supply of Hairsprings	

PROCEDURE:	REFERENCE:
1. Place hairspring on flat glass surface.	Sec. 385
2. Grasp outer coil with two fine pointed tweezers, side by side, and held straight up, about 7/8ths of the distance from the outer end.	Fig. 19-11 Fig. 19-12
3. Hold firmly with the innermost tweezer. Tilt the tweezer nearest the end away from the spring so as to raise the outer coil at a point directly across from your tweezers.	
4. Release the tweezer you tilted but hold with the other until you have checked that the coil has been raised high enough (two or three times the width of the spring for your practice spring).	Fig. 19-13
5. Pick up the spring with the tweezer still in place and see that the coil is as high as you want it. If so, replace spring on glass and continue on. If height is not correct, replace the other tweezer and tilt it further away or back toward the spring to raise or lower the coil as necessary.	
6. When you have the correct height, release both tweezers and move them directly across to the point you have just raised. Repeat the tilting procedure as you did in 3 above until the overcoil is level from this point to the end.	
7. Move to a point about halfway between the first two bends and where the overcoil will clear the body of the spring. Form the overcoil with overcoiling tweezer or taper pin and tweezer to follow a selected coil or space between coils. If the pattern you are following requires a second bend, make it in the same way.	Fig. 19-12 Fig. 19-17
8. Check the regulation arc to be sure it is properly rounded and follows the proper space or coil.	Fig. 19-18 Fig. 19-19
9. When finished, check the level and height of the overcoil in relation to the body of spring.	

CHECK YOURSELF

Progress Check 19 — A Self Test Review of Lesson 19

After you have studied Sections 383 through 386, see if you can answer these questions without looking back. DO NOT SEND ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the quiz. If you have missed any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The shape of an overcoil is established by the ____________________.	383
2. The repairman's job is usually ____________________ an overcoil.	383
3. Although the shape of an overcoil may vary, the section which lies between the ____________________ is just about the same in all.	383
4. The direction of the overcoil is determined by the location of the ____________________ and ____________________ on the balance cock.	383
5. The difference between the two types of overcoil is in the formation of the ____________________.	384
6. The height of the overcoil is determined by the space between the ____________________ and ____________________ when fitting a hairspring to a watch.	385
7. The gradual bend overcoil is raised with ____________________.	385
8. The knee bend overcoil is raised with ____________________.	386
9. Although there are various methods used to form the overcoil itself, the most common one makes use of ____________________ ____________________.	385
10. Leveling the overcoil may be done with ____________________ or with ____________________.	385 386

ANSWERS TO PROGRESS CHECK 19:

1. manufacturer
2. reshaping or correcting
3. regulator pins
4. stud
   regulator pins
5. bend
6. balance cock
   arm of balance wheel
7. two tweezers
8. one tweezer
9. overcoiling tweezers
10. two tweezers
    one tweezer and taper
    pin or pegwood

MASTER WATCHMAKING

LESSON 19 – COLLETING THE HAIRSPRING

Sections 385 - 386

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

SEC. 385—Centering Collet

The results obtained when truing a hairspring in the round or centering the collet are theoretically the same. As the student becomes more proficient at his trade many of the elementary principles he has learned will fade into the background. This is very evident in truing hairsprings in the round. The average watchmaker cannot begin to equal the speed of a factory trained man when it comes to truing a hairspring. A factory trained man can true a hairspring in the round and flat (sometimes with one bend) in a surprisingly short time. They average upwards of 200 a day. This speed comes only with constant practice.

The illustrations to follow show some of the common errors found when a hairspring is out of true in the round or when colleting a hairspring, and the closer the student gets the center of the collet to the theoretical center of the hairspring the less work he will have in truing the hairspring on the wheel. It is possible to make these corrections so exact that when the hairspring is put on the wheel it does not need any further corrections. However, this is the exception rather than the rule. It is, therefore, of the utmost importance that the student learn now the elementary principles of truing a hairspring in the round.

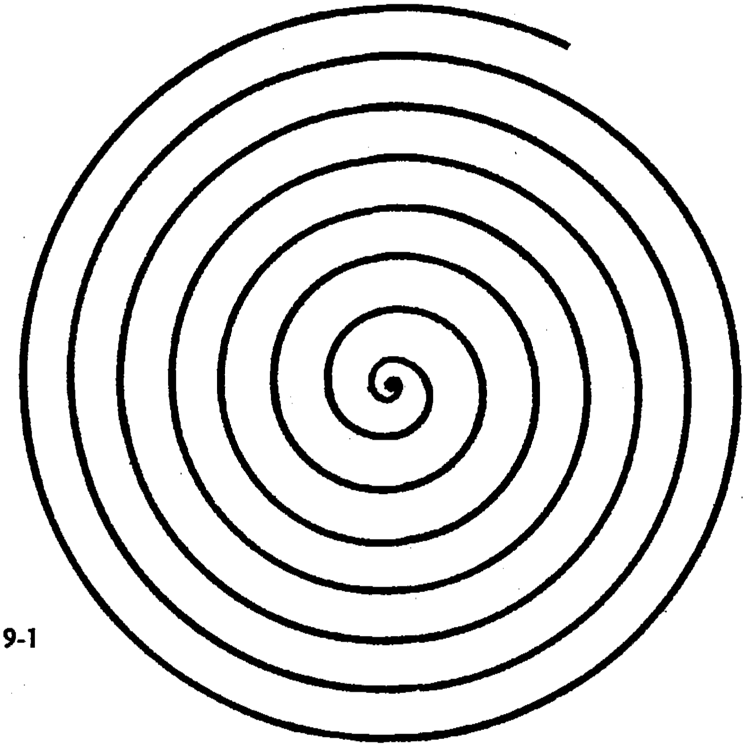


Fig. 19-1

At the expense of repetition let it be understood that when a hairspring is true in the round the exact center of the hairspring and the center of the collet are one and the same. In figure 19-1 the center of the hairspring is located at the inner end of the spiral and if the center of the collet concurred with this center the hairspring would be true in the round.

Figure 19-2 ilustrates an enlarged view of the collet and inner coils of the hairspring. The small dot in the center of the collet is the theoretical center of the **collet** and **hairspring.** In order to illustrate that the removal of an excess amount of center coils does not in any way affect these centers, a dotted line is shown from the outside coil to the collet. This proves that any hairspring can be trued perfectly in the round provided there is enough space around the collet. The student must learn to visualize this.

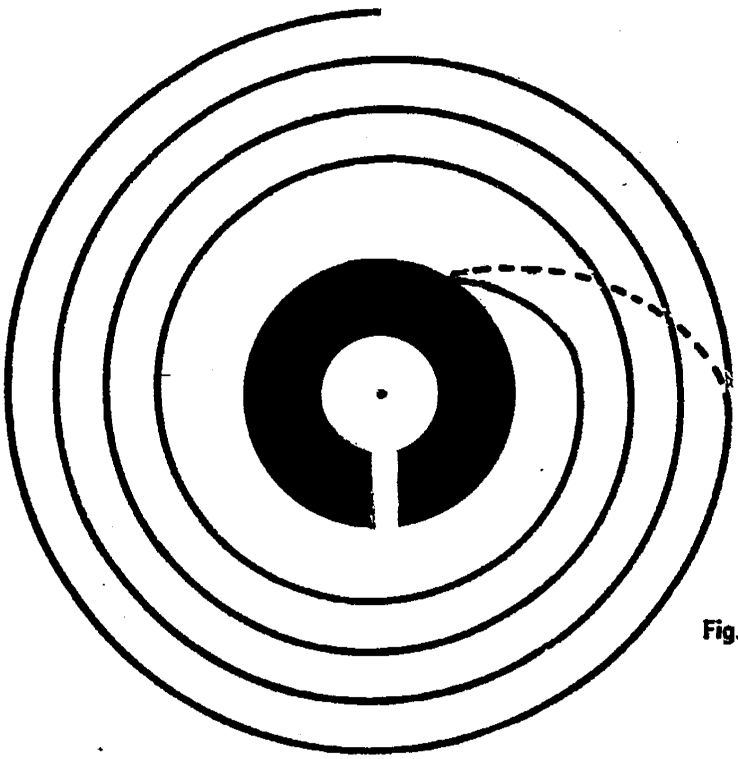


Fig. 19-2

The following illustrations show by the two black dots the theoretical centers of the collet and hairspring respectively. It is easy to see the direction in which the collet must be moved in order to make these centers coincide.

Figure 19-3: The center of the collet is to the left of the hairspring center due to the inside coil being too far from the collet where it leaves the collet. Closing this space until it appears as in figure 19-2 will center the collet. A pair of hairspring tweezers placed in the approximate position shown and carefully closed would bring the desired results.

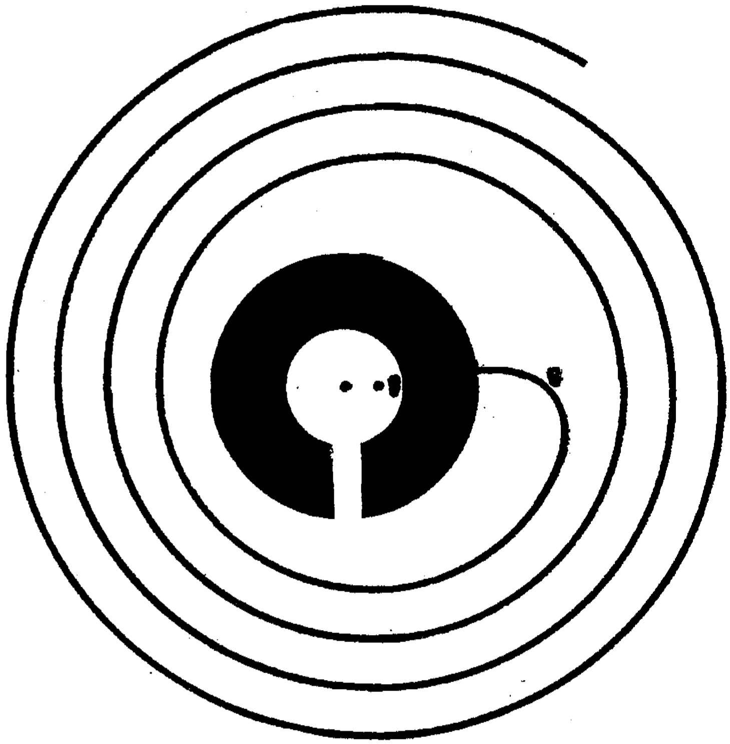


Fig. 19-3

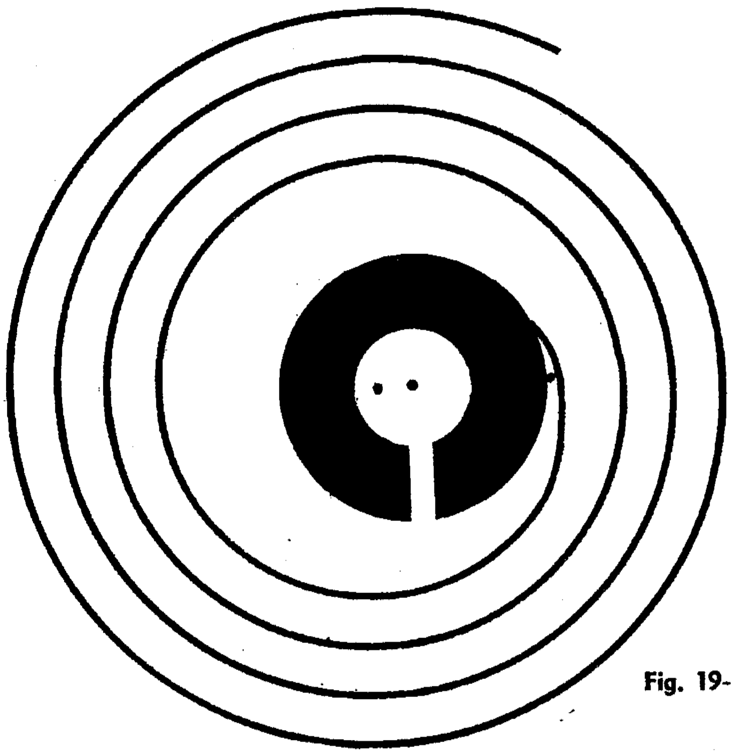


Fig. 19-4

Figure 19-4: The center of the collet is to the right of the hairspring center due to the inside being too close to the collet as it leaves the pinning point. Inserting the taper pin between the collet and the inner coil will force collet in the proper direction. Refer to and compare with figure 19-2.

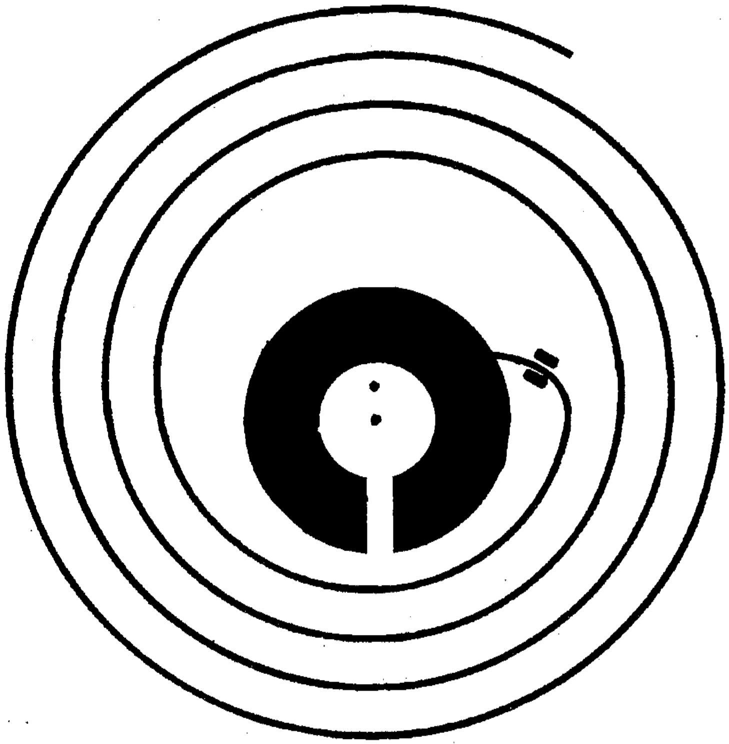


Fig. 19-5

Figure 19-5: The tweezers placed in the proper position and twisted in a manner which would bring the center of the collet toward the theoretical center of the hairspring would be the first correction. If in making this correction the center of the collet should swing slightly to the right of the hairspring center, it may be moved into the correct position with the taper pin.

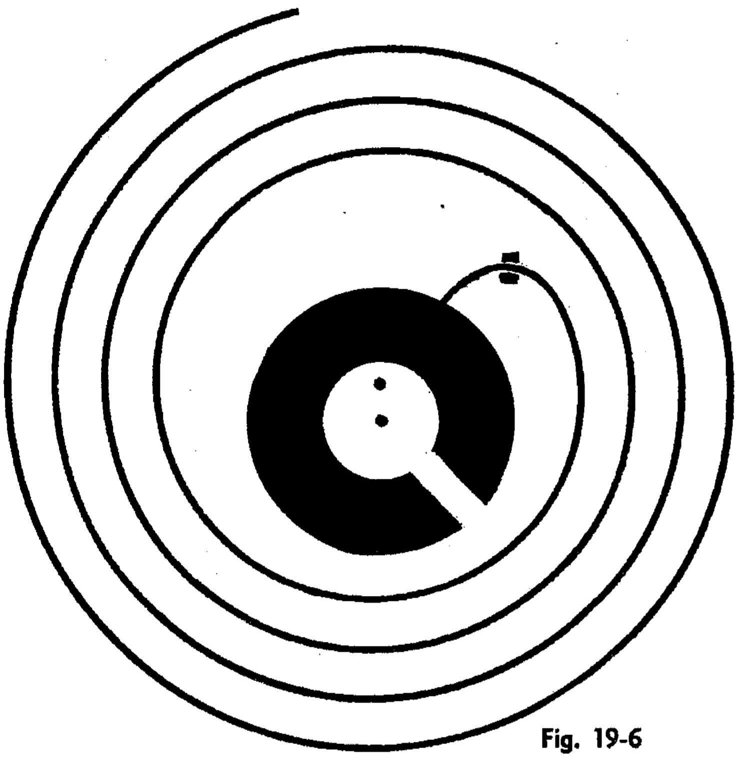


Fig. 19-6

Figure 19-6: To move the center of the collet toward the hairspring center place tweezers in approximate position shown and make the bend. In all probability the center of the collet will swing toward the left slightly making necessary another bend similar to figure 19-3. Check with figure 19-2.

Figure 19-7: The center of the collet should move easily and quickly to the hairspring center by placing tweezers in approximate position shown. In this case the best results would be obtained by applying pressure to the tweezers in order to flatten the curve of the hairspring between the tweezers slightly. Check with figure 19-2.

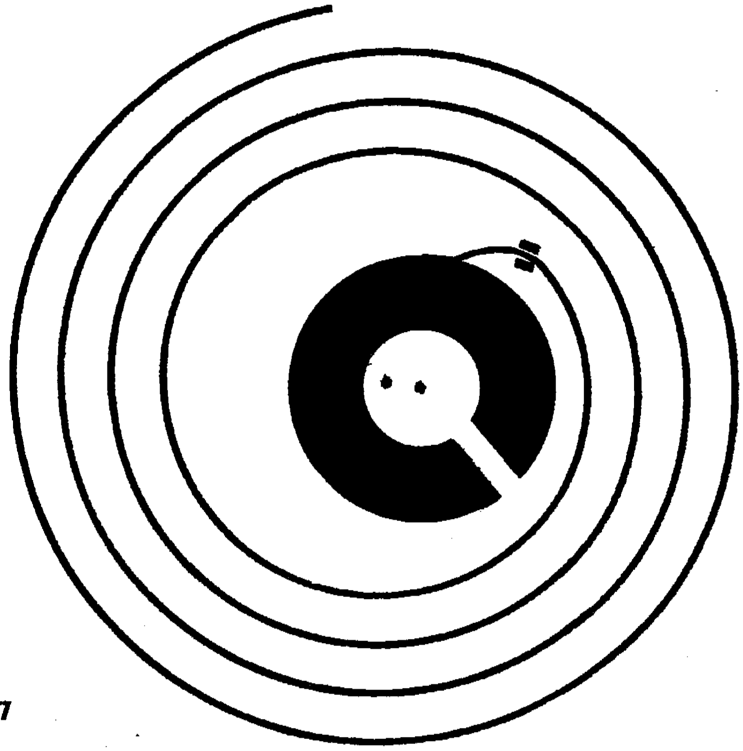


Fig. 19-7

Figure 19-8: The amount of space between the inside coil and the collet is excessive and with the tweezers placed in the approximate position shown carefully exert just enough pressure to close this space. In so doing another bend similar to the one illustrated in figure 19-7 may be required. Check with figure 19-2.

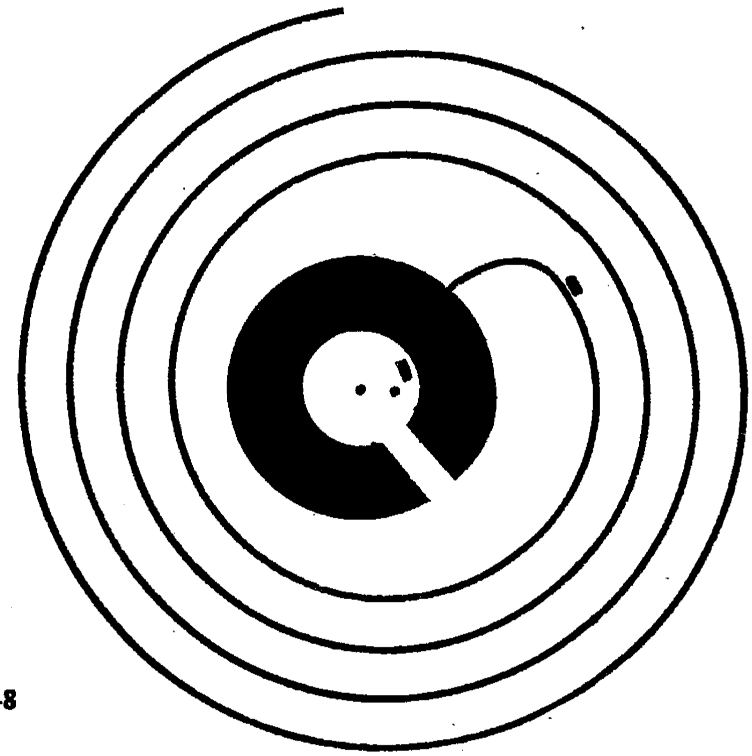


Fig. 19-8

Figure 19-9: The tweezers placed in the approximate position shown should enable the student to bring the center of the collet directly over the hairspring center easily. Compare with figure 19-2.

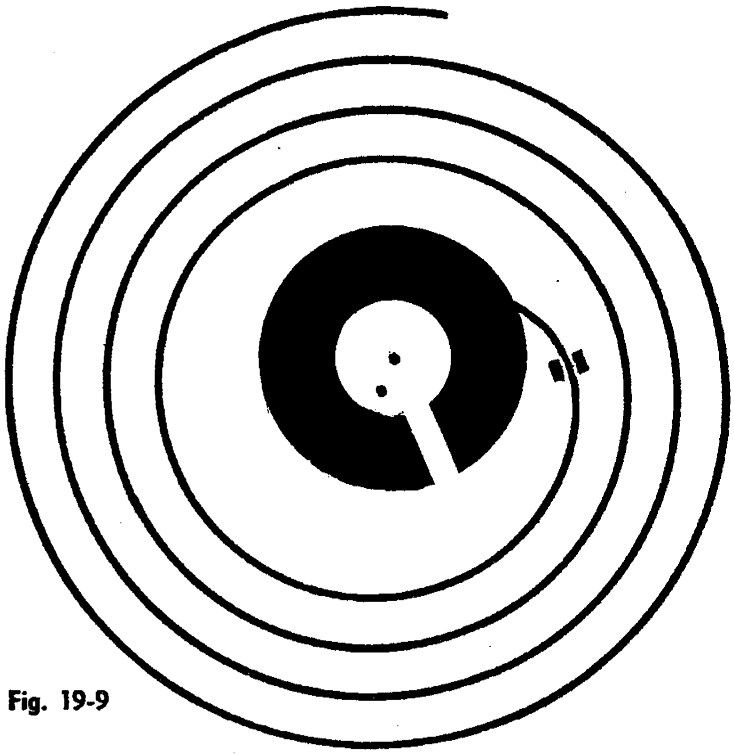


Fig. 19-9

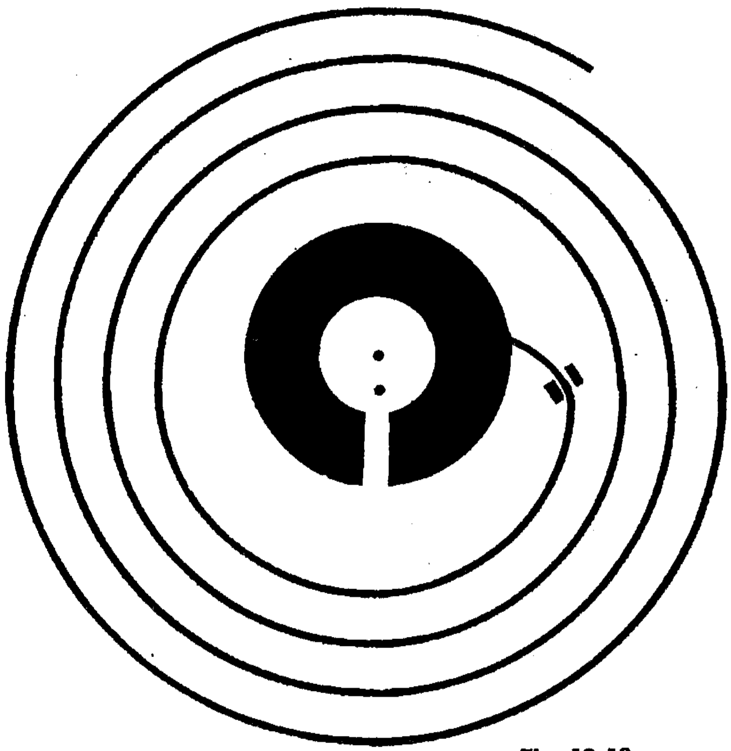


Figure 19-10: This bend is made similar to figure 19-9. Compare with figure 19-2.

Fig. 19-10

SEC. 386—Colleting the Hairspring

These illustrations should help the student when determining the procedure required to bring a collet to center. This is true not only when preparing to true the hairspring in the round but also when colleting a hairspring. If the student has a fairly good conception of the location of the collet center with the hairspring center it will be helpful when colleting a hairspring.

Colleting a hairspring is a job that the watchmaker is not often required to do in this day and age of modern watch repairing. Most new hairsprings come colleted and are selected to fit the collet shoulder properly. At times it is necessary to replace a collet when some careless watchmaker has endeavored to force a collet over a collet shoulder which is too large, which usually causes the collet to crack.

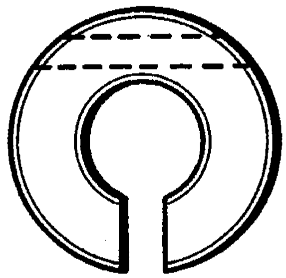


Fig. 19-11

Fig. 19-12

The collet is a small split collar made of spring brass, figure 19-11. Directly opposite the slot in the collet is a small hole, illustrated by the dotted line, large enough to receive the inner end of the hairspring prior to pinning.

The small tapered brass pin illustrated in figure 19-12 is used to pin the hairspring in the collet. They may be purchased from a supply house under the name of hairspring stud pins.

At times the watchmaker is called upon to file his own stud pins or tapered pins of similar design. Figure 19-13 illustrates how this may be done. A small block of wood, preferably hard wood, has a notch cut in it with the edge of a file. The deepest end is toward the front and tapers up the block depending upon the length of taper desired. A piece of brass wire of a small diameter is held in a pin vise and alternately rotated with the left hand while in the notch of the hardwood block. The file illustrated by the dotted line is moved lightly back and forth over the wire until the pin is formed.

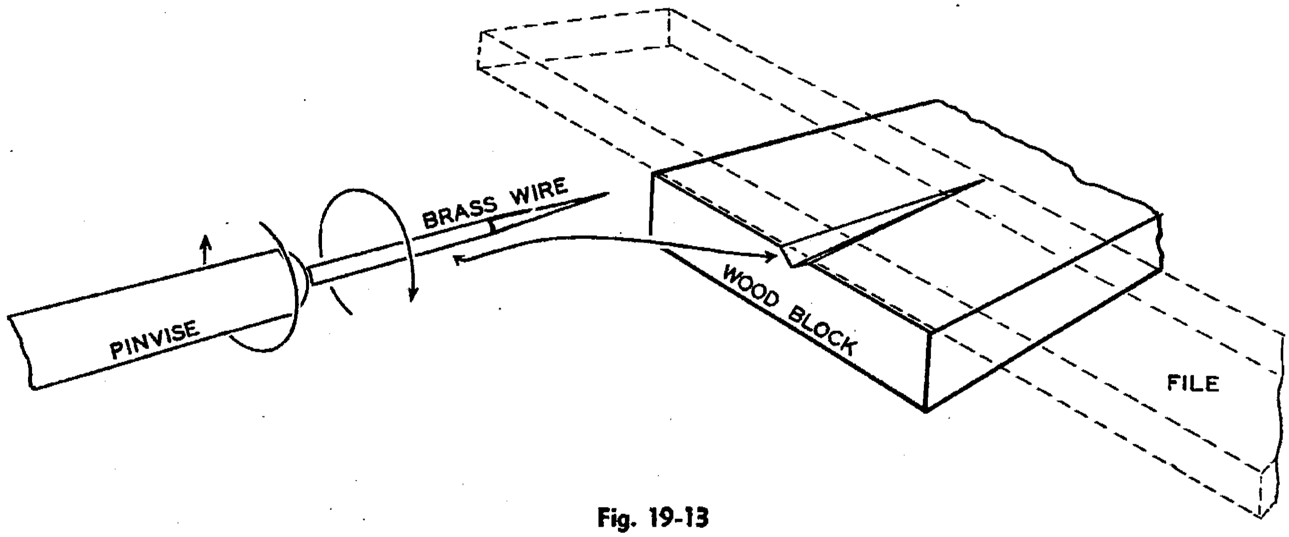


Fig. 19-13

When working on the collet or pinning the hairspring to the collet the collet can be held on a tempered tapered steel pin or a broach, figure 19-14. The pinning hole should be cleaned out with a small broach before attempting to pin the hairspring.

Always try the pin in the hole in the collet before attempting to pin the hairspring. It should go through the collet similar to pin illustrated in figure 19-15.

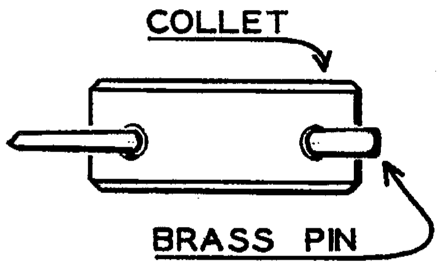


Fig. 19-15

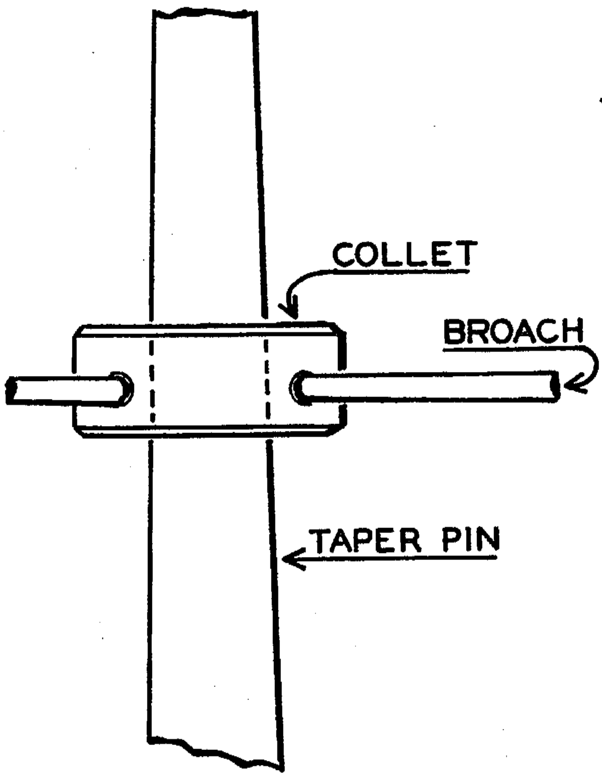


Fig. 19-14

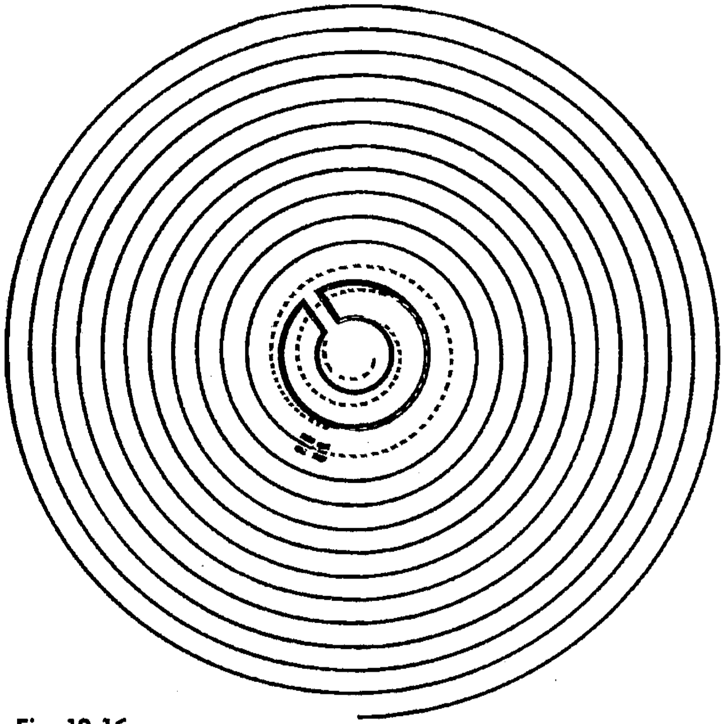


Fig. 19-16

It is sometimes necessary to break out the inner coil of the hairspring in order to get enough space between the coil and the hairspring to true it properly. Figure 19-16 illustrates a hairspring with the collet placed directly over the center of hairspring. Breaking the coil at the point where dotted line joins solid line will allow enough space for the collet. Break at this point by using two pairs of fine pointed tweezers held vertical with the points close together, twisting back and forth.

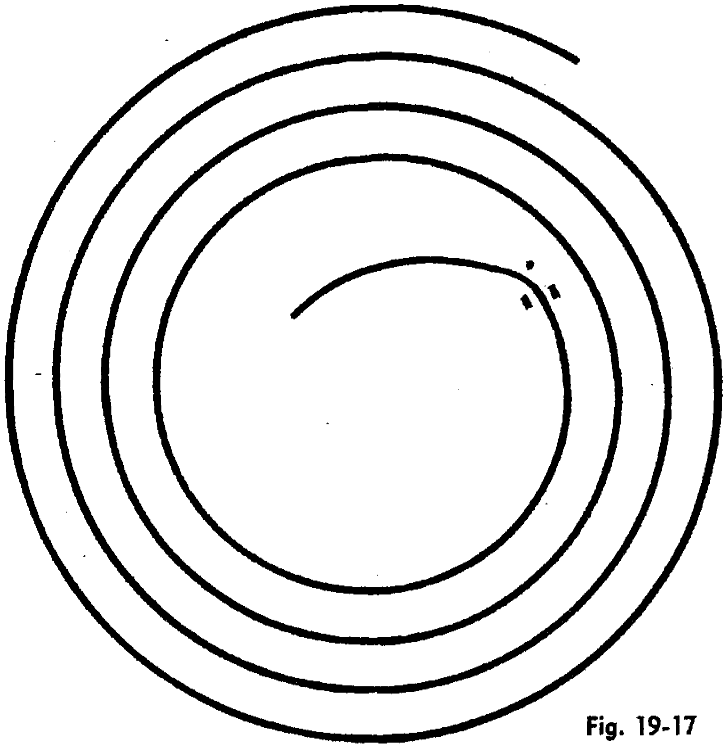


Fig. 19-17

A portion of the inner coil will be bent in the manner shown in figure 19-17, to form the tongue. The length of this tongue should not exceed the length of the hole in the collet. It is formed by holding coil with a pair of hairspring tweezers and bending with taper pin. The tweezers are represented by the two black dashes and the taper pin by the dot.

With the collet in place on the taper pin or broach which you will hold in your left hand, insert the tongue of the hairspring into the hole in the collet, figure 19-18.

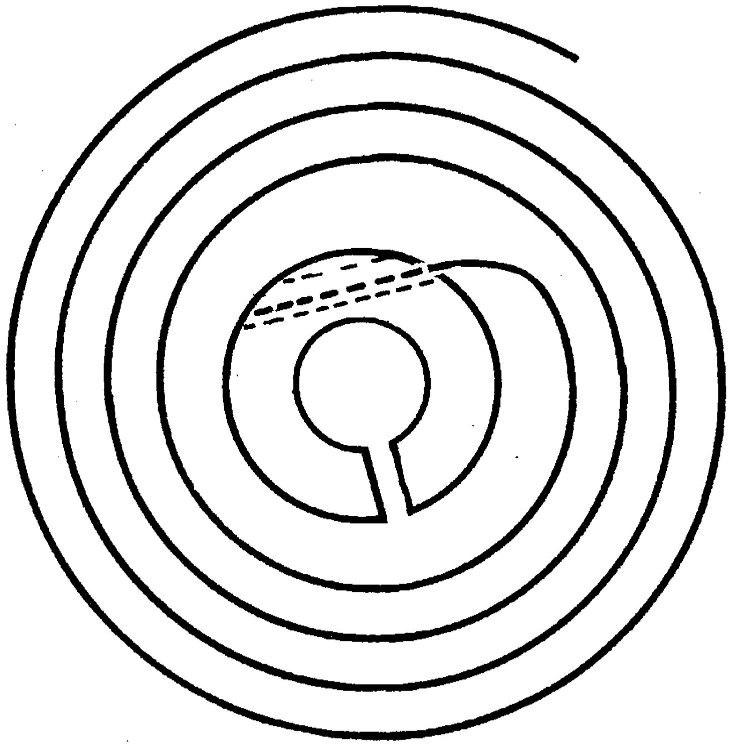


Fig. 19-18

In order to keep the hairspring level you may use the forefinger of your left hand as a guide, letting the hairspring rest upon this finger until the brass pin is in place, figure 19-19.

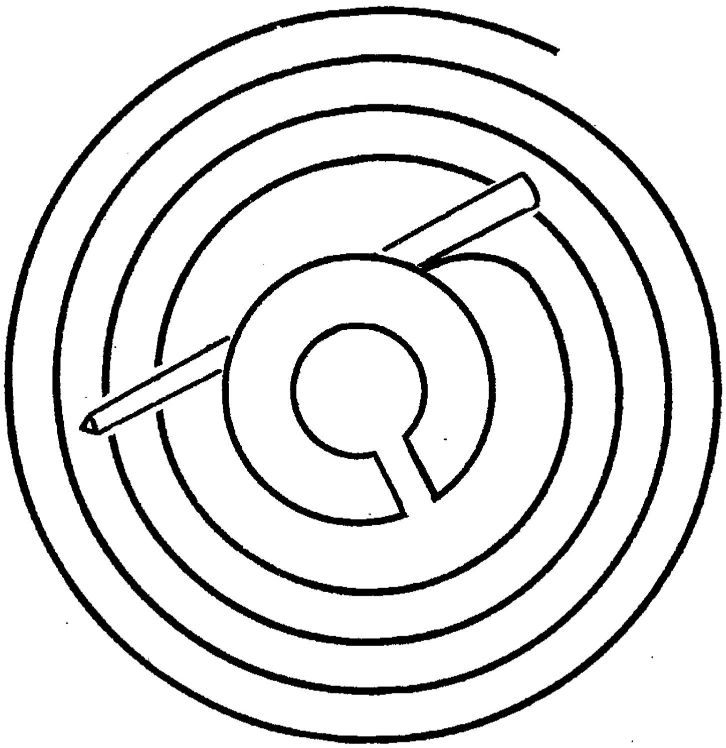


Fig. 19-19

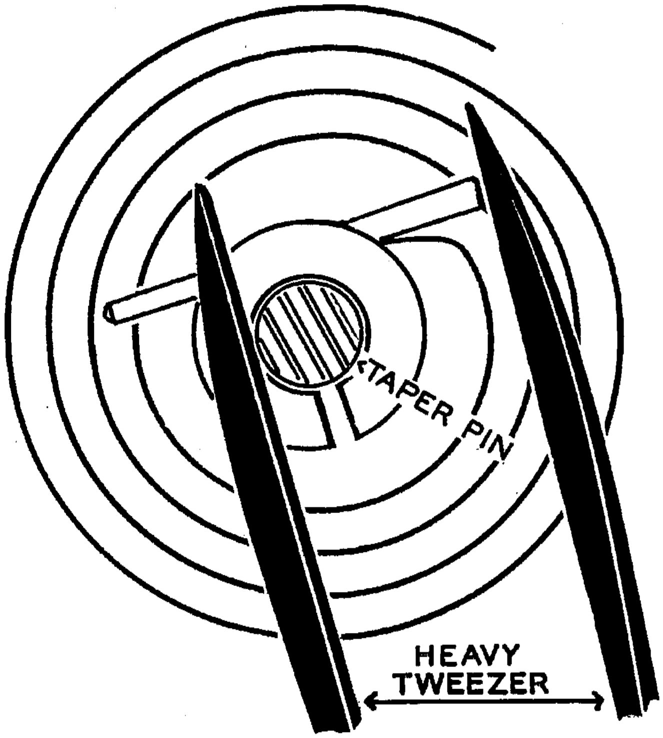


Fig. 19-20

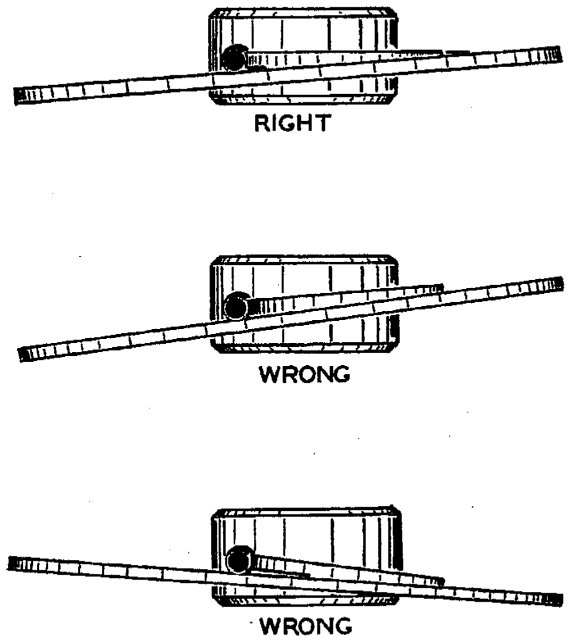


Fig. 19-21

The pin may be forced into place with a pair of heavy tweezers in the manner shown in figure 19-20. However, before forcing the pin in as far as it will go make certain that the inner coil is parallel with the top or bottom of the collet as shown in the upper illustration in figure 19-21. In this illustration the body of the hairspring is held below the hole in the collet by the pin which has not been cut off as yet, but the inner coil is parallel with the upper edge of the collet. When the pin is cut off the body of the hairspring will resume its position in the same plane as the inner coil.

The center and lower illustrations, figure 19-21, show the inner coil out of position prior to forcing the pin in as far as it will go. If the hairspring is pinned properly it will not require much truing in the flat.

There are other methods of pinning the hairspring to the collet and every watchmaker uses the method he prefers, usually the one he adopted when learning the trade. No matter what method is used the student or watchmaker must use the greatest of care not to make a slip and ruin his work. This is very true when cutting off the pin after it has been forced into place. One of the oldest methods of performing this operation is with a small **sharp** knife or heavy razor blade. If carefully executed it will assure the workman of a clean job and there is no danger of leaving the pin protruding.

The collet is held in place on the taper pin and the end of the knife blade is worked across the pin in a sawing manner. Only the very end of the blade is used. The blade is used tangent to the collet at the pin which is illustrated by the dotted line in the upper illustration of figure 19-22. When the pin is cut almost through the remaining portion may be removed with the tweezers.

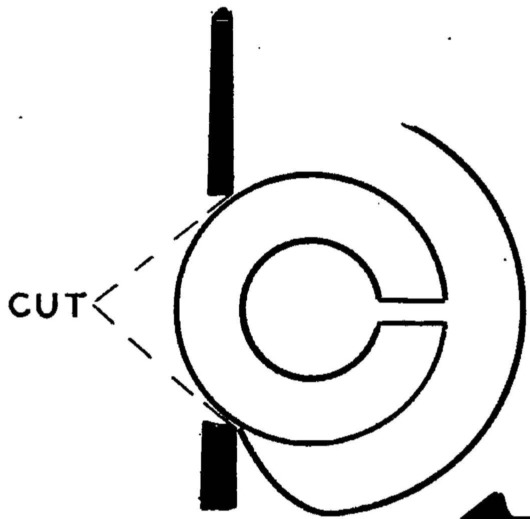
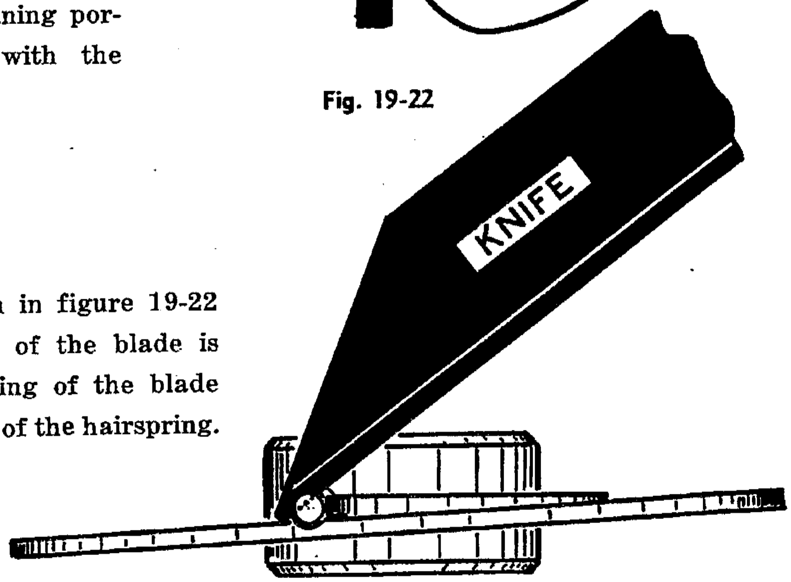


Fig. 19-22

The lower illustration in figure 19-22 shows why only the tip of the blade is used. Any further lowering of the blade would endanger the body of the hairspring.



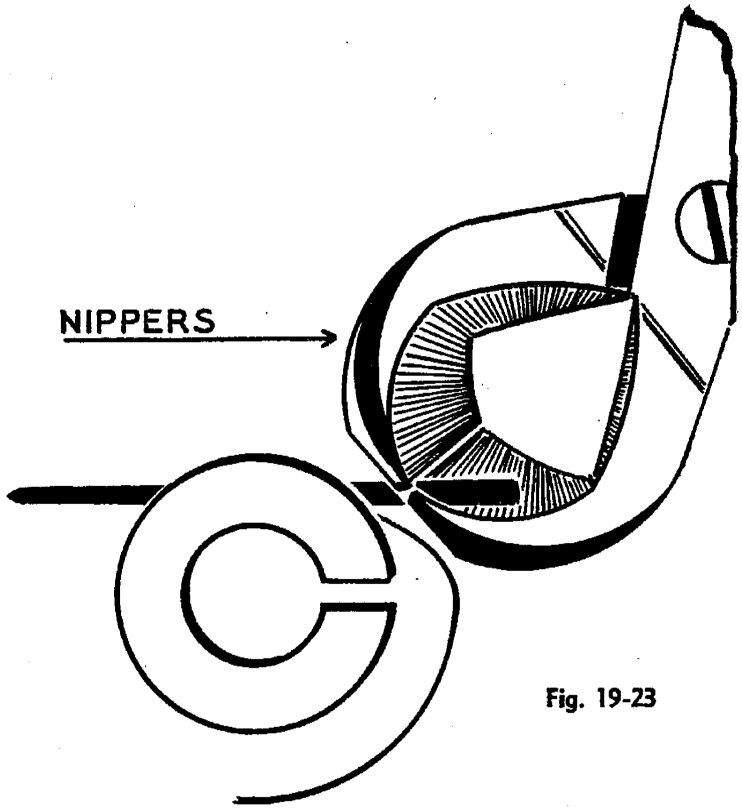


Fig. 19-23

Another method of cutting off the pin is shown above. The jaws of the nippers are ground especially for this purpose and should not be used for any other purpose than cutting small brass pins. The cut off is made before the pin is pushed into place. The protruding end may be removed in the same manner making certain that the nippers are as close to the collet as possible. The methods explained above are the same as will be used when pinning the outside coil of the hairspring to the stud.

INTRODUCTORY INFORMATION

The application to practical watch repairing of the work in this lesson is usually in replacing broken collets, recolleting when the hairspring is broken at the collet, and tightening the hairspring in the collet. When fitting a new hairspring to a watch, the original collet found in the watch is used in the new spring.

KEY POINTS OF ASSIGNMENT 60:

The proper procedure used in colleting.
How to true the hairspring after colleting.

ASSIGNMENT NO. 60: Review Section 385.
Study Section 386.

Study Questions:

1. What kind of pin is used to collet the hairspring?
2. How is the collet held while working on it?
3. What tools are used to form the tongue of the hairspring?
4. What tool is used to cut off the stud pin?

Supplement to Section 386: An alternate method of inserting and cutting the pin.

Follow the procedure as outlined through Figure 19-19. Make a right angle bend on small end of stud pin. Using heavy tweezers, pull the pin into collet until snug. Cut off large end of pin a little away from collet, making cut parallel to edge of collet. Use the knife in a sawing manner, holding it parallel to the body of the spring rather than at the angle illustrated in Figure 19-22. We suggest you try this alternate method and decide which method works best for you.

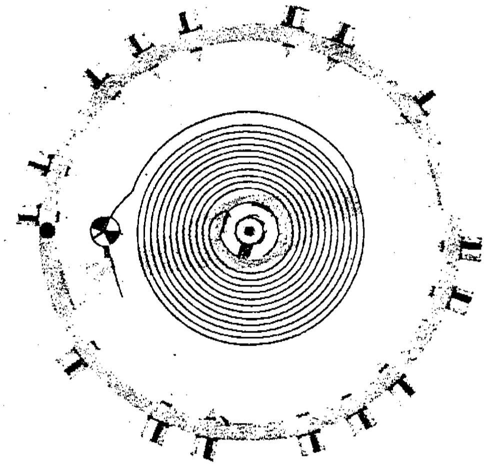
Recommended Practice:

1. Remove the collet from a hairspring by placing on a taper pin and carefully breaking off the hairspring at the collet.
2. Push out the old pin and recollet.
3. Center the collet on a piece of glass as in Lesson 18.
4. Level the hairspring to the collet while holding it on the taper pin.
5. Continue centering the collet on glass and leveling on the taper pin until no further corrections are necessary. By so doing, you will be truing the hairspring in the round and flat respectively.

REQUIREMENT:

Answer the Test Questions for Lesson 19 and send in for grading.

MASTER WATCHMAKING



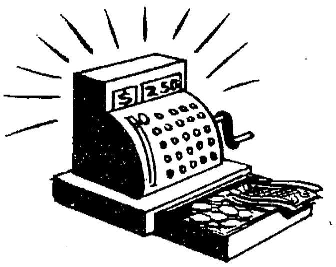
LESSON 20 – FITTING HAIRSPRINGS IN WATCHES

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

Printed in the United States of America

20

INTRODUCTORY INFORMATION



Hairsprings seldom need to be replaced if the watch repairman knows how to make the adjustments covered in these hairspring lessons. Replacement is necessary only when it is not possible to restore the spring to its original condition, as in a rusted hairspring. However, individual springs are no longer available. With so many models of watches now on the market, it is no longer practicable for the repairman to stock the necessary replacement springs. The present day repairman must now have a material house select the correct spring, electronically vibrate it, stud it, and form it to fit the watch. The repairman has only to check the work, install the hairspring in the watch and make minor adjustments to accomplish the replacement. The material house will charge \$2.50 to \$3.25 for such work. The customer pays from \$5.00 to \$7.50 for the job.

KEY POINTS OF LESSON ASSIGNMENTS 63, 64, 65, 66:

- Methods of fitting hairsprings.
- How to order a new vibrated spring.
- How to vibrate hairsprings.
- How to fit a flat hairspring to a watch.
- How to fit a Breguet hairspring to a watch.
- Checking the hairspring.
- Analyzing hairspring faults.

ASSIGNMENT NO. 63: Study Sections 387 through 389.3.

Study Questions:

1. What is the present trend in fitting hairsprings?
2. How do you order a new vibrated hairspring?
3. What is meant by "vibrating a hairspring"?
4. How many times an hour do the balances of most watches swing back and forth?
5. How can you calculate the train of a watch or clock?
6. Which way are the tweezers moved along the hairspring to increase the number of vibrations the balance will make?

Recommended Practice:

1. Make the vibrating stand shown in figure 20-5. Bend a 4 mm brass rod into an L shape with the short portion about 2-1/2 inches long. Saw a slot about 30 mm long in this short piece. Bend it apart sufficiently to file slot smooth. Round sharp corners slightly. Then reshape to hold a pair of tweezers as shown in figure 20-5.

2. Use a large balance with hairspring. Catch the outer coil near the end of hairspring with fine pointed tweezers. Adjust tweezers in slot of stand so pivot will just rest on glass of watch, figure 20-5.

ASSIGNMENT NO. 63 (Continued):

3. Count the vibrations for one minute, Sec. 389.3. Note the number. Is it more or less than 300? Now move your tweezers and count again until you get exactly 300 vibrations per minute. Count several times until you are sure you have it right. Continuing the same count for two or even three minutes will reduce error to a minimum.

4. Repeat this practice on other springs until you know you can vibrate a spring.

ASSIGNMENT NO. 64: Study Sections 390 through 390.4.

1. Where is the desired point of vibration in a flat hairspring?
2. How far apart should the regulator pins be?
3. What makes a watch gain when wound and lose when run down?
4. What is meant by "putting a watch in beat"?
5. What other adjustments might have to be made on a flat hairspring?

Recommended Practice:

1. Obtain a watch which requires a flat hairspring and fit one to the watch. Take the movement apart and count the number of teeth in wheels and number of leaves in pinion. Calculate vibrations balance must make, Sec. 389.1.

2. Note in which direction coils of old spring develop and which side of collet is up. Remove collet and stud from old spring and lay them aside. Now follow steps two through eight in Sec. 390.

3. Study Section 390.1 and illustrations. Regulator must be exactly in center of index. Pin, level and center hairspring, Sec. 390.2.

4. Replace hairspring, Sec. 390.3 and put watch in beat. Make any other adjustments necessary, Sec. 390.4.

5. For additional practice, fit flat hairsprings in the same way to other watches. One of the main purposes of this practical work is to train you to have the finished hairspring perfectly trued in round and flat and perfectly centered and leveled to the bridge.

ASSIGNMENT NO. 65: Study Section 391.

1. How many coils should a Breguet hairspring have?
2. What can you use to help you adjust regulator pins for a Breguet hairspring?
3. How can you correct saucer-shaped or umbrella-shaped hairsprings?

Recommended Practice:

1. Fit a Breguet hairspring to a watch. Calculate train. Note how the coils of the old spring develop and which side of collet is up. Remove collet and stud. Follow steps in Section 391. Have regulator in center of index when pinning hairspring. The overcoil must be correctly formed and perfectly level with the body of the spring. Collet pins and stud pins should be properly cut off and the entire hairspring should look like an original factory-installed spring.

ASSIGNMENT NO. 66: Study Sections 392 and 393.

1. What are the standards for a properly fitted hairspring?
2. When is the best time to check a hairspring?
3. How are hairspring levelers used?
4. What are the main points to check on a hairspring?

Recommended Practice:

Apply what you learn in these sections to every hairspring you encounter.

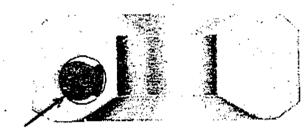
REQUIREMENT:

➧ Answer the Test Questions for Lesson 20 and send in for grading.

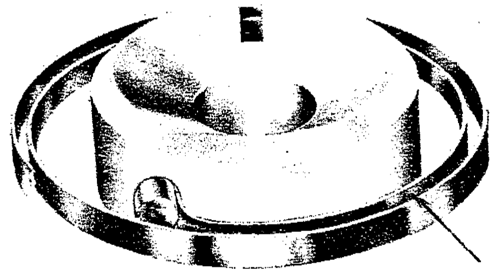
SUPPLEMENTARY INFORMATION

This lesson, like those ahead of it, is concerned with the conventional hairspring, stud and collet arrangement found on most watches. In recent years Elgin Watch Company has developed a method of attaching the hairspring to the collet and stud with a special bonding material by means of which the spring is automatically true in the flat and round. The disadvantages of the ordinary arrangement and the advantages claimed for this newer method are illustrated ir figures 1 and 2 below: (Illustrations from Elgin National Watch Co.)

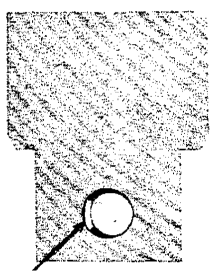
FIGURE 1 OLD METHOD



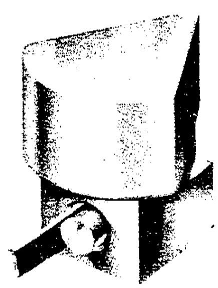
Spring was stressed when brass pin was used to wedge it into hole in collet.



Added stress occurred when spring was trued (bent) in the flat and in the round.



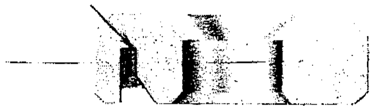
Spring was stressed when brass pin was used to wedge it into hole in stud.



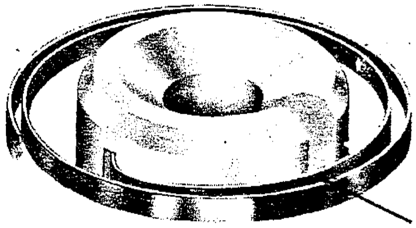
Added stress occurred when stud was twisted into level position and flexed so it would fit into hole in balance cock.

SUPPLEMENTARY INFORMATION (Continued):

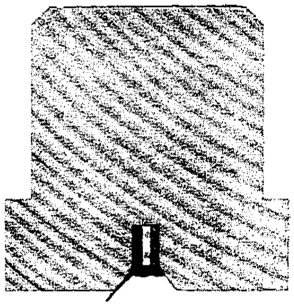
FIGURE 2 NEW METHOD



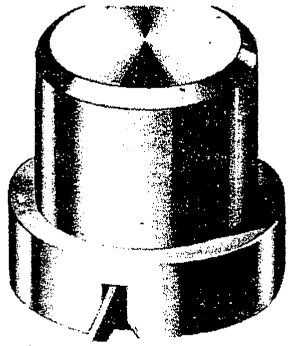
Spring is bonded into slot cut across collet, without stressing.



Spring is centered on collet and leveled horizontally before bonding.



Spring is bonded into slot cut across new type of stud and is automatically level.



Round stud seeks own position in balance cock and is then anchored with stud screw.

Elgin has not marketed this bonding material because its use requires special techniques and expensive equipment. Under ordinary handling the bond will not loosen. It is not affected by most cleaning solutions but may be weakened if left too long in a commercial cleaning solution which has a high proportion of chlorinated solvents. Because of this, take special care when cleaning hairsprings fastened with this bonding material so they do not remain in any cleaning solution over 60 seconds. If you should need more time for cleaning -- and it is seldom necessary -- remove the hairspring. Dry it immediately in warm sawdust or warm air and then dip it again in the cleaning solution.

If a bonded spring does loosen, you can repair it by completely removing the bonding material and rebonding with shellac. However, this makes the hairspring very vulnerable to trouble the next time it is cleaned, as shellac dissolves much more readily in alcohol. A more practical repair is to use a regular round hole collet and pin the hairspring in the regular way. If the hairspring loosens at the stud, you can use a Swiss stud with a round hole and pin the hairspring here in the ordinary way.

SEC. 387—Fitting Hairsprings

The balance wheel and hairspring are like people and clothes. They must be fitted to each other. Just as a small man would be weighted down in a big man's overcoat, so a small balance wheel would be over powered with a heavy hairspring. There is one right spring for each size balance wheel and your job as a repairman is to find it.

Formerly you could select, vibrate, and fit the hairspring yourself. You still can if you can find a suitable spring. Some repair shops may still have stocks of hairsprings, but you can no longer buy individual springs or assortments of them as before. There are simply too many makes of watches on the market today. It would take an enormous stock just to be sure that you had the right spring on hand when you needed it. The modern practice is for the repairman to send out for a new hairspring.

This helps the repairman in several ways: It eliminates the need for an expensive inventory of hairsprings. It saves time, for vibrating is a time consuming job if you are not doing it regularly. It also does away with need for a new hairspring.

But even though the actual work is now done by the material house, it is still your job to check the final result to be sure the hairspring is as perfect as it should be. When you are through with this lesson, you will know what to look for.

SEC. 388—How to Order a New Vibrated Hairspring

It is a rather simple matter to order a new vibrated spring. You simply send the material dealer the balance complete (trued and poised), the balance cock, the hairspring stud and the old collet. The dealer will then select a hairspring of correct strength and fit it to the wheel.

SEC. 389—Vibrating Hairsprings

By now you may be wondering what vibrating a spring means. It means simply this: The balance and hairspring together control the number of times the balance swings back and forth or oscillates in one day, one hour or one minute. (An oscillation is a double swing, forward and back. A vibration is a single swing, either forward or back.) You must know the vibrations a balance makes in order to vibrate the hairspring to match.

The biggest percentage of watches have balances which vibrate 18,000 times per hour, 300 times per minute, or five times per second. This amounts to 432,000 vibrations in 24 hours.

Slight errors in vibration can mean large errors in timing. For example, suppose that a balance vibrates only 298 times in one minute instead of exactly 300 times a minute. Instead of vibrating 432,000 times in 24 hours, the balance would vibrate only 429,000 times. This is a difference of 2880 vibrations in 24 hours. Each vibration equals 1/5 of a second, so this difference amounts to 9 minutes and 36 seconds a day. This is why accurate vibrating is important.

Not all watches vibrate 18,000 times an hour. Some old watches run 14,400 and 16,600. And some of the newer small watches vibrate 21,600, 22,500 19,500 and so on. As a result, you must be able to calculate the train to find out how many times any balance will vibrate in 24 hours, one hour or one minute.

SEC. 389.1 - Calculating the Train of a Watch

Calculating a train is easier than it looks. You already know the center wheel makes one turn in one hour so you start from there. Now multiply all the teeth in the train wheels together with the 2 pallet stones. Multiply all the leaves in the 3rd, 4th, and escape pinions together. Divide the first result by the second. Your answer will be the number of vibrations in one hour. Here is the method illustrated:

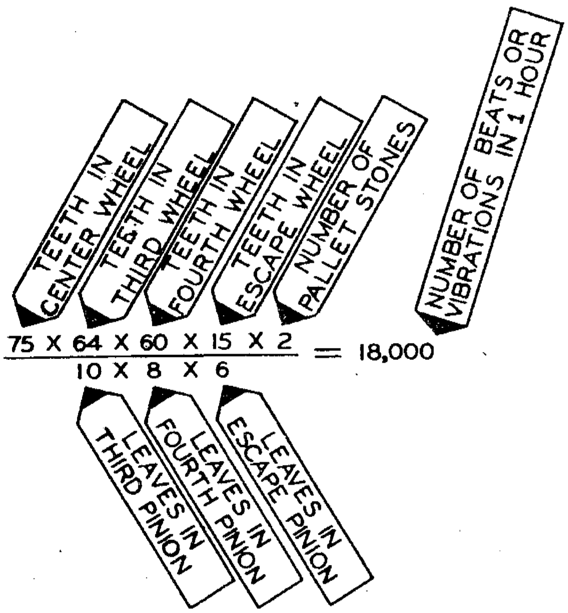


Fig. 20-1

Knowing the beats per hour, simply divide by 60 to get the beats per minute:

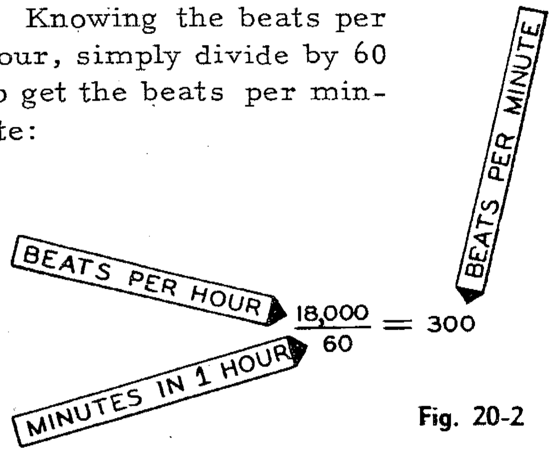


Fig. 20-2

The train of a clock can be figured in the same way.

If the watch has a second hand, you can simplify the procedure and find the beats per minute directly. In this case, divide the teeth in the fourth wheel by the number of leaves in the escape pinion. Multiply this result by twice the number of teeth in the escape wheel. For example:

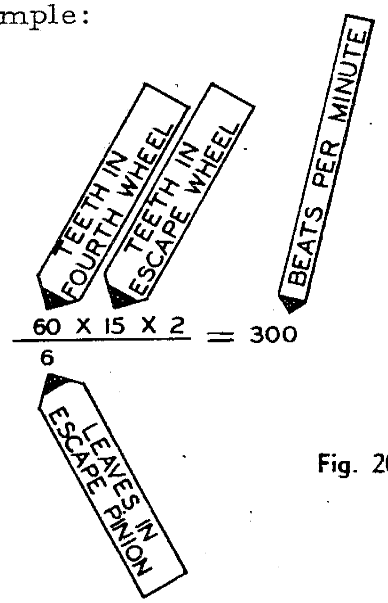


Fig. 20-3

Here's how the full equation appears when we have an extra wheel and pinion and an escape wheel with 12 teeth:

$$\frac{42 \times 42 \times 35 \times 35 \times 12 \times 2}{7 \times 7 \times 7 \times 7} = 21{,}600 \text{ (vibrations per hour)}$$

SEC. 389.2 - Hairspring Vibrating Tools

In vibrating a hairspring, you will need some means to aid you in counting the vibrations. Figure 20-4 shows one type of balance spring vibrating tool. It uses a master balance vibrating 18,000 times per hour and cannot be used for balances which vibrate more or fewer times than this.

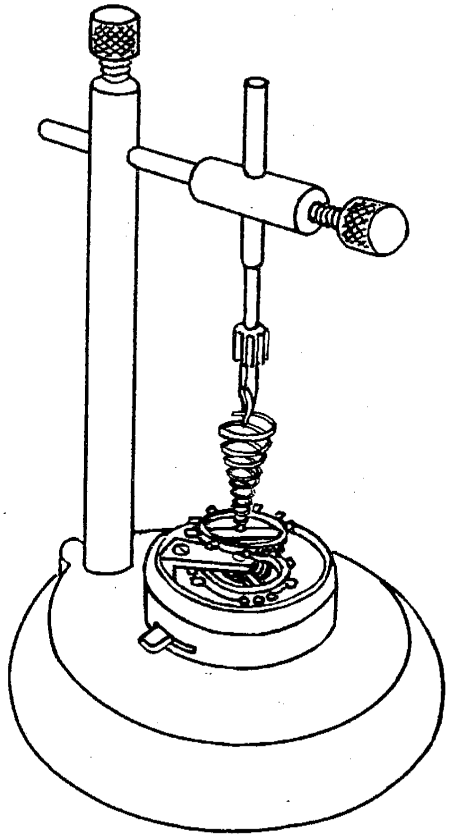
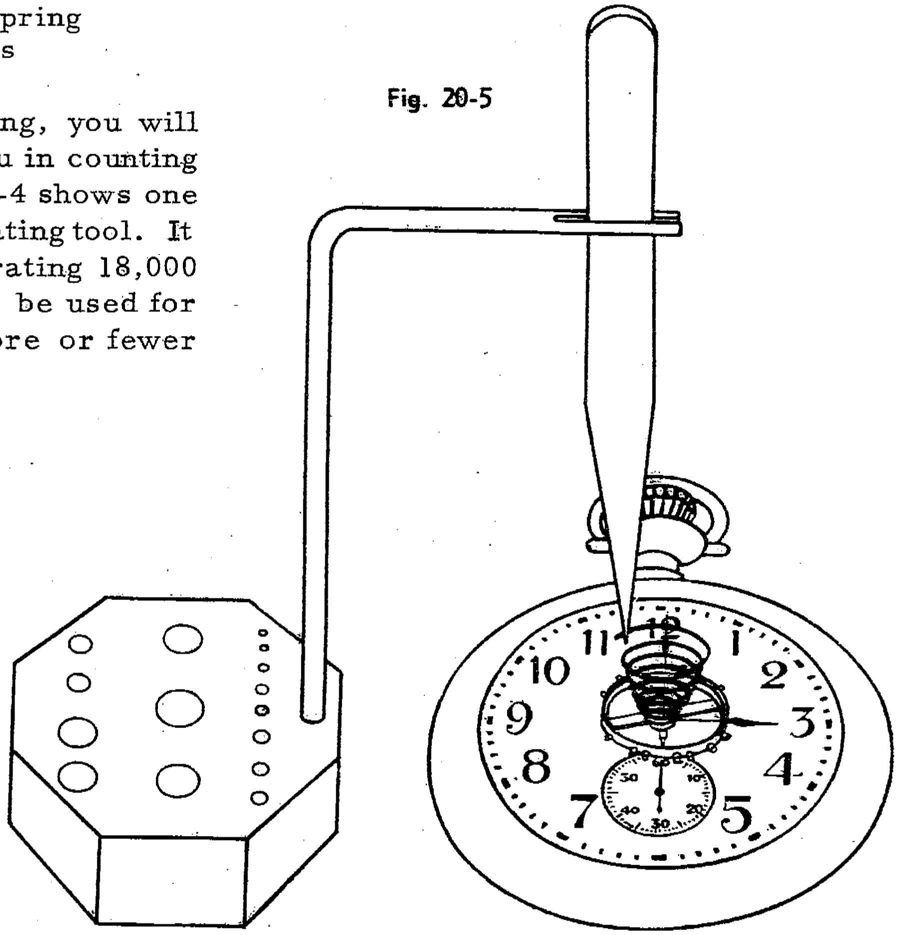


Fig. 20-4

You can readily improvise a suitable tool by bending a piece of 4 mm brass rod to the shape shown in figure 20-5. In the upper section cut a slot to hold a fine pointed hairspring tweezer as illustrated. Use a bench block for a stand.

In vibrating a hairspring, adjust the rod and tweezer holding the hairspring so the lower pivot just rests on the glass of the watch used as a timekeeper. This watch should run accurately and have a large second hand.

Fig. 20-5



SEC. 389.3 - Counting the Vibrations

Your task now is to count the vibrations. A beat of 300 times a minute is difficult to count. You will find you can readily count if you count every other vibration and multiply your answer by 2. Figure 20-6 illustrates a balance wheel. A is the balance arm at rest. B is the balance arm at the 1st vibration. C is the balance arm at the 2nd vibration. Now suppose the balance is vibrating from C to B and B to C. If you will count only the times the arm stops at line B or C and multiply by 2, you will have the actual number of vibrations the balance makes. Now by timing these vibrations with an accurate indicator (the second hand on your master timepiece), you can tell exactly how many vibrations the balance makes in one minute.

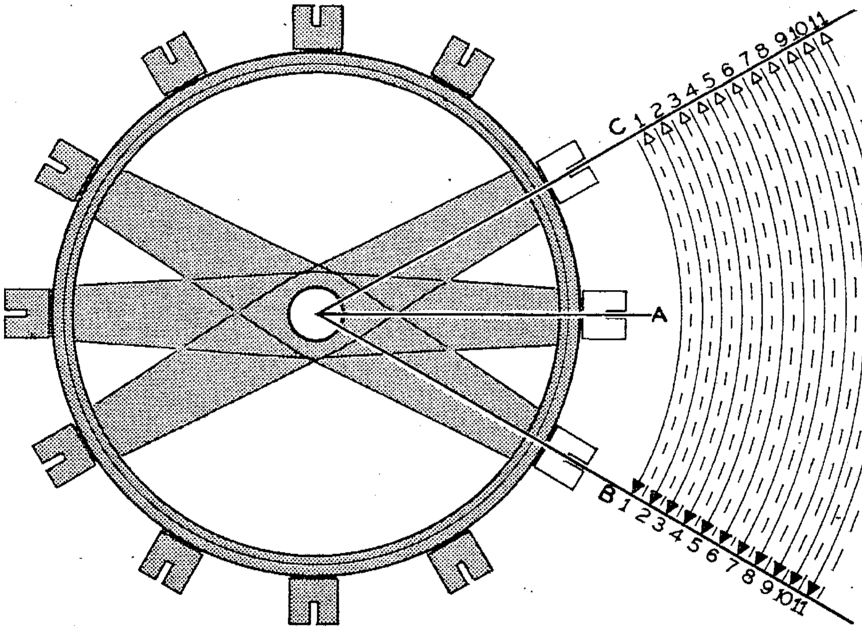
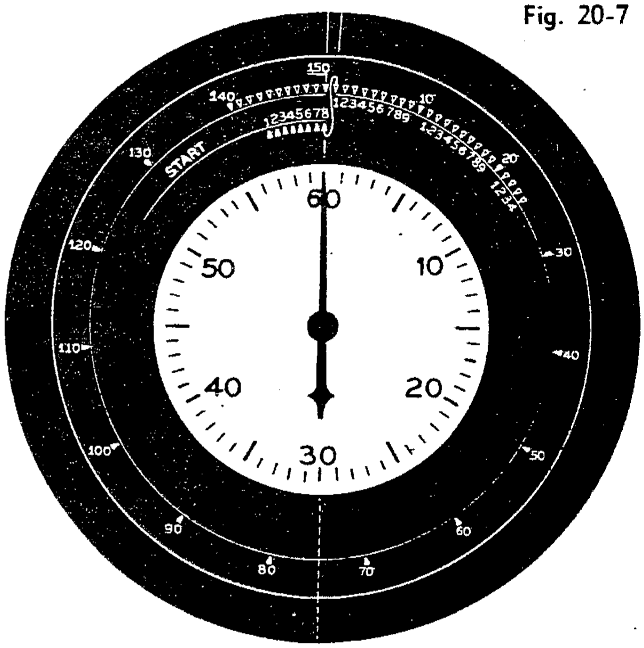


Fig. 20-6

Fig. 20-7



The white center in figure 20-7 shows a second bit as found on the average railroad grade watch. Place the balance with hairspring in your vibrating stand with the pivot resting lightly on the glass of the master watch. Start the balance moving with a dial brush or pegwood and practice counting the vibrations.

Count as follows: 1-2-3-4-5-6-7-8-9-10-1-2-3-4-5-6-7-8-9-10 and so on. The important part of counting is to start and end correctly. Refer to figure 20-7 and start counting as the balance vibrates: 1-2-3-4- etc. and, on any count that reaches 60 at the same time as the second hand of the master watch, start over, counting 1 and going up to 150 which should end exactly at 60. The black section around the second bit in figure 20-7 shows this procedure.

If the hairspring vibrates less than the desired count, loosen tweezer in stand and slide the points of the tweezers along the coil toward the collet. This will increase the number of vibrations.

If you move the points of the tweezer along the coil of the hairspring away from the collet it will decrease the number of vibrations.

When the exact point of vibration has been located, break off the hairspring exactly one coil larger. This will enable you to locate the point of vibration readily until secured to the stud.

SEC. 390—Fitting a Flat Hairspring to a Watch

You are now ready to fit a hairspring to a watch. We'll start with a flat hairspring. These are the steps:

1. Calculate the number of vibrations the balance should make in one minute. Section 389.1.

2. Select hairspring and place in position over inverted balance cock as in figure 20-8. The theoretical center of the hairspring should be over the center of the balance hole jewel.

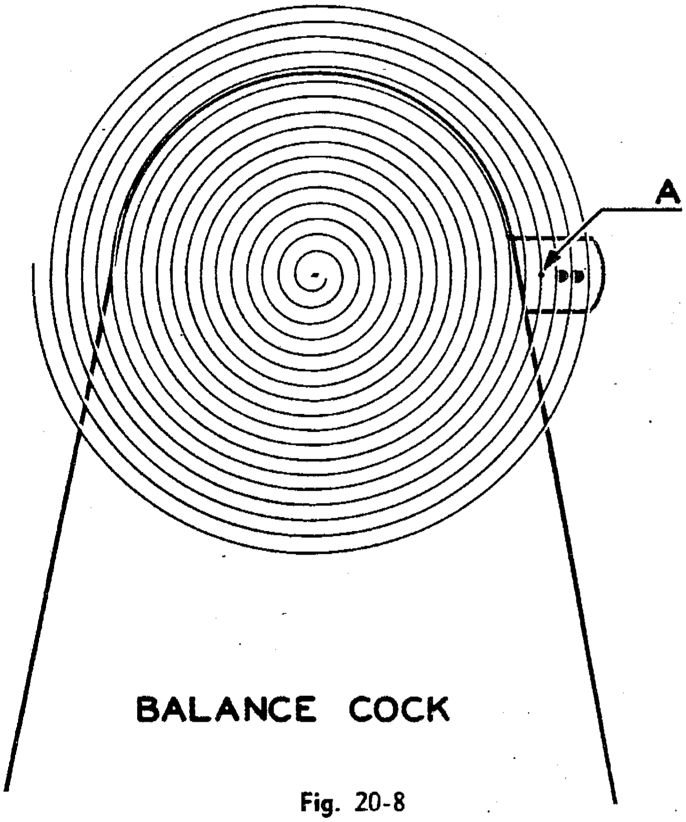


Fig. 20-8

3. The desired point of vibration should be about one coil inside the regulator pins, A of figure 20-8. The hairspring from this point to the collet should have approximately 11 or 12 coils.

4. Place hairspring on balance and push collet on staff, which will hold hairspring in place securely enough for a vibration test. Or use a small amount of beeswax, if you prefer.

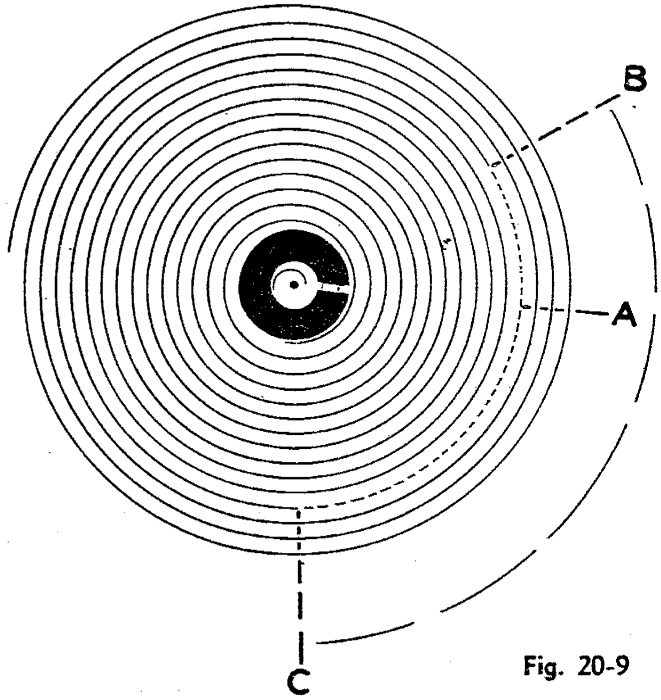


Fig. 20-9

5. Grasp hairspring somewhere along a section of coil B-C, figure 20-9, which corresponds to either side of desired vibration point A in figure 20-8 and 20-9, and place in vibrating stand.

6. Count the number of vibrations. In this manner you can quickly tell if you need a weaker or stronger hairspring.

7. When you have found a hairspring of correct diameter and strength, collet it and true it in flat and round. (Lesson 18)

8. Vibrate to the number of vibrations calculated in step 1 and break off hairspring exactly one coil larger, figure 20-10.

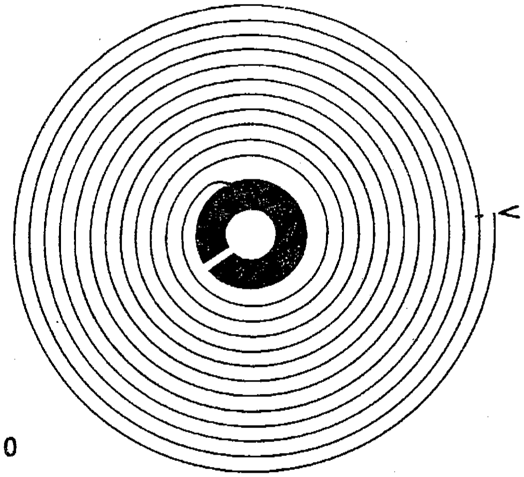


Fig. 20-10

SEC. 390.1 - Outer Terminal Pinning Point

The exact location of the point of vibration is very important when pinning the outer terminal coil of the hairspring to the stud.

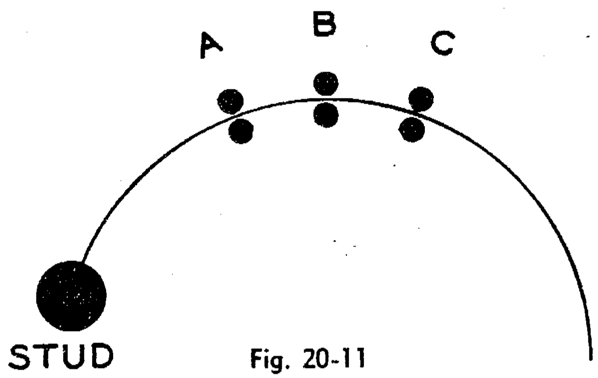


Fig. 20-11

Figure 20-11 shows the outer coil of a hairspring pinned to a hairspring stud. The regulator pins at B are in the position they would be with the regulator in the center of the index (not shown). If you move the regulator pins from B to A, it would lengthen the hairspring by moving the point of vibration away from the inner terminal pinning point (at the collet). This would make the watch run slower.

In figures 20-12 through 20-13, the outer coil is shown as a straight line to make this discussion easier to follow. However, in figures 20-12 and 20-13, the top drawing of a regular shaped outer coil shows the same conditions as the straight line drawing below.

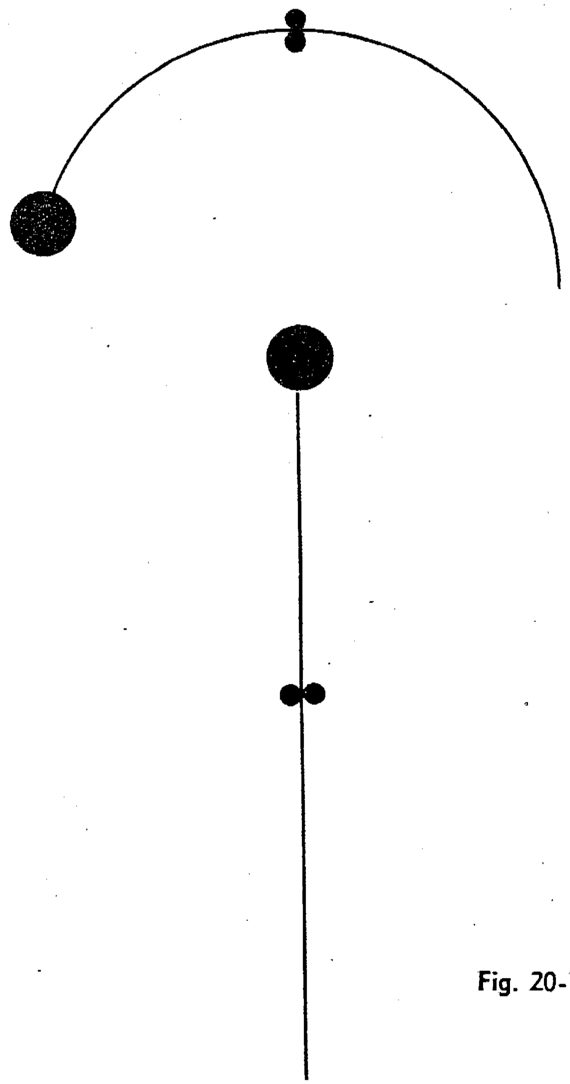
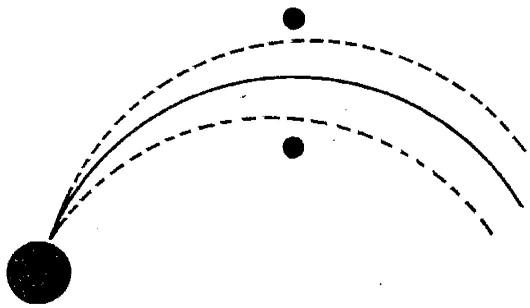


Fig. 20-12

In figure 20-12 there is no freedom between the regulator pins and the hairspring. The point of vibration is theoretically at the point of contact between the hairspring and the regulator pins.

As soon as the regulator pins are spread apart more than the width of the hairspring, the point of vibration moves toward the stud. As the regulator pins are spread still further, the point of vibration shifts closer toward the stud. When the regulator pins are further apart than the largest arc the spring can make, the point of vibration is right at the stud. Figure 20-13 shows this.



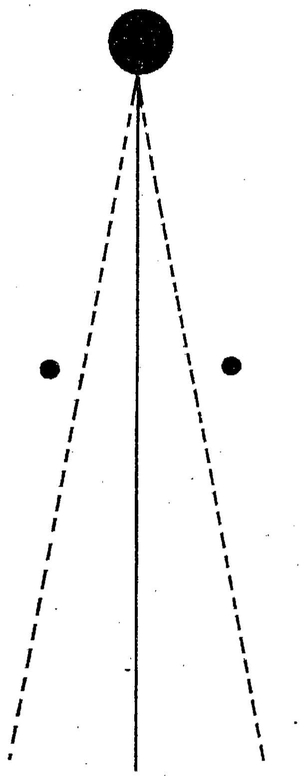


Fig. 20-13

Now if you start with the condition shown in figure 20-13 and close the regulator pins, the point of vibration will move back toward the regulator pins. Note how this happens in figures 20-14 and 20-15.

In figure 20-14, the regulator pins

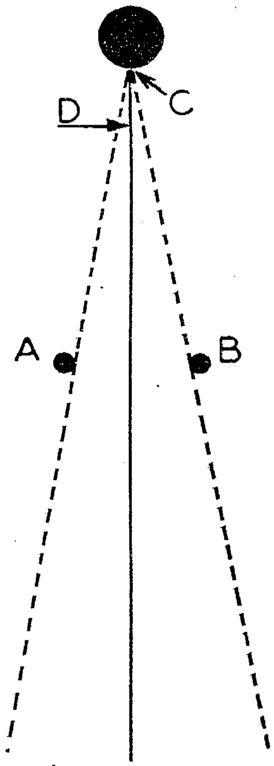


Fig. 20-14

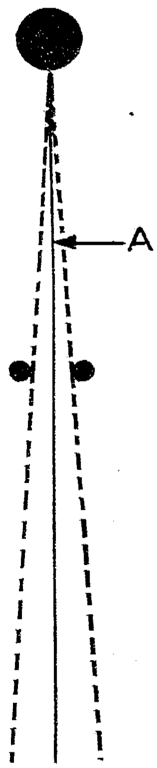


Fig. 20-15

have been closed until the hairspring comes in contact with each regulator pin when the balance wheel has swung as far as it can each way.

When the hairspring is in contact with regulator pin A, the length of the hairspring will be from A to the inner end pinning point at the collet. As soon as the balance starts on its return trip, the hairspring will move away from A toward B.

When the spring touches B, the length of the hairspring will be the same as from A.

In between these two points, during the excursion of the balance, the spring is out of contact from the time it leaves A until it reaches B. The length of the hairspring therefore will be from the pinning point of the outer end C at the stud to the inner pinning point at the collet. Thus, when the regulator pins are too far apart, the point of vibration will be closer to the stud as illustrated by arrow D in figure 20-14.

Closing the regulator pins, as in figure 20-15, will move the point of vibration nearer to the regulator pins as illustrated by arrow A, figure 20-15.

Illustration 20-15 is an excellent one to make clear why it is possible for a watch to gain when fully wound and to lose when it is run down or say after 20 hours of running.

When the watch is fully wound and the balance is taking a full motion (long arc), the hairspring is contacting first one regulator pin and then the other and the point of vibration is at the regulator pins when contact is made. When the hairspring moves away from either of the regulator pins, the point of vibration is from the stud. As a result, we can assume the average point of vibration to be at arrow A, figure 20-15.

Now suppose this watch gains when fully wound. What happens when it runs down? When it has run long enough, the hairspring no longer touches either of the regulator pins (short arc). The point of vibration is therefore from the stud at all times and the watch loses.

In summary, the point of vibration varies according to the space between the regulator pins. It should now be clear that the closer the regulator pins are together, the less error there is in time between the long and short arcs.

The distance between the regulator pins varies with the grade of watch. Figure 20-16 shows the regulator pins ad-

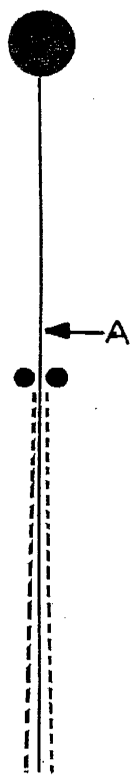


Fig. 20-16

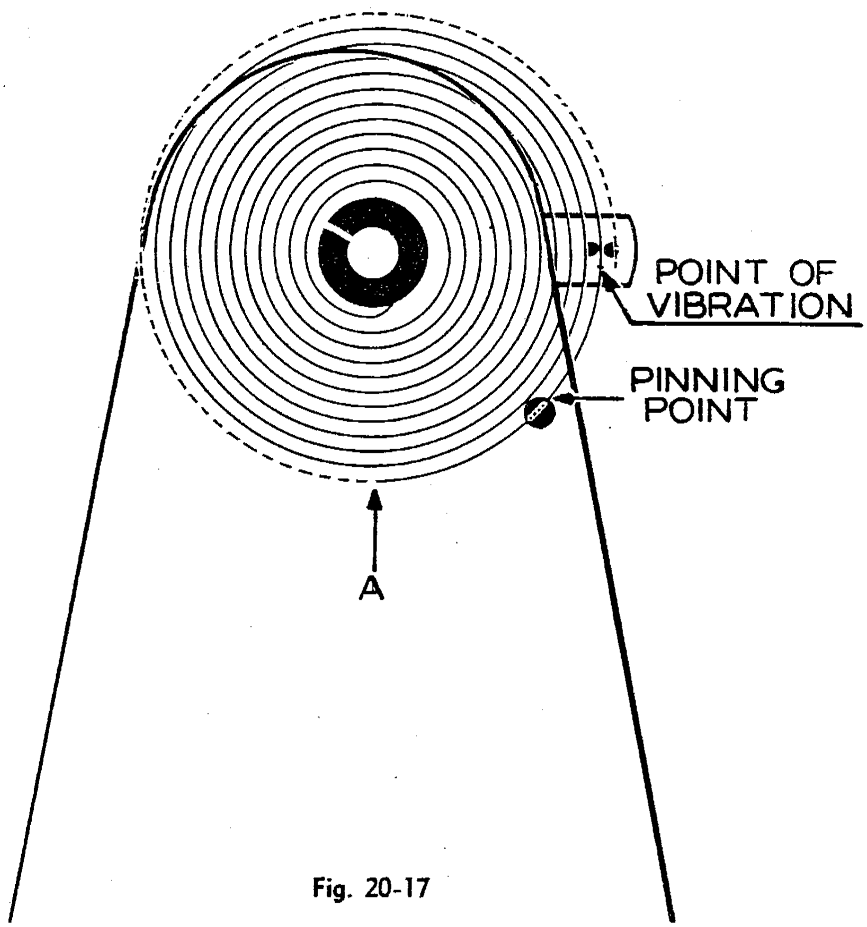


Fig. 20-17

justed to a width of about 3 times the thickness of the hairspring. The point of vibration is about at arrow A. In better grade watches, twice the thickness of the hairspring is recommended. Thus, each watch is a problem in itself. You can only estimate where to place the point of vibration when pinning the outer coil of the hairspring to the stud.

SEC. 390.2 - Pinning, Leveling and Centering Hairspring

1. Pin the hairspring to the stud. Screw the stud in the cock and slide the outer coil of hairspring through the stud, figure 20-17. Pin the spring with a brass pin just as you did when you pinned the collet.

Figure 20-17 shows about where the outer terminal pinning point will be when the regulator pins are slightly apart as in the average watch using a flat hairspring. The pinning point is at the stud. The point of vibration is near the regulator pins. The center of the hairspring collet will not be over the center of the balance jewel at this time.

2. After pinning the hairspring to the stud, break off the outer coil at A, figure 20-17. Leave the excess of spring shown in case of further adjustment when regulating. After you have regulated the watch, you can break off this extra portion.

3. Level the hairspring to the bridge, figure 20-18. Raise the assembly to eye level so you can see it from the side. If you have to do any bending to level the hairspring, do it as close as you can to the stud.

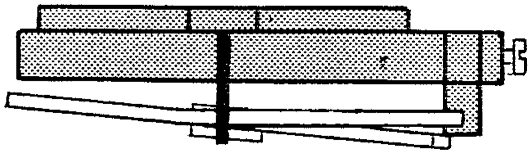


Fig. 20-19

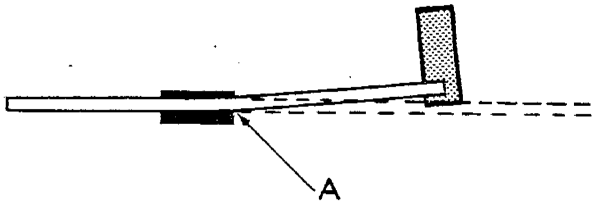


Fig. 20-20

Figure 20-19 shows a flat hairspring with the stud in place. However, the outside coil does not lie in the same plane as the body of the hairspring. Until it is, you can't level the hairspring to the bridge. Take the bent hairspring off the balance cock to make the correction, figure 20-20. Grasp the outer coil at A with two pairs of fine pointed hairspring tweezers and bend the coil downward until it is back even with the rest of the hairspring, shown by two dotted lines. Then replace the spring and level it to the bridge.

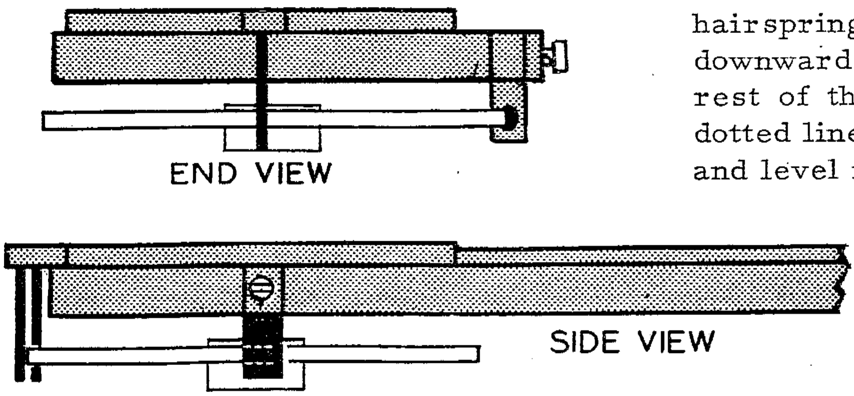


Fig. 20-18

4. Now center the hairspring. This means to place it so the outer coil falls between the regulator pins and the center of the collet is directly over the hole in the balance jewel. Invert the balance cock and lay the hairspring with the collet center over the pivot hole of the balance jewel. The outside coil will probably appear as shown in the dotted line in figure 20-21.

You will have to bend the outside coil away from the body of the hairspring so it will fall between the regulator pins. This is called circling.

5. Place the hairspring on a ground glass plate. Grasp the outer coil at about C, figure 20-21, with a pair of fine pointed hairspring tweezers. Now take a taper pin and open the outer coil a little bit. Move your tweezers to A and bend the outside coil at A until the section from A to B falls between the regulator pins and the center of the collet is still over the pivot hole in the balance jewel. Make any further adjustments only at A or C. Be sure to place the tweezer in the same spot as when you made the first bend.

6. After circling, place the stud in position and tighten the stud screw. The outside coil may or may not fall between the regulator pins. Since you have already circled it properly, you have only to make a bend close to the stud to bring the coil between the regulator pins. Now see if the center of the collet is directly over the hole in the balance jewel. If not, make another bend near the stud to bring the collet directly over the center of the balance jewel. This is shown by the dotted lines in figure 20-22.

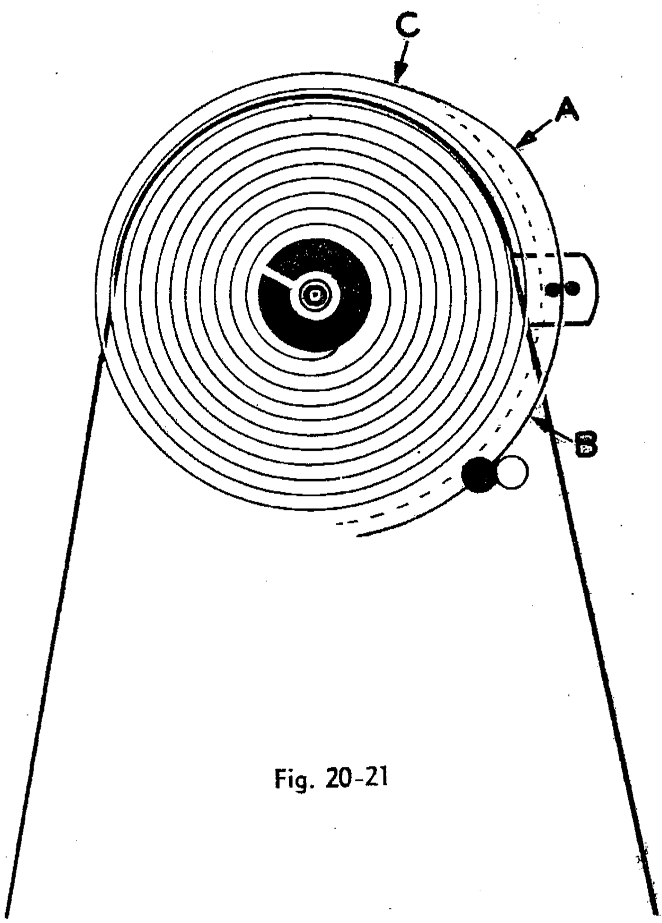


Fig. 20-21

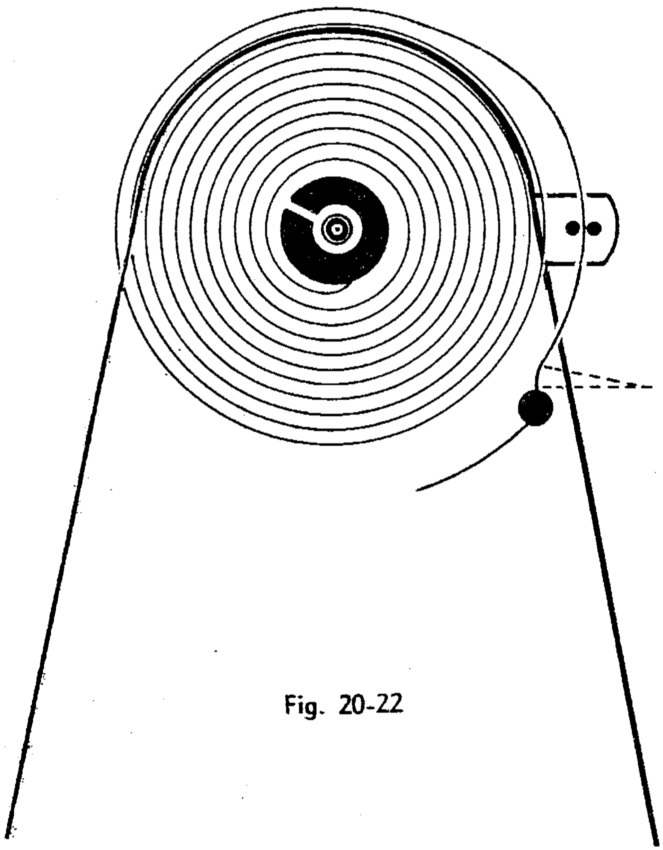


Fig. 20-22

Check your work now by moving the regulator from fast to slow. If the hairspring does not move, it is properly centered. If the pins touch the spring anywhere in their sweep, you have not properly circled this portion of the outer coil. You will have to bend it further away from the body of the spring.

7. When you have finished centering and circling, check again for level, figure 20-18.

SEC. 390.3 - Putting the Watch in Beat

"Putting a watch in beat" seems to hold a horror for many. All it means is replacing the hairspring so the roller jewel is in line with the escapement. Many Swiss watches have a small indentation on the balance rim to help you line up the stud. However, any changes that other repairmen have made in replacing a balance staff may have changed the location of the hairspring stud. The method we give you here will assure you of placing the stud in its approximate location. This method can be used for either flat or breguet hairsprings.

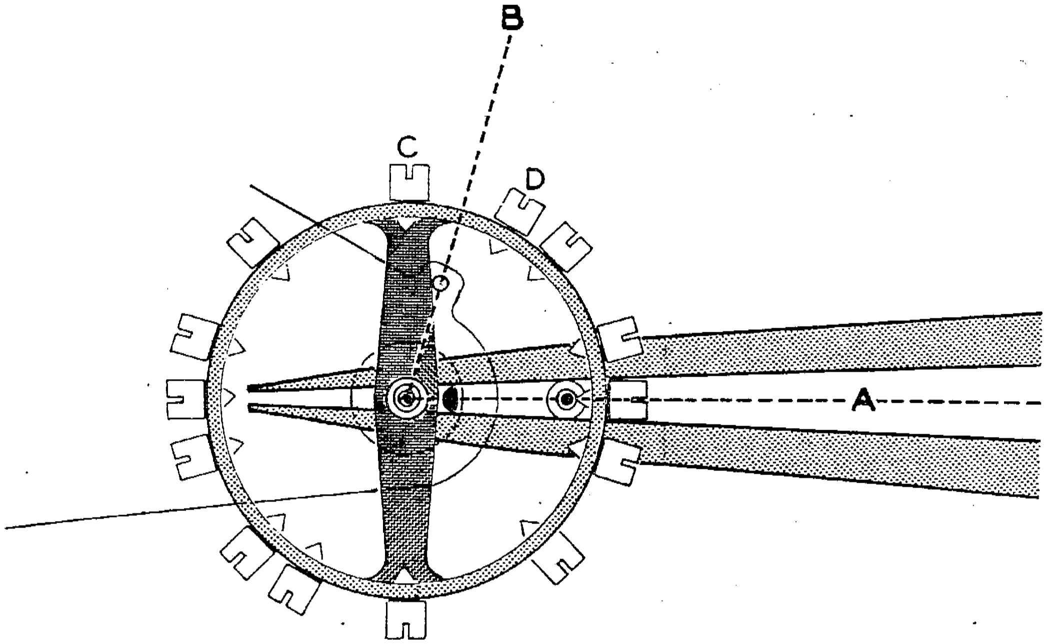
Place the balance cock in position and screw it in place.

Now put a pair of tweezers on the underside of the roller table with the roller jewel exactly in the center of the jaws of the tweezer, figure 20-23. Hold the balance directly over the balance cock with the lower pivot centered right above the upper cap jewel. Turn the balance until the imaginary line A, shown in figure 20-23, crosses directly over the center of the upper pivot hole in the pallet bridge and through the center of the roller jewel.

Now notice the dotted line B in figure 20-23. This line runs from the center of the balance through the center of the stud receptacle in the balance cock. In this example, this line crosses the rim of the balance about halfway between the balance screw C and D. Note where it crosses the rim in the balance you are using.

With this point in mind, replace the hairspring in the position shown by line B. After the hairspring collet has been

Fig. 20-23



pressed into place, go through the same procedure to see that everything lines up as before. If not, move the hairspring to the left or right as needed. The balance will then be very close in beat. In the escapement lessons, which follow, you will learn a method for putting the watch in absolute beat.

Meanwhile, do this with every watch so you become proficient.

SEC. 390.4 - Other Adjustments

Figure 20-24 illustrates a cut away view of a flat hairspring in which the outer coils are higher than the inner ones. This saucer shape sometimes appears after the hairspring has been leveled to the bridge and replaced in the watch.

Fig. 20-24

In most cases, lowering the stud will lower the outside coils to the correct level.

If the collet shoulder is too low and the stud cannot be lowered because the outside coil would drop out of the regulator pins, the balance staff is probably incorrect.

Figure 20-25 shows a flat hairspring which is somewhat umbrella shaped. In most cases, raising the stud will overcome this fault. If raising the stud and outside coil does not correct the error, you may find the collet is one which has the pinning hole above the

Fig. 20-25

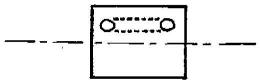


Fig. 20-26

center of the collet, figure 20-26. This holds the center coils up too high. Here you would have to re-collet the hairspring by turning the collet over so as to lower the center coils.

SEC. 391— Fitting a Breguet Hairspring to a Watch

A Breguet hairspring should have from 13 to 16 coils, not counting the outside coil which will be used as the overcoil.

1. Calculate the train and determine number of vibrations per minute. (Section 389.1.

2. Select, test and vibrate a hairspring until one of suitable strength

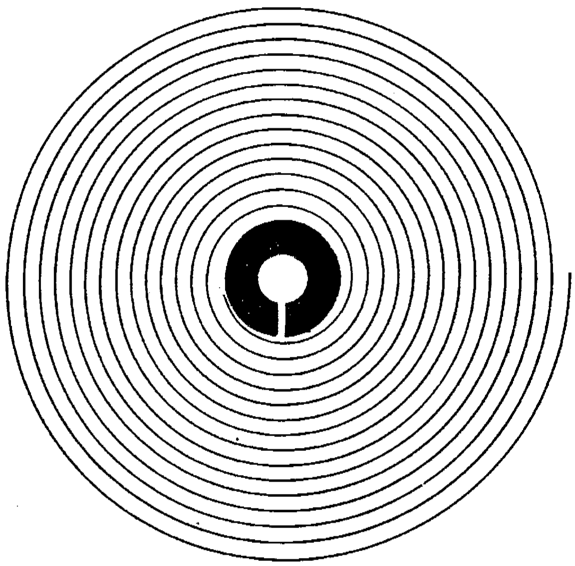


Fig. 20-27

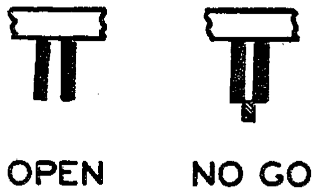
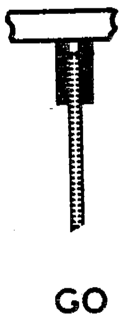


Fig. 20-28

Fig. 20-29



and diameter is obtained.

3. Collet and true in flat and round.

4. Vibrate accurately and break off one coil too large, figure 20-27.

5. Adjust regulator pins allowing about 1/100 mm for clearance.

You can adjust regulator pins for the Breguet hairspring very accurately by making a set of gauges of varying thickness. Make these from pieces of mainspring of thickness .05 mm, .06 mm, .07 mm, .08 mm, and so on.

To use these gauges, measure the tip of the outside coil of the hairspring with a micrometer. Select a gauge 1/100 mm larger than the thickness of the hairspring. Close the regulator pins until the outside coil of the hairspring or a gauge of the same thickness will not enter, figure 20-28. This is called "No Go". Now open regulator pins carefully until the gauge 1/100 mm larger will enter but have no side play. This is called "Go", figure 20-29.

Make certain that the regulator pins are parallel.

This adjustment is extremely important for position adjusting.

6. Pull outside coil of hairspring through stud until the point of vibration is just back of regulator pins A, figure 20-30. This point should be very close to the regulator pins as they are closer together (Section 390.1).

7. Pin hairspring to stud and break off excess spring. Leave a small amount as in figure 20-30 until you are sure the watch will time properly.

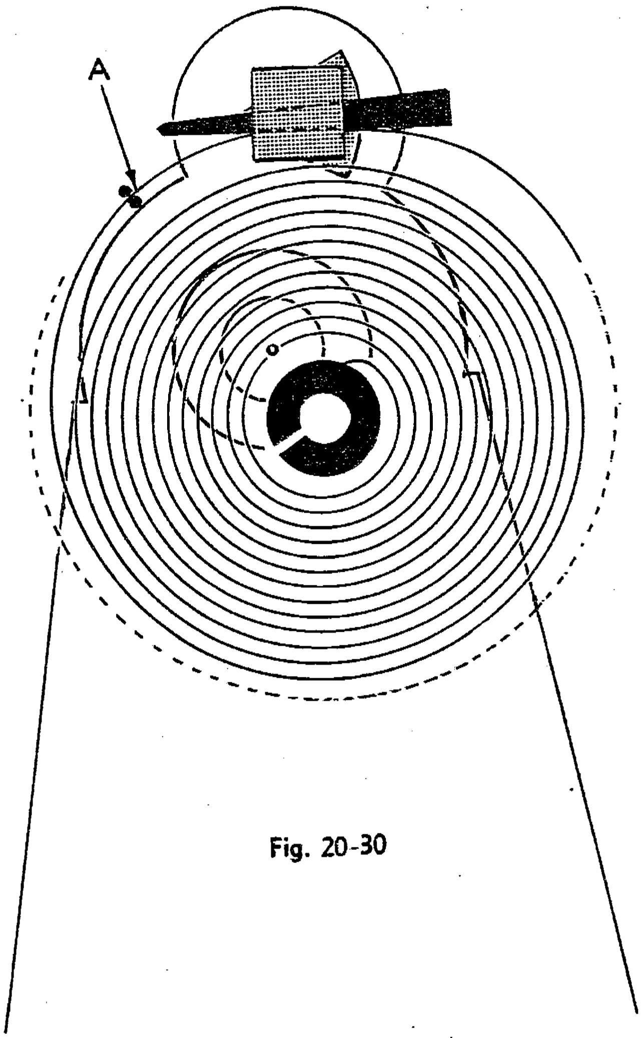


Fig. 20-30

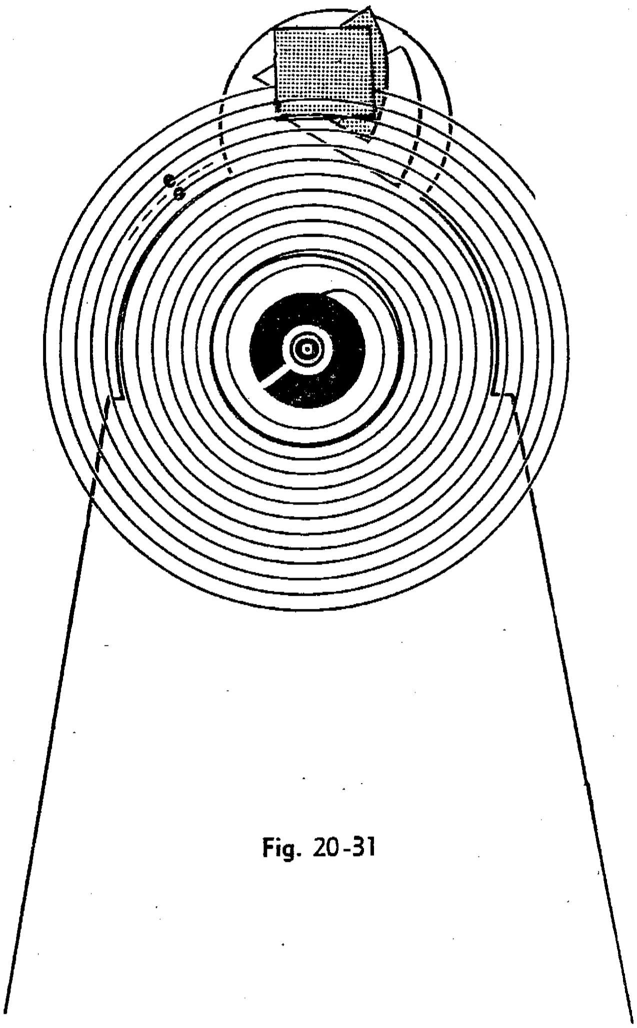


Fig. 20-31

8. Now locate the coil or space which the overcoil is to follow. Place the hairspring over bridge as in figure 20-31 with the center of the collet right over the center of the balance jewel. See which coil or space between coils falls between the regulator pins. In figure 20-31, it is the space between the 3d and 4th coil, not counting the outside coil. In this example, the overcoil will follow this space.

9. Raise the overcoil to the proper height. You can usually judge this by eye, using the old hairspring as a guide. Height is usually about 2-1/2 times the width of a coil, figure 19-13, lesson 19.

10. Form the overcoil as explained in lesson 19.

11. Center the overcoil by circling the part between the regulator pins, just as you did for the flat spring:

Lay the hairspring over the bridge with overcoil between the regulator pins and the stud in line with the stud hole in cock. Look down through the collet. If the overcoil is correct, the collet will lie directly over the center of the balance jewel. If it does not, re-check that it follows the proper space or coil. The fact that the stud does or does not lie directly over the hole in the balance cock is not important at this time.

If overcoil seems correct, place the stud in the balance cock and tighten the stud screw. The overcoil may or may not fall between the regulator pins. If you have formed it correctly, you have only to make a little S bend near the stud to bring the coil between the regulator pins, figure 20-32.

12. Check the center of the collet again to see if it is still over the hole in the balance jewel. See if it stays there as you move the regulator from extreme slow to extreme fast position. If this movement throws the spring off center, you'll have to make another slight bend at the stud.

The direction of this bend is found by watching the action of the overcoil as the regulator pins are moved. If the overcoil moves toward the staff, as the regulator pins move from the stud, bend the overcoil toward the staff also. Make this slight bend at the stud. If the overcoil moves away from the staff as the regulator pins move away from the stud, bend the overcoil away from the staff also.

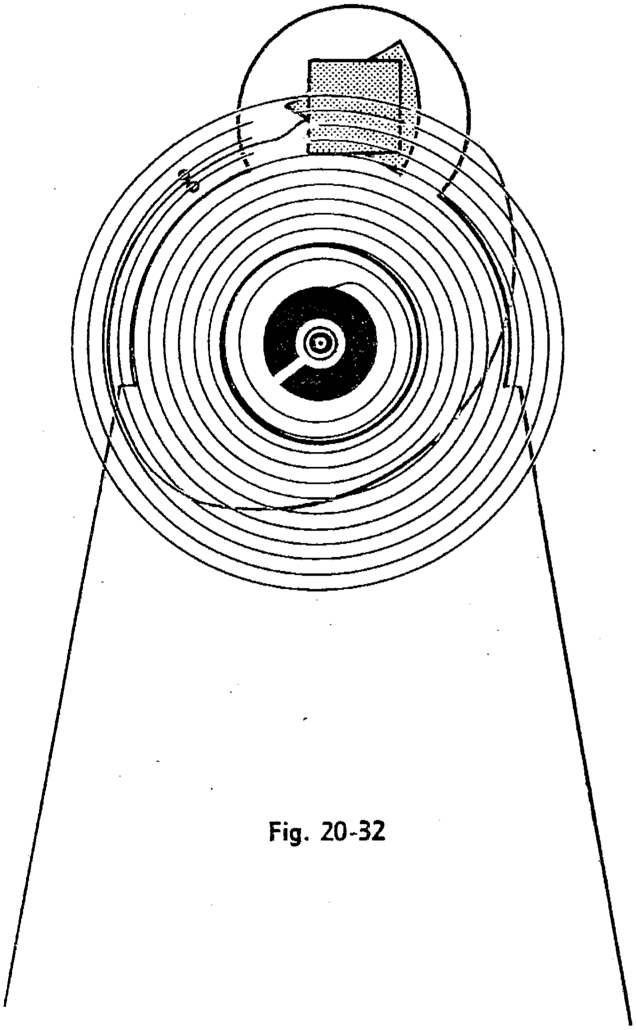


Fig. 20-32

13. Level the hairspring to the balance cock. Figure 20-33 shows how it should look in two different watches. If the body of the hairspring is not level with the balance cock, remove hairspring and level the overcoil to the body of the hairspring. Use the methods you learned in lesson 19.

After it is level, check again to be sure the spring is still centered. The hairspring must be leveled and centered to the bridge before it is replaced on balance.

14. Locate the position of the stud as in Section 390.3. Replace the hairspring with a staking tool. Check the exact beat after you have learned this in Section 455, Lesson 26.

If the body of the hairspring takes a saucer shape after the spring has been replaced in the watch, lowering the stud may correct it provided the overcoil stays between the regulator pins. Otherwise you may have to raise the overcoil slightly.

If the hairspring takes an umbrella shape, raising the stud may correct it. Otherwise, lower the overcoil slightly. Check the hairspring collet to be sure it is down to the base of the collet shoulder.

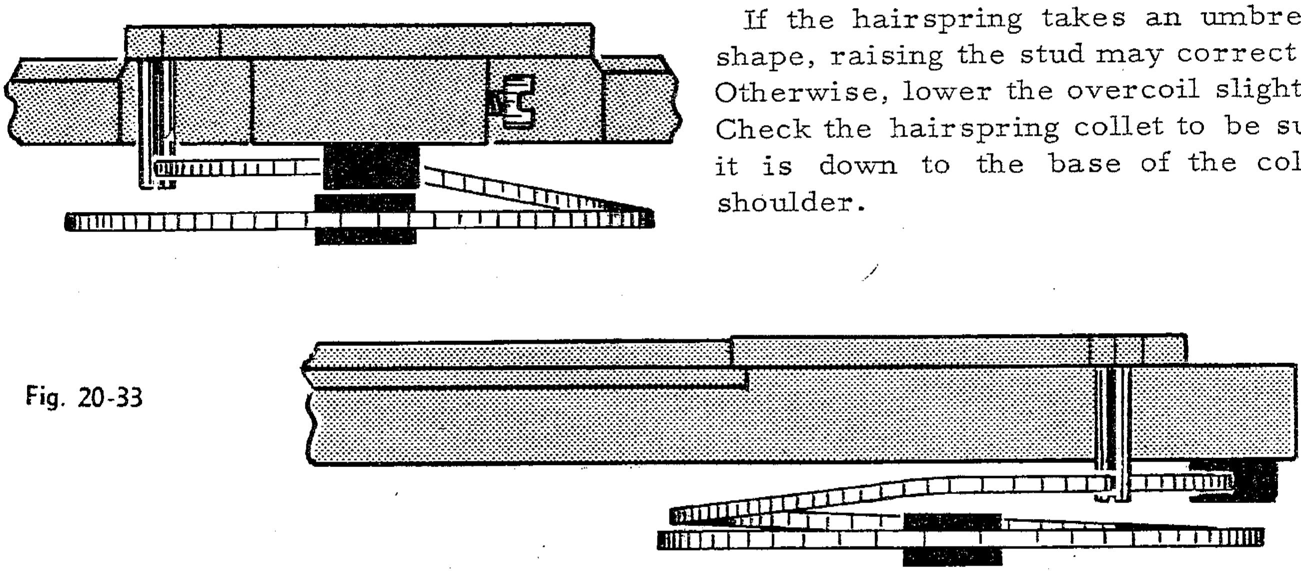


Fig. 20-33

SEC. 392—Checking the Hairspring

You must check every hairspring. Minor adjustments may be needed. This is true whether it is a spring already in the watch or one which has been newly vibrated and fitted.

Let's sum up now the standards which properly fitted hairsprings should meet:

1. The hairspring must be true in flat and round.

2. The outside coil must lie between regulator pins and conform to their circular movement. At the same time, the hole in the collet must be centered over the hole in the balance jewel.

3. A flat hairspring must be level with the balance cock and not scrape on any part during winding and unwinding caused by the swing of the balance.

4. An overcoil must be level with the body of the spring and parallel to the balance cock.

5. The body of the overcoil spring must be level with the balance arm.

6. The overcoil hairspring must be free and not scrape any part of the balance during winding and unwinding.

If the hairspring is one already in the watch, the best time to check it is before it is removed if the watch is running. Because the hairspring is anchored at both collet and stud, errors look different than when the spring is out of the watch.

Minor corrections to level the hairspring to the bridge can often be made in American watches of 12, 16 or 18 size. By minor corrections, we mean only those which can be made where the hairspring is pinned at the stud.

Special tools, called hairspring levelers, figure 20-34, or fine-pointed hairspring tweezers can be used for such corrections.

Fig. 20-34

You can make your own levelers by grinding the eye of a needle with a hard Arkansas stone or oilstone and mounting the needle in a handle. Different size needles will provide varying size levelers, figure 20-35.

Fig. 20-35

These tools are used as shown in figures 20-36 and 20-37.

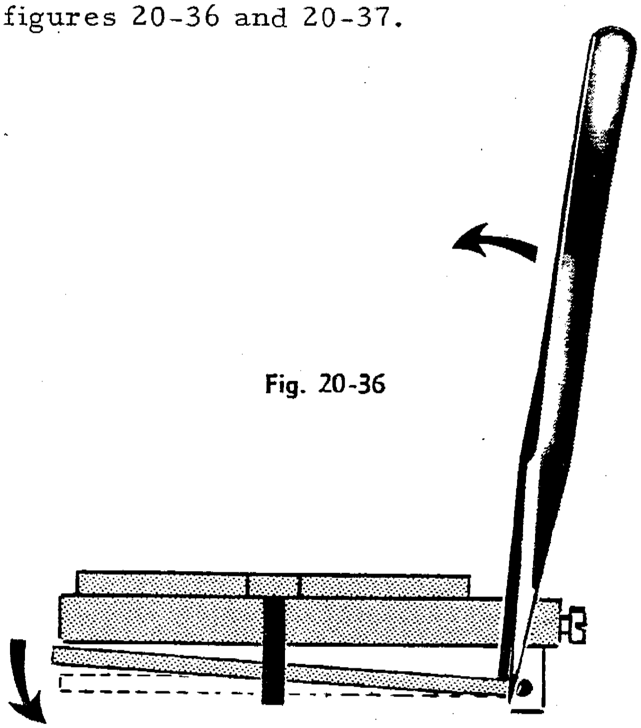


Fig. 20-36

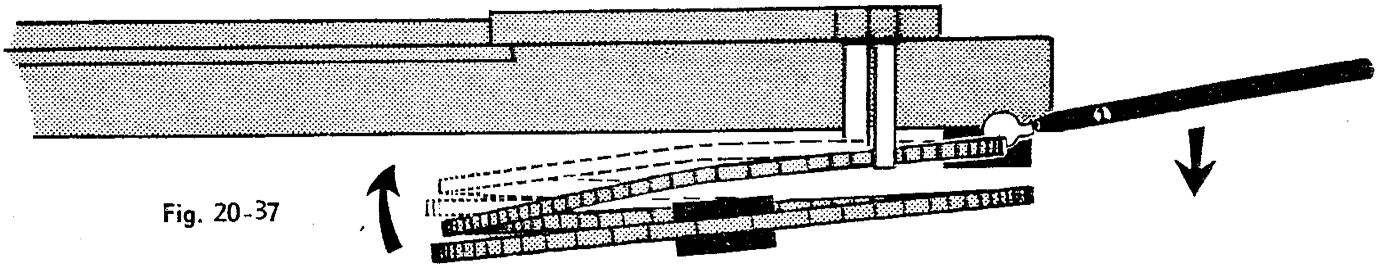


Fig. 20-37

Levelers cannot usually be used on very small movements because of lack of room. All corrections on small movements, as well as major corrections on larger sizes, are best made by removing the hairspring from the wheel and placing it on the bridge.

SEC. 393—Analyzing Hairspring Faults

These are the main points to check in a hairspring:

1. Magnetism. The spring is free of oil but coils appear distorted or stuck together. Usually, this results from a magnetized spring. Check with a demagnetized compass as in Lesson 11. You can demagnetize the spring in the watch or out. If you take it out, wrap it in watch paper or enclose it in a capsule before putting it in the demagnetizer. This keeps it from getting tangled.

2. Oil or dirt on the spring. Just a little of any of these may cause the coils to stick together. Cleaning will get rid of this fault.

3. Position of the regulator. Look where the regulator is set to see if the watch has been running slow or fast. For example, if the regulator is toward the fast side, it means the watch has been running slow and has been adjusted by moving the regulator. It is best to have the regulator centered. The regulator pins may be at fault here.

4. Regulator pins. These should be straight, parallel and properly spaced. If the regulator has been moved to the fast side, it may be that the space between regulator pins should be less.

5. True in the flat. An error in the flat appears as a wavy motion instead of the smooth, spiraling motion of a spring which is true in the flat. Take the balance out of the watch to make this correction. See lesson 18.

6. True in the round and collet centered. When the collet is not centered in the body of the spring, the coils will seem to jerk rapidly away from and back toward the collet as the spring oscillates. Take the balance out of the watch to make this correction. See lesson 18.

7. Level to bridge. You can check the level by noting if the body of the spring is level with the wheel. If one edge of the spring is tilted down, it may rest against arm of wheel and prevent normal motion of the balance. Or the tilted up edge may be resting against the bridge or other part of the watch. This makes the balance turn more rapidly. Re-level as in Sections 390 and 391.

8. Centered to the bridge. Look down upon the flat of the hairspring to see if it is centered to the bridge. If it isn't, the spacing between coils will be wider on one side. Take the hair-

spring from the wheel and place it on the balance bridge to make the correction as in Sections 390.2 and 391.

9. Circling between regulator pins. Move the regulator from side to side to see if the outer coil is circled properly. If the spring shifts from side to side and throws the collet off center with the bridge, it means the outer coil should be recircled. Do this out of the watch with the spring off the wheel and on the balance bridge.

10. Saucer or umbrella shape. If the spring in the watch has its outer coils pressing downward in an umbrella shape, it means either the stud is too low or the overcoil too high. If the outer coils are raised in a saucer shape, it shows a stud too high or overcoil not high enough. Both corrections are made with the spring out of the watch as in Sections 390.4 and 391.

11. Rust on the hairspring. Rust weakens the spring. In time it breaks. There is no effective method of removing or preventing rust on a steel spring. You should replace the spring.

12. Coils tangled or overlapped. A sudden jar may cause some coils of a hairspring to overlap one or more other coils. There are several methods for remedying this. One method is to insert the edge of a piece of paper between the coils under the tangled part. Turn the spring with tweezers in its outward direction. This can be done with the spring on the balance wheel. Another method is to needle the error. If you can find the coil that is overlapped and reach it with a fine taper pin, you can untangle the spring in the watch. Otherwise take it from the balance wheel. Place the collet on a taper pin and put the fine steel pin in between the coils at a point between the tangle and the collet. Gradually work the pin outward between the spirals of the spring and work the tangle to the outer edge. Then use a tweezer to lift the overlapped coil out of the tangled coils. A third method is to unpin the spring at the stud. This works in most cases.

A FINAL NOTE:

You may meet many different combinations of errors. The best procedure is to start at the collet and correct each error as you come to it, just as if you were fitting a hairspring to a watch.

CHECK YOURSELF

Progress Check 20 — A Self Test Review of Lesson 20

After you have studied Sections 387 through 393, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of this quiz. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. Most watches have balances which vibrate __________ times an hour.	389
2. The vibrations for any watch or clock can be determined by calculating the __________.	389.1
3. In counting vibrations, it is usually easier to count the __________ and multiply by 2.	389.3
4. Moving the tweezers along the coil toward the collet will __________ the vibrations, while moving tweezers away from the collet will __________ the vibrations.	389.3
5. In fitting a flat hairspring, the desired point of vibration is approximately __________ inside the regulator pins.	390
6. Moving regulator pins toward the stud will cause the watch to run __________.	390.1
7. The more the regulator pins are opened, the more the point of vibration moves toward the __________.	390.1
8. The desired distance between the regulator pins is approximately __________ times the __________ of the hairspring, depending on the watch.	390.1
9. Number in proper order these steps in pinning and centering a flat hairspring: ( ) Check centering of collet with stud in place. ( ) Screw stud in cock and pin hairspring. ( ) Bend outside coil to lie between regulator pins. ( ) Center the collet over balance jewel. ( ) Level hairspring to the bridge. ( ) Break off excess hairspring.	390.2
10. If a flat hairspring appears umbrella shaped after it is replaced in the watch, it may be corrected by __________.	390.4

(Continued)

Progress Check 20 (Continued) | Section Ref.

11. A Breguet hairspring should have ______________ coils not counting the outside coil. 391

12. Number in proper order these steps in fitting a Breguet hairspring to a watch:

( ) Pull outside coil through stud.
( ) Collet and true in flat and round.
( ) Vibrate to select hairspring of proper strength and diameter.
( ) Calculate train.
( ) Pin hairspring to stud and break off excess.
( ) Vibrate accurately and break off one coil larger.
( ) Center hairspring.
( ) Form overcoil.
( ) Adjust regulator pins.
( ) Check that center of collet lies directly over center of balance hole jewel.
( ) Replace stud in balance cock and tighten stud screw. 391

13. Before replacing a Breguet hairspring on the balance, the hairspring must be ______________ and ______________ to the bridge. 391

==

ANSWERS TO PROGRESS CHECK 20:

1. 18,000
2. train
3. oscillations
4. increase
decrease
5. one coil
6. slower
7. stud
8. 2 to 3
thickness
9. (6)
(1)
(5)
(4)
(3)
(2)
10. raising the stud
11. 13 to 16
12. (6)
(3)
(2)
(1)
(7)
(4)
(8)
(9)
(5)
(11)
(10)
13. leveled
centered

HOW TO FIT A FLAT HAIRSPRING TO A WATCH.

Tools, Equipment and Supplies:

Truing Caliper	Hairspring	4mm Brass Rod as in Fig. 32-3
Poising Tool	Collet	3C Hairspring Tweezer
Assembly Tweezer	Taper Pin	Knife or Razor Blade
Master Timing Watch (One with second hand)	Stud Pins	Hairspring Leveler
	Beeswax	

PROCEDURE:	REFERENCE:
1. True balance wheel in flat and round.	Lesson 16
2. Poise balance wheel.	Lesson 17
3. Calculate train to determine number of vibrations.	Sec. 389.1
4. Select hairspring.	Sec. 390
5. Recollet, using the collet that was in the watch.	Lesson 18
6. True hairspring in round and flat.	Lesson 18
7. Vibrate hairspring.	Sec. 389.2-389.3-390
8. Check regulator pins and make any required adjustment.	Sec. 390.1 & Les. 11
9. Move regulator to center of scale.	Sec. 390.1
10. Stud hairspring.	Sec. 390.1 & 390.2
11. Level hairspring to balance bridge.	Sec. 390.2
12. Circle outside terminal coil between regulator pins.	Fig. 20-21
13. Center hairspring collet to the balance hole jewel in bridge.	Sec. 390.2
14. Replace hairspring on balance wheel.	Sec. 390.3
15. Put in beat.	Sec. 390.3 & Les. 26
16. Adjust and regulate watch to keep time.	Lesson 11

HOW TO FIT A BREGUET OR OVERCOIL HAIRSPRING TO A WATCH.

Tools, Equipment and Supplies:

Truing Caliper
Poising Tool
Assembly Tweezer
Master Timing Watch
(One with second hand)

Hairspring
Collet
Taper Pin
Stud Pins
Beeswax

4mm Brass Rod as in Fig. 32-3
3C Hairspring Tweezer
No. H Hairspring Tweezer
Overcoiling Tweezer
Knife or Razor Blade
Hairspring Leveler

PROCEDURE:	REFERENCE:
1. True balance wheel in flat and round.	Lesson 16
2. Poise balance wheel.	Lesson 17
3. Calculate train to determine number of vibrations.	Sec. 389.1
4. Select hairspring.	Sec. 391
5. Recollet, using the collet that was in the watch.	Lesson 18
6. True hairspring in round and flat.	Lesson 18
7. Vibrate hairspring.	Sec. 389.2-389.3-391
8. Check regulator pins and make any required adjustment.	Sec. 391
9. Move regulator to center of scale.	Sec. 390.1
10. Stud hairspring.	Sec. 391
11. Form overcoil.	Lesson 19
12. Circle overcoil between regulator pins.	Sec. 391
13. Level hairspring to balance bridge.	Sec. 391
14. Replace hairspring on balance wheel.	Sec. 390.3
15. Put in beat.	Sec. 390.3 & Les. 26
16. Adjust and regulate watch to keep time.	Lesson 11

Detach page or cut along this line - - and send to the School for grading

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 20

Name: No.: Date:

SUBJECT: Fitting Hairsprings in Watches GRADE: ____________

DIRECTIONS: In the following statements, select the ONE BEST answer and place the letter of that answer on the short line in front of the question number.

_____ 1. How many times a minute does the balance vibrate in most watches?

A. 350
B. 300
C. 270
D. 240

_____ 2. The center wheel of the ordinary watch is used as a starting point in calculating the train because:

A. It has the most teeth.
B. It has the least teeth.
C. It turns more slowly than others.
D. It makes one revolution in one hour.

_____ 3. In fitting a flat hairspring to a watch, with the new spring over the balance cock and the center of spring over the center of the balance jewel, the desired point of vibration should be:

A. Directly over space between regulator pins.
B. About three coils outside of space between regulator pins.
C. One coil outside of regulator pins.
D. One coil inside of regulator pins.

_____ 4. After colleting a hairspring which is to be fitted to a watch, the next step will be to:

A. Shape the outer coil.
B. Stud the spring.
C. Vibrate and break off.
D. True in round and flat.

_____ 5. If the regulator pins of a watch were closed so there was no freedom between the pins and the hairspring, the point of regulation theoretically would be:

A. At the stud.
B. At point of contact between spring and pins.
C. At one-fourth the distance from stud to pins.
D. At one-half the distance between stud and pins.

(Please turn over)

____ 6. After pinning a flat hairspring to the stud, the next step will be to:

A. Assemble hairspring and balance.
B. Center the hairspring to the bridge.
C. Level the hairspring to the bridge.
D. Bend outside coil so it falls between the regulator pins.

____ 7. In fitting a Breguet hairspring to a watch, we center the hairspring over the balance jewel. The overcoil should then be formed to follow:

A. The outside coil of the spring.
B. The second coil of the spring.
C. The coil or space which falls between the regulator pins.
D. The fifth coil of the spring.

____ 8. The regulator pins for a Breguet type hairspring should be adjusted:

A. With space twice as wide as thickness of hairspring.
B. With space 2/100 mm wider than thickness of hairspring.
C. With space 1/100 mm wider than thickness of hairspring.
D. So hairspring will just vibrate against pins when watch is fully wound.

____ 9. If the body of a flat hairspring is saucer-shaped, it may be corrected by:

A. Re-pinning the collet.
B. Raising the collet on the balance staff.
C. Lowering the stud.
D. Raising the stud.

____ 10. If the body of a Breguet hairspring is umbrella-shaped, it may be corrected by:

A. Lowering the overcoil.
B. Lowering the stud.
C. Raising the overcoil.
D. Raising the collet on the balance staff.

Cut along this line and send - - to the School with your work for grading

CHICAGO SCHOOL OF WATCHMAKING

Proficiency Exam No. 3

A test of your Master Watchmaking Shop Skills.

This examination covers the practical work for:

Lessons 18 through 20.

You may send in this examination any time after you have completed study of the lessons above up to 3 years from your date of enrollment.

Student number ________________ Date ________________

Name	
Address	
City State Zip Code	

YOUR GRADE: ________________

Certificate Awarded: ________________

PURPOSE OF THIS EXAMINATION: To test your job skills and ability to do the practical work covered in the lessons included in this examination. It is not compulsory, but if satisfactorily completed will count toward your Diploma requirements. STUDENTS WHO ACHIEVE A SCORE OF 75 or better on this examination will be awarded a special Certificate of Proficiency for Hairspring Adjusting and Fitting.

SEND IN FOR THIS EXAMINATION: (Pack carefully and mark as your property.)

One gradual bend overcoil patterned on Fig. 19-4, preferably on balance wheel.
One knee bend overcoil patterned on Fig. 19-4, preferably on balance wheel.
One watch to which a flat hairspring has been fitted.
One watch to which an overcoil hairspring has been fitted.

ERRORS NOTED: (Consider your work correct except where a check mark appears below.)

POSSIBLE SCORE: 15
Less points lost for errors:

Gradual Bend Overcoil: (Follow Job Sheet L19-J1)

____ Colleted incorrectly		
____ Pin not cut close to collet	(- 1)	______
____ Elbow incorrectly formed	(- 1)	______
____ Pin not tight	(- 1)	______
____ Not true in flat	(- 3)	______
____ Not true in round	(- 3)	______
____ Body of spring distorted or bent	(- 1)	______
____ Overcoil incorrect as noted:		
FIRST BEND (X in figure 19-12)		
____ Wrong location	(-1/2)	______
____ Bent out of spiral	(-1/2)	______
____ Not raised high enough	(-1/2)	______
____ Raised too high	(-1/2)	______
SECOND BEND (Y in figure 19-12)		
____ Wrong location	(-1/2)	______
____ Not level to end of spring	(-1/2)	______
THIRD BEND (Z in figure 19-12)		
____ Wrong location	(-1/2)	______
____ Touching first coil as it passes over	(-1/2)	______
REGULATION ARC		
____ Not following directly over coil	(- 1)	______
____ UNSATISFACTORY JOB due to type of errors made.	(- 15)	______

YOUR SCORE: ______

(Please turn over)

Knee Bend Overcoil: (Follow Job Sheet L19-J2)	POSSIBLE SCORE: 15 Less points lost for errors:	
____ Colleted incorrectly		
____ Pin not cut close to collet	(- 1)	____
____ Elbow incorrectly formed	(- 1)	____
____ Pin not tight	(- 1)	____
____ Not true in flat	(- 3)	____
____ Not true in round	(- 3)	____
____ Body of spring distorted or bent	(- 1)	____
____ Overcoil incorrect as noted:		
FIRST BEND (Figure 19-24)		
____ Wrong location	(-1/2)	____
____ Bent out of spiral	(-1/2)	____
____ Not raised high enough	(-1/2)	____
____ Raised too high	(-1/2)	____
SECOND BEND (A in figure 19-26)		
____ Wrong location	(-1/2)	____
____ Not level to end of spring	(-1/2)	____
THIRD BEND (Where overcoil turns across spring)		
____ Wrong location	(-1/2)	____
____ Touching first coil as it passes over	(-1/2)	____
REGULATION ARC		
____ Not following directly over coil	(- 1)	____
____ UNSATISFACTORY JOB due to type of errors made.	(- 15)	____
	YOUR SCORE:	____

Movement fitted with a flat hairspring: (This watch should be clean and in running order. Follow procedure on Job Sheet L20-J1.)	POSSIBLE SCORE: 35 Less points lost for errors:	
____ Wheel not true	(- 2)	____
____ Wheel not poised	(- 2)	____
____ Hairspring not colleted correctly	(- 2)	____
____ Hairspring not true in flat	(- 3)	____
____ Hairspring not true in round	(- 3)	____
____ Outer coil not formed in arc of regulator pins	(- 2)	____
____ Outer coil not level with body of spring	(- 2)	____
____ Outer coil not smoothly formed	(-1/2)	____
____ Too many coils in spring	(-1/2)	____
____ Vibrated too fast	(- 1)	____
____ Vibrated too slow	(- 1)	____
____ Body of spring not centered to bridge	(- 3)	____
____ Body of spring not level with bridge	(- 2)	____
____ Distortions in outer coils	(-1/2)	____
____ Stud too high	(- 1)	____
____ Stud too low	(- 1)	____
____ Regulator pins too wide apart	(-1/2)	____
____ Regulator pins too close	(-1/2)	____
____ Regulator pins tilted	(-1/2)	____
____ Regulator pins staggered	(-1/2)	____
____ Regulator pins rough	(-1/2)	____
____ Not in beat	(- 2)	____
____ Not adjusted to keep time	(- 3)	____
____ Movement not clean	(- 1)	____
____ UNSATISFACTORY JOB due to type of errors made.	(- 35)	____
	YOUR SCORE:	____

(Continued on next page)

 | Name: Student number

Movement fitted with an overcoil hairspring:
(This watch should be clean and in running order.
Follow procedure on Job Sheet L20-J2.)

POSSIBLE SCORE: 35
Less points lost
for errors:

____	Wheel not true	(- 2)	____
____	Wheel not poised	(- 2)	____
____	Hairspring not colleted correctly	(- 2)	____
____	Hairspring not true in flat	(- 3)	____
____	Hairspring not true in round	(- 3)	____
____	Distortions in coils	(-1/2)	____
____	Overcoil not level	(- 1)	____
____	Overcoil not following in arc of regulator pins	(- 2)	____
____	Overcoil not smoothly formed	(-1/2)	____
____	Overcoil too high	(-1/2)	____
____	Overcoil too low	(-1/2)	____
____	Overcoil touching ____________	(-1/2)	____
____	Body of spring not level with bridge	(- 2)	____
____	Body of spring not centered to bridge	(- 3)	____
____	Stud too high	(- 1)	____
____	Stud too low	(- 1)	____
____	Vibrated too fast	(- 1)	____
____	Vibrated too slow	(- 1)	____
____	Regulator pins too wide apart	(-1/2)	____
____	Regulator pins too close	(-1/2)	____
____	Regulator pins tilted	(-1/2)	____
____	Regulator pins staggered	(-1/2)	____
____	Regulator pins rough	(-1/2)	____
____	Not in beat	(- 2)	____
____	Not adjusted to keep time	(- 3)	____
____	Movement not clean	(- 1)	____
____	UNSATISFACTORY JOB due to type of errors made.	(- 35)	____

YOUR SCORE: ____

End of Proficiency Examination No. 3.

Job Inspection Request

CHICAGO SCHOOL OF WATCHMAKING
310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Use this Request whenever you need help or have questions on the practical work. Use a Student Consultation Sheet for all other questions or service.

Student number ________________ Date ________________

Name	
Address	
City State Zip Code	

IDENTIFY the work you are sending in for inspection:

____

____

____

( ) Enclosed
( ) Sent separately

When sending in work for inspection, be sure to pack it carefully to prevent damage in the mails. Surround your watches with crumpled papers. Insure valuable movements or other items of value.

To CHIEF INSTRUCTOR
Chicago School of Watchmaking

I am working on lesson number______. Please tell me what to do about this:

(Tell briefly what work you did and where you had trouble with it.)

( ) PLEASE RETURN BY INSURED MAIL. ( ) DO NOT RETURN BY INSURED MAIL.

ENCLOSED________¢ INSURANCE FEE

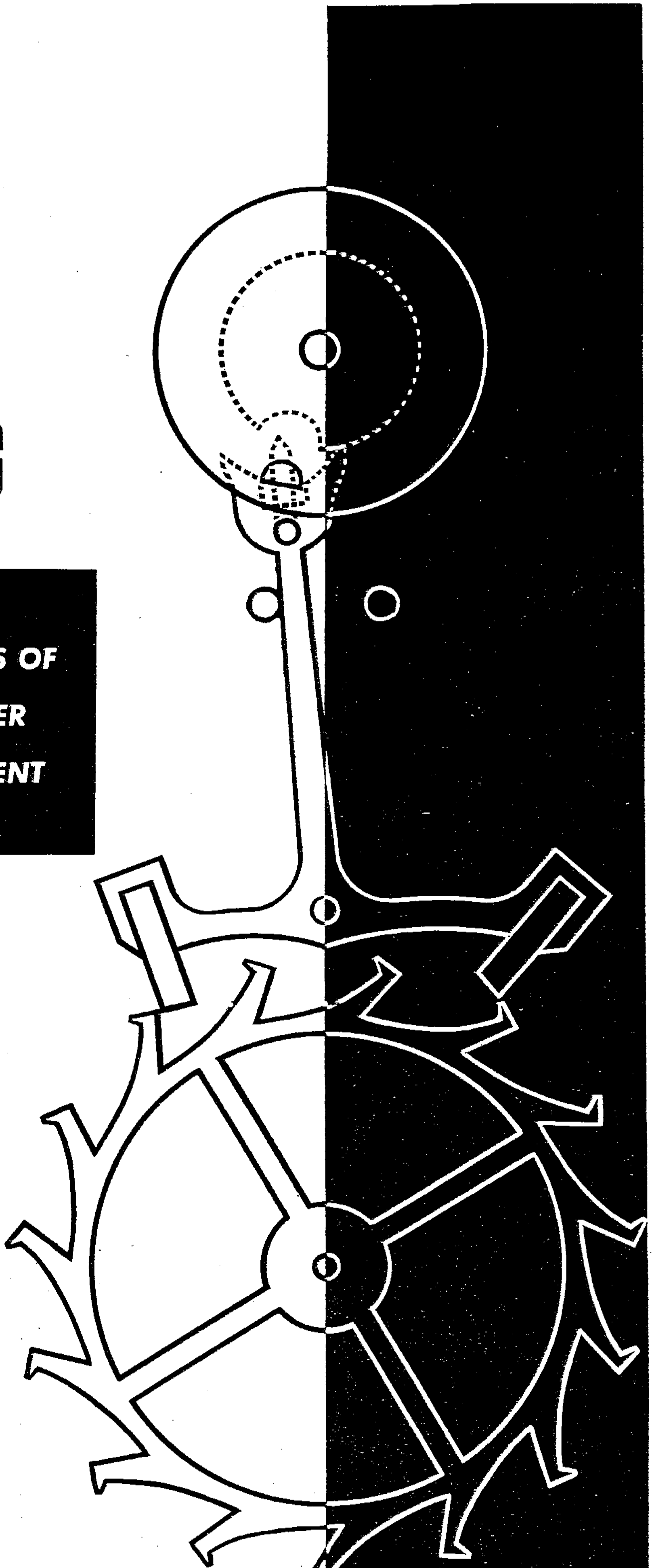
● INSTRUCTOR NOTE: Please send a new Request Sheet back with this one.

Cut along this line and use this sheet - when you need help on your shop work.

Master WATCHMAKING

LESSON 21

PRINCIPLES OF THE LEVER ESCAPEMENT



CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by THOMAS B. SWEAZEY

Printed in the United States of America

21

INTRODUCTORY INFORMATION

In actual practice, the escapement seldom needs repairing. Most of the time the repairman needs only to check that it is in proper working order. But sometimes, through accident or careless handling, defects will occur, such as a pallet stone getting loose. The repairman who understands the escapement can make such repairs quickly while the man who lacks this understanding may struggle for hours to restore the watch to proper action.

When you hear a watch tick, you are actually hearing the escapement at work. Each tick means the escapement is letting the power of the mainspring pass (or escape) from the train to the balance wheel and hairspring. It does this at regular intervals which must be maintained if the watch is to run accurately. Because of its important role in maintaining this regularity, the escapement is sometimes called the "traffic policeman of the watch."

Seemingly minor adjustments can affect this action of the escapement to such an extent that an understanding of its workings is most important. The quickest way to gain this understanding is to study the theory behind the escapement. This theory is a "must" is you really want to know what you are doing in your repair work. It will challenge your learning ability, but your lessons and assignments are designed to enable you to master the subject as easily as possible.

Four lessons (21, 22, 24 and 25) of this unit are to help you understand the theory and action of the detached lever escapement. Lesson 23 deals with types of escapements other than the detached lever escapement. In the last lesson of the unit (26), you will see how the theory is applied to actual repairing.

Follow your assignments closely if you want to master the subject most easily. Dig into them, because knowledge develops interest as well as understanding. And once you've learned the escapement, you are well on your way to completing your basic understanding of watch repair.

KEY POINTS OF LESSON ASSIGNMENTS 67, 68:

- The names of the parts of the escapement.
- Comparison of double and single roller escapements.
- The fork and roller action.
- Positioning the roller jewel.
- The safety action.

ASSIGNMENT NO. 67: Study Sections 395 through 399.

Study Questions:

1. How does a theoretical knowledge of the escapement help a watchmaker in practice?
2. Why does changing one part of the escapement change the way other parts perform?
3. What parts are properly included in the escapement?
4. What is the basic difference between a single and double roller escapement?

ASSIGNMENT NO. 67 (Continued):

5. What advantages are claimed for the double roller over the single roller type?
6. How is power lost in the escapement?
7. What is a conservative estimate of the total power lost in the escapement?

ASSIGNMENT NO. 68: Study Sections 400 through 403.

1. What is the most common error in escapements?
2. How can you tell if a roller jewel is too far back?
3. What methods have you for telling if a roller jewel is too far forward?
4. What is meant by "Lock"? "Slide"? "Drop"? "Banked to the drop"?
5. What is the difference between lock and slide?
6. What is the purpose of the guard pin?
7. Why is correct safety action important?
8. How can you check the safety action?
9. What is the correct position for the guard pin in a single roller escapement?
10. Why is a single roller more likely to let the fork go out of action than a double roller?

REQUIREMENT:

➧ Answer the Test Questions for Lesson 21 and send in for grading.

Important!

Note carefully the relationship of the fork horns, guard dart, roller jewel, and safety roller in the side view of Figure 21-1. Note they are all under the large impulse roller.

It is usual in drawings to show parts which are underneath, inside of or behind other parts by means of dotted lines, as in Fig. 21-1. However, this is not always done in these escapement lessons because dotted lines are also used in some illustrations to show movement of parts of the escapement. Many times, therefore, the parts named above will be drawn in solidly as if they were on top of the impulse roller.

No matter how they appear in the drawings -- solid or dotted -- remember the fork horns, guard dart, roller jewel and safety roller are always actually underneath the large impulse roller.

ASSIGNMENT NO. 67 (Continued):

5. What advantages are claimed for the double roller over the single roller type?
6. How is power lost in the escapement?
7. What is a conservative estimate of the total power lost in the escapement?

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1. What is the most common error in escapements?
2. How can you tell if a roller jewel is too far back?
3. What methods have you for telling if a roller jewel is too far forward?
4. What is meant by "Lock"? "Slide"? "Drop"? "Banked to the drop"?
5. What is the difference between lock and slide?
6. What is the purpose of the guard pin?
7. Why is correct safety action important?
8. How can you check the safety action?
9. What is the correct position for the guard pin in a single roller escapement?
10. Why is a single roller more likely to let the fork go out of action than a double roller?

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No matter how they appear in the drawings -- solid or dotted -- remember the fork horns, guard dart, roller jewel and safety roller are always actually underneath the large impulse roller.

SEC. 395—The Detached Lever Escapement

There is no part of a watch that involves so many complications or requires such an amount of study and practice as the escapement. There is no part of its mechanism about which more has been written, yet half has not been told.

In order to adjust an escapement intelligently, a thorough knowledge of the nature of all its functions is essential. Theory and practice are both required. Theory alone will not make a good workman. Practice without theory may do so, after a fashion; the two united make the rapid and skillful workman.

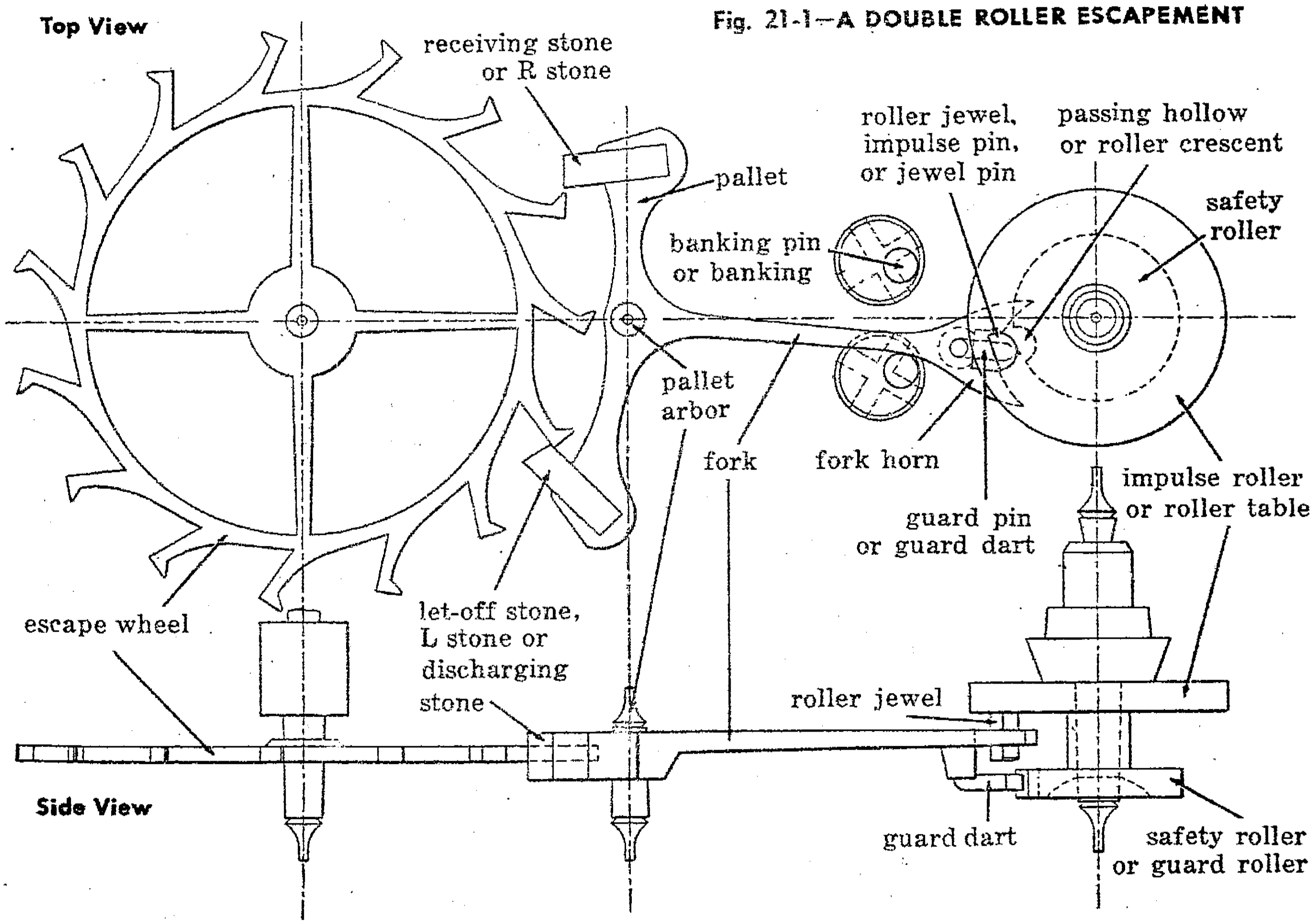
The escapement is complex in its character. The various individual functions are so intimately related to each other that no single one can be altered without affecting others to a greater or lesser degree. The consequence is that a workman will often make an alteration to correct an error, and in doing so will create another error, or aggravate a previously existing one. Without a good theoretical knowledge, hours may be spent over an escapement that, with sound theoretical knowledge, might have been made right in minutes.

The theory will be presented in plain language, accompanied by a multiplicity of illustrations so that the problems involved will be clear. The effects produced by the different alterations that may be made will be described and illustrated, thus directing the practice of the student. Every operation performed will be for definite results, results that may confidently be expected.

SEC. 396—Names of Parts

The term escapement is applied to that part of the watch by means of which the rotary motion of the wheels is transformed into the vibratory motion of the balance. The members included in the escapement are: The escape wheel, the pallets, the fork, the roller jewel and the roller table or rollers. The balance is not properly a part of the escapement. Inasmuch as more than one term is frequently used to designate the same part, it is deemed well to give the different names in general use:

Fig. 21-1—A DOUBLE ROLLER ESCAPEMENT



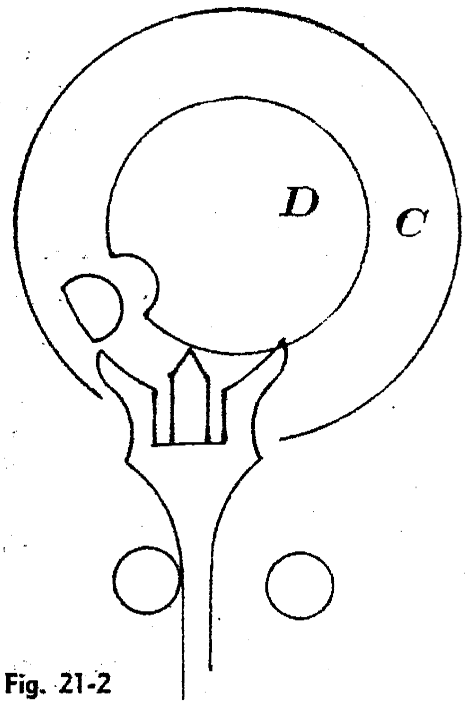


Fig. 21-2

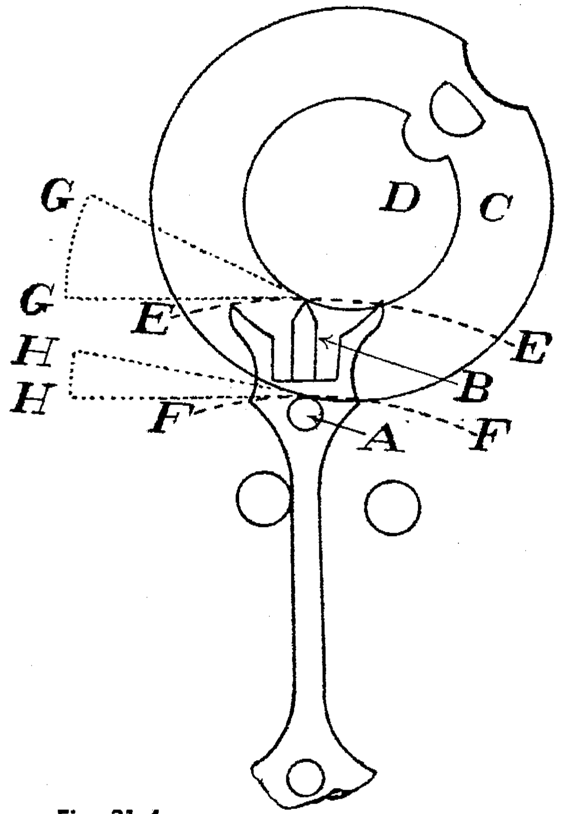


Fig. 21-4

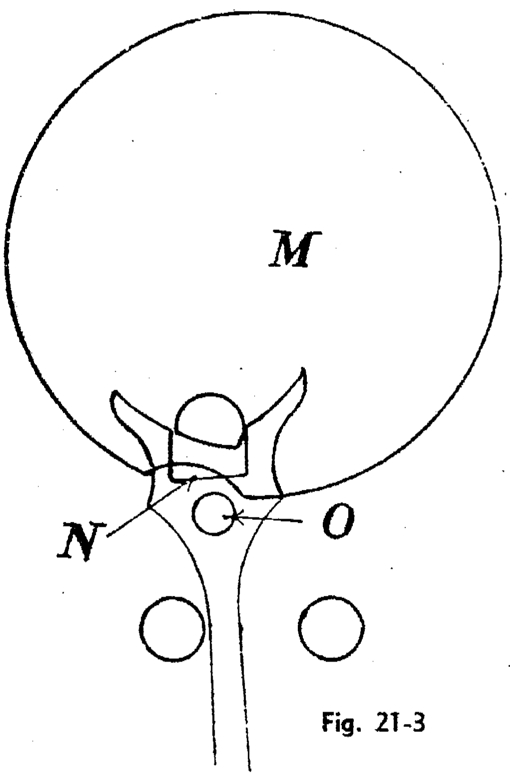


Fig. 21-3

SEC. 397—Comparison Between the Single Roller and the Double Roller Escapements

The difference between the single and the double roller escapement is entirely in the safety action; the escape and pallet action and the fork and impulse action may be identical in both forms.

The guard pin and safety roller are provided for the sole purpose of preventing what is commonly called "overbanking" or more properly speaking, "going out of action."

Referring to figure 21-6 it will be seen that the fork is to the left, and that the roller is making its excursion in the direction indicated by the arrow, **H.** The roller jewel is in the act of unlocking the escapement and in this position the fork cannot go out of action, as it is held in place by the roller jewel. When the roller jewel is out of reach of the fork horn the fork is kept in position by the safety roller; it cannot pass the safety roller until the passing hollow comes into position.

Figure 21-2 illustrates the latter condition. This figure shows the fork at the left as in figure 21-1, but the roller jewel is farther to the left, and out of reach of the fork horn. The fork is now prevented from overbanking by the edge of the safety roller projecting beyond the path of the guard pin. It is not deemed necessary to letter the parts in this drawing.

Figure 21-3 shows a single roller under the same conditions as the double roller in figure 21-1. **M** is the roller table, **N** the passing hollow, **O** the guard pin. The roller table, **M,** performs the offices of both rollers **D** and **E** in figure 21-1. In the double roller, the guard pin projects forward, under and beyond the roller jewel. In the single roller it stands perpendicularly with the fork and is back of the fork slot. The roller table, **M,** not only carries the roller jewel, but its edge in conjunction with the guard pin provides the safety action.

SEC. 398—Advantages Claimed For Each Form of Safety Action

Figure 21-4 shows a portion of an escapement with both forms in combination. The guard pin **A** is for the single roller action; the guard pin **B** is for the double roller action; **C** is the impulse roller in the double roller form; **D** is the safety roller in the double roller form; **C** takes the place of both rollers in the single roller escapement.

The fork is shown against the left banking pin. The broken line **EE** is the path of the double roller guard pin; the broken line **FF** is that of the single roller guard pin. It will be seen that line **EE** penetrates beyond the periphery of the safety roller to a much greater extent than line **FF** penetrates beyond the periphery of the roller **C.** The dotted lines **GG** are drawn tangent to the circumference of the safety roller and to the path of the guard pin at their point of contact in the double roller escapement; the dotted lines **HH** are in the same relation in the single roller escapement. These lines embrace the angles at which the respective guard pins make contact with their rollers. It will be observed that the angle embraced by lines **GG** is more than twice that embraced by line **HH.** It is therefore justly claimed that the double roller is much less liable to allow the escapement to overbank than is the single roller. It is also claimed, justly, that in case the fork is thrown against the roller edge, less resistance is offered to the motion of the balance, owing both to the respective sizes of the rollers and the difference in the angles at which they contact, as shown by the lines **GG** and **HH.**

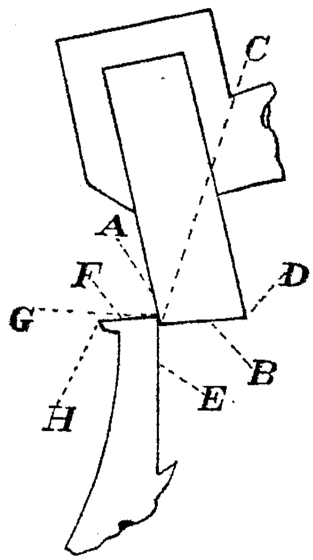


Fig. 21-5

SEC. 399—Loss of Power

Before considering the important subject of loss of power, it might be well to give the terms used to designate the acting parts of the pallet stones and the escape wheel teeth.

The parts of the pallet stone, figure 21-5, are: **A,** the locking face; **B,** the impulse face; **C,** the locking corner; **D,** the releasing corner.

The parts of the escape tooth are: **E,** the locking face; **F,** the impulse face; **G,** the locking corner; **H,** the releasing corner.

There is a great loss of power from the lever escapement even under the most favorable conditions. There is more loss of power entailed in conveying the motion from the escape to the balance than in all other losses of power combined. Of the force conveyed from the mainspring through the train up to the escape wheel teeth, upwards of one-third of the power is lost before it reaches the balance. This will no doubt seem surprising, but it will be explained by figure 21-6 and the specifications connected therewith. In order to avoid confusion, the guard pin and passing hollow, which constitute the safety action, have been omitted from this figure as they have nothing to do with the conveyance of power.

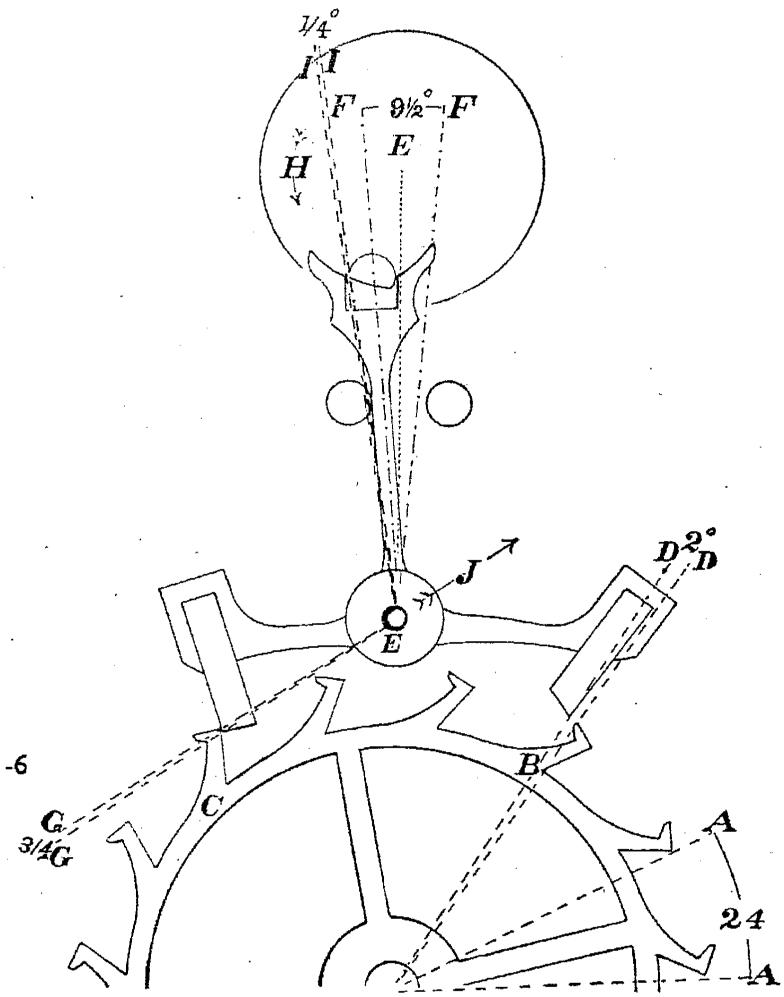


Fig. 21-6

The escape wheel has 15 teeth; the quotient of 360 degrees divided by 15 is 24 degrees; therefore, the angular distance between similar points of adjacent teeth is 24 degrees as shown by lines **AA**. One revolution of the escape wheel causes each tooth to deliver two impulses to the pallets, or thirty impulses in all—one impulse on the receiving stone and one on the discharging stone. This gives 12 degrees of angular motion for each impulse. The entire 12 degrees, however, cannot be used for impulse as a certain amount is necessary for freedom. This freedom is called the drop. In the drawing, tooth **B** has just been released from the discharging stone and tooth **C** arrested by the receiving stone. The angular distance between the releasing corners of the discharging stone and tooth **B** is the amount of the drop; the drop is just that much lost power. The wheel passes through that portion of each revolution without doing any effective work, its force being lost in the impact when it is stopped by the pallet. The amount of drop is usually 2 degrees, as shown by the lines **DD**. This involves a loss of 16-2/3 per cent, exclusive of that in the impact.

In figure 21-6 the arc of impulse of the fork from banking to banking is 9½ degrees as shown by lines **FF**. In the drawing **EE** is the line of centers: the lines **FF** include the arc of vibration. Of this 9½ degrees of vibration, ¾ of a degree must be deducted for lock, as shown by lines **GG** which pass through the locking corners of tooth **C** and the receiving stone. This leaves 8¾ degrees of actual impulse which is a loss of more than 7 per cent; and bear in mind that this 7 per cent loss is 7 per cent of the power left after deducting the loss from drop.

The roller jewel must be allowed some freedom in the fork slot. This freedom is called roller jewel shake, and can be readily understood by referring to the drawing, which shows the fork held against the left banking, the tooth locked on the receiving stone. Let us assume that the roller is making an excursion in the direction indicated by the arrow **H**. In making this excursion, the roller jewel enters the fork slot, and, coming in contact with its right side, moves the fork to the right, thereby unlocking the wheel tooth. When the tooth passes to the impulse face of the stone the fork immediately moves to the right until the left side of the slot makes contact with the roller jewel. This is referred to as roller jewel shake. Its amount is usually ¼ degree, as shown by lines **II.** A loss of 3 per cent is thus incurred. The losses thus far given bring the aggregate up to about 27 per cent, for we must bear in mind that each deduction for loss is the given percentage of the amount remaining after the previous deduction. There remain other losses, such as friction, impact and side shake, the exact amount of which cannot be readily calculated. Perhaps the side shake in the pallet arbor jewels is the most serious of these.

As the various impulses are applied and resistance is encountered by the members of the escapement, their pivots are forced against their bearings in different directions. This may readily be detected through a double eye-glass by looking directly down on the pallet arbor pivot while the balance is in motion. The side shake will show more plainly when the jewel and pivot are clean and unoiled. When the parts are in contact under the conditions shown in figure 21-6 the pallet arbor is pressed against the side of the jewel hole in the direction indicated by the arrow **J.** As the impulses are delivered alternately to the stones, and the resistance of the roller jewel is encountered, the pivot will be seen to rock from side to side in the jewel, thus incurring a loss of power. Hence it is important that the side shake in these jewels be as close as possible.

Another loss of power to which attention is called is the result of the impacts of the escape teeth with the pallet stones, and the roller jewel with the fork. To fully appreciate this, the fact must be kept in mind that the fork is started up from a dead rest at each vibration and that it comes to a sudden stop at the end of each vibration.

Another condition existing in the fork and roller action is that the movement of the fork is practically uniform, while that of the balance varies. A balance having a motion of one turn must necessarily travel at a higher rate of speed than if the vibration were half a turn. When the roller jewel is in contact with the fork, the balance is at its maximum velocity. As the roller jewel first contacts the fork, it releases the escape wheel by unlocking and immediately the resistance of the fork is reversed. It begins to exercise force to accelerate the motion of the balance. but the balance is moving at a higher rate of speed and consequently has a tendency to recede from its pressure—to get away from it, so to speak. The result is that as the motion of the balance increases, the efficiency of the force of the fork decreases.

It will be seen from the foregoing that placing the loss of power at one-third is a very conservative estimate.

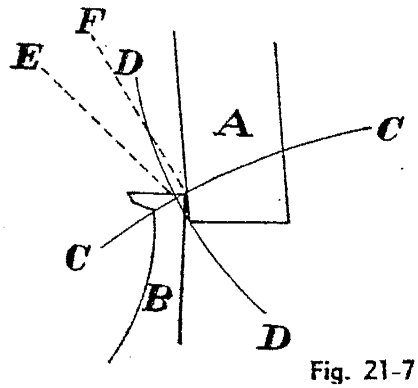


Fig. 21-7

The recoil in unlocking is a source of error that sometimes makes itself felt in adjustment. Figure 21-7 illustrates what is meant. The drawing is made to exaggerate the condition for the purpose of making the point clear.

A is a pallet stone, **B** an escape wheel tooth. The circular line **CC** is the path of the locking corner of the tooth. The circular line **DD** is the path of the locking corner of the stone. In unlocking, the stone passes along the arc **DD** and the tooth along the arc **CC.** The unlocking takes place at **E,** where the lines **CC** and **DD** intersect. It follows then that the tooth must be forced backwards from the point **F,** where it is shown on the drawing, to the point **E,** where it unlocks. This backward motion is known as the recoil. In forcing the escape wheel backwards, the fourth, third, center, and barrel are all in their turn reversed. This actually winds up the mainspring 300 times a minute. True, it is an infinitesimal amount, but let it be understood that the entire impulse delivered by the escape wheel is but a minute fraction of the rotation of the barrel.

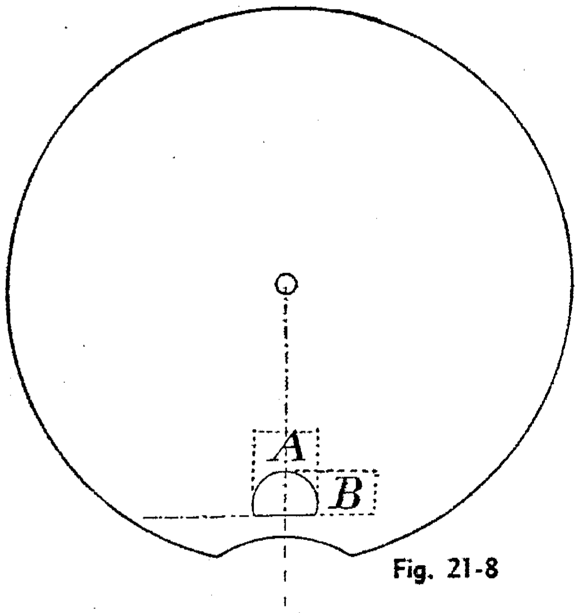


Fig. 21-8

SEC. 400—The Fork and Roller Action

An improperly fitted or incorrectly located roller jewel is perhaps the most common error found in escapements. A roller jewel should have 1½ to 2 hundredths of a millimeter shake in the fork slot. The roller jewel should be set firmly in the roller. It should be perfectly upright, its face square to the front, that is, at right angles with a radial line from the center of the roller, as shown in the broken lines in figures 21-8.

A D-shaped roller jewel should be flattened to about two-thirds of its diameter. The diameter **B** should be two-thirds that of **A.**

Figure 21-9 shows the effect of a roller jewel tilted sidewise. In this figure **A** shows a jewel set upright while **B** shows a jewel set out of upright. Referring to **A,** it will be seen that the roller jewel **c** has a certain amount of sideshake, as indicated by the black portion at the right of the jewel; referring to **B,** the roller jewel **c** being tilted, takes up all the sideshake.

Figure 21-10 shows the effect of tilting a roller jewel forward. In this figure, **A** is a roller, **B** a fork, **C** a roller jewel. The point where the section lining ceases at the lines **dd** is the bottom of the fork slot. The perpendicular dotted lines **ee** represent the front end of the slot, where the curve of the horn **f** begins. The fork is shown in two relative positions to the roller jewel. It is evident that owing to the necessary endshakes of the balance and fork, the fork will vary with regard to longitudinal position on the roller jewel. In the uppermost position, the roller jewel penetrates a greater distance into the fork slot than in the lower. This variation (being liable to constant change) is detrimental to regularity of rate. Its effect on escapement adjustment will be more fully explained as we proceed.

Fig. 21-10

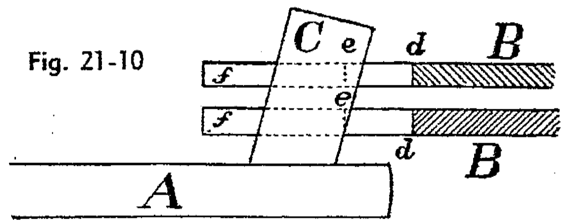


Figure 21-11 illustrates the proper position of the roller jewel when entering or leaving the fork slot. The bankings are set correctly for lock and slide; the escape wheel and pallet are not shown. It will be observed that the face of the roller jewel clears the curve of the fork horn. The fork is against the left banking, but if at this instant it should be moved to the right, the left corner of the slot would come in contact with the face of the roller jewel, thus preventing overbanking.

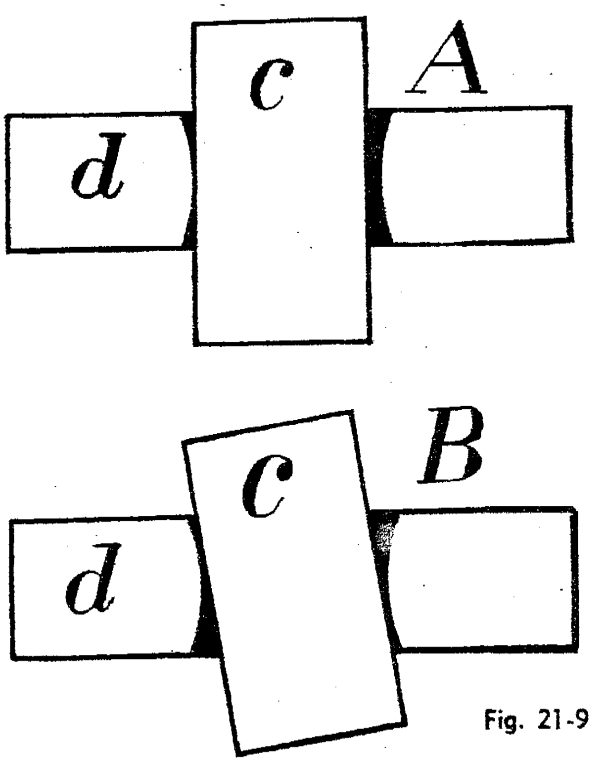


Fig. 21-9

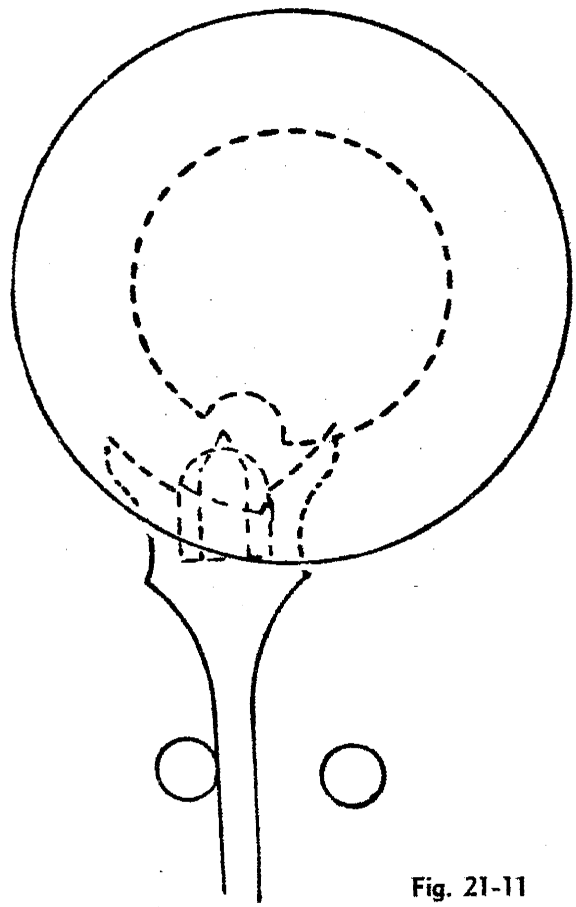


Fig. 21-11

Figure 21-12 below, shows this condition. In this figure the roller jewel is in the same position as in figure 21-11, but the fork is moved to the right, away from the banking pin. The guard pin is not shown, as it is not involved in this action. It will be noticed that further movement of the fork to the right is prevented by the roller jewel and that this also prevents unlocking the escape tooth.

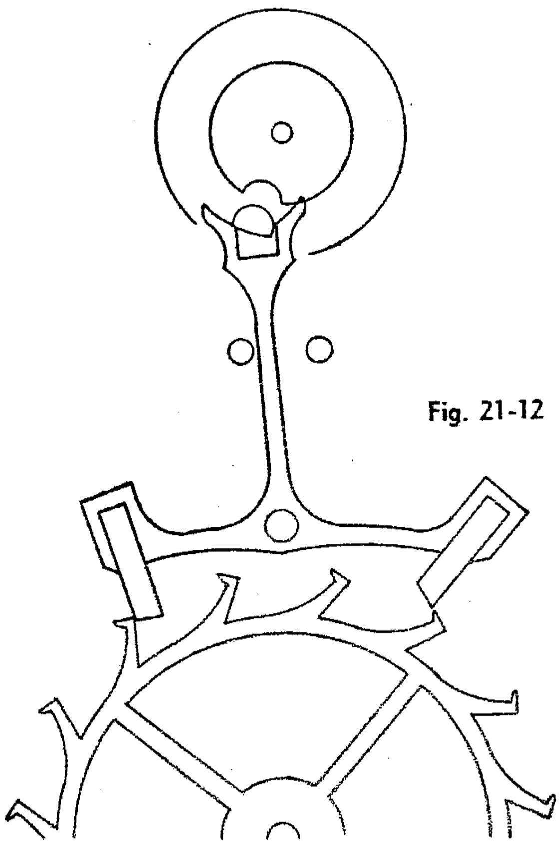


Fig. 21-12

SEC. 401—Correct Position for Roller Jewel

The fork and roller jewel actions can not be readily seen in the watch; the student is therefore compelled to rely to some extent on the sense of touch. How this may be done will now be explained.

Prepare a piece of tissue paper as follows: Take a piece of watch paper, fold it over the top of the index finger of the right hand, securing it with a light rubber band, as shown in figure 21-13. The purpose of this paper is to act as a shield. It permits the finger to be placed upon the balance without danger of smearing it. Placing the finger lightly on the balance, bring the escapement to the position shown in figure 21-14. Now move it in the direction indicated by the arrow until the escape tooth is released by the discharging stone and a tooth drops on

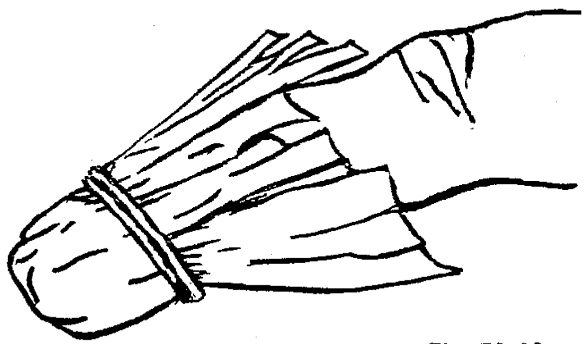


Fig. 21-13

the receiving stone. Stop instantly at this point. Press the fork lightly to the right. If the escape tooth unlocks with this action, the roller jewel is too far back and should be brought forward. Figure 21-15 shows this condition. The fork is shown pressed away from the left banking until it is arrested by the left horn coming in contact with the face of the roller jewel; but before this has taken place the escape tooth has been unlocked and passes on to the impulse face of the pallet stone.

There are two methods by which it may be determined whether or not the roller jewel is too far forward. The balance may be taken out and the escapement banked to drop; that

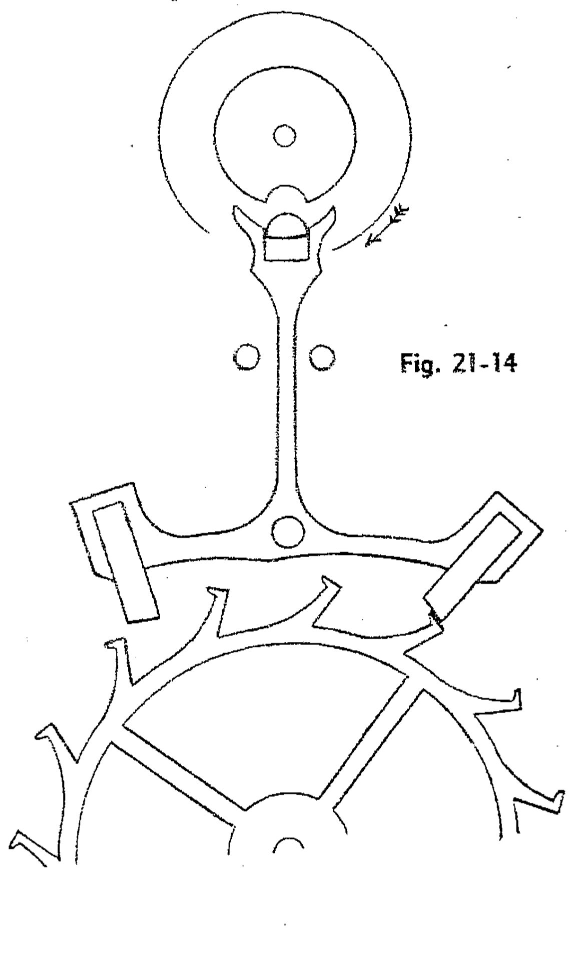


Fig. 21-14

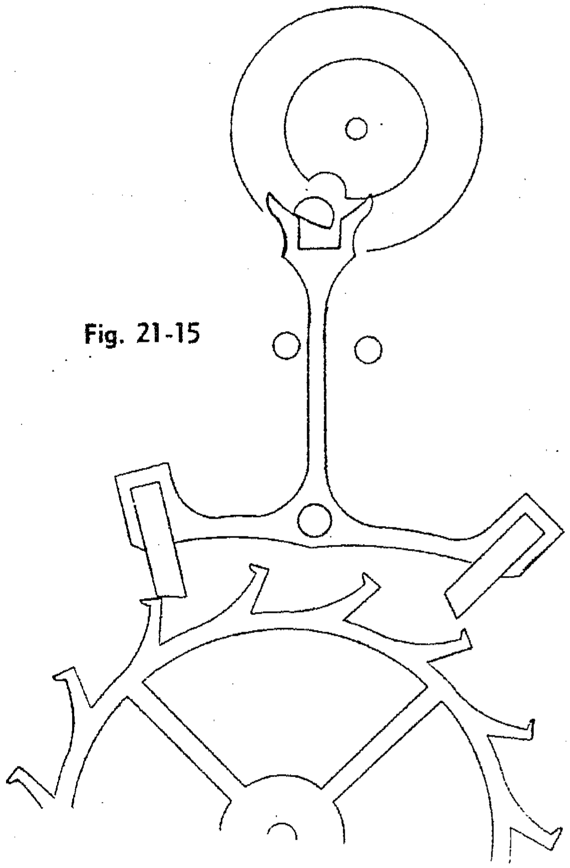


Fig. 21-15

This is frequently done but is entirely wrong, for it gives too much slide. At the locking point, the roller jewel should just pass out of the fork slot without shake. The necessary freedom is given by opening the bankings slightly. Any opening of the bankings beyond this imposes unnecessary work on the balance.

When a banking pin is opened in an escapement banked to drop, it allows the locking face of the pallet stone to slide along the locking corner of the wheel tooth. This is slide—sometimes called run. A perfect understanding of the difference between the terms lock and slide should be acquired.

Lock is the amount that the locking corner of a pallet stone projects beyond the locking corner of an escape tooth at the instant the drop takes place. Lock can only be changed by drawing out or pushing in one or both of the pallet stones. Opening or closing the bankings produces no change in the lock.

When a properly adjusted escapement is in action, a tooth drops on the locking face of a stone. At this moment the fork is a slight distance from one of the banking pins. In its further movement the locking face of the stone slides along the escape tooth until the fork is arrested by the banking pin. This is the slide.

is, the bankings closed up so that the escape wheel will not be released at either side. Now open them until the wheel will be barely released. Leaving them in this condition, replace the balance in such a position that the roller jewel is away from the fork. If on rotating the balance the roller jewel will not enter the fork slot, this is evidence that it is too far forward.

Another way of testing this is by banking to drop while the roller jewel is in the fork slot. If after doing this the roller jewel will not be released by the fork slot, it is evidence that the pin is too far forward.

Figure 21-16 illustrates the first method. The escapement is banked to drop; the roller is assumed to be moving in the direction indicated by the arrow, but the roller jewel is arrested in its motion by the end of the fork horn. It is quite evident that if the roller jewel should be moved back so as to clear the horn, the roller might continue its rotation. Figure 21-17 shows the escape wheel, pallets and fork in the same position as in figure 21-16. The roller jewel here is prevented from leaving the fork slot for the same reason that it is prevented from entering it in figure 21-16.

In either case, opening the bankings would allow the roller jewel to enter or leave the slot.

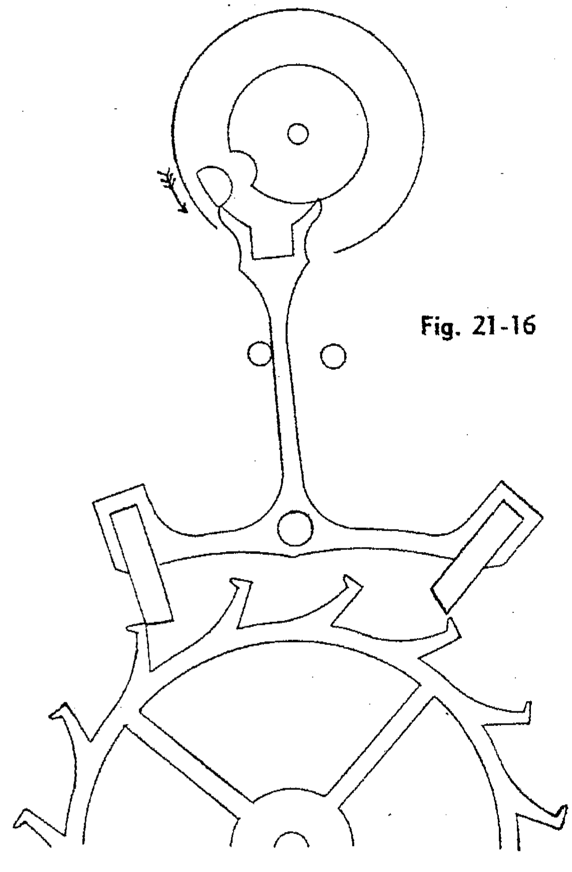


Fig. 21-16

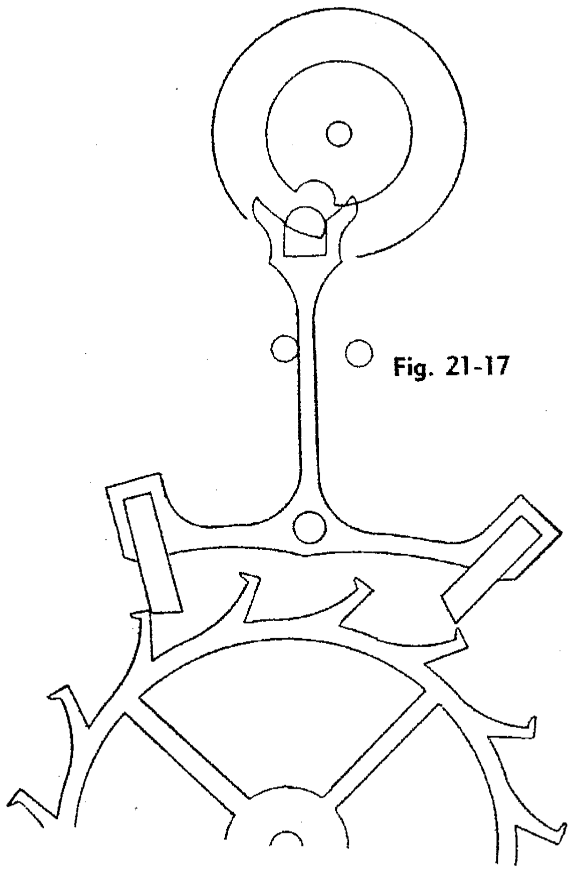


Fig. 21-17

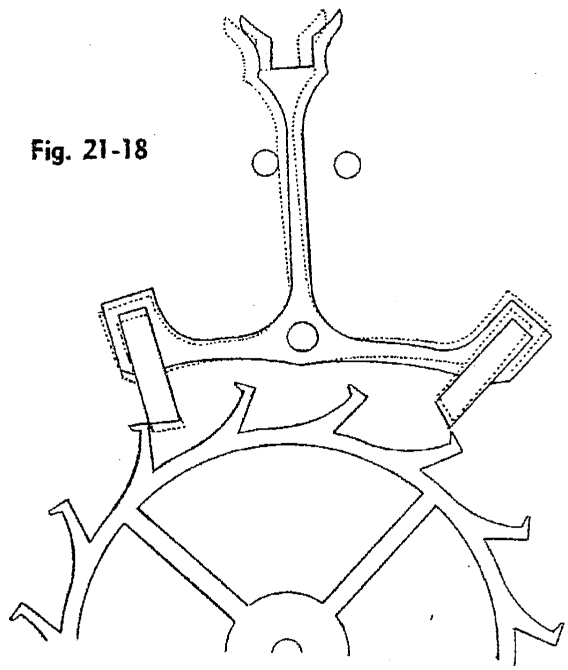


Fig. 21-18

The slide may be increased by opening a banking pin or decreased by closing it, but these operations produce no effect whatever upon the lock.

Figure 21-18 will serve to illustrate the difference between the lock and slide. In this figure the amount of slide is exaggerated for the purpose of making it more readily distinguishable from the lock. The fork and pallets in full lines show the escapement at the lock; the broken lines show it after the slide has taken place.

SEC. 402—The Safety Action

The guard pin in a lever escapement is purely a safety device. It could be dispensed with without impairing the timekeeping quality of a watch, provided the watch was not subjected to any sudden or rapid motion. In order that it may be perfectly reliable as a time-piece a guard pin becomes a necessity. During the free excursion of the balance in the interval between two impulses, the combined action of the guard pin and roller edge prevents the fork going out of position to receive the roller jewel. Without this safety provision a sudden motion given the watch would be liable to cause what is generally called overbanking, or more properly speaking, going out of action.

When the roller jewel leaves the fork slot, the first part of the safety action is secured by the roller jewel and the fork horn. This is due to the fact that the passing hollow cuts away a part of the roller edge and while that cut-away part stands in the path of the guard pin some other means must be provided to prevent going out of action.

Figure 21-19 illustrates the above condition. In this figure the roller is moving in the direction indicated by the arrow. The guard pin, I, is just about to leave the roller edge and enter the passing hollow. Almost immediately the roller jewel will strike the right side of the fork slot, moving the fork and unlocking the escapement. The roller jewel will then be embraced by the fork slot.

In this drawing the passing hollow is not in position to release the roller jewel until it has been embraced by the fork slot. The passing hollow, however, is rarely as narrow as represented in full lines. As a matter of fact, it would not be practical to make it so. It will be seen that if the passing hollow were as wide as represented by the broken lines, the safety action at the point shown in figure 21-19 would be between the fork horn and the roller jewel. If the fork horn should be cut off entirely, as represented by the broken lines, **3, 3,** the safety action would still be perfect. The passing hollow

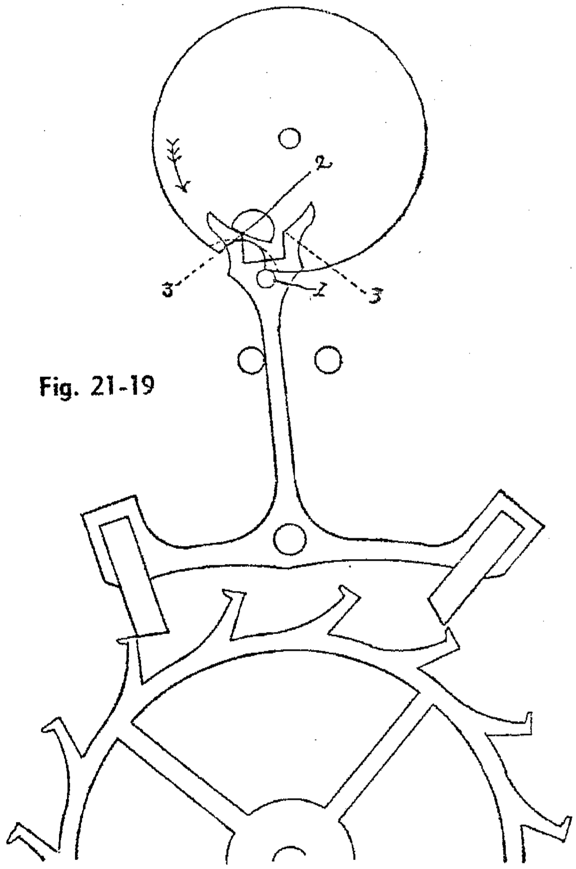


Fig. 21-19

in figure 21-19 represented by broken lines, is wider than is necessary. A passing hollow of a medium width would answer the purpose quite as well. When the roller jewel is made with a circular face as shown, the passing hollow may be left wider without impairing the action, but when the face is flat and the passing hollow wide, the action can not be so nicely adjusted. A double roller should always have an impulse pin with circular face. This condition will become apparent when we reach the description of the double roller escapement. In view of the above, long horns on a single roller escapement are more ornamental than useful.

Figure 21-20 shows how the safety action takes place in the double roller escapement under conditions similar to those prevailing in the single roller shown in figure 21-19. In figure 21-20 the roller is moving in the direction indicated by the arrow and the passing hollow is approaching the guard pin. It will be seen that the roller jewel is still some distance from the fork slot and that before it can enter, the safety action between the guard pin and roller will have ceased. Therefore, a fork horn to provide this safety action is necessary, or else it would go out of action.

When the guard pin in figure 21-20 first comes opposite the passing hollow, the roller jewel will still have a considerable distance to travel before contacting the fork. It is therefore evident that a much greater proportion of the safety action occurs between the roller jewel and fork horn in the double roller than in the single roller escapement.

The curves of the fork horn faces in figures 21-19 and 21-20 are arcs of circles having the same radius, but the centers from which they are described are not in the same location. These arcs are so described that when the fork lies against either banking the curve of the fork horn at that side coincides with the circle described by the face of the impulse pin in its path. In the single roller escapement this is of little importance, but in the double roller it is a great advantage owing to the fact that a greater portion of the safety action must be provided for by the fork horn.

It is a common practice for manufacturers to form fork horn hollows from a common center, in which case the radius must be greater than when two centers are used. These curves are apt to be so wide and to vary so widely from the path of the roller jewel that, especially in a double roller escapement, the safety action may be somewhat uncertain. Add to this a wide passing hollow and we have a combination liable to make trouble and be extremely puzzling to the student.

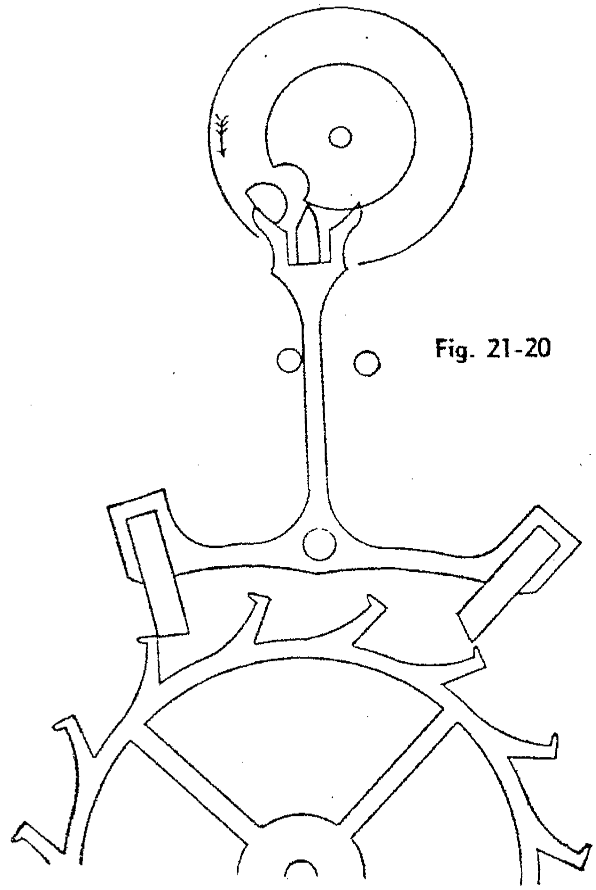


Fig. 21-20

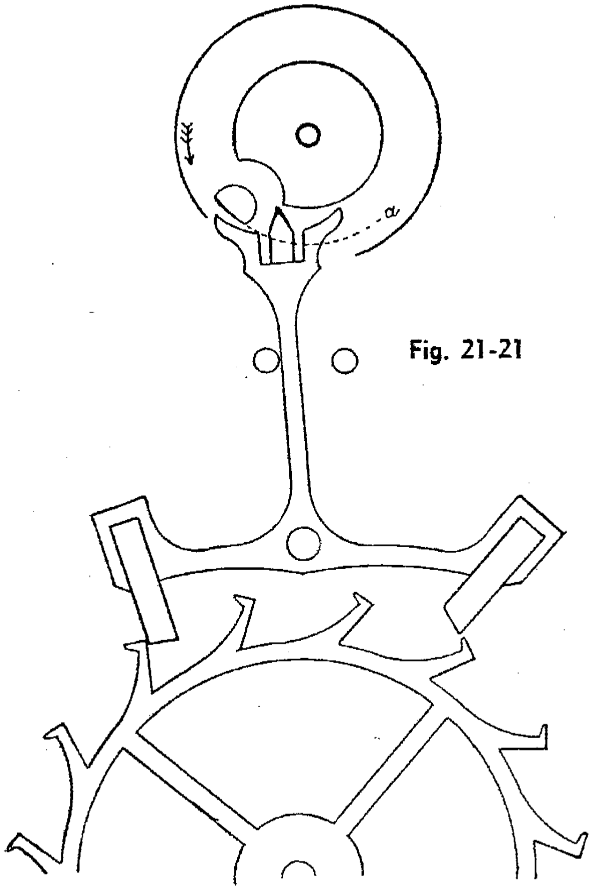


Fig. 21-21

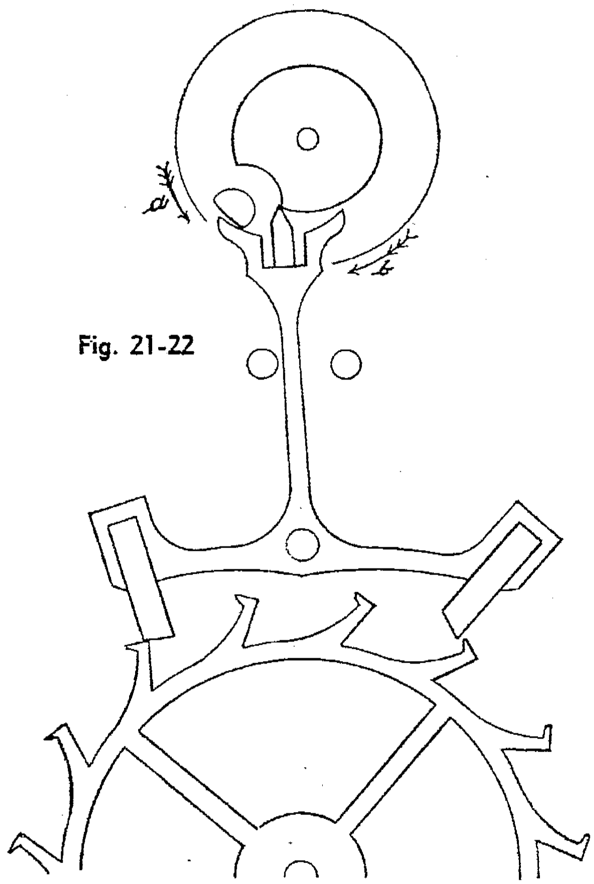


Fig. 21-22

Figure 21-21 illustrates the evil to be apprehended from the condition above described. In this sketch the escapement is shown in the same position as in figure 21-20. The particulars in which escapements differ are: In figure 21-21 the fork horns are curved from a common center, and the passing hollow is wider than in figure 21-20. It will be observed that the curve of the left fork horn does not coincide with the path of the roller jewel, which is the broken line, **a.** The corner of the fork slot is tangent to that line while the extreme end of the fork horn is some distance from it. Under these conditions any sudden jar might throw the fork to the right, thereby wedging the guard pin against the edge of the passing hollow, unlocking the escapement and stopping the watch. This is made clear in figure 21-22.

Figure 21-22 shows the roller in the same position as in figure 21-20. The fork is assumed to have been thrown to the right by a sudden jar. It will be seen that the escapement is now unlocked, an escaped tooth having passed down for a slight distance on the impulse face of the receiving stone. When this occurs and the roller is moving in the direction of the arrow, **a,** it will cause a wedging of the parts that must stop the watch and possibly break the roller jewel, or else bend or break the balance pivot. If it is moving in the direction of the arrow, **b,** it may only trip-check the motion—and pass on, but in that case the escapement must unlock momentarily, causing the watch to lose time to a greater or lesser extent according to the frequency of its occurrence.

It is not intended to imply that every fork in which the curve of the horns is developed from a common center will produce the condition described above. It is only intended to show what may ensue, and to caution the student against neglect in observing this particular feature.

This condition may readily be detected by following the directions below. Turn the balance slowly in either direction until an escape wheel tooth drops on a pallet stone. Then press the fork lightly toward the center position—away from the banking—continuing to turn the balance for about ¼ revolution. If the condition described prevails the escapement will unlock. Now make the same trial on the other stone.

SEC. 403—Guard Pin and Roller Action

In a single roller escapement the guard pin should be upright. Bending it forward, backward, or sideways to adjust the roller shake is not recommended. The evil of this practice will be demonstrated further on.

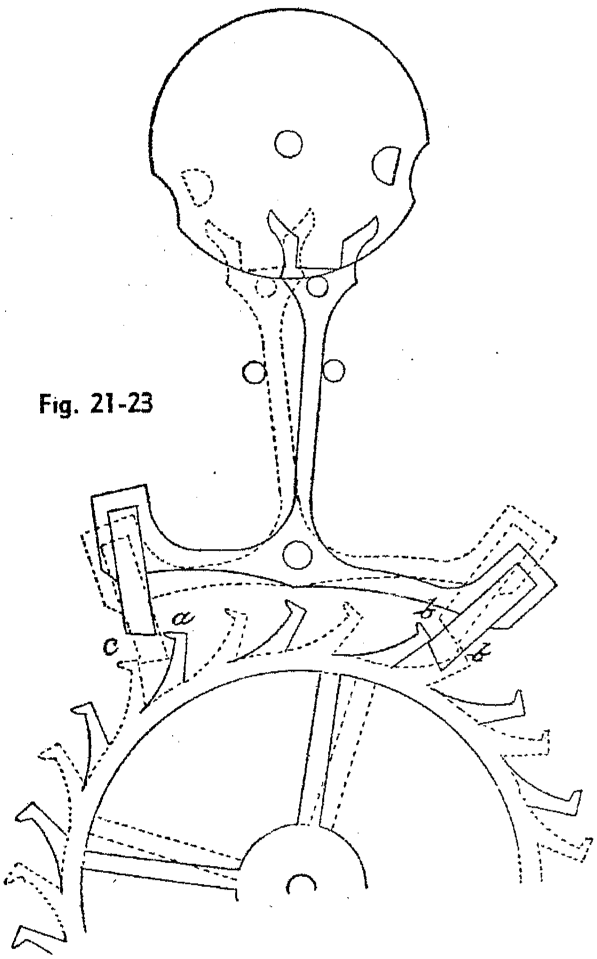


Fig. 21-23

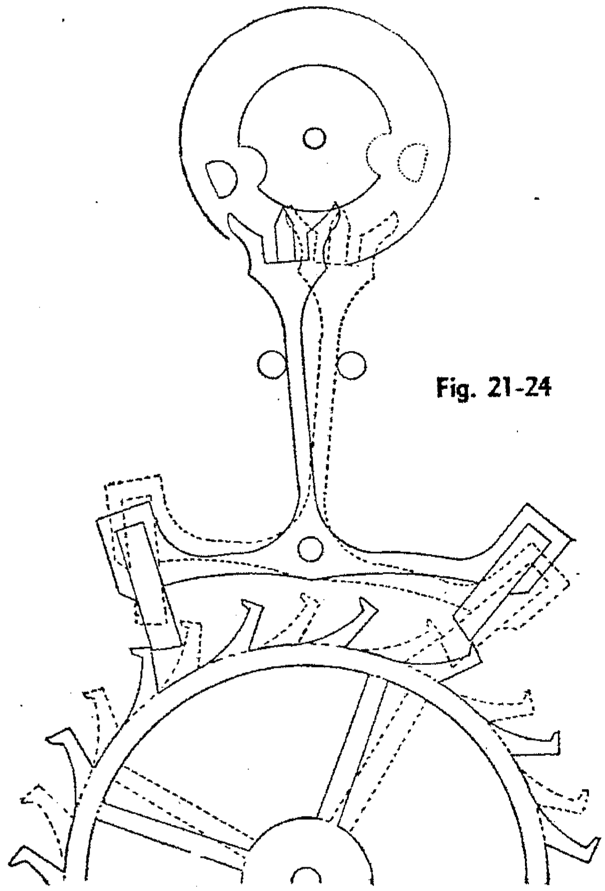


Fig. 21-24

Figure 21-23 shows a single roller escapement banked to drop. In the escape wheel, the full lines show tooth, **a,** of the escape wheel released from the receiving stone. The broken lines show tooth, **b,** after it has passed across the impulse face of the discharging stone, and tooth, **c,** has locked on the receiving stone. It will be observed that the fork lies against the bankings at both sides and that the guard pin contacts the roller at both sides also. This is called "Banked to Drop—No Shake—No Slide," which means that it is banked without either shake between the roller edge and guard pin or slide on either pallet stone.

Figure 21-24 shows the double roller escapement in the same condition as the single roller in figure 21-23. These last two figures show both fork and roller in two positions. Now turn to figure 21-25 which shows the fork in two positions and the roller in one. In this figure the fork, in full lines, is just about to embrace the roller jewel. The safety action which has been, until this instant, between the fork horn and the face of the roller jewel now ceases. In the fork, shown in dotted lines, the safety action is between the edge of the safety roller and guard pin.

Figure 21-26 shows a single roller and figure 21-27 a double roller. By comparing the two it will readily be seen why the single roller is more liable to allow the fork to go out of action than is the double roller. By comparing, in figure 21-26, the broken line **aa** which indicates the path of the guard pin with the broken line **bb,** which is the path it should take, it will be seen that it only requires a slight difference such as might arise from a pallet arbor with too much side shake, to allow the fork to go out of action. The roller is moving in the direction of the arrow and the fork should be at the right with its slot in position to receive the roller jewel. But in going out of action it has passed to the left. The roller jewel is arrested by coming in contact with the outside of the fork horn, and the watch immediately stops.

Now turn to figure 21-27. The two broken lines, **aa** and **bb** are in the same relation to the guard pin as they are in figure 21-26. Although the fork in figure 21-27 is thrown against the roller edge, it can not pass and the escapement is not unlocked. It therefore follows that a slight error which might cause a single roller escapement to go out of action might not seriously affect a double roller.

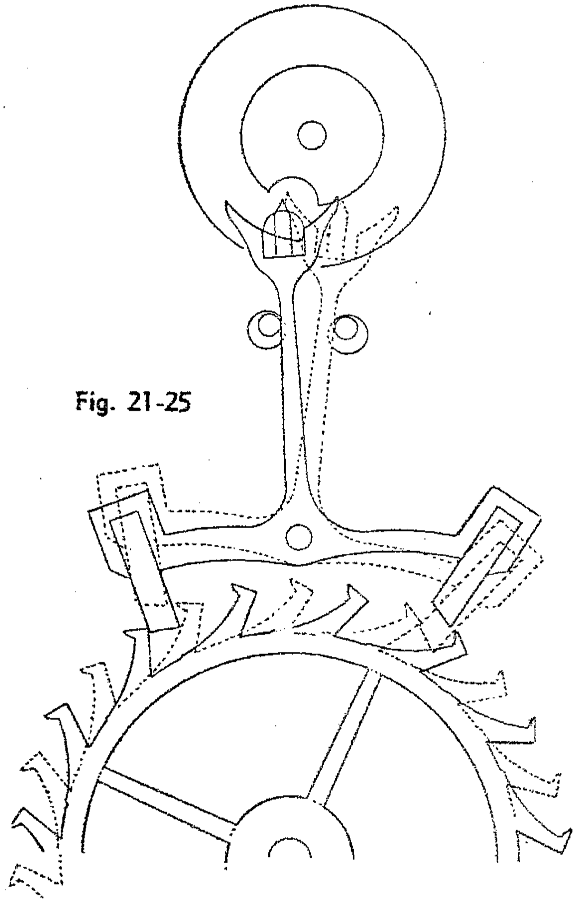


Fig. 21-25

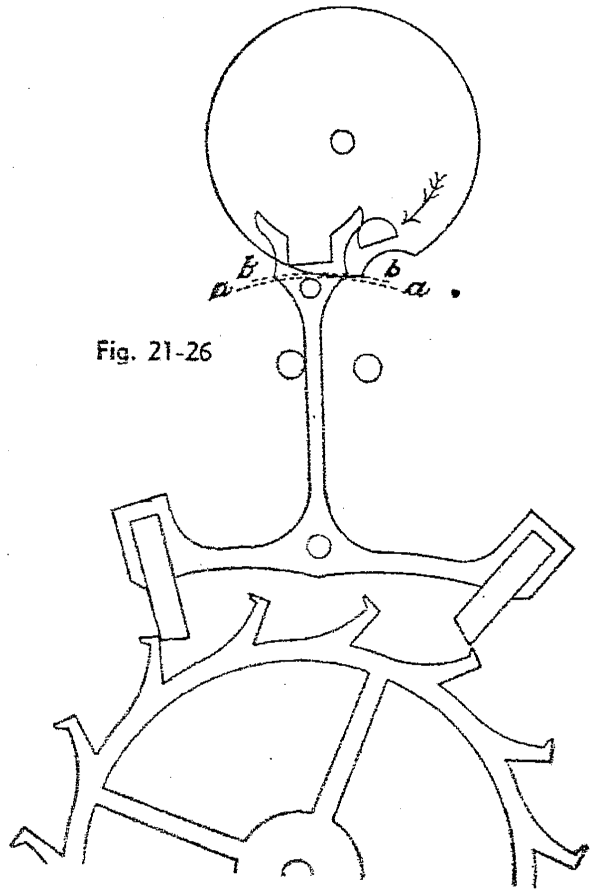


Fig. 21-26

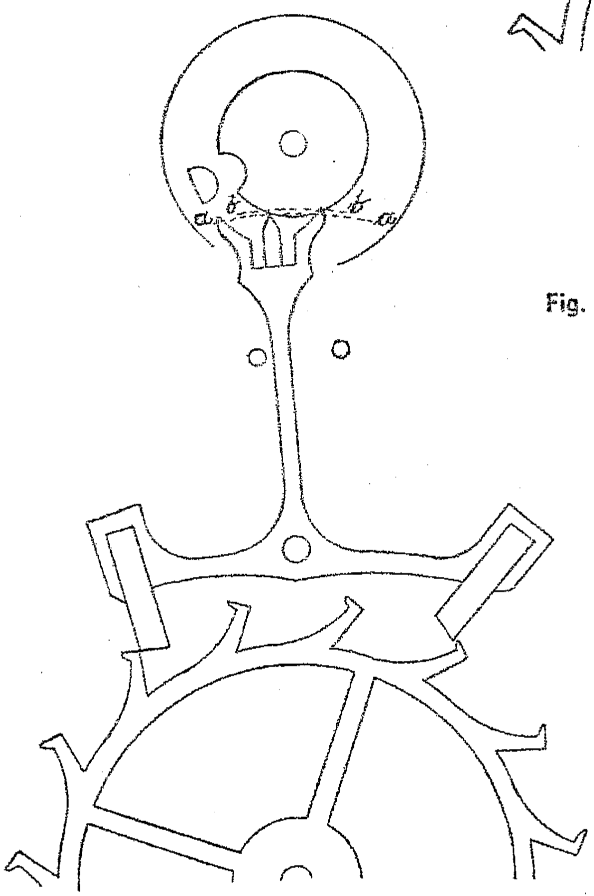


Fig. 21-27

CHECK YOURSELF

Progress Check 21 — A Self Test Review of Lesson 21

After you have studied Sections 395 through 403, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you see you have missed any, re-study the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or phrase in the blank spaces.	Section Ref.
1. The principal parts of the escapement are: a. ______ b. ______ c. ______ d. ______ e. ______	396
2. The parts which receive the power from the train are the ______ and ______.	Fig. 21-1
3. Going out of action is commonly called ______.	397
4. The double roller is almost universally used today instead of the single roller because the double roller is less likely to let the escapement ______.	398
5. All of the following produce a loss of power except one. The one which DOES NOT is ______ a. Drop b. Lock c. Roller jewel shake d. Friction e. Pallet arbor jewels f. Side shake g. Impact of escape teeth on pallet stones h. Guard pin or dart i. Increased motion of the balance j. Recoil in unlocking	399
6. One of the most common errors in the escapement is an improperly fitted ______.	400
7. The amount of freedom between the roller jewel and the sides of the fork slot is called ______. It should be approximately ______ hundredths of a millimeter.	400
8. Closing the bankings so the escape wheel will just be released at either side is known as ______	401
9. Opening or closing banking pins will change ______ but not ______.	401
10. The purpose of the guard pin is to keep the watch from ______.	402

Progress Check 21 (continued)

	Section Ref.
11. The fork horns serve a more useful purpose in a ______________ roller escapement than in a ______________ roller.	402
12. Which ONE of the following has NO part in the safety action of a double roller escapement? ______________	402 & 403

a. Roller jewel
b. Fork horns
c. Safety roller
d. Passing hollow
e. Banking pins
f. Pallet arbor
g. Fork slot

ANSWERS TO PROGRESS CHECK 21:

1. Escape wheel
   Pallets
   Fork
   Roller jewel
   Roller table or rollers
2. pallets
   fork
3. overbanking
4. go out of action
5. guard pin or dart
6. roller jewel
7. roller jewel shake
8. 1-1/2 to 2
8. banking to the drop
9. slide
   lock
10. going out of action
11. double
    single
12. pallet arbor

SUMMARY

1. The escapement is a means for transferring the power of the mainspring to the balance in controlled amounts. The accuracy of the watch depends on how well this is done.

2. The modern lever escapement is the most efficient so far, but loses a surprising amount of the power it transfers before the power reaches the balance. This is due to unavoidable forces and frictions.

3. The escape wheel transmits power to the pallet assembly which carries it to the balance to keep it rotating.

4. The pallet assembly also checks or locks the escape wheel while the balance is moving.

5. The balance assembly unlocks the escapement at regular intervals, which allows the train to turn the hands at fixed speeds. Unlocking is accomplished by the back and forth rotation of the balance wheel and the action of the roller jewel pin and pallet fork.

6. The roller jewel must be carefully fitted and properly located in relation to the fork slot and roller to insure proper action.

7. The safety action prevents the escapement from unlocking at the wrong time and stopping or damaging the watch. Safety action is obtained in two ways: action of the guard pin and safety roller and action of the fork horn and roller jewel.

8. The double roller escapement has replaced the single roller because the double roller has a more certain safety action.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions **Master Watchmaking** Lesson No. 21

Name: No.: Date:

SUBJECT: Principles of the Lever Escapement. GRADE: ____________

DIRECTIONS: Circle the ONE BEST answer.

1. Three of the following terms refer to the same escapement part. Which one DOES NOT refer to this part?

   Roller jewel — Impulse pin — Jewel pin — Guard pin

2. The difference between the single and double roller escapement is entirely in the:

   Pallet action — Impulse action — Fork action — Safety action

3. In the single roller escapement, the guard pin:

   Is bent at an angle to the fork — Is fastened to the roller itself — Stands perpendicular to the fork — Is parallel with the fork

4. One advantage of the double roller escapement over the single roller is:

   Simpler to construct — Employs shorter roller jewel — Less liable to allow the escapement to go out of action — Balance requires very little change in weight to poise

5. The escape wheel of nearly all modern watches has how many teeth?

   20 — 16 — 15 — 12

6. A roller jewel should be approximately .02 mm smaller than the width of the fork slot. This clearance is called:

   Drop — Impulse — Roller jewel shake — Roller jewel guard action

7. One revolution of the escape wheel causes the teeth to deliver how many impulses to the pallets?

   15 — 20 — 30 — 60

8. The backward motion of the escape wheel, which occurs when the pallet stone unlocks from a tooth is called:

   Drop — Recoil — Excursion — Unlocking action

9. Opening or closing the banking pins increases or decreases the:

   Slide — Lock — Drop — Safety action

10. Provided the watch was never subjected to any sudden or rapid motion, we could dispense with which of the following?

    Jewel pin — Roller — Banking pin — Guard pin

11. To prevent as much loss of power as possible, the pallet pivots should fit in their jewels with how much side shake?

    As little as possible — 3 or 4 hundredths of a millimeter — 20 per cent of the diameter of the pivots — None

12. Of the force conveyed from the mainspring through the train to the escape wheel teeth, how much is lost before it reaches the balance?

    More than 2/3 — More than 1/3 — Less than 1/4 — About 1/8

Detach page or cut along this line — and send to the School for grading

(Please turn over)

13. Identify each numbered part of the escapement by writing the number of the part in front of its name in the list below: (Note: There are more parts named than numbered.)

____ A. Pallets

____ B. Bankings

____ C. Escape Wheel

____ D. Guard Roller

____ E. Roller Table

____ F. "L" Stone

____ G. "R" Stone

____ H. Guard Pin

____ I. Escape Tooth

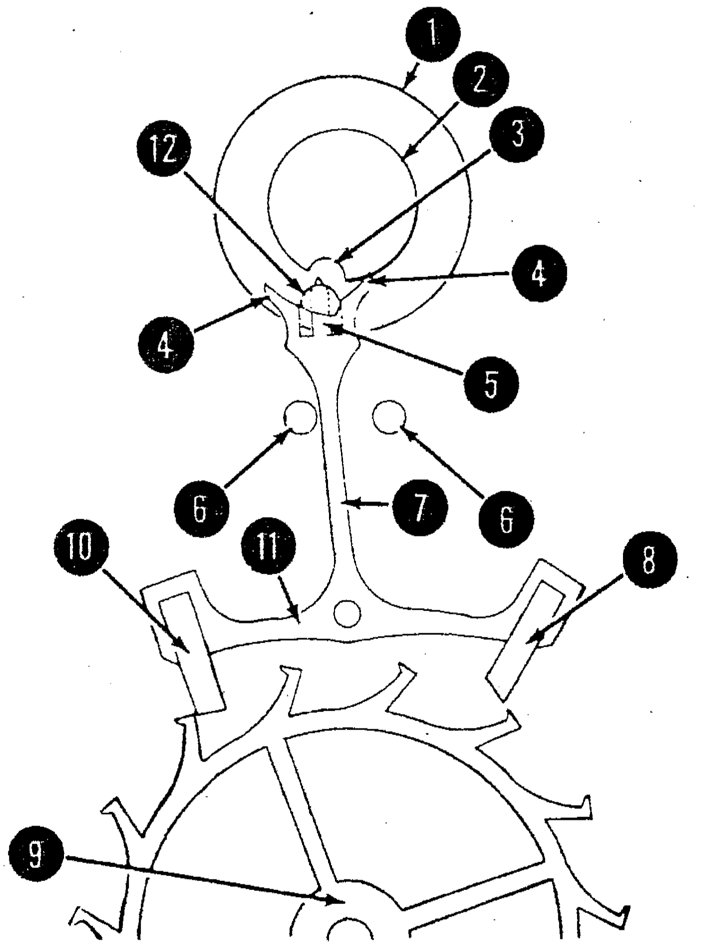
____ J. Roller Jewel

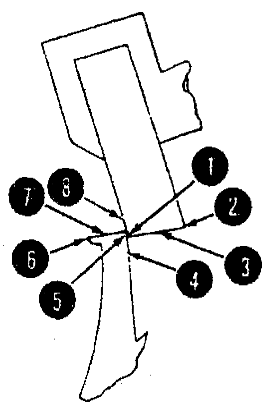
____ K. Fork Horns

____ L. Fork

____ M. Passing Hollow

____ N. Pallet Arbor





14. Identify each numbered part in the drawing at the left by writing the number in front of its name in the lists below:

Pallet Stone:

____ O. The locking face.

____ P. The impulse face.

____ Q. The locking corner.

____ R. The releasing corner.

Escape Tooth:

____ S. The locking face.

____ T. The impulse face.

____ U. The locking corner.

____ V. The releasing corner.

(Continued on next page.)

Name: Student number

DIRECTIONS: In the next two questions, select the ONE BEST answer and place the letter of the answer on the short line in front of the question number.

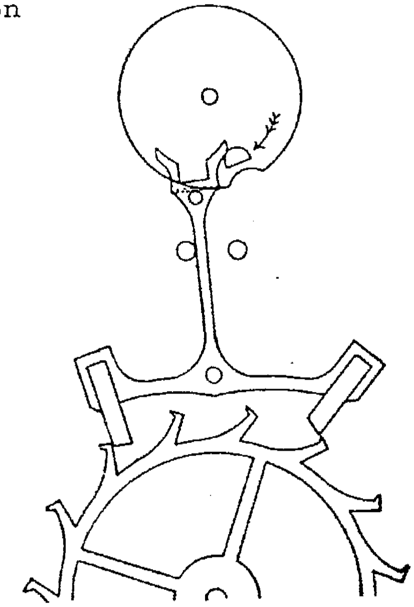
____ 15. What condition is shown in the illustration at the right?

A. Roller jewel too far forward.

B. Out of action.

C. Banked to drop.

D. Fork horns curved from common center.



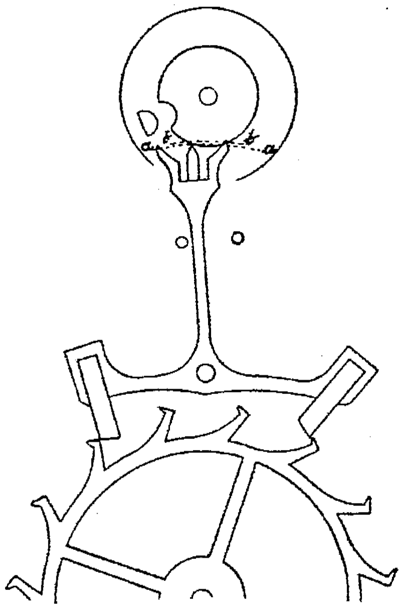
____ 16. What does the illustration at the right show in comparison with the one in question 15?

A. Not banked to drop.

B. Fork horns correct.

C. Better safety action.

D. Roller jewel properly set.



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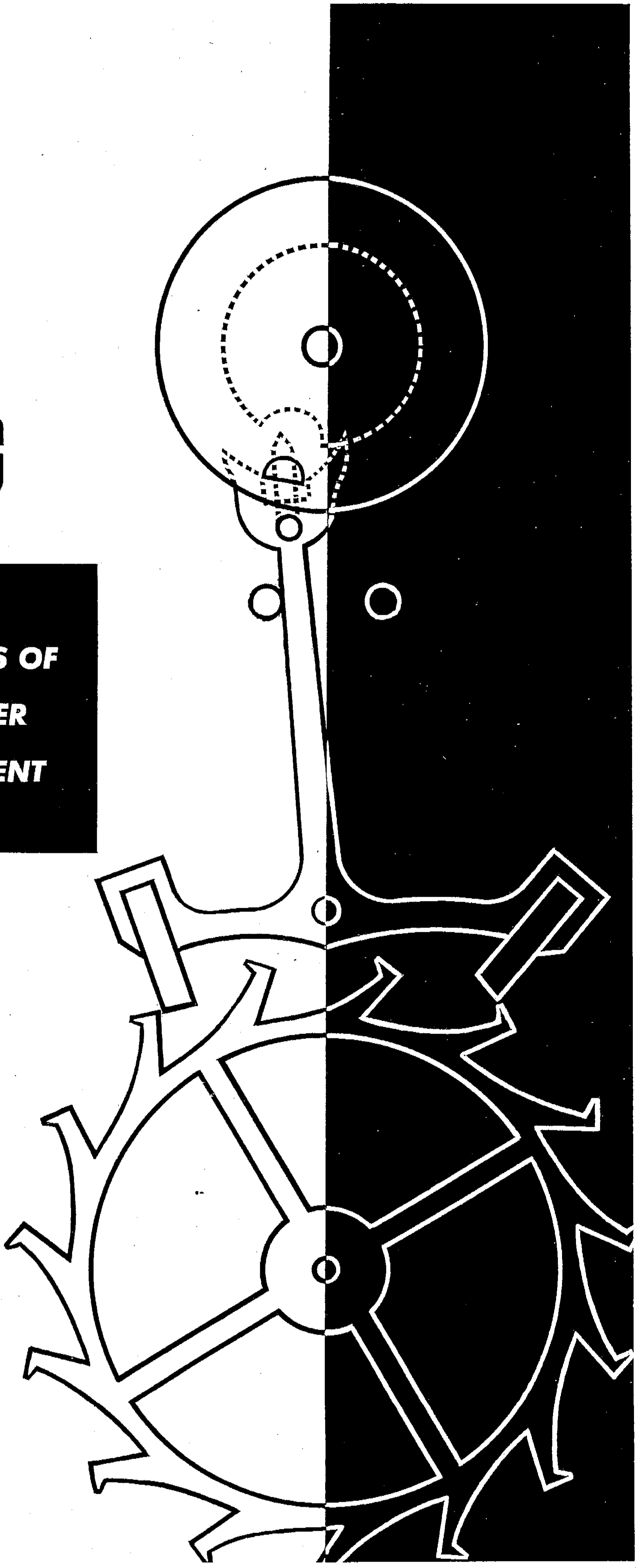
Master WATCHMAKING

LESSON 22

PRINCIPLES OF THE LEVER ESCAPEMENT



CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by THOMAS B. SWEAZEY

KEY POINTS OF LESSON ASSIGNMENTS 69, 70:

- How to recognize unequal roller shake.
- What happens when a guard pin is too short or too long.
- Functions of the escapement.
- Adjustments used to correct errors in the escapement.

ASSIGNMENT NO. 69: Study Sections 404 through 406.

Study Questions:

1. Why should the guard pin be straight up in a single roller escapement?
2. What is the result of uneven roller shake?
3. Why is it inadvisable to change the position of the guard pin to correct errors in safety action?
4. What disadvantage is there in changing pallet stones to correct roller shake?
5. What is the simplest way to correct roller shake?
6. What conditions are necessary for correct safety action?
7. What is a good way to correct a guard pin that is too far forward?
8. How can you correct a guard pin that is too far back?

ASSIGNMENT NO. 70: Study Sections 407 through 413.

NOTE for Section 409: The word "draft", used in these lessons, is an American term for the word "draw". It refers to exactly the same thing.

1. What is meant by "Impulse"? "Lift"?
2. What are the advantages of a club toothed escapement over a ratchet toothed escapement?
3. What effect does changing a stone have on the impulse action?
4. What is meant by "draft" (or draw)?
5. What happens if there is insufficient draft (or draw)?
6. How can you test for insufficient draft (or draw)?
7. How can you test for too much draft (or draw)?
8. What are some methods for altering draft (or draw)?
9. What is a normal amount of lock?
10. How can lock be altered?
11. What is the purpose of slide?
12. How much slide should there be?
13. How can the slide be changed?
14. How can the drop be changed?
15. What is the difference between equi-distant locking and equi-distant center escapements?

REQUIREMENT:

- Answer the Test Questions for Lesson 22 and send in for grading.

HOW THE ESCAPEMENT WORKS

The escapement has three main parts: The escape wheel, the pallet assembly, and the rollers. Power from the mainspring turns the escape wheel clockwise while the rotation of the balance wheel turns the rollers, which are on the balance staff.

In Fig. A, the escape wheel is locked on the receiving stone. Nothing is moving except the balance, which is turning counter-clockwise, as indicated by the arrow. (The balance and hairspring are not shown because they would block the view of the fork and roller action.) The roller jewel is approaching the fork.

In Fig. B, the roller jewel has entered the fork slot and struck its far side, putting the fork lever into motion. This pulls up one arm of the pallet and also causes the escape wheel to back up slightly or recoil. The pallet stone slides on the corner of the escape wheel tooth until the corner of the tooth passes the corner of the escape wheel. This releases the escape wheel.

Power from the mainspring now drives the freed escape wheel clockwise. As it turns, the tooth of the escape wheel slides on the impulse face of the pallet stone and kicks it up out of the way, driving the pallet arm higher, Fig. C. This speeds the movement of the fork compared to the speed of the roller jewel. The fork strikes the jewel from behind and gives it a shove. This gives the impulse to the balance which continues to turn, causing the hairspring to contract or wind up.

As the escape wheel tooth slides off the impulse face of the pallet stone, the wheel turns freely for a short distance. This phase is known as the drop. When the impulse forces up the receiving arm of the pallet, it also forces the discharging arm of the pallet to move down and halt another tooth on the discharging stone. This phase is called lock, Fig. D.

After halting the tooth, a force called draw causes the stone to move further into the wheel. This movement after lock is called slide, Fig. E.

With the escape wheel locked, the roller jewel, carried by the balance, swings free of the fork slot and continues to move counter-clockwise until it is stopped by the contracting hairspring. At this point it reverses direction and the same sequence begins again going the other way.

FIG. A. Escape wheel locked on R stone. Note guard dart does not touch safety roller.

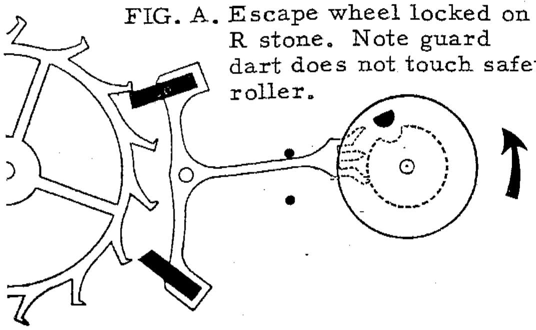
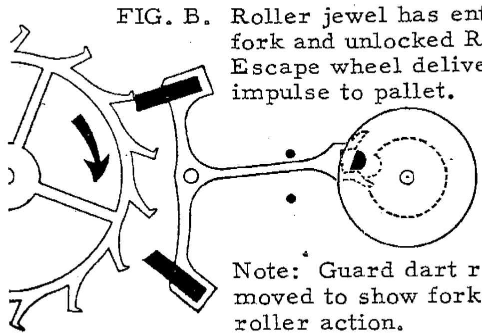
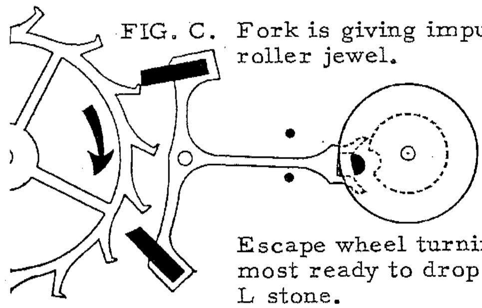


FIG. B. Roller jewel has entered fork and unlocked R stone. Escape wheel delivering impulse to pallet.



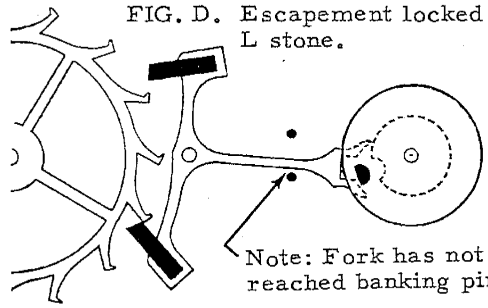
Note: Guard dart removed to show fork and roller action.

FIG. C. Fork is giving impulse to roller jewel.



Escape wheel turning, almost ready to drop onto L stone.

FIG. D. Escapement locked on L stone.



Note: Fork has not yet reached banking pin.

FIG. E. Draw forces fork against banking, causing slide to follow lock.

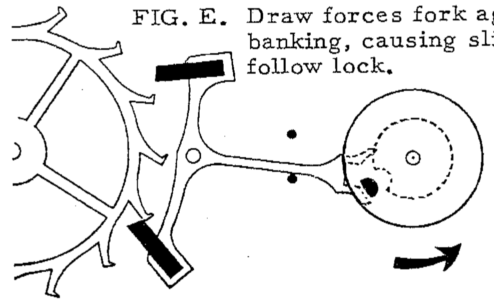


CHART A

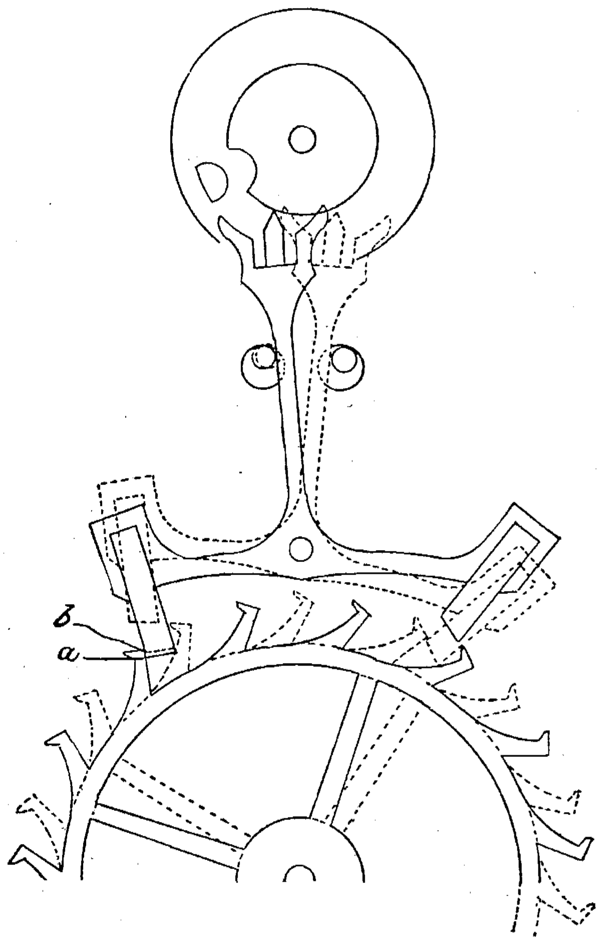


Fig. 22-1

SEC. 404—Unequal Roller Shake

The guard pin should be perfectly central with the fork slot under all conditions. It should never tilt from the perpendicular in a single roller escapement. In a double roller escapement, a line drawn from the point of the dart to the center of the pallet arbor should pass through the center of the fork slot and be parallel with its sides.

Figure 22-1 shows an escapement with unequal roller shake. The full lines show an escape tooth locked by the receiving stone, the guard pin touching the left edge of the safety roller. When the lock takes place on this escapement the locking corner of the tooth strikes the face of the stone at the position shown by the broken line parallel with it, but in order that the dart should free the safety roller, the left banking pin was opened from the position shown as dotted line to that shown as a full line. This allowed the pallet stone to slide down on the tooth until the locking corner of the tooth was at point **b**, and the locking corner of the stone at point **a**. Now inasmuch as the banking pin must be moved even more in order to give sufficient freedom to the safety roller, the distance that the stone projects below the locking corner of the tooth will be further increased to the detriment of the escapement, and entailing a loss of power.

The fork shown in broken lines in the same figure is in the position in which a tooth is released by the receiving stone and is properly locked on the discharging. Examining the position of the dart with reference to the safety roller we find that it is at some distance from its edge. This is the condition technically called "Out of Angle." There are several impractical means resorted to for its remedy. One is to bend the guard pin as shown in figure 22-2. This, however, throws it out of line with the center of the fork slot and should therefore not be tolerated. Another method is to draw out the discharging stone and push in the receiving stone a sufficient amount to correct the out of angle; but moving a pallet stone in or out produces several changes in an escapement and it should never be done without previously thoroughly examining the escape wheel and pallet action so as to avoid the danger of creating another error.

Figure 22-2 shows the effect of bending the guard pin out of line with the center of the fork slot. In this drawing the guard pin is bent to the left to correct the defect in the safety action shown in figure 22-1. This alteration leaves the escapement with correct lock and slide. The safety action is correct so far as the guard pin and roller are concerned, but the impulses, delivered by the pallets to the roller jewel, are at unequal distances from the line of centers. The

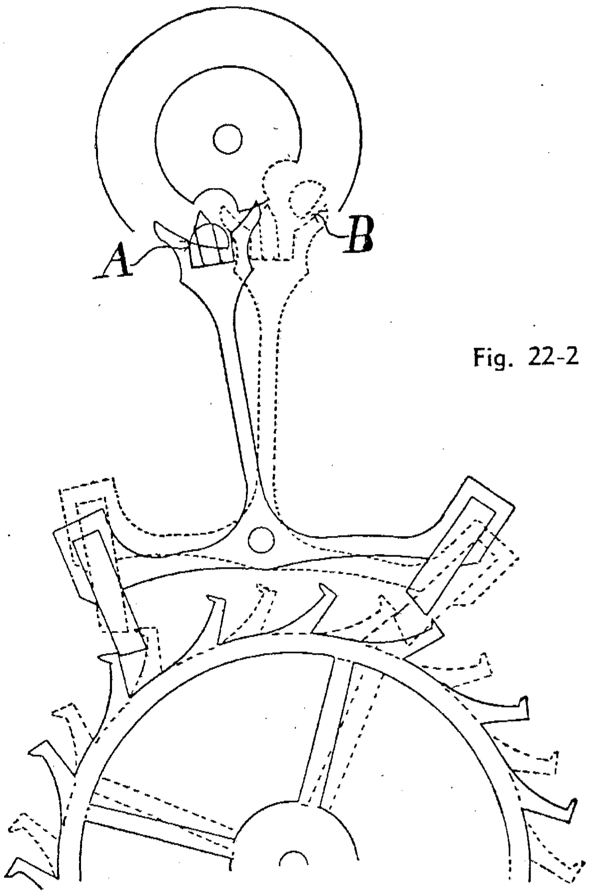


Fig. 22-2

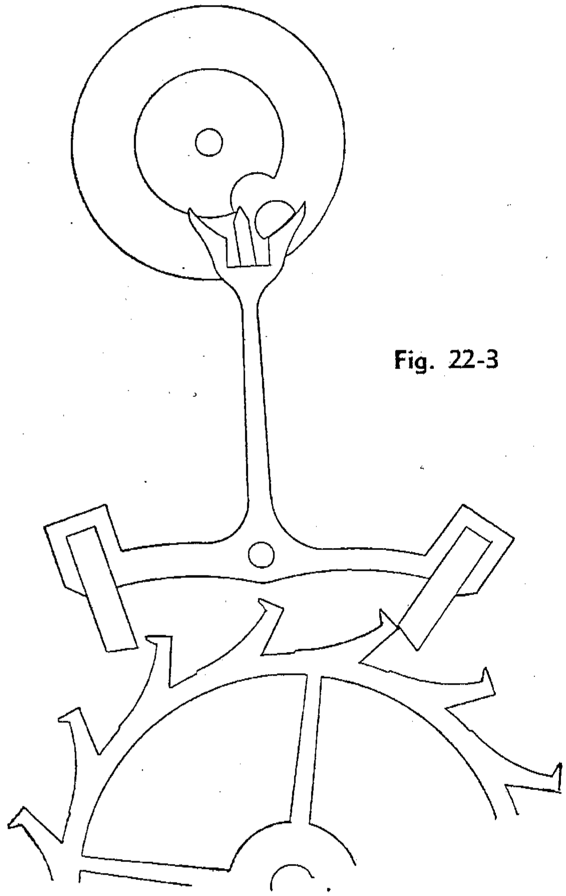


Fig. 22-3

greatest portion of the impulse on the receiving stone is delivered after the line of centers has been passed; the least amount on the discharging stone. A condition of this character would seriously affect isochronism and position adjustment. A more serious error has also been created. Referring to figure 22-2 it will be seen that corner **A** of the fork slot will not permit the impulse pin to pass freely out of it, while at the other side at the point marked **B,** there is more room than is required. This might be remedied by grinding way the left horn of the fork, but it would still leave the unequal impulse.

The condition just described, however, is not the most serious one resulting from bending the guard pin to equalize the roller shake. The escapement is liable to do what is technically called "Trip." The escapement shown in figure 22-2 would do this. If the fork should be pressed to the left when the escape tooth is locked on the discharging stone and the point of the guard pin is opposite the passing hollow, the tooth might unlock from the discharging stone.

Figure 22-3 illustrates the above. In this figure an escapement is shown with the guard pin bent as in figure 22-2. The roller is assumed to have moved from the position there shown to the position shown in figure 22-3, or until the passing hollow is opposite the guard pin. In this position the fork has been pressed to the left. The safety action between the roller jewel and fork horn fails to arrest the movement of the fork until the escapement has unlocked on the discharging stone as shown.

Moving the pallet stones for the sole purpose of changing the roller shake is a method often practiced, but it is not to be advised. It necessitates more time and jeopardizes the escapement action. A pallet stone can not be moved without altering the escapement in at least four particulars: Impulse, draft, lock and drop.

The simplest and best method of making the alteration is to bend the fork. This alters no other functions of the escapement.

Bending a fork is an operation of which many students stand in awe, but there is little danger if done carefully.

Before attempting to bend a fork ascertain whether it is of sufficiently low temper to permit doing so with safety. It is not necessary to disfigure a piece made of steel in order to ascertain whether it is hard or soft. Use a fine, sharp file. Place it on an unpolished part of the piece to be tried. Without actually moving the file,

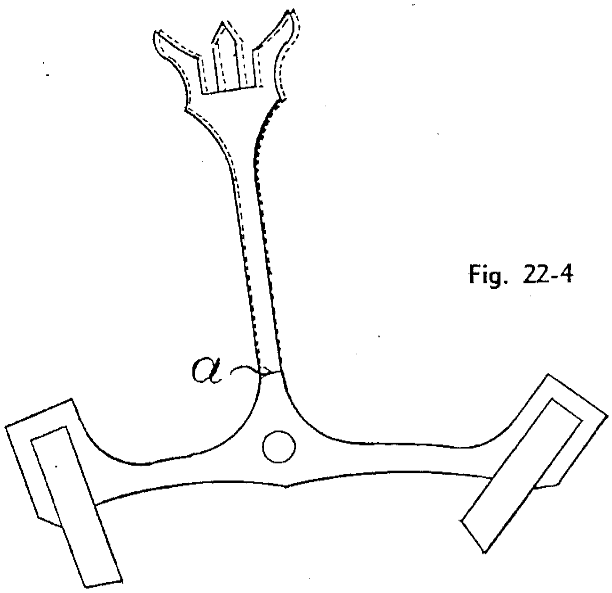


Fig. 22-4

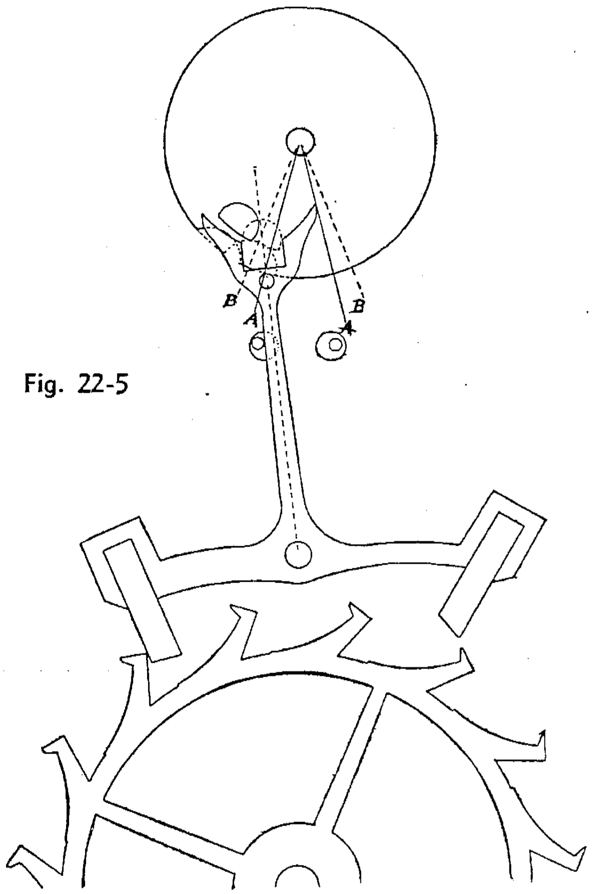


Fig. 22-5

exercise a gentle forward pressure. If the steel is hard it will offer no resistance to the movement of the file. If it is not hard the file will cling to the steel, more or less, in proportion to the temper. A little practice will enable anyone to become expert at this method. It is seldom that a fork is too hard to permit bending, but should it be, there remains but one of two courses to pursue: Let it alone or take the stones out and draw the temper. There is no objection to reducing the temper of a fork to a sufficient amount to allow it to be bent with safety. Figure 22-4 shows where the bend should be made. If it is done at point **a**, a very little bending will be sufficient.

There are several methods practiced in bending a fork. It may be set edgewise on a soft metal block and struck lightly with a punch. It may be bent between dies or jaws of pliers especially shaped for the purpose. Or it may be peened with a hammer.

To summarize the conditions necessary for correct safety action: The guard pin central with the fork slot; the sides of the fork slot parallel and of equal length; the inside curves of the fork horn of the proper arc and equal in relation to the fork slot; the roller jewel squared in front and upright; the edge of the safety roller perfectly polished and free from imperfection; the escapement in angle.

SEC. 405—Guard Pin Too Far Forward

When the guard pin is too far forward the banking pins are sometimes opened to allow the roller to pass. This method should never be resorted to for the reason that it increases the slide as well as the angle of contact between the roller jewel and fork, both of which incur a loss of power.

Figure 22-5 illustrates this condition in a single roller escapement. The single roller is used for the reason that it is desired to show how that form of escapement can be corrected for errors caused by the incorrect distance of the guard pin from the pallet center.

It will be observed that, in order to clear the guard pin from the roller edge, the banking pins have been opened, thus making the slide excessive as indicated by the position of the receiving stone with relation to the tooth which it locks. This imposes additional work upon the balance in unlocking the escapement. It also, as has already been pointed out, increases the angular distance during which the roller jewel and fork remain in contact. The full lines, **AA**, indicate the angle of contact as it should be; the broken lines, **BB**, indicate the angle of contact with the banking pin open to allow the guard pin to clear the roller edge.

The angle of impulse of a roller is where the two radii from the roller center through the roller jewel center intersect lines running from the pallet arbor through the center of the fork slot. In figure 22-5 this angle is shown in broken lines. It will be noticed that the lock in this figure is excessive. If reduced to the proper amount the impulse angle would be as represented by the full lines **AA**.

Experience has taught us that a short arc of impulse produces better results than a long one.

To remedy a guard pin in a single roller escapement which is too far forward, proceed as follows: Push the guard pin through a small piece of tissue paper, the object being to prevent marring the polished face of the fork. With a fine file, dress the pin to a point as shown at **B**, figure 22-6. **A** is the pin before being dressed down. It may be reduced as much as necessary without injury to the safety action. In fact, a V-shaped safety pin is superior to a cylindrical one in this particular.

In the double roller escapement an alteration in the length of the guard pin is so simple that instruction is deemed unnecessary.

SEC. 406—Guard Pin Too Far Back

A guard pin which is too far back in a single roller can be corrected by simply driving the guard pin out, broaching out the hole in the fork and inserting a larger pin.

The guard pin in figure 21-27 is rather short. It is short the same amount as the guard pin in figure 21-26 is too far back. As has been previously explained, the fork in figure 21-26 would go out of action, but while that in figure 21-27 would not, its action would be improved by stretching the dart.

SEC. 407—The Escape and Pallet Action

The escape and pallet action is the most intricate function of the escapement. A thorough knowledge of it calls for thoughtful study. Yet there is nothing about it that can not be mastered by the student. In treating it, it is deemed best to divide it into five branches: Impulse, Draft, Lock, Slide, Drop.

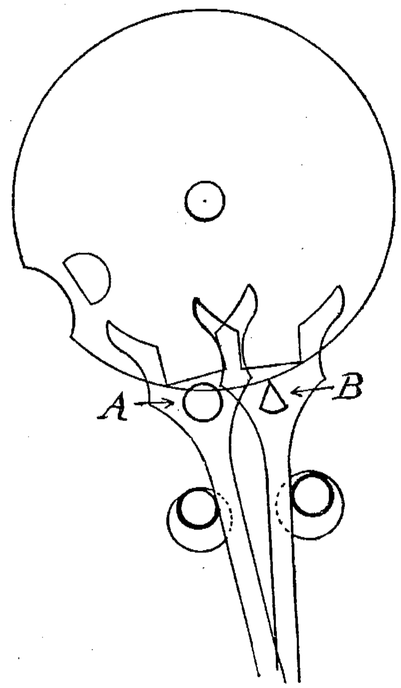


Fig. 22-6

SEC. 408—Impulse

An escape tooth, in delivering impulse to a pallet, moves in an arc of 12 degrees.

In the ratchet tooth escapement all the impulse is on the pallet; otherwise the same rules apply to it as to the club tooth. A brief description of the ratchet tooth escapement will be given later on.

The chief advantage of the club tooth escapement over the ratchet tooth is that the former can be constructed with less loss of power from drop. A minor advantage is that there is less liability of wedging the guard pin against the roller edge when the train is reversed, which sometime occurs in setting the hands backward.

In the club tooth escapement, the circular

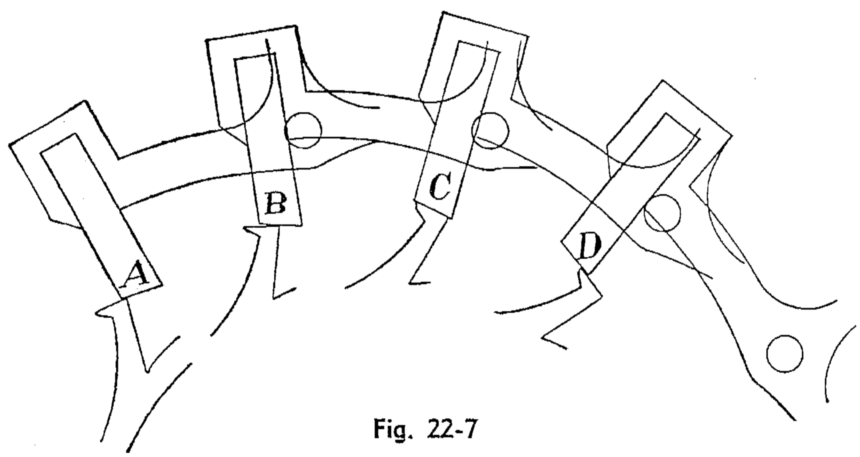


Fig. 22-7

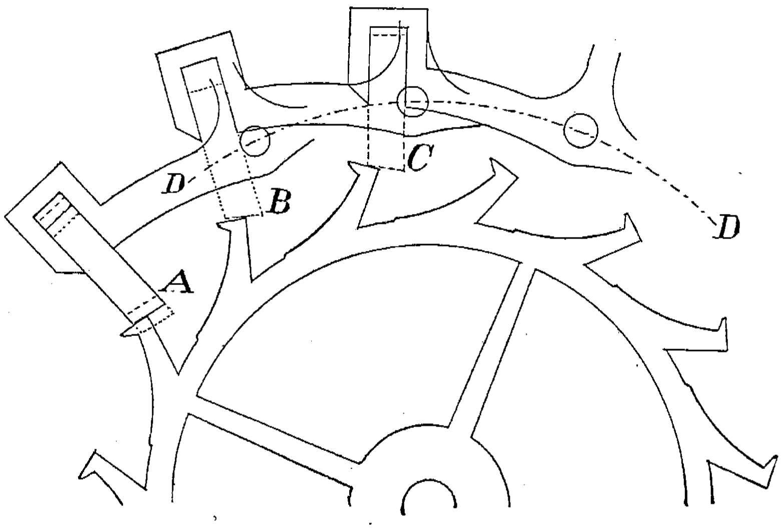


Fig. 22-8

impulse is divided between the wheel tooth and the pallet stone. This division is in various proportion, usually within the narrow limits of four-tenths to the tooth and six-tenths to the stone, and equal amounts to both.

Figure 22-7 illustrates a good type of action. In this drawing an escape tooth is shown in four positions while delivering impulse to the receiving stone. It will be observed that when the tooth begins to pass over the stone, as at **A,** the impulse faces diverge from each other. In this position only the locking corner contacts the impulse face of the stone, and from this point the faces diverge backwards to the locking corner of the stone. At **B** the tooth is shown having passed further along on the impulse face of the stone and a divergence at a somewhat less angle is seen. As the impulse progresses the faces of the tooth and stone coincide in the position shown at **C.** From that point the divergence begins to appear in the reverse direction as at **D,** and continues until the tooth is released. This is called a natural divergence. It is less apt to cause wear and also reduces friction.

As previously stated, an alteration made in an escapement by moving a stone in or out changes the impulse action. Figure 22-8 shows the effect of changing the position of a receiving stone. In order to demonstrate the actual result of moving a stone, the pallets are drawn in three positions in relation to the wheel. At **A,** the stone is shown in correct position in full lines. It is shown in dotted lines drawn out. It is shown in broken lines pushed in. The back as well as the impulse face of the stone is indicated by similar lines. The centers of the three pallets are equi-distant from the center of the escape wheel, as indicated by the line **DD.** The position at **A** is normal; that at **B** is with the stone drawn out to the dotted line; that at **C** is with the stone pressed in to the broken line.

It will be seen that moving the stone outward as at **B** increases the divergence backwards from the locking corner of the wheel; that moving the stone inward as at **C** produces a divergence in the opposite direction. The latter is considered a bad action for the reason that the locking corner of the stone scrapes across the impulse face of the tooth, wearing it away rapidly.

Moving a discharging stone produces results directly opposite to those resulting from moving the receiving stone.

Figure 22-9 shows the effect on the impulse of moving a discharging stone. At **C,** where the stone is pushed in, the divergence is excessive; at **B,** where the stone is drawn outward, the divergence is in the wrong direction; at **A,** where it is in proper position, the divergence is natural.

There is another result from moving a pallet stone which must not be overlooked. It changes the extent of the arc of vibration of the pallets. In other words—changes the lift.

The term "lift" is applied to the thrust given to the pallets by an escape tooth. In the lift the pallets swing on their own center and the extent of that swing is called the arc of vibration. It has been explained that the circular impulse is measured from the center of the escape wheel and is divided between an escape tooth and a pallet stone. The lift is measured from the pallet center and is also divided between an escape tooth and a pallet stone.

Figure 22-10 shows variation in lift caused by changing the position of a receiving stone.

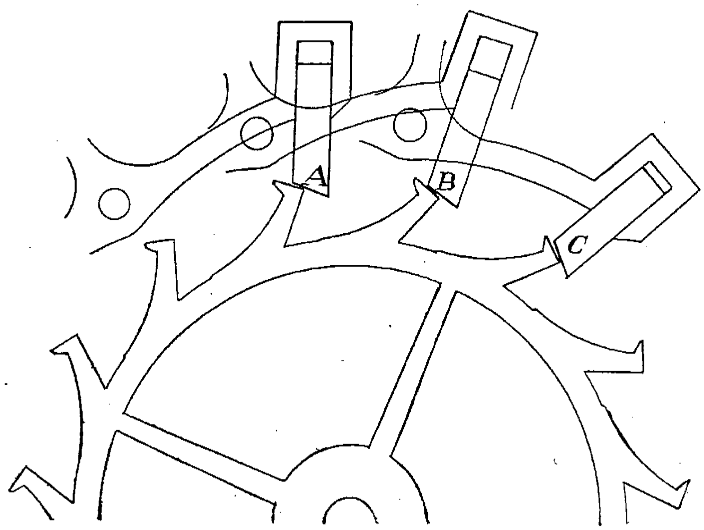


Fig. 22-9

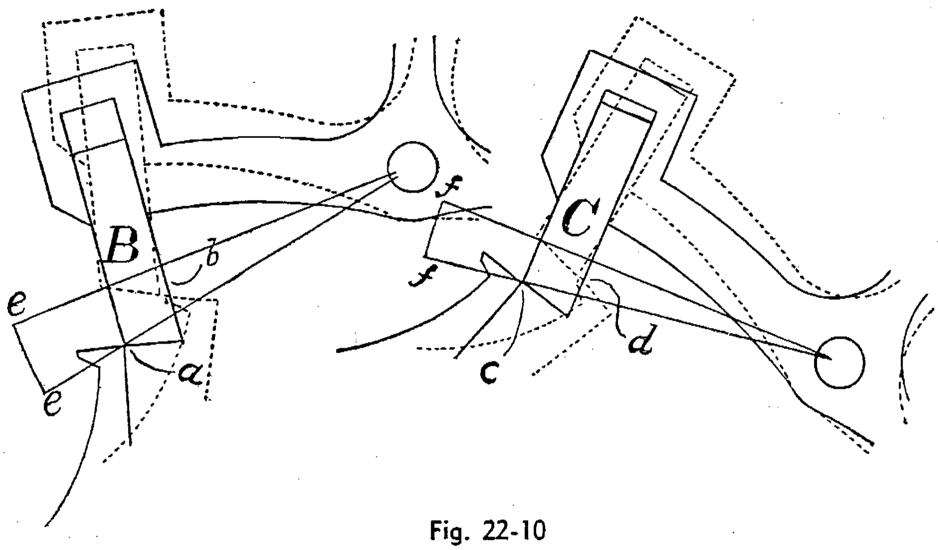


Fig. 22-10

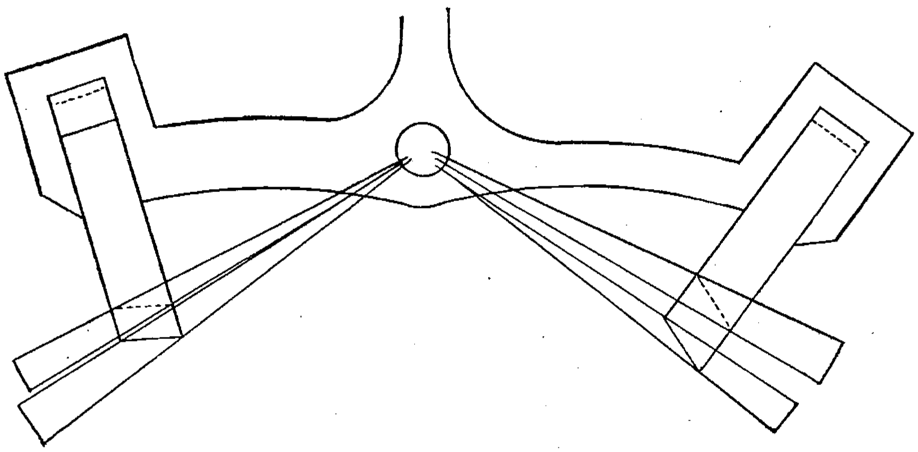


Fig. 22-11

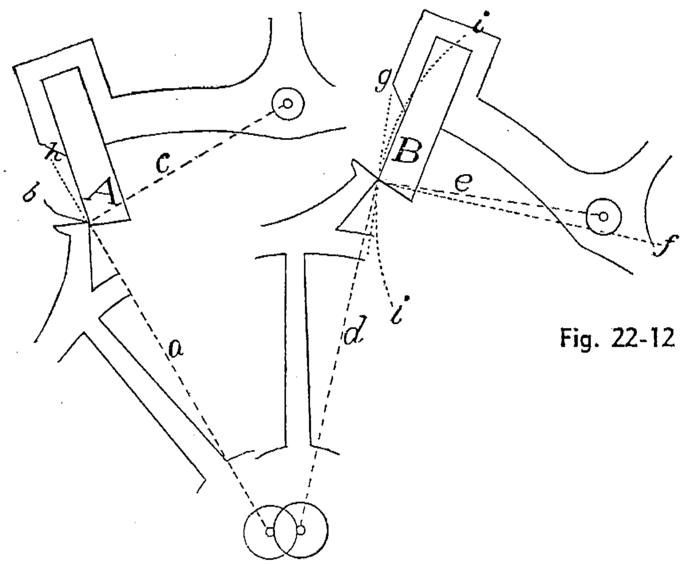


Fig. 22-12

The positions of the stones **B** and **C** are identical with those similarly marked in figure 22-8. That is, they are located in the same position at **B,** figure 22-10, as at **B,** figure 22-8; also at **C,** figure 22-10, as at **C,** figure 22-9. Both wheel and stone are shown in full lines at the beginning of the lift and in dotted lines at the end. Referring to **B,** the lift begins at **a** and ends at **b.** The lines **ee** radiating from the pallet center intersect the pallet stone at the locking corner at the beginning and end of the lift. Referring to **C,** it begins at **c** and ends at **d,** the lines **ff** intersecting at the locking corner. Now it is quite evident that the angle inclosed by the lines **ee** is greater than the angle inclosed by **ff,** which shows that drawing out a receiving stone increases the lift.

Another result brought about by moving a receiving stone would seem anomalous. It is this: While drawing out the receiving stone deepens the lock on both stones, it deepens the lock more on the discharging stone than on the receiving. Drawing out the discharging stone has the opposite effect, deepening it more on the receiving than on the discharging stone.

Figure 22-11 will show more clearly how the difference in the lift is produced. The pallets have both stones shown in two positions. The position with regard to the receiving stone is identical with that shown in figure 22-10. The dotted lines indicating the face and back of the stone correspond with **C,** figure 22-10, and the full lines with **B** in the same figure. In the discharging stone the same conditions are indicated by dotted and by full lines. This figure shows clearly that drawing out the receiving stone increases the impulse, while drawing out the discharging stone decreases it.

SEC. 409—Draft

The draft of an escapement is that power which draws the fork away from the roller after it has delivered an impulse. It is secured by setting the pallet stones at such an angle in relation to the direction in which the force exercised against the locking face is resisted, that it will draw the fork against the banking.

The term "resisted" is used for the reason that a misunderstanding on this point prevails to some extent.

The draft is determined by the inclination of the locking face of a pallet stone from a line drawn at right angles to a radius from the pallet center to the point of contact between the locking corner of the wheel tooth and the locking face of the pallet stone. Figure 22-12 will make this detailed explanation of draft more clear.

At **A** is shown what is known as "Tangential Locking." In this form the broken radial line **a** from the wheel center to the locking point **b** forms a right angle with the broken line **c,** from the pallet center to the same point. In the form shown at **B,** the broken radial lines **d** and **e** do not form a right angle. This is known as non-tangential locking.

In the former case the force exercised by the escape wheel is directly towards the pallet center and the resistance to that force is precisely on the same line. In the latter case the force is directed as indicated by the dotted line **f,** while it is resisted in the direction of the broken line **e.** In other words, at the tangential locking the force and the resistance are on the same line, while at **b** non-tangential the force and the resistance are on different lines. The resistance being in the same direction in both cases, the draft angle must be determined in relation to a radial line from the center of the pallets to the locking point.

The dotted line **g** is termed the tangential line, meaning that it touches the arc **ii** at the intersection of the radial line **e**. The draft angle is laid out from this tangential line. In the escapement shown at **A,** the broken radial line **a** is continued by the full line **h** in order to show that the tangential and the radial lines are in this case identical.

Insufficient draft is a serious error. Where it exists there is a constant liability that when the watch is subjected to some sudden motion, the fork will leave the banking and strike the safety edge of the roller, thus retarding the motion of the balance. It is a waste of time to attempt adjusting a watch having this fault.

A common method of testing the draft of an escapement is to lay the watch in a horizontal position, then draw the fork slightly away from the banking and see that it returns to its original position. It is advisable to try the banking under the most unfavorable conditions to which the watch is likely to be subjected in its owner's possession. First, see that the watch is let down to the point it would have reached after a run of 24 hours, then hold the watch in a vertical position. If the fork is poised it will make no difference in what position the watch is held as long as it is vertical, but if the fork is unpoised it should be held with the heaviest part lying in a horizontal line with its center. If the fork is without a counterpoise the arm would then be horizontal. In this case first try the fork by drawing it slightly away from the banking while the fork is in horizontal position to the right. This will usually be on the receiving stone. Then turn the fork to the left which will be on the discharging stone. The object of using this method is to insure against insufficient draft. If the draft is not sufficient to draw the fork against the banking under the conditions stated, it should be increased.

It is rarely that an escapement is found with too much draft. Should there be a suspicion that such is the case it can be easily determined: Take a small piece of wax and attach it to the fork by inserting it on the guard pin or by any other method that may suggest itself; then try the draft as before. Judgment will dictate the additional weight that should overcome the draft.

Draft can sometimes be changed by tilting a pallet stone in its slot. This, however, cannot be done when the stone is closely fitted. Another method by which the draft may be altered is by pushing in one stone and drawing out the other.

Drawing out the receiving and pushing in the discharging stones increases the draft on both stones. Drawing out the discharging and pushing in the receiving stones decreases the draft on both stones. That is, drawing out the receiving stone causes an escaped tooth to drop farther upon the locking face of the discharging stone, which of course increases the draft on the discharging stone, but it also increases the lock, which must be remedied by pushing in the discharging stone. This causes a tooth to drop farther down on the receiving stone, increasing the draft. A slight movement of the stone in or out will change the draft to a considerable extent. In changing a draft by this method extreme care should be used to avoid introducing other errors.

It should be borne in mind that drawing a receiving stone increases the drop on the discharging stone, but does not alter the drop on the receiving, but in pushing in the discharging stone to correct the lock, the drop is decreased on the receiving stone.

It should also be borne in mind that drawing out the receiving stone increases the divergence of the impulse face of the wheel with that stone, and that pushing in the discharging stone increases the divergence on that stone in the same manner.

That is, drawing out the receiver and pushing in the discharger increases the divergence on both stones.

Pushing in the receiver and drawing out the discharger decreases it.

When the draft is altered by pushing and pulling the stones, that operation puts the fork out of angle, which must be corrected by bending. Later on in this work, directions will be given for making a drawing of an escapement.

Figure 22-13 shows effect on the drop of moving a stone. At **A** the pallets and wheel are shown in two relative positions. In the first position they are shown in full lines and the teeth marked **1, 2, 3, 4.** The wheel will move forward when a tooth is released by the receiving stone. The pallets are then in the position shown in dotted lines and the wheel teeth, in dotted lines, are marked **1, 2, 3.** In the drawig shown at **A** the drop is equal. The distance between the releasing corners of the receiving stone and tooth **1,** as shown at **a,** is exactly the same as the distance between the releasing corners at **b.**

Now referring to the pallets shown at **B,** it will be observed that the receiving stone has been drawn out, as indicated by the black space in the pallet slot, and that the discharging stone has been pushed in, as indicated by the disappearance of the black space that was shown in the discharging stone slot in pallets **A.** At **B** the escapement is shown under the same conditions as at **A:** Lock on the receiver in full lines; on the discharger in dotted lines. It will be

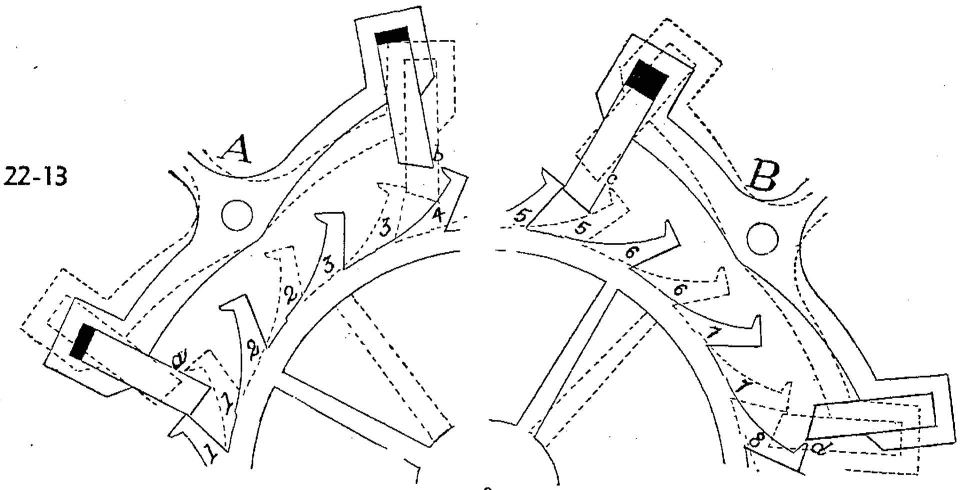


Fig. 22-13

plainly seen that the distance between the releasing corners at **c** is greater than at **d.** This is to say that while the lock was equal with the stones in position, as at **A,** drawing out the receiving stone and pushing in the discharging made them unequal, as at **B.**

Figure 22-14 shows a pair of pallets with escape wheel teeth in three positions on each stone. The three positions are indicated by the wheel teeth shown in dotted lines and in broken lines. From the points of contact are drawn dotted, broken, and full lines running radially to the pallet center and at right angles to the radii. These lines are marked **a, b, c** on the receiving side and **d, e, f** on the discharging side. The inclination of the locking faces of the stones toward these lines determines the draft. The drawing is for the purpose of showing the opposite effects produced by moving a receiving stone from that produced by moving a discharging stone. Referring to figure 22-14, it must be evident to the observer that the farther up the locking takes place on the receiving stone the less will be the draft, and that the further up it takes place on the locking face of the discharging stone the greater will be the draft.

In case the foregoing is not perfectly clear to the student, let him suppose the tooth locked on the receiving stone at the junction of the lines **cc** and that a tooth dropped on the discharging stone at the junction of the lines **ff.** In this position the draft will be represented by the angle formed between the locking faces of the stones and the lines **c** and **f,** respectively. Now if—leaving the wheel tooth as it is—we draw out the receiving stone until its locking corner coincides with the junction of the lines **aa,** we have not changed the draft; but when the stone is thus drawn out the pallets will have to swing further to release the tooth, with the result that the lock will now take place on the discharging stone at the junction of the lines **dd.** Thus it would be seen that the moving of a stone does not alter the draft on it, but on the opposite stone.

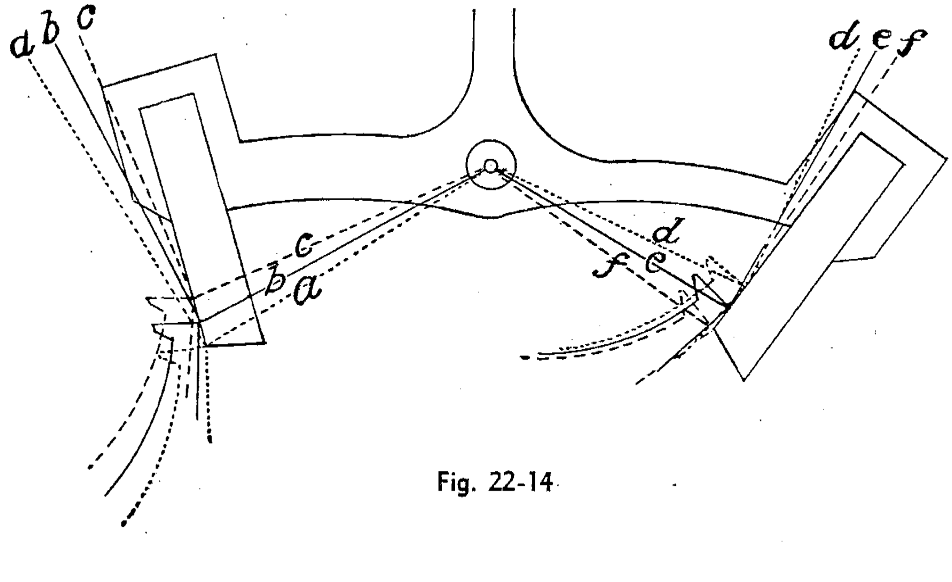


Fig. 22-14

SEC. 410—Lock

Lock is the distance from the locking corner of a pallet stone to the point at which the wheel tooth strikes it at the instant it drops. It should be as little as possible, consistent with the proper allowance which should be made to cover certain unavoidable mechanical defects, such as side-shake in the pivot holes, inaccuracy in the escape wheel teeth, etc. The amount of lock measured in angular distance is about three-quarters of a degree. In actual measurement it would be, on a 16 or 18 size escapement, 2 to 3 hundredths of a millimeter.

Figure 22-15 will give an idea of this amount in proportion to the size of the escapement.

Moving one pallet stone either outward or inward alters the lock on both stones. While it does not alter them exactly in the same proportion, yet the difference is trifling for ordinary alterations of this nature. In equi-distant center escapements, when the lock is equal as to angular measurement, it will be slightly greater in actual measurement on the receiving stone than on the discharger. This is due to the fact that the locking face of the receiving stone is farther from the center of the pallet than the locking face of the discharging stone. Judgment should be used when making an alteration for lock. Bear in mind what has been said in reference to the effect, in other particulars, of moving a stone.

SEC. 411—Slide

Slide—sometimes called run—is the distance from the point at which the wheel tooth strikes the locking face of a stone at the instant of drop to the point it reaches when the motion of the pallet is arrested by the fork coming in contact with the banking. The purpose of the slide is to allow proper freedom for the impulse pin to pass out of the fork slot; also, freedom between the guard pin and the edge of the roller. Its amount should be about the same as the lock. Figure 22-15 shows both lock and slide on the receiving stone as indicated by the lines radiating from the pallet center.

Lock and slide, in combination, are sometimes referred to as "total lock." This term seems confusing as it necessitates the use of the two terms "lock" and "total lock." It leads to a confusion of terms. Lock and slide are two distinct functions. Opening or closing a banking alters the slide but does not change the lock. A pallet stone must be moved to change the lock.

Referring back to figure 21-18, it will be seen that a wheel tooth is locked on the receiving stone, but the fork is not quite in contact with the left banking. Moving it into contact will make the slide on the stone. The slide is very easily changed by moving the banking, but should never be increased beyond an amount equaling the correct lock.

SEC. 412—Drop

Drop is the space that the escape wheel passes through during the interval between the release of one tooth by a pallet stone and the arrest of another tooth by the opposite stone. The drop is clearly shown in figure 22-15. At the point marked **A** the tooth has just been released by the discharging stone; at **B** a tooth has contacted the locking face of the receiving stone. The space intervening between the releasing corners of tooth and stone at **A** exactly equals the space between the locking corner of the tooth and its point of contact with the stone at **B** before it dropped. This is the drop and should be alike on both stones.

Drop may be altered by spreading the stones apart or closing them. The former increases the drop from the receiving stone to the discharger and decreases the drop from the discharger to the receiver. Closing the stones has the opposite effect; hence it is seen that a change made in this manner may affect a correction with a very slight movement, as its effect is always multiplied by two. Another way in which the drop may be altered is by moving a pallet stone in or out. Moving a pallet stone does not change the drop on that stone, but on the opposite one.

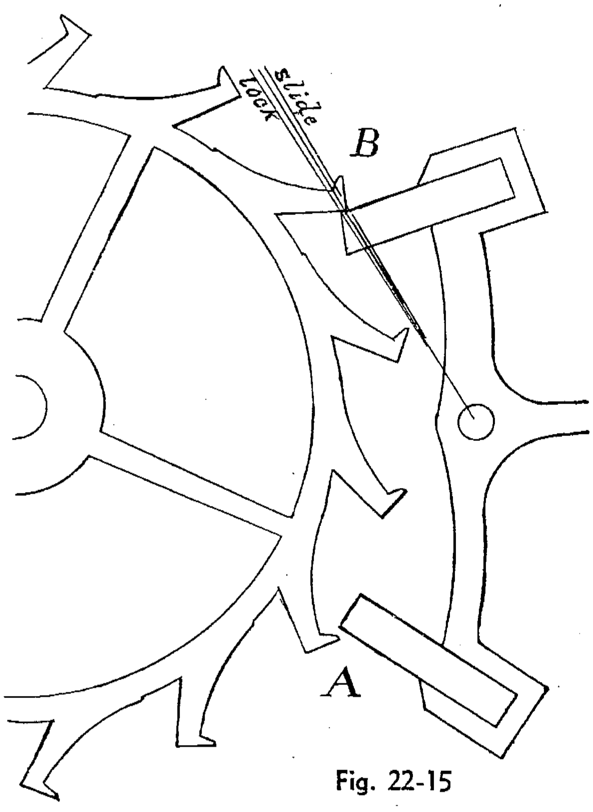


Fig. 22-15

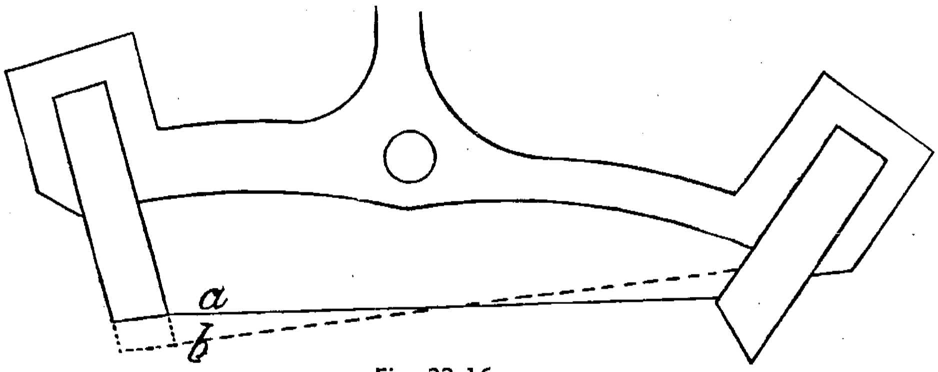


Fig. 22-16

Moving the receiver out increases the drop on the discharger; moving the discharger out increases it on the receiver; moving it in has the opposite effect.

Drop is sometimes termed inside and outside shake, meaning that when a tooth has been released by the discharging stone and another locked on the receiving, if the pallets are then swung so as to almost—not quite—lock, the wheel may be moved to and fro. The locking corner is arrested by the receiving stone and the releasing corner of another tooth is arrested by the discharging stone. This is called the outside shake. With a tooth just locked on the discharging stone there will be three teeth embraced by the stones and the play between them is called the inside shake.

Figure 22-13 will illustrate what is meant by inside and outside shake. In both **A** and **B** the escapement in full lines shows the outside shake; that in dotted lines the inside shake. At **A** the lock is equal and the inside and outside shakes are equal, while at **B** the locks are unequal, making the outside shake close. In speaking of shake as applied to pallets, it is technically termed "close inside" and "close outside," the former meaning that the drop is less on the discharging stone, the latter that it is less on the receiver.

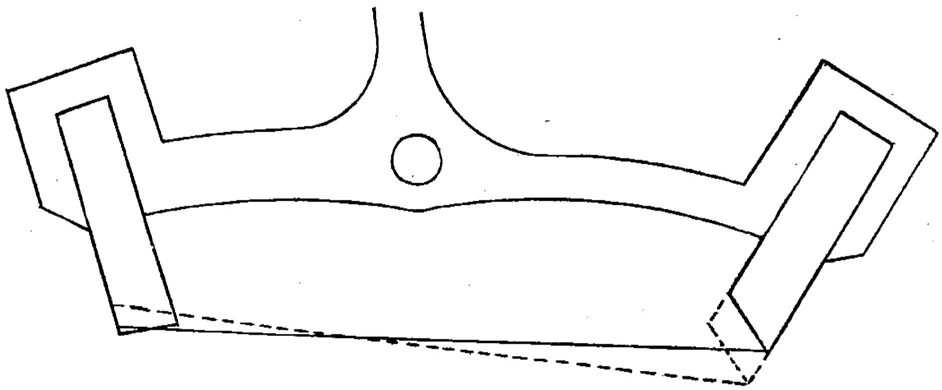
The effect upon the drop—shake—of moving a pallet stone is clearly demonstrated by figures 22-16 and 22-17. In figure 22-16 the full line **a** gives the distance that embraces three escape wheel teeth when the escapement is properly locked on the discharging stone. The broken line **b** gives the distance when the receiving stone has been drawn out to the position shown in dotted lines. This proves that drawing out the receiving stone increases the inside shake. Figure 22-17 shows the effect of drawing out the discharging stone, which decreases the outside shake, but not to so great an extent as the effect of moving the receiving stone.

SEC. 413—Equi-distant Locking and Equi-distant Center Escapement

It is well that the student should learn the precise meaning of the above terms and the different conditions they produce. They apply solely to the pallet.

Figure 22-18 shows both forms. At **A** is shown equi-distant locking. The locking corners of both stones are at equal distances from the center of the pallet as indicated by the full circular line. This feature gives the escapement its name. The releasing corner of the receiving stone is nearer the center by the distance be-

Fig. 22-17



tween the broken and full circle. The releasing corner of the discharging stone is farther from the center by the distance between the dotted and the full line circle; thus it will be seen that, while the locking corners are equi-distant, the releasing corners differ in distance by double the width of the stone.

At **B** is shown the equi-distant center escapement. In this drawing two full circular lines are drawn from the pallet center. The locking corner of the receiving stone and the releasing corner of the discharging stone are at equal distances from the pallet center. The same is the case with the locking corner of the discharging stone and the releasing corner of the receiving. This brings the centers of the impulse faces equi-distant from the pallet center, which gives this escapement its name.

As has been explained, the lift— the angular impulse—is measured from the pallet center. It is shown at **A** as indicated by lines embracing the angles **1** and **2**. It will be noticed that the impulse face of the discharging stone forms a greater angle with its locking face than the impulse face of the receiving stone does with its locking face. At **B** the angles **3** and **4**, determining the impulse angles of the stone, are the same as **1** and **2**, but in this case the impulse faces form equal angles with the locking faces.

Another feature in connection with these escapements is that in the equi-distant locking the discharging stone must embrace a greater angle than the receiving. This peculiar feature will be demonstrated in the latter part of this work when the subject of drafting an escapement is taken up.

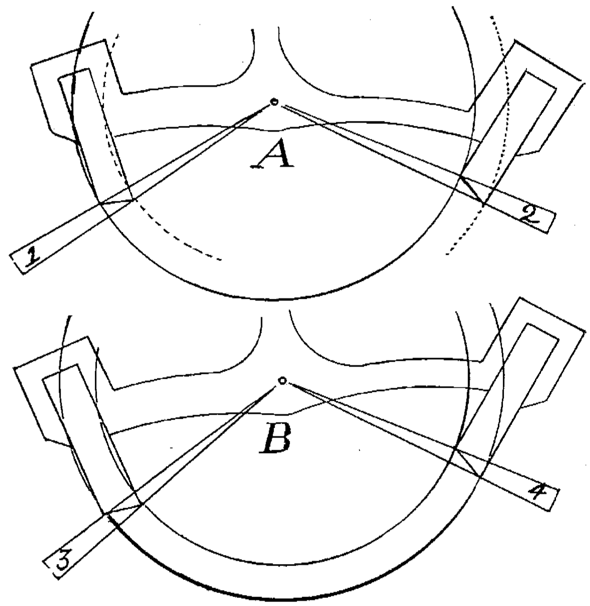


Fig. 22-18

Students often have trouble understanding what is meant by draft (or draw, as it is more commonly called nowadays) and how draw differs from slide. Draw is a force which cannot be seen. It is created when the teeth of the escape wheel and the pallet stones are set at such an angle as to cause the tooth to pull (or draw) the fork against the banking.

The result of draw is slide (Sec. 411), which can be seen. A simple experiment will make this relationship clear.

You will need two unsharpened pencils and two pins (push pins preferred). Drill a small hole through the center of one pencil and just before the eraser cap of the other. Pin the two pencils at right angles on a piece of flat board or heavy cardboard as shown below:

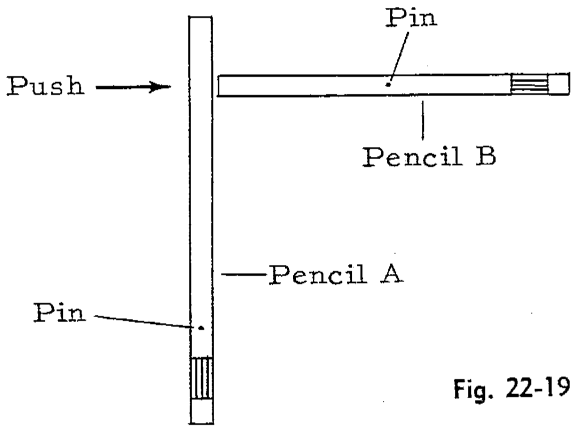


Fig. 22-19

If you now try to push Pencil A towards Pencil B, as indicated by the arrow, nothing happens, because the two opposing forces are equal and cancel each other.

If you now turn both pencils slightly, so they form less than a right angle as shown above at the right and again put pressure on A, both pencils will move, with B sliding down A. What you have just seen is slide. The force which caused it is draw.

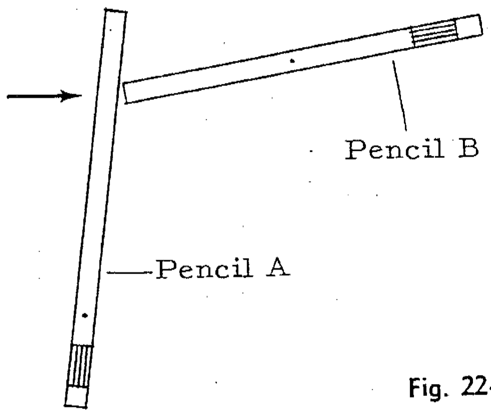


Fig. 22-20

The angle which causes draw is set by the manufacturer of the watch. The repairman is seldom justified in changing it and normally doesn't. What appears sometimes as a lack of draw is usually the result of improper cleaning and oiling rather than an improper angle of draw. When you replace a pallet stone, therefore, you should fit it snugly in the fork slot without sideplay in order to keep the correct amount of draw.

You can test the draw with the balance out of the movement by pushing the fork away from the banking with a pointed pegwood but not to the point of unlocking. If you now lift the pegwood and release the fork, it should return promptly to the banking pin.

When the balance is in the movement, you can test draw by turning the balance wheel so the roller jewel is outside the fork horns. While it is in this position, push the fork away from the banking with a pointed piece of pegwood or small broach until the guard dart contacts the roller. Now take away the pegwood. If draw is present, the fork will at once return to the banking.

CHECK YOURSELF

Progress Check 22 — A Self Test Review of Lesson 22

After you have studied Sections 404 through 413, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of the test. If you see you have missed any, re-study the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or phrase in the blank spaces.	Section Ref.
1. Bending the fork slightly will correct what condition? ______________.	404
2. A guard pin too far forward will affect slide and ______________ ______________ between roller jewel and fork.	405
3. When a guard pin is too far back in a single roller, it can be corrected by inserting a ______________ while a guard pin that is too short in a double roller can be corrected by ______________.	406
4. The main advantage of a club tooth escapement over a ratchet tooth is less loss of power from ______________.	408
5. Impulse is changed by moving the ______________.	408
6. The thrust given the pallets by an escape tooth is called ______________.	408
7. The force which returns the fork to the banking after an impulse is called ______________.	409
8. The angle at which the locking face of a pallet stone is set with respect to the escape tooth produces ______________.	409
9. Moving one pallet stone will change the lock on how many stones? ______________	410
10. Moving the banking pins will change ______________.	411
11. Moving a stone to alter drop will change the drop on the ______________ stone.	412
12. Drop may also be referred to as ______________ or ______________.	412
13. Draft (draw) can be changed by moving the ______________.	409
14. When the locking corners of both stones are the same distance from the pallet center, the escapement is known as an ______________ ______________ escapement.	413

ANSWERS TO PROGRESS CHECK 22:

1. Out of angle
2. angle of contact
3. larger guard pin
   stretching the dart
4. drop
5. pallet stones
6. lift
7. draw (or draft)
8. draw (or draft)
9. both
10. slide
11. opposite
12. inside shake
    outside shake
13. pallet stones
14. equidistant locking

SUMMARY

1. For correct safety action, the guard pin must be straight and centered in the fork slot and neither too far forward nor back in relation to the roller.

2. The five main functions or actions of the escapement are Impulse, Drop, Lock, Draw (or Draft), and Slide. The order in which these actions take place depends upon the position of the balance and roller jewel. For example, if the balance is at rest and power is applied to the mainspring, impulse would be the first action.

3. The impulse transfers the power from the escape wheel to the balance when an escape wheel tooth passes along the impulse face of a pallet stone and kicks or lifts it out of its way. This kick raises the pallet arm which swings the fork and which in turn gives a push to the balance.

4. For a brief instant after impulse, the escape wheel turns freely between the time it is released by one pallet stone and caught by the other. This period of travel is called drop. The purpose of drop is to provide clearance or freedom at the time a stone is unlocked. In order to unlock, the escape wheel must back up or recoil slightly. Drop is the clearance needed to keep the other stone from bumping into a tooth during the recoil.

5. The purpose of lock is to halt the escape wheel while the balance is turning as a result of the impulse it has received. Lock should be as small an amount as possible that will still hold the tooth on the locking face of the stone.

6. After lock the stone must move deeper into the escape wheel in order to provide clearance for the guard pin and to allow for the possibility that escape teeth may not be exactly the same length. This added movement is called slide and the invisible force which causes it is draw. This slide occurs on the locking face of the tooth and begins after lock has taken place.

7. Draw is the force exerted by the power of the mainspring pressing a tooth against a stone at an angle which forces the fork against a banking pin to keep the escapement locked. It is rarely necessary to change the draw. The main reason for lack of draw is improper cleaning and oiling rather than a mechanical fault.

8. Most escapement adjustments are made by moving one or both pallet stones in or out. Think carefully before doing so, for moving stones affects more than one function.

Test Questions — Master Watchmaking — Lesson No. 22

Name: No.: Date:

SUBJECT: Principles of the Lever Escapement. GRADE: ____________

DIRECTIONS: Circle ONE correct answer unless told otherwise.

1. In a double roller escapement, a line drawn from the point of the guard dart to the center of the pallet arbor should pass:

Through fork slot but at an angle to the sides	Through the center of the fork slot	Slightly off center of fork slot toward discharging side of pallet	Slightly off center of fork slot toward receiving side of pallet

2. If a fork has to be bent, what is the first tool to be applied?

Pliers	Punch	Hammer	File

3. The impulse of the escape and pallet action is delivered by:

The pallet stone to the escape tooth	The pallet stone to the fork	The escape tooth to the pallet stone	The fork, to the pallet stone

4. The draft of an escapement is the:

Amount of slide which occurs in the escapement	Force which draws fork away from roller	Force which draws guard pin to roller	Force which fork imparts to roller jewel

5. How may the amount of lock be changed on both stones?

Moving either stone in or out	Moving guard pin closer or farther from roller	Opening or closing banking pins	Bending the fork

6. In actual measurement, the amount of lock on an average 18 or 16 size escapement would be:

4 to 5 hundredths of a millimeter	2 to 3 hundredths of a millimeter	About 1/4 the width of face of stone	1/3 to 1/2 the width of face of stone

7. How may the amount of slide be changed?

Move one pallet stone in and the other out	Spread stones apart or close them	Move guard pin closer or farther from roller	Open or close banking pins

8. Drop may be altered by:

Spreading the stones apart or closing them	Bending guard pin to left or right	Opening or closing banking pins	Bending the fork

9. Which of the following are found in the escape and pallet action? (Circle <u>all</u> correct answers.)

Draft	Safety action	Lock	Slide

10. Moving a pallet stone in or out alters the escapement in which of the following? (Circle <u>all</u> correct answers.)

Impulse	Draft	Lock	Roller shake

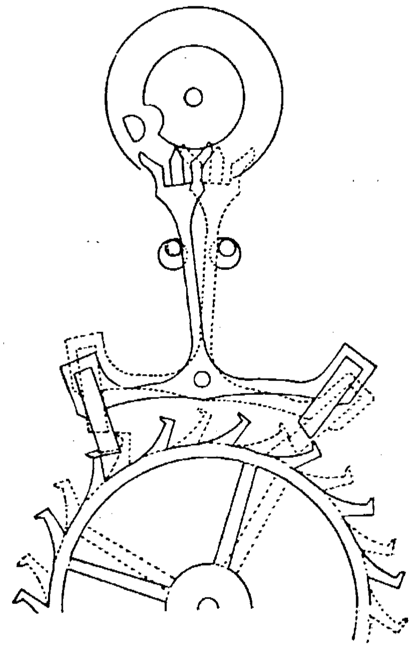
11. Which of the following conditions are necessary for correct safety action? (Circle <u>all</u> correct answers.)

Roller jewel squared in front and upright	Edge of roller cleaned and polished	Drop equal on each stone	The escapement in angle

(Please turn over)

Detach page or cut along this line — and send to the School for grading.

DIRECTIONS: In the remaining questions, select the ONE BEST answer and put the letter of your answer on the short line in front of the question number.

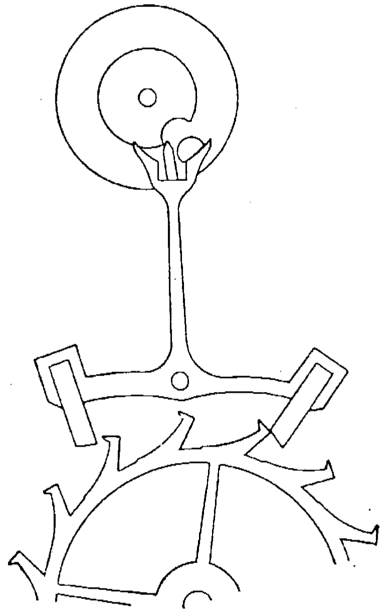


_____12. What error is shown in the sketch at right?

A. Escapement has tripped.
B. Guard dart too far back.
C. Unequal roller shake.
D. Banking pins too far back.

_____13. What is the best way to correct it?

A. Close banking pins.
B. Replace guard dart with longer one.
C. Bend guard dart.
D. Bend fork.



_____14. What has happened in the sketch at the right?

A. Escapement has tripped.
B. Escapement is out of angle.
C. Escapement is overbanked.
D. Roller jewel has no clearance.

_____15. What caused this condition?

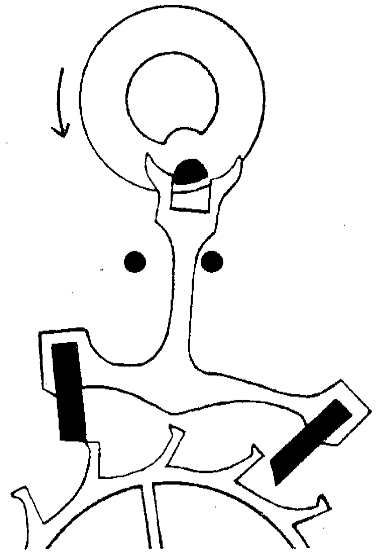
A. Roller jewel too far forward.
B. Fork horns improperly formed.
C. Bent guard dart.
D. Unequal roller shake.

_____16. What is the best way to correct it?

A. Reshape fork horns.
B. Reset roller jewel.
C. Bend fork.
D. Straighten guard dart.

 (Continued on next page)

In Questions 17 and 18, assume the balance is moving as shown by the arrow in the illustration at the right.



_____ 17. In what order will these actions take place as the escape tooth lets off the R stone?

A. Impulse, Drop, Lock, Draw, Slide.
B. Drop, Lock, Draw, Slide, Impulse.
C. Draw, Slide, Impulse, Drop, Lock.
D. Lock, Draw, Slide, Impulse, Drop.

_____ 18. Which of these conditions is shown in this same drawing?

A. There is not enough room for the roller jewel to clear the fork horn.
B. The fork horn has just struck the roller jewel.
C. The roller jewel has just unlocked the receiving stone.

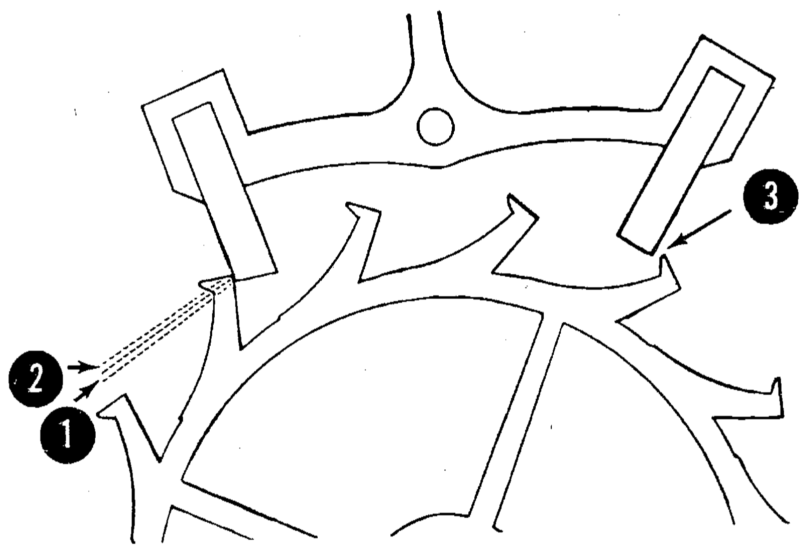
_____ 19. In the illustration below, the numbers and arrows show the amounts of three actions which have taken place. Which list below correctly identifies these three actions by number?

A. 1. Slide
2. Lock
3. Drop

B. 1. Draw
2. Lock
3. Drop

C. 1. Lock
2. Slide
3. Drop

D. 1. Lock
2. Slide
3. Draw



(Please turn over)

_____ 20. Which set of statements best states the purpose of Drop, Lock and Slide?

A. Drop is the space that the escape wheel passes through during the interval between the release of one tooth by a pallet stone and the arrest of another tooth by the opposite stone.

Lock is the distance from the locking corner of a pallet stone to the point at which the wheel tooth strikes it at the instant it drops.

Slide is to allow proper freedom for the impulse pin to pass out of the fork slot as well as freedom between the guard pin and edge of roller.

B. Drop is part of the impulse action and is usually considered a loss of power.

Lock is to stop the escape wheel at equal intervals.

Slide is to position fork so the roller edge, guard pin and impulse pin will have freedom.

C. Drop provides freedom for the escape wheel to recoil or back up during unlocking.

Lock halts the escape wheel while the balance is turning from the impulse it has received.

Slide allows room for the roller jewel to leave the fork slot as well as clearance between guard pin and edge of roller.

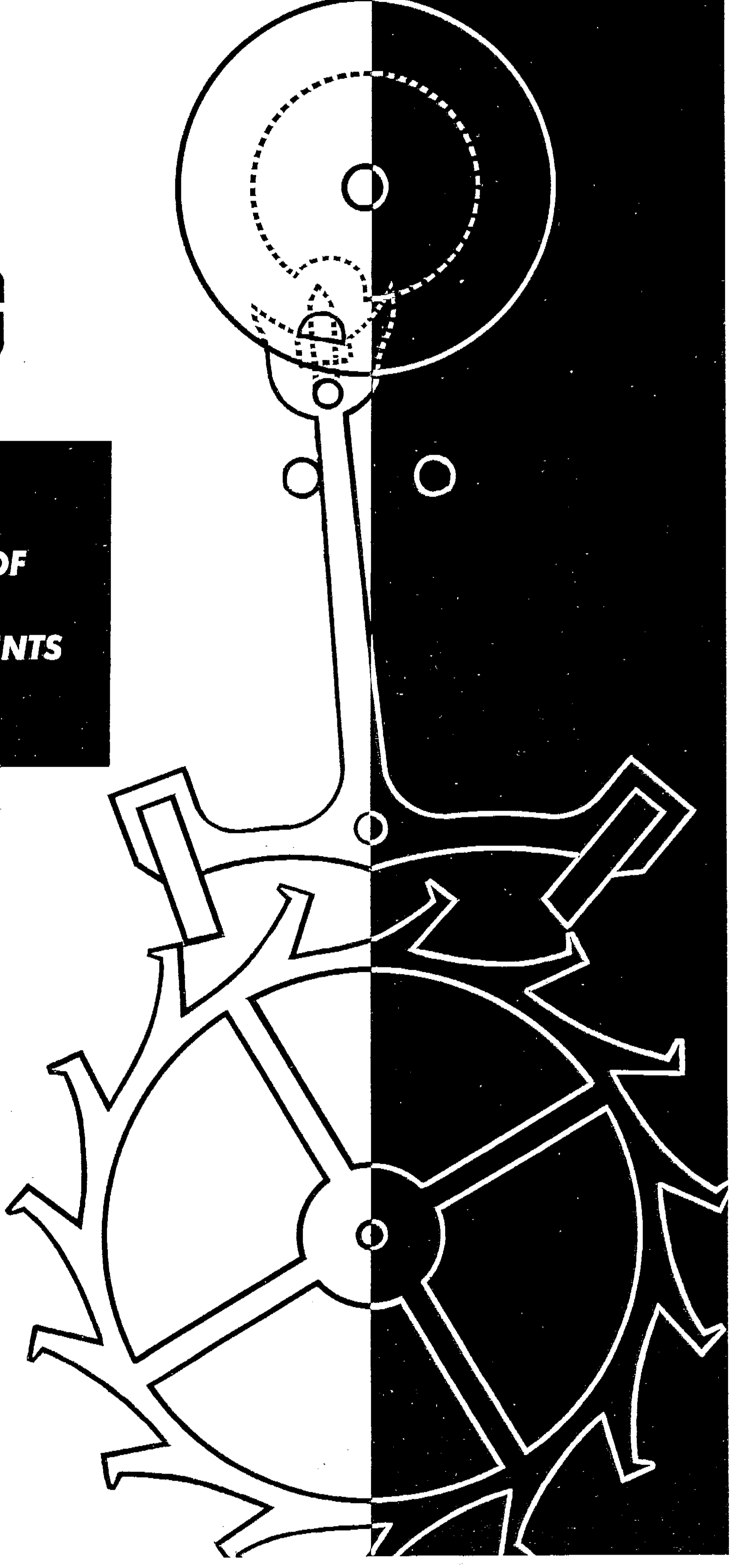
 (End of Test Questions 22)

Master

WATCHMAKING

LESSON 23

TYPES OF ESCAPEMENTS



CHICAGO SCHOOL OF WATCHMAKING

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23

INTRODUCTORY INFORMATION

The types of escapements described and illustrated in this text are no longer in common use. Nonetheless, you may sometimes have to repair a watch with one of them in, so it is well to know something about them. At present you need only learn to recognize these obsolete escapements and how they differ from the lever escapement. When an actual case of repair is necessary, you can refer back to these texts to refresh your memory.

KEY POINTS OF LESSON ASSIGNMENTS 71, 72, 73:

- Other types of lever escapement.
- The cylinder escapement.
- The verge escapement.
- The duplex escapement.
- The chronometer escapement.

ASSIGNMENT NO. 71: Study Sections 414 through 416.

Study Questions:

1. What other types of lever escapements are there?
2. What did these men have to do with the development of the escapement?
   Thomas Mudge   Abbe Hautefeuille   Savage
   Peter Litherland   Perron
3. What is meant by a "dead beat" escapement?

ASSIGNMENT NO. 72: Study Sections 417 through 419.

1. Who was George Graham?
2. How does the cylinder escapement differ from the lever escapement?
3. What are some disadvantages of the cylinder escapement?
4. What precautions should you observe in fitting a new cylinder?
5. How can you test a cylinder escapement for correctness?

ASSIGNMENT NO. 73: Study Section 420.

1. In what type of timepiece is the chronometer escapement used?
2. For what position is this timepiece adjusted?
3. Is it accurate in other positions?
4. Is periodic cleaning enough to keep a marine chronometer in good working order? Why?
5. What are the two common forms of chronometer escapement?
6. Does a chronometer escapement lose more or less power than a lever escapement?

REQUIREMENT:

➧ Answer the Test Questions for Lesson 23 and send in for grading.

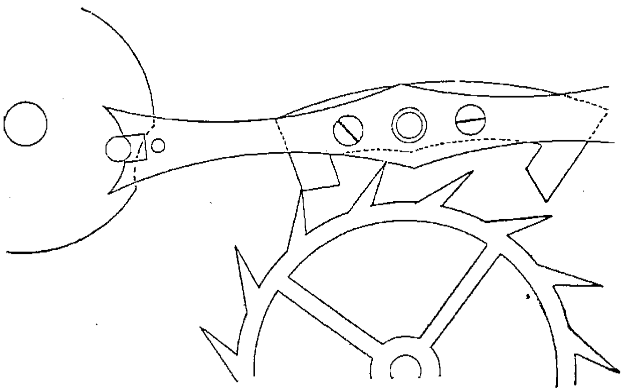

Fig. 23-1

SEC. 414—Other Forms of Lever Escapement

The form of escapement under consideration thus far has been the club tooth, short impulse. The short and the long impulse are generally designated as the short and the long fork. A long or a short fork can be constructed with either long or short impulse. When we come to consider the roller, however, the distance from its center to the roller jewel cannot be changed without altering the arc of impulse of the roller jewel.

The relative distance between the roller jewel and the balance center, as compared with the distance from the pallet arbor to the fork slot, is as four and one-half to one, whereas in in the short fork it is usually about three to one. The effect is that the roller jewel is in contact with the fork for a greater extent of the vibration of the balance in the long impulse—long fork—than in the short one. The short fork being usually about three times the length, it is in action with the roller jewel about 30 degrees —three times the arc of vibration of the fork.

In the first forms of detached lever escapements the active impulse was 10 or more degrees; sometimes as high as 12. This has been reduced from time to time until, in the modern escapement, it is usually found to be about eight and one-half. The roller impulse makes it more difficult to secure the safety action of the guard pin on the single roller, hence the general adoption of the double roller.

The detached lever escapement owes its superiority to the fact that the balance performs so great a portion of its vibration free from contact with any other part of the mechanism. As has been said, in modern forms the fork is only in contact for about 30 degrees. The shorter the duration of contact the better the rate secured. This, however, has its limit. We have been approaching the present form gradually and it would seem as though we had reached the limit. Further reduction would necessarily be secured only by a sacrifice of power, which, as already stated, is now very great.

SEC. 415—The Poised and Unpoised Fork

For many years it was considered to be an important advantage to have the fork and pallets perfectly poised. In order to secure this it became necessary to add considerable weight to these parts. The Swiss usually use the fleur-de-lis pattern for a counterpoise, but whatever is used the adding of weight increases the resistance of inertia which the balance must overcome in unlocking the escapement. This is not compensated for by the questionable advantage of a poised fork.

A fork without counterpoise requires a slight increase in the draft angle. A noted horologist and writer, Mr. Grossman, in his prize essay on the lever escapement, gives 12 degrees draft angle for each stone. Doubtless this would be enough for a poised fork, equi-distant locking, but it would not be safe for an unpoised fork, equi-distant center. This form of escapement should have 14 degrees for the discharging stone and 15 for the receiving stone.

One disadvantage of the unpoised fork is that the additional draft increases the resistance —especially when the watch is in a vertical position with the fork horizontal. This is quite true so far as the lowermost stone is concerned. Assuming the fork points to the right, the resistance on the discharging stone would be increased, but it should be remembered that the resistance on the receiving stone would be decreased in exactly the same amount. Thus the mean of the two resistances would exactly equal the resistance with the fork in a vertical position, either up or down.

Figure 23-1 illustrates the ratchet tooth escapement, which was the first form of detached lever to come into general use. This form of pallet is known as "close-pallet," as distinguished from "exposed pallet." In the "close-pallet" the pallet arm is slotted longitudinally with its plane, while in the "exposed pallet" it is slotted transversely. The "close pallet" method is a more secure way of fastening the stone, but does not permit of alteration as readily as the "exposed pallet." In the "close-pallet" the steel and the stone are finished flush on both locking and impulse faces which precludes the possibility of drawing out or pushing in either stone.

The escapement shown in figure 23-1 is what is known as the right angle escapement, which means that a line drawn from the center of the escape wheel to the center of the pallets and thence to the center of the balance forms a right angle. All the early forms of levers were almost universally laid out on this plan. The inconvenience of having to locate the pallet arbor and the escape wheel under the balance brought about the use of the straight line escapement, which is now the invariable form.

In the right angle-escapement, as shown in figure 23-1, the fork was attached to the pallets by two screws, the threads being in the pallet steel. The pallet arbor was fitted to the pallet steel, the hole in the fork through which it passed being a little larger. The holes in the fork for the screws permitted adjusting the fork with relation to the pallet, so that bending a fork was never necessary.

SEC. 416—Evolution of the Lever Escapement

The evolution of the detached lever escapement is a most interesting history. It is not quite two centuries ago that the idea of transferring the motion from the escape wheel to the balance by means of a lever was successfully applied.

Thomas Mudge, an English watchmaker, in 1765, was the first to produce a lever escapement. Figure 23-2 illustrates his invention.

The pallets were so formed that the locking faces gave no draft. Instead they were inclined in the opposite direction, thus pressing the end of the lever against the roller. The roller was provided with a notch **A** into which the point of the fork entered in delivering its impulse. No bankings were required in this escapement. Its great defect was the constant pressure of the fork against the edge of the roller. Reference to figure 23-2 will clearly illustrate this. The leverage exercised against the edge of the roller was of the same force as that to impart motion,

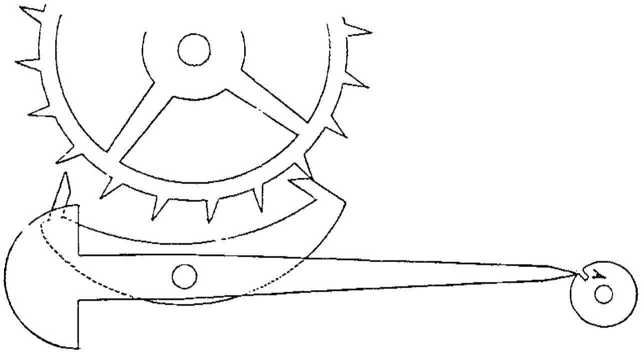

Fig. 23-2

and inasmuch as the pressure against the roller was at an acute angle with its periphery, the retarding effect was great. If the reader will picture in his mind the effect of a guard pin continually pressed against the edge of a roller, he can form an idea of this serious defect in the Mudge escapement. Increasing or decreasing the diameter of the roller in no way helped matters because decreasing the roller diameter decreased the resistance to the revolution of the balance, but it also decreased the force of impulse of the fork. Increasing the diameter of the roller increased the force of the impulse, but also increased the resistance to the motion of the balance. In consequence of this radical defect, Mudge's escapement did not come into use. In fact, he did not adopt it in watches of his own production, using the cylinder and the duplex instead.

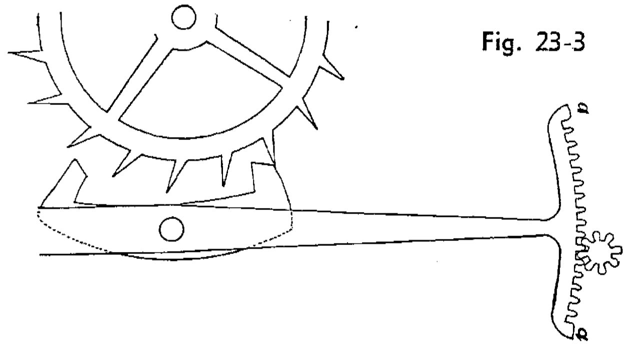

Fig. 23-3

The next important step in development was the rack and pinion lever shown in figure 23-3. In this form the lower part of the balance staff carried a small pinion into which was geared a circular rack on the end of the lever—the term fork was not then used. The pallets were what is technically termed "dead beat," that is, they produced no recoil to the escape wheel. The locking faces of both stones were arcs of circles, the center of which was the pallet arbor. The motion of the balance was limited by the toothless ends of the rack, **aa,** which acted as bankings. When the rack teeth and pinion leaves were properly proportioned and well finished, this escapement gave fairly good results and was in use many years. It was patented by Peter Litherland in 1791, but is said to have been invented by Abbe Hautefeuille half a century prior.

Another form of escapement that came out about the same time is shown in figure 23-4. This escapement was a "dead beat." The escape teeth stood perpendicularly to the plane of the wheel. The balance is not shown. The annular wheel **A** is a part that performs the function of the roller in the modern lever watch. The short segment **a** attached to the under side of one of the arms takes the place of the roller-pin. The projecting arms **bb** include a space that acts as a fork slot. **B** is the escape wheel, **C** the fork.

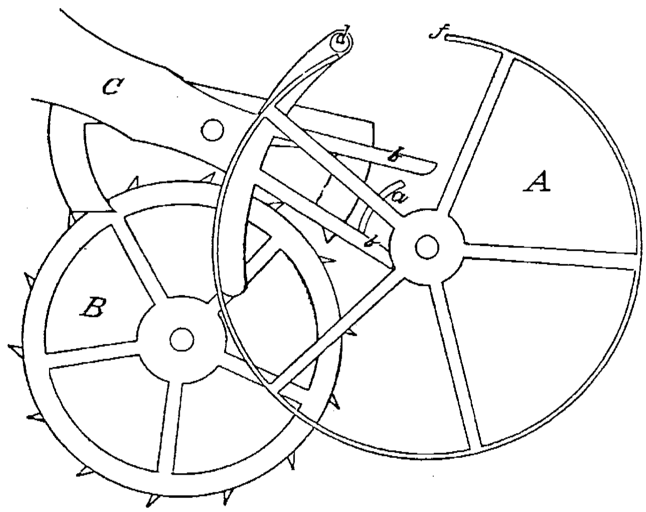

Fig. 23-4

The fork carries two circular arms in the end of one of which is a stud, **d,** which serves as a guard pin. This stud, in connection with the annular rim, **f,** provides the safety device. Bankings are provided but not shown. When the wheel is locked on the receiving pallet the guard pin is on the outside of the safety ring. When the impulse begins, as shown in figure 23-4, the guard pin is in position to enter the opening in the safety ring and pass to the inside thereof. Thus the pin **d** and rim **f** perform the function of the guard pin and safety roller. The fork and pallets required perfect poise, which accounts for the otherwise useless arm extending from the right side of the fork.

The locking faces of the pallets were so formed that they acted as a sort of brake to prevent the movement of the fork while locked. The fork and pallets were perfectly poised. Despite this the guard pin must necessarily sometimes be thrown against the safety ring which is located so far from the center that the motion of the balance would be much retarded. It is surprising that draft was not given to the pallets in order to overcome the weakness just spoken of. This, however, is the exact condition of the escapement made, being drawn to scale from the original. This was probably the first attempt at making a detached lever escapement. As will be seen, it was exactly the reverse of the double roller. In the escapement shown in figure 23-4 the impulse was delivered nearer to the balance center than the safety action, while in the double roller the impulse is delivered farther from the center than the safety action.

Figure 23-5 shows a form of escapement suggested by Perron, a French watchmaker. This form is also a detached lever and was probably the first detached lever made. The pallets consisted of two pins, the impulse being entirely

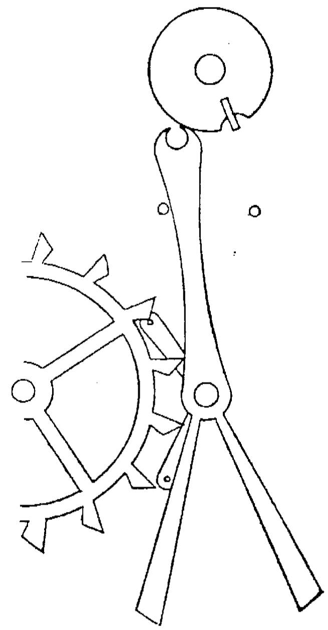

Fig. 23-5

on the teeth, a radical departure from anything heretofore done. Another novel feature was the inclination of the locking faces of the teeth to draw the fork against its bankings. The safety action is performed by the outside of the horns of the fork and the roller edge. The impulse is delivered by a pin projection radially from the roller. A passing hollow, the first device of the kind, permits the passage of the fork during the impulse.

Fig. 23-6

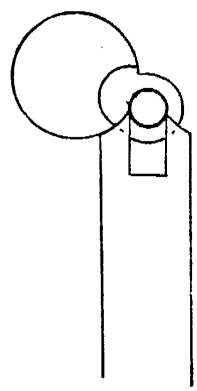

Figure 23-6 shows a form of fork and roller action called the crank lever, so called from its resemblance to the crank of an engine. This form succeeded the rack and pinion and was in use for a long period. It had the advantage over the rack lever of being more simple to manufacture and to adjust. Like the Perron, the safety action was effected between the horns of the fork and the roller edge. The pallets and fork required a vibration of about 25 degrees and the roller about 70.

It has been thought that this form of fork and roller action may have been suggested by the rack and pinion for the reason that a resemblance may be traced to that form. If in a rack and pinion we cut off all but one leaf and all but two rack teeth we shall have, virtually, a crank lever. However, it seems the semblance is more accidental than incidental.

The form of escapement shown in figure 23-1 was the standard for many years, being known as the detached lever. As other forms became popular other terms were added to distinguish them, such as exposed pallets, straight line, club tooth, double roller, anchor, equi-distant center, equi-distant lockings, poised fork, etc., many of which are no longer used.

A form of escapement that deserves special mention is shown in figure 23-7. It is the invention of a London watchmaker named Savage. Theoretically this escapement embraces ideal conditions, especially in the unlocking and impulse. The unlocking is performed at a shorter radius from the roller center than the impulse is delivered. The two pins **AA** perform the unlocking, taking no part in the impulse. The pin **B** which is in the end of the fork performs the double office of impulse pin and guard pin. This form simplifies the production of a non-setting escapement for the reason that both unlocking and impulse are performed under more favorable conditions than any other escapement. Its delicacy of adjustment, however, proved prohibitive to its general use.

SEC. 417—The Cylinder Escapement

The cylinder escapement was invented by George Graham in 1720. It met with little favor at first, being condemned by most of the celebrated watchmakers of that time, among whom was Berthoud who actually attempted to demonstrate that the verge escapement was much its superior.

It is a dead beat escapement which is, of course, a point in its favor. This point is more than offset by the fact that the escape tooth is in constant contact with the cylinder, and at a considerable distance from the center.

Figure 23-8 is a perspective view of the cylinder and its plugs. The letters indicate the names applied to the different parts: **a,** the arbors; **b,** the great or top plug; **c,** the small or bottom plug; **d,** the great shell; **e,** the small shell; **f,** the plug face; **g,** the receiving lip; **h,** the discharging lip; **i,** the banking slot; **j,** the half shell; **k,** the cylinder column.

Figure 23-9 is designed to show the action of the escape tooth on the cylinder. The names applied to the different parts of the teeth are: **a,** the top or flat of the tooth; **b,** the impulse face; **c,** the arm of the tooth; **d,** the locking point; **e,** the heel; **f,** the space. That part of the tooth connecting it with its arm is not shown. It is called the column.

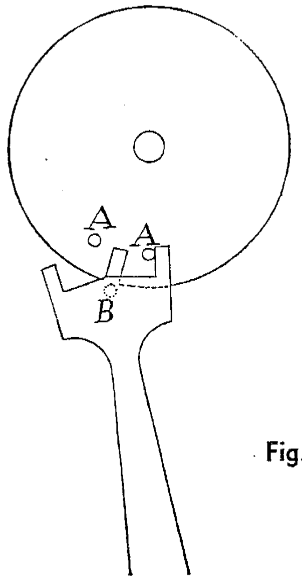

Fig. 23-7

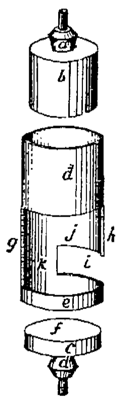
Fig. 23-8

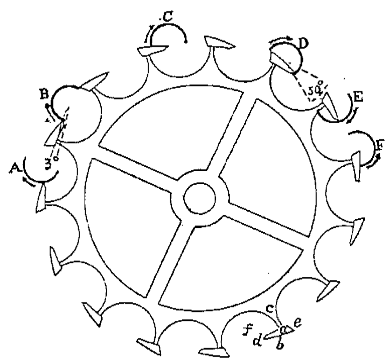
Fig. 23-9

Six positions of the cylinder in action are shown, the cylinder moving as indicated by arrows. At **A** the locking point of the tooth is in contact with the half-shell. At **B** the tooth is about to unlock. At **C** the face of the tooth is delivering an impulse on the receiving lip of the cylinder. At **D** the impulse has been delivered and the tooth is in contact at the locking point with the inside of the half-shell. At **E** the tooth is still in contact with the inside of the half-shell, the cylinder having revolved until the tooth arm has entered the banking slot. The purpose of this slot is to allow the balance a wider arc of vibration than if it were not introduced into the half-shell. At **F** the motion of the cylinder has reversed, the tooth has been released and is delivering an impulse to the discharging lip of the cylinder.

The impulse faces shown in the drawing are slightly curved, but they are more frequently formed of a straight plane. There is some difference of opinion as to the best form.

When a curve is used it can be so formed that equal proportions of its length cause the cylinder to rotate through equal arcs, or it may be so formed that an equal resistance to the changing force of the hairspring is offered throughout the entire impulse. The straight face, however, causes the balance to give the greatest arc of vibration.

A condition brought about by the action of the escapement is that the size of the balance as well as its weight, is confined to comparatively narrow limits. When the balance is heavier than those limits the watch loses with an increase of the motive force, and when the balance is too small it gains. This seems to conflict with mechanical laws but is nevertheless a fact.

There is no other escapement that requires more frequent cleaning. If this is not properly attended to, any approach to a steady rate is not to be expected. Owing to the peculiar shape of the teeth and their constant contact with the cylinder, dirt and thick oil will quickly accumulate on the parts, shortening the arcs of vibration of the balance.

The arc that the cylinder describes during the delivery of an impulse by an escape tooth is called "the lift." This is usually about 30 degrees, as shown at **D**, figure 23-9. The aperture in the cylinder shell is generally about 180 degrees. The thickness of the shell is about 1/16 the length of the impulse face of the tooth. The drop should be as small as possible, consistent with freedom. The smallest drop practical for a lever escapement is 1½ degrees. In the cylinder escapement it need not exceed 1 degree.

The amount of lock of the tooth on the cylinder shell should be 3 degrees, as shown at **B**, figure 23-9.

Le Toy says that in its progress the point of the tooth should pass through the axis of the cylinder. Berthoud says that the middle of the locking face should pass through the axis. The latter seems preferable but in other respects the rules laid down by Berthoud for the construction of the cylinder escapement are not to be recommended.

When this escapement was first introduced the escape wheels were of brass and, as might be expected, gave poor results. Later, when steel wheels were adopted and the parts were highly finished, the time-keeping qualities were much improved.

There has been a great diversity of opinion on the part of experts as to the proportions of the parts, forms of curves, extent of angles, etc. Tavan, Moinet, Wagner, Robert, Jodin, Lepaute, Berthoud and Jurgensen, all eminent watchmakers, differ widely on many points but inasmuch as no good purpose would be served by going minutely into details, particularly as the escapement is fast falling into disuse, their various opinions and arguments will not be discussed here.

There are two important matters to be observed in fitting a new cylinder. First, see that the depth between the cylinder and the escape wheel is so pitched that the center of the impulse face of the tooth passes through the axis of the cylinder. If the depth is too deep or too shallow the friction of the tooth on the cylinder is increased, also the drop will not be equal. Second, see that the drop is equal on the inside and the outside of the shell.

To sum up, the cylinder has in its time given good results and should be appreciated from the fact that it filled the gap in a most satisfactory manner between the old verge and the detached lever. Indeed, Mudge, the inventor of the lever, preferred the cylinder to it and used it in his own watches.

It must not be inferred that the cylinder in its best days made any approach in performance to the detached lever of today. Mudge's lever would hardly be recognized when compared with the modern lever escapement.

The cylinder escapement has degenerated into a poorly executed counterfeit of what it was in its day, when the shell was a ruby and the other parts beautifully executed. Add to this the fact that many of the escape wheels of cylinders as now made up have but six leaves and it will be readily understood why it has fallen into disrepute.

An improperly designed or executed cylinder escapement can only be improved to a limited extent. No amount of manipulation will make it perfect.

Watches having this escapement are usually provided with an adjustable potence which contains the lower jewels and carries the steady pin holes for the balance cock. This enables an adjustment to be made for the depth of the cylinder into the escape wheel teeth. Any other alteration is at best a makeshift.

The description already given will enable the repairer to know when a cylinder escapement is correct. To test its action, move the balance slowly in either direction until the drop takes place. Now reverse the motion a slight amount, just enough to insure a lock, and try the shake of the wheel on the cylinder. Repeat this on the other lip and again try the shake. It should be equal. If it is not it indicates that either the wheel tooth or the cylinder, or possibly both, are not of correct size. If the inside shake, the shake when the tooth is resting against the inside of the shell, is the greatest, it indicates that the cylinder is too large in diameter. If the outside is the greatest, it is too small. The correct way to remedy this is to put in a new cylinder of proper size.

In fitting a new cylinder, see that the shake is equal.

SEC. 418—The Verge Escapement

The verge escapement is so rarely found in use at the present day that only an exceedingly brief description of it is deemed necessary.

This escapement first came into use in clocks in the early part of the 14th century, not being applied to watches until some time later. It continued to be used in watches to a constantly diminishing extent until about a century ago, when it ceased altogether.

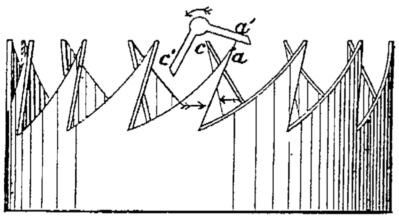

Fig. 23-10

Figure 23-10 illustrates the form and action of the verge escapement. Tooth **a** is delivering an impulse to the pallet, **a'** driving the balance in the direction indicated by an arrow. This tooth moves to the right, also indicated by an arrow. Tooth **c** is moving to the left as indicated. When tooth **a** is released, tooth **c** will drop on the pallet **c'** and deliver an impulse in the opposite direction.

It is evident that this escapement has an excessive amount of recoil, hence its unreliability. Even a slight variation in the power produces a material rate error so that under the most favorable conditions it is unreliable. The wearing of the parts, which in this escapement is always very great, soon causes the watch to gain on its rate, and as the balance, or rather verge, is seldom jeweled this wear soon makes itself manifest.

Another part of the escapement which soon becomes deranged is the escape wheel teeth. These not only wear away, but do so very unevenly, leaving them of varying lengths. In fact, this is one of the most common defects to be found in an old verge watch. It can be remedied by the process known as "topping and filing." The usual method is to fasten a screw collet to the escape staff and, using a Swiss Jacot lathe or an English pivot lathe and a fiddle-bow, true the teeth to length with a slip of bluestone or water of Ayr stone.

The stone should be held firmly against the T rest and brought carefully forward until the longest tooth touches it. Then proceed carefully until all the teeth are of an equal length. Using oil on the stone has the effect of cutting without throwing a burr. After this operation the teeth should be dressed upon the back with a small, fine, half-round file.

When the operation has been performed it will generally be found that the escape wheel does not engage deeply enough into the pallet, but in this escapement that trouble is easily corrected. The escape wheel in a verge watch usually has much more end shake than is necessary. It does no harm for the reason that the action of the escapement keeps the escape wheel constantly pressed away from the center of the verge. The outer pivot finds its bearing in what is called by the English "a follower," which is frictionally inserted into a hole and can be adjusted forward to bring the escape wheel teeth to the proper depth in the verge.

In Swiss watches the same alteration can be made by moving forward the piece called "the counter-potence" which contains the bearing in Swiss verges.

SEC. 419—The Duplex Escapement

This escapement made its appearance about the middle of the eighteenth century. It was the invention of an ingenious French watchmaker, Dutertre, but was perfected by LeRoy. It acquired its name from the fact that in its original form it had two escape wheels, hence the application of the Latin word, duplex—double.

The duplex escapement met with favor among the English watchmakers and was very popular for a considerable period. In this connection it is a remarkable fact that although a French invention it did not become popular in France, but the cylinder, an English invention, was extensively used there and but very little used in England.

Figure 23-11 illustrates the appearance and action of the duplex escapement.

A, the escape wheel.

a, the locking tooth; lying in the plane of the wheel.

a', the impulse tooth; standing at right angles with the plane of the tooth.

B, the impulse arm, carried by the balance staff.

b, the impulse pallet.

C, the roller, carried by the balance staff.

c, the releasing slot.

The impulse arm is located above the roller. The roller is generally of ruby or sapphire, but is sometimes omitted, a slot in the staff taking its place.

The action of the escapement will be made clear by referring to figure 23-11, the parts being represented as moving in the direction indicated by the arrow. **1** shows a locking tooth about to enter the releasing slot in the roller. As the roller moves forward the tooth passes into the slot and is in turn released, thus allowing an impulse tooth to drop on the impulse pallet as shown at **2.** When the impulse tooth has de-

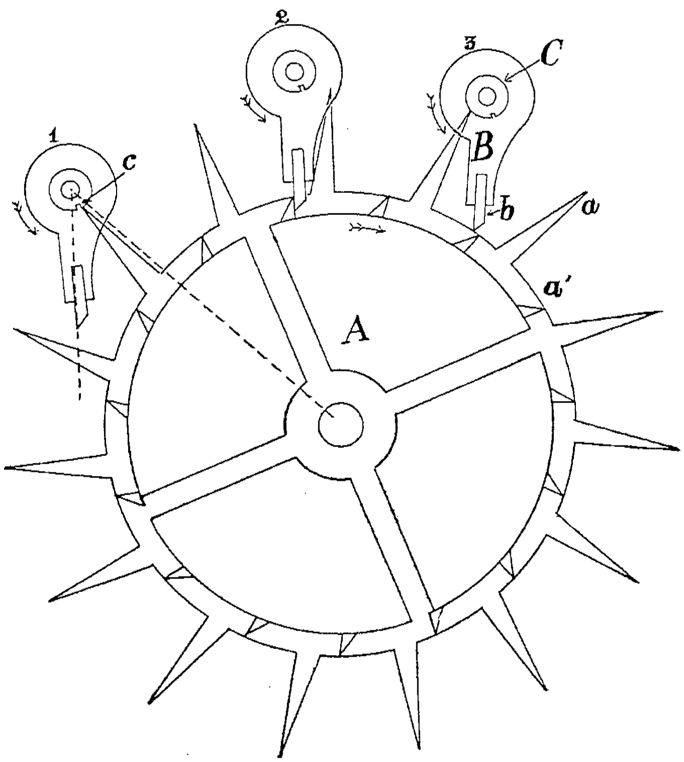

Fig. 23-11

livered its impulse it is released and a locking tooth drops upon the roller as shown at **3.**

On the return excursion the locking tooth again enters the roller slot which allows the tooth to drop forward a slight amount but not enough to release it, and it is immediately forced back to place against the outside of the roller. This exercises a slight retarding influence on the balance which is compensated for when the roller moves in the opposite direction—the direction indicate by the arrow. When it drops into the slot under this condition it delivers a slight impulse which is called "the lesser lift." The lift delivered by the impulse tooth is termed "the great lift."

The adjustment of the rollers to the proper angular relation to each other is of vital importance. The releasing slot must be so placed that it will release a tooth at exactly the right instant. If the tooth is released too soon the impulse tooth will not engage the pallet because the pallet will not have entered the path of the tooth, which will then go forward without delivering an impulse. If the tooth does not enter the slot soon enough and its release is too long delayed, the impulse will be shortened and a poor motion will result.

In the drawing the parts are shown in correct position, but are not strictly correct from a draftsman's point of view, which would require some of the lines to be shown broken.

The duplex escapement requires extreme delicacy in its manufacture and adjustment; a wide side-shake or other slight error being fatal to its proper action. There is comparatively little loss from drop, and it utilizes the movement of the wheel in delivering the impulse to fully as great an extent as in the lever. In the lever the balance revolves without any restraint (except that imposed by the hairspring) except during the brief period that the unlocking and impulse are taking place, whereas in the duplex escapement there is continual contact between the escape wheels and the rollers. For the greater portion of the time a tooth is pressed against the edge of the roller at an extremely unfavorable direction—74 degrees from a right angle, or its complement, 16 degrees from a tangent.

A high authority on horology refers to the duplex as possessing a rate equal to the lever. This might have been true at the time the comparison was made nearly a century ago—but it is far from being the case at the present time. Those who have had much experience with the duplex will agree. The duplex is not manufactured at the present time.

As in laying out the lever escapement, authorities differ to a certain extent as to the proportions that give the best results in the duplex. Saunier in his excellent work, giving for his authority Jurgensen, says:

"The diameter of the roller should be a third of the distance between two adjacent locking teeth of the escape wheel.

"The lifting action on the roller—the small life—extends over an arc of 20 degrees.

"The drop of the impulse tooth on the impulse pallet should be 10 degrees.

"The active impulse on the impulse pallet, measured from the center of the staff, should be 30 degrees."

He quotes many authorities, all of whom, with one exception, agree upon the arc of impulse; the exception referred to is M. Winnerl, who gives the greater lift as 60 degrees, 15 of which is drop, leaving 45 degrees for active impulse.

The lift is determined to some extent by the proportions between the roller, impulse pallet and diameter of the escape wheel.

SEC. 420—The Chronometer Escapement

Next in importance to the lever is the chronometer or detached detent escapement. Its chief value is its adaptability to navigation.

The instrument known as the marine chronometer is capable of close rating when it is kept in a horizontal position and is specially adjusted therefore. It is invariably hung in gimbals which maintain it in a horizontal position, face up.

Marine chronometers are not adjusted to other positions, and if placed in any other than the horizontal will vary in rate.

The fuzee is always used to equalize the power. This facilitates their adjustment and enhances their accuracy. They are frequently to be seen in jewelers' windows as standards of time for the public. The mistaken idea prevails to some extent that a ship's chronometer is a more accurate timepiece than a fine clock. As a matter of fact, a well constructed and adjusted clock with a well compensated seconds, mercurial pendulum, located so as to be free from jar or vibration, is much more reliable.

Many of the chronometers used in show windows are inferior instruments and are often sadly neglected, the owner fondly supposing that cleaning once a year is all that is necessary. Actually frequent cleaning is required. The main spring will have lost a portion of its energy, pivots may need polishing, a readjustment of the escapement may be called for and other things require attention.

When a chronometer receives its annual cleaning, the main spring should be tested with an adjusting rod. The adjusting rod is attached to the fuzee square and the chain is in place connecting the fuzee and barrel. The adjusting rod is provided with one or more sliding weights by which the rod may be balanced in a horizontal position by the force of the main spring. With the chain entirely on the barrel, the mainspring is wound to a certain extent by means of the ratchet on the barrel arbor, the amount of winding—setting up—being changed

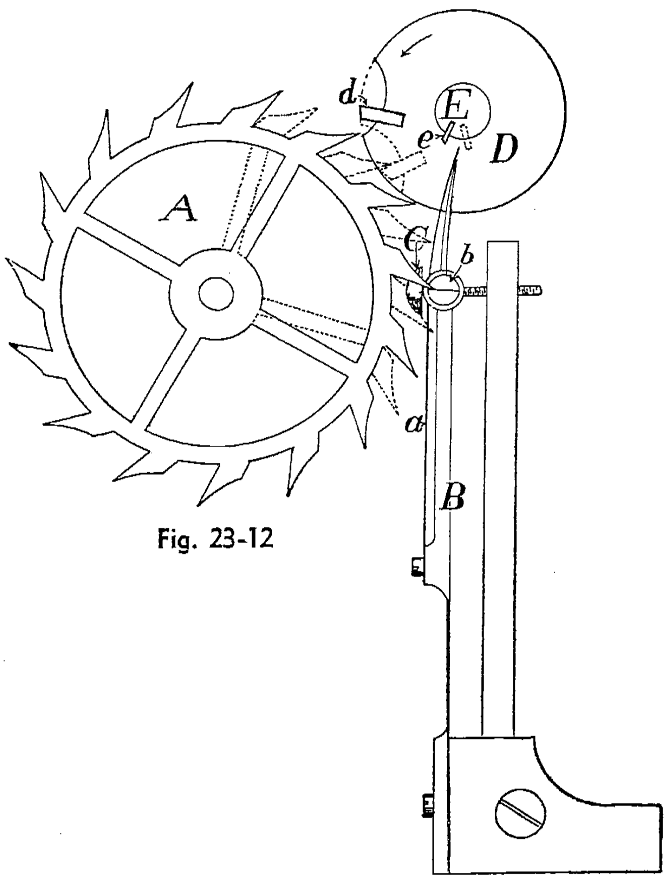

Fig. 23-12

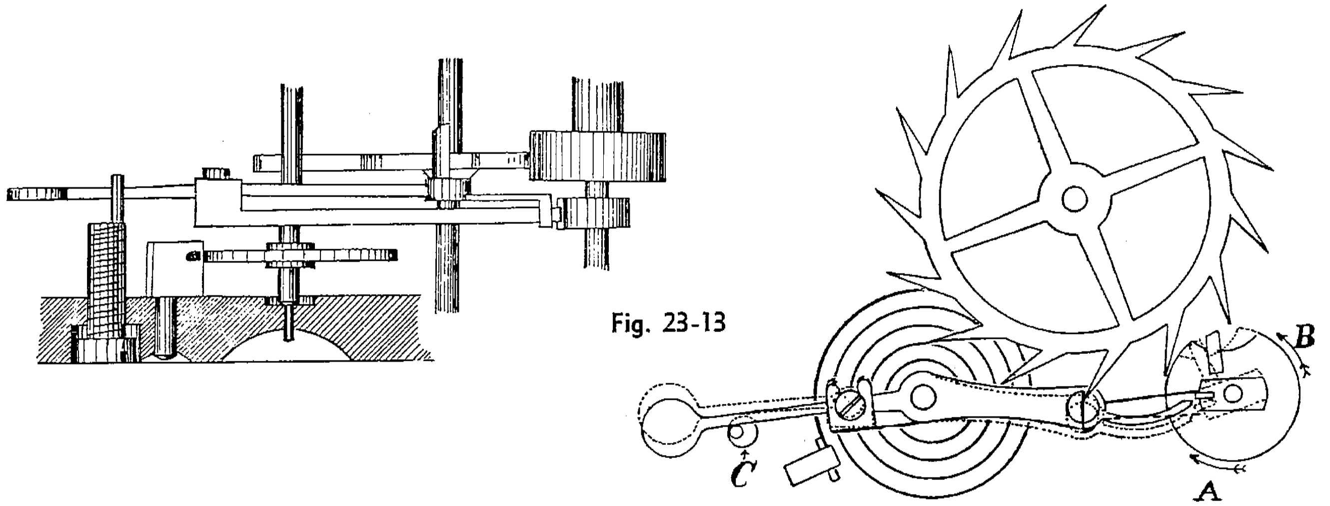

Fig. 23-13

until an approximation to a uniformity of power is attained. When the mainspring becomes set to any extent it is impossible to secure accuracy of rate. This invariably takes place in the course of time, and if the old spring is not replaced by a new one the rate of the instrument is impaired. The same is true to a greater extent of the balance spring. In view of these facts, it will be readily understood that although a chronometer be cleaned at proper intervals, the pivots polished, etc., yet it may become inaccurate and unreliable as a timepiece.

The parts of the chronometer escapement are, referring to figure 23-12:

A, the escape wheel.
B, the locking detent.
a, the unlocking spring, commonly called the gold spring, it being usually made of that metal.
b, the detent jewel.
C, the banking screw.
D, the impulse roller.
d, the impulse pallet.
E, the discharging or releasing roller.
e, the releasing pallet.

There are two principal forms of the chronometer escapement. That shown in figure 23-12 is called "the spring detent" and is generally used in marine instruments. The other, called "the bascule," meaning see-saw, is the form generally used in watches. In this form the detent is pivoted and a coiled spring, called the recovering spring, is colleted to the arbor carrying the detent, the outer end of the spring being secured in a stud attached to the watch plate. The office of the spring is to bring the detent against its banking **C,** figure 23-13.

The chronometer escapement gives impulse to the roller only in one direction, usually when the balance vibrates to the left. Figure 23-12 shows in broken lines the action when the balance, revolving to the left as indicated by the arrow, receives its impulse. In this action the releasing pallet comes in contact with the extreme end of the gold spring and forces the detent aside, releasing an escape wheel tooth. While this is taking place, the impulse pallet has moved into the path of another escape wheel tooth, and when the wheel is released that tooth drops on the impulse jewel thus communicating an impulse to the balance. On the return excursion of the balance the releasing jewel lifts the gold spring from the detent and is allowed to pass on its excursion to the right. The outer end of the impulse jewel is flush with the periphery of the roller and passes between two teeth without contact.

Figure 23-13 shows a plan view and an elevation of the bascule. It is shown in full lines with the balance revolving to the right as indicated by the arrow **A.** The releasing pallet is in contact with the gold spring, lifting it from the detent. The broken lines show the releasing pallet in contact with the other side of the gold spring, forcing the detent from its banking and carrying the detent jewel to a point where it is about to release the escape wheel for the delivery of an impulse. The roller is rotating as indicated by the arrow **B.**

The elevation is for the purpose of showing the position of the parts as in the watch. Note that the extreme ends of the detent, gold spring, releasing roller and releasing jewel, are all located beneath the impulse roller. The same condition prevails in the escapement depicted in figure 23-12.

A close scrutiny of the chronometer escapement will disclose the fact that fully four-tenths of the power is lost in the drop of the wheel tooth on the impulse pallet. There is also a loss of power in forcing the detent aside to release the escape wheel, and in raising the gold spring from the detent to allow the releasing jewel to pass. It has been shown that there is a loss of one-third in the lever escapement. The loss in the chronometer is still greater.

Many modifications of the chronometer escapement have been made from time to time but the two forms shown are those found in general use.

CHECK YOURSELF

Progress Check 23 — A Self Test Review of Lesson 23

Study Sections 414 through 420 before answering these questions. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of this test. If you miss any, review the indicated section.

DIRECTIONS: Complete the following statements by writing the correct word or phrase in the blank spaces.	Section Ref.
1. The less time the fork contacts the ______________ the better the rate of the watch.	414
2. A ratchet tooth escapement is one with ______________ teeth in contrast to ______________ teeth.	415
3. A right angle escapement gets it name from the fact that a line drawn from the center of the ______________ to the pallets forms a right angle with a line from the balance to the center of the ______________.	415
4. The man credited with inventing the lever escapement is ______________ ______________.	416
5. The rack and pinion escapement was invented by ______________	416
6. In a Perron escapement, the pallets were ______________	416
7. Successor to the rack and pinion escapement was the ______________	416
8. Savage's escapement had a pin in the end of the fork which doubled as a ______________ and ______________.	416
9. Although still used, the cylinder escapement has the disadvantage of constant contact between ______________ and cylinder.	417
10. The oldest known escapement is the ______________.	418
11. The duplex escapement is characterized by a double set of ______________	419
12. The chronometer escapement is used chiefly for ______________	420
13. The form of chronometer escapement used in watches is known as a ______________.	420

===

ANSWERS TO PROGRESS CHECK 23

1. balance
2. pointed
   club
3. escape wheel
   pallets
4. Thomas Mudge
5. Abbe Hauteville
6. two pins
7. crank lever
8. guard pin
   impulse pin
9. escape tooth
10. verge
11. teeth
12. navigation
13. bascule

Detach page or cut along this line — and send to the School for grading.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 23

Name: No.: Date:

Circle the correct answer or answers: SUBJECT: Types of Escapements

1. The modern detached lever escapement owes its superiority to the fact that:

It has fewer parts than any other form of escapement	Its balance fork has relatively brief contact with other parts of the mechanism	It is now almost always fitted with a half round roller jewel	It employs an unpoised fork

2. The cylinder escapement was invented in 1720 by:

George Graham	Thomas Mudge	Peter Litherland	Abbe Hautefeuille

3. The cylinder escapement: (Circle all correct answers)

Varies in construction	Is a dead beat escapement	Requires more frequent cleaning than any other type	Has an escape tooth always in contact with the cylinder

4. After studying Sec. 417, what conclusion did you reach concerning modern watches equipped with cylinder escapements?

Coming into general use again	Equal to modern lever watches	Hardly worth repairing	Easier to repair than lever watches

5. The chief value of the chronometer escapement is:

Its adaptability to navigation	Seldom gets out of order	Has best position ratings	Better timekeeper than any other

6. One difference between the chronometer and modern lever escapement timepiece is:

Chronometer has no roller	Chronometer uses no jewels	Lever escapement uses the spring detent	Fuzee is always used in chronometer

7. The Marine Chronometer is invariably hung in:

Racks	Guides	Brackets	Gimbals

8. When a chronometer is being repaired, the mainspring should be tested with:

Mainspring gauge	Mainspring tester	Testing rod	Adjusting rod

9. The duplex escapement:

Has two sets of escape wheel teeth	Is extensively used at the present time	Performs with a rate equal to modern lever escapement	Is never fitted with jewels

10. Mudge's lever escapement had faults which caused him to use in place of his own invention:

The crank lever escapement	The cylinder escapement	The rack and pinion escapement	The chronometer escapement

11. The verge escapement:

Is used in some watches now being made	Showed very little wear after long service	First came into use in clocks	Was very reliable

12. The rack and pinion escapement employed a pinion which:

Was actuated by a pointed lever	Did not make use of a lever	Was geared to a circular rack on end of lever	Was given its impulse by pins on the lever

LESSON 24 DRAWING THE LEVER ESCAPEMENT

CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by Thomas B. Sweazey

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INTRODUCTORY INFORMATION

These next two lessons will show you how to make a mechanical drawing to scale of an escapement. Since you may never have made such a mechanical drawing, we must first explain briefly a few of its terms and procedures. However, the purpose here is NOT to train you as a draftsman or engineer. It is not likely you will be called upon to design an escapement or even to make parts for it in actual repairing. Rather, we expect these drawings, if carefully done, to give you a better understanding of why the escapement is designed as it is as well as helping you to recognize when corrections are needed. Your job as a repairman will usually be one of merely checking to see that the escapement is still set up as the manufacturer designed it. You will learn in Lesson 26 how to make these checks.

Modern drafting practice is to make drawings in pencil only. This is both easier and quicker and you are free to do this too. Such drawings are usually done on transparent tracing cloth or tracing paper so additional prints can be made directly from the tracing. Any finished drawing made on tracing cloth or tracing paper is called a "tracing" even though it is not an actual tracing of another drawing. It may or may not be. The drawings you are to make are not traced duplicates.

Since your drawings are for your own instruction and not for reproduction, the kind of paper you use is not so important. Use tracing paper if you have it, but otherwise, any ordinary paper will do as well.

Use a 4H pencil for your working lines and a 2H for your finished lines and lettering. Sharpen your pencil after every three or four lines you draw. For lettering, the point can be dulled slightly.

You can best remove the guide lines from your pencil drawing by using a steel or plastic erasing shield such as typists use. But if you have none, you can use a thin card, such as a 3x5 file card, to shield the lines you want to keep.

You may, of course, ink your drawings as indicated in the text, if you intend to keep them and don't mind the double work and skill involved.

KEY POINTS OF LESSON ASSIGNMENTS 74, 75, 76, 77:

- Basic principles of mechanical drawing needed to complete this lesson.
- How to design an escape wheel.
- Why each part is designed as it is.

ASSIGNMENT NO. 74: Study Sections 421 through 425.

Study Questions:

1. How do you use a T-square?
2. How do you use triangles?
3. How do you measure and draw angles?

ASSIGNMENT NO. 75: Study Sections 426 and 427.

1. What is meant by the following terms?

Point	Circumference	Sides of an angle
Line	Arc	Vertex
Parallel lines	Diameter	Obtuse angle
Perpendicular	Radius	Acute angle
Right angle	Chord	Degree
Plane	Tangent	

2. What type of measurement do degrees measure?

Recommended Practical Work:

Make the drawings illustrated in Plate 24-8.

ASSIGNMENT NO. 76: Study Section 428.

1. How do you make drawings to scale?
2. How do you make these basic constructions:
   - Perpendiculars?
   - Bisect an angle?
   - Draw a tangent to a circle?

Recommended Practical Work:

Make the drawings illustrated in Plate 24-9.

ASSIGNMENT NO. 77: Study Sections 429 through 434.

1. What are "working lines"?
2. How much distance is there between escape and pallet centers?
3. What determines the number of degrees in an arc of impulse?
4. How can you measure the true diameter of an escape wheel?
5. What considerations affect the angle of the locking face of the tooth?
6. What precautions must be taken in shaping the backs of the teeth?

Recommended Practical Work:

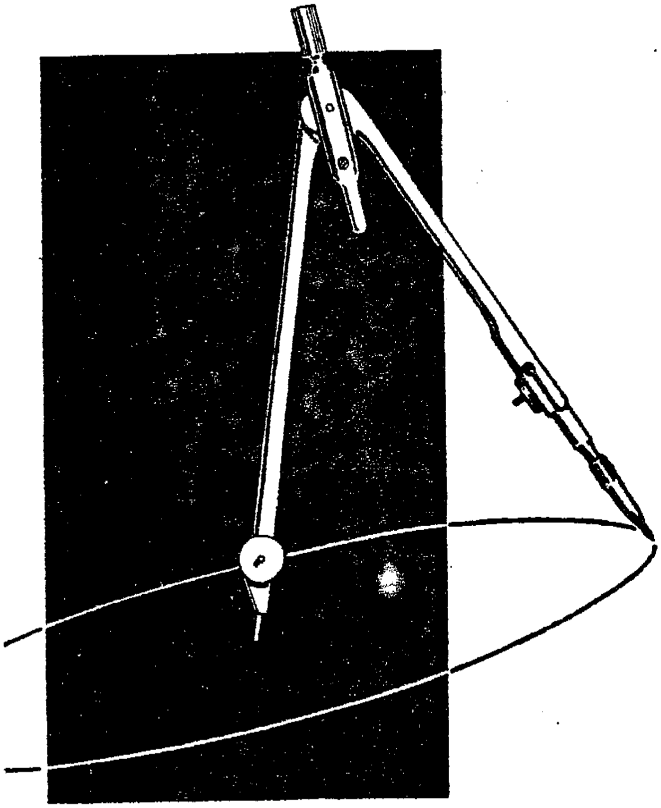
1. Draw the escape wheel as illustrated in plates 24-10 through 24-19. Follow directions in the text. Pay special attention to these important points, angles, circles, and so forth:

   Plate 24-11. Stop and check your work after drawing 115 mm line.
   Plate 24-11. Stop and check after drawing 30° angle.
   Plate 24-12. Stop and check after drawing arc G.
   Plate 24-15. Stop and check after drawing 15 points and circle S.
   Plate 24-18. Stop and check 28° angle, circle V and circle W.

2. After completing the drawing, erase all unwanted pencil marks.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 24 and send in for grading.



SEC. 421—Purpose of Mechanical Drawing

It should be the aim of every watchmaker to acquire a theoretical as well as a practical knowledge of the craft. He should not be content with the simple fact that making a certain alteration will produce a definite result, but should learn through what mechanical laws that result was brought about. With this knowledge he proceeds logically with his work. He applies the correct methods to remedy the defect; thus he accomplishes it in the shortest time and in the most workmanlike manner. Without this knowledge he works on the "cut and try" plan, and while he may eventually succeed in remedying the defect, it is often at the cost of valuable time wasted in futile attempts before success is achieved. This is particularly true of the lever escapement.

The ability to make and read drawings aids greatly in developing inventive and constructive powers, and when applied to the study of the mechanism of the watch, helps the student in mastering the principles of the various actions of trains and escapements. In preparation of these lessons, it has been assumed that the student has a knowledge of elementary mathematics and that he has some understanding of mechanics as applied to watches and clocks. No attempt has been made to give a treatise on drafting. Only such elementary principles of mechanical drawing are included as will enable one to work out the various projects which the author feels will prove most beneficial. If the student has had training in mechanical drawing, the projects to be studied offer few dificulties, but for those who have not had the benefit of such training, it is necessary to give a brief description of the instruments and methods used in making various plane figures before assembling them into the completed drawings. Study diligently the lessons that follow and make all the drawings in the order in which they are given. Only such problems are given as are needed in the lessons to follow and if these are mastered thoroughly, very little dificulty will be encountered in completing the advanced work.

The purpose of this lesson is to give such instruction as will enable a student, though he may not be a draftsman, to make these drawings.

SEC. 422—Drawing Instruments Required

The drawing instruments necessary for a beginner are:

1 Drawing Board or Drafting Machine with Metric Scales

1 T Square 1 45° Triangle 1 30° Triangle	These articles are not required if drafting machine is used.

1 Metric Scale
1 Pair 6-inch Compasses with Pencil and Attachments
1 4½-inch Ruling Pen
1 Bottle Waterproof Drawing Ink
2 Hard Drawing Pencils (2H-4H)
1 Rubber Eraser
1 Art Gum Eraser
Drawing Paper
Drafting Tape (or Thumb Tacks)
1 Protractor

Sharpen pencils to fine point. In sharpening, use pencil sharpener or knife and shape lead on sand paper. KEEP YOUR PENCILS SHARP.

SEC. 423—Using the Drawing Board

A right-handed person uses the T square with the head of the T square against the left end of the board, figure 24-1. Let the pencil slant in the direction in which you are moving the hand and apply only enough pressure to make a distinct line. Draw lines as lightly as possible. The head of the T square is held against the left hand edge of the drawing board, moving parallel. In drawing horizontal lines, the upper edge of the T square is used as a straight edge. Vertical lines are drawn by means of a triangle resting against the T square, A, figure 24-2. B, figure 24-2, illustrates the method used to obtain a line making a given angle with the horizontal.

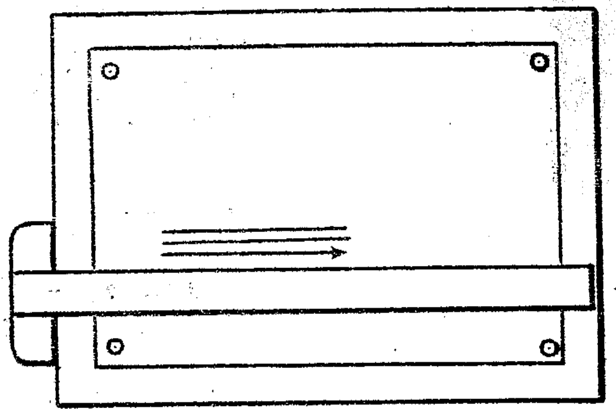


Fig. 24-1

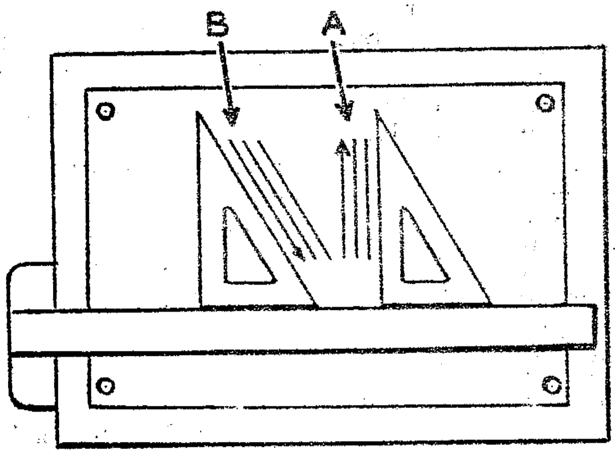
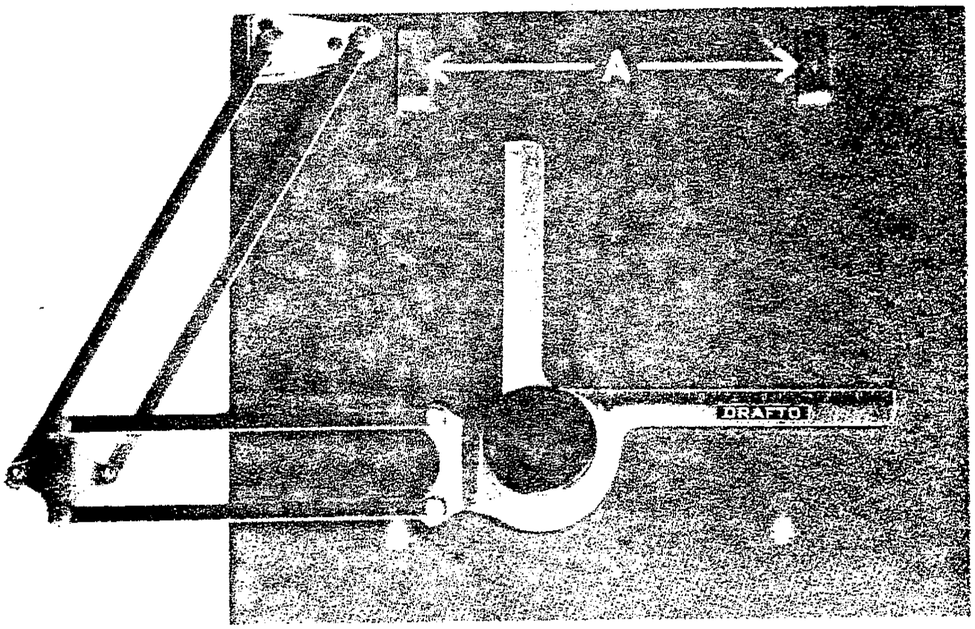


Fig. 24-2

Fig. 24-3



SEC. 424—Using the Portable Drawing Machine

The Portable Drawing Machine, figure 24-3, operates smoothly and easily and eliminates the use of triangles, thumb tacks and T square. The paper clamps, **A**, figure 24-3, hold securely one or more sheets of drawing paper. They are tightened underneath the board and do not interfere with the movement of the scales.

For our use the detachable metric scales with millimeters on one edge and half millimeters on the other are attached as in figure 24-4. The two fingers of the attaching clip are slipped over the ruling side of the integral scale. Then by pressing the two scales firmly together the detachable scale is locked rigidly and in accurate alignment. The detachable scale can be easily removed by applying slight pressure against the spring lock of the attaching clip. There are two clips on each scale permitting either edge to be used on the ruling side.

COURTESY DRAFTO CORP.

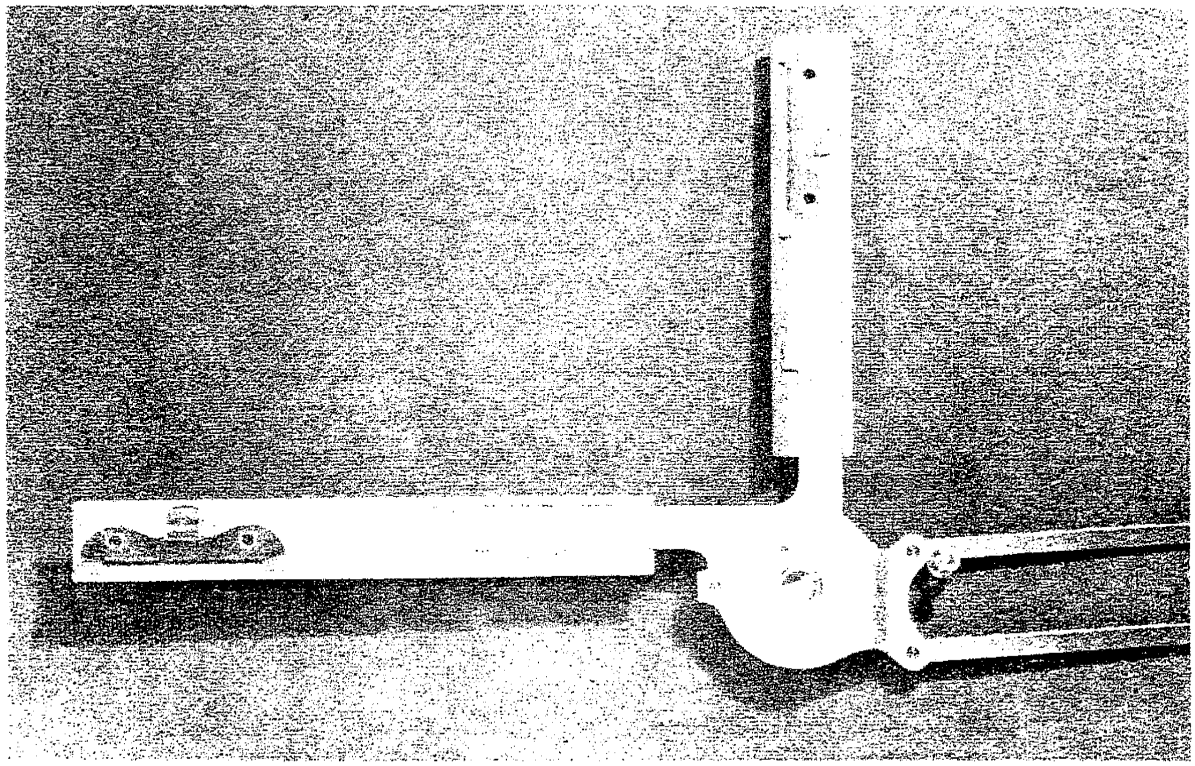


Fig. 24-4

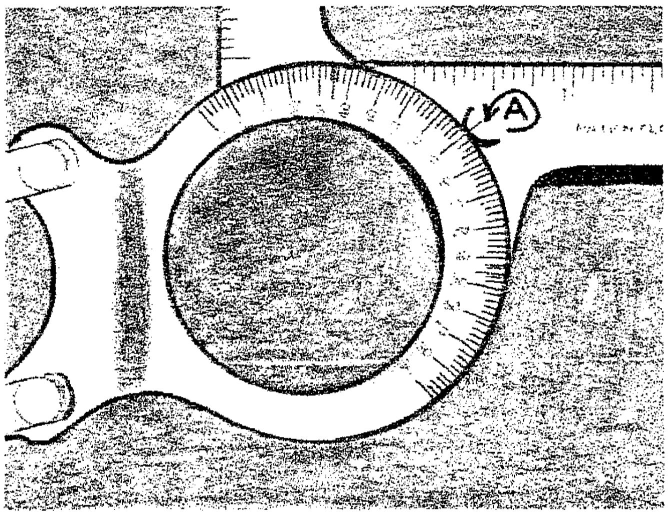


Fig. 24-5

COURTESY DRAFTO CORP.

The protractor feature, figure 24-5, is graduated to 2 degrees. To draw a horizontal line, the index on the scale **A,** figure 24-5, is set at zero. The vertical scale is used to draw vertical lines and these lines are always perpendicular to the horizontal scale.

Example: Set index **A** at **0** and draw horizontal line **AB,** figure 24-6. From point **A,** draw vertical line **AC,** using the vertical scale. Now move horizontal scale up until the index line is opposite the 30 degree marker and draw line **AD** from **A** - the angle **DAB** is an angle of 30 degrees. Using the vertical scale, draw line **AE** from **E** and the angle **EAC** is an angle of 30 degrees. When an angle of odd degrees is desired as 15 degrees, the index will have to be set midway between 14 and 16 as each graduation represents 2 degrees.

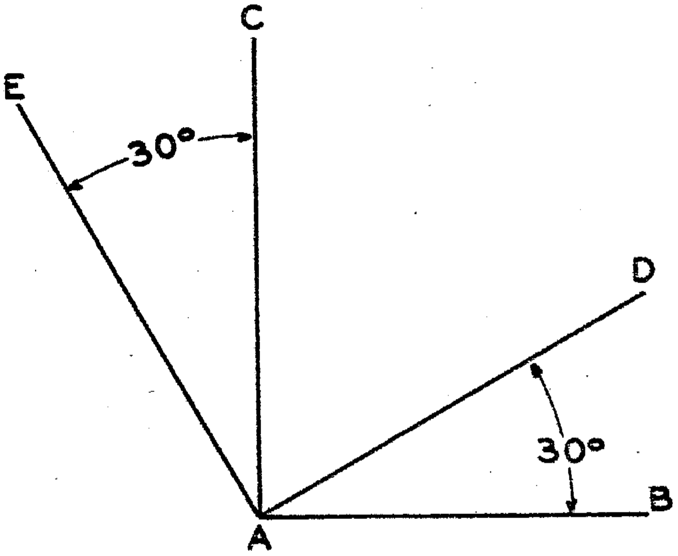
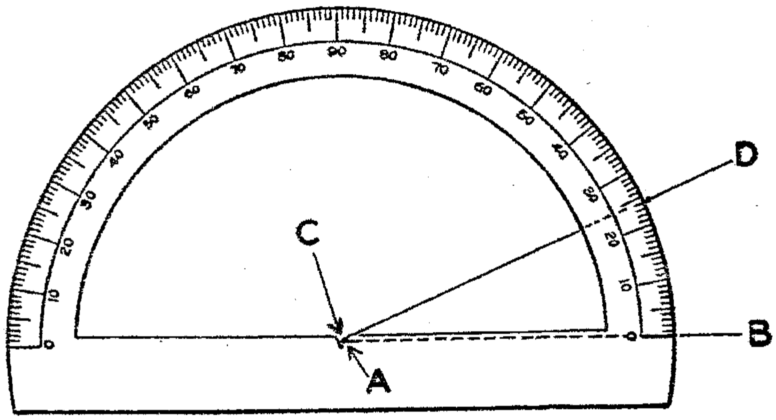


Fig. 24-6

Fig. 24-7



SEC. 425—The Protractor

Figure 24-7 illustrates a protractor used for measuring and laying out angles as follows:

Problem: With **A** as center, draw an angle of 24 degrees above line **AB**. Place the center of protractor **C**, figure 24-7, directly over point **A** and the zero on the right side of protractor directly over the line **AB**. With a sharp pointed pencil, mark a dot at the 24 degree mark on the protractor scale and draw line **AD**. The angle **DAB** is an angle of 24 degrees.

SEC. 426—Geometrical Constructions

Our first drawing will consist of a series of geometrical constructions as illustrated in figures 1 through 17 of Plate 24-8.

First draw in "trim lines". These lines are drawn inside the thumb tack holes of drafting tape, and after the drawing is completed these lines are cut away. For our purpose, the horizontal trim line will be 225mm and the vertical trim line 290mm. Inside of the trim lines draw the border lines; the horizontal border line to be 215mm and the vertical border line to be 280 mm. It is not necessary to ink in the trim line. Divide the drawing paper into 3 equal vertical columns, draw and letter each figure as close as possible to the illustrations in Plate 24-8.

PLATE 24-8

Fig. 1. A **point** is that which has position but no magnitude. It is represented by a dot.

Fig. 2. A **line** is that which has but one dimension - namely length.

Fig. 3. A **straight** or **right line** has the same direction throughout its length.

Fig. 4. A **curved line** or **curve** changes its direction at each succeeding point.

Fig. 5. A **vertical line** is perfectly erect—namely is parallel with a plumb line.

Fig. 6. A **horizontal line** is one that is level throughout its length.

Fig. 7. Parallel lines are those lines which lie in the same plane.

Fig. 8. A **perpendicular** is a straight line so meeting another that the two adjacent angles formed are equal. Each of these angles is called a right angle.

Fig. 9. A **right angle** is composed of 90 equal parts called degrees.

Fig. 10. A **circle** is a plane figure bounded by a curve, all points of which are equi-distant from the center of the circle.

Fig. 10. The boundary of a circle is called the **circumference.**

Fig. 11. Any part of the circumference is called an **arc.**

Fig. 11. Any Chord passing through the center is a **diameter.**

Fig. 11. Any straight line from the center to the circumference is called a **radius.**

Fig. 12. Any straight line having its ends in the circumference is called a **chord.**

Fig. 12. Any straight line which touches a circle at but one point is a **tangent** to the circle and it is always perpendicular to a radius drawn to that point.

A **plane** or **plane surface** is one in which the straight line connecting any two points will lie wholly within the surface. Example: The surface of a drawing board.

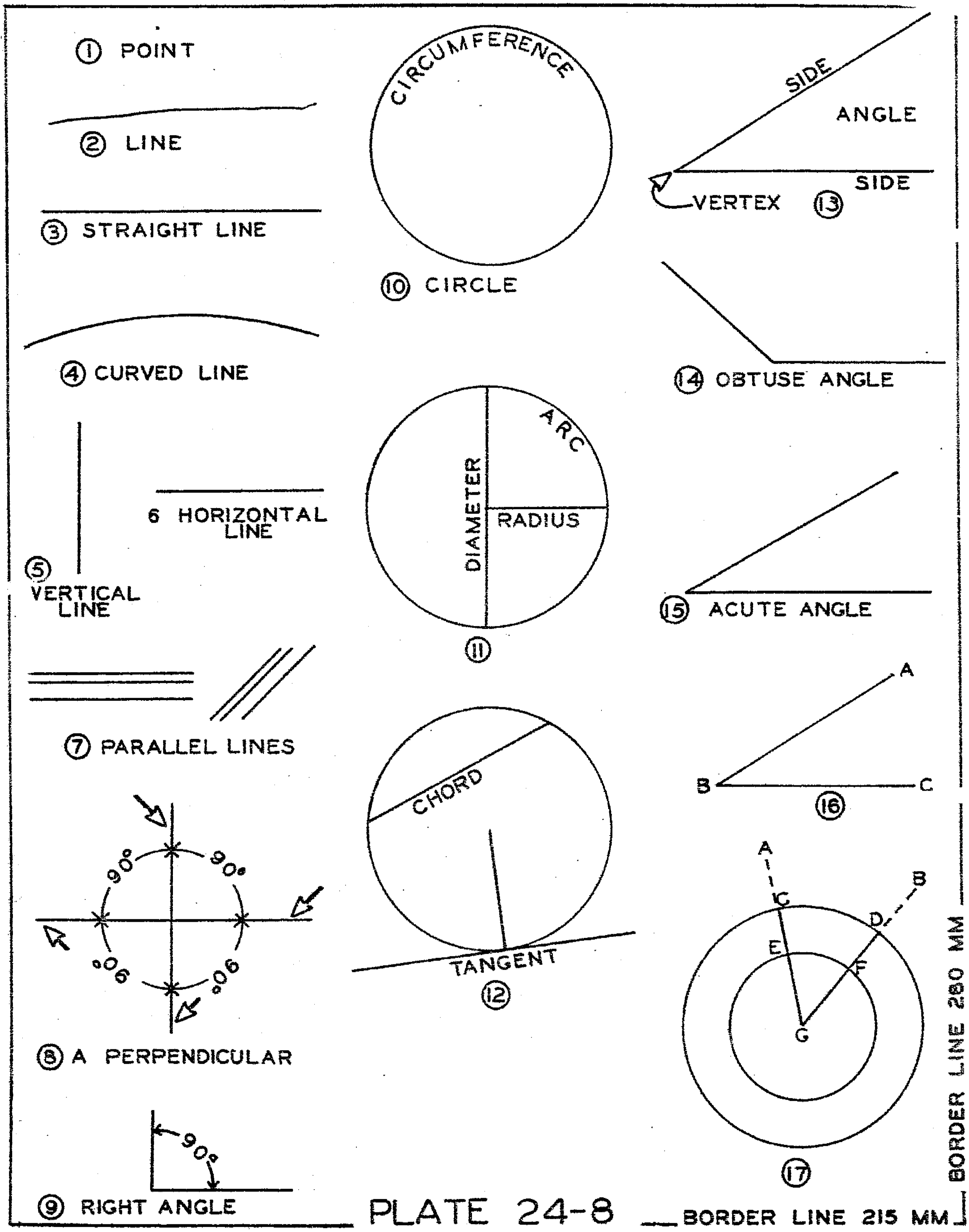
Fig. 13. When any two straight lines meet at a point the figure so formed is called an **angle.** The two lines are called the **sides** of the **angle.** The point of meeting of the sides is called the **vertex** of the **angle.** The **size** of the **angle** is the amount of its opening and doesn't depend on length of its sides.

Fig. 14. If the opening between the sides is greater than a right angle, the angle is an **obtuse angle.**

Fig. 15. If the opening is less than a right angle, the angle is an **acute angle.**

Fig. 16. In figure 16 is shown an **angle,** the two lines **BA** and **BC** being the sides and the point B the **vertex. Angles** in drawings are designated by three letters, the center letter indicating the vertex of the angle. Figure 16 would be described as the **angle ABC.**

If the circumference of a circle is divided into 360 equal parts, each one of these parts is called a **degree.** In other words, a degree is 1/360th of the circumference of a circle regardless of the diameter of that circle. For instance, a degree on the rim of a balance wheel from a man's size watch would be a very small amount if measured in inches, not to exceed 1/200th of an inch, being but 1/360th of the circumference of that wheel. If we were to take a degree on the rim of an automobile wheel, it would be larger, measured in inches rather than in hundredths of an inch. If we go still further and speak of a degree upon the circumference of the earth at the equator, it would measure about 69 miles. Hence a degree is not a **linear** measurement but an **angular** measurement, and while the angle as shown in the circle, figure 17, is 40 degrees, it would remain 40 degrees regardless of how far the lines **AG** and **BG** might be extended from the Center **G,** and also regardless of the size of any circle that might be described from the Center **G.** If we were to draw a circle as shown at **E** and another one at **C,** figure 17, using **G** as a center, the actual distance between the lines on these two arcs would vary greatly, but the angular measurements of **CGD** and **EGF** would still be the same, 40 degrees. Therefore, the size of the angle is the amount of its opening and does not depend upon the length of its sides.


① POINT
② LINE
③ STRAIGHT LINE
④ CURVED LINE
⑤ VERTICAL LINE
6 HORIZONTAL LINE
⑦ PARALLEL LINES
90°
90°
90°
90°
⑧ A PERPENDICULAR
90°
⑨ RIGHT ANGLE
CIRCUMFERENCE
⑩ CIRCLE
ARC
DIAMETER
RADIUS
⑪
CHORD
TANGENT
⑫
SIDE
ANGLE
SIDE
VERTEX
⑬
⑭ OBTUSE ANGLE
⑮ ACUTE ANGLE
A
B
C
⑯
A
B
C
D
E
F
G
⑰
BORDER LINE 280 MM
BORDER LINE 215 MM
PLATE 24-8

ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890

Fig. 24-9

SEC. 427—Lettering Your Drawing

In lettering your drawing, always draw horizontal and vertical guide lines as shown in figure 24-9 and sketch the letters or figures in pencil. In this way, any errors may be corrected before inking which is best done with a lettering pen and a good black drawing ink.

When you have completed the pencil drawings and lettering, proceed to ink the plate as follows:

1. Ink main center lines.
2. Ink small circles and arcs.
3. Ink large circles and arcs.
4. Ink irregular curves.
5. Ink horizontal lines.
6. Ink vertical lines.
7. Ink inclined lines.
8. Ink dotted lines.
9. Ink extension and dimension lines.
10. Ink arrow heads.
11. Letter.
12. Ink border lines.
13. Check drawing.
14. Clean with art gum and cut away trim lines.

SEC. 428—Drawing to Scale

PLATE 24-9

If you wish to show the purpose or function of certain mechanical actions, it should be possible to convey your ideas by means of free hand drawings, but if the different parts of such a drawing are to be of proper proportions and the work accurate, it is necessary to use drawing instruments and make the drawings **to scale.**

In making our drawing to scale, the actual measurements of our object can be increased or decreased in any proportion. Most of our drawings will be increased proportion because of the minuteness of the parts with which we work. This will enable the student to see clearly the proper shapes or mechanical principles involved in any part or combination of parts he desires.

Example: If we have a part such as a balance staff and we desire to draw it proportionately larger, it is necessary to predetermine the ratio. **Example:** Let 20mm. equal 1mm. Then if our staff measures 5:50mm, we would increase it twenty times and the length of the staff in our drawing would be 110mm, figure 18, Plate 24-9.

All of the figures referred to in the following text are contained in Plate 24-9.

Fig. 18 is a drawing of a balance staff which will be drawn to the scale of 1mm equals 20mm. All the necessary dimensions are given in millimeters. Keep your drawing in the upper left hand corner and inside the trim lines.

The following problems in Geometrical Constructions are essential because of their particular bearing on the work to follow. Solve these problems with great care and keep your drawings neat and accurate.

Fig. 19. To erect a perpendicular to a given line from a point on the line. Given point **A** on line **BC.** With **A** as a center and any convenient radius, describe arcs intersecting the line **BC** at points **1** and **2.** With points **1** and **2** as centers, and with a radius greater than half the distance between points **1** and **2,** describe arcs which intersect at **3.** Draw line **3-A,** which is the required perpendicular.

Fig. 20. To erect a perpendicular to a given line from a point outside the line. Given point **A** and line **BC.** With **A** as a center and any radius intersect the given line at points **1** and **2.** With points **1** and **2** as centers and any radius, describe arcs intersecting at **3.** Join **A** and **3. A-4** is the required perpendicular.

Fig. 21. To erect a perpendicular at the end of a given line. Given line **AB.** With **B** as a center and any radius describe an arc of a circle **1-2-3.** With **1** as a center and the same radius, cut the arc at **2.** With **2** as a center and the same radius, cut the same arc at **3.** With the same radius and with points **2** and **3** as centers, describe arcs which intersect at **4.** Draw **4B** the required perpendicular.

Fig. 22. To bisect an angle. Given angle **CAB.** With **A** as a center and any convenient radius describe an arc intersecting **AC** at **1,** and **AB** at **2.** With **1** & **2** as centers and any radius describe arcs intersecting at point **3.** Draw **A3** the bisector of the given angle.

Fig. 23. To draw a tangent to a circle at a given point in the circumference. Draw radius **BA** and extend beyond circumference. Erect a perpendicular **3-4** to the radius through point **A.** This is the required tangent.

Fig. 24. To draw a line tangent to a given circle thru a given point outside the circle. Assume any point outside the circle, as **C.** Draw a line from the point **C** to the center of the circle as **CB.** Bisect this line at point **3,** illustrated by line **1-2.** With **3** as a center and radius equal to **3B,** draw arcs intersecting the circumference at points **4** & **5.** These are the points of tangency for lines drawn from point **C** through points **4** & **5.**

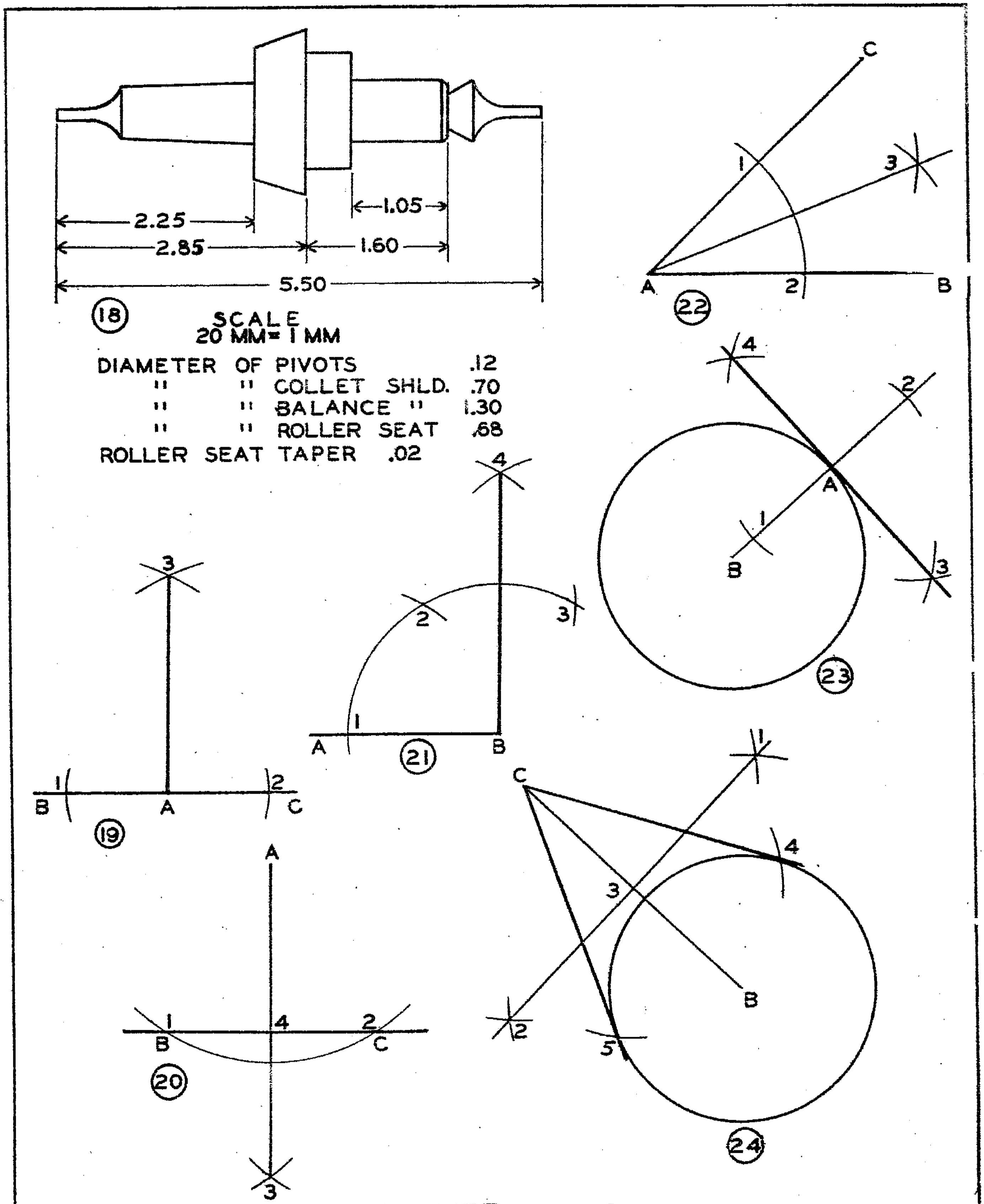

1.05
2.25
2.85
1.60
5.50
18
SCALE
20 MM = 1 MM
DIAMETER OF PIVOTS .12
" " COLLET SHLD. .70
" " BALANCE " 1.30
" " ROLLER SEAT .68
ROLLER SEAT TAPER .02
19
20
21
22
23
24

PLATE 24-9

SEC. 429—Working Lines

PLATE 24-10

Our next problem will be to draw an escape wheel containing 15 teeth. This type of escape wheel is used in most modern watches.

Many of the lines necessary in laying out an escapement are solely for the purpose of locating the several parts that constitute the finished drawing. They are called **working lines.**

In Plate 24-10 as in the preceding Plates, these lines are broken. This is done in order that they may be printed readily, but the student may use pencil lines, which he can erase when they have served their purpose. Such of these as he may desire to retain should be inked in red. The first step in drawing the escape wheel will be to draw in the border lines 280 mm and 215 mm respectively. Draw center line **AA** and divide it equally at **B.**

SEC. 430—Distance Between Escape and Pallet Center

The relative distances between the escape and the pallet centers and the pallets and balance centers may be taken at pleasure, provided it is within reasonable limits, say from escape center to pallet center, being anywhere between 30 per cent and 40 per cent of the entire distance between pallets and balance. These proportions are sometimes exceeded to accommodate other conditions, such as those existing in extra thin watches.

Decide upon the center distances between the escape and pallets and the pallets and balance. In the following instructions it will be understood that the measurements given are not from actual sizes.

Take 115 millimeters on the scale for the distance between the center of the escape wheel (point **B**) and the center of the pallets (point **C**) on center line **AA.**

SEC. 431—Relative Position of Parts

The escapement may be drawn with its parts in any relative position to each other that they assume during action. In this case, we will show them at the instant of locking on the receiving stone. In order to do this, we must find the exact point of contact of the locking corner of an escape tooth with the locking face of the receiving stone. Before we do this, however, it is well to decide what the circular impulse is to be and how it is to be proportioned between the wheel teeth and pallet stones.

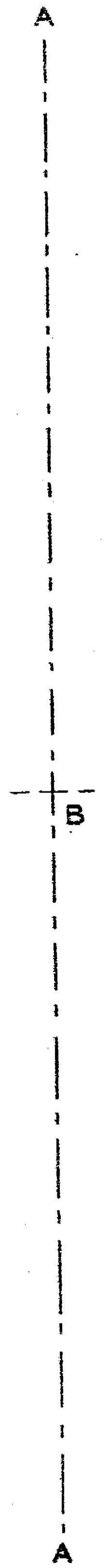
SEC. 432—Locating The Arc Of Impulse

The arc through which an escape tooth passes at each impulse is called the arc of impulse, and in an escape wheel of **15 teeth** is **12** degrees. The reason that it must be **12** degrees is that each tooth delivers two impulses —one to the receiving stone and one to the discharging stone—during each revolution of the escape wheel. There being 15 teeth in the escape wheel, we divide the entire circle (360 degrees) by twice that number, which gives us 12 degrees. This 12 degrees is not entirely taken up by impulse. A part of it is required for drop. In this case, we will give 1½ degrees for drop. The remaining 10½ degrees is what is termed active circular impulse and is divided between a pallet stone and an escape wheel tooth. We will divide this active circular impulse by giving 4½ degrees to the tooth and 6 degrees to the stone.

SEC. 433—Number of Degrees Between Escape Teeth

When the tooth of the escape wheel is locked on the receiving stone, two teeth stand between it and the locking face of the discharging stone. From the locking corner of a tooth to that of the next adjacent tooth is 24 degrees, which is divided into 2 equal impulses of 12 degrees each. From the locking corner of the tooth that is locked on the receiving stone to the locking corner of the second tooth in advance is, therefore, 48 degrees. The third tooth, which has just been released by the discharging stone, is just one impulse — 12 degrees — in advance, making an arc of 60 degrees in all between the locking corners of the pallet stones when measured from the escape wheel center. In an equi-distant locking escapement, the locking corners embrace angles of 30 degrees at each side of the line of centers, but in an equi-distant center escapement these 30-degree angles of measurement pass through the centers of the stones, or, to be exact, midway between where the paths of the locking and releasing corners intersect like paths of the escape teeth. This being the case, lines drawn from the escape center 30 degrees each side of the line of centers will pass through the centers of the stones; for this is to be an equi-distant center escapement.

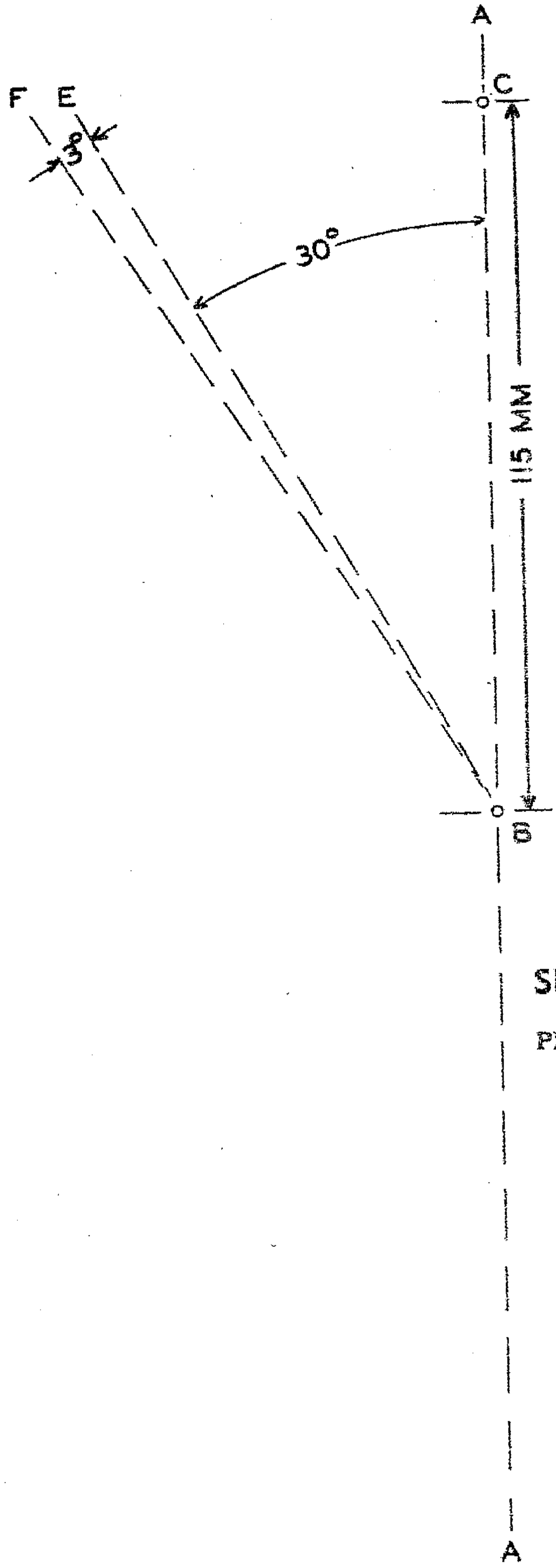
The foregoing has been gone into minutely in order that the student may understand clearly why we use 30 degrees from each side of the line of centers to determine the location of the pallet stones. It must be understood, however, that this only applies to pallets spanning 2½ teeth of a 15-tooth escape wheel.



BORDER LINE 280 MM

PLATE 24-10

BORDER LINE 215 MM



SEC. 434—Drawing an Escape Wheel

PLATE 24-11. From **B** draw line **E,** 30 degrees to the left of the line of centers. Inasmuch as this line runs through the center of the stone, and that the locking corner is half the angle—6 degrees—to the left of this point, draw a line, **F,** 3 degrees to the left of **E.**

PLATE 24-11

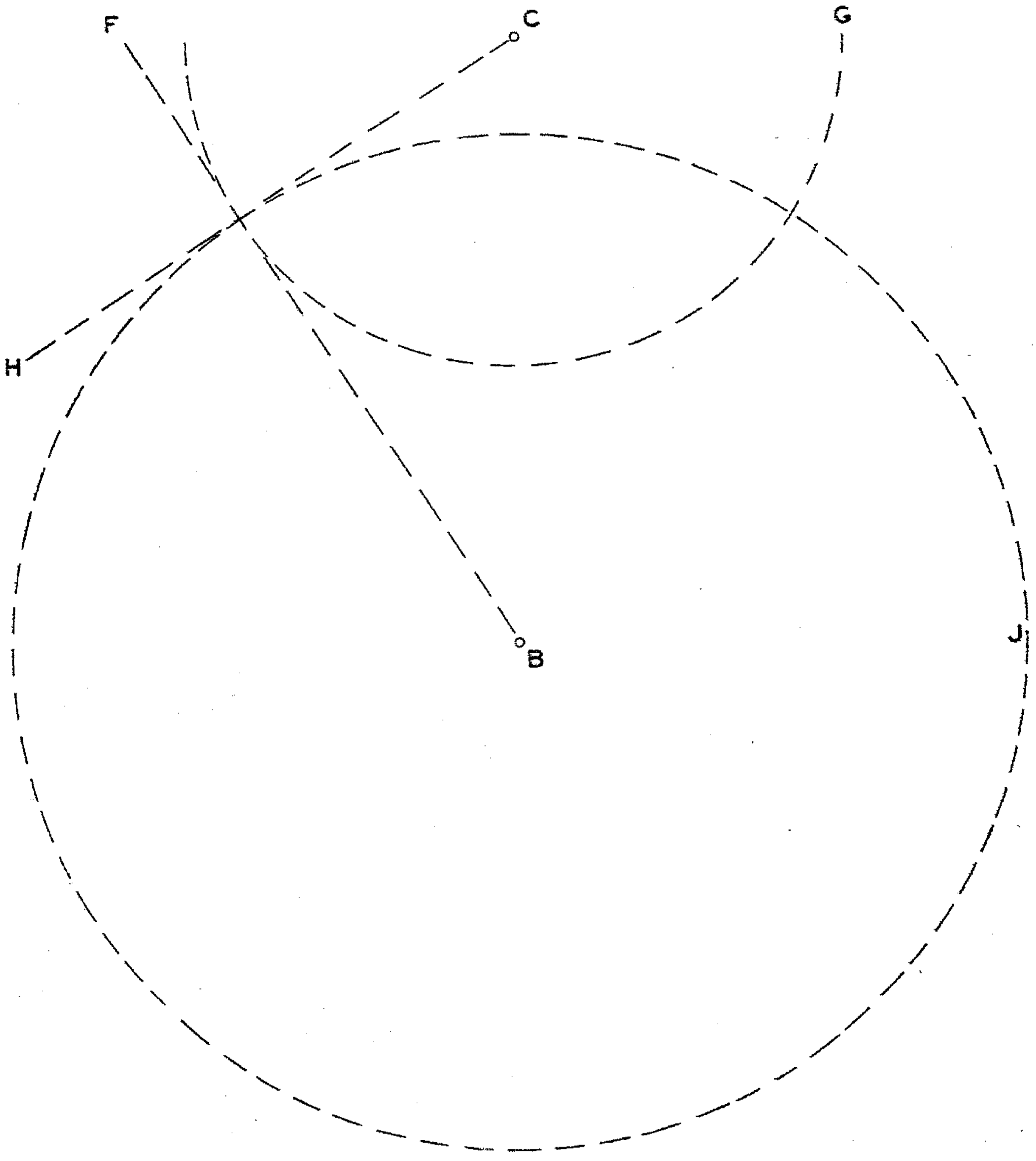


PLATE 24-12. The circular path of the receiving stone locking is tangent to this line. From **C** as a center draw an arc **G** tangent to line **FB**. At the intersection of arc **G** and line **F** from **C** draw line **H**. This line will form a right angle with line **F**.

With **B** as a center describe the circle **J** thru the intersection of lines **H** and **F**. This circle is called the primitive diameter of the escape wheel, and would be its diameter if the wheel were trimmed down to the locking corners.

PLATE 24-12

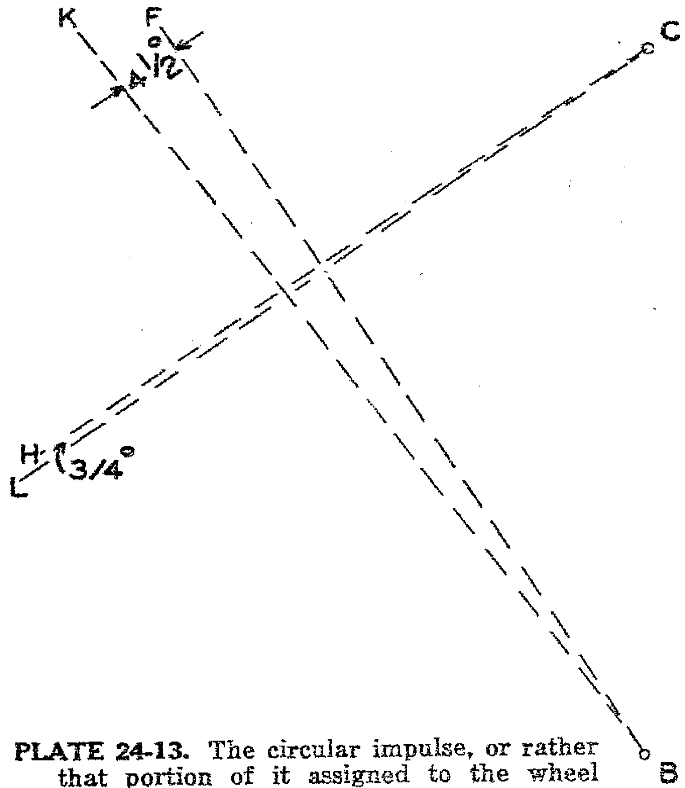


PLATE 24-13. The circular impulse, or rather that portion of it assigned to the wheel tooth, being 4½ degrees measured from the center **B**, draw line **K** that amount to the left of **F.** Upon this line will fall the releasing corner of the tooth. We will now decide upon the amount of lock, which should be as light as possible, consistent with safety, say ¾ degree. From **C** draw line **L,** ¾ degrees below **H.** Where this line intersects line **F** will mark the locking corner of the pallet stone.

PLATE 24-14. We may now decide upon the arc of vibration of the fork and pallets. Let it be 10 degrees. Of this, ¾ degree will be for slide, ¾ degree for lock, leaving 8½ for active impulse—sometimes called lift. This amount should be divided between the tooth and stone in about the same proportion as the circular impulses bear each other. We will give 5 degrees to the stone, 3½ degrees to the tooth. From **C,** 5 degrees below **L,** draw line **M** and from the same center, 3½ degrees above line **H,** draw line **N.** From **B,** draw line **O,** 6 degrees to the right of line **F** (or 3° from **E.**)

From **B** as a center, through the intersection of lines **N** and **G,** draw circle **P.** This circle will embrace the diameter of the escape wheel over points.

From **C** as a center through the intersection of circle **P** with line **O,** draw arc **Q.** This will be the path of the releasing corner of the stone.

The student cannot be too strongly **urged** to make himself familiar with the principles involved in locating these few lines, for they embody the fundamental principle of the lever escapement.

At this point it may be well to give a simple way whereby the true diameter of an escape wheel may be found. In spanning an escape wheel with a micrometer gauge we do not get its true measurement for the reason that the gauge must necessarily bridge two teeth, which leaves us short of its true measurement by the height of the arc between these teeth. The process of measuring this accurately is somewhat complicated but can be closely approximated by simple addition. To illustrate: Let us assume that the apparent diameter of the wheel is 7.55 mm. Write it this way and add:

$$\begin{array}{r} 7.55 \\ .0755 \\ .00755 \\ \hline 7.63305 \end{array}$$

Then 7 63 mm is the true diameter of the escape wheel.

PLATE 24-13

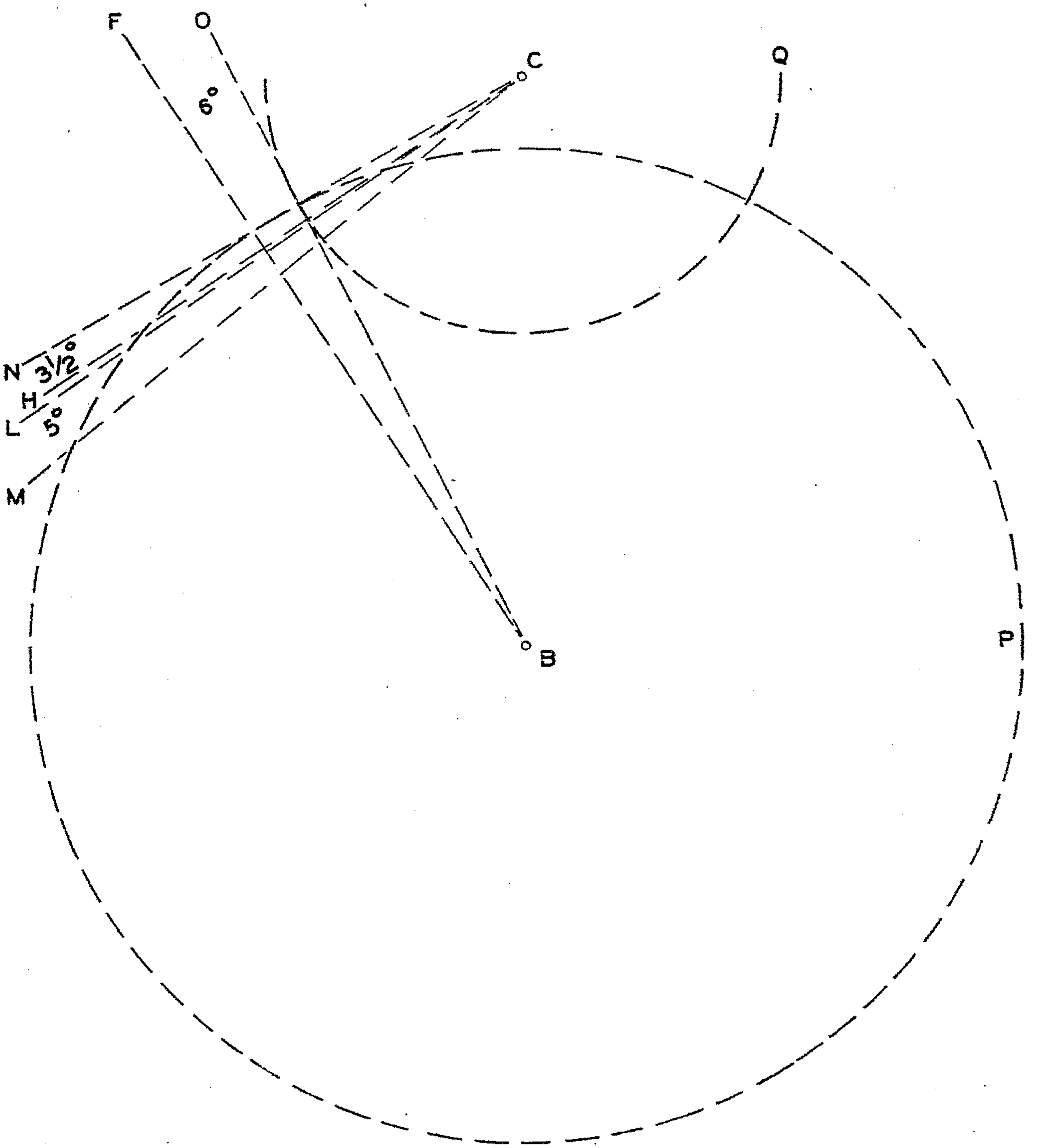


PLATE 24-14

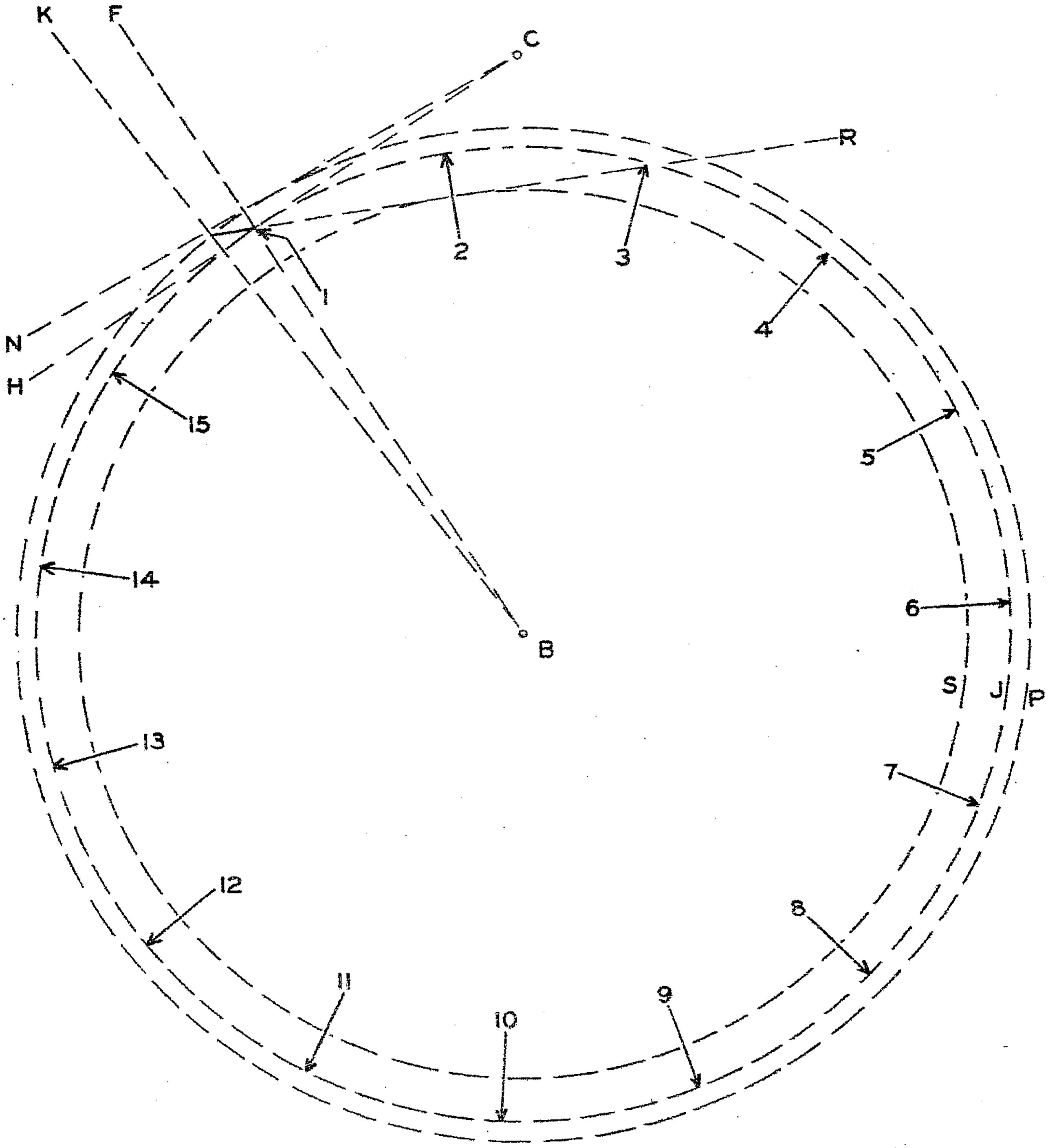


PLATE 24-15. The impulse face of a tooth is formed by drawing a full line from the intersection of lines **P** and **K** to the intersection of lines **H** and **F**. Extend this line to the right to **R**. Its use is to aid in drawing the impulse faces of the other teeth. From the locking corner of the impulse face just drawn in, mark off circle **J** into **15** equal spaces, **1, 2, 3, etc.** These will be the locking corners of the teeth.

To divide the circle **J** into 15 equal arcs from the intersection of line **F** with arc **J** with **B** as a center, mark point **2** 24 degrees below line **F**. With **B** as a center mark point **3** 24 degrees from point **2**. With **B** as a center mark point **4** 24 degrees from point **3** and so on until you have 15 equal arcs.

PLATE 24-15

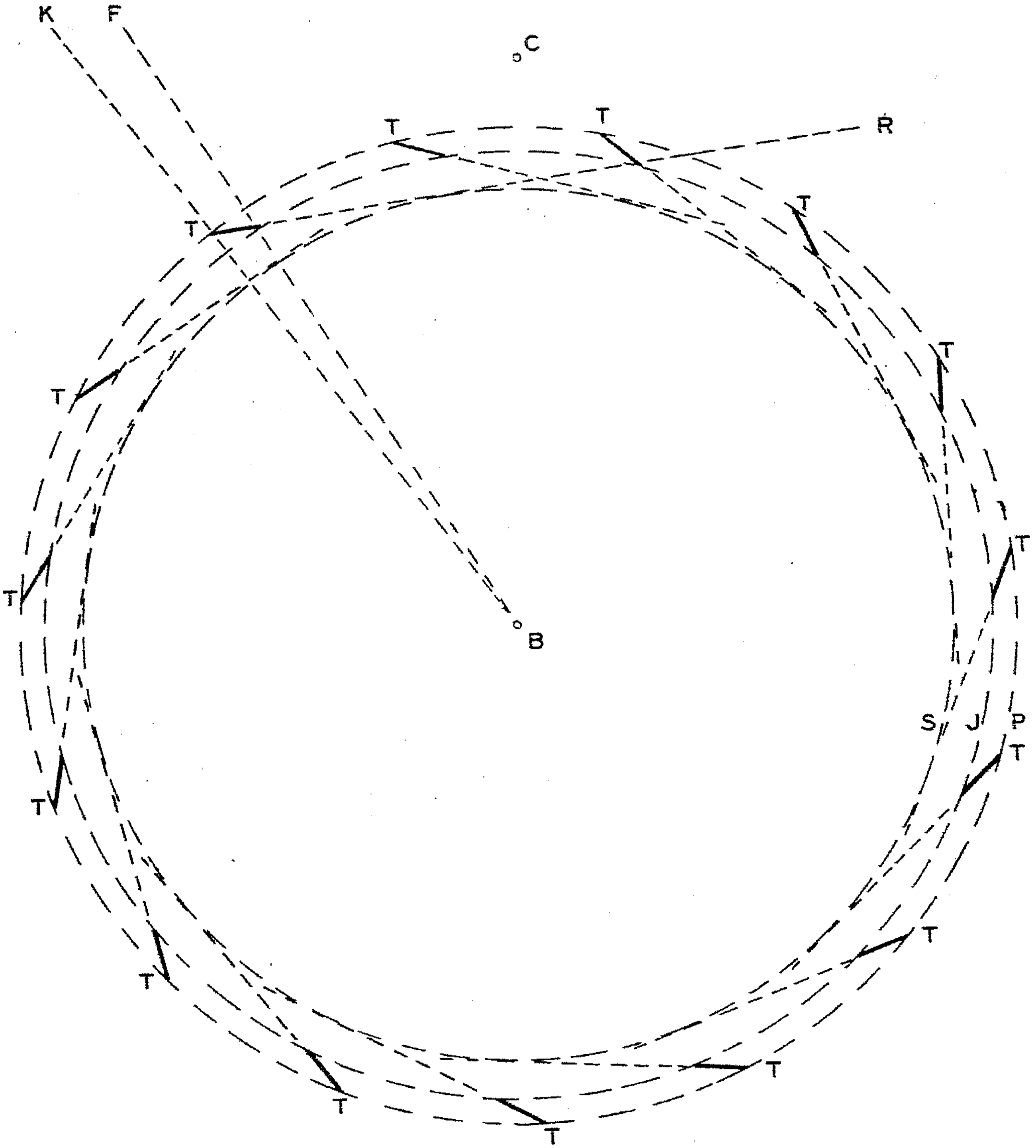


PLATE 24-16. From these points with dividers set to the length of the impulse face already drawn in, mark points **T, T, T,** etc., on circle **P.**
These points will embrace the length of the impulse for the other teeth, being guided by the tangential circle **S.**

PLATE 24-16

PLATE 24-17. We will now draw the hub, arms and rim of the escape wheel.

The dimensions of these are more or less a matter of taste.

Taking the full radius of the wheel (approx. 100 mm) as a basis, we will draw in the wheel to certain proportions, as follows:

For the hub 20%
For the inside rim 73%
For the outside rim 80%
For the thickness of the arms 8%

Setting the compass at **20 mm**, draw a circle for the wheel hub from center **B.**

Setting the compass at **73 mm**, draw a circle for the inside of the rim.

Setting the compass at **80 mm**, draw a circle for the outside of the wheel rim.

Setting the compass at **4 mm**, draw a circle to be used as a guide in drawing the arms of the wheel. Draw two lines parallel to each other and tangent to this circle.

At right angles to these lines and tangent to the same circle, draw two more parallel lines.

These will form the arms of the escape wheel.

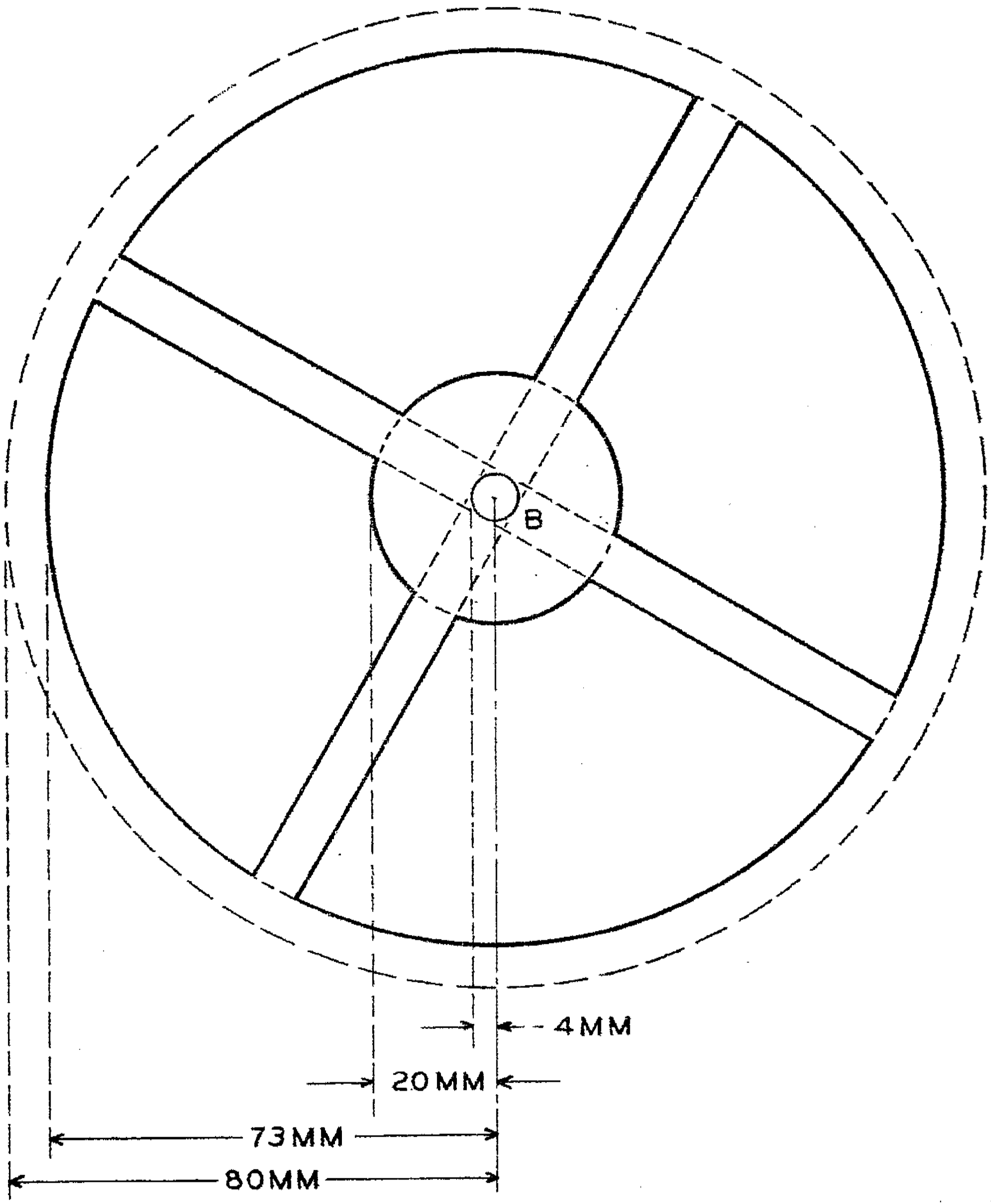


PLATE 24-17

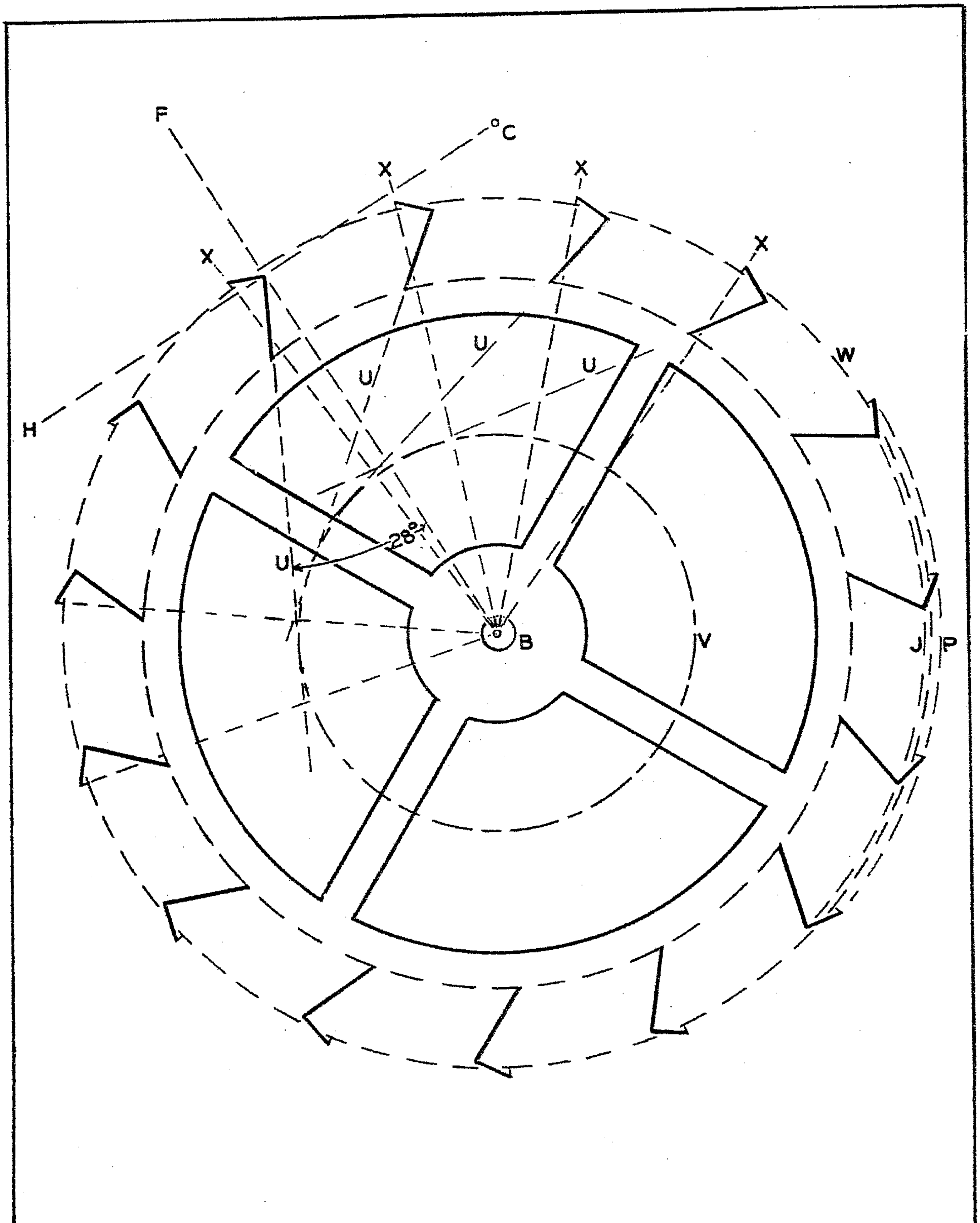


PLATE 24-18

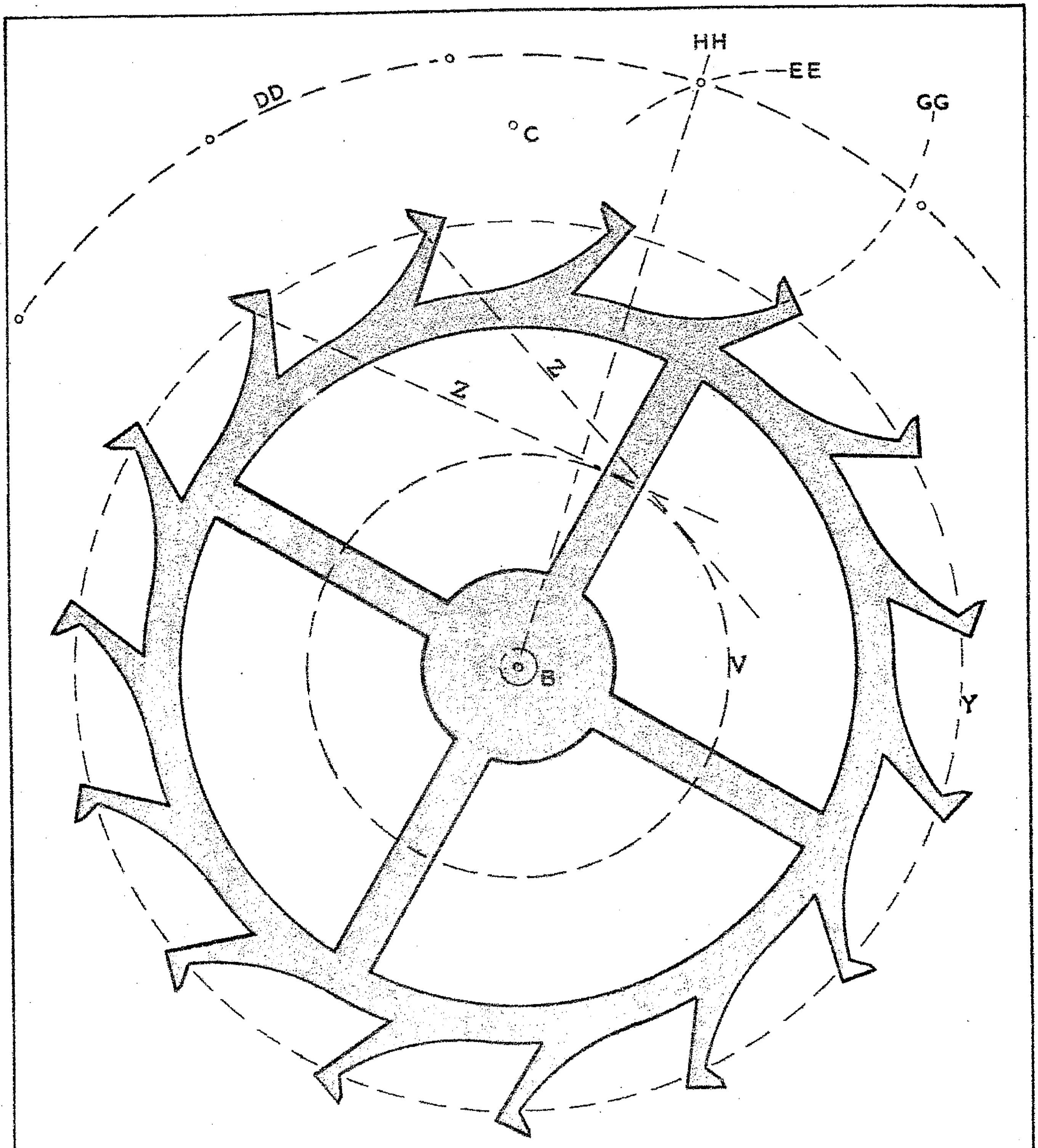


PLATE 24-19

PLATE 24-18. The angle at which the locking face of the tooth should be formed may now be determined. This angle is frequently placed at 24 degrees from a radial line to the center of the wheel but 28 degrees will be found better for the purpose, especially for an equi-distant center escapement. The reasons for this are that an unpoised fork requires increased draft for the pallet stones, and with this increased draft the locking face of the wheel tooth almost coincides with the locking face of the stone; furthermore, as the slide takes place on the discharging stone, the angle between the face decreases, with the result that when the oil becomes viscid, resistance is produced by adhesion.

On the receiving stone, the greater the slide the more the divergence, but on the discharging stone, the greater the slide the less the divergence.

With the intersection of the lines **HC** and **FB** as a center, draw line **U,** forming an angle of 28 degrees with **FB.**

This is the locking angle of the wheel tooth.

Draw circle **V** tangent to **U.** It will be a guide for forming the locking faces of the other teeth.

From the points marked **1, 2, 3,** etc. (Plate 24-15) draw lines tangent to circle **V.** These will be the locking faces of the teeth.

Draw circle **W** halfway between circles **J** and **P.**

From the points marked **T, T, T,** etc., (Plate 24-16) draw radial lines **X** to circle **W.** These form the toes of the teeth.

PLATE 24-19. From the points where these lines touch the circle **W,** draw lines in a direction that would make a tangent with circle **V,** as at **Z.** These form the under side of the club.

The next step is to form the backs of the teeth. In doing this, care should be taken that they are so shaped that when the train of the watch is reversed they will not contact the releasing corners of the pallet stones in such a manner as to wedge the guard pin against the roller.

Draw a circle **DD,** 1.3 the radius of the wheel, which will be approximately 130 mm.

Draw a circle 95% of the wheel radius, which will be 95 mm. (Circle **Y).**

With the dividers set at 50 mm, which is the difference between the radius of circle **DD** and the outside of the wheel rim, draw arc **EE** from the intersection of circle **Y** and line **Z.**

Using the same radius from the intersection of arc **EE** and circle **DD,** draw an arc **GG** from intersection of circle **Y** and line **Z** tangent to the outside of the wheel rim.

The point of tangency is located at the intersection of a line drawn from **HH** to center **B.** Draw similar arcs for the other teeth from similar points on circle **DD.** These arcs will form the backs of the teeth.

This completes the directions for drawing the escape wheel which may now be inked in as shown. Clean with art gum and print in ink your name and student number in lower right hand corner.

CHECK YOURSELF

Progress Check 24 — A Self Test Review of Lesson 24

After you have studied Sections 421 through 433, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers upside down at the end of this test. If you have any wrong answers, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or phrase in the blank spaces.	Section Ref.
1. The instrument used to measure parts of a circle or lay out angles is called a ____________________.	425
2. 1/360th of a circle is called a ________________, which is an ________________ measurement.	426
3. Lines used to lay out a mechanical drawing are called ____________________.	429
4. An escape wheel of 15 teeth has an arc of impulse of ____________ degrees, of which part is used for ____________________.	432
5. Drawing to scale means to make each part of the drawing in the same ________________ as the original being followed.	428
6. The locking face of the tooth is drawn at an angle to insure proper ____________________.	434 & Plate 24-18
7. The arc of vibration of fork and pallets is divided between lock, slide, and lift. Which one get the largest number of degrees? ____________	Plate 24-14
8. The true diameter of an escape wheel is more accurately found by means of a ____________________ than by ____________________.	Plate 24-14
9. In an escape wheel of 15 teeth, the locking corners will be __________ degrees apart.	433 & Plate 24-15
10. In drawing the escape wheel, which dimensions are optional? ____________________ ____________________	430 & Plate 24-17

ANSWERS TO PROGRESS CHECK 24:

1. protractor
2. degree
   angular
3. working lines
4. 12
   drop
5. proportion
6. draft (or draw)
7. lift
8. constant
   measurement
9. 24
10. hub
    arms
    rim of wheel
    distance between escape
    and pallet centers

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 24

Name: No.: Date:

Circle one correct answer: SUBJECT: Drawing the Lever Escapement

1. A right handed person uses the T-square with the head of the T-square against what part of the board?

   Front edge | Back edge | Right end | Left end

2. When drawing, you should slant the pencil:

   Opposite the direction you are moving your hand | In the direction you are moving your hand | Toward the T-square | Away from the T-square

3. A right angle is composed of how many degrees?

   270 | 180 | 90 | 45

4. A degree is known as what kind of measurement?

   Angular | Linear | Metric | Inch

5. If one-tenth of the circumference of a 100 mm circle equals 36 degrees, how much would one-tenth of the circumference of a 200 mm circle equal?

   144 degrees | 72 degrees | 36 degrees | 18 degrees

6. The protractor is used for:

   Drawing vertical lines in connection with the T-square | Measuring and laying out angles | Drawing circles of different sizes | Drawing curved lines

7. Any straight line having its ends in the circumference of a circle is called:

   A chord | A tangent | A radius | An arc

8. Any part of the circumference of a circle is called:

   A chord | A diameter | A curve | An arc

9. In drawing the escape wheel, we find that there are 10-1/2 degrees of active circular impulse. How is this apportioned between the pallet stone and escape wheel tooth?

   Entire impulse on stone | Entire impulse on the tooth | 6 degrees to the tooth; 4-1/2 degrees to the stone | 4-1/2 degrees to the tooth; 6 degrees to the stone

10. The true diameter of a 15 tooth escape wheel cannot be found by simply measuring with a micrometer because:

    The angle of the locking edge of the teeth makes the measurement uncertain | The micrometer must bridge two teeth, which leaves the height of arc out of the measurement | The angle of the face of the teeth prohibit accurate measurements | The teeth are too delicate to measure

11. In a 15 tooth escape wheel, how many degrees are there from the locking corner of a tooth to the locking corner of the next tooth?

    48 | 30 | 24 | 12

Detach page or cut along this line — and send to the School for grading

LESSON 25 DRAWING THE LEVER ESCAPEMENT

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by Thomas B. Sweazey

70-25 REVISED 1970 Printed in U.S.A.

INTRODUCTORY INFORMATION

You should now have a basic knowledge of the escape wheel. In this lesson you will tie this in with the pallet fork and balance wheel. While making the drawing for this lesson, it would be well to refer back to Lessons 21 and 22 for a review of the function of each part.

KEY POINTS OF LESSON ASSIGNMENTS 78 and 79:

- How to design the pallets, roller, fork horns, guard pin, banking pins, and impulse roller.

ASSIGNMENT NO. 78: Study Sections 435 through 438.

Study Questions:

1. What effect does the position of the wheel have on the circular impulse?
2. What result is desired for combined impulse and lift?
3. How is it obtained?
4. How do you measure the lifting angle of a tooth?
5. What determines the angle of locking faces?
6. What determines the form of pallet steels?

Recommended Practical Work:

Make the drawing illustrated in plates 25-1 through 25-4.

Note: Stop and check after drawing in lines 3, 4 and 5 on Plate 25-2

ASSIGNMENT NO. 79: Study Sections 439 through 442.

1. What conditions govern the proportion of roller jewel and fork slot from the line of centers?
2. What is meant by the phrase "set on the impulse"?
3. What is meant by "set on the locking"? What causes this?
4. What is a "free escapement"?
5. How far do fork horns extend on each side of the slot?
6. What is the usual radius of the safety roller?
7. Where is the guard pin located?
8. Where are banking pins located?

Recommended Practical Work:

1. Continue your drawing by laying out the fork and roller as illustrated in Plates 25-5 through 25-8. Make the following checks while so doing:

   Plate 25-6. Stop and check after drawing arc 15A.
   Plate 25-7. Stop and check after drawing arcs MM.
   Plate 25-8. Check after completing drawing.

2. Now add the four escape wheel teeth (or full wheel, if desired). Refer back to Lesson 24 for guidance.
3. Erase all unwanted pencil lines.
4. If desired, color the completed escapement as indicated in Sec. 442.

REQUIREMENT:

➧ Answer all Test Questions for Lesson 25 and send in for grading.

SUMMING UP

This completes your basic study of the lever escapement. In the next lesson, you will make practical use of the information you have gained.

SEC. 435—Drawing the Pallets

We will now proceed to draw the pallets, transferring lines as are needed in making Plate 25-1.

In order that we may keep our finished drawings of uniform size, we will show only four teeth of the escape wheel in the following drawing. Consequently, some of the working lines will be located outside of the border lines and will serve no purpose on the finished drawing. If the student desires to make a larger drawing in order to show a full escape wheel, it is permissible and desirable.

Locate Center **B** 55 mm, below the border line.

Locate Center **C** 115 mm, above **B** on center line **A.**

Transfer lines **E, F, K, O, H, L, M, N.**

Transfer circles **J** and **P.**

Transfer arcs **G** and **Q.**

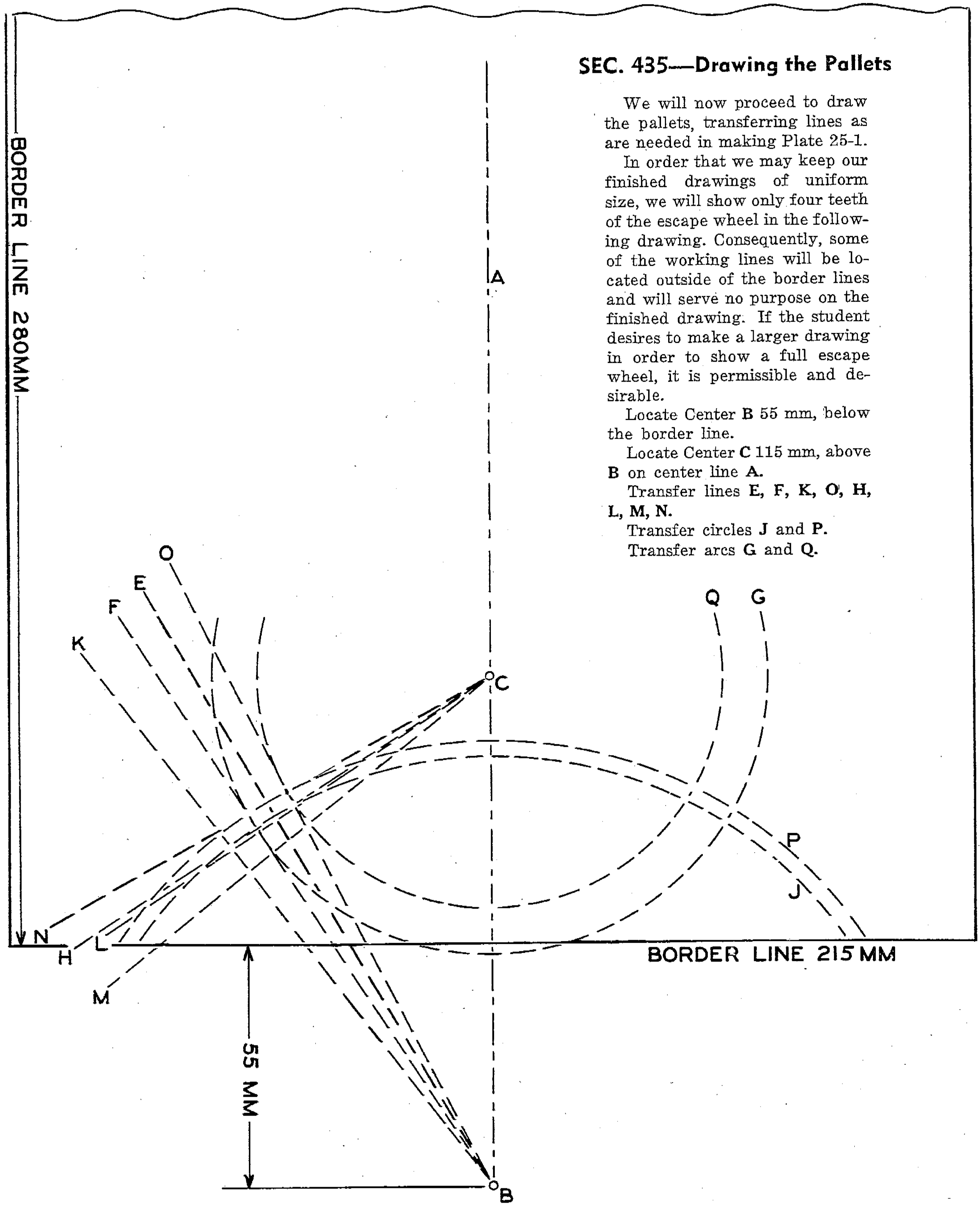


PLATE 25-1

SEC. 436—Circular Impulse and Lift

The circular impulse and lift combined must be the same on both the receiving and the discharging sides. The circular impulse of the teeth is always the same, regardless of the position of the wheel. The circular impulse of the stones and the lift of the teeth must be modified according to location. As has been stated, the lift must be the same on both sides, but the proportions between the lift of the wheel and that of the stone vary.

Extend arcs **G** and **Q.**

The points from which the circular impulse of the discharging stone is determined are the intersections of arc **Q** with circle **J** and of arc **G** with circle **P**; therefore, draw lines **1** and **2** from **B** through these points. These lines embrace an angle of 6 degrees, as do lines **F** and **O** on the receiving side, and are the circular impulses of the stone.

The lift of the tooth is determined on the discharging side from the same intersections; therefore, draw lines **3** and **4** from **C** through these points.

Compare the angle included between **H** and **N** with that between **3** and **4.**

The lift of the tooth at the discharging side is greater than at the receiving side. In order that the combined lift be alike on both sides, it follows that the lift of the stone must be less on the discharging side. At the discharging side the wheel lifts the pallets through an arc of 4½ degrees; the lifting angle of the discharging stone must be just enough to make up the difference between that amount and 8½ degrees, which is the entire lift. This amount will be 4 degrees.

From **C** draw line **5,** 4 degrees above line **4.**

Connect the two points of intersection: **Q** and **5** with **G** and **4.** This will give the impulse face of the discharging stone.

Connect the intersection of arc **G** with line **L** and arc **Q** with line **M.** This will give the impulse face of the receiving stone.

The student who desires to acquaint himself thoroughly with the principles involved in this type of escapement should carefully note the points referred to above. At the risk of repetition we will explain again.

The action of the escape wheel tooth in oscillating a pair of pallets drives them through an arc of a circle the angular extent of which is measured by radial lines from the pallet center. The angle formed by these lines is called the lift. The lift given in the drawing under consideration is 8½ degrees, exclusive of the lock —the lock being no part of the active impulse.

The lines that measure the lift of the pallets pass, one through the locking corner, the other through the releasing corner of each stone, the angles formed thereby being identical, regardless of the changing position of the pallet.

Radial lines from the pallet center also measure the lift of the wheel tooth. These lines pass, one through the locking corner, the other through the releasing corner of the wheel tooth. There is this difference, however, between the two conditions: The locking and releasing corners of the stones do not change their relation to the center from which the lift is measured, while the locking and releasing corners of the escape wheel teeth are constantly changing their relation to the center from which their lift is measured.

This being the case, the manner in which the lifting angle of a tooth is measured is to draw one line from the center of the pallets through the locking corner of an escape tooth at the point where the lift begins and another where the lift ends, the embraced angle being the lift of the wheel tooth.

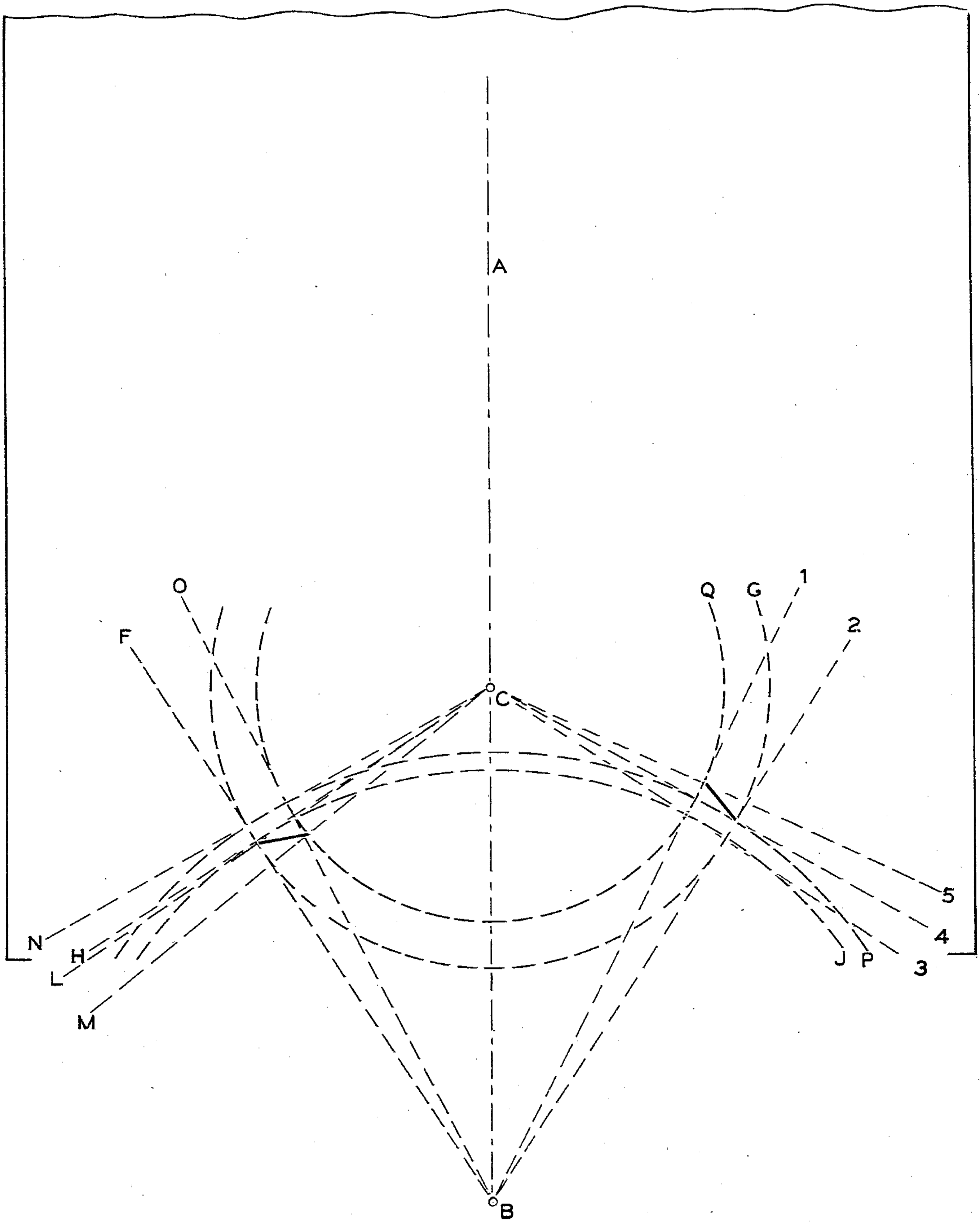


PLATE 25-2

A

SEC. 437—Angle at which Locking Faces Are Drawn

We will now determine the angle at which the locking faces of the stones should be drawn. They should be at such an inclination that the pressure of the wheel teeth will bring the fork to its bankings, holding it there until released by the action of the roller jewel. This is called the draft or draw. Its force is determined by the angle that the locking face forms with a line at right angles to a radial line from the pallet center to the locking corner of the stone. **L** is such a radial line, **6** is a line at right angle, and **7** is the line upon which the locking face of the stone should be drawn.

From the locking corner of the receiving stone draw line **6** at right angles with **L.** From the same point, draw line **7** at the right of, and **14** degrees from **6.** From the releasing corner draw line **8** parallel with **7.** This will give the form of the receiving stone.

Instead of drawing line **6** from which to take the angular measurement, it may be taken directly from line **L,** the angle being 76 degrees. The complement of an angle is the difference between that angle and **90** degrees. Now inasmuch as **6** forms an angle of 90 degrees with **L,** and we wish to draw a line 14 degrees less, if we draw it 76 degrees from **L** it will amount to the same thing.

From the locking corner of the discharging stone draw line **9** at right angles with **5.** From the same point, draw line **10** at the right of, and **14** degrees from **9.** From the releasing corner draw line **11** parallel with **10.** This will give the form of the discharging stone.

For our purpose, the length of the **R** stone measured from the locking corner will be **33** mm. The length of the **L** stone from locking corner is **34** mm.

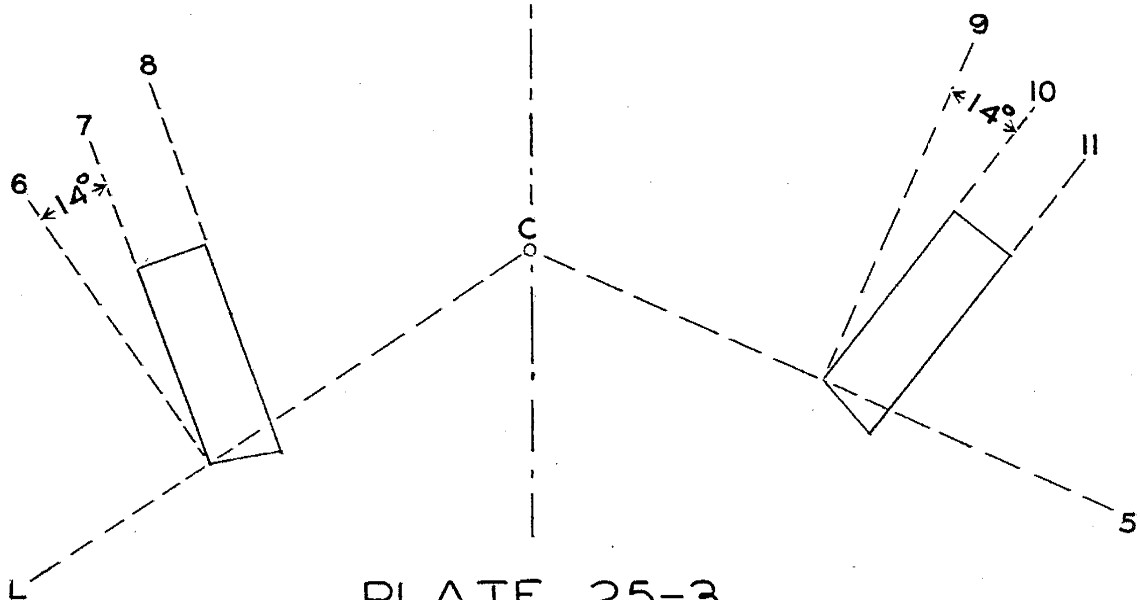


PLATE 25-3

SEC. 438—Form of Pallet Steels

The form of the pallet steels is to a large extent a matter of taste. Lightness of structure, however, is to be aimed at. Another condition that plays an important part is to have the arms of the pallets as near the wheel as possible in order that they may act, to some extent, as a counterpoise to the fork. The lower part of the fork only is represented in this drawing. It should be borne in mind that the fork as shown is at half its arc of vibration to the left of the line of centers; therefore, from the pallet center **C**, draw the line **12** at an angle of 4½ degrees from the line of centers. Draw two lines **13** and **14**, 6 mm at each side of and parallel with **12.**

The amount of steel surrounding the stones may be about 7 mm. The position of the lines forming the steels does not call for letting, but the means of locating them will be described. The arms being formed of arcs of circles, their centers must be located. For this purpose four centers, **JJ** - **MM** - **LL** - **KK** are found.

Locate center **JJ** 9.5 mm to the left of and 5.2 mm below the center **B.** Locate center **MM** 4.4 mm to the right of center **B.** Locate center **LL** 17.3 mm to the right of the center **B.** Locate center **KK** 29.2 mm to the right ofand 2 mm below the center **B.**

Arcs of 111 mm radius are drawn from **JJ** and **KK** to form the belly of the pallets. Arcs of 123 mm from **LL** and **MM** form the back of the pallet.

To form the circles that connect the pallets with the fork, two arcs of circles are drawn, each with a radius of 22 mm, from centers **NN** and **OO** and tangent to line **13** and arc **MM** and line **14** and arc **LL.** This completes the pallets.

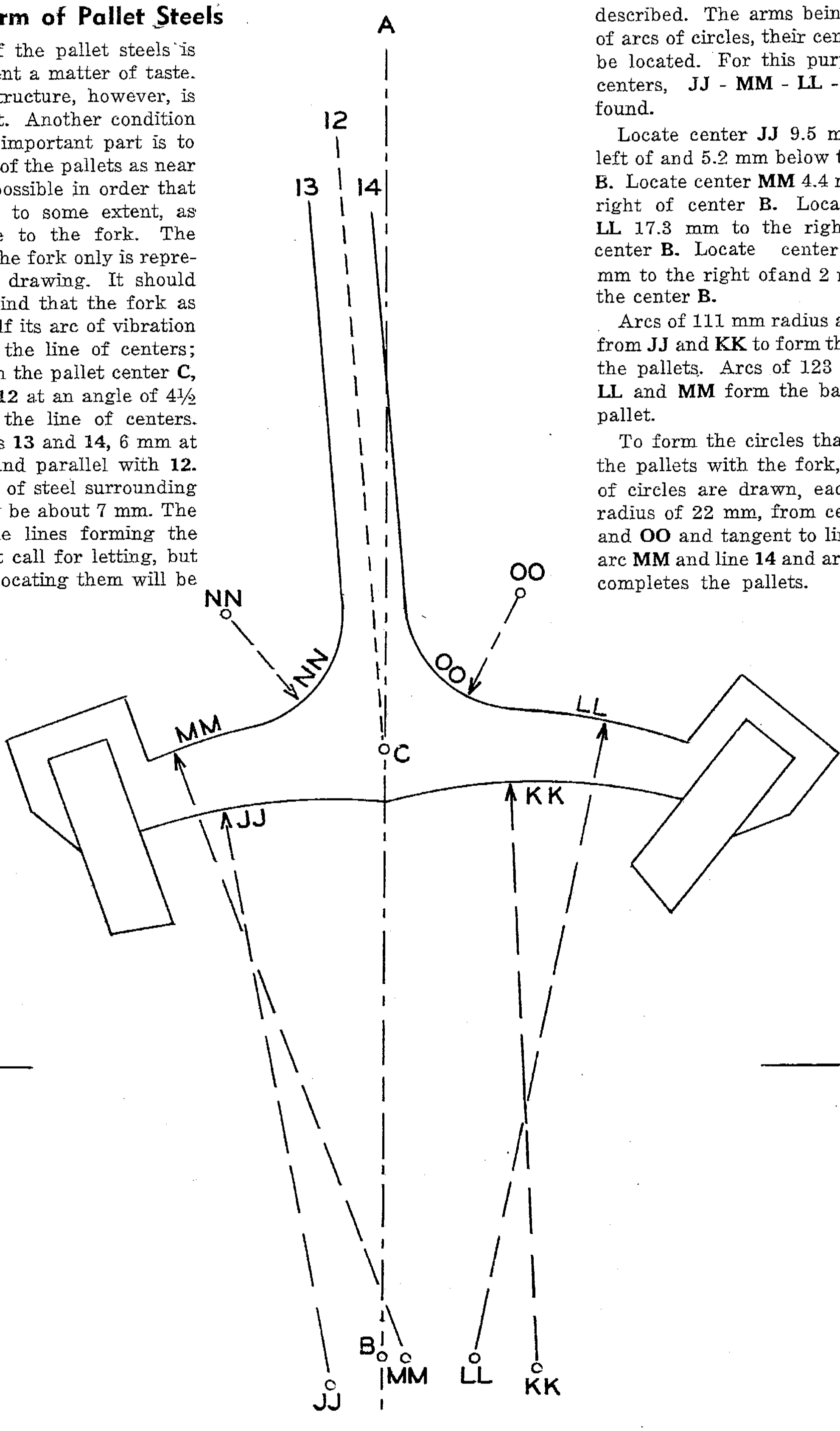


PLATE 25-4

SEC. 439—Laying Out the Fork and Roller

We will now proceed to lay out the fork and roller. Locate center **D**—170 mm above center **C** on line **A.** This will be the center of the balance and of the impulse and safety roller. With **C** as a center, extend line **12** at the left of center line **A.** The first point to be decided is the proportional distance of the roller jewel. On this will depend what is usually termed the freedom of the escapement. The proportional distances of the roller jewel and the fork slot from the centers upon which they vibrate is a highly important matter for consideration. The farther the roller jewel is from the center of the balance, the greater the force delivered by the fork, and the shorter the arc of contact; but as the force delivered by the fork to the roller jewel is increased by decreasing the length of the fork, the force delivered by the roller jewel in unlocking is decreased.

When a balance is stopped with the roller jewel on the line of centers and then released carefully, the watch should start even when the power is light—at the end of a 24 hour run. When a watch does not start under these conditions, it is said to "set on the impulse." A watch which is wound to the top but will not start when the balance is drawn to a position with the wheel tooth on the locking face, almost ready to unlock, is said to "set on the locking." This condition will be found when the fork is too short in proportion to the roller. An escapement that is free from these conditions is said to be a "free escapement." To avoid one or the other of these conditions it is necessary to have the distances properly proportioned to each other.

We will make them **3** to **1**; **3** for the fork, **1** for the roller jewel. With the dividers set at 42.5 mm, draw the arc of the circle **15** from **D** as a center. From **D** through the intersection of line **12** and arc **15,** which is the center of the roller jewel, draw line **16.** For the size of the roller jewel divide the total center distance 285 mm by **21,** which will give 13.6 mm. This is the diameter of the roller jewel. Setting the dividers at 7 mm, draw the circle **17** from the intersection of line **16** and arc **15.** This will be the roller jewel. The face of the roller jewel should now be drawn as follows: With the dividers set at 44.5 mm from center **D** draw the arc **18.** This arc will give the face of the roller jewel. Theoretically, the face of the roller jewel should be the arc of this circle instead of being flat, as is often seen. Draw the lines **19** and **20** parallel to **12** and tangent to circle **17.** These will give the sides of the fork slot. For the bottom of the fork slot draw the line **21,** 10 mm from the center of the roller jewel and at right angles to lines **19** and **20.**

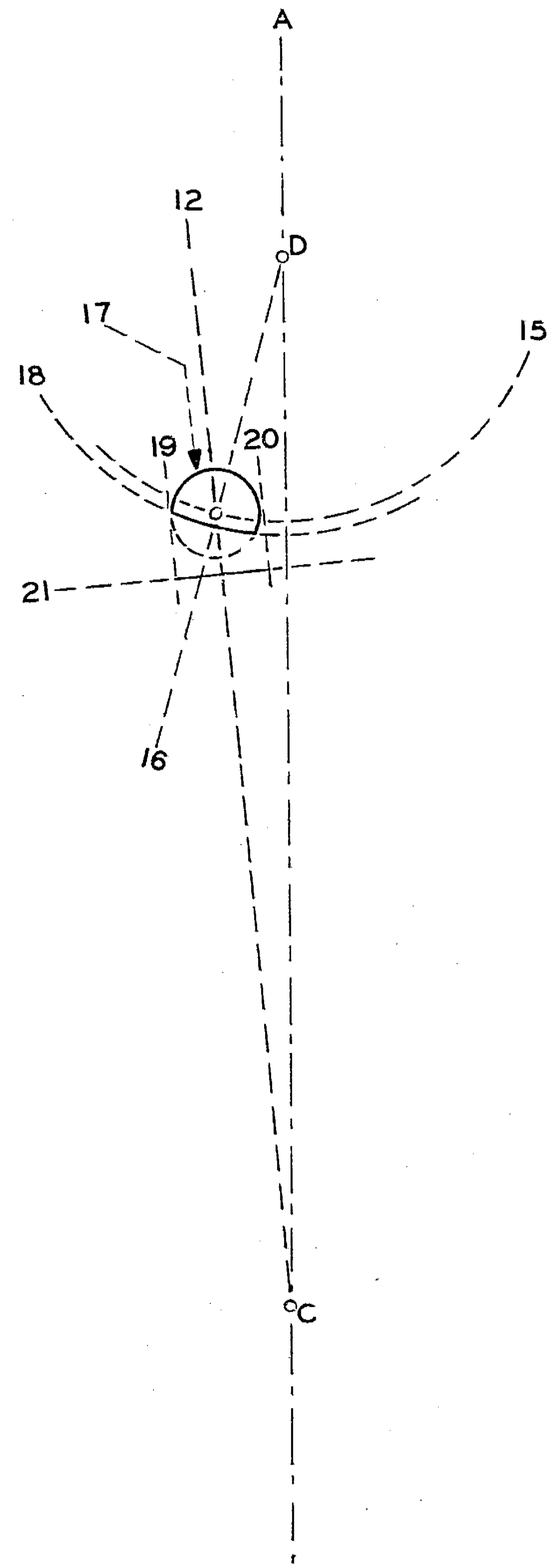


PLATE 25-5

SEC. 440—Fork Horns

The fork horns should extend at each side of the slot to a distance at least equalling its width. Setting the dividers at 22.5 mm, draw two short arcs, **22** and **23,** from the intersection of line **12** with arc **18.** The inside curves of the fork horn will end at these arcs.

The curves of the fork horns should be arcs of circles of the same radius, but not from the same center. In the position in which the fork is shown, the arc which forms the left horn is drawn from the roller center **D** and corresponds with arc **18.** To find the center for the curve of the right horn draw arc **24** from **C** as a center and through **D.** On this arc, to the left of its intersection with **12,** mark point **LL** at a distance equal to that from the intersection to **D.** From **LL** using the radius of arc **18,** draw an arc from Line **20** to arc **23.** This will be the right fork horn. From **LL** using the radius of arc **15,** draw arc **15A,** which will be used to locate center **MM** on plate 25-7.

The radius of the safety roller is usually two-thirds the distance from the roller center to the roller jewel center. With the dividers set at 28 mm, draw the circle **25.** This will be the safety roller.

The passing hollow may be of generous dimensions for the reason that the fork horns when made as directed provide additional safety against the fork going out of action. With the dividers set at 10.5 mm, draw arc **26** from a center at the intersection of line **16** with circle **25.** This will be the passing hollow.

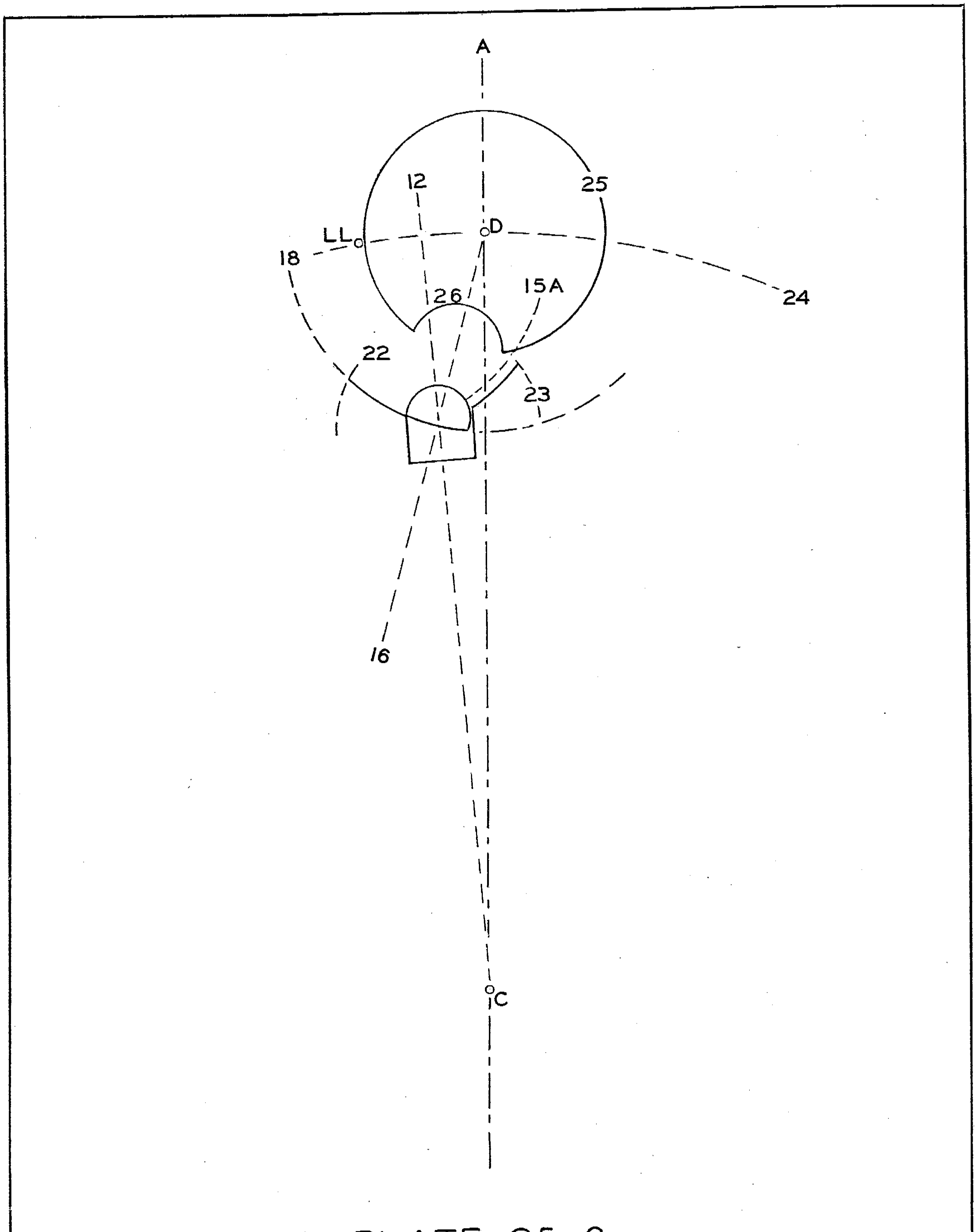


PLATE 25-6

SEC. 441—Guard Pin

The guard pin—sometimes called the dart—should be drawn with its point at the intersection of line **12** with circle 25. From this point draw lines **27** at each side of and 25 degrees from the line **12**. These will form the point of the guard pin. At each side of and parallel to the line **12** draw the lines **28**. These lines may be half the diameter of the roller jewel apart. They will form the sides of the guard pin.

The form of the fork is largely a matter of taste, lightness being a desirable feature.

Setting the dividers at 15 mm, mark the point **MM** on the arc **15** from center of roller jewel. Mark a similar point **MM** on arc **15A** to the right. From these points, with the dividers set at 7 mm, draw arcs of circles to form the ends of the horns as shown. These arcs are not lettered, but the student will have no difficulty in distinguishing them. From **C**, with the dividers set at 125 mm, draw the arc **29.** From the intersection of this arc with **12,** with the dividers set at 41 mm, mark the points **NN.** These points are the centers from which to draw arcs tangent to those forming the ends of the horns, thus forming the sides. With dividers set at 121 mm, from **C** locate center on line **12.** Draw arc from this center from sides of the horn to sides of fork (lines **13** & **14**). This completes the fork.

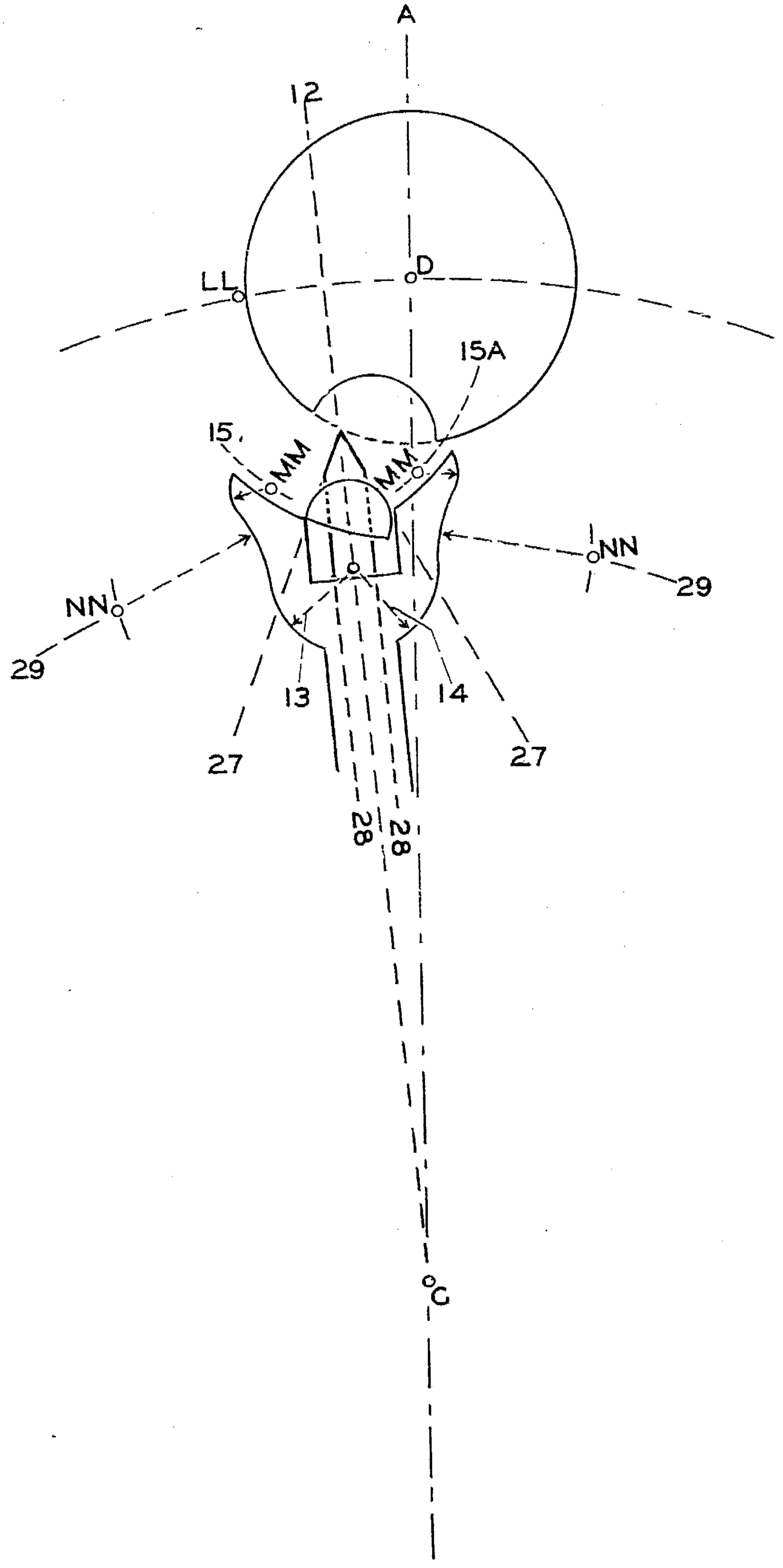


PLATE 25-7

SEC. 442—Banking Pins

The location of the banking pins, so far as their distance from the pallet center is concerned, is a matter of no vital importance. The best position would be the points which would arrest the fork by contacting it at its center of percussion. It is rarely, however, that circumstances will permit this. We shall locate them in about the usual place. With the dividers set at 95 mm, from **C** draw the arc **30.** Set the dividers at 20 mm, and mark the points **00** from the intersection of the arc **30** with the line of centers **A.** These will be the centers of the bankings. In drawing the bankings, it should be borne in mind that the pallets as shown are at the locking point, the slide not having taken place; consequently, the fork should not be represented in contact with a banking; therefore, draw them as shown leaving a space between.

The piece which carried the impulse roller jewel pin is generally made in the form of a disc and is called the impulse roller. Setting the dividers at 52 mm from the center **D,** draw the circle **31** to form the impulse roller. This will complete the entire escapement.

If the student has used a sharp, hard pencil for the working lines and drawn them lightly, they may now be erased. In case it is desired to keep the drawing for use as a reference, the working lines may be drawn in red.

Plate 25-9 shows the escapement divested of the working lines. Coloring the drawing will greatly improve the appearance. For this purpose colored pencils or crayons are most suitable. Color the pallet stones and roller jewel red. Color the roller tables blue, using two shades—light blue for the impulse roller and a little darker blue for the safety roller. Color the banking pins and escape wheel yellow. This completes the drawing.

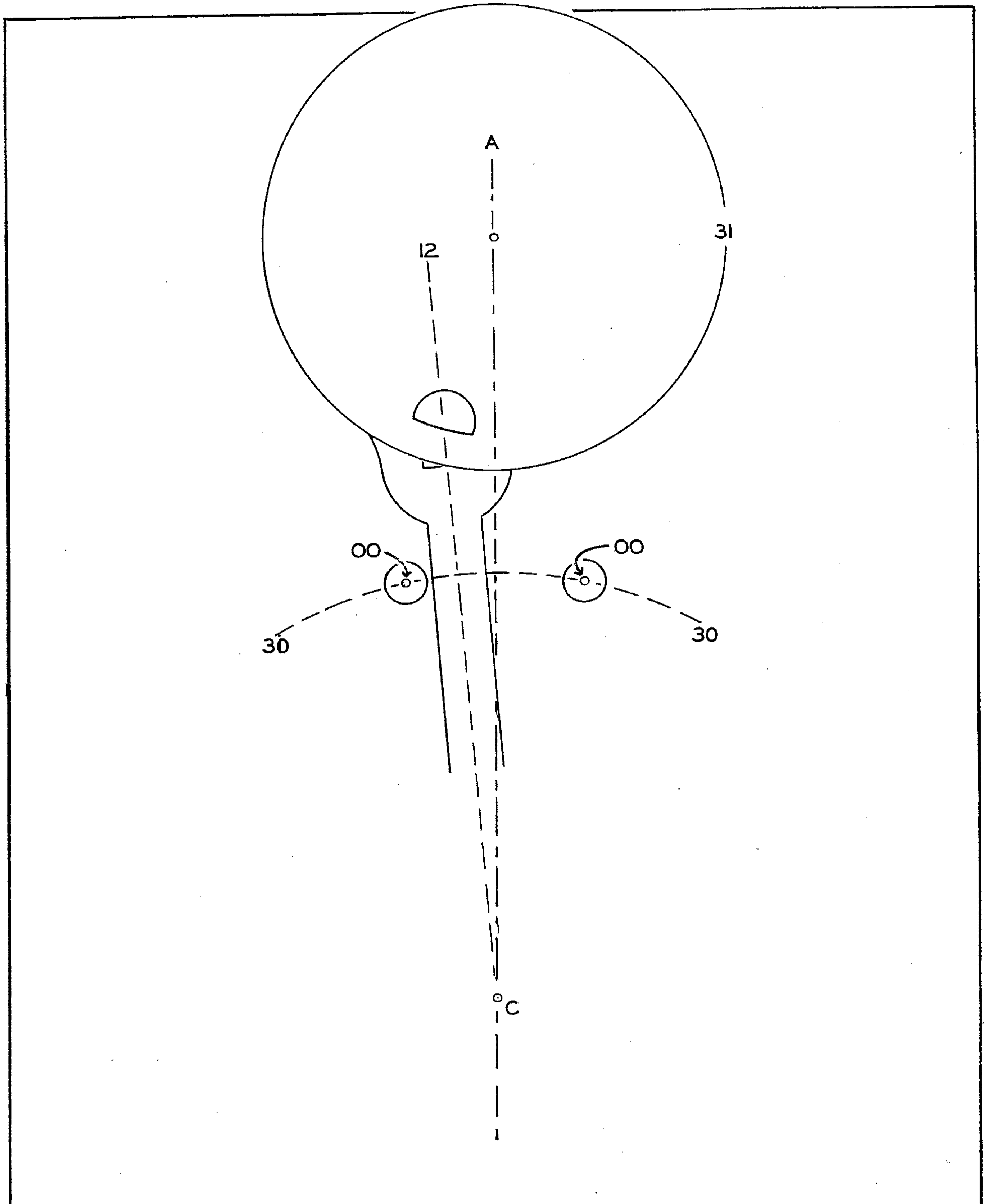


PLATE 25-8

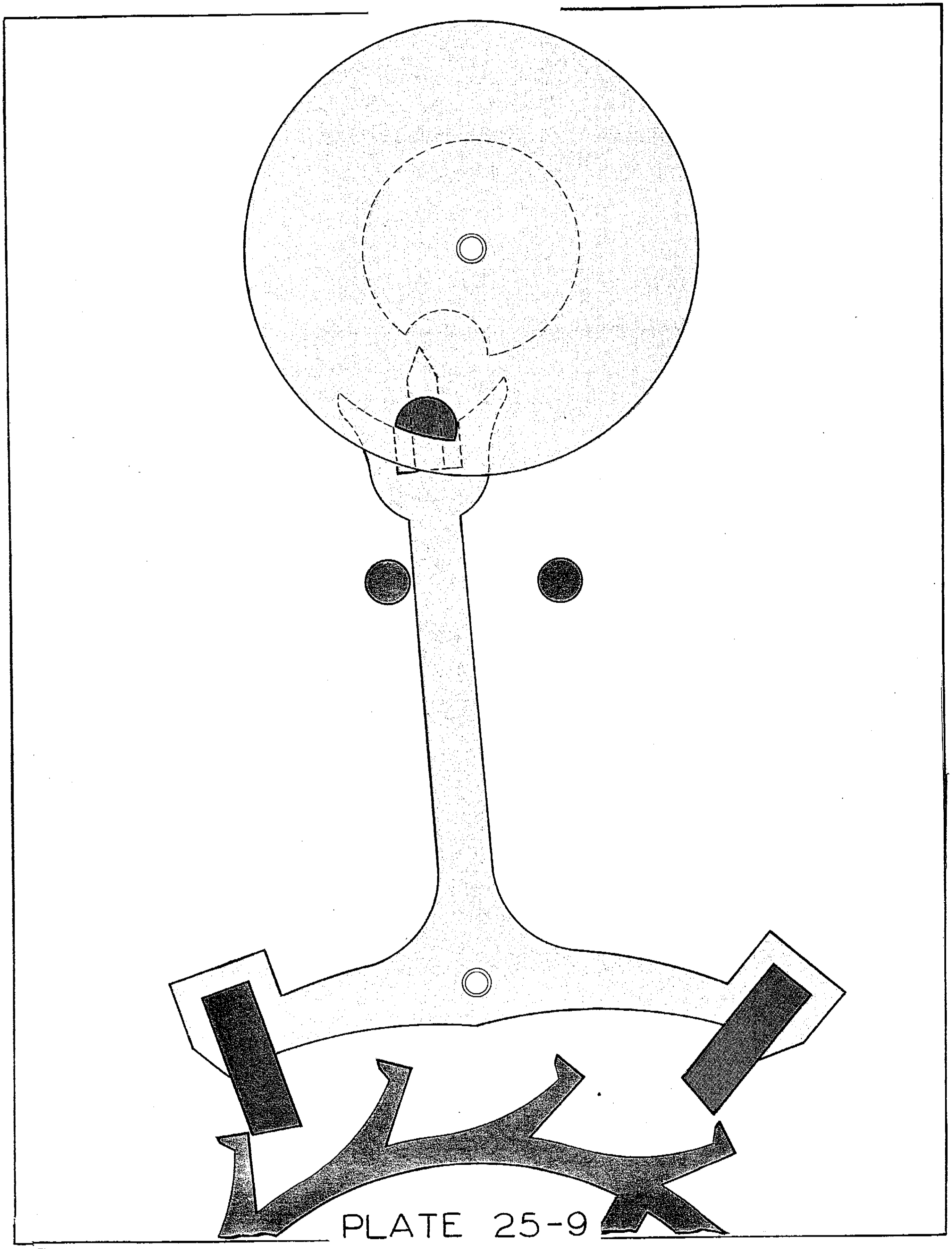


PLATE 25-9

CHECK YOURSELF

Progress Check 25 | A Self Test Review of Lesson 25

After you have studied Sections 435 through 442, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of this test. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. To make the circular impulse and lift equal on both the receiving and discharging sides, it is necessary to make the lift of the stone ________ on the discharging side because the lift of the tooth is ________ than on the receiving side.	436
2. The angle of the locking faces of the stones must provide for ________.	437
3. The main consideration in establishing the form of pallet steels is ________.	438
4. Moving the roller jewel farther from the center of balance ________ the force delivered by the fork, ________ the arc of contact and ________ the force delivered by the roller jewel in unlocking.	439
5. "Set on the impulse" is most likely to occur in a watch which is ________ wound while "set on the locking" occurs in a watch which is ________ wound.	439
6. The minimum distance for the fork horns on each side of the slot is equal to the ________ of the ________.	440
7. 2/3 the distance from the roller center to the roller jewel center is usually allowed for the radius of the ________.	440
8. Since the fork horns provide additional safety against the fork going out of action, the dimensions of the ________ can be generous.	440
9. The guard pin is ________ in the fork slot and is about ________ the width of the roller jewel.	441
10. The term "center of percussion" has to do with location of the ________, but rarely applies in reality.	442

ANSWERS TO PROGRESS CHECK 25:

1. less
greater
2. draw (or draft)
3. lightness
4. increases
shortens
lessens
5. lightly
5. (continued) fully
6. width
slot
7. safety roller
8. passing hollow
9. centered
half
10. banking pins

Cut along this line and use this sheet if you have questions on the course.

CHICAGO SCHOOL OF WATCHMAKING 310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Student Consultation Sheet

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Date ______________ Student No. ______________

Lesson No. ________

Name ______________________________

Address ______________________________

City State Zip Code ______________________________

Please check ( ) if you have CHANGED YOUR ADDRESS.

ASK YOUR QUESTIONS HERE...	WE'LL ANSWER HERE...
	INSTRUCTOR: Return an unused sheet with each used one.

(If necessary, use other side.)

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 25

Name: No.: Date:

Circle one correct answer:

SUBJECT: Drawing the Lever Escapement

1. The circular impulse and lift combined must be:

   - More on receiving side than on discharging side
   - More on discharging side than on receiving side
   - Same on both receiving and discharging side
   - All on the receiving side

2. The action of the escape wheel tooth in oscillating a pair of pallets drives them through an arc of a circle. The angular extent of this arc, measured in degrees from the pallet center, is:

   - 4 degrees
   - 4-1/2 degrees
   - 8-1/2 degrees
   - 12 degrees

3. The pallet steels are usually formed in such a manner as to arrive at:

   - A specified weight
   - Lightness
   - Beauty
   - Strength

4. Another condition that plays an important part is to:

   - Have pallet steels thinner than fork
   - Have corners of steel rounded
   - Have fork tapering toward slot
   - Have arms of pallets as near to wheel as possible

5. The farther the roller jewel is from the center of the balance:

   - The greater the force delivered by the fork
   - The less the force delivered by the fork
   - The greater the arc of contact with the fork
   - The greater the force delivered by the roller jewel in unlocking

6. At the end of a 24 hour run, the balance of a watch is stopped with the roller jewel on the line of centers. When released carefully, if the watch does not start, it is said to:

   - Set on the locking
   - Set on the impulse
   - Have too much lock
   - Have too much draw

7. A watch which is wound to the top, but will not start when balance is drawn to a position which puts wheel tooth on locking face, is said to:

   - Set on the impulse
   - Set on the locking
   - Have too much lock
   - Have too much drop

8. An escapement that is free from the conditions noted in the correct answers of questions 6 and 7 is said to be:

   - A correct escapement
   - A good escapement
   - A free escapement
   - A light escapement

9. How far should the fork horns extend at each side of the slot?

   - At least the depth of slot
   - At least half the width of impulse roller
   - At least the width of roller jewel
   - At least the width of the slot

10. Theoretically, the face of the roller jewel should be:

    - An arc drawn from opposite edge of roller
    - An arc drawn from the center of roller
    - An arc drawn from half the distance from center of roller to center of roller jewel
    - Flat

11. The radius of the safety roller is usually what proportion of the distance from the roller center?

    - 2/3
    - 1/3
    - 3/4
    - 1/4

12. Although circumstances will rarely permit, the best location of the banking pins, so far as their distance from the pallet center, would be to have them contact the fork:

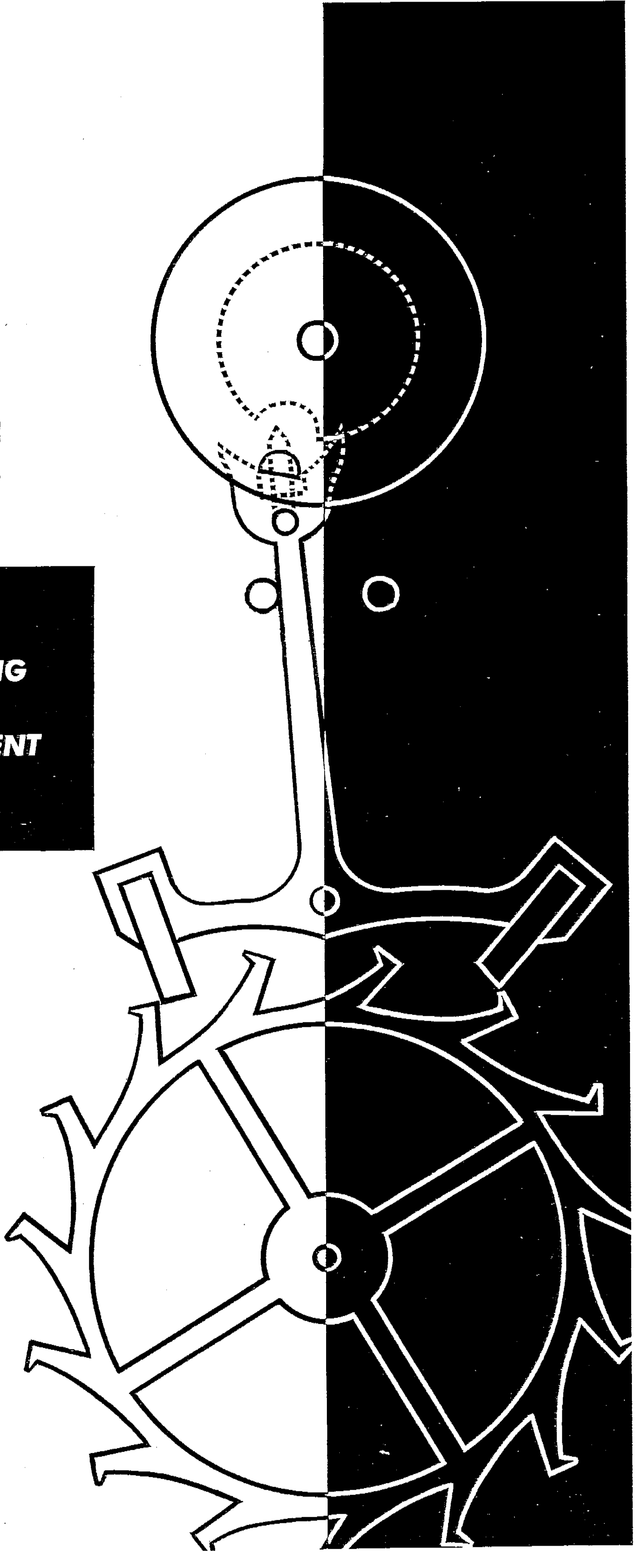
    - Near the pallets
    - Near its middle
    - 3/4 the distance from horns to pallets
    - At the center of percussion

Detach page or cut along this line — and send to the School for grading

Master WATCHMAKING

LESSON 26

MATCHING THE ESCAPEMENT



CHICAGO SCHOOL OF WATCHMAKING
Founded 1908 by THOMAS B. SWEAZEY

Printed in the United States of America

KEY POINTS OF LESSON ASSIGNMENTS 80, 81:

- Why pallet stones become loose.
- Checks to make before setting pallet jewels or stones.
- How to match an escapement with movable bankings.
- How to use a pallet warmer.
- How to set pallet stones.
- How to adjust the safety action.
- How to replace the guard pin in a single roller escapement.
- How to replace the guard dart in a double roller escapement.
- How to match an escapement with immovable bankings.
- Checking the guard action.
- How to put a watch in beat.

ASSIGNMENT NO. 80: Study Sections 445 through 454.

Study Questions:

1. What are some causes for loose pallet stones?
2. What should you check on the movement before setting pallet stones?
3. How do you match an escapement with movable bankings?
4. How do you use a pallet warmer?
5. What is the correct way to pick up a pallet stone?
6. Is the lifting angle the same on all pallet stones?
7. How should you set a pallet stone?
8. In testing for lock and draw, after setting stones, should the power be on or down?
9. What must be done each time you move a pallet stone?
10. How do you adjust the safety action?
11. How do you replace a guard pin in a single roller escapement?
12. How do you replace a guard dart in a double roller escapement?
13. What is the "boss"? (See plate 26-22.)
14. What kind of watches use immovable bankings?
15. How does the procedure differ in matching an escapement with immovable bankings from that used in matching an excapement with movable bankings?

Recommended Practice:

Match an escapement in a watch with movable bankings. This training is to acquaint you with all of the adjustments and checks normally required in escapement repair. In actual practice, you do only as much of this as is necessary to get the escapement working properly. In this exercise, be sure you have each step right before going ahead as each step depends on the one before it.

1. Remove balance from movement and remove hairspring. (Section 352, Lesson 15.)
2. Remove pallet bridge and fork.

ASSIGNMENT NO. 80 (Continued):

3. Remove pallet stones. To remove them, place pallet fork on pallet warmer as in Figure 26-5. Heat one side of the pallet warmer at a time until cement is softened. Then, with a piece of pegwood sharpened to a blunt point, push out pallet stone from the back as shown by center arrow, Figure 26-6.
4. Remove guard dart or guard pin. (Section 451 or 452.)
5. Remove roller jewel by reversing the procedure given in Section 323, Lesson 13.

NOTE: After removal, pallet stones and roller jewels will still be covered with some of the shellac that held them in place. This old shellac should be removed before the jewels are reset. This is done by boiling them in alcohol. Proceed as follows:

Fill a boiling bottle about half full of alcohol and place the jewels in the bottle. Replace the cap, which should have a hole in it to allow the fumes to escape. Place the bottle in a boiling cup about one-fourth full of water. This is done because ALCOHOL IS HIGHLY INFLAMMABLE and cannot be heated directly over an open flame. Heat the cup over an alcohol lamp until the alcohol in the bottle starts to boil. KEEP FLAME AWAY FROM THE FUMES AS THEY TOO ARE VERY INFLAMMABLE. Let the alcohol boil until the old shellac is dissolved from the parts. Do not boil alcohol entirely away or it will leave a residue on the jewels which is very difficult to remove.

6. Prepare roller for setting roller jewel. (See Section 321, Lesson 13.) Be sure roller and jewel are absolutely clean. Replace roller jewel with a new one if the original is damaged or is not the correct size. (Section 320, Lesson 13.)
7. Set roller jewel. (Section 323, Lesson 13.) Be sure it is set straight. (Section 324, Lesson 13)
8. Bank the escapement to the drop; that is, close the banking pins so that the roller jewel will just pass through the slot in the fork with a minimum of working clearance. (Section 447.) The banking pins should remain in this position until after the stones have been set and adjusted, and the guard pin is replaced and adjusted.
9. Set and adjust the pallet stones as outlined in Sections 448 and 449. After the stones are set correctly, clean off any excess cement with the tool illustrated in Figure 13-20, Lesson 13.
10. Replace the guard dart or guard pin. (Sections 451 or 452.) Make the necessary adjustments so the guard pin will pass through the passing crescent of the guard roller, allowing the roller to turn freely without side shake between the guard dart and roller on either side.
11. Open the banking pins to allow the correct amount of slide. (Sec. 450)
12. Check the guard action. (Section 454)
13. Replace hairspring. Select hole in die plate of staking tool to accommodate the lower portion of balance staff. (Figures 15-16 or 15-17, depending upon whether a single or combination roller is used.) Using one or the other of these set-ups, lift the flat face hollow punch and place collet over the collet shoulder. Press collet in place with the punch. (A bench block may be used in place of a staking tool, and the collet pressed in place with tweezers.)

ASSIGNMENT NO. 81: Study Section 455.

Recommended Practice:

Put in beat the watch used for Assignment 80.

NOTE: As mentioned in the text, a watch is theoretically in beat when the center of the roller jewel is in line with the center of the pallet arbor and the center of the balance staff. In checking the beat, a minimum amount of power is all that is necessary. We suggest winding the watch one or two clicks of the ratchet wheel. Look through the peep holes in the pillar plate and see how far the tooth of the escape wheel has moved up the impulse face of the stone. Has it gone half way? Three fourths? It should also move the same distance up the face of the other stone. If it does not, adjust the collet so that the teeth will move equally up the impulse face of each stone. (Figures 26-28 and 26-30, Section 455.)

The bench work of Assignments 80 and 81 can also be done on a watch with immovable bankings, which are much more common now. In using this type of watch, keep in mind the slight variation in procedure given in Section 453.

Repeat the work of these two assignments at least twice more on the same or different movements. Then concentrate on removing and replacing pallet stones without removing guard pin or guard dart or roller jewel.

REQUIREMENT:

➧ Complete the Test Questions for Lesson 26 and return for grading.

SUMMING UP

In these escapement lessons we have gone into great detail to enable you to understand the escapement and to know as many as possible of the conditions which may exist. Much of this is theory, however, and is not used in actual practice. The Job Guides for this lesson cover the corrections most frequently needed.

At this time you should have a thorough understanding of what lock is. You should be aware that lock is not the same in every watch, but varies with the manufacturer and the quality and size of the movement. Beginners are frequently confused by varying recommendations as to the most desirable amount of lock. These range from 1/10 to 1/5 of the width of the pallet stone (one to two degrees). Since either of these or anywhere in between will give satisfactory results, there is no need for concern. It is the safety action which really sets the amount of lock to be used. Too little lock will "trip" while too strong a lock increases friction and contributes to a poor motion of the balance. Wrist watches generally need a little deeper lock than pocket watches. In every case, the lock should be equal on both stones or the escapement will be out of angle.

SUMMING UP (Continued)

Adjustments in the lock are made by moving the pallet stones in or out. As you know, these changes also affect other elements of the escapement action. It is not likely you can learn these changes by simply reading about them. You must actually try them out, moving first one stone, then the other, and finally both stones. See what happens each time. This will quickly give you a practical working knowledge. As this will probably be the most frequent adjustment you will make, you should know it thoroughly.

You should know the relationship of draw (draft) and slide. Draw is caused by the force of the escape wheel tooth acting against the pallet stone. The amount of draw is determined by the angle of the locking face of the pallet stone and the slant of the tooth of the escape wheel. The result of draw is to hold the lever against the banking pin. Slide is caused by draw. The amount of slide is controlled by the position of the banking pins; that is, how much they are opened in watches with movable bankings, or their placement in watches with immovable bankings. The amount of slide is measured by the distance the fork moves from the instant of lock until the fork is stopped by the bankings.

Slide, then, can be changed only by moving the bankings, whereas draw is altered by moving stones in or out.

In modern watches, the manufacturer has taken care of the draw by cutting the fork slots at the proper angle. Thus, in practice, it is seldom necessary to adjust stones for draw alone. If stones are properly set for lock and slide, the draw will generally take care of itself. The apparent lack of draw which some watches show is nearly always due to other faults -- bent or dirty pivots on the pallet arbor, rough wheel teeth, and so on. If the movement is properly prepared as in Section 446 and the stones are set in place where they belong, you should have little trouble with draw.

Much of what has been said for draw applies to drop as well. (Drop, you know, is the distance the escape wheel travels free of contact from the time one tooth disengages until the next tooth is arrested and locked.) The manufacturers have allowed for drop and setting the stones for proper lock and slide will normally reestablish the proper drop.

In short, you can be confident of being able to deal with escapements if you:

Understand lock.

Recognize when slide is present or absent.

Learn the technique of moving pallet stones and what happens when you do so.

Recognize when the fork or guard dart rubs the roller or the roller jewel lacks clearance in the fork curve or slot.

Understand these few fundamentals and you'll know what you are looking for in checking an escapement. You'll also know what adjustments to make -- if any. In truth, escapement adjustments in the average shop are few and far between.

SEC. 445—Reasons for Loose Pallet Stones

You have completed an elementary treatise on the purpose, function, and theory of the lever escapement as applied to the vast majority of pocket and wrist watches in use today. Many books have been written about the lever escapement and although they are comprehensive and theoretically correct, it is practically impossible for the student to ascertain if the escapement in the average watch is good or bad. Right now you can assume they are all good. The escapement holds a horror for many so-called watchmakers because they do not understand it. In the average shop there is so little actual escapement work that one man could do all of it in a few hours out of each month. When a watch leaves the factory we must believe that the escapement is properly matched and satisfactory for that type and grade or it should not pass inspection. After the watch leaves the factory there is not much possibility of the escapement getting out of order except through improper handling. In most cases, a pallet stone becomes loose because the watch repair man has left the pallet fork in the cleaning or rinsing solution too long, or in replacing the fork in the movement, he did not place the stones between the teeth of the escape wheel. It is now time to put to practical use the knowledge gained from the preceding lessons on theory and drafting. Follow each step carefully and if it becomes confusing, start over.

SEC. 446—Checking The Movement

Before attempting to set the pallet jewels, a thorough check of the watch should be made as follows:

1. Check balance and cap jewels. They should be clean and freshly oiled in order that the balance may oscillate freely.
2. The pivots on the balance must be straight, polished and free from dust.
3. The staff must be riveted securely to the balance.
4. The roller table must be tight on the staff and the edge smooth and polished.
5. The roller jewel must be clean and set securely in the roller.
6. The train must be free.
7. The pivots on the pallet arbors must be straight and clean, and the jewels clean.

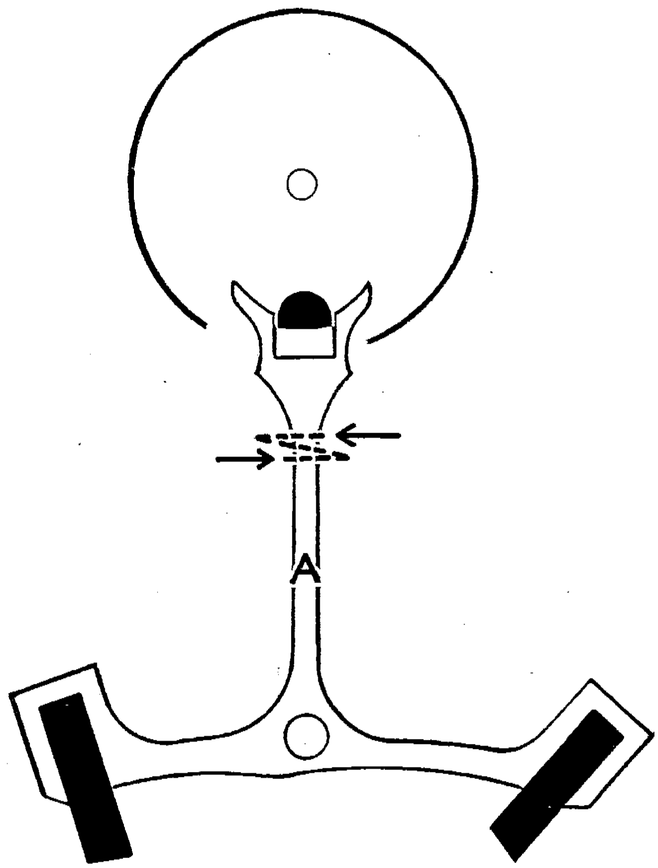


Fig. 26-1

SEC. 447—Matching an Escapement with Movable Bankings

In matching an escapement with movable banking pins, plan each step before making any alterations or moving the pallet stones.

1. Check the roller jewel for freedom in the fork slot. (Reference: Sec. 320, Lesson 13).
2. To check the freedom of the roller jewel in the fork slot with the balance in place, proceed as follows:

A. Let down the power.

B. Turn balance until the roller jewel is in line with the slot in the fork, figure 26-1.

C. Hold balance in this position with thumb or forefinger and grasp fork at **A** with pair of fine tweezers.

D. Carefully move back and forth in direction shown by arrows.

E. If roller jewel is of the correct width, you can "feel" this freedom.

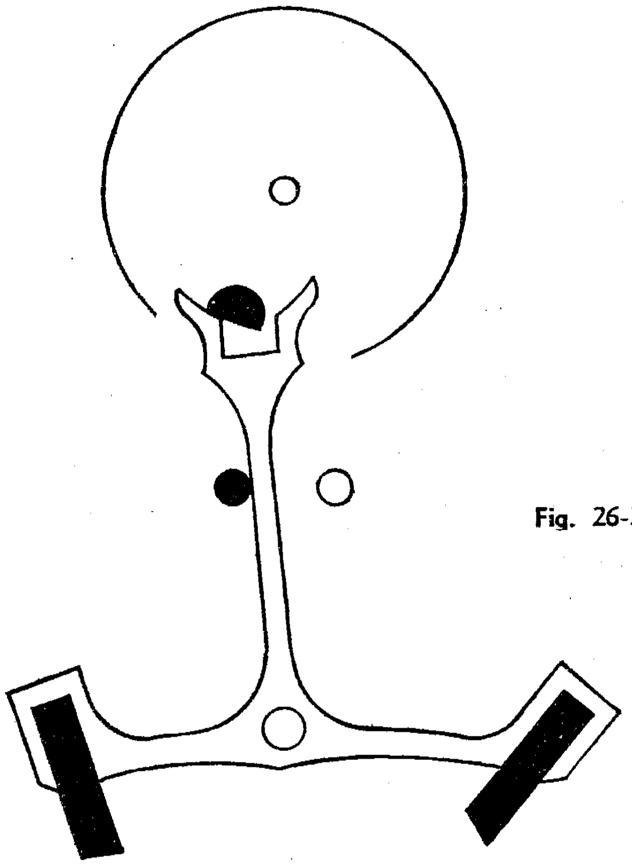


Fig. 26-2

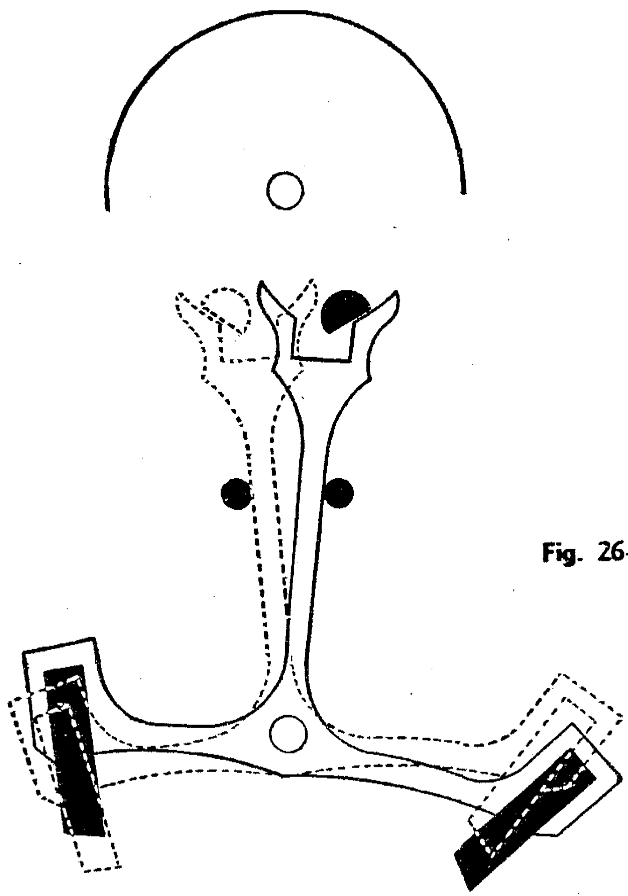


Fig. 26-3

3. Turn in one banking pin until the roller jewel will just pass through the horn of the fork and the corner of the fork slot, figure 26-2.

4. Turn in the opposite banking pin until the roller jewel will just pass by the opposite corner of the fork, figure 26-3.

The banking pins are left in this position until the stones have been set properly for lock, drop and draw and the safety action is found to be correct. Matching the escapement or making any safety action tests with the banking pins in this position is known as **banked to the drop.** When you are satisfied that the fork and roller action are correct, you may proceed to set the pallet stones.

SEC. 448—The Pallet Warmer

Setting a pallet stone is similar to setting a roller jewel—with the exception of the tool used to heat the shellac. Figure 26-4 shows a common type of pallet warmer. The pallet fork

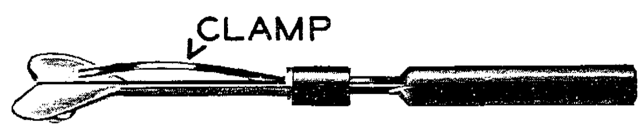


Fig. 26-4

is placed on the pallet warmer bottom side up with the upper pivot in the slot in the plate and then clamped in place. The cement is always placed on the under side of the pallet stones. The pallet stones are set flush with the top of the pallet fork and, in some cases, the lower side of the pallet stone will protrude a little on the underside. In case of a loose pallet stone, it is often possible to warm the pallet fork until the cement just melts in which case the pallet stone will again be set securely in place. However, it is best to remove the pallet stone and clean it. Place the stone between two pieces of pithwood which have been moistened with alcohol and rub the sides and face of the pallet stone until clean. Clean the slots in the pallet fork with pegwood and alcohol. In case there is an excess of cement on either the stone or the fork, use the tool described in Lesson 13, figure 13-20, to chip off the excess cement before cleaning.

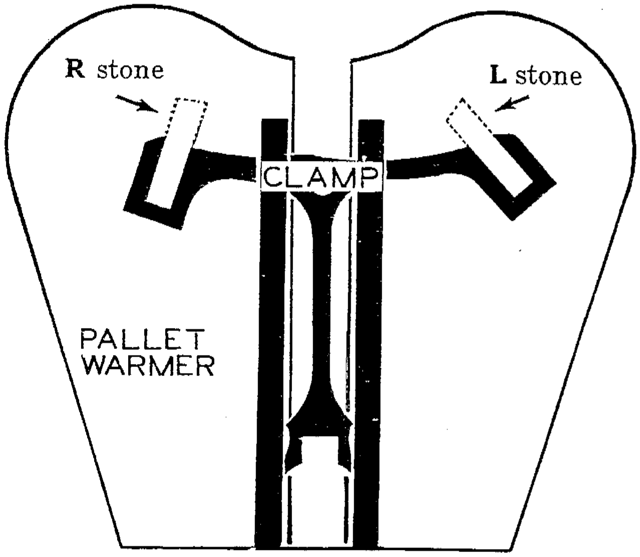


Fig. 26-5

SEC. 449—Setting the Stone

In setting pallet stones, be very careful as the stones are easily chipped or lost. Do not attempt to pick up a pallet stone except by the sides and then toward the back of the stone so that you will not injure the face or locking corner of the pallet stone. Figure 26-5 shows a diagram of the pallet fork clamped upside down on a pallet warmer. The dotted lines illustrate the correct position of the pallet stones with regard to the angles on the lifting faces. The pallet stone with the greater lifting angle is the **L** stone and the one with the lesser angle is the **R** stone.

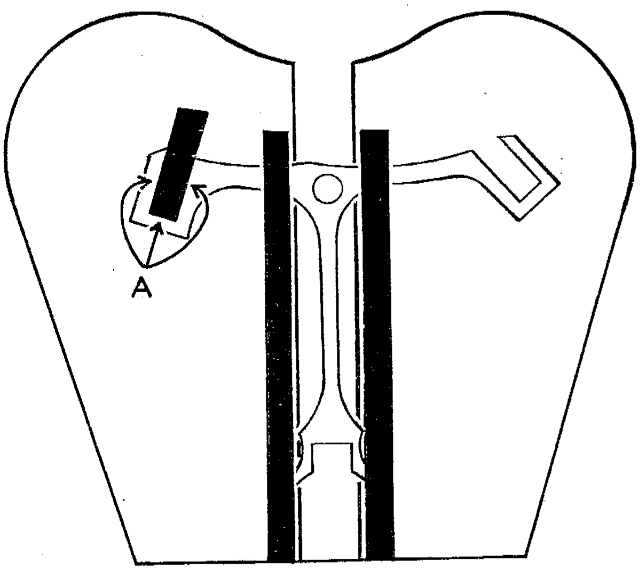


Fig. 26-6

Start with the **R** stone. After placing stone in position, push it to the bottom of the slot, figure 26-6. Use pegwood when moving a pallet stone. If the watch is one of excellent manufacture and has had careful handling, it is very possible that when the stone is pushed into the back of the slot, the amount of lock will be correct. Do not take this for granted, however. Warm slowly with alcohol lamp, heating one stone at a time. The pallet warmer is made so that one stone can be heated without danger of heating the other. Use shellac which has previously been drawn threadlike (Lesson 13, figure 13-21) and place on both sides and back of stone where it joins the pallet fork, arrows **A,** figure 26-6. Let cool before attempting to remove pallet from pallet warmer and remove any excess cement with the tool in figure 13-19, Lesson 13. Clean the lifting face and sides of the pallet stone with pithwood wet with alcohol. Now set **L** stone in place exactly the same as the **R** stone and as far back in the slot as possible, figure 26-7.

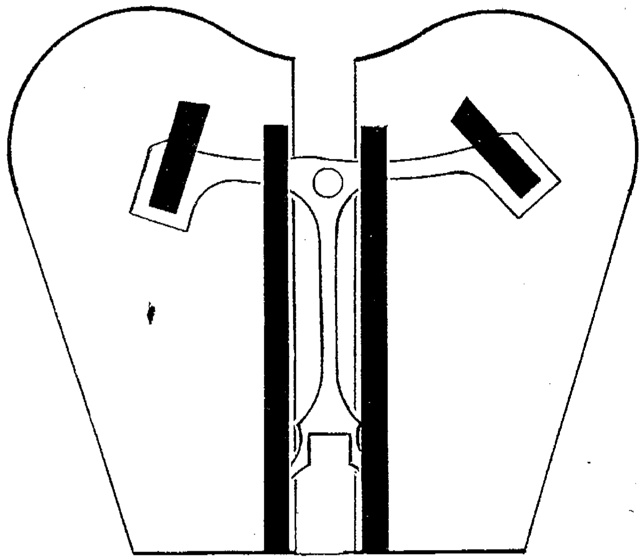


Fig. 26-7

Testing for lock and draw is always done with the power on. It is not necessary to wind the watch fully. The stones are adjusted until there is the correct amount of lock and drop. The fork should be arrested by the banking pin at the instant the drop takes place. When this occurs on the **R** stone and then the **L** stone, the escapement is banked to the drop. Each time it becomes necessary to move a pallet stone, the fork must be removed from the movement and reheated on the pallet warmer. Be careful not

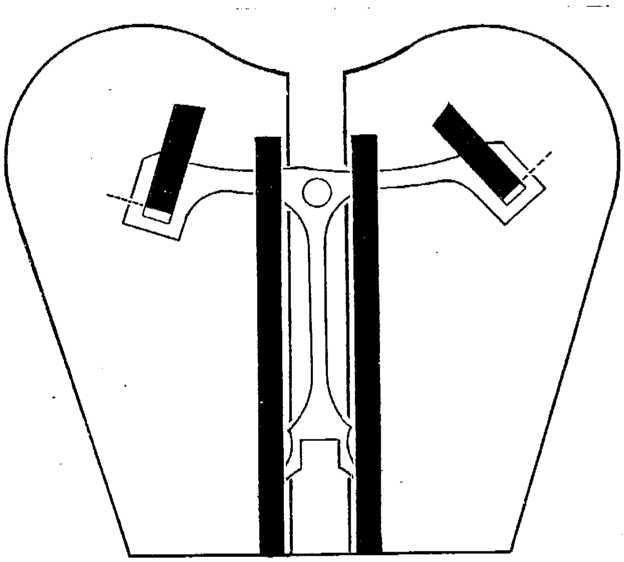


Fig. 26-8

to overheat or burn the shellac. If this should occur, it will be necessary to remove the stone and clean both it and the slot in the fork before applying new cement. Use pegwood when moving a pallet stone forward or backward. The distance you wish to move the stone can be carefully judged by the distance between the back of the pallet stone and the bottom of the slot, figure 26-8.

Figure 26-9 illustrates an **R** stone with too much lock. Moving the **R** stone in the direction of arrow **A** will decrease the amount of lock on the **R** stone but it will also decrease the lock on the **L** stone. Therefore, it would be necessary to move the **R** stone in and the **L** stone out until both locks are equal. This also holds true when there is too much lock on the **L** stone and not enough lock on the **R** stone.

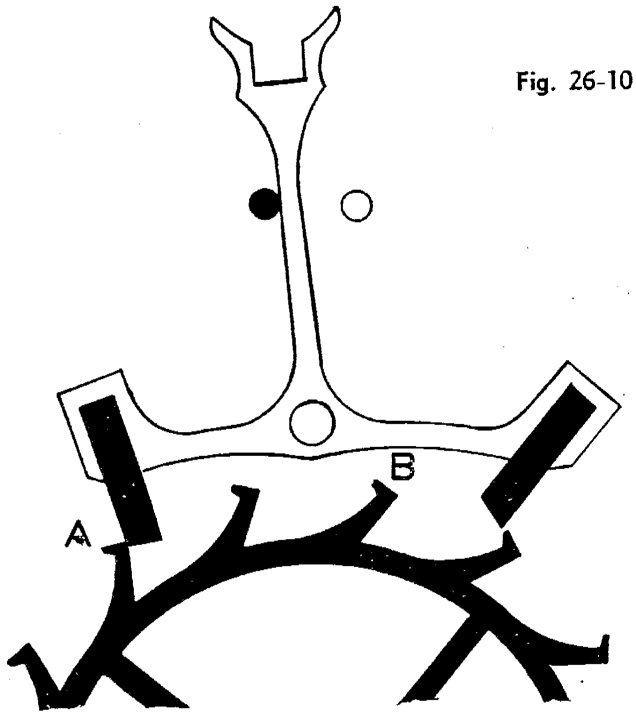


Fig. 26-10

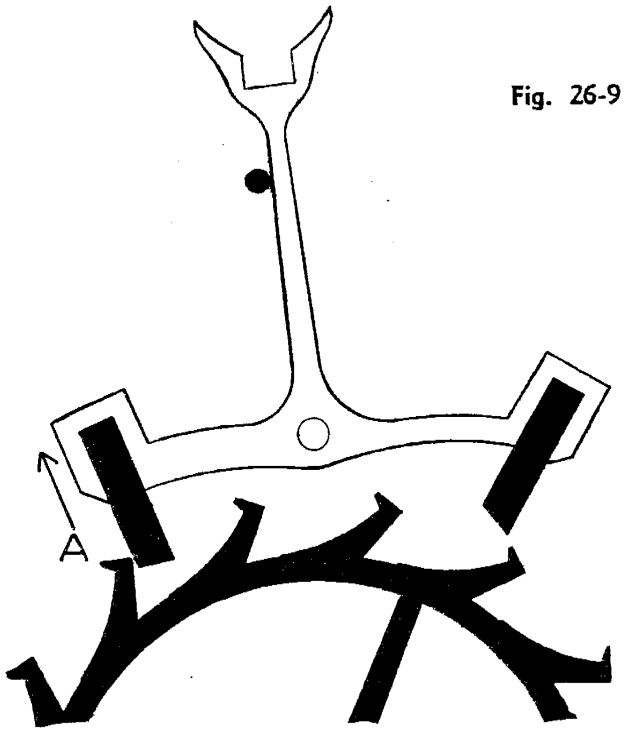


Fig. 26-9

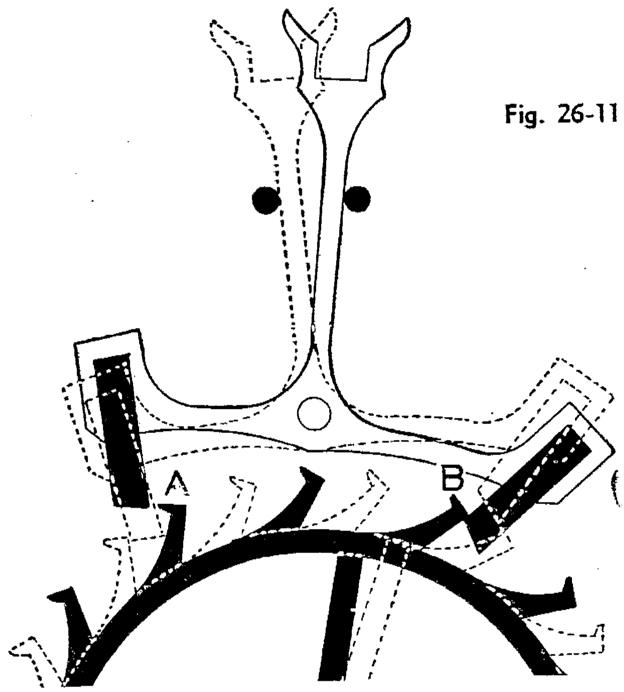


Fig. 26-11

Figure 26-10 illustrates the correct amount of lock on the **R** stone at the moment of drop. As the escape wheel tooth "lets off" from the **L** stone, the fork is against the banking pin and the **R** stone intercepts the escape wheel tooth **A.** When the fork is moved away from the banking pin far enough to allow the **R** stone to unlock, the escape wheel tooth **A** passes across the lifting face of the **R** stone and when the tooth has completed the lift, the fork will be against the opposite banking pin at the instant the escape wheel tooth **B** is arrested by the **L** stone, figure 26-11. The escapement is now banked to the drop. This can be seen readily by placing the escape wheel and fork in these positions and moving back and forth.

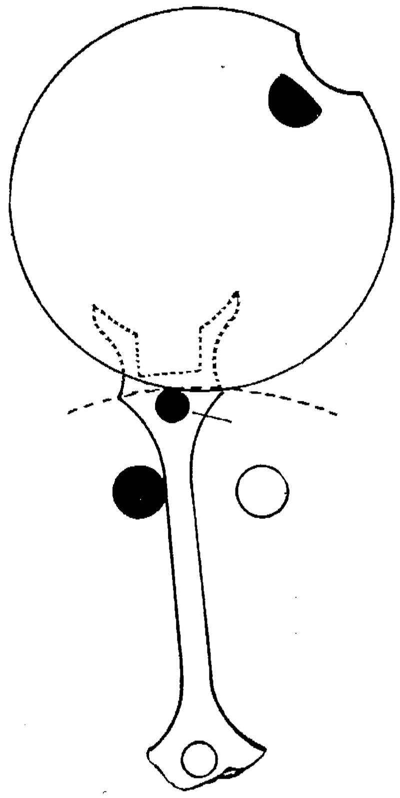


Fig. 26-12

SEC. 450—The Safety Action

When you have banked your escapement to the drop, adjust the safety action. Figure 26-12 illustrates the guard pin in a single roller escapement set as close as possible to the edge of the roller when the fork is against the banking pin. Test the safety action on both sides.

Figure 26-13 illustrates the guard dart set properly in the double roller escapement. Test action on both sides.

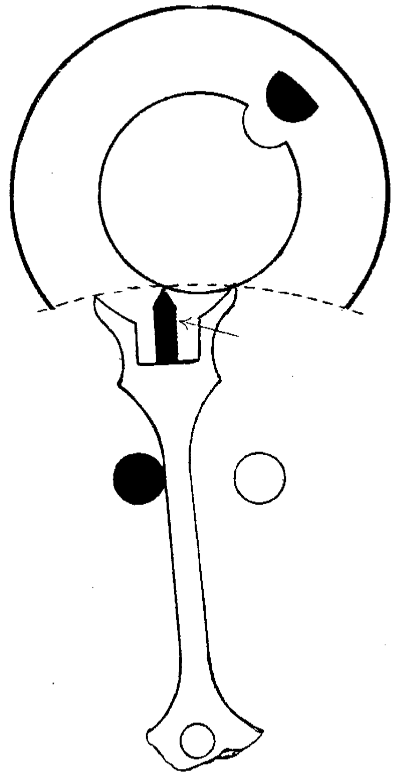


Fig. 26-13

Now open each banking pin slightly. This will allow the escape wheel tooth to slide on the face of the pallet stone, figure 26-14. The dotted lines illustrate the **R** stone after slide has taken place. Now the roller jewel will enter the horn in the fork without danger of it rubbing on the horn. There will be a small amount of clearance between the guard pin and the roller.

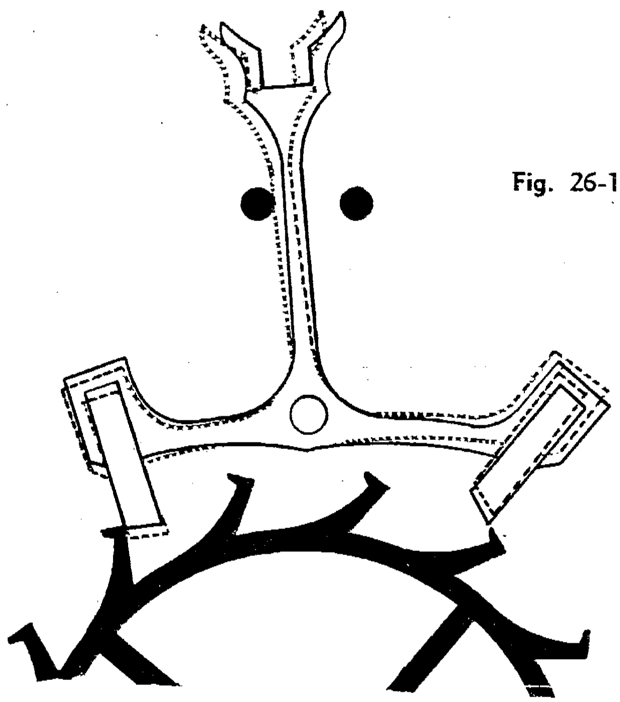


Fig. 26-14

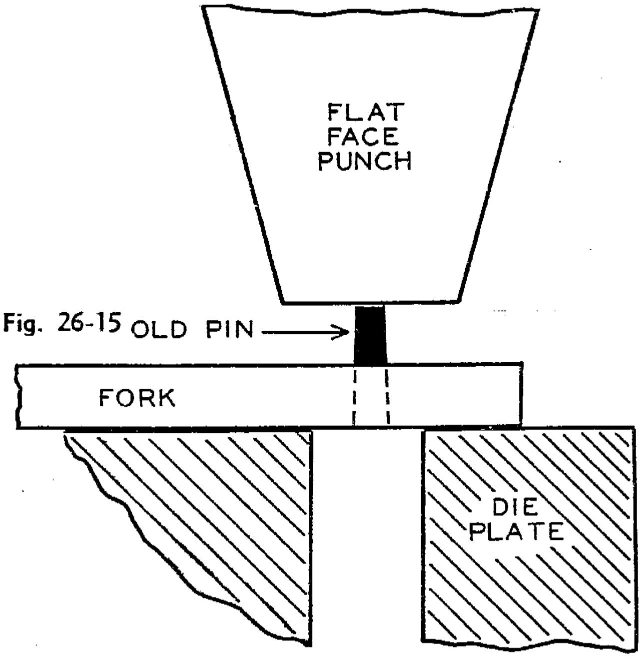


Fig. 26-15

SEC. 451—Replacing Guard Pin in a Single Roller Escapement

The old guard pin is usually inserted from the bottom. It can be removed by placing pallet fork over a hole in the bench block and pressing out with a flat face staking punch, figure 26-15. If the guard pin bends, cut it off about .5 mm above the fork and stone the end flat with a hard arkansas slip before attempting to push it out, figure 26-15. If the guard pin was put in from the top, turn the fork over and push out with a small pointed punch or needle.

It is desirable at times to have small punches such as the punch used for forcing out the guard pin. Such punches are not manufactured. Figure 26-16 illustrates a method whereby any number of small, specially shaped punches can be made from tempered steel wire and held in a hollow staking punch. **A,** figure 26-16, represents a cross section of a round face hollow punch. **B** represents a length of blued steel wire shaped in the form of a sub-punch and placed in the staking punch. It should fit as closely as possible without binding. Notice that the punch **B** rests at the bottom of the hole in the staking punch and extends beyond the face just enough to serve the purpose for which it is intended.

Replace the guard pin as follows:

1. Remove old guard pin.
2. Select a brass stud pin that will enter hole as in figure 26-17. If student desires to make a tapered brass pin, refer to Sec. 386, Lesson No. 19, figure 19-13.

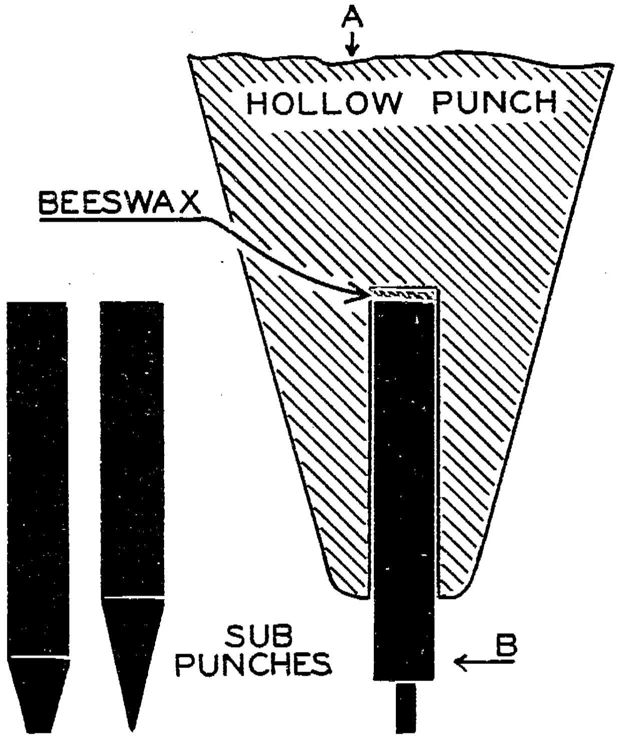


Fig. 26-16

3. Insert from the under side and press in until pin comes to a stop.
4. Cut off a little longer as illustrated and stone the end flat.
5. Press in until pin is flush with bottom of fork, figure 26-18.
6. Cut pin slightly longer than the top edge of roller table, figure 26-19, and stone flat with arkansas slip.
7. Adjust guard pin.

SEC. 452—Replacing Guard Dart in Double Roller Escapement

Replacing the guard dart in a double roller escapement is not a difficult job but great care must be used when removing an old dart. The dart in a double roller escapement is usually put in from the front. Consequently, if the guard dart in a double roller should become loose, it would seem to be too long. Replacing a guard dart of this type allows the thicker portion of the pin to form the safety action with the safety roller.

It is usually an easy matter to force out the old pin with a pair of heavy tweezers. Figure 26-20 illustrates the method used when a small section of the guard pin extends through the hole in the "boss."

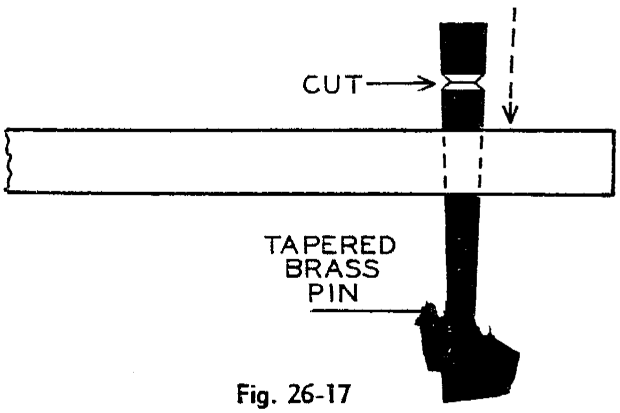


Fig. 26-17

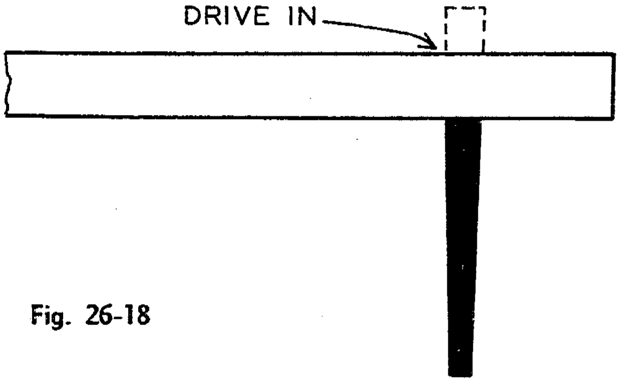


Fig. 26-18

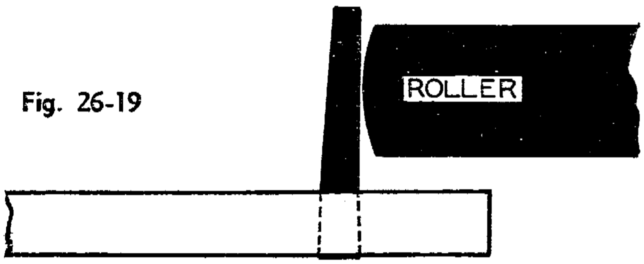


Fig. 26-19

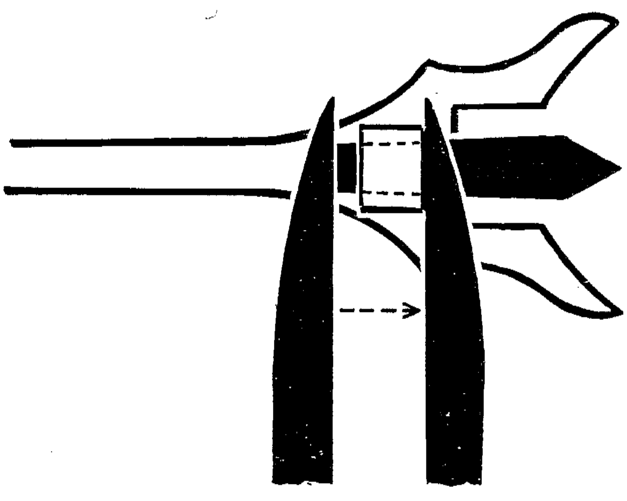


Fig. 26-20

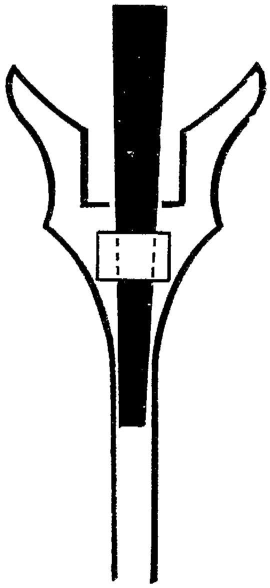


Fig. 26-21

In some forks the pin will be cut off flush with the "boss." Place the fork over a staking tool stump and force out the old pin with a sharp pointed punch or needle.

In replacing the guard dart, use a brass stud or taper pin and insert from the front, figure 26-21. Hold the fork with a heavy tweezer, the points of which can be rested on an anvil and tap in gently with the back of another pair of tweezers, figure 26-22. The pin must have very little taper in order to hold securely.

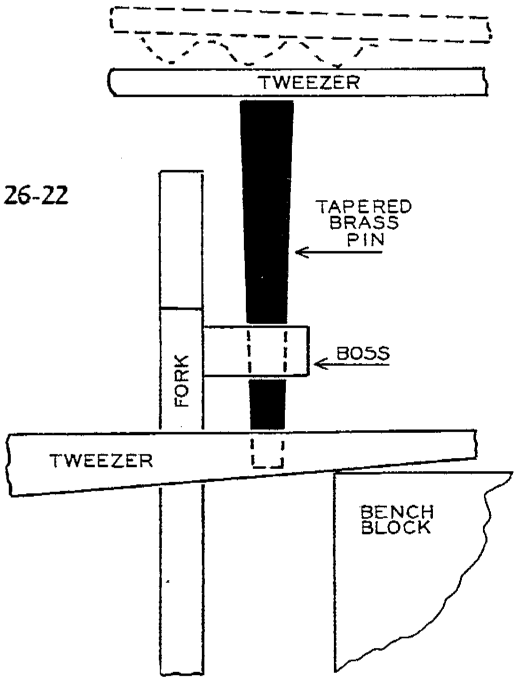


Fig. 26-22

Cut off pin a little longer than necessary with a pair of hairspring nippers and shape as in figure 26-23. This can be accomplished with a hard arkansas stone or needle file. In using either of these, place a piece of scotch tape over the side of stone or needle which comes in contact with the underside of the fork. This will prevent cutting or marring the under side of the fork. Cut each side a little at a time until shaped properly.

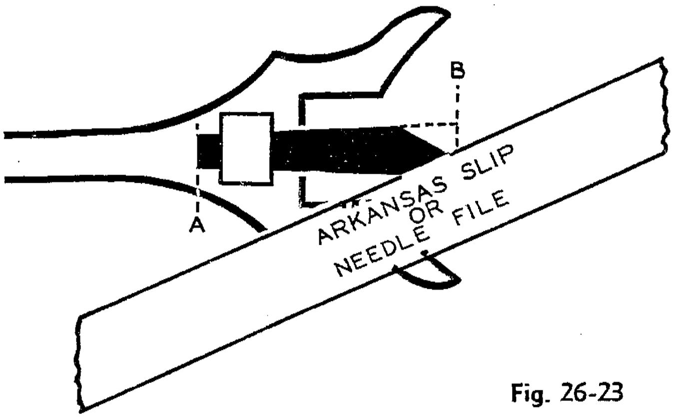


Fig. 26-23

SEC. 453—Matching an Escapement with Immovable Bankings

Most Swiss watches use the permanent type of banking pins. In the better grades the bankings are often milled out of the plate. In the common type of Swiss watches, the bankings are considered immovable and are merely pins driven through a hole in the plate. It is possible but seldom necessary to bend them slightly as these pins were adjusted properly at the factory.

The procedure used to match this type of an escapement is identical with the procedure described for typical American watches with movable bankings except that you must allow for slide at the time you make each test of fork and roller action and lock and drop.

Use the same procedure as described in Sec. 447:

1. Test roller jewel in fork slot.
2. Test fork and roller action as in figure 26-2 by placing the face of the roller jewel opposite the corner of the fork slot. In figure 26-2, the roller jewel has only enough freedom to pass the corner of the fork slot. Figure 26-24 shows the space between the roller jewel and the corner of the slot when the bankings are immovable. This space is determined by the amount of slide allowed which is the difference between the position of the permanent banking **B** and the position of the banking when banked to the drop and illustrated by dotted circle **C.**
3. Proceed to set pallet stones in the same

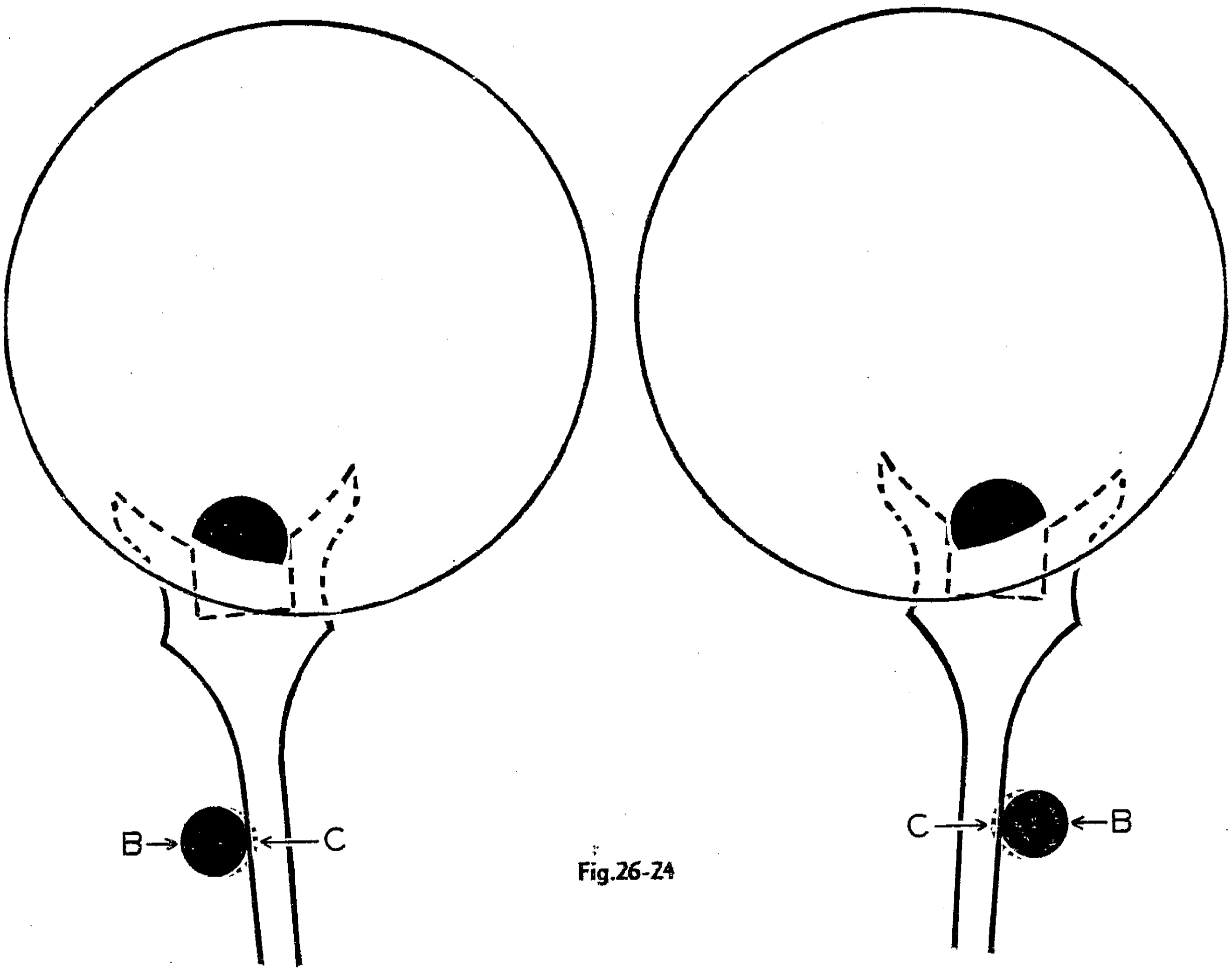


Fig.26-24

manner as described in Sec. 449. At this time remember that the lock is exactly the same as described in this section, and illustrated in figure 26-25. The fork is illustrated to show the locking corner of the escape wheel tooth locked on the locking corner of the pallet stone at the moment of drop. Notice, however, that this fork is **not** against the banking pin. The space between the fork and the banking pin is the amount left for slide. This space must be equal on both sides and the student must be certain that he has the proper amount of lock **before** the fork rests against the banking pin.

One of the most successful methods of holding the fork stationary at this instant is to insert a small piece of pithwood under the fork as shown in figure 26-26. It is very easy to observe the amount of lock and drop on each stone and the distance the fork is from the banking pin. After you are certain the stones are set correctly, remove pithwood and test the draw.

SEC. 454—Checking the Guard Action.

The guard action is tested next and this test is illustrated in figure 26-27. Notice that the guard dart is arrested by the safety roller when the fork is moved away from the banking but the escape wheel tooth is still **locked** on the corner of the receiving stone.

This then insures perfect safety action.

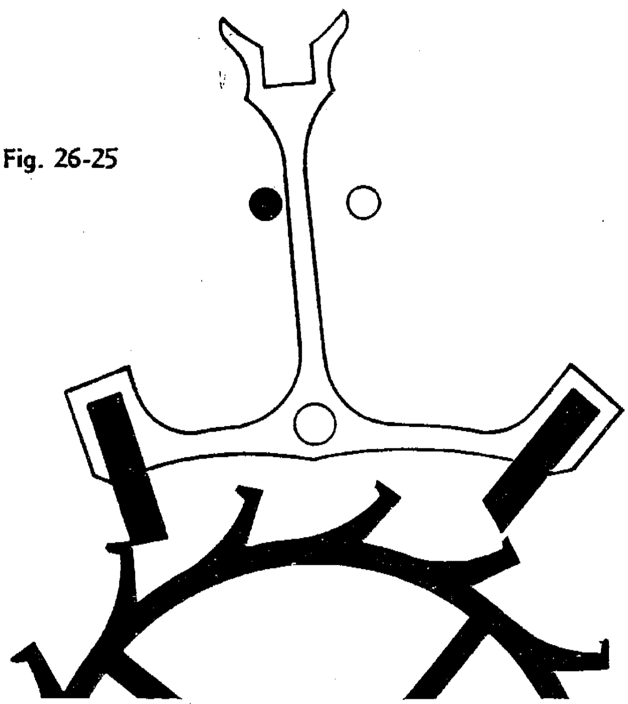


Fig. 26-25

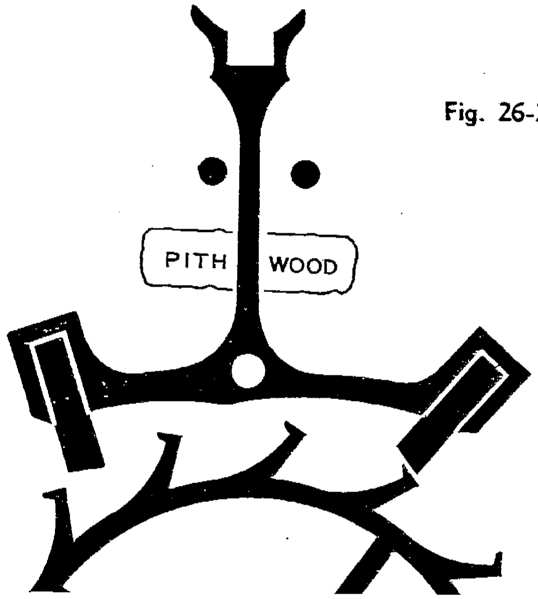


Fig. 26-26

This same action takes place between the guard pin and the edge of the roller table in the single roller escapement and is tested in the same manner. When the fork is arrested by either banking pin you should find:

1. A small amount of play between the corner of the fork slot and face of the roller jewel.
2. The proper amount of lock **and** slide.
3. Freedom between the safety roller and guard dart. There are very few watches in use today using immovable bankings with a single roller.

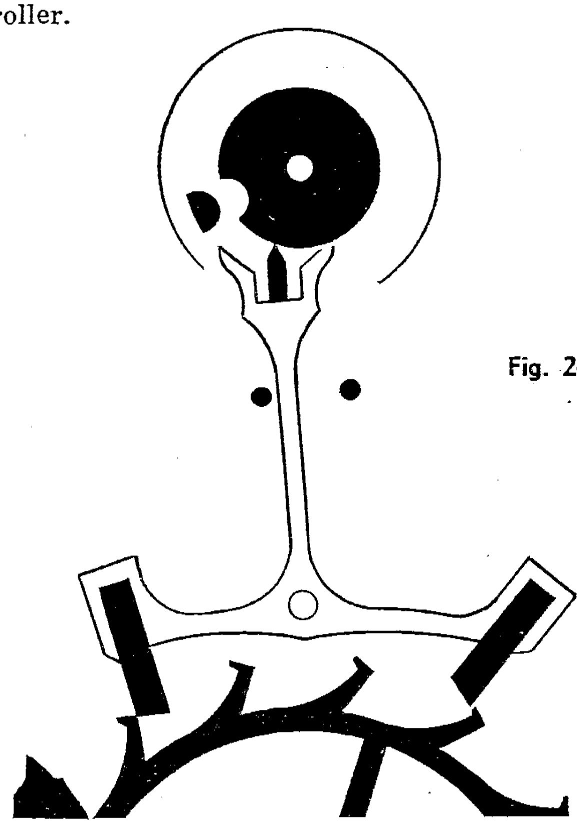


Fig. 26-27

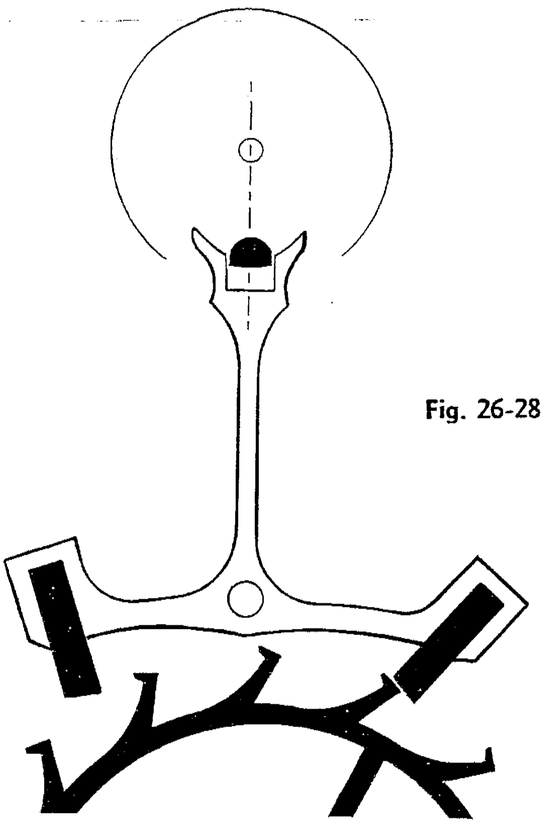


Fig. 26-28

SEC. 455—Putting in Beat

Theoretically, the watch is in beat when the center of the roller jewel is in line with the center of the pallet arbor and the center of the balance staff. Figure 26-28 illustrates this condition and shows the escape wheel tooth about half way across the face of the **L** stone. If you apply a **small** amount of power to the train so that a tooth of the escape wheel rests equally on the faces of both the **R** and **L** stones, your watch should be in beat. Figure 26-29 shows an escape tooth which has come to rest at the front of the **R** stone. Notice too that the roller jewel is not in line with the fork. Turning the roller jewel in the direction of the arrow **A** until the roller jewel is in line will allow the escape wheel tooth to come to rest at the approximate center of the **R** stone, figure 26-30, and this amount is equal to the amount shown in figure 26-28. In this case the hairspring collet would have to be moved in the direction of the arrow **B,** figure 26-29. This is one of the best methods by which to determine if a watch is in beat.

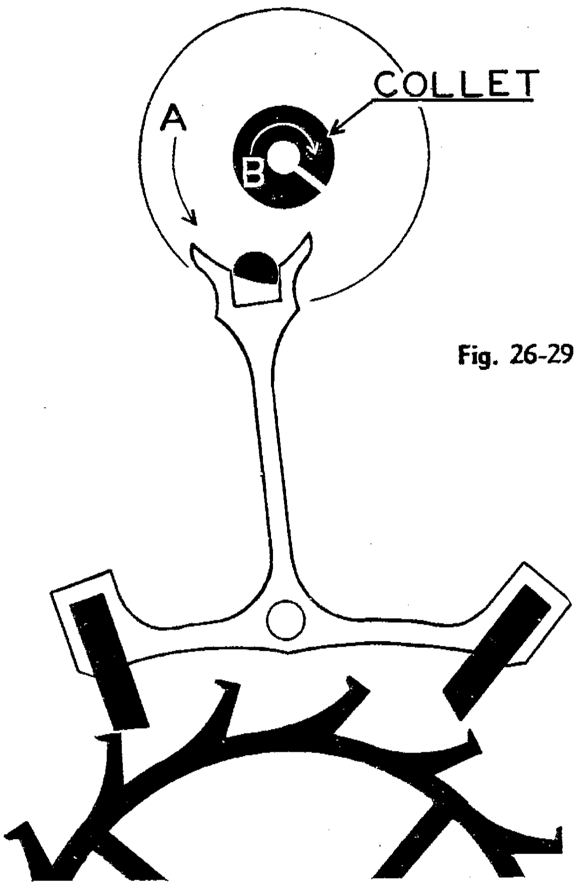


Fig. 26-29

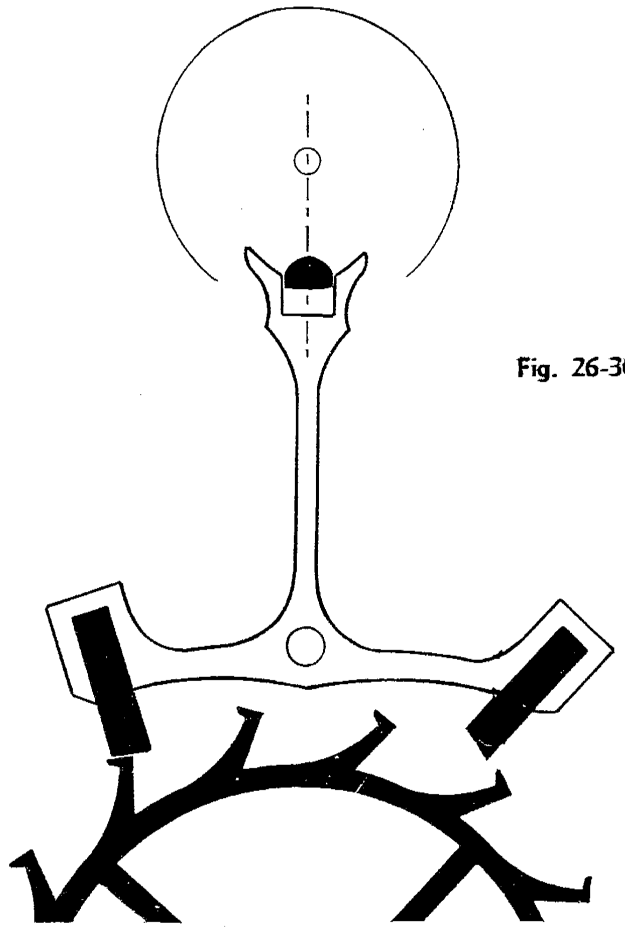


Fig. 26-30

CHECK YOURSELF

Progress Check 26 — A Self Test Review of Lesson 26

Study Sections 445 through 455. Then see if you can answer these questions without looking back. DO NOT SEND TO THE SCHOOL FOR GRADING. You'll find answers later in this lesson. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. From the repairman's point of view, most escapement troubles will center around the ________________.	445
2. Banking to the drop can be safely done only on watches with ________________ bankings.	447 453
3. The tool used to heat shellac when re-setting pallet stones is called a ________________.	448
4. Pallet stones should be set ________________ the top of the fork.	448
5. Pallet stones should be cleaned with ________________ and alcohol while the fork slot is cleaned with ________________ and alcohol.	448
6. Pallet stones should be picked up by the ________________.	449
7. The ________________ angle differs on R and L stones.	449
8. As a start in obtaining correct lock, set the stone as far ________________ in the slot as it will go.	449
9. Each time a pallet stone is moved, it is necessary to ________________ it.	449
10. In proper safety action, there should be a slight clearance between ________________ and ________________ when slide has taken place.	450
11. A ________________ is used to remove a guard pin from a single roller escapement.	451
12. The guard dart in a double roller escapement may be removed with either a ________________, a ________________ or a ________________.	452
13. In a watch with immovable bankings, the allowance for ________________ must be equal on both sides and be established ________________ the fork touches the bankings.	453
14. A watch will be in beat if an escape wheel tooth moves an equal distance on the ________________ of both stones when a little power is applied to the train.	455

ANSWERS TO PROGRESS CHECK 26:

1. pallet stones

2. movable

3. pallet warmer

4. flush with

5. pithwood
   pegwood

6. sides

7. lifting

8. back

9. reheat

10. guard pin or dart
    roller

11. punch

12. heavy tweezers
    sharp pointed punch
    needle

13. slide
    before

14. impulse face

LESSON	26
ESCAPEMENT	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L26-J1

HOW TO REPLACE AN "R" STONE (RECEIVING) IN A SWISS WATCH.

Tools, Equipment and Supplies:

Pallet Warmer   Shredded Shellac   Alcohol Lamp

PROCEDURE:	REFERENCE:
1. Remove damaged stone and old cement from pallet. NOTE: To remove stone, place fork in pallet warmer, warm, and push out stone.	Sec. 448
2. Select replacement "R" stone. NOTE: To determine correct width of stone, measure slot in pallet with roller jewel gauge and determine metric thickness of stone. Replacement should be a snug fit.	Lesson 13
3. Place fork on pallet warmer, bottom side up.	Sec. 448
4. Insert stone in pallet with angled impulse face of stone in proper direction. (Must face oncoming escape wheel tooth.)	
5. Cement stone in place.	Sec. 449
6. Allow fork to cool, then remove from pallet warmer and clean.	Sec. 449
7. Place pallet fork in movement.	
8. Test lock, drop and slide. Each should be equal to opposite or "L" side of escapement.	Sec. 453 Sec. 454
9. If adjustment is necessary, place fork on pallet warmer and move stone with pointed pegwood as required.	
10. Continue testing and adjusting until you know stone is in correct position.	

NOTE: Moving "R" stone outward in slot increases lock on <u>both</u> stones.

Moving "R" stone inward in slot decreases lock on <u>both</u> stones.

LESSON	26
ESCAPEMENT	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L26-J2

HOW TO REPLACE AN "L" STONE (LET OFF) IN A SWISS WATCH.

Tools, Equipment and Supplies:

Pallet Warmer   Shredded Shellac   Alcohol Lamp

PROCEDURE:	REFERENCE:
1. Remove damaged stone and old cement from pallet. NOTE: To remove stone, place fork in pallet warmer, warm, and push out stone.	Sec. 448
2. Select replacement "L" stone. NOTE: To determine correct width of stone, measure slot in pallet with roller jewel gauge and determine metric thickness of stone. Replacement should be a snug fit.	Lesson 13
3. Place fork on pallet warmer, bottom side up.	Sec. 448
4. Insert stone in pallet with angled impulse face of stone in proper direction. (Must face oncoming escape wheel tooth.)	
5. Cement stone in place.	Sec. 449
6. Allow fork to cool, then remove from pallet warmer and clean.	Sec. 449
7. Place pallet fork in movement.	
8. Test lock, drop and slide. Each should be equal to opposite or "R" side of escapement.	Sec. 453 Sec. 454
9. If adjustment is necessary, place fork on pallet warmer and move stone with pointed pegwood as required.	
10. Continue testing and adjusting until you are satisfied stone is in correct position.	

NOTE: Moving "L" stone outward in slot increases lock on both stones.

Moving "L" stone inward in slot decreases lock on both stones.

HOW TO REPLACE AN "R" STONE (RECEIVING) IN AN AMERICAN WATCH.

Tools, Equipment and Supplies:

Pallet Warmer   Shredded Shellac   Alcohol Lamp

PROCEDURE:	REFERENCE:
1. Remove damaged stone and old cement from pallet. NOTE: To remove stone, place fork in pallet warmer, warm, and push out stone.	Sec. 448
2. Select replacement "R" stone. NOTE: Pallet stones for American watches are ordered for the particular make and model, so always give the make, size, and model or movement number when you order. Also specify "R" or "L" stone.	Lesson 13
3. Place fork on pallet warmer, bottom side up.	Sec. 448
4. Insert stone in pallet with angled impulse face of stone in proper direction. (Must face oncoming escape wheel tooth.)	
5. Cement stone in place.	Sec. 449
6. Allow fork to cool, then remove from pallet warmer and clean.	Sec. 449
7. Place pallet fork in movement.	
8. Test lock, drop, slide and guard action. Each should be equal to opposite or "L" side of escapement.	Sec. 453 Sec. 454
9. If adjustment is necessary, place fork on pallet warmer and move stone with pointed pegwood as required.	
10. Continue testing and adjusting until you are satisfied stone is in correct position.	

NOTE: Moving "R" stone outward in slot increases lock on both stones.

Moving "R" stone inward in slot decreases lock on both stones.

LESSON	26
ESCAPEMENT	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L26-J4

HOW TO REPLACE AN "L" STONE (LET OFF) IN AN AMERICAN WATCH.

Tools, Equipment and Supplies:

Pallet Warmer   Shredded Shellac   Alcohol Lamp

PROCEDURE:	REFERENCE:
1. Remove damaged stone and old cement from pallet. NOTE: To remove stone, place fork in pallet warmer, warm, and push out stone.	Sec. 448
2. Select replacement "L" stone. NOTE: When ordering pallet stones for American watches, give the make, size, and model or movement number and specify "R" or "L" stone.	Lesson 13
3. Place fork on pallet warmer, bottom side up.	Sec. 448
4. Insert stone in pallet with angled impulse face of stone in proper direction. (Must face oncoming escape wheel tooth.)	
5. Cement stone in place.	Sec. 449
6. Allow fork to cool, then remove from pallet warmer and clean.	Sec. 449
7. Place pallet fork in movement.	
8. Test lock, drop, slide and guard action. Each should be equal to opposite or "R" side of escapement.	Sec. 453 Sec. 454
9. If adjustment is necessary, place fork on pallet warmer and move stone with pointed pegwood as required.	Sec. 453 Sec. 454
10. Continue testing and adjusting until you are satisfied stone is in correct position.	

NOTE: Moving "L" stone outward in slot increases lock on <u>both</u> stones.

Moving "L" stone inward in slot decreases lock on <u>both</u> stones.

HOW TO REPLACE A GUARD PIN IN A SINGLE ROLLER ESCAPEMENT.

Tools, Equipment and Supplies:

Heavy Tweezers   Bench Block   Staking Tool   Stud Pins

PROCEDURE: REFERENCE:

1. Remove old guard pin. Sec. 451

2. Select tapered brass pin (stud pin). Fig. 26-17

3. Insert from underside of fork to snug fit. Cut off pin.

4. Drive pin tight. Fig. 26-18

5. Replace pallet fork and balance wheel (without hairspring) in watch.

6. Adjust guard pin for proper guard action. Les. 21-22-26

   a. Pin should be just long enough to protrude slightly above the roller, but not so long that it will hit the arms of the wheel.

   b. To test guard action, give the balance a half turn with your finger until the roller jewel is out of the fork slot. Hold balance wheel steady. The fork will be against the banking and you should have a very slight clearance or play between guard pin and roller edge.

   c. To check this clearance, gently push the fork toward the other banking pin with tweezer or needle. The fork should move a slight distance before the guard pin contacts the roller.

   d. Now reverse the balance and make the same check with the roller jewel on the other side of the fork slot. The clearance should be equal on both sides.

7. If there is no freedom on either side, the guard pin is too close to the roller. Stone down the guard pin to an inverted V shape until you have equal play on both sides, or bend slightly away from roller, as you prefer. Fig. 22-6

8. If the fork moves over to the other banking pin without stopping or allows the escapement to unlock, the guard pin is too far from the roller. Either bend the guard pin closer to the roller edge or replace the pin with a larger size, as you prefer. Sec. 406

HOW TO REPLACE THE GUARD DART IN A DOUBLE ROLLER ESCAPEMENT.

Tools, Equipment and Supplies:

Heavy Tweezers Bench Block Staking Tool Stud Pins

PROCEDURE:	REFERENCE:
1. Remove old guard dart. Take care to remove in proper direction.	Sec. 452
NOTE: Guard darts in American watches are usually put in from the front of the boss with the thick end of pin toward the roller. In Swiss watches, the thin end is toward the roller.	
2. Select tapered brass pin. (Stud pin.)	
3. Insert in boss from proper direction. Press in tight and cut off unused part of pin.	
4. Cut off guard dart at a point slightly longer than fork horns.	
5. Shape end with arkansas slip.	Fig. 26-23
6. Replace wheel and pallet fork in watch, without hairspring.	
7. Check guard action:	Sec. 454
a. Give the balance a half turn with your finger until the roller jewel is out of the fork slot. Hold the wheel.	
b. With a tweezer or needle, see if you can wiggle the fork slightly back and forth from the banking pin. You should feel a little play or clearance.	
c. Reverse the balance and check the other side in the same way. The amount of play should be equal.	
d. If it is not equal on both sides, the guard dart is bent. Take out the fork and with a tweezer bend the guard dart sideways toward the side that had the least clearance.	
e. If you cannot feel any freedom on either side, the guard dart is too long. Dress down the tip as in Fig. 26-23.	

(Continued)

f. If the escapement unlocks, you have too much freedom and the guard dart is too short. You can either stretch the guard dart or replace it with a longer one, as you prefer. To stretch it, take out the fork and place the guard dart on a flat face stump. Use a flat face punch and give it a very light tap with a brass hammer.

g. Continue your trials and adjustments until you are sure the guard dart is the correct length and has equal clearance on both sides.

h. Make a final check by again moving the roller jewel out of the fork slot. Then gently push the fork away from the banking with a tweezer or needle until it is stopped by the safety roller. Hold the fork there while you slowly turn the balance and roller jewel back to the fork slot. The roller jewel should reenter the slot without catching on the fork horn. If it catches, the guard dart is still too short.

HOW TO CHECK THE ESCAPEMENT FOR PROPER OPERATION:

Introductory Information:

You will normally make a routine check of watches coming in for repair to be sure the escapement is operating correctly, which it will be in most cases. The items to check are guard action, roller jewel, lock, drop, and slide. Ordinarily you will test these and make any needed corrections as part of your repair procedure which you will learn in Lesson 32. This summary of these tests is given separately here so you can check the escapement itself anytime you have need for it.

PROCEDURE:

1. Remove dial and hands and place movement with dial side down on movement holder.

2. Turn balance wheel a half turn with your finger and hold balance wheel steady. This will move the roller jewel out of the fork horn and allow you to test the guard action.

3. Check the guard action by reaching down under the balance with a needle or tweezer and gently push the fork toward the other banking pin. This testing must be done by "feel" as the action is hidden by the balance. A properly adjusted guard action provides a little clearance or play between the guard pin or guard dart and the roller when the fork is against the banking. You should, therefore, be able to jiggle the fork back and forth very slightly if this clearance exists. At the same time, this movement must not unlock the escapement so this clearance must always be less than the amount of lock.

4. Now reverse the balance and make the same check on the other side to be sure this clearance is equal on both sides.

   NOTE: If the action is unequal or escapement unlocks, remove balance and hairspring and then replace balance without hairspring so you can see the guard action in the watch. If guard action is unequal, you must check the banking pins and fork as well as the guard dart. If any of these are bent it can cause unequal action. Make any needed corrections as indicated on the Job Sheets for replacing guard pins or guard darts.

5. Remove balance bridge and wheel and check that roller jewel is tight and straight. (If roller jewel is loose, reheat, tighten and return to movement for recheck of correct placement. Otherwise, leave off balance wheel and continue checking below.)

6. Place a piece of pithwood or paper under the fork to hold it (Fig. 26-26) and check lock, drop and slide.

(Continued)

NOTE: If pallet stones are not visible in your movement, turn it over dial side up and look through the two inspection holes in the pillar plate.

a. Observe lock at the instant a tooth drops onto a pallet stone. Turn the balance slowly and stop the instant the tooth drops. This is the amount of existing lock. As you recall, lock may vary from 1/5th the width of the impulse face of the pallet stone to 1/10th of this width. The important point is that lock must be equal on both stones.

b. Observe slide by noting the space between the halted fork and the banking pin at the instant of lock. (Sec. 453). This distance will equal the amount of slide. Slide actually is the action of the pallet stone moving further into the escape wheel after locking. Its purpose is to insure the tooth does not unlock ahead of time because of the possibility of some escape wheel teeth being shorter than others. Slide must not be more than the amount of lock nor less than half the amount of lock. It must be equal on both sides.

c. Observe drop by noting the distance between the opposite stone and the tooth which it just released. (Fig 26-25). It must also be equal on both sides.

d. After you have noted the amount of lock, drop and slide, push the fork to the other side to be sure you have the same amount of each one.

7. Remove pallet fork and arbor and check that stones are tight. If loose, reheat and replace as directed in Job Sheets covering stone replacement. Return the pallet fork to the movement and recheck lock, drop, slide, and guard action.

8. While you have the pallet out is a good time to check the freedom of the roller jewel in the fork slot. It should be about .02 mm less in width than the fork slot.

Test Questions — Master Watchmaking — Lesson No. 26

Name: No.: Date:

SUBJECT: Matching the Escapement GRADE: ____________

DIRECTIONS: In the following statements, select the ONE BEST answer and place the letter of that answer on the short line in front of the question number.

____ 1. Which is the least likely cause for an escapement getting out of order after it leaves the factory?

A. Pallet fork left too long in cleaning solutions.
B. Stones not placed between teeth of escape wheel in assembling.
C. Wear.
D. Improper handling.

____ 2. Which one of the following conditions is unnecessary when setting pallet stones?

A. Hairspring on balance wheel.
B. Pallet arbor pivots straight and clean.
C. Balance pivots straight, polished, and free from dust.
D. Roller table tight on staff and edge smooth and polished.

____ 3. When the banking pins are set in such a position that the roller jewel will just pass by the corner of the fork slot without freedom, the escapement is said to be:

A. Out of bank.
B. Overbanked.
C. Out of action.
D. Banked to the drop.

____ 4. Which statement correctly applies to the lifting angle of pallet stones?

A. Only small watches have a difference in angle.
B. L stone has greater angle than R stone if any difference exists.
C. R stone has greater angle than L stone.
D. Both R and L stones have same angle in all watches.

____ 5. After banking the escapement to the drop and adjusting the safety action properly, if you then open each banking pin slightly, what will be the effect?

A. Provide small amount of clearance between guard pin and roller.
B. Escapement will go out of action.
C. Less lock.
D. More lock.

____ 6. If you have difficulty removing a guard pin from a single roller escapement, what procedure is recommended?

A. Heat the fork to loosen the old guard pin.
B. Use a punch made from tempered steel held in a staking punch.
C. Drill out the old guard pin.
D. Fit an entire new fork.

Detach page or cut along this line — and send to the School for grading.

(Please turn over)

____ 7. Which statement is correct for a double roller escapement in an American movement?

A. A steel pin is used to make a new guard dart.
B. Guard dart is usually put in from the front.
C. Pin should be shaped before inserting in fork.
D. Thinner portion of pin forms safety action with safety roller.

____ 8. Which action is incorrect when replacing a guard dart in a double roller escapement?

A. Hold fork with a heavy tweezers.
B. Rest points of tweezers on anvil.
C. Use a pin with no taper.
D. Tap in gently with another pair of tweezers.

____ 9. Which statement would NOT apply to an escapement with immovable bankings which are undamaged after leaving the factory?

A. Procedure for matching escapement is same as for watch with movable bankings except allowance must be made for slide.
B. When checking lock and drop, a good method is to insert pith under fork.
C. It is unnecessary to bend pins when matching the escapement.
D. Pins must be bent when matching the escapement.

____10. Which is the best method to use to see if a watch is in beat?

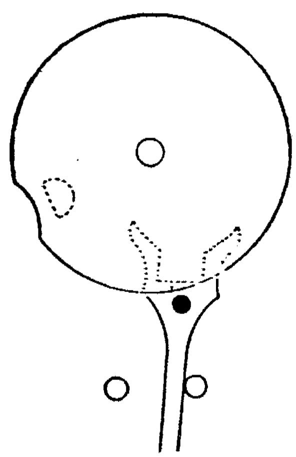
A. See if pallet fork is midway between banking pins.
B. See if an escape tooth rests equally on R and L stones when small amount of power is applied to train.
C. See if roller jewel is in line of centers of pallet arbor and balance staff.
D. Check on timing machine.

DIRECTIONS: Study the illustrations and information given in the following questions. Then select the ONE BEST answer for the CAUSE of the fault and the ONE BEST answer for the CORRECTION needed. Place the letter of the answer you select on the short line in front of the question number.

11. The balance in a single roller escapement goes out of action (overbanks).

You have checked the following and found them correct:

Balance pivots. Pallet arbor pivots.
Balance jewels. Side shake.



____11a. What is the likely cause of this condition?

A. Guard pin too far back.
B. Guard pin too far forward.
C. Banking pins too far to right.
D. Banking pins too far apart.

(Continued on next page.)

 Name: Student number

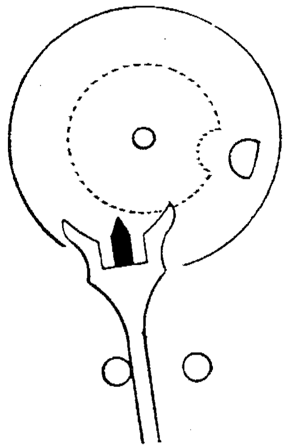
___11b. Which of these methods will best correct it?

A. Adjust banking pin to left.
B. Close banking pins slightly.
C. Ream hole and replace with larger guard pin.
D. Dress down guard pin.

12. The balance in a double roller escapement goes out of action after you have replaced the pallet fork.

You have checked the following and found them correct:

Balance pivots. Pallet arbor pivots.
Balance jewels. Side shake.
End shake.



___12a. What is the likely cause of this condition?

A. No slide.
B. Guard pin too short.
C. Too much drop.
D. Banking pins too far apart.

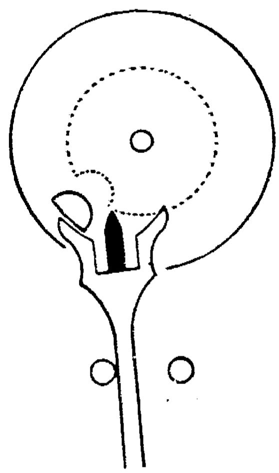
___12b. How would you correct it?

A. Move banking pins in.
B. Move R stone in slightly.
C. Replace guard dart.
D. Adjust for slide.

13. After replacing a guard dart in a double roller escapement, you find the motion of the balance is retarded.

You have checked the following and found them correct:

Balance pivots. Pallet arbor pivots.
Balance jewels. Side shake.



___13a. What is the likely cause of this condition?

A. Fork bent.
B. Guard dart loose.
C. Guard dart too long.
D. No bank or slide.

___13b. How would you correct it?

A. Straighten fork.
B. Adjust for bank and slide.
C. Shorten guard dart.
D. Tighten guard dart.

(Please turn over)

Detach page or cut along this line - - and send to the School for grading.

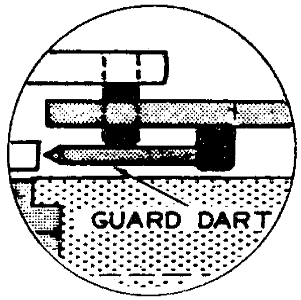
14. You have replaced a roller jewel and find the motion is retarded in the Dial Down position.

You have checked the following and found them correct:

Lower cap jewel.
Balance pivots.
Guard dart is straight.

____14a. What is the likely cause of this condition?

A. Fork bent.
B. Roller table not on correctly.
C. Roller jewel rubs guard dart.
D. Guard dart too long.



____14b. How would you correct it?

A. Raise roller jewel.
B. Shorten guard dart.
C. Straighten fork.
D. Stake roller table to hub.

---

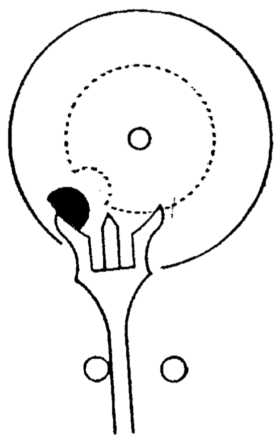
15. You have replaced a roller jewel and find the motion is retarded when the balance is falling toward the fork.

You have checked the following and found them correct:

Pallet arbor pivots.
Balance pivots.
Roller jewel is clean of all cement.

____15a. What is the likely cause of this condition?

A. Guard dart too short.
B. Fork horn rubs roller.
C. Banking pin bent.
D. Roller jewel not straight.



____15b. How would you correct it?

A. File fork horn.
B. Straighten roller jewel.
C. Straighten banking pin.
D. Insert longer guard dart.

(Continued on next page.)

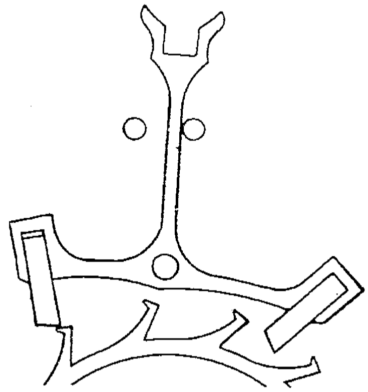
 Name: Student number

Detach page or cut along this line and send to the School for grading.

16. After replacing an R stone, you find when testing the escapement for lock that the escape wheel tooth fails to pass completely across the lifting face of the R stone before the fork strikes against the banking pin.

____16a. What is the likely cause of this condition?

A. Fork horn catching on roller.
B. Banking pin too close in.
C. No safety action.
D. R stone too far out.



____16b. How would you correct it?

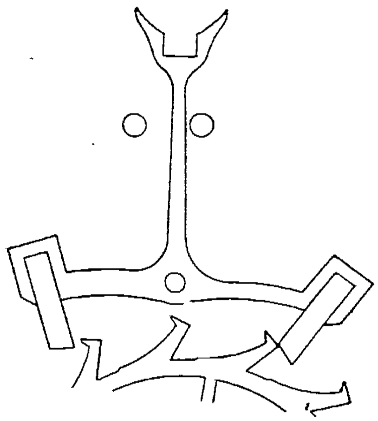
A. Shorten fork horn.
B. Adjust safety action.
C. Reheat and set R stone up into slot.
D. Straighten banking pin.

---

17. After replacing an L stone, you find when testing the escapement for lock that the escape wheel tooth fails to lock on the locking corner of the L stone at the instant of drop.

____17a. What is the cause of this condition?

A. R stone in too far.
B. L stone in too far.
C. Too much sideshake.
D. Banking pins too close.



____17b. What would you do to correct it?

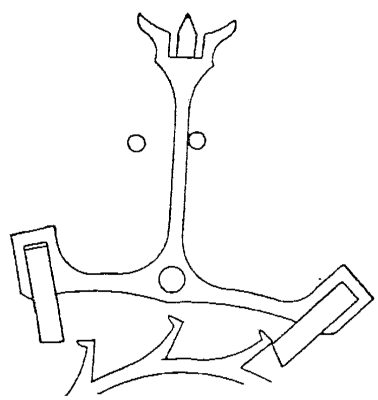
A. Move both banking pins out.
B. Move right banking pin out.
C. Reheat and move L stone out.
D. Reheat and move L stone in and R stone out.

---

18. You have replaced an R stone and find when testing the escapement for lock, drop and slide that the fork is against the banking at the instant of drop. The result is no slide.

____18a. What is the cause of this condition?

A. R stone out too far.
B. L stone in too far.
C. Banking pins too close.
D. Guard dart too close to roller jewel.



____18b. How can you correct it without moving the bankings?

A. Straighten guard dart.
B. Reheat and move R stone in and L stone out.
C. Reheat and move L stone out.
D. Reheat and move R stone in.

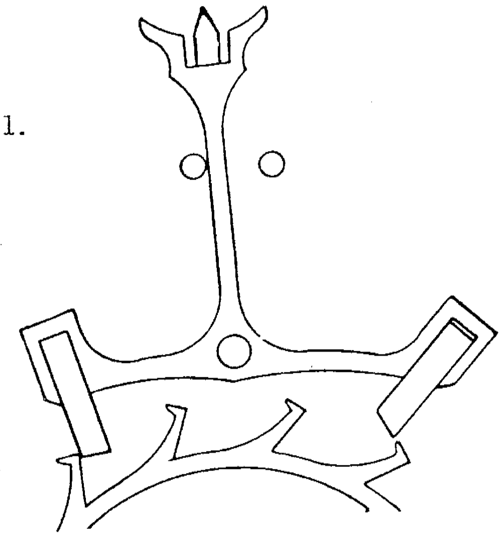
19. You have replaced an L stone and find when testing the escapement for lock, drop and slide that the fork is against the banking at the instant of drop. The result is no slide.

____19a. What is the cause of this condition?

A. Guard dart too close to roller jewel.
B. Banking pins too close.
C. L stone out too far.
D. R stone in too far.

____19b. How can you correct it without moving the bankings?

A. Reheat and move R stone out.
B. Reheat and move L stone in.
C. Reheat and move R stone out and L stone in.
D. Raise roller jewel.



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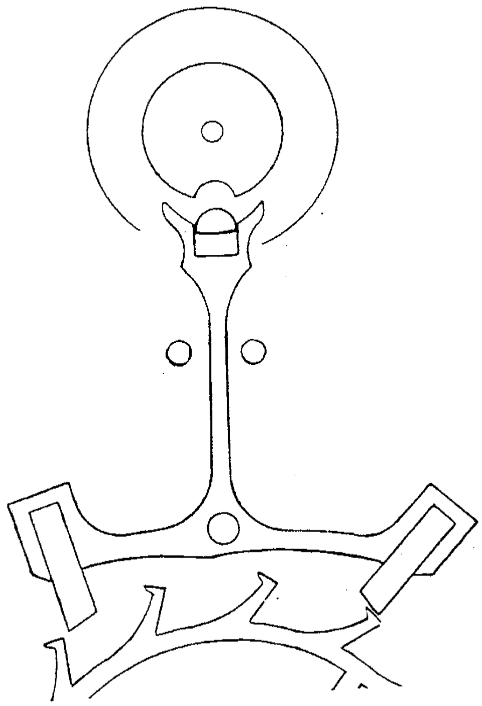
20. The escapement shown here will not work properly because of an error commonly made by beginners.

____20a. What is the error?

A. Roller jewel crooked.
B. Fork horns too short.
C. R stone has lifting angle reversed.
D. Out of beat.

____20b. What would you do to correct it?

A. Straighten roller jewel and switch R and L stones.
B. Remove and replace R stone with impulse face at correct angle.
C. Move collet.
D. Replace escapement.



(End of Test Questions 26)

CHICAGO SCHOOL OF WATCHMAKING

Proficiency Exam No. 4

A test of your Master Watchmaking Shop Skills.

Student number ____________ Date ____________

Name ____________

Address ____________

City State Zip Code ____________

This examination covers the practical work for:

Lessons 21 through 26.

You may send in this examination any time after you have completed study of the lessons above up to 3 years from your date of enrollment.

YOUR GRADE: ____________

Certificate Awarded: ____________

PURPOSE OF THIS EXAMINATION: To test your job skills and ability to do the practical work covered in the lessons included in this examination. It is not compulsory, but if satisfactorily completed will count toward your Diploma requirements.

STUDENTS WHO ACHIEVE A SCORE OF 75 or better on this examination will be awarded a special Certificate of Proficiency for Escapement Adjusting.

SEND IN FOR THIS EXAMINATION:

One Pocket Size Watch.
One Wrist Watch.

NOTE: Pack carefully and mark as your property.

DO THE FOLLOWING WORK ON EACH WATCH:
(Use Assignments 80 and 81 and Job Sheets as guides.)

1. Remove both pallet stones and replace. Check lock, slide, guard action, roller jewel, and beat. Make any adjustments necessary.

2. Make any other needed repairs, clean, and bring to time.

ERRORS NOTED which particularly affect escapement action:

YOUR RATING:

Possible score on:

		Pocket Watch	Wrist Watch
		50	50
		Less deductions for indicated errors:	
_____ Balance pivots broken.	(-2)	_____	_____
_____ Balance pivots bent.	(-2)	_____	_____
_____ Balance jewels broken.	(-2)	_____	_____
_____ Roller jewel loose.	(-2)	_____	_____
_____ Roller jewel tilted.	(-2)	_____	_____
_____ Roller jewel has excess cement.	(-1)	_____	_____
_____ Pallet stones improperly set.			
_____ Excess cement.	(-1)	_____	_____
_____ R stone in pallet slot too far.	(-3)	_____	_____
_____ R stone out too far.	(-3)	_____	_____
_____ L stone in pallet slot too far.	(-3)	_____	_____
_____ L stone out too far.	(-3)	_____	_____
_____ Impulse face reversed on ___ stone.	(-2)	_____	_____

Cut along this line and send with - - your work to the School for grading

		Pocket Watch	Wrist Watch
_____ Unequal lock.	(-6)	_____	_____
_____ Unequal slide.	(-2)	_____	_____
_____ Too much slide.	(-2)	_____	_____
_____ Too little slide.	(-2)	_____	_____
_____ Incorrect guard action.			
_____ Guard pin too long, dragging on roller.	(-1)	_____	_____
_____ Guard pin too short.	(-1)	_____	_____
_____ Unequal guard action.	(-2)	_____	_____
_____ Pallet fork bent.	(-2)	_____	_____
_____ Movement not clean.	(-2)	_____	_____
_____ Parts magnetized.	(-2)	_____	_____
_____ Not in beat.	(-2)	_____	_____
	Total deductions:	_____	_____
	Final scores:	_____	_____

SUGGESTED CORRECTIONS:

Pocket Watch: ______________________________

____

____

____

Wrist Watch: ______________________________

____

____

____

EXTRA CREDIT: (The work which follows is not required for the Special Certificate, but any points earned as a result of it will also count toward your total rating on which a Certificate is awarded.)

NOTE: If you have previously done this work and received a satisfactory rating, check here ( ) and you need not send it in again.

	Extra Credit	Your Score:
( ) 1. Draw to scale a 15 tooth escape wheel as described in Lesson 24. (If drawing is not to scale given in text, it will not be graded.)	5	_____
( ) 2. Draw to scale the pallet fork and arbor as described in Lesson 25. (If drawing is not to scale given in text, it will not be graded.)	5	_____

Master WATCHMAKING

Lesson 27

Tools —

Hardening and

Tempering

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

27 REVISED 1971 Printed in U.S.A.

Chicago School of Watchmaking
310 LINCOLN AVENUE • FOX RIVER GROVE, ILLINOIS

Dear Student:

From time to time in your lessons we have pointed out the value of knowing how to use a watchmaker's lathe. In this group of lessons you will learn the techniques of lathe work and get some idea of the kind of work than can be done with its aid. Even though you may not now be prepared to do any actual lathe work, study of these lessons will help you to determine whether or not a lathe will be useful in your own work. Not all professional repairmen use a lathe, although the best repairmen invariably do.

Lesson 27 will show you how to make three tools: an iron grinding slip, a stripping tool and a seat cutting tool. Instructions for making them are in Assignments 83, 84 and 86. Instructions for sharpening the stripping tool and seat cutting tool are in Assignment 96. These tools are very useful for your lathe work and for the lathe Proficiency Examination. However, you should make them even though you do not plan to do any actual lathe work at this time. Making these tools will teach you a great deal about filing, polishing, hardening and tempering. But have them checked by us before you actually use them. An inspection request is included in Lesson 27 for this.

Another tool -- a steel burnisher -- is necessary for the work of this study group. Instructions for it are in Assignment 92. It, too, should be checked by us before you start to use it. An inspection request for it is in Lesson 29.

To save you the trouble of locating the special materials needed for these tools and the Proficiency Examination, we are furnishing them for these lessons except for the necessary jewels. Those were sent at the time you identified them in Lesson 14.

The lathe Proficiency Examination is contained in Lesson 27 although it is not required at this time. You may send it in whenever you have access to a lathe. If you live in continental United States, the School will rent you a lathe for the lathe portion of the course. (Unfortunately, we cannot send lathes outside the U. S. A. for reasons beyond our control.) We have only a limited number of lathes available for rental and they are offered on a first come, first served basis. Information on rental is available upon request.

As the final practical examination also requires some lathe work, we have arranged it so you can do that work just as soon as you have completed the Proficiency Examination for this group of lessons. Thus, if you are renting a lathe, you can complete all the requirements at one time with very little cost.

I hope you will find it possible to do the actual lathe work. You'll find it both challenging and rewarding.

Sincerely yours,

John Wrath

John Wrath - Chief Instructor

INTRODUCTORY INFORMATION

In your career as a watchmaker, you may find it necessary to make certain small tools and parts for obsolete watches. This lesson will show you how to do it. You will learn how to file, to work from drawings, to harden steel and to draw or anneal it to the proper temper. You will also make three small hand tools, not readily obtainable, and which you can use in Lessons 30 and 31. If properly made, these tools will last a good many years.

KEY POINTS OF LESSON ASSIGNMENTS 82, 83, 84, 85, 86, 87:

- Why you should use good tools.
- Equipment for making tools and parts.
- How to make a stripping and seat cutting tool.
- How to harden and temper steel.
- How to make an iron grinding slip.
- The principles of making watch parts.
- How to use soft solder.

ASSIGNMENT NO. 82: Study Sections 460 and 461.
Read Tools and Materials of the Trade, page 33.

Study Questions:

1. What tools does the present day watchmaker have to make?
2. What equipment is necessary?
3. How is the jeweler's saw used?
4. How are emery buffs used?
5. What is the proper way to file?

Preparation for Practice Work:

1. Set up equipment.
2. Number emery buffs from 1 to 6, starting with the coarsest as No. 1 and the smoothest as No. 6. This is their order of use.
3. Insert saw blades in jeweler's saw frame with teeth toward handle.

ASSIGNMENT NO. 83: Study Section 462 (Paragraphs 1 through 7)

Recommended Practice:

Using a piece of 3mm square steel, make a stripping tool as outlined in paragraphs 1 through 7, Section 462. When filing bevel, Figures 279 and 279P, file within one-tenth mm of the top edge. This will allow for finishing, at which time the bevel and edge should meet.

Polish with emery buffs (Section 461). It is very necessary to get a high polish on tools before hardening or it will be very difficult to get a good polish afterward.

ASSIGNMENT NO. 84: Study Section 462 (Paragraphs 8 through 11).

Recommended Practice:

Using a piece of 3 mm square steel, make a seat cutting tool as outlined in paragraphs 8 to 11, Section 462. Check your measurements very carefully to be sure the tip is no larger than the measurements given in Figure 27-14.

Polish with emery buffs (Section 461).

ASSIGNMENT NO. 85: Study Sections 463 and 464.

1. How is steel hardened?
2. What is meant by tempering?

Recommended Practice:

Harden the seat cutting and stripping tools as outlined in Section 463. Test with a file for hardness as directed in the text. Do not make the hardness test with the file on any of the cutting edges. If the file seems to "bite," stop and re-harden. When you are satisfied that tools are hard, repolish each tool with emery buffs until they have a high gloss. Keep tools free of finger marks or oil after polishing.

Next, temper the tools as outlined in Section 464. These tools will be used for brass and should be drawn to a light straw color. If the color goes darker than you want, to say a dark straw, purple or blue, you will have to repeat the entire hardening and tempering process from beginning to end as given in this assignment. When you are satisfied as to hardness and proper temper, polish again with emery buffs to remove all color.

ASSIGNMENT NO. 86: Study Section 465.

Recommended Practice:

Make a grinding slip, using a piece of flat iron, and following the procedure given in Job Sheet L27-J1.

ASSIGNMENT NO. 87: Study Sections 466 through 469.

1. How are springs or small parts made?
2. When and how is soft solder used?

Recommended Practice:

Do the work outlined in Sections 466, 467, 468, and 469.

REQUIREMENT:

➧ Complete the Test Questions for Lesson 27 and return for grading.

SEC. 460—Reasons for Using Good Tools

In bygone years, it was necessary for the watchmaker to make a great many of his tools. Many watchmakers, especially old timers, consider tool making an essential part of an apprentice's or student's training. The student learned to file and shape tools from brass and steel, make screws, rivet parts, harden and temper wire from which to make staffs, pinions, setting parts, etc., thus becoming very proficient at tool and parts making. Most good watchmakers of this era could calculate a lost wheel and pinion; and if they had the proper equipment, make a wheel or pinion or any part of the watch including the jewels. In most cases, the tools made were not of exceptional quality due in part to a lack of machinery with which to make them. With the advent of modern machinery, the toolmaker became interested in making precision watchmakers' tools and the modern up-to-date teachings tend away from tool and parts making and are concentrated on watch repairing, using factory replacement parts and tools made by modern methods and machinery. It is an old adage that "any workman works better with good tools." Concentrate on obtaining the best tools, the proper materials for the proper movements, and then use these materials and tools, to do a better job. Quality work is the supreme achievement and it can be done better and faster with quality tools and materials.

There are times in every watchmaker's career when he may be called upon to devise a tool suitable for his own needs, or one that will do a job quicker than some tool already on the market. Such is the case of the collet removing tools mentioned in Lesson 15, Section 352. The three tools which you are required to make in order to complete this lesson are tools which are unobtainable. You will learn the types of files, the steel to use, how to file, how to harden and temper, etc.

SEC. 461—The Vise, Saw, Files, Etc.

The first requirement is a bench and a bench vise. The vise illustrated in figure 27-1 is a small bench vise suitable for the watchmaker which can be mounted on the extreme right hand corner of his bench. It is best, however, to mount the vise elsewhere as it is not used too often. When filing work which you

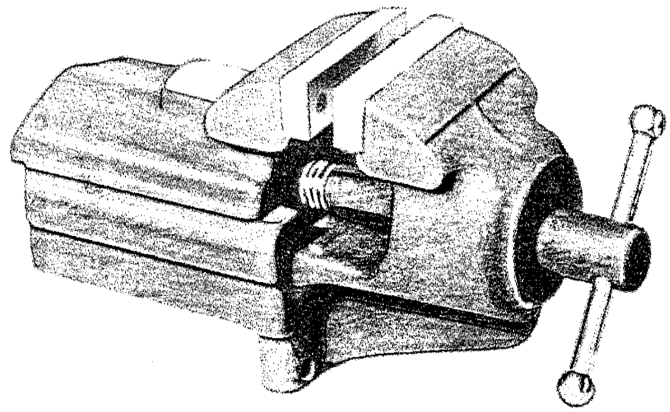


Fig. 27-1

do not wish to mar, it is advisable to form a pair of jaws out of copper similar to those in figure 27-2. These are placed over the jaws of the vise and the work is placed between the copper jaws. This will prevent marring of the work.

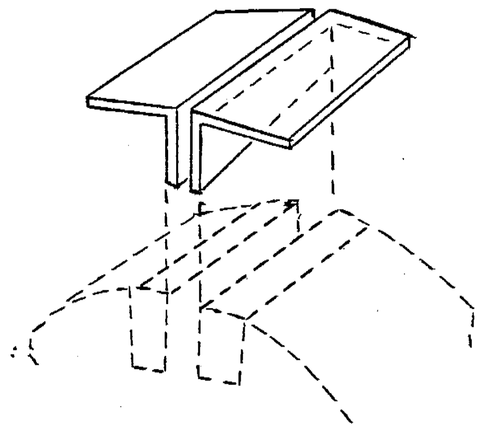


Fig. 27-2

Figure 27-3 illustrates a jeweler's saw frame which is a necessity for the watchmaker. It is much smaller than a hack saw. The small blades come in different cuts from 4 to 4/0, 4 being the coarsest and 4/0 the finest, figure 27-4. These blades are held in place by the clamps at **A**, figure 27-3, which are closed by means of the thumb screws **B**. The saw blade is inserted as follows: Place the head or top of the saw frame against the bench with the handle against your chest. Press against the handle, place saw blade in the lower clamp and tighten thumb screw. When pressure is released, the saw blade will be tight and have a high pitch when picked with your finger in the manner in which you would pick a string on a violin. The

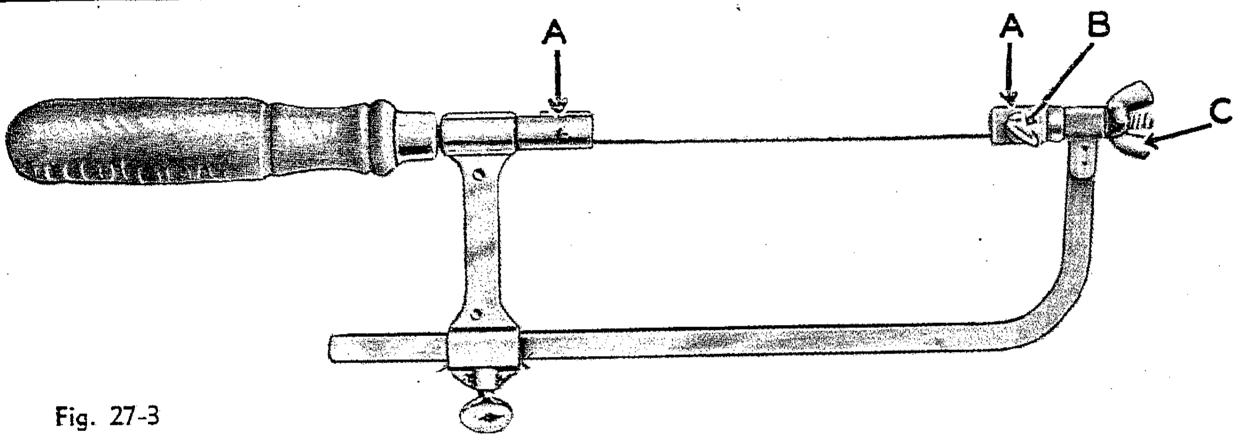


Fig. 27-3

teeth of the saw blade should **point toward the handle.** Further adjustment can be made by means of wing screw at **C.** These saws will cut soft steel, brass, nickel, gold, silver, etc. The work should be held securely in a bench or hand vise and the saw frame pulled down or toward you at which time a slight pressure is

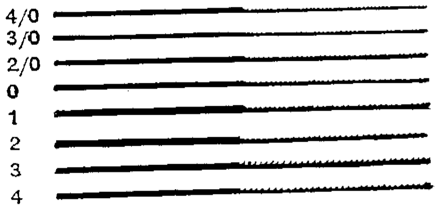


Fig. 27-4

exerted. When reversing the direction of the saw frame, the pressure is released until the downward motion is again started. In sawing flat pieces of steel or brass, etc. in which you wish to follow a line or pattern, the saw frame is held in a vertical position and the work should be held over a wood filing block, figure 27-5. After sawing, the work is usually finished with

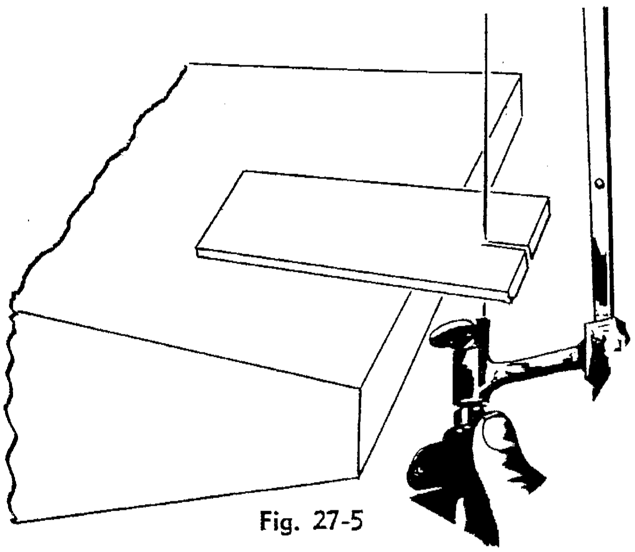


Fig. 27-5

a file and polished if necessary.

For the watchmaker 6 emery buffs of 6 different grades of emery from 2 to 4/0 are generally used to polish steel, figure 27-6.

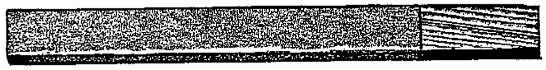


Fig. 27-6

Polishing any metal is the removing of surface roughness or scratches. When a piece of steel has been filed to the proper shape and we wish to polish it, we start with an emery buff No. 2. The work is carefully gone over with the No. 2 emery buff until all lines or marks left by the file have been removed. Clean the work carefully until all traces of scratches or marks left by emery buff No. 2 have been removed. Repeat the process with emery buffs Nos. 0, 1/0, 2/0, 3/0, and 4/0, being certain to clean the work each time another grade of emery is used. When you have finished with the No. 4/0 emery buff, you will have a piece of work with a high polish. This high polish is very necessary when we temper our work. The polishing of brass, nickel, gold, silver, etc., is not done with emery but with an electric polishing buff and tripoli to remove the scratches, and rouge to give it a high luster.

There are numerous types of files and hundreds of different shapes depending upon the type of work to be performed. There are files with a rough cut, bastard cut, 2nd cut and smooth cut in all sizes and shapes. For ordinary filing in brass and steel, a good flat file will serve our purpose, figure 27-7. For our work a 5-inch to 8-inch file with a 2nd or medium cut is preferred. The file is a cutting tool and should be used as such. To hold a file in the

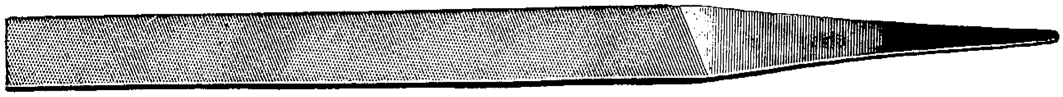


Fig. 27-7

proper position, grasp it firmly in the right hand with the end of the handle butting against the palm of the hand and the thumb resting along the top of the file. The left hand is used to guide the file when pushing it across your work and to regulate the pressure.

The stroke should not be straight across the work in flat filing but should be in a diagonal direction so that the file takes a shearing cut. After the completed forward stroke, the file should be lifted above the work and returned for the next forward stroke. Do not drag the file back across the work. Remember that the teeth of an ordinary file cut only when the file is moving forward. Keep your file clean with a file cleaning brush.

The watchmaker usually works in steel, brass, or nickel. Drill Rod or "Stubs" steel in rod or plates is high carbon steel which can be hardened. Low carbon steel cannot be hardened; consequently, it does not have much value to the watchmaker. Brass or nickel should be procured in the hard form as it is easily annealed.

SEC. 462—Making a Stripping and Seat Cutting Tool

In order to obtain practice in filing, polishing, hardening and tempering, we will make two jewelling tools. They are made from 3 mm square tool steel or drill rod approximately 100 mm in length, figure 27-8. Each step is accompanied by two illustrations. One gives the dimensions in millimeters or fraction thereof and the other is a projection illustrating each cut as it is made. For example: figure 27-8 illustrates a piece of square steel 100 mm long and 3 mm square. Figure 27-8P is a projection of the end to be worked upon. Figure 27-9 illustrates the same piece of steel with a section 20 mm long and 1 mm down from the front edge to be filed away. The projection, figure 27-9P, illustrates the piece of steel after this has been done. Follow each step carefully and work slowly.

1. Clamp the rod in vise allowing approximately 22 mm to extend beyond the jaws of the vise, figure 27-8 and 27-8P.

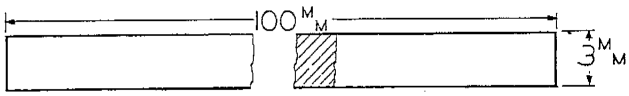


Fig. 27-8

Fig. 27-8P

2. Scratch a line with the edge of the file approximately 20 mm from the end, figure 27-9.

3. Holding the file at an angle of about 18 degrees, file a bevel as in figure 27-9 and 27-9P. Figure 27-9P shows this section after it has been filed.

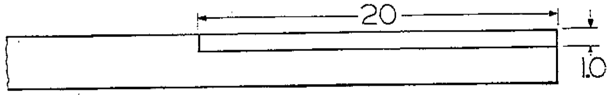


Fig. 27-9

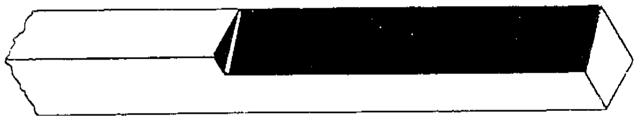


Fig. 27-9P

4. Turn rod over in vise and file the lower side off as in figure 27-10 and figure 27-10P leaving the end measurement at .6 mm thick and the taper about 30 mm back from the end.

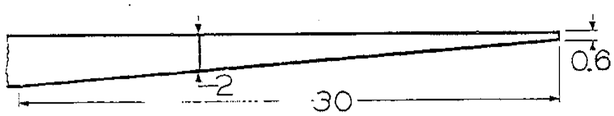


Fig. 27-10

Fig. 27-10P

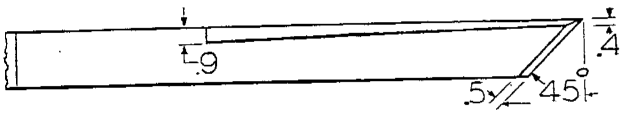


Fig. 27-11

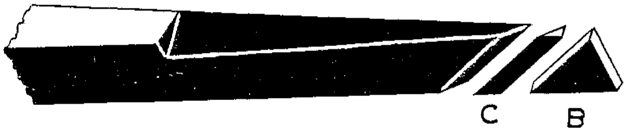


Fig. 27-11P

5. File angle of approximately 45 degrees as shown in figure 27-11 which will remove section **B,** figure 27-11P.

6. File second cut as shown at **C,** figure 27-11P.

7. Reverse steel and file tang which fits into handle as shown in figure 27-12 and 27-12P. Polish all sides of the stripping tool with emery buffs as described in Section 461 until you have a very high polish. It is not necessary to polish the tang.

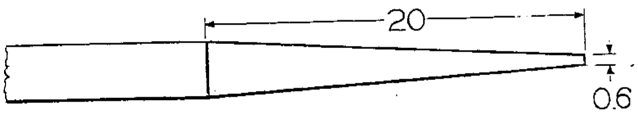


Fig. 27-12

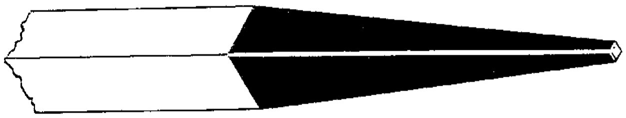


Fig. 27-12P

8. Take another rod of the same length and diameter and repeat steps 1, 2, 3, and 4. The rod should then appear as in figure 27-13 and 27-13P.

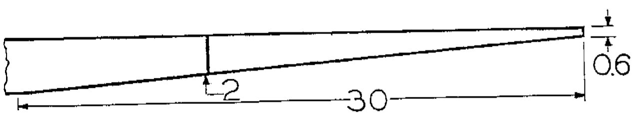


Fig. 27-13

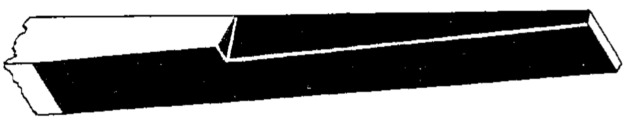


Fig. 27-13P

9. File off the under side and tip as shown in figure 27-14 and figure 27-14P. This will be used as a seat cutting tool.

10. File tang on the other end as in figure 27-12 and 27-12P.

11. Polish as in step 7.

Fig. 27-14

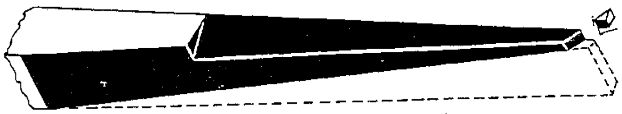


Fig. 27-14P

SEC. 463—Hardening

We are now ready to harden the tools. It is necessary to have some means of heat, preferably a bunsen burner, in order to obtain a red heat. Place a jar of cold water as close to the burner as possible. Wet the stripping tool with water and dip into powdered boric acid. The boric acid will form a glass-like covering over the steel and prevent "burning." In order to make the tool hard, heat it gradually until it is a bright cherry red and plunge it quickly and vertically into the water, holding it in the water until it is cool. A pair of heavy soldering tweezers is used to hold it. Remove from water and test with file. If it is hard, the file will not "bite" into the metal. If the file will bite, it is soft and it is necessary to repeat the process. Be careful when hardening tools such as the jewelling tools just made to apply heat to the bulkiest part of the stock first. Figure 27-15 illustrates a stripping tool. Apply heat at **A** until you are certain the stock is heated through thoroughly; then carefully let the flame heat toward the tapered end, first at **B** then back to **A,** back to **B,** down to **C,** back to **B** and **A,** and then reverse until section **D** of the tool from the end to **B** is cherry red. Quickly plunge into cold water and cool slowly. Test with a file.

When steel is hardened by the method just described, it is sometimes referred to as glass hard. The significance is that it is brittle and will break easily. Every piece that has been

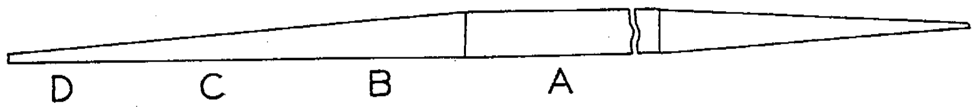


Fig. 27-15

hardened must be handled carefully. After your tools are hardened, they must be repolished using emery buffs 2/0, 3/0, and 4/0 in the order stated. Apply the buffs carefully in order not to break your tool.

SEC. 464—Annealing and Tempering

In order to toughen the tools, they must be annealed. This is known as tempering. Annealing brass, nickel, gold or silver is done by heating to a dull red and then plunging the stock into cold water. Annealing steel is done by heating the stock carefully and slowly and letting it cool gradually. Great care must be used to prevent overheating, and if you happen to overheat your work, it must be rehardened and repolished before attempting to temper it again. For the student, tempering is best done with an alcohol lamp, observing the colors which appear on the highly polished surface of the work.

Colors appearing when tempering	Degrees Fahrenheit (Average)	Tools
Light Yellow	430	Tools for cutting steel
Light Straw	460	Tools for cutting brass, nickel, gold and silver.
Medium Straw	470	
Dark Straw	480	
Reddish Purple	525	
Bluish Purple	550	
Blue	570	Click springs, set levers, balance staffs, pinions, arbors, screws etc.
Gray Blue	600	Soft

Fig. 27-16

The chart in figure 27-16 gives the temperature in Fahrenheit of the different tempers and the tempers to be used with the different tools and springs used by the watchmaker.

The first color to appear when annealing is a very light yellow which is barely visible. It is hard to differentiate between this light yellow and the succeeding light straw color. As you can ascertain by the chart in figure 27-16, the jewelling tools will be tempered to a medium or light straw. Figure 27-17 illustrates how this can be obtained when heated slowly over the

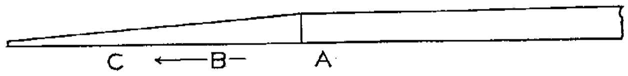


Fig. 27-17

flame of an alcohol lamp. Heat slowly the heaviest part first as at **A**. As the first color appears, move gradually in the direction of Arrow **B** until Section **C** is the desired color. The fact that from **B** to **A** may be a purple or blue is an advantage, as this part of your tool will be tougher. After the desired color is obtained, repolish and mount in small graver handle.

SEC. 465—Making an Iron Grinding Slip

For the purpose of grinding both square and cone shaped pivots, we will make an iron grinding slip as shown in figure 27-18. File one long edge at an angle of approximately 15 degrees,

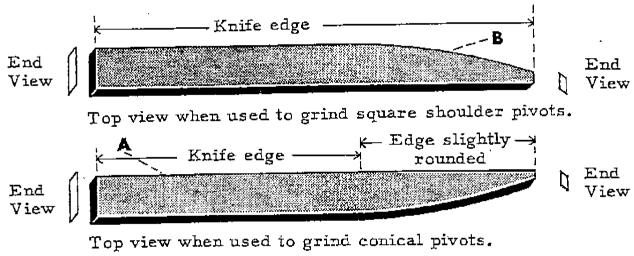


Fig. 27-18

but curved as shown at B. File the other edge **A** at the same angle. Finish by leaving No. 2 emery buff marks on both top and bottom flat surfaces at right angles to the filed edges.

SEC. 466—Hardening and Tempering Small Springs

Watchmakers can usually purchase all the necessary springs such as click springs, clutch, and lever springs, etc. It is also possible to ob-

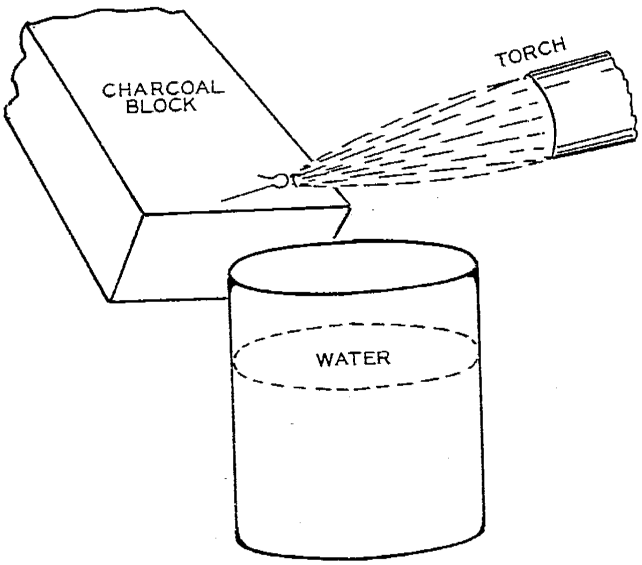


Fig. 27-19

tain click spring wire of assorted widths and diameters from which the watch repairman can shape his own springs. There are times when this is necessary, especially for old watches. At times it is necessary to alter the shape of the spring slightly in order to get the proper results. In order to reshape or form a new spring, proceed as follows:

1. Heat spring to a dull red and let cool slowly. This will anneal the spring.
2. Shape the spring to the desired form.

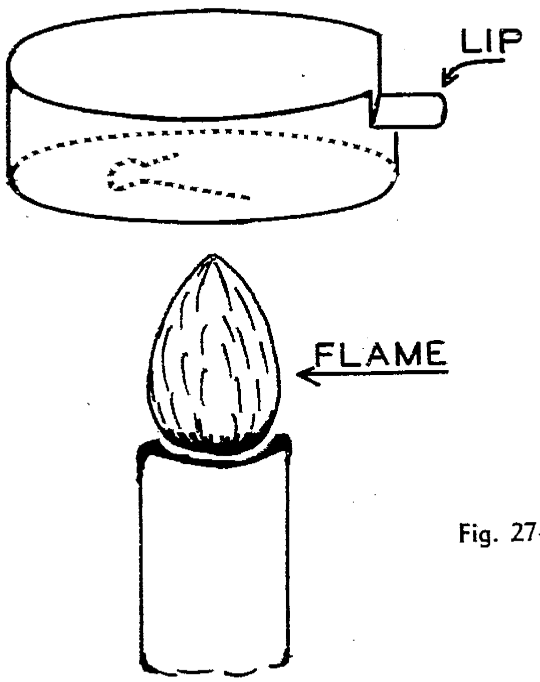


Fig. 27-20

3. Cover with soap and press lightly into a charcoal block, figure 27-19.
4. Heat spring to a bright cherry red with a blow-pipe or small torch.
5. Strike edge of charcoal block against the edge of a jar containing cold water. This will project the spring into the water and if properly executed, the spring will be "glass hard."
6. Remove and carefully polish the end of spring with your emery buffs.
7. Select a small material box and break the edge with a pair of flat nose pliers forming a small lip as in figure 27-20.
8. Place the spring in box and grasp lip with a pair of soldering tweezers and move box rapidly back and forth over the flame of an alcohol lamp.
9. Observe carefully until polished section turns blue and remove from the flame.

The above method can be used for annealing and tempering all small parts.

SEC. 467—Duplicating Broken Levers, Etc.

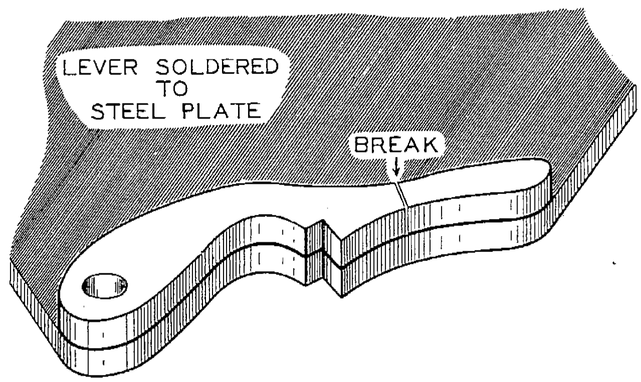


Fig. 27-21

Sometimes it is necessary for the watchmaker to make a small detent or lever. Figure 27-21 illustrates a broken clutch lever soft soldered to a piece of high grade steel. The two pieces can be matched perfectly in this manner and an outline made with a fine saw and finished carefully with small files of various shapes. The hole is also drilled at this time. After this much has been shaped, the process can be repeated on the back edge. Separate by heating over an alcohol lamp. Finish the top and bottom with emery and harden and temper to a blue. (Section 466).

SEC. 468—Soft Solder

Soft soldering is rarely used in watch repair work. Soft soldering a lever to a piece of steel as shown in figure 27-21 is permissible, however. To do the job properly, brighten the surfaces of the lever and the steel plate which come in contact with each other, using a fine file or emery. Cover each of the brightened parts with a soldering flux and a small amount of soft solder. Heat each part separately over an alcohol lamp until solder melts, and brush off the surplus solder while hot with a hard watch brush. This should leave each surface with a thin covering of solder. Put additional flux on steel plate, put lever in place, and reheat until solder turns bright. At this temperature the broken parts can be maneuvered into position. Set aside and let cool before proceeding with the shaping process.

SEC. 469—Soldering Bits in Enamel Dials

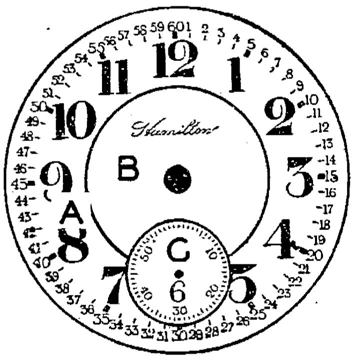


Fig. 27-22

The enamel dials used on high grade watches are usually made of two or three separate pieces which are soft soldered together. Such dials are known as **double sunk** dials. These different sections are shown in figure 27-22 at **A, B** and **C.** Figure 27-23 shows a single sunk dial with the two sections labeled **A** and **B.** The center bit and second bit are held in place with a special soft solder. This solder can be made of 3 parts of lead, 5 parts of tin, and 8 parts of bismuth. Figure 27-24 illustrates where the solder is placed. The copper center of the dial which is illustrated in the left half of the illustration is

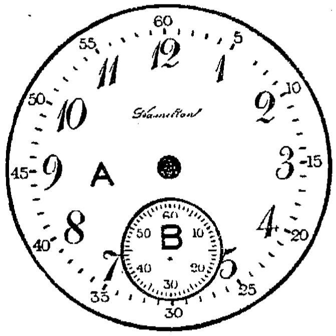


Fig. 27-23

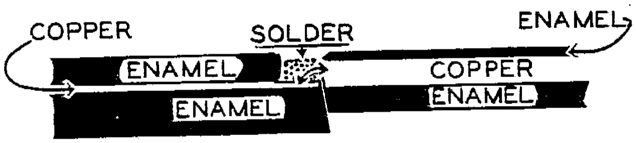


Fig. 27-24

represented by a thin white section extending beyond the upper section of enamel. The bit represented in the right half of the illustration shows the copper center of the bit in white. The edge of this bit must be brightened with a file as must the copper ledge of the dial. The solder is made to flow in the groove fusing the copper centers together as shown, which will hold the bit securely in place. Flux must be applied before soldering. The dial may be placed on a copper plate and warmed carefully until the solder starts to flow. Use a small brush and while the dial is warm, brush the solder around the groove as shown by Arrows **A** and **B,** figure 27-25. Be certain that the solder is below the enameled surface. Clean all solder-ing flux off with water and dry carefully with a clean, lintless cloth.

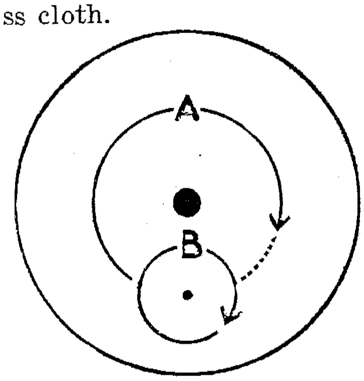


Fig. 27-25

CHECK YOURSELF

Progress Check 27 — A Self Test Review of Lesson 27

After you have studied Sections 460 through 469, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of the test. If you miss any, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or phrase in the blank spaces.	Section Ref.
1. The jeweler's saw differs from ordinary saws in that the teeth point ______________ and sawing is done on the ______ stroke.	461
2. In polishing steel with emery buffs, start with No. ________ and end with No. ________ .	461
3. Brass and precious metals are polished with ______________ and ______________ .	461
4. Flat filing is done in a ______________ direction.	461
5. High carbon steel is used in watchmaking because it can be ______________ .	461
6. Steel to be hardened is best protected from burning with ______________ .	463
7. Testing with a _______ will show if steel is hard.	463
8. Metals are toughened by ______________ .	464
9. The proper degree of tempering is indicated by the ______________ of the metal when it is heated.	464
10. An iron grinding slip is used to grind ______________ and ______________ .	465
11. The first step in altering a spring is to ______________ it.	466
12. Duplicating broken small levers is usually done by ______________ ______________ the lever to a piece of high grade steel before ______________ .	467
13. Double sunk dials have ______________ sections held together with ______________ .	469

ANSWERS TO PROGRESS CHECK 27

1. Toward the handle
down
2. 2
4/0
3. tripoli
rouge
4. diagonal
5. hardened
6. powdered boric acid
7. file
8. annealing and
tempering
9. color
10. square
cone shaped pivots
11. anneal
12. soft soldering
shaping
13. two or more
soft solder

LESSON	27
GRINDING SLIP	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L27-J1

HOW TO MAKE A GRINDING SLIP.

Tools, Equipment and Supplies:

Bench Vise   Flat File (5-8 inches)   No. 2 Emery Buff   1 piece Flat Iron

PROCEDURE: | REFERENCE:

1. Clamp flat iron in vise. — Sec. 465

2. File the top edge to an angle of 15 degrees by filing forward (away from yourself). Start at your left and work to the right. As you near the right side, bear down harder on the file to round the edge, as at B, Fig. 27-18.

3. Turn the slip over and file what is now the top edge straight across at an angle of 15 degrees. The small end of the slip should now look like this: 

4. Draw file all four sides to get a smooth finish. (Draw filing is finishing a surface by rubbing it lengthwise with a file held crosswise to the length of the work.)

5. Finish by cross filing the two broad flat surfaces with No. 2 emery. This slip is used to apply grinding compound as illustrated and explained in Lesson 31, Sections 521 and 522, and Figures 31-5 and 31-15. The very fine, shallow grooves left by the emery are to hold the compound. — Secs. 521 and 522, Lesson 31

6. Do not try to temper this grinding slip. Iron cannot be tempered.

Detach page or cut along this line and send to the School when you send work for inspection.

Job Inspection Request

CHICAGO SCHOOL OF WATCHMAKING
310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

The simple tools which you will learn to make in this lesson from the materials furnished to you should be inspected by your instructor before you attempt to use them to be sure you have made them correctly.

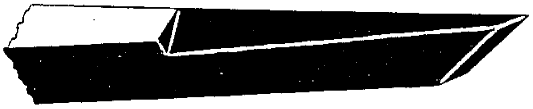
Student No. __________ Date __________

Name	
Address	
City State Zip Code	

Chief Instructor
Chicago School of Watchmaking

Please inspect and approve these tools I have made:

( ) STRIPPING TOOL (Sec. 462)



____ Satisfactory.

____ Unsatisfactory.
(Marked in red)

____ Should be rehardened and drawn to proper temper.

Other Suggestions: ____________________

( ) JEWEL SEAT CUTTING TOOL (Sec. 462)

____ Satisfactory.

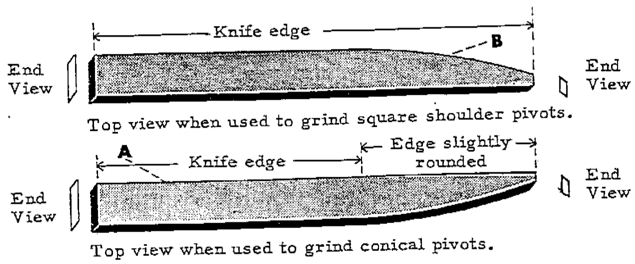
____ Unsatisfactory.
(Marked in red)

____ Should be rehardened and drawn to proper temper.

Other Suggestions: ____________________

(Please turn over)

( ) GRINDING SLIP (Sec. 465)



____ Satisfactory.

____ Unsatisfactory.
(Marked in red)

____ Not flat. Both broad surfaces should be perfectly flat.

____ Finish is too coarse.

Other Suggestions: ____

____

Detach page or cut along this line and send — with your work to the School for grading.

CHICAGO SCHOOL OF WATCHMAKING

Proficiency Exam No. 5

A test of your Master Watchmaking Shop Skills.

Student number ________________ Date ________________

Name	
Address	
City State Zip Code	

This examination covers the practical work for:

Lessons 27 through 31.

You may send in this examination any time after you have completed study of the lessons above up to 3 years from your date of enrollment.

YOUR GRADE: ________________

Certificate Awarded: ________________

PURPOSE OF THIS EXAMINATION: To check your ability to use a watchmaker's lathe in a professional manner.

THIS EXAMINATION IS REQUIRED of all students aiming for a diploma. Students who satisfactorily complete the required work of this examination will be awarded a special Certificate of Proficiency for lathe work.

YOU WILL FIND IT HELPFUL to have the iron grinding slip, stripping tool and seat cutting tool you were instructed to make in Lesson 27. YOU MUST HAVE the steel burnisher from Lesson 29 for this examination. These tools should be checked by us before you try to use them as it is important they be correctly made. Job Inspection Requests are included in Lessons 27 and 29 for this purpose.

MATERIALS for these tools and the other requirements of this Examination are included with this study group of lessons, except jewels. You received the jewels with Lessons 12 through 14, where you identified them.

REQUIRED TO BE SENT IN FOR EXAMINATION: (Errors will be marked on drawings in red.)	Possible Score:	Your Score:
1. Make and sharpen a flat drill. (Assignment 93, Lesson 29.)	5	______

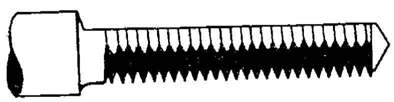
Materials required: 2 mm round steel (drill rod)

_____ Satisfactory

_____ Unsatisfactory

2. Make a tap. (Assignment 94, Lesson 29.)	10	______

Materials required: 2 mm round steel (drill rod)



_____ Satisfactory

_____ Unsatisfactory

(Please turn over)

	Possible Score:	Your Score:
3. Set a train jewel in setting. (Assignments 96 and 97, Lesson 30.)	10	______
4. Set a balance jewel in setting. (Assignment 98, Lesson 30.)	10	______
5. Set a cap jewel in setting. (Assignment 99, Lesson 30.)	5	______

3. Set a train jewel in setting. (Assignments 96 and 97, Lesson 30.)

   Materials required: 4 mm round half hard brass.
   Train or plate jewel.

4. Set a balance jewel in setting. (Assignment 98, Lesson 30.)

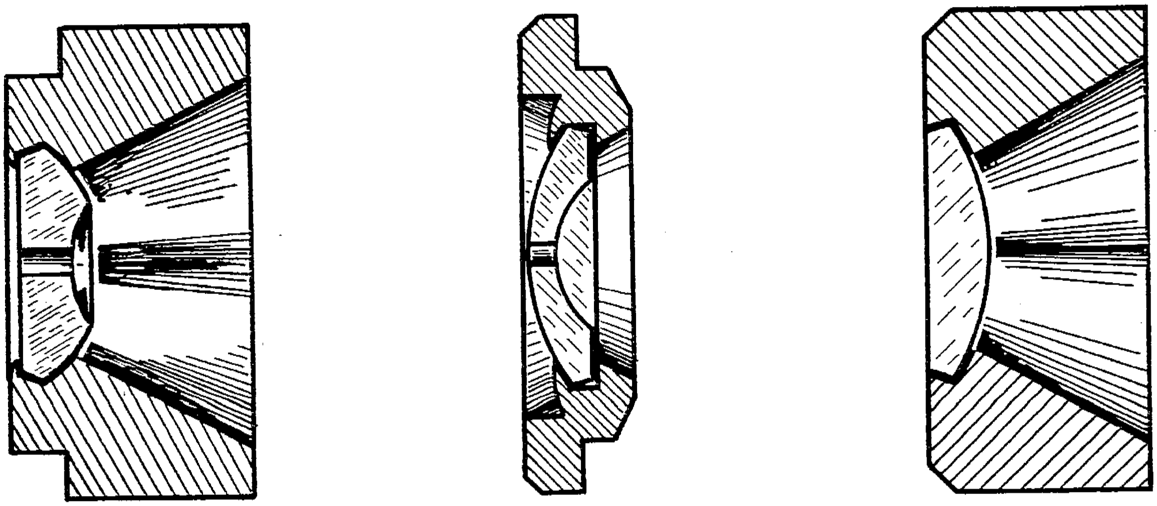
   Materials required: 4 mm round half hard brass.
   Balance hole jewel.

5. Set a cap jewel in setting. (Assignment 99, Lesson 30.)

   Materials required: 4 mm round half hard brass.
   Cap jewel or endstone.

POSSIBLE FAULTS:	Train Jewel	Balance Jewel	Cap Jewel
Jewel broken or chipped.			
Jewel tilted.			
Jewel too deep.			
Jewel not deep enough.			
Jewel off center. Setting not centered on cement brass.			
Stripping not smooth. Tool not sharp.			
Not stripped deep enough.			
Stripped too deep.			
Setting not clean.			
Not faced off flush with jewel.			
Countersink shoulder not deep enough.			
Countersink shoulder too deep.			
Setting not flush with surface of plate.			
Too little endshake.			
Too much endshake.			

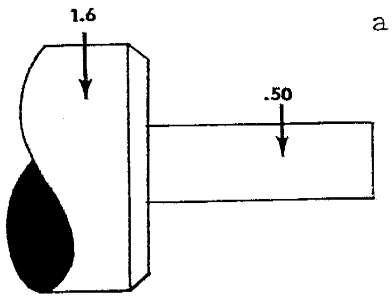
Note: Each step in setting jewels is important and depends on the others being correct. A beautiful setting with a tilted jewel would not work in a watch; therefore, it is unsatisfactory. So it is with all phases of setting jewels. It is either all right or all wrong. This is precision work which requires that you skillfully handle the lathe and lathe tools.



 | Name: | Student number

	Possible Score:	Your Score:
6. Make a square shoulder pivot with a diameter of .50 mm. (Assignment 103, Lesson 31.)	5	_____

Materials required: 1.6 mm round steel (drill rod) which has been hardened and tempered to a blue.

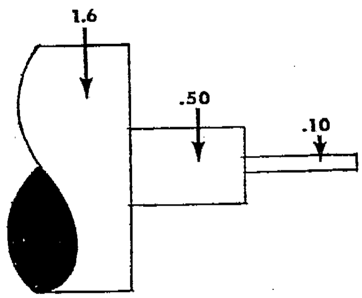


_____ Satisfactory

_____ Unsatisfactory:
____ Shoulder not squarely cut.
____ Not properly ground.
____ Not properly polished.
____ Wrong dimensions.

7. Make a square shoulder pivot with a diameter of .10 mm. (Assignment 103, Lesson 31.)	5	_____

Materials required: 1.6 mm round steel (drill rod) which has been hardened and tempered to a blue.

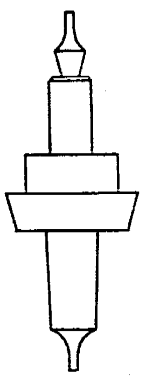


_____ Satisfactory

_____ Unsatisfactory
____ Shoulder not squarely cut.
____ Not properly ground.
____ Not properly polished.
____ Wrong dimensions.

8. Make a balance staff to the dimensions given for a 16 size balance. (Part 2 of Assignment 106, Lesson 31.)	30	_____

Materials required: 2 mm round steel (drill rod) which has been hardened and tempered to a blue.



_____ Satisfactory.

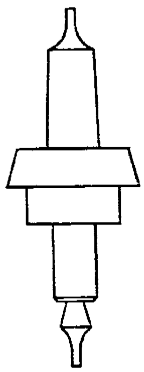
_____ Unsatisfactory:
____ Shoulders not squarely cut.
____ Cone pivots:
  ____ Too long.
  ____ Too short.
  ____ Not in proportion.
____ Not properly ground.
____ Not properly polished.

(Please turn over)

Cut along this line and send with your work to the School for grading.

	Possible Score:	Your Score:
9. Alter the sample staff furnished with this group of lessons as follows:		
Reduce diameter of upper pivot to 11/100 mm. Reduce diameter of lower pivot to 11/100 mm. Reduce diameter of roller seat to 58/100 mm at the hub and 56/100 mm at the cone.	10	______

Note: See Job Sheet L31-J1 in Lesson Manual 31.

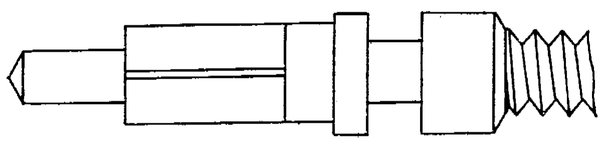


____ Satisfactory.

____ Unsatisfactory:
- ____ Wrong measurements
  - ____ Upper pivot
  - ____ Lower pivot
  - ____ Roller seat
- ____ Pivots not properly polished.
- ____ Shoulders not kept square.

	Possible Score:	Your Score:
10. Make a Swiss type stem using measurements given in Assignment 110, Lesson 31.	10	______

Materials required: 2 mm round steel (drill rod).



____ Satisfactory.

____ Unsatisfactory:
- ____ Threads not cut deep and clean.
- ____ Shoulders not squarely cut.
- ____ Slot in hub not cleanly cut.
- ____ Square of stem not filed square.

End of Proficiency Exam No. 5

( ) Check here if you want us to send you the lathe work portion of the Final practical exam at this time.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 27

Name: No.: Date:

Circle ONE correct answer: SUBJECT: Tools - Hardening and Tempering

1. Which one of the saw blades listed below has the coarsest cut?

4/0	3	2	0

2. The teeth of the jeweler's saw blade should point:

Away from the handle for cutting soft metals	Away from the handle for cutting steel	Toward the handle for all types of cutting	Away from the handle for all types of cutting

3. When polishing a piece of steel after it has been filed, which of these procedures is <u>incorrect</u>?

Use remaining buffs in correct order, removing marks left by each preceding buff	Use of buffs #2, 1/0 and 3/0 is usually sufficient	Use buff #2 until all file marks are removed	Clean work between use of each buff

4. Which one of the following statements on filing is true?

The teeth of the ordinary file cut when the file is moving backward	The teeth of most files cut in either direction	The file should be kept on the work during the return stroke	The filing stroke should be in a diagonal direction

5. Which one of the following statements on hardening tools is true?

Place a jar of warm water near the burner	Heat the tool to a sparkling white heat	Wet the tool and dip into powdered boric acid	Wet the tool and dip into powdered borax

6. The way to tell if steel is properly hardened is by:

Its appearance while hot	Its appearance after cooling	Testing it with a file	Its color

7. The process of annealing a tool is sometimes known as:

Polishing	Shaping	Hardening	Tempering

8. The jeweling tools discussed in this lesson should be annealed to a:

Dark straw	Light straw	Blue	Purple

9. After annealing and reshaping a click spring and before heating to reharden, cover the spring with:

Oil	Soap	Bowdered borax	Powdered boric acid

10. After hardening the spring and polishing the end, heat it in a small material box until the polished section turns:

Blue	Reddish purple	Dark straw	Light straw

11. Which of the following is the correct procedure when making a detent or lever?

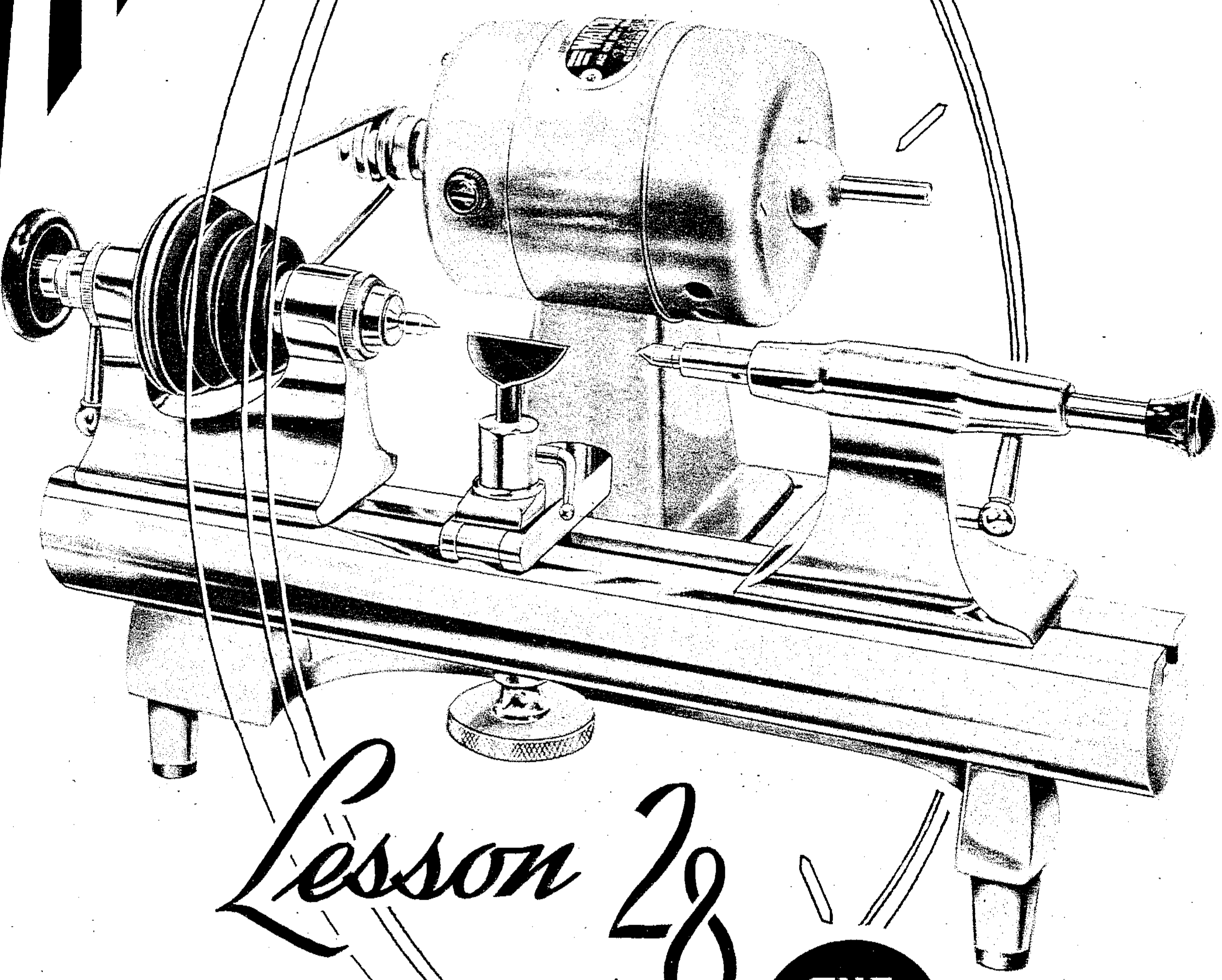
Shape from soft steel; harden and blue, and drill hole	Shape from soft steel; then solder to steel plate	Harden and blue first; then shape	Saw and file into shape and drill hole after making outline

12. In watch repair work, soft solder is used:

To repair levers or springs	Rarely	To repair hands	To fill in worn places in watch parts

Detach page or cut along this line and send to the School for grading.

Master Watchmaking



Lesson 28

THE LATHE

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

68-28 REVISED 1968 Printed in U.S.A.

INTRODUCTORY INFORMATION

The present state of perfection in watches depends to a great extent upon the accuracy of the tools used to produce and repair them. One of the most important and useful tools is the watchmaker's lathe. So many repair jobs are best done or quickest done upon a lathe, that lathe work is a necessary and basic part of the modern repairman's training. It takes skill to use a lathe and its accessories properly. These lessons are designed to develop that skill if you will study them well and follow up your study with lots of careful practice.

KEY POINTS OF LESSON ASSIGNMENTS 88, 89:

- How to care for your lathe.
- Nomenclature of the watchmaker's lathe.
- How to adjust the T-rest.
- How to mount the watchmaker's lathe.
- The lathe motor and rheostat.
- How to hold work in the lathe.
- How to sharpen the square graver.

ASSIGNMENT NO. 88: Study Sections 475 through 482.
Read Tools and Materials of the Trade, pages 26 through 32.

Study Questions:

1. What are some uses for the watchmaker's lathe?
2. What are the principal parts of the lathe?
3. What is the advantage of the tip-over T-rest?
4. What is the purpose of the rheostat?
5. What is the purpose of the split chuck?
6. How is the size of the opening determined?

Recommended:

Prepare a working surface of convenient height and set up your lathe. Oil the lathe and motor and wipe clean with a piece of lintless cloth. Make it a habit to oil the lathe each working day. Place belt in position and adjust.

NOTE: If you are using plastic belting and it breaks, you can repair it in this way: Apply heat to ends of plastic belt until they soften. Press ends firmly together until they have cooled. Either an electric soldering iron or a flat piece of metal, such as a knife blade, which has first been heated, may be used to apply the heat to the belt ends.

Required:

Study the nomenclature of the lathe in Figure 28-1. If you have a lathe at hand, locate these parts on your lathe.

ASSIGNMENT NO. 89: Study Sections 483 and 484.

1. What is the most common graver?
2. What is the best lubricant to use on your oilstone?
3. At what angle should the face of the graver be sharpened?
4. What is the quickest method of testing the point of your graver?

Recommended Practice:

Mount graver in handle. Practice sharpening graver, using the coarse side of the stone. Finish on the smooth side. If using a graver sharpener, place the graver in sharpener in such a position as to form approximately a 45 degree angle between the face of the graver and the stone. Keep oilstone well lubricated. Remove burrs. This can be done by plunging the graver point into a piece of hard wood. Test point as shown in Figure 28-15. It is important to keep a sharp point on your graver at all times, so make it a habit to test frequently and resharpen if necessary. You may have to resharpen your graver several times during one project while learning.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 28 and return for grading.

SEC. 475 — The Watchmaker's Lathe

In the lessons so far you have been shown some of the practical work of watch repairing without the use of that very important part of the expert's equipment—the watchmaker's lathe.

Before proceeding with the more advanced problems in watch repairing, it is essential that you be able to cut square shoulders, polish pivots, reset jewels, turn down jewel settings, fit balance staffs and pinions, and do numerous other jobs that can only be accomplished on an accurately made lathe of proper size and with sufficient equipment.

Very few people outside the profession know the part which this tool plays in the delicate work of creating the timepieces of today. In its present perfection, the modern lathe combines a degree of accuracy and ease of operation undreamed of by the old masters who toiled long and laboriously to accomplish what today's Master Watchmaker is able to do in a few moments with the aid of his ever-ready lathe. Many do not realize that with a first class lathe and its attachments such as should be found on every Master Watchmaker's bench, the expert workman is able to make a complete watch capable of keeping the most accurate time. While the modern lathe will accomplish such work in skilled hands, the mastery of it cannot be acquired by merely studying from any text book. However, as in any other watchmaking projects, only by constant and consistent practice can the beginner hope to become expert.

Through abuse, a lathe may be easily thrown out of its fine adjustments or out of true as to be practically worthless for the fine work for which it is intended. For this reason, it is best for the beginner to secure a new lathe and attachments and thus have the pleasure of working upon one that is capable of doing the highest grade of work. When you purchase a second hand lathe, you have no means of telling how much it has been abused or how much it is out of true. Only an expert has the equipment and ability to make the proper tests necessary to insure you against trouble when purchasing such second hand equipment. A lathe that has been ruined by improper handling is a handicap to good work that is mighty hard to overcome.

With proper handling, a well made watchmaker's lathe is good for a lifetime of service. For this reason, you should treat your lathe with the care to which it is entitled, keeping it clean and oiled at all times and never allowing any person unskilled in its use to try it out or play with it.

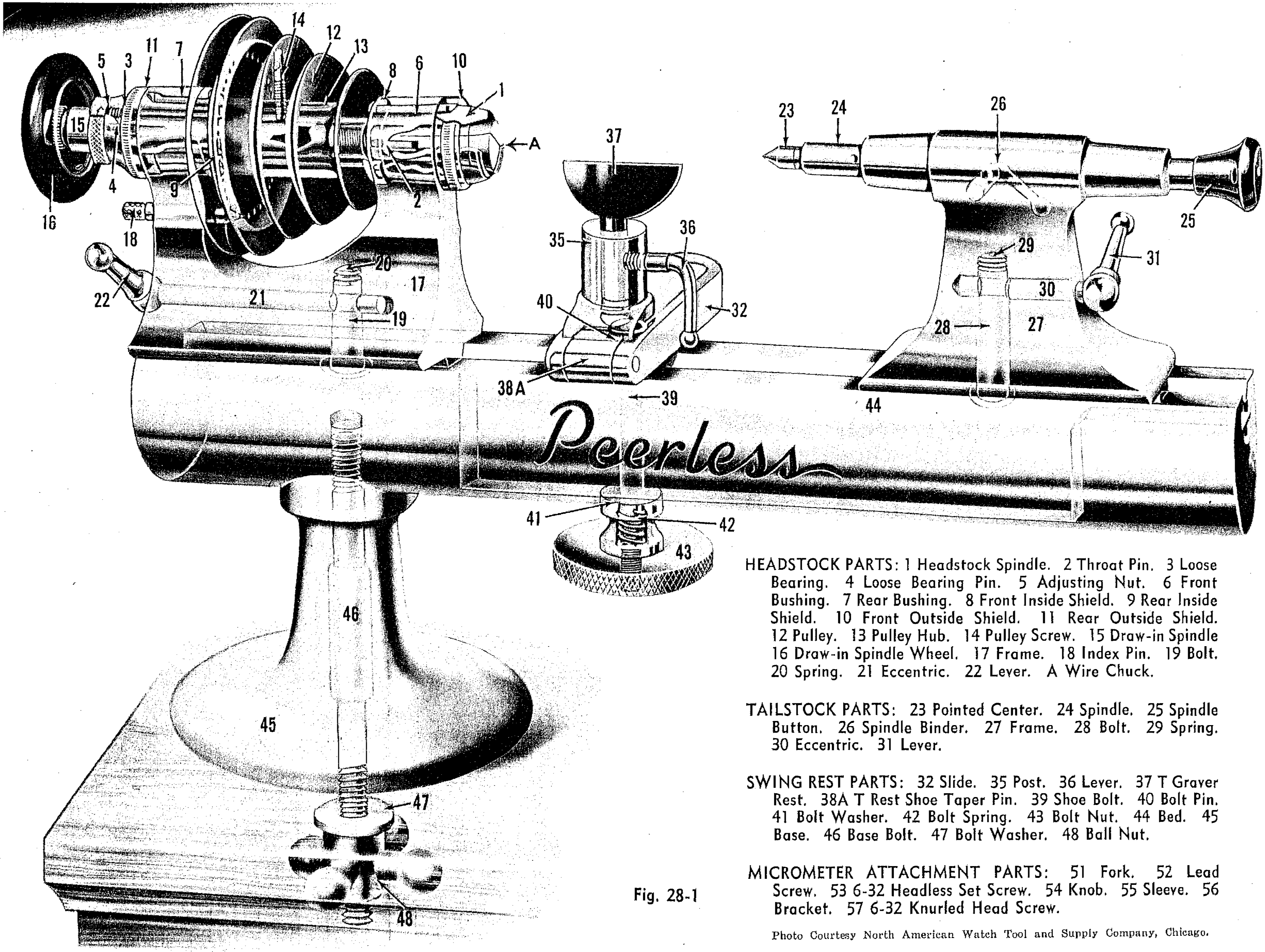


Fig. 28-1

HEADSTOCK PARTS: 1 Headstock Spindle. 2 Throat Pin. 3 Loose Bearing. 4 Loose Bearing Pin. 5 Adjusting Nut. 6 Front Bushing. 7 Rear Bushing. 8 Front Inside Shield. 9 Rear Inside Shield. 10 Front Outside Shield. 11 Rear Outside Shield. 12 Pulley. 13 Pulley Hub. 14 Pulley Screw. 15 Draw-in Spindle 16 Draw-in Spindle Wheel. 17 Frame. 18 Index Pin. 19 Bolt. 20 Spring. 21 Eccentric. 22 Lever. A Wire Chuck.

TAILSTOCK PARTS: 23 Pointed Center. 24 Spindle. 25 Spindle Button. 26 Spindle Binder. 27 Frame. 28 Bolt. 29 Spring. 30 Eccentric. 31 Lever.

SWING REST PARTS: 32 Slide. 35 Post. 36 Lever. 37 T Graver Rest. 38A T Rest Shoe Taper Pin. 39 Shoe Bolt. 40 Bolt Pin. 41 Bolt Washer. 42 Bolt Spring. 43 Bolt Nut. 44 Bed. 45 Base. 46 Base Bolt. 47 Bolt Washer. 48 Ball Nut.

MICROMETER ATTACHMENT PARTS: 51 Fork. 52 Lead Screw. 53 6-32 Headless Set Screw. 54 Knob. 55 Sleeve. 56 Bracket. 57 6-32 Knurled Head Screw.

Photo Courtesy North American Watch Tool and Supply Company, Chicago.

SEC. 476 — Lathe Nomenclature

The new lathe as it comes from the dealer may be already assembled or it may come "knocked down" for packing, in which case the different parts are assembled but not located in their places on the bed. Figure 28-1 shows a modern American-made lathe together with its nomenclature. The following lists the most common parts:

44 Lathe bed
17 Frame and headstock
A Chuck
15 Draw in spindle
16 Draw in spindle wheel
18 Index pin
12 Pulley
37 T Rest—tip-over style
39 Shoe bolt and bolt nut (43)
43 Bolt nut
27 Tail stock frame

On the bottom of the head stock at **19** is a bolt with **T** head which fits into the slot in the bed. This bolt is controlled by the locking lever **22.** Turn this locking lever until the head of the bolt is at its lowest point and then slide the headstock on the left side of the bed as shown, figure 28-1, the throat in which the chuck **A** fits being toward the right. The draw in spindle **15** is inserted in the left end of the lathe spindle. The index pin **18** fits in the hole found in the headstock but it is not necessary to have this in place at this time, but rather keep it in your chuck box.

Before attempting to assemble the bed plate, notice that the washer at **41** is counterbored to permit a coiled spring to be placed between this washer and the hand wheel nut **43.** It is essential that this spring be in place when these parts are assembled on the bed. The coiled spring keeps a tension on the bolt and prevents to a great extent the danger of the key getting out of its seat. The base of the T rest has a slot which fits over the head of the bolt projecting above the bed plate and the next step is to slip this into place. Loosen the nut enough so that by pressing up on the bolt to overcome the tension of the coil spring, it is possible to slip the T rest into place on the bed plate. Tightening the nut at the bottom permits you to secure the base of the T rest firmly in place on the bed plate and your assembly will appear as in figure 28-1. The tailstock is placed on the right side of the bed, securing in place with a locking lever as was done with the headstock, but it will not be necessary to use this tailstock at this time.

SEC. 477—The T Rest

On the older model lathes, the T rest was stationary and each time the watchmaker wished to check a measurement and the T rest interfered, it was necessary to loosen the hand nut and move the entire T rest, after which it was again adjusted to the proper position and secured in place by turning the hand nut. The modern tip-over T rest is a great timesaver when compared with the old model. After it is once adjusted to position, it is not necessary to disturb that adjustment. The T rest can be tipped back out of the way, the measurement or fitting tested and the T rest tipped back into its original position.

SEC. 478 — Mounting The Lathe

In mounting a lathe on your bench for use with a motor, drill a hole of proper size to receive the bolt which extends down from the foot of your lathe. This hole for the average size person should be about six inches in from the left side of the bench top and the same distance from the front edge. Secure the lathe in position by means of the hand nut, placing an iron washer between the nut and bench top. If you are going to have the motor connected with the lathe, set the motor on the bench about 8 inches back from the lathe. If the motor is too far from the lathe, the belt is inclined to vibrate too much. See that the cone pulley on the motor is so placed that its largest diameter is opposite the smallest part of the lathe pulley. Have the axis of the motor parallel to the edge of the bench top and fasten in place by means of screws.

The lathe is connected to the motor by means of 1/8" twisted leather belting which is preferable to solid round belting. The stopping and starting together with the speed of the motor is governed by means of a foot control which is placed on the floor of the bench in such a position that it is easily reached. When properly connected, pressure on the foot control will start the motor and the further it is pressed down, the faster the speed. When the pressure is released, the current is shut off and the motor stops.

To connect motor and lathe, thread a piece of 1/8 inch twisted leather belting through the pulley of the lathe and then over the pulley of the motor. Let the belting rest in the middle groove of each pulley, pull it up rather tight and cut off so the ends of the belting will just come together without lapping. Have the ends of the belt cut off square and punch a hole in each end to receive the fastener which you can make from a piece of brass wire about 1 millimeter in diameter. The hole should be about 3 millimeters from the end and can be made by means of a broach or even a larger needle, twisting it around in the leather until it is of the right size to receive the wire.

Take a piece of one millimeter wire and with a flat or snipe nose plier shape one end as shown in figure 28-2, the space at **A** being slightly smaller than the diameter of the belting. The end forming the hook should be approximately 3 mm long. Make the next bend at **B** and the wire will appear as in figure 28-3. Make a bend at **C,** figure 28-3, at approximately a 45 degree angle. The wire should then appear as in figure 28-4. Flatten the ends of the belting and start the long end of the wire **D,** figure 28-4, through the inner side of the belt and pull wire through. Thread the belt through the lathe pully and push the long end of the wire D through the hole in the other end of belt and slide belt in place.

Before going further, slip belt over the two pulleys and see if you have the proper tension. If belt is too loose, it may be tightened by taking wire out of one end and then giving it a few twists, or untwist it a few turns to loosen it.

If tension is correct, bend the long end of the wire tight against the belt and cut off wire at **E,** figure 28-4. With the jaws of your flat pliers, press ends of clamps tight against the belt.

SEC. 479 — The Lathe Motor

Figure 28-5 shows a popular type of motor with foot control, which can be used in driving a lathe. These are usually universal motors, working on either AC or DC current with a voltage of from 110 to 130, and come already wired with separate types of plugs on the two free ends of the wire, one a standard plug which fits into the regular receptacle or base connec-

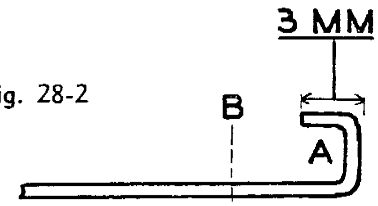


Fig. 28-2

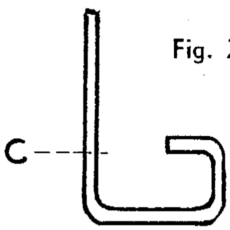


Fig. 28-3

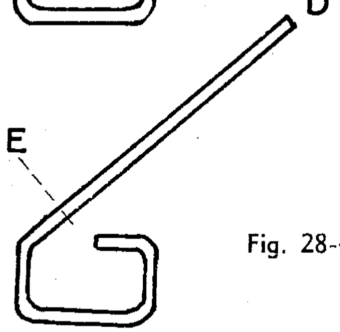


Fig. 28-4

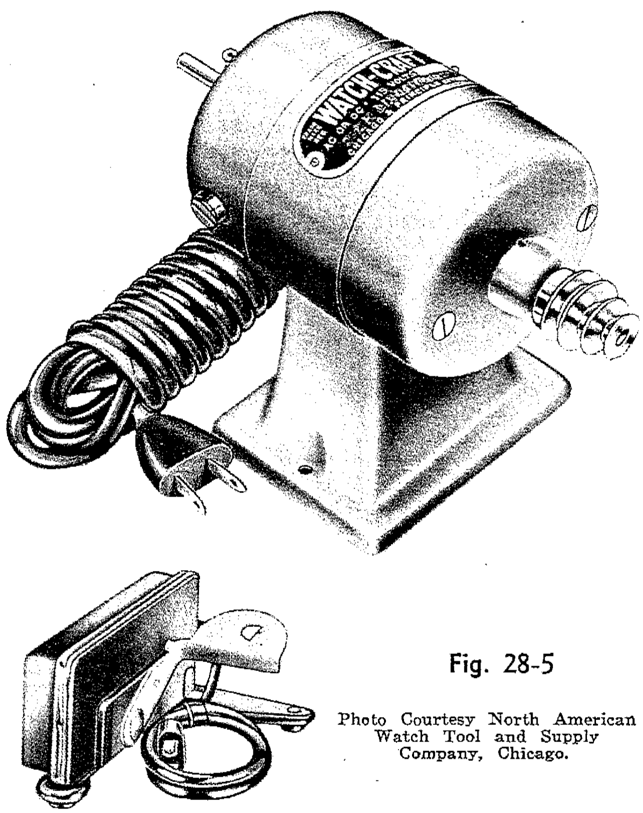


Fig. 28-5

Photo Courtesy North American Watch Tool and Supply Company, Chicago.

tion of the house or store current, the other a special plug which fits on the foot control or the connection to the motor, depending on style used. The stopping and starting together with the speed of the motor is governed by means of the foot control which is placed on the floor of the bench in such a position that it is easily reached. When properly connected, pressure on the foot control will start the motor and the further it is pressed down, the greater the speed. When the pressure is released, the current is shut off and the motor stops.

Sec. 480 — Oiling The Lathe

Now having set up your lathe and motor and tested the latter by making sure the electric current is on and properly connected and that the foot control is in working order, it is time to get a little better acquainted with the lathe. As the lathe comes from the factory, it generally is already oiled and greased to prevent rust but it does no harm to go over it again after wiping off all old grease and dust.

As stated before, a lathe as it comes from the factory is good for a great many years of every day service, provided it is properly cared for and never abused. One of the principal causes of lathe failures is a lack of oil and accumulation of dust and grit in the bearings of the head stock. You should always keep your lathe covered when not in use and once a day apply a light grade of oil on the bearings. It is better to apply too much oil than not enough. Push the dust caps at **10 and 11**, figure 28-1, far enough out to permit you to place several good sized drops from your oil can in the oil holes for the bearings. Have your lathe running at a moderate speed and apply oil until it forms a ring around the bearing. Let it continue to run for a half minute or so and then wipe off all surplus oil with a clean cloth. Press the dust caps firmly back in place and again wipe off any oil that may be on the surface.

On some lathes you will find a hole at the inside edge of the dust caps which can be turned until in line with the oil hole in the bearings, thus enabling you to oil the bearings without removing the cap. In others, the dust caps are split. In either of these types, be sure that the hole or the split portion is down to prevent as much as possible the entrance of dirt or grit into the bearings.

Apply a drop of oil on the draw in spindle at **15;** also a drop in the throat of the lathe spindle at **1,** figure 28-1.

SEC. 481 — Footwheels

If you are not convenient to a 115 or 120 volt AC or DC current, it is a very easy matter to arrange your lathe to be driven by a foot wheel. In fact, with a foot wheel driven lathe it is possible to do just as fine work as with a motor.

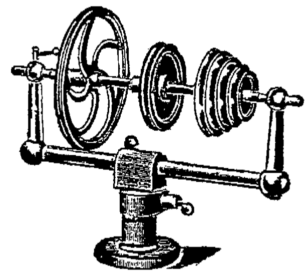


Fig. 28-6

In setting up a lathe with a foot wheel, it is better to use a counter shaft as shown in figure 28-6. The use of a counter shaft eliminates the moving belt that is right in front of you when you are working and also permits a variety of speed and the use of a speed wheel for special work which will be described further on in these lessons.

SEC. 482 — Chucks

Before the invention of the split chuck, any work which was to be turned in a lathe had to be held between centers or clamped on some form of face plate. The "fiddle bow" lathe, some of which are still in use, is an example of the dead center style of lathe. These lathes were generally small and held in a vise. The workman was compelled to use one hand to drive the lathe by means of the so-called fiddle bow, while with the other hand he manipulated the tool upon whatever piece he was working.

The modern watchmaker's lathe uses two general types of chucks for holding work—the hollow split chuck and solid chuck. Your first work will be with the split chuck, sometimes called wire chuck.

Figure 28-7 is an illustration of the conventional type of split chuck as used in the majority of watchmaker's lathes. It is split lengthwise at a trifle over half of its length, to form three

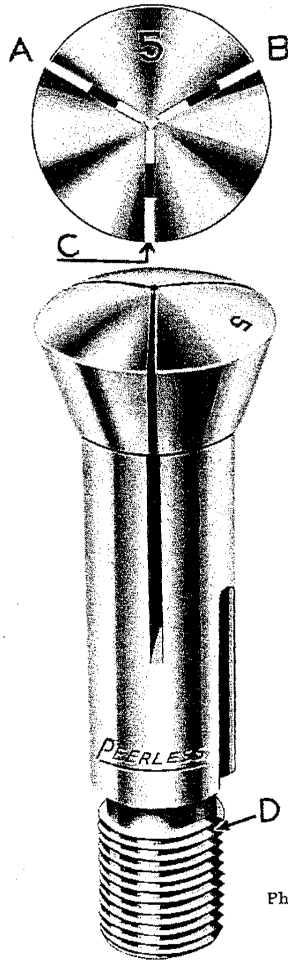


Fig. 28-7

Photo Courtesy North American Watch Tool and Supply Company, Chicago.

jaws at the face, these splits being shown at **A, B,** and **C.** This chuck fits into the spindle of the lathe and the object to be turned is held firmly in place by the compression of the three split portions. This is accomplished by means of the draw in spindle which fits on the threaded portion of the chuck at **D.** As the chuck is drawn into the throat of the lathe by means of the draw-in spindle, the jaws are forced toward the center and act as a clamp.

A properly made chuck is so tempered that the jaws will close equally when compressed by the draw-in spindle and care must be used to see that they are never sprung out of true.

On the face of each chuck is stamped its size, figure 28-8. This refers to the diameter of the opening in the jaws and this opening when received from the factory has been ground and lapped true and will remain in that condition if treated as it should be. For that reason, you should measure every piece which you wish to "chuck up" and select a chuck according to the measurement you find.

With some of the older lathes, the chucks were sized to match wire dimensions as found on a stubs gauge but this was not satisfactory to most watchmakers who were not accustomed to working with such a gauge and they found it somewhat confusing owing to the fact that the larger the number on a stubs gauge the smaller the size. Thus a wire that gauges 50 by stubs gauge measures about one and three-fourths millimeter while No. 20 wire would be a trifle over four millimeters in diameter.

The universal standard for marking and gauging chucks at the present time is one tenth of a millimeter. If the chuck is stamped 20, it means that its opening in the jaws is twenty tenths of a millimeter or 2 mm, No. 8 equals 8/10 mm, 16 equals 1-6/10 or decimally 1.6 mm, etc. This makes it very easy for the workman to select the proper chuck by merely measuring the piece he wishes to hold in the chuck, provided he has a millimeter gauge and knows how to use it.

If a workman has but a small assortment of chucks, he may be tempted to use one that is too large or too small and thus spring the jaws to such an extent that it will never run true.

For this reason, it is well to secure as large an assortment of chucks as you can afford when purchasing a lathe. For your preliminary lathe work, you can get along very nicely with 10 chucks but when you are prepared to do all kinds of watch repairing, do not have less than 24 split chucks beside the taper chuck and cement chuck which come with the lathe.

For a complete set of split chucks, one each of the following numbers is recommended: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 47, 48 and 50. This will insure your having a sufficient variety of split chucks for practically all ordinary watch work you may be called upon to do. Later you can add to these any which you may find necessary.

In the spindle of the lathe is a pin or key to match the slot or key seat shown at **2,** figure 28-1. It is necessary that the key seat in the chuck matches this key in the spindle when you place any chuck in the headstock of a lathe. Occasionally this key is worn or cut off by having a chuck forced into place but this can be avoided by anyone who will learn to seat each chuck properly.

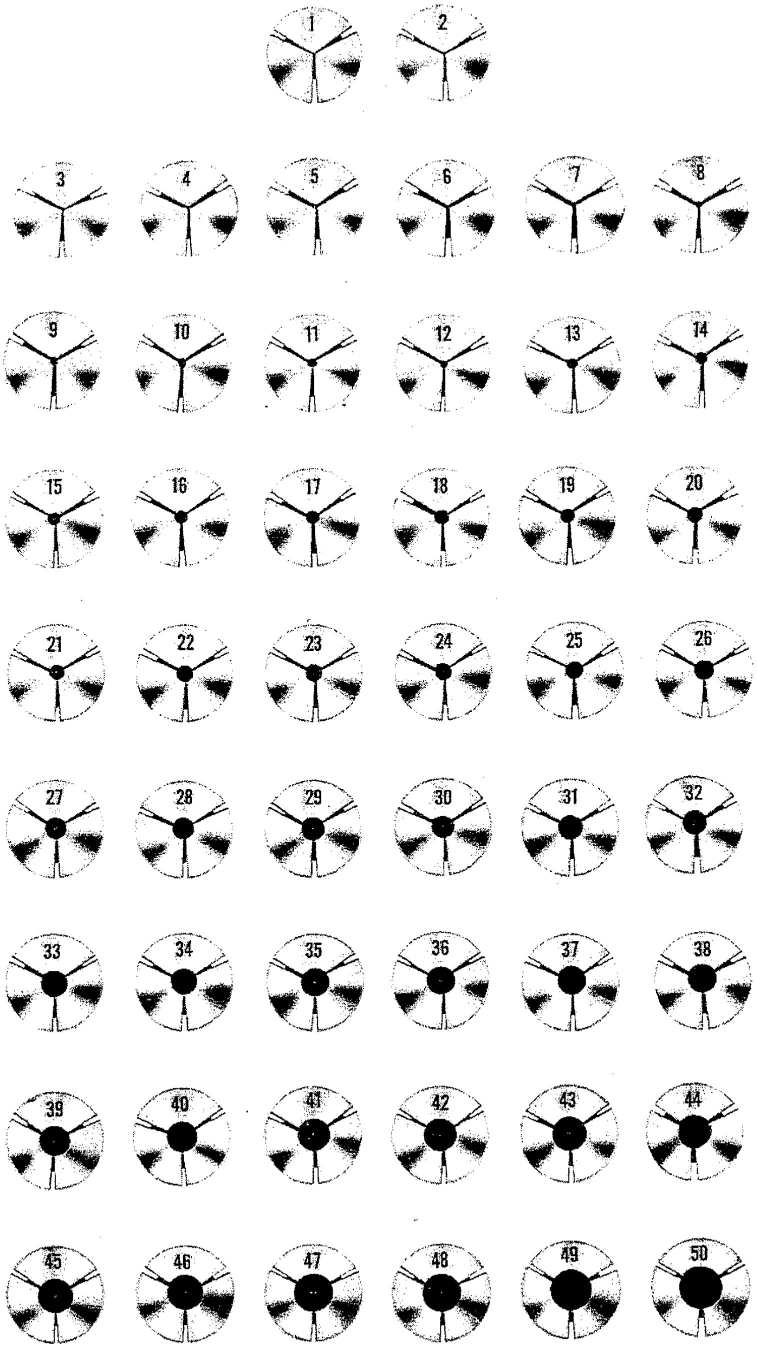


Photo Courtesy North American Watch Tool and Supply Company, Chicago.

Fig. 28-8

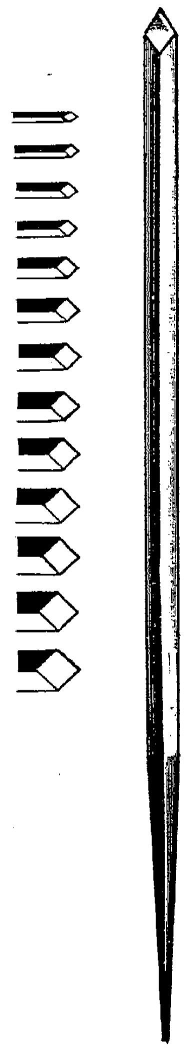


Fig. 28-9

Fig. 28-10

SEC. 483 — Types of Gravers

There are two common shapes of gravers used in turning, the square and lozenge or diamond shape as indicated in figure 28-9.

The square graver is most commonly used and it is this form that you will use in your preliminary lathe work. It can be had in different sizes but the most practical for all around work should be from 2½ to 3 mm square. As it comes to you it is about 5½ inches long and should be mounted in a handle before using. The most practical type of handle is shown in figure 28-10, a pivot graver handle. This is somewhat on the order of a file handle though shorter and about ¼" in diameter. These handles generally are drilled ready to receive the graver. In mounting the graver, it is only necessary to clamp the graver in a vise with the tapered end out and drive the handle down firmly in the graver. Some prefer to "burn in" the handle in which case the end of the graver protruding above the vise is heated to a red heat by means of a blow torch or bunsen burner and the handle driven on as before while the graver end is red hot. Care must be used to see that the balance of the graver is not heated enough to draw the temper on the cutting edge. You will find, however, that it will prove satisfactory to merely drive the handle on with heating provided you do not drive it hard enough to split the handle. A series of sharp taps is better than attempting to drive it down with one or two hard blows.

The new graver will be found to have the end cut off at about the correct angle but the edges are liable to be rather round and your first step after mounting will be to sharpen it ready for turning. To do this, you should provide yourself with a combination oil stone of good quality, figure 28-11, one side of which is coarse for rapid cutting and the other much finer for finishing. Be sure to use plenty of oil

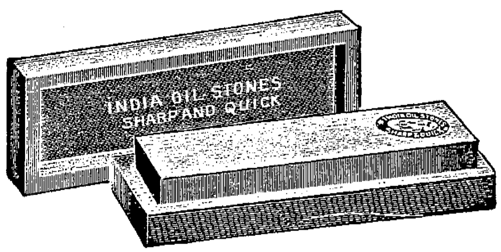


Fig. 28-11

on the stone when sharpening the graver in order to keep the surface in good cutting condition. If the stone is used dry, the small particles of steel ground off the tool will imbed themselves in the pores of the stone and in time the surface will become glazed and greatly hinder its use for sharpening. Plenty of the right type of oil will prevent this and keep the stone in first class condition. Never use a vegetable oil for this purpose, however. Ordinary kerosene will give very good results and it is well to have a bottle of this always at hand and keep the surface of your oil stone saturated with it whenever sharpening the tool. Thoroughly wipe off the stone when you are finished and thus have it clean and ready the next time it is used.

SEC. 484 — Sharpening the Graver

The angle of the cutting end of the graver should be about 45 degrees for the general run of lathe work as shown in figure 28-12. As received from the manufacturer, the graver is usually ground at about that angle but as stated

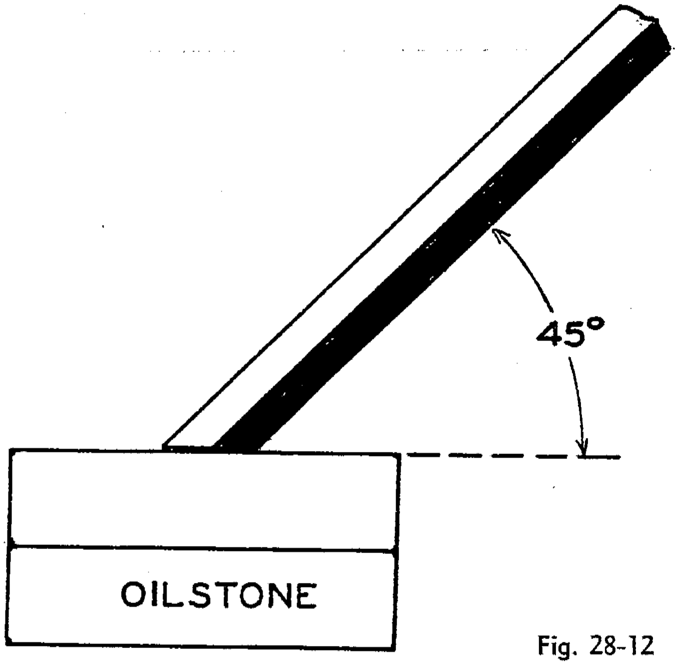


Fig. 28-12

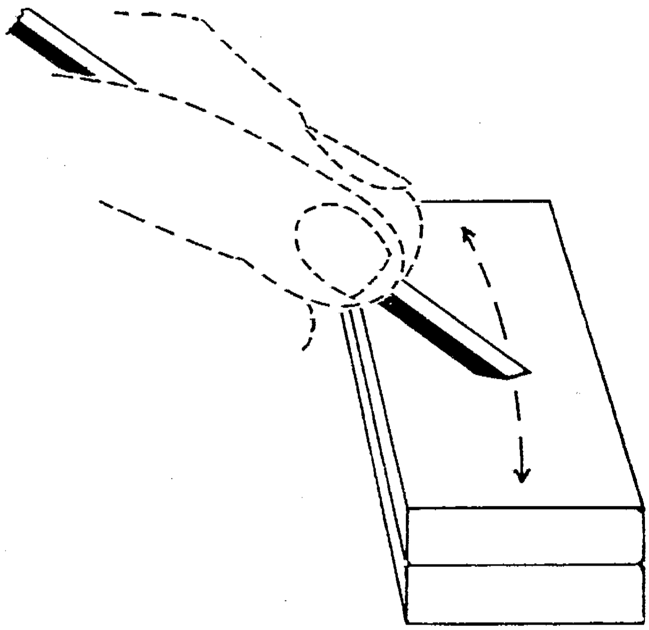


Fig. 28-13

before, it is too rough and should be resharpened on a fine oilstone. If you find this angle about correct, you need only smooth it upon the finer side of your combination oil stone. Place a liberal supply of oil on the stone and holding the graver as shown in figure 28-13, grind it by moving the hand steadily back and forth as indicated by the double headed arrow. The graver should be held so that an imaginary line down through the upper and lower angular corners of the tool will be at right angles with the surface of the stone. If the graver is twisted either to right or left, the result may appear as in figure 28-14. The beginner usually has a tendency to roll the handle slightly while moving it back and forth thus giving the face of the graver a convex surface instead of flat.

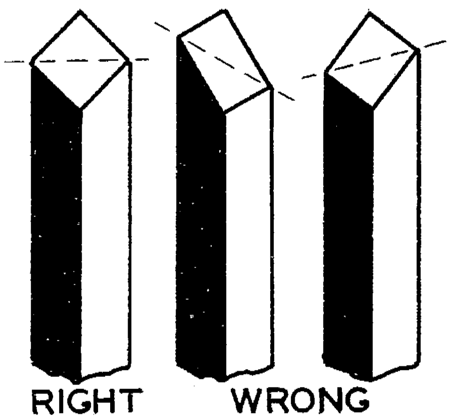


Fig. 28-14

The contact of the cutting edge and the moving piece generates heat, the degree being dependent upon the depth of cut and speed. To keep the tool as cool as possible kerosene or light oil is applied to its edge to carry off this frictional heat. With the old type of carbon steel cutters, the speed had to be kept slow enough to prevent them from losing their cutting temper. With some of the new alloy cutting bits, the cutting edge is retained even though the cutter reaches a red heat.

The greater portion of turning in lathe work as done by watchmakers is accomplished by hand tools and high speed with heavy cuts is not so essential.

Before applying the graver to whatever you may be turning, it is well to test the point of your graver. This may be done on your thumb nail. If you rest the point of a properly sharpened graver on your nail as shown in figure 28-15 without exerting any downward pressure except the weight of the graver and while so holding it press lightly in the direction indicated by the arrow, the point will catch in the surface of the nail, while if the graver is dull the point will slip over the nail without catching. If the graver proves to be dull, proceed to sharpen it before attempting to cut anything.

It is essential that you as a student follow these instructions very closely. Do not attempt to proceed with the next lesson until you have satisfactorily sharpened your gravers.

SEC. 485 — Modern Lathe Mount

Figure 28-16 illustrates a watchmaker's lathe and motor mounted on an aluminum base. With this arrangement the watchmaker can move his lathe to suit his purpose. It can be removed from the bench when not in use, thus allowing the watchmaker additional room.

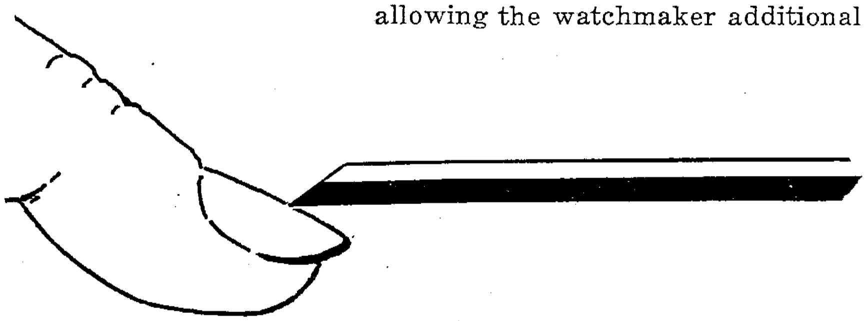


Fig. 28-15

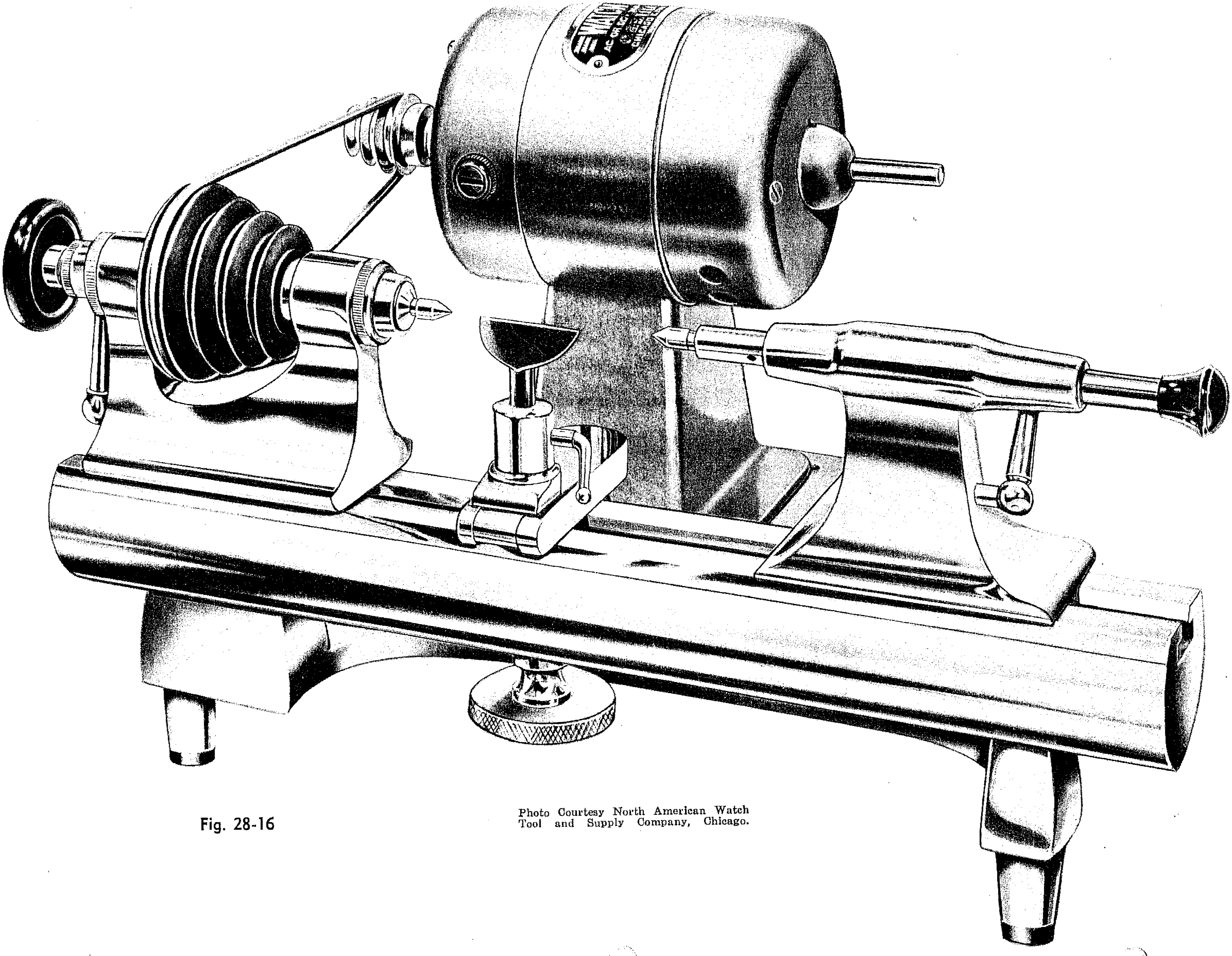


Fig. 28-16

Photo Courtesy North American Watch Tool and Supply Company, Chicago.

CHECK YOURSELF

Progress Check 28 — A Self Test Review of Lesson 28

After you have studied Sections 475 through 485, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers after this test. If you have missed any, restudy the section on which the statement is based.

DIRECTIONS: Draw a circle around the (T) if you think the statement is true or around the (F) if you believe it is false.			Section Ref.
1. With a good lathe and attachments it is possible to make a complete watch.	T	F	475
2. The position of the modern tip-over T rest does not need to be changed when checking measurements.	T	F	477
3. When mounting the lathe on your bench, place the motor 10 inches back of the lathe to prevent the belt from vibrating too much.	T	F	478
4. You start and stop the lathe motor as well as control its speed by means of a foot wheel.	T	F	479
5. It is necessary to avoid overoiling the lathe.	T	F	480
6. Two general types of chucks are used to hold work; a hollow split chuck and a solid chuck.	T	F	482
7. The number on modern chucks refer to wire sizes as measured with a Stubs' gauge.	T	F	482
8. To avoid springing the chuck, select one which fits the stock closely.	T	F	482
9. The diamond shaped graver is most commonly used for cutting on a lathe.	T	F	483
10. Putting oil on the stone used for sharpening gravers will prevent "glazing."	T	F	483
11. The proper angle to sharpen gravers is 45 degrees.	T	F	484
12. A graver point that is too dull will slip across your thumb nail.	T	F	484
13. The lathe must be permanently fastened to the bench to have it steady enough for fine work.	T	F	485

ANSWERS TO PROGRESS CHECK 28:

1. True
2. True
3. False
4. False
5. False
6. True
7. False
8. True
9. False
10. True
11. True
12. True
13. False

CHICAGO SCHOOL OF WATCHMAKING 310 LINCOLN AVENUE, FOX RIVER GROVE, ILLINOIS

Student Consultation Sheet

(Use this sheet to ask any questions you may have on the lesson or assignments. Use the left half of the sheet. Number your questions. Your instructor will write the answer opposite your question and return this sheet for your file.)

Date ____________________ Student No. ______________

Lesson No. ________

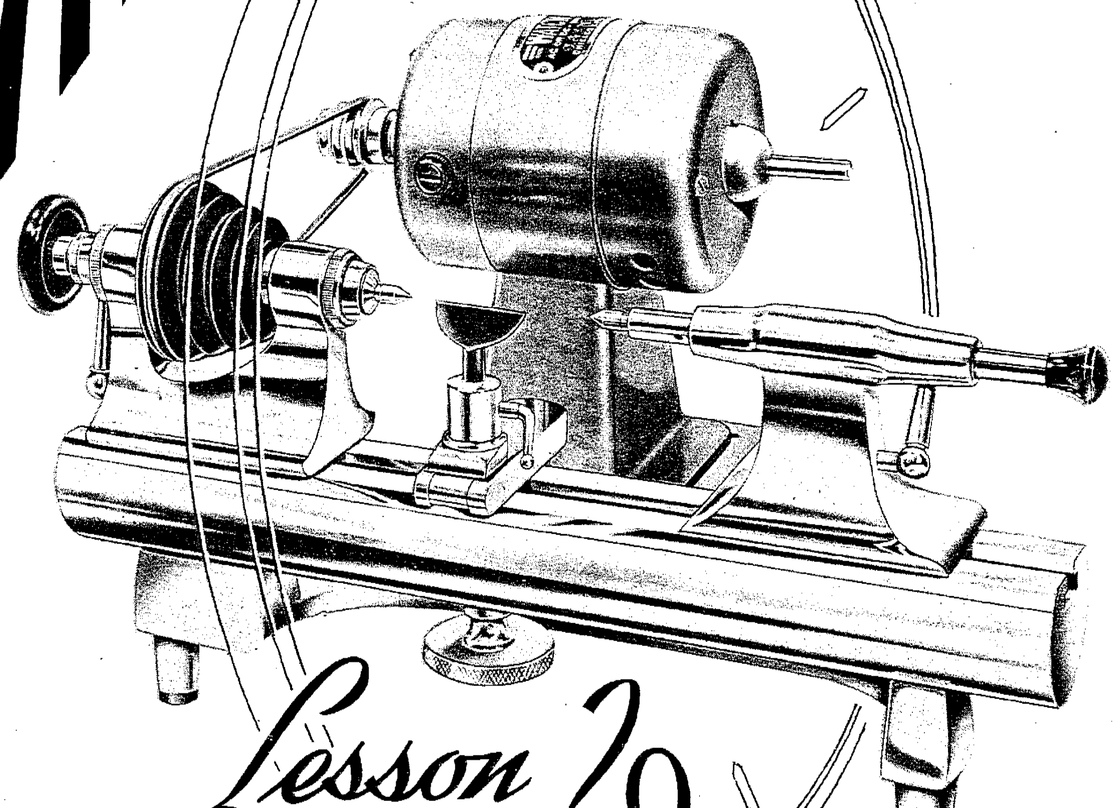
Name	
Address	
City State Zip Code	

Please check ( ) if you have CHANGED YOUR ADDRESS.

ASK YOUR QUESTIONS HERE...	WE'LL ANSWER HERE...
	INSTRUCTOR: Return an unused sheet with each used one.
(If necessary, use other side.)	

Detach page or cut along this line and use this sheet if you have questions on the course.

Master Watchmaking



Lesson 29

LATHE WORK

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

INTRODUCTORY INFORMATION

Basic lathe work consists of turning first in a soft metal such as brass and then in a harder metal such as steel. These first projects should be practiced until you are proficient in the use of the graver and can make smooth cuts. The methods explained in the text are basic; you may develop variations.

KEY POINTS OF LESSON ASSIGNMENTS 90, 91, 92, 93, 94, 95:

- The importance of lathe work.
- How to hold a square graver.
- The proper setting of the T-rest.
- How to center a piece of stock.
- How to use a jeweler's saw to cut off work held in a lathe.
- Using the lathe to make a hardened steel burnisher.
- Using the lathe to make drills, taps and screws.

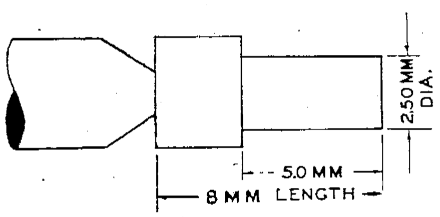
ASSIGNMENT NO. 90: Study Sections 490 through 493.

Study Questions:

1. How important is lathe work to the Master Watchmaker?
2. What is the proper height of the T-Rest?
3. What is the position of the T-Rest in relation to the work?
4. How is the first cut made?
5. Is this first cut parallel to or at right angles to the stock?
6. What must be done first before you cut off your work with the jeweler's saw?

Recommended Practice:

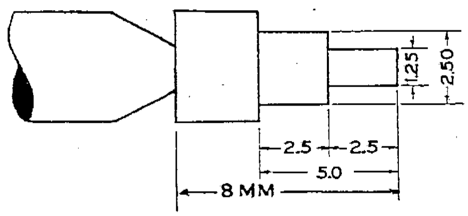
1. a. Turn a square shoulder in brass (Section 491) to the following dimensions:



NOTE: Face off end of stock (Fig. 29-11) before marking off the length. If end is uneven or rough, smooth with a file before placing in lathe. "Break" all sharp corners with a graver to remove burrs and feathered edges. Use millimeter gauge to measure the length and micrometer to measure diameters. To obtain a bright or polished cut when turning brass, polish lightly the cutting edge of the graver on a 4/0 emery buff. Be careful not to round the edge.

b. With a jeweler's saw, cut off to a length of 8 mm (Section 493).

2. a. Turn two square shoulders in brass (Section 491) to the following dimensions:



ASSIGNMENT NO. 90 (Continued):

b. Cut off to a length of 8 mm. (Section 493)

c. Points to remember:

(1) Test the graver frequently. Resharpen, if necessary.
(2) Stop the lathe when using the millimeter gauge or micrometer.
(3) Do not remove work from lathe until completed.
(4) It is unnecessary to run the lathe fast. High speeds are used when polishing.

3. Repeat the practical work given above, using a piece of 3.2 mm steel rod.

NOTE: Do not polish the cutting edge of the graver when working on steel. Run the lathe slowly and keep the graver sharp.

ASSIGNMENT NO. 91: Study Sec. 492.

1. Why is it necessary to locate the exact center of your work in cutting centers?
2. What common household item is used to test the center?

Recommended Practice:

Cut centers in brass by following the procedure outlined in Section 492. Cut off several for examination.

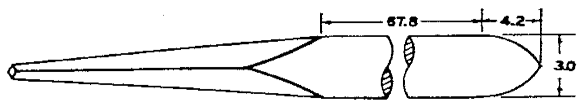
NOTE: Practice cutting centers until you can make them quickly and without effort.

ASSIGNMENT NO. 92: Study Sec. 494.

1. What is the purpose of the hardened steel burnisher?
2. After it is hardened, is it necessary to temper it?

Recommended Practice:

Make a burnisher from a piece of 3.2 mm steel rod. Follow the procedure outlined in Section 494. Use the dimensions given below:



NOTE: When polishing with the buff sticks, reverse the direction of the lathe. Apply the buffs to the underside of the work and run the motor at top speed. In this way you will be able to observe the surface of your work as you polish.

Only the tip needs to be hard and of the correct color. No harm is done if the colors back of the tip are darker. When drawing the tip, if the color becomes too dark; that is, a dark straw, purple, or blue, begin again and reharden and temper.

ASSIGNMENT NO. 93: Study Sec. 495.

1. Why is it best to have the shanks of your drills all the same size?
2. How do you make a drill?
3. How many index holes are in your lathe?

ASSIGNMENT NO. 93 (Continued):

Recommended Practice:

Using 2 mm steel rod, make a set of drills, following the dimensions given in this chart:

DIAMETERS	LENGTHS	DIAMETERS	LENGTHS
1.60 MM	8.0	1.00 MM	5.0
1.40 MM	7.0	0.80 MM	4.0
1.20 MM	6.0	0.60 MM	3.0

Follow carefully the instructions in paragraphs 1 through 7, Section 495. STOP. Compare your work closely with illustration 29-22. When you are certain that your work is OK, proceed with paragraphs 8 through 12.

NOTES: Do not cut off drill until it has been hardened, tempered, polished, and sharpened.

Allow about 4/100 mm for polishing.

Harden the full length of the blade.

Make the shank of the drill (not including the blade) about 25 mm long.

Drills should be sharpened on a smooth oilstone. Hold drill in fingers as you would a pencil. Keep the flat side of the drill at right angles to the stone, with the bevel edge (Figure 29-20) lying along the stone. Holding the drill firmly in this position, tip your hand to the right and wipe or stroke the drill across the face of the oilstone. Move several times but only in one direction; that is, to the right, until you have a flat cutting edge. Repeat this operation on the other edge.

ASSIGNMENT NO. 94: Study Sec. 496.

1. How is the thread started with a screwplate?
2. How is the length of a tap determined?
3. What is the reason for reversing the direction of the screwplate?
4. Is oil necessary when chasing threads?

Recommended Practice:

Make a tap as outlined in Section 496, using any desired hole in your screwplate.

NOTE: Before placing stock in lathe, anneal it by placing rod over an alcohol lamp, heating metal to a cherry red and allowing it to cool slowly. HARDENED STEEL WILL DAMAGE A SCREW PLATE. Use plenty of oil when cutting thread.

Observe these points:

a. Do not cut off tap from stock until finished.
b. Cut shanks about 25 mm in length.
c. Harden the full length of threaded portion.
d. Touch up surface shown in Figure 29-39 with oilstone.

ASSIGNMENT NO. 95: Study Sections 497 through 499.

1. What is the name given to the type of file used to cut slots on the heads of screws?
2. Is it necessary to harden and temper screws?
3. What is the purpose of the tripod used in polishing screwheads?

ASSIGNMENT NO. 95 (Continued):

4. From which side should the hole in the second hand be broached (opened or enlarged)?
5. Is it practical to replace a foot on a metal dial?

NOTE: Making screws for watches is practically outmoded, due to the fact that most watchmakers have assortments of screws from which one of proper thread size may be selected. Alterations of the head, if necessary, can be quickly made on the lathe. In event an odd screw is needed for an obsolete watch, you can refer to and be guided by Section 497. In all probability, you will first have to make a tap to retap the hole for which the screw is being made.

Making a pipe for a second hand is hardly practical anymore, since you can readily obtain almost any type of second hand. However, the instructions in Section 498 are for use if the need should arise.

Replacing a dial foot on an enamel dial can be done by following the instructions in Section 499. A foot can also be replaced on a metal dial. However, doing so may cost more than a new dial because the old dial, in all likelihood, would have to be refinished and lacquered. New metal dials are inexpensive.

REQUIREMENT

Answer the Test Questions for Lesson 29 and send in for grading.

SUMMING UP

These first assignments in lathe work are generally considered as basic, even though it is possible to purchase drills, taps and screws for all general repairs. In later assignments, as in actual watch repair, you will have to do precision work, some of it in steel which is tempered. It is therefore important that the basic principles of using the lathe be well mastered and that is the real purpose of these projects.

Do not be content simply to do a project once, even if you do well by carefully following the directions. Continue to practice simple turning of square shoulders in brass and steel until you can practically do them "with your eyes shut." You are now nearing the time when all this work can be put to practical use, and the assignments on jewels and staff work should prove very exciting.

SEC. 490 -- The Importance of Lathe Instruction

By now you should be familiar with the principles and functions of the average watch movement. These principals and functions have been presented step by step in order that you may make the repairs necessary to qualify you as an expert. It should be obvious to you by now that it is much better to purchase good tools and the proper material for replacements in watch repairing than it is to endeavor to make such repair parts yourself. In years gone by, this was not always possible. The manufacturers of American watches endeavored to produce watches and materials with interchangeable parts. This was not true of imported watch movements and it was necessary for the watch repairman to be able to make a great many parts. Many times he had to make the tools to make these parts. In recent years the manufacturers of American watches have greatly improved the standardization system because they have been benefited by automatic machinery. The same is true of imported watches and today it is much more profitable for the watchmaker to purchase his replacement parts and devote the time he would spend making them to making repairs on other watches. However, the Master Watchmaker must be able to determine quickly if replacement parts will function properly when used. Many times he will find watches which have been botched by so-called repairmen and in order to make the repairs correctly, he will have to undo the botch work before he can proceed in a workmanlike manner.

For this reason it is necessary for the student to acquaint himself with the methods used in making certain parts. The satisfaction derived from doing a job better than the next man cannot be measured in dollars and cents, but is the main difference between the ordinary repairman and the one whose success is measured by the better things in life he seems to acquire.

The lessons on lathe work are made up of a series of explanations and illustrations covering the making of a few small tools and the principles of parts making. The student will gain much by practicing these problems and will, upon occasion, have to make repairs along these lines. He will become adept at handling the watchmaker's lathe without which no watchmaker can do a master job. Each problem is approached step by step. Read your instructions carefully and refer to the illustrations frequently.

SEC. 491 -- Turning Square Shoulders

Our first exercise will be the turning of square shoulders in brass. Take a piece of 4 mm brass rod and insert it in a 40 chuck, figure 29-1, extending it about 10 mm from the face of the chuck. Set the T rest parallel to the 4 mm brass rod as illustrated in figure 29-2. The height of our T rest should be about on the center line of our work, figure 29-3.

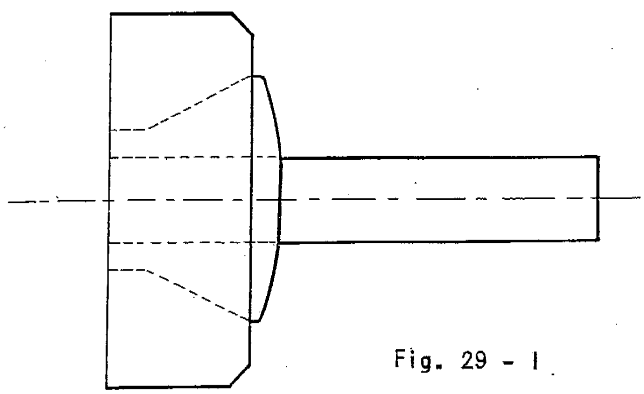


Fig. 29 - 1

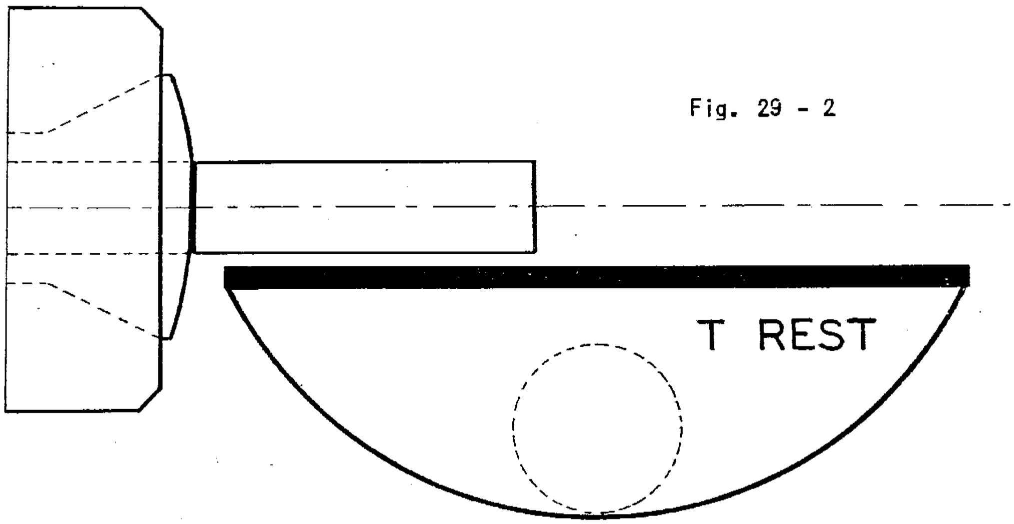


Fig. 29 - 2

Figure 29-4 illustrates the method of holding a square cutting graver. The forefinger of the right hand is placed along the edge of the graver as illustrated with the handle in the heel of the hand. The thumb and the rest of the fingers fall naturally in place. Figure 29-4 illustrates the graver held in position ready to make a cut. The forefinger of the left hand is placed on the side of the graver as illustrated. In this way, the graver can be moved to the right or left depending on which finger exerts the most pressure. Now running the lathe toward you in the direction of the arrow, figure 29-4,

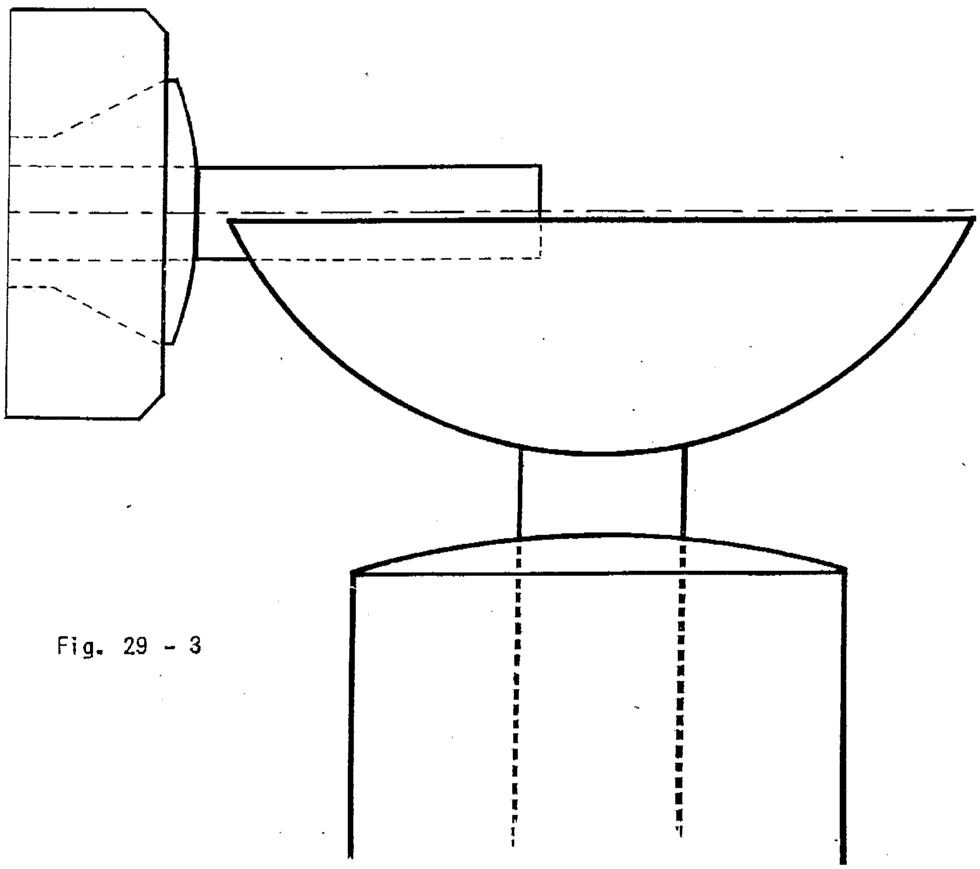


Fig. 29 - 3

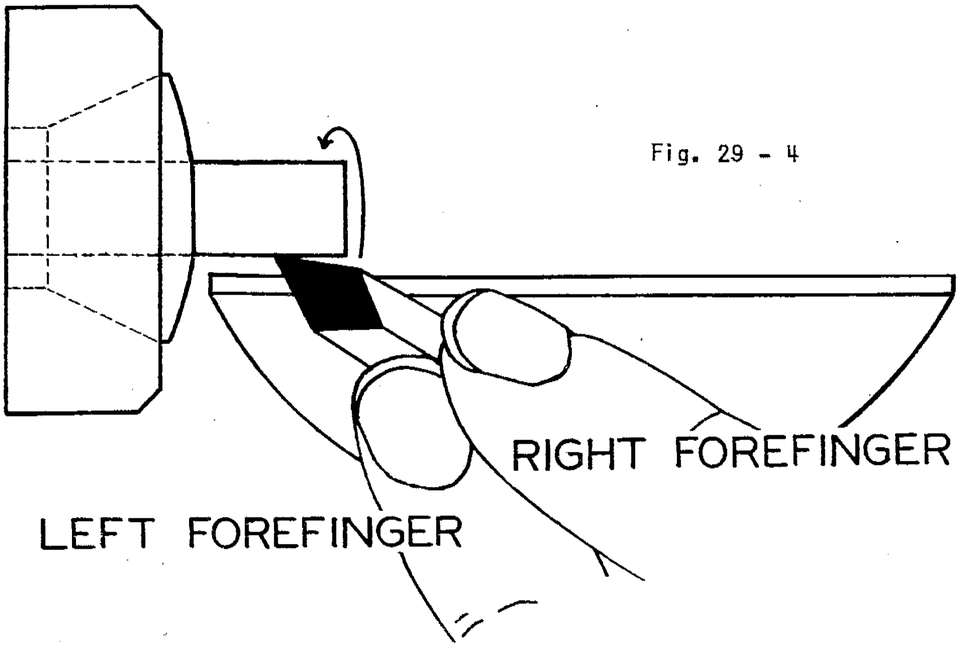


Fig. 29 - 4

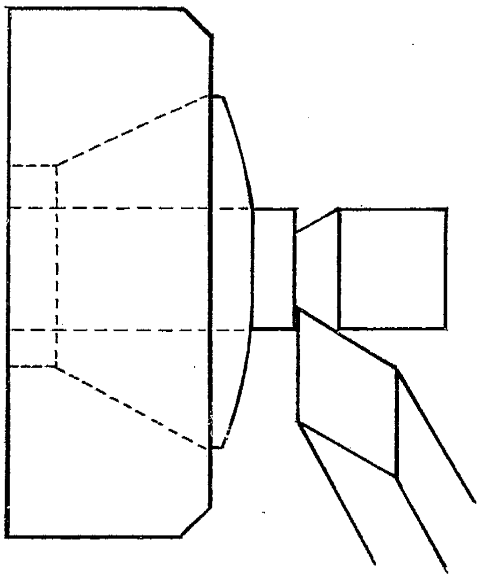


Fig. 29 - 5

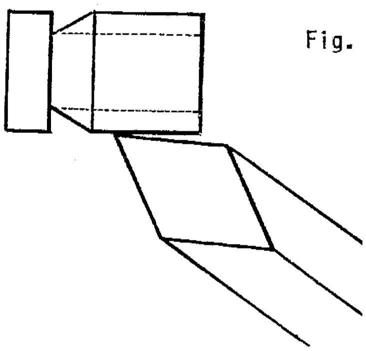


Fig. 29 - 6

move the graver against the brass rod until a small shaving appears. The position of the graver in figure 29-4 will produce this shaving if we have met all the conditions in figures 29-2 and 29-3. If your graver fails to produce shavings, it will be up to you to move your graver handle up or down or to either side until the cutting edge of the graver produces these shavings. Do not proceed any further until you can cut shavings rapidly, moving the graver either to the right or to the left.

Figure 29-5 illustrates the first cut necessary to produce a square shoulder. The point is carefully moved forward until we produce a small cut as shown in this figure. Do not go too deep with the first cut. Holding the graver in the position shown in figure 29-6, remove the section illustrated by the dotted line. Figure 29-7 shows the finished square shoulder. It is possible for us to make a square shoulder of any desired diameter and length.

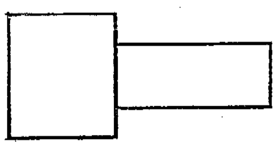


Fig. 29 - 7

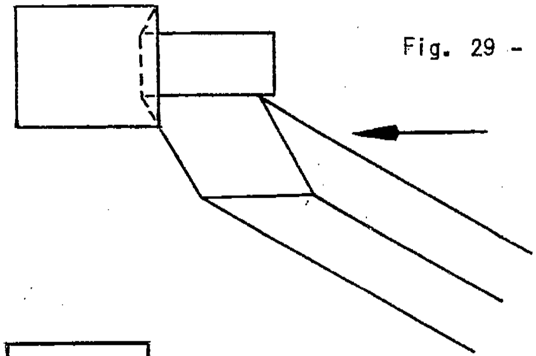


Fig. 29 - 8

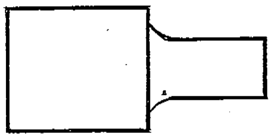
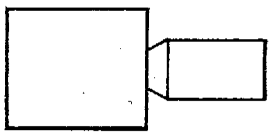


Fig. 29 - 9

Fig. 29 - 10



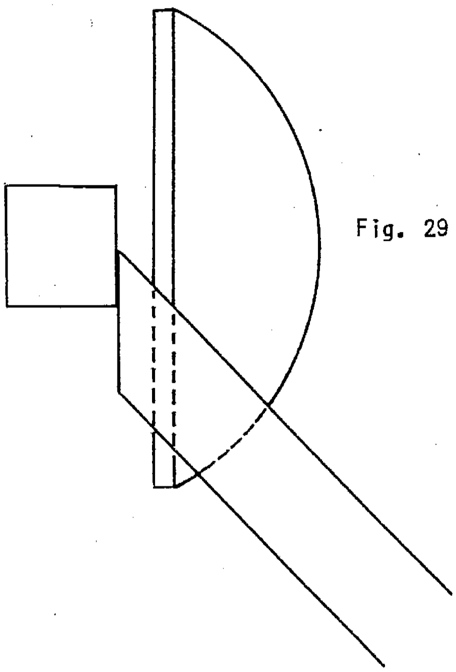


Fig. 29 - 11

Fig. 29 - 12

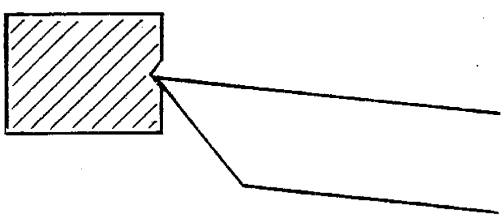


Figure 29-8 illustrates an under cut. It is done by starting the graver in the position shown and moving in the direction of the arrow. Figures 29-9 and 29-10 illustrate two types of incorrect square shoulders. In turning square shoulders in steel, the same method is followed but you will find steel will cut much more slowly and you will probably have to sharpen your gravers oftener.

SEC. 492 -- Centering Stock

In order that we may drill brass or steel which is held in a lathe, it is necessary to locate the exact center of our material. Move the T rest parallel with the face of the rod as in figure 29-11 and face off material. Start cutting point of graver as close as possible to the center of the work until you have obtained the cut shown in figure 29-12.

This is the exact center of our work and can be tested by using an ordinary small needle held in the position shown in figure 29-13 with the lathe revolving. If the work is centered properly, the needle will stand still. If you have not obtained the exact center, the needle will wobble. If such is the case, it is because you have left in your center a little point which must be removed. Figure 29-14 illustrates incorrect centers.

Fig. 29 - 13

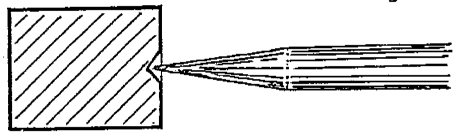
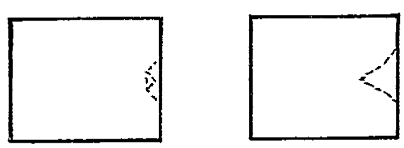


Fig. 29 - 14



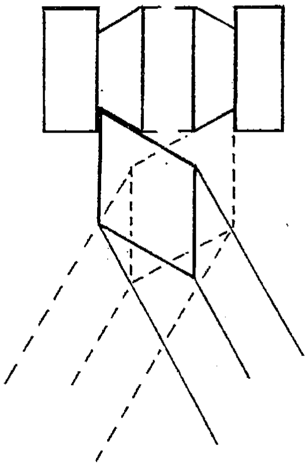
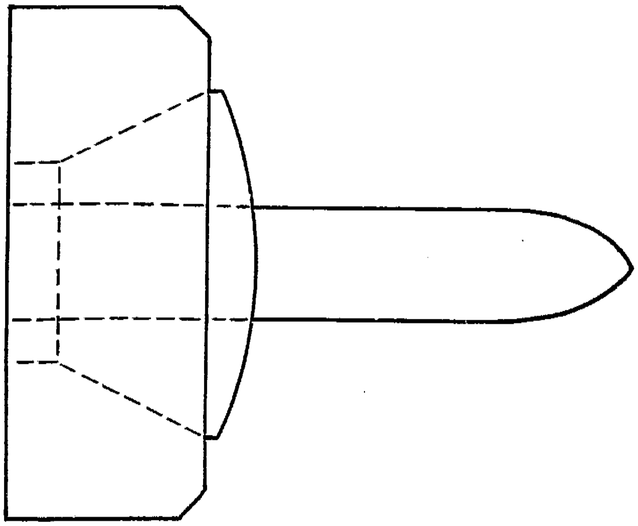


Fig. 29 - 15

Fig. 29 - 16



SEC. 493 -- Using A Saw with the Lathe

To cut off work held in a lathe, cut a groove in your work as shown in figure 29-15. Use a jeweler's saw with the teeth of the saw pointing toward the handle and place saw blade in groove while the lathe revolves backward.

Be careful not to use too much pressure when nearing the center of your work as your work is liable to jump away.

SEC. 494 -- Making a Hardened Steel Burnisher

When setting a jewel, it is necessary to burnish the metal over the edge of the jewel. For this purpose a hardened steel burnisher is required. It can be made from 3 mm round drill rod about 3 inches in length as follows:

1. Turn down the end as in figure 29-16. Do not get it too pointed or too round.
2. Polish with emery buffs in the following rotation: #2, #1, #0, #2/0, #3/0, and #4/0.
3. Harden. (Lesson 27 - Sec. 463.)
4. Temper to a very light straw at the tip. (Lesson 27 - Sec. 464.)
5. File Tang, figure 29-17, and re-polish.
6. Mount in graver handle.

SEC. 495 -- Making Flat Drills

1. Determine the diameter of the drill and select a section of drill rod slightly larger than that diameter. It is best to have the shanks of all your drills of one size.

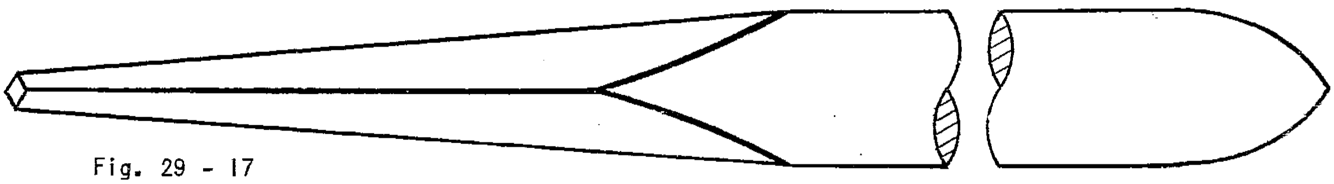


Fig. 29 - 17

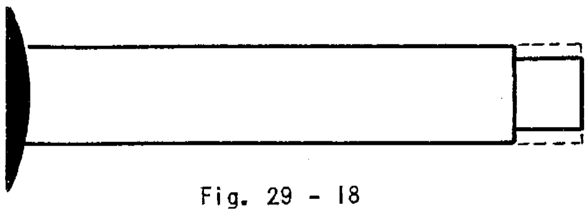


Fig. 29 - 18

2. Turn a square shoulder at the end of the rod to the diameter of your drill, figure 29-18. The length of the drill is then determined by this diameter, being usually about five times the diameter. (Example: The shank of a drill measuring .5 mm in diameter would be about 2.5 mm long.)

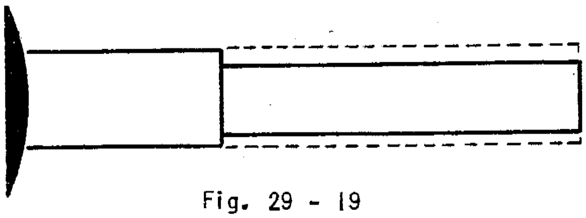


Fig. 29 - 19

3. Turn back shoulder as illustrated in figure 29-19 to the correct length.

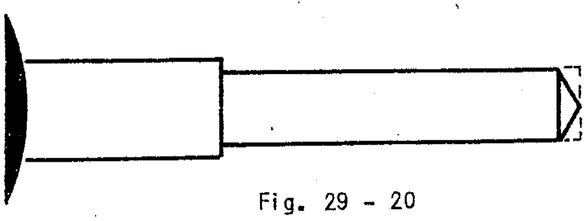


Fig. 29 - 20

4. Bevel end of rod at about 30 degrees, figure 29-20.

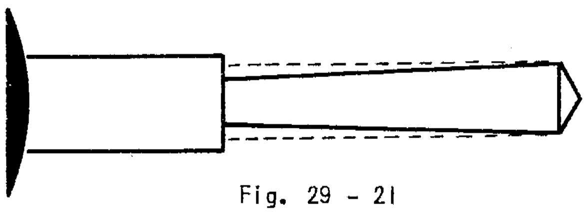


Fig. 29 - 21

5. Taper from the corner of bevel to back of drill as in figure 29-21.

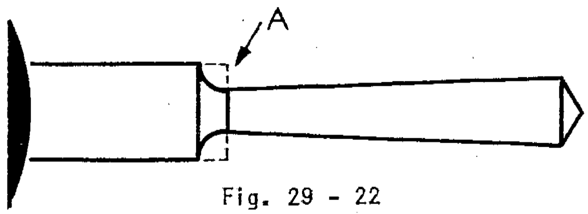


Fig. 29 - 22

6. From this point make a small curve at A, figure 29-22.

7. Reverse lathe motor and polish with emery buffs in the following rotation: #2, #1, #0, #2/0, #3/0, and #4/0. Hold your emery buffs on the underside and use the full length of the buff while moving it back and forth with the lathe running in reverse.

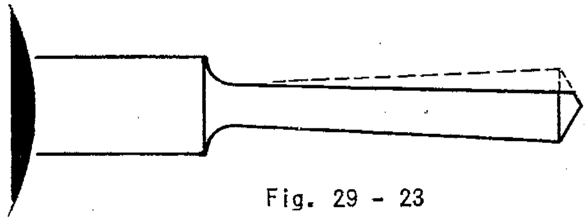


Fig. 29 - 23

8. Set index pin in hole zero and with a flat file, file top of drill as illustrated by dotted line, figure 29-23. The T rest can be used as a steady rest for your file.

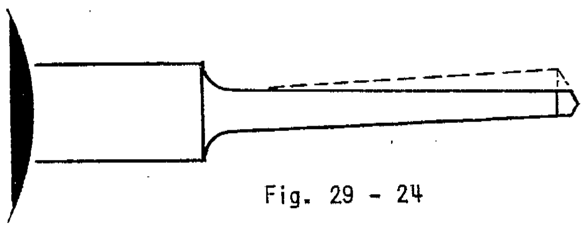


Fig. 29 - 24

9. Remove index pin and turn head of lathe 1/2 turn. Replace index pin in hole marked 30 and file this side exactly the same as in figure 29-24. The drill will now appear as in figure 29-25.

10. Polish the flat sides of the drill with emery buffs in the following rotation: #2, #1, #0, #2/0, #3/0, and #4/0.

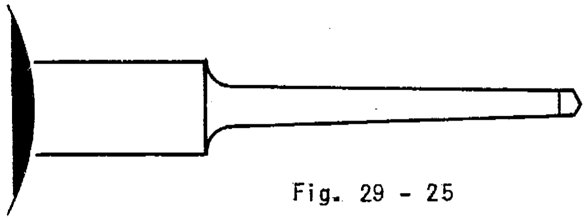
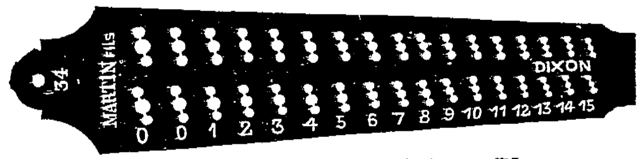


Fig. 29 - 25



Double Notched Screw Plate

Fig. 29 - 28

11. Cover drill with soap or boric acid, heat to a cherry red and plunge into cold water. (Lesson 27 - Sec. 463.)

12. Repolish and temper to a light straw (Lesson 27 - Sec. 464) then polish off the color and polish shank.

Most drills purchased are marked in 10/1000ths of an inch. However, we will mark ours to correspond to the metric system.

1. Reverse drill in lathe, finish the end of stock with a graver, and polish with emery buffs. File a small notch as in figure 29-26.

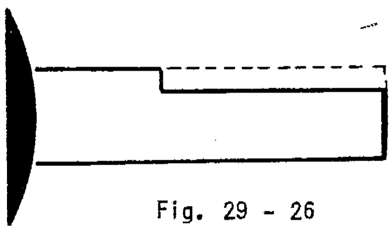


Fig. 29 - 26

2. With the edge of a file, mark the drill with Roman numerals to correspond with the metric measurement, figure 29-27.

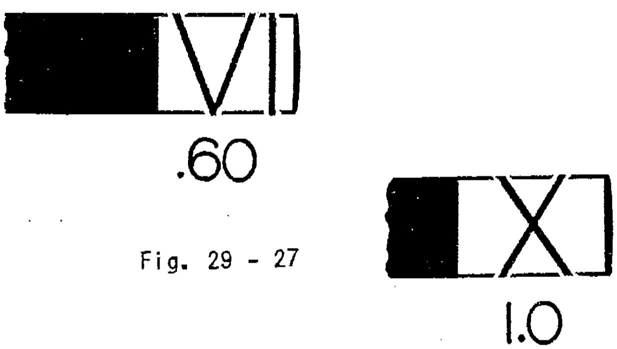


Fig. 29 - 27

SEC. 496 -- Making Taps

In making taps use a Swiss Screw Plate as shown in figure 29-28 to cut the threads. There are different types of Screw Plates containing from 5 to 60 holes and having double or single notches. The screw plate illustrated in figure 29-28 is double notched and these notches allow the shavings to break clear. In this particular screw plate the die holes directly across from each other are of the same size.

To make a tap, use any size drill rod of suitable diameter and proceed as follows:

1. Determine the diameter of tap. If the finished tap is to be a #6, allow a difference of 2 numbers when ascertaining the diameter of the tap; in this case, it would be #4 hole.

2. Turn a square shoulder on the end of rod, figure 29-29, that will just enter hole #4 on the screw plate.

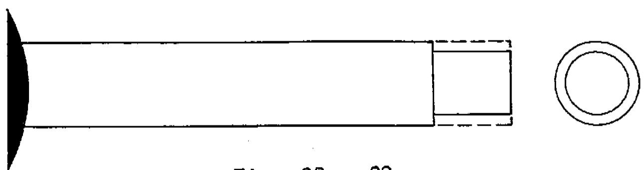


Fig. 29 - 29

3. Measure this diameter with millimeter gauge and multiply by 5. This will give the length of the tap.

4. Turn back shoulder to this length as shown in figure 29-30.

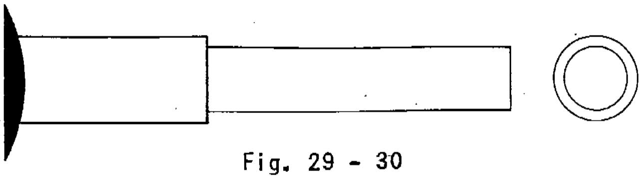


Fig. 29 - 30

5. Bevel the end at about a 60 degree angle, figure 29-31. Turn curve and cut back, figure 29-32.

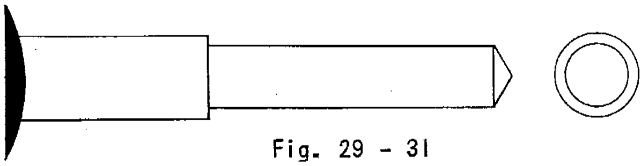


Fig. 29 - 31

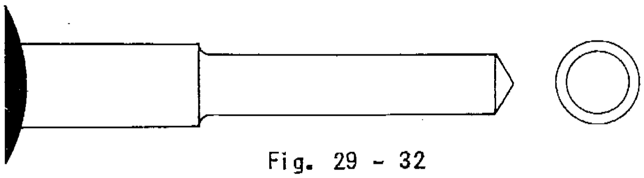


Fig. 29 - 32

6. Place screw plate on end of rod using hole one size larger than the finished tap, figure 29-33; in this case hole #5.

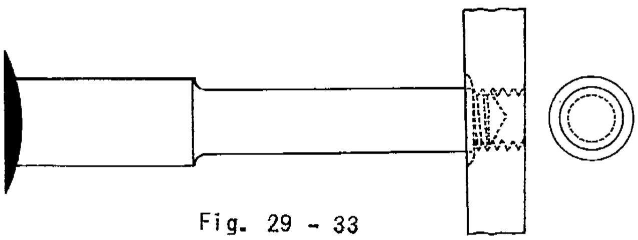


Fig. 29 - 33

7. Hold screw plate with right hand and with left hand on lathe pulley, turn pulley toward you about 1/2 turn. This should start the thread.

8. Place a little oil on the rod and continue turning lathe pulley another half turn. A good thread should now be started.

9. Now reverse motion of left hand about 1/4 turn and then turn forward 1/2 turn. Each forward turn will chase a new section of thread and the reversing breaks out the excess metal, figure 29-34.

10. Repeat this forward and backward motion until tap is completely threaded, and then remove screw plate.

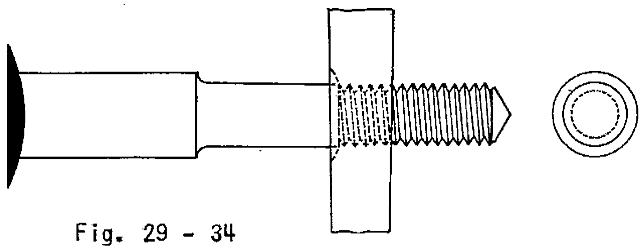


Fig. 29 - 34

11. Now place screw plate on rod using selected finished thread size, in this case #6, and repeat steps 7, 8, 9, and 10. Your finished work should appear as in figure 29-35.

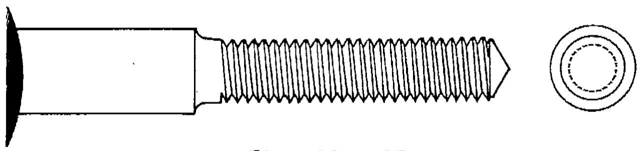


Fig. 29 - 35

12. Set index pin at zero and file across and through threads as shown in figure 29-36.

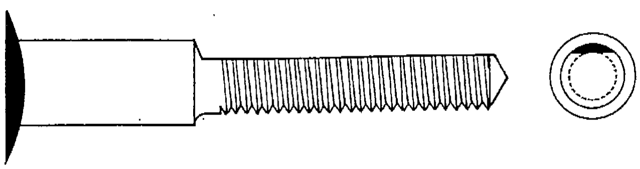


Fig. 29 - 36

13. Turn index 1/3 the way around and file through and across threads as shown in figure 29-37.

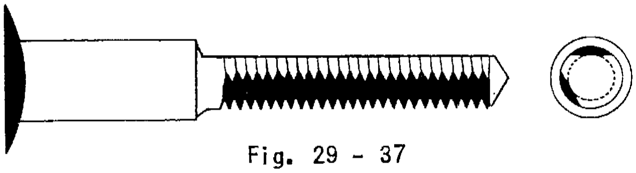


Fig. 29 - 37

14. Turn index 1/3 way around and repeat filing process. The tap will now appear as in figure 29-38 side and end view.

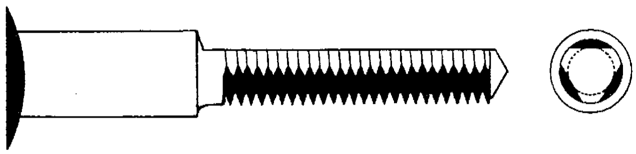


Fig. 29 - 38

15. Set index back at zero and then move backward 3 holes. With file held at an angle of about 10 degrees, cut away the back of the first few threads, figure 29-39. Do this on all three sides. This will allow your tap to start easily.

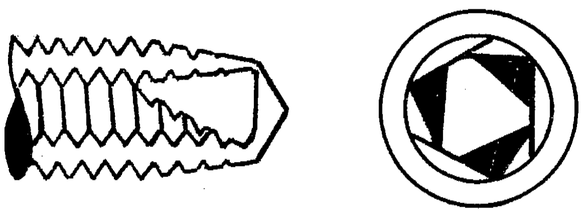


Fig. 29 - 39

16. Polish with emery buffs.
17. Harden. (Lesson 27 - Sec. 463.)
18. Temper to a light straw at the tip to a medium straw at the back. (Lesson 27 - Sec. 464.)

19. Taps are used the same as a screw plate, 1/2 turn forward and 1/4 turn backward. The hole to be tapped must first be drilled. Use a drill about 2 numbers smaller than the size of tap measured by holes in the screw plate. Taps can be marked the same as drills, figure 29-27.

SEC. 497 -- Making A Screw

1. Turn down drill rod to the proper diameter for the head of the screw, figure 29-40, and polish.

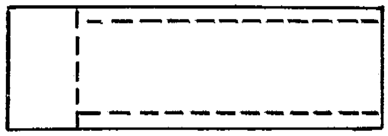


Fig. 29 - 40

2. Select thread size and follow procedure for making tap, figures 29-41, 29-42, 29-43, and 29-44.

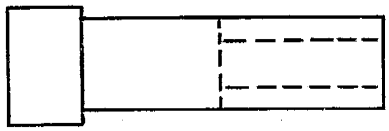
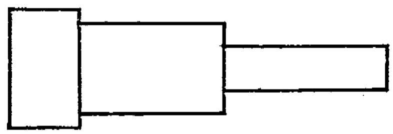


Fig. 29 - 41

Fig. 29 - 42



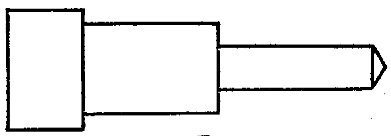
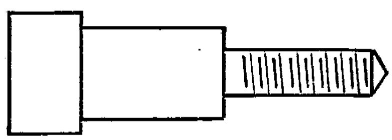


Fig. 29 - 43

Fig. 29 - 44



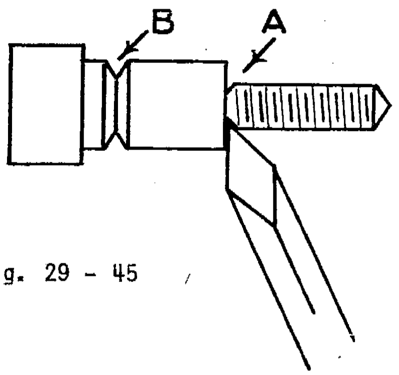


Fig. 29 - 45

3. Face off under side of screw leaving a small notch as shown at A, figure 29-45.

4. Cut notch as shown at B, figure 29-45, and saw off.

5. Reverse screw in lathe, face off the head of screw, and bevel the corner, figure 29-46.

6. With a screw head file cut slot in head of screw, figure 29-47, using the T rest as a support.

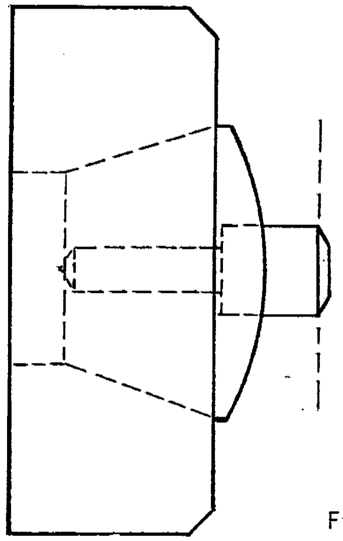


Fig. 29 - 46

7. Polish head of screw with emery and harden (Lesson 27 - Sec. 466) and temper to a blue (Lesson 27 - Sec. 466, figure 27-20).

8. Polish off the color or leave blue, whichever is preferred.

9. Figure 29-48 illustrates the screw held in a tripod device when a flat surface is desired.

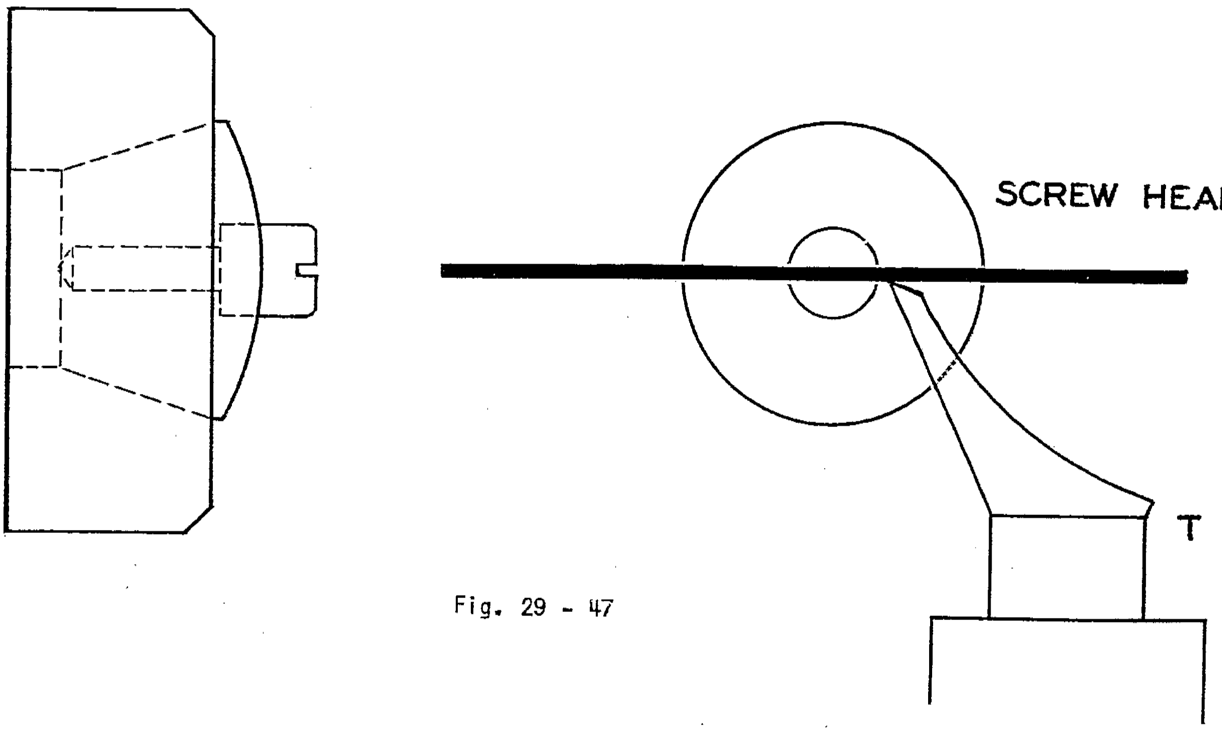


Fig. 29 - 47

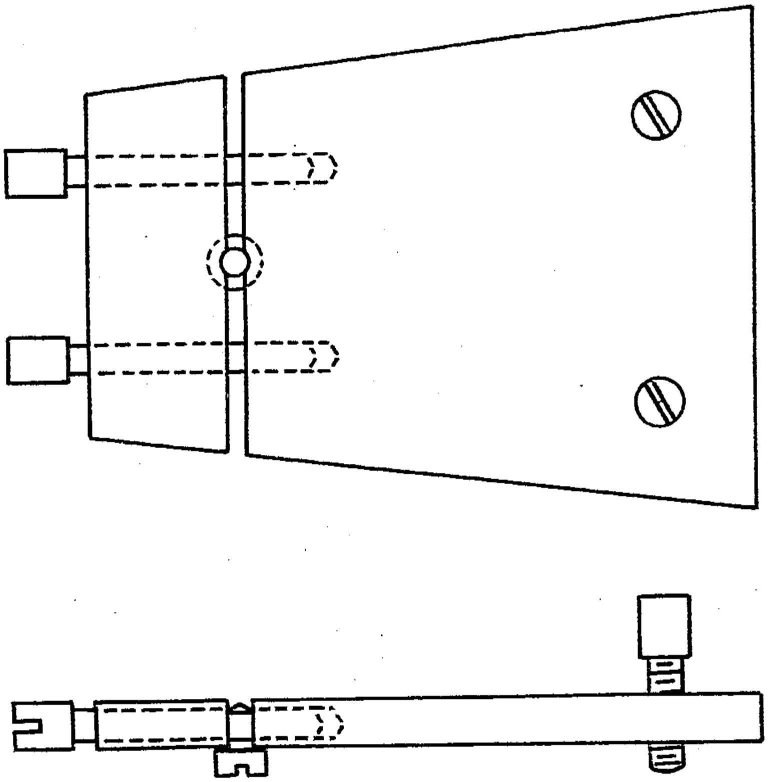


Fig. 29 - 48

SEC. 498 -- Making A Pipe for a Second Hand

1. Select a piece of brass wire of small diameter and place in chuck, figure 29-49.

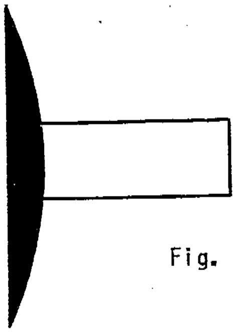


Fig. 29 - 49

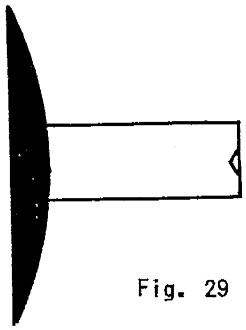


Fig. 29 - 50

2. Center, figure 29-50, and drill hole as illustrated in figure 29-51. This hole should be slightly smaller than the 4th wheel pinion pivot.

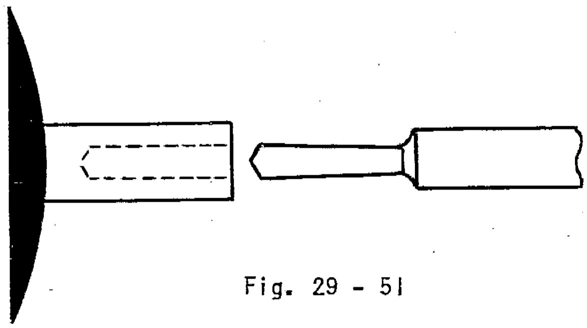


Fig. 29 - 51

3. Turn down outside diameter to desired measurement.

4. Turn square shoulder seat on which hole in second hand will fit snugly, figure 29-52.

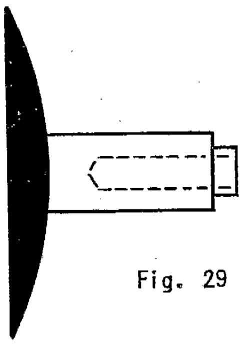


Fig. 29 - 52

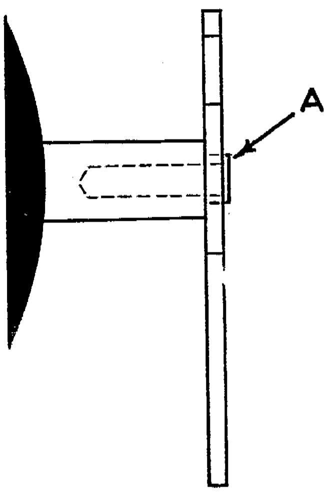
5. Place second hand in place and burnish brass over second hand at A, figure 29-53.

6. Finish with stripping tool.

7. Cut notch in wire at desired length and saw through wire carefully, figure 29-54.

8. Broach hole in pipe from the under side with pivot broach. The second hand should fit friction tight.

Fig. 29 - 53



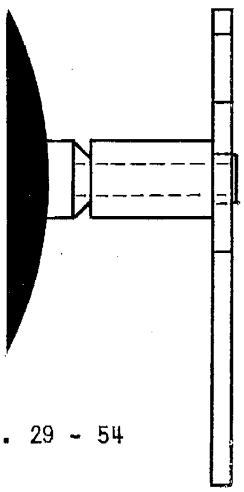


Fig. 29 - 54

SEC. 499 -- Replacing a Dial Foot

The following procedure of replacing a dial foot is for a hard enamel dial. Replacing a dial foot on a metal dial is not too practical as in most cases the dial must then be sent out to a dial painter to replace the figures, finish, and lacquer.

1. With a small carborundum wheel held in the lathe cut off old dial foot by grinding through a section of enamel until the copper center is exposed, figure 29-55.

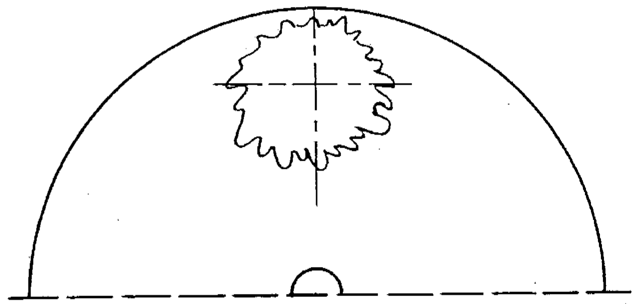


Fig. 29 - 55

2. With a sharp pointed scriber and steel straight edge draw two lines at right angles to each other through the center of the old dial foot, which usually can be distinguished even through the ground finish, figure 29-55. It is also possible to place dial in place over the pillar plate and with a small, sharp pointed scriber, locate the center of the proposed dial foot.

3. Place a piece of brass wire in lathe and turn down the end until it will enter hole in pillar plate, figure 29-56. Turn larger diameter for the base about three times the diameter of the small end.

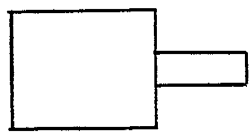


Fig. 29 - 56

4. Curve back corner slightly as shown in figure 29-57.

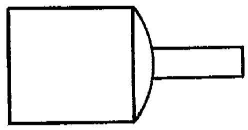


Fig. 29 - 57

5. Cut notch as shown in figure 29-58 and saw off.

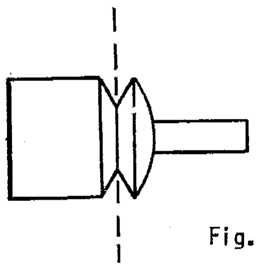


Fig. 29 - 58

6. Reverse in chuck, figure 29-59, and hollow slightly as shown in figure 29-60.

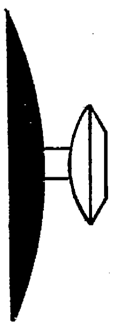


Fig. 29 - 59

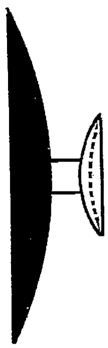


Fig. 29 - 60

7. Place dial foot in soldering tweezers, figure 29-61, with soldering flux and heat over alcohol lamp. Fill hollow with bismuth soft solder. (See Lesson 27 - Sec. 468.)

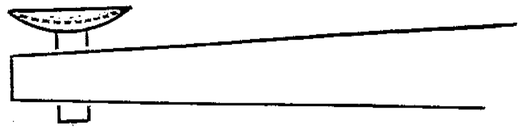


Fig. 29 - 61

8. Place dial on thin copper plate, cover ground section with soldering flux and place dial foot directly over center lines, figure 29-62.

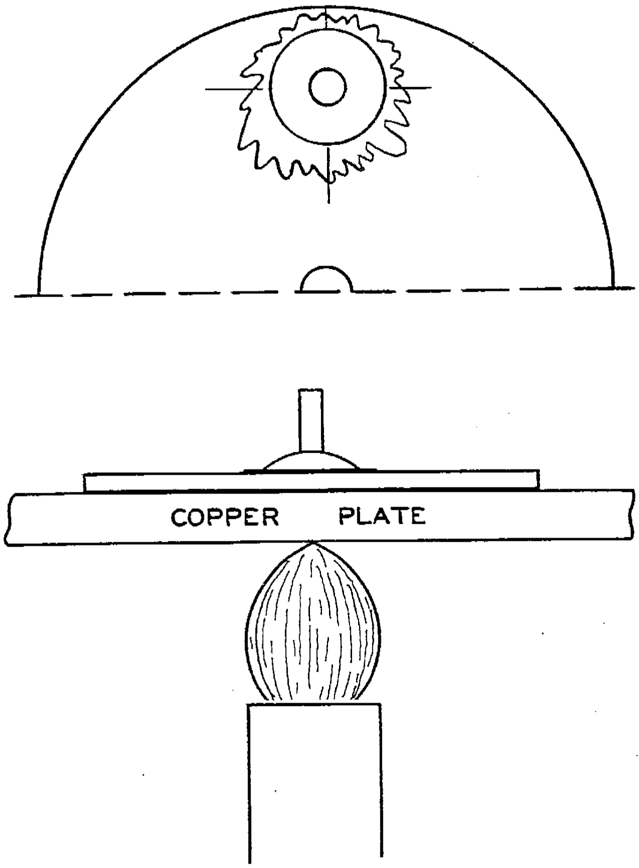


Fig. 29 - 62

9. Warm this copper plate over alcohol lamp until solder flows. Remove dial and let cool slowly. Wash thoroughly with water and dry carefully.

CHECK YOURSELF

Progress Check 29 — A Self Test Review of Lesson 29

After you have studied Sections 490 through 499, see if you can answer these questions without looking back. DO NOT SEND YOUR ANSWERS TO THE SCHOOL. You'll find answers at the end of the test. If you miss any, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or phrase in the blank spaces.

Statement	Section Ref.
1. The T rest should be on the ____________ line of the work.	491
2. In cutting square shoulders, the lathe is turned ____________ ____________.	491
3. When cutting, the graver is best held with ____________ ____________.	491
4. Before drilling brass or steel, it is necessary to determine its exact ____________.	492
5. The first step in cutting off work held in a lathe is to cut a ____________ for the jeweler's saw.	493
6. The hardened steel burnisher is used to burnish the metal over the edge of ____________.	494
7. The length of flat drills is usually about ____________ times its diameter.	495
8. Use of an ____________ in the ____________ plate will keep the drill from turning while it is being filed.	495
9. In making taps, you start with a hole in the screw plate that is ____________ sizes ____________ than the finished tap.	496
10. The length of the tap is ____________ times its diameter.	496
11. When using a tap, the hole to be tapped must first be ____________.	496
12. Screw threads are made in the same way as ____________.	497
13. A ____________ is used to grind off the old dial foot from a hard enamel dial.	499

ANSWERS TO PROGRESS CHECK 29:

1. center
2. toward the operator
3. both forefingers
4. center
5. groove
6. jewel settings
7. five
8. index pin
   index
9. two
   larger
10. five
11. drilled
12. tap threads
13. carborundum wheel

Job Inspection Request

CHICAGO SCHOOL OF WATCHMAKING
310 LINCOLN AVE., FOX RIVER GROVE, ILL. 60021

Use this sheet to have your burnishing tool checked by your instructor before you begin using it. An improperly made tool will give unsatisfactory results.

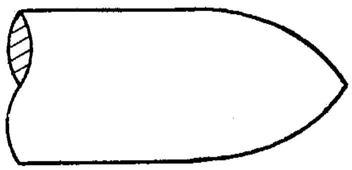
Student No. ____________ Date ____________

Name	
Address	
City State Zip Code	

Chief Instructor
Chicago School of Watchmaking

Please inspect and approve the burnishing tool I have made according to the dimensions in Assignment No. 92:

BURNISHING TOOL (Sec. 494)



____ Satisfactory.

____ Unsatisfactory:

- ____ Too soft
- ____ Too blunt
- ____ Too sharp

Instructor comments:

____

____

____

68-29

Detach page or cut along this line and send to the School when you send work for inspection.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 29

Name: No.: Date:

Circle ONE correct answer: SUBJECT: Lathe Work

1. When turning square shoulders, how high should the top of the T-rest be in relation to the work to be turned?

   A little below the top | Even with the top | Even with the bottom | About on the center line

2. When using the graver, how should it be held?

   Hold handle between palms; grip graver between thumbs | Between right thumb and left forefinger | Between the forefingers | Gripped in the palm of the hand

3. Why is it necessary to center brass or steel stock in the lathe?

   In order that we may be able to drill it | To determine if stock runs true | To establish a point for measurements | To insure accuracy in facing off stock

4. The centering can be tested with:

   A pencil point | A small needle | Point of graver | Bench knife

5. To cut off work held in lathe, you should:

   Revolve lathe towards operator | Revolve lathe backward | Have teeth of saw pointing away from handle | Stop lathe and work saw slightly

6. How is the turned portion of the hardened steel burnisher shaped?

   Flattened on end | To a sharp point | To a rounded point | Square

7. When making a drill five times as long as its diameter, a drill .65mm in diameter would be how long?

   32.5 mm | 3.25 mm | 65.0 mm | 6.50 mm

8. If you wished to make a tap size #8, you would turn the drill rod to enter what number hole in the screw plate?

   8 | 7 | 6 | 4

9. When making a screw, the slot in the head is put in with:

   A circular saw | A jeweler's saw | A graver | A file

10. When replacing a dial foot on a hard enamel dial, how is the old dial foot and enamel removed from back of dial?

    By chipping | By scraping | By filing | By grinding

11. How is the new dial foot correctly located?

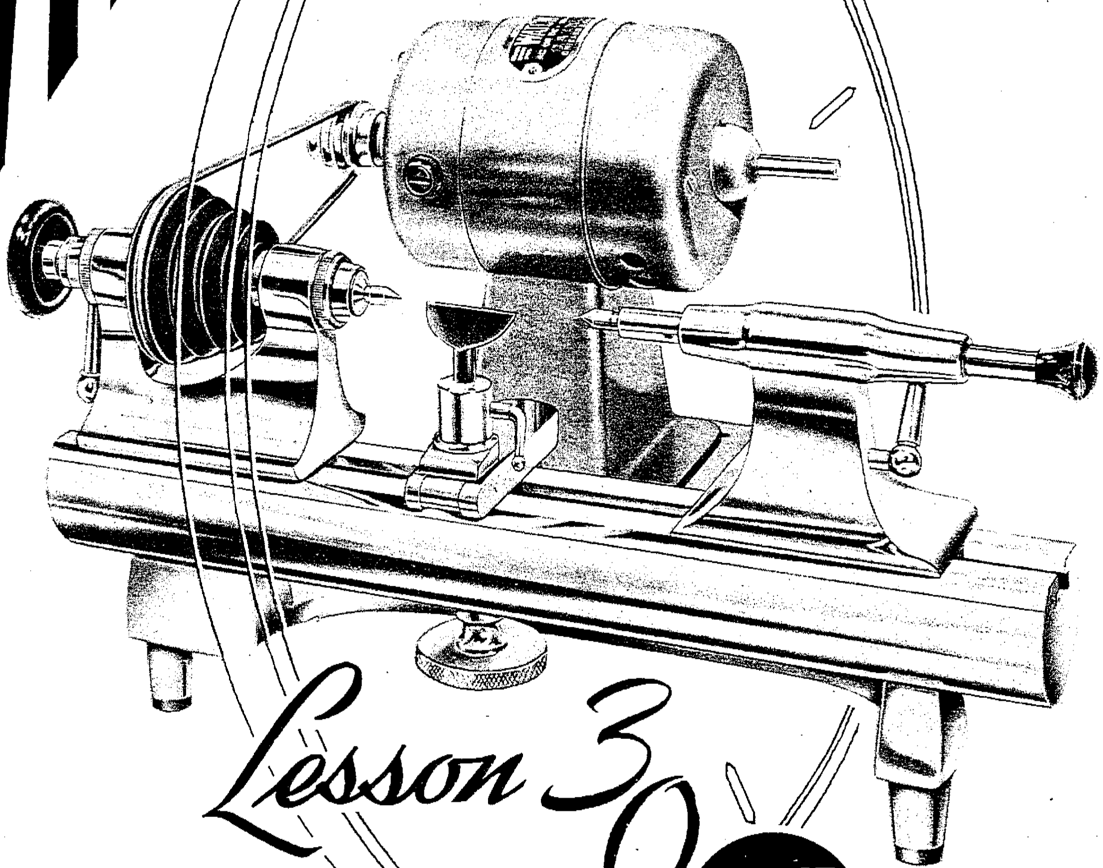
    By scribing lines | By measurement | Moving to correct position while solder is soft | By placing over old foot

12. How is dial heated when soldering a new foot?

    Place on sheet iron | Place across soldering tweezers | Place on copper plate | Hold dial over lamp flame

Detach page or cut along this line — and send to the School for grading.

Master Watchmaking



Lesson 30

LATHE WORK

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

Printed in the United States of America

CHICAGO SCHOOL OF WATCHMAKING

Assignments for **Master Watchmaking** *Home Study Course*

LESSON 30 Lathe Work

INTRODUCTORY INFORMATION

At times you will find it necessary to replace train, balance and cap jewels in settings. Or you may have to make slight alterations on jewel settings ordered from your supplier. Also, you may find it desirable to make a new bushing and put a friction jewel in the bushing or setting. This lesson will show you the basic procedures involved in all of this type of work. The jewels are set in brass rod, which can then be turned to any desired dimensions. For your practice work, these dimensions will be given you. In actual watch repairing, they would be taken from the old setting or from the watch movement. In doing the assignments, you will also learn how to use the seat cutting tool, stripping tool, drills, and burnisher which you made.

KEY POINTS OF LESSON ASSIGNMENTS 96, 97, 98, 99, 100, 101, 102:

- Metals used in watchmaking.
- How to set train jewels, balance jewels and cap jewels.
- Countersinking jewel screws.
- How to rebush worn pivot holes.
- How to plug a Swiss bridge.
- Raised settings.
- How to replace a Swiss-style regulator key.

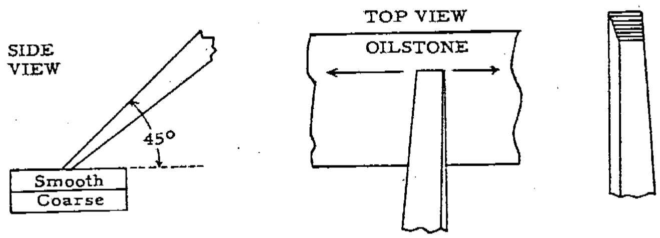
ASSIGNMENT NO. 96: Study Sections 500 and 501.

Study Questions:

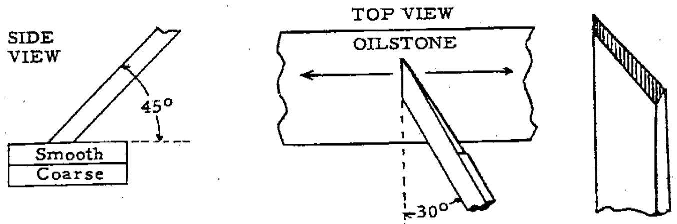
1. What are the principal base metals used in watchmaking?
2. How is a polish obtained on the graver?
3. What is used to hold the train jewel preparatory to setting?
4. What is the ratio between the diameter of the drill and the diameter of the jewel to be set?
5. In what direction is the lathe run when using the seat cutting tool?

Recommended Practice:

1. Sharpen your seat cutting tool as illustrated. Note the angle and how the tool is moved on the oilstone.

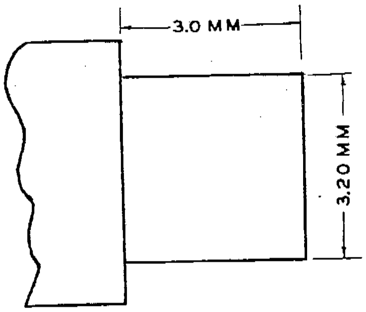


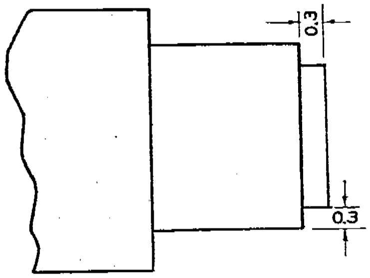
2. Sharpen your stripping tool as illustrated. Polish top edge of tool with a 4/0 emery buff. This will assure a bright cut.



ASSIGNMENT NO. 96 (Continued)

3. a. Set a train jewel as outlined in Section 501.
   b. Next, turn down the rod to a diameter of 3.2 mm for a length of 3 mm as illustrated at the left below.
   c. Cut a square shoulder 0.3 mm long and 0.3 mm deep as shown at the right below:





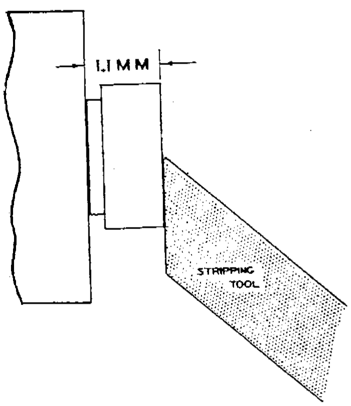
   d. Cut a small groove close to the back shoulder and cut off the setting with a jeweler's saw.
   e. Repeat the above steps with several other train jewels.

ASSIGNMENT NO. 97: Study Sections 502 and 503.

1. What type of chuck is used when cementing jewel settings?
2. What kind of cement is used?
3. How does cement lose its adhesive qualities?
4. How is excess cement removed from jewel settings?

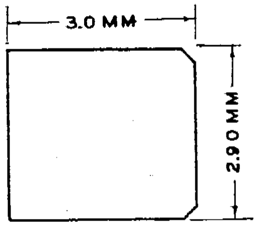
Recommended Practice:

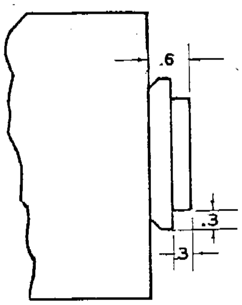
Now complete the work you started in the previous assignment by stripping out the jewel setting. Be sure the setting is free of oil or wax before it is set on the cement chuck.



1. Face off the cement brass each time the cement chuck is used. This will assure its running true.
2. Cement the jewel setting to the face of the cement brass and true with pegwood, Section 502.
3. In order to establish the proper length of the setting with the millimeter gauge, it may be necessary to chip or cut away the excess cement from the face of the cement chuck with a graver.
4. Face off the jewel setting to a length of 1.1 mm.
5. Polish the edge of the stripping tool with 4/0 emery and strip out (open up) the jewel setting as shown in Figure 30-20.
6. Heat jewel setting until it can be easily removed with tweezers.
7. Clean the setting as outlined in Section 503.
8. Repeat this work on the other jewels you have set.

ASSIGNMENT NO. 98: Study Sections 504 and 505.





Recommended Practice:

1. Set several balance jewels as outlined in Sec. 504. Make the diameter 2.9 mm and the length 3 mm.

   NOTE: No bevel is cut at the base of the jewel seat. If your practice balance jewels are flat on both top and bottom, be sure to set the oilcup IN.

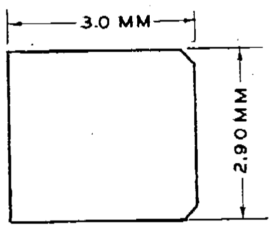
2. Cut off and cement balance jewel settings to cement brass.

   a. Face off to a length of .6 mm.
   b. Cut a square shoulder .3 mm wide and .3 mm deep, as illustrated.
   c. With a highly polished stripping tool, strip out as shown in Figure 30-33.
   d. Remove setting from cement brass and clean (Section 503).

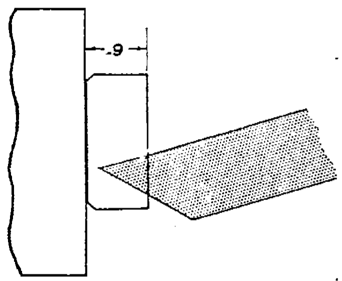
ASSIGNMENT NO. 99: Study Sections 506 and 507.

1. How is a cap jewel held preparatory to setting?
2. How are cap jewels set?

Recommended Practice:



1. Set several cap jewels as explained in Section 506.
2. Make the diameter 2.9 millimeters and the length 3 mm.
3. Cement up the setting. Section 507.
4. Cut off to a length of 0.9 mm.
5. Strip out.
6. Clean settings as explained in Section 503.



ASSIGNMENT NO. 100: Study Sections 508 and 509.

1. What is the average amount in hundredths of a millimeter allowed for side shake in setting train jewels?
2. What determines the amount of end shake?

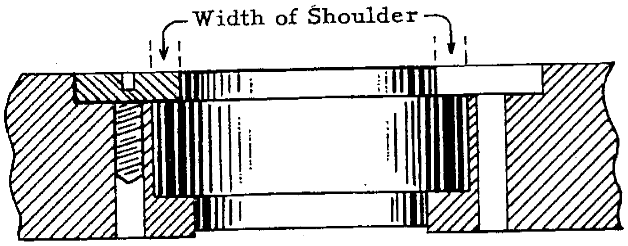
Recommended Practice:

1. Set a train jewel in a movement. An American movement, 6s or larger, with train jewels held in place by screws, is best for this practice. Follow the outline in Section 508. (See the note below before doing paragraph 6.)

2. Countersink jewel screws as in Section 509 (or follow the note below).

ASSIGNMENTS NO. 100 (Continued):

NOTE: If jewel screw countersinks are not available, use this alternate method: Turn a seat for the jewel screw head to rest upon after cementing the setting to a cement brass but before stripping. The cut shoulder should not be any wider than the amount the screw head projects over the jewel seat and should be slightly less in depth than the thickness of the screw head. The jewel setting and screw heads should be level with the plate or bridge. See the accompanying illustration:



ASSIGNMENT NO. 101: Study Sections 512, 513 and 514.

1. What is the amount allowed for side shake when fitting balance hole jewels?
2. What determines the amount of end shake?
3. What is a raised setting?

Recommended Practice:

1. Fit a balance jewel in setting to balance cock as outlined in Section 512.

   NOTE: Shoulder on setting should not be cut until after it is cemented to cement brass. The amount of end shake depends upon thickness of shoulder A, Figure 20-62.

2. Fit a cap jewel in setting to a balance cock, following the outline in Section 513.

   NOTE: Countersinking or cutting a shoulder for cap jewel screws is the same as for train jewels.

ASSIGNMENT NO. 102: Study Sections 510, 511 and 515.

1. What type of watch will frequently have worn pivot holes?
2. What is the name of the tool used in uprighting a worn pivot hole?
3. How can a Swiss bridge be plugged?
4. How is a regulator key replaced?

NOTES: In most cases, it is more practical and economical to repair a worn pivot hole with a friction jewel replacement. Sometimes, though, it may be necessary to upright (that is, to true up the hole in the plate or bridge) before setting a friction jewel.

Replacing a Swiss style regulator key (Section 515) is not often required. In most cases it is more economical to use a new regulator.

REQUIREMENT:

➧ Answer all Test Questions for Lesson 30 and return for grading.

SUMMING UP

Careful measurements, close fitting and frequent inspection of work are the keys to success in the work of this lesson. You have seen that well-made and sharp jeweling tools make it possible to rejewel a damaged plate or bridge with workmanship equal to the original. In stripping, particularly, practice on a piece of brass rod until you can leave a polished cut with no circular scratches. The stripping tool must be frequently sharpened during this work and polished after each sharpening. The tool edge must be so keen as to cut with scarcely any pressure against the setting. This keenness must be kept while the edge is polished to a mirror finish.

SEC. 500 -- Metals Used

This lesson deals with lathe work as concerned with base metals. The base metals used in watchmaking are brass and nickel and occasionally oreide, which has a high copper content. These metals are easy to work and if the student will keep the cutting edge of his graver polished, a smooth polished finish can be obtained. Polishing the graver is best done with a 4/0 emery buff.

SEC. 501 -- Steps in Setting a Train Jewel

1. Select train jewel to be set. Push a pointed piece of pegwood through the hole in jewel keeping the oil cup down, figure 30-1. Tap slightly on bench plate in order to flatten pointed end of pegwood. This will hold jewel securely and make it easy to handle.

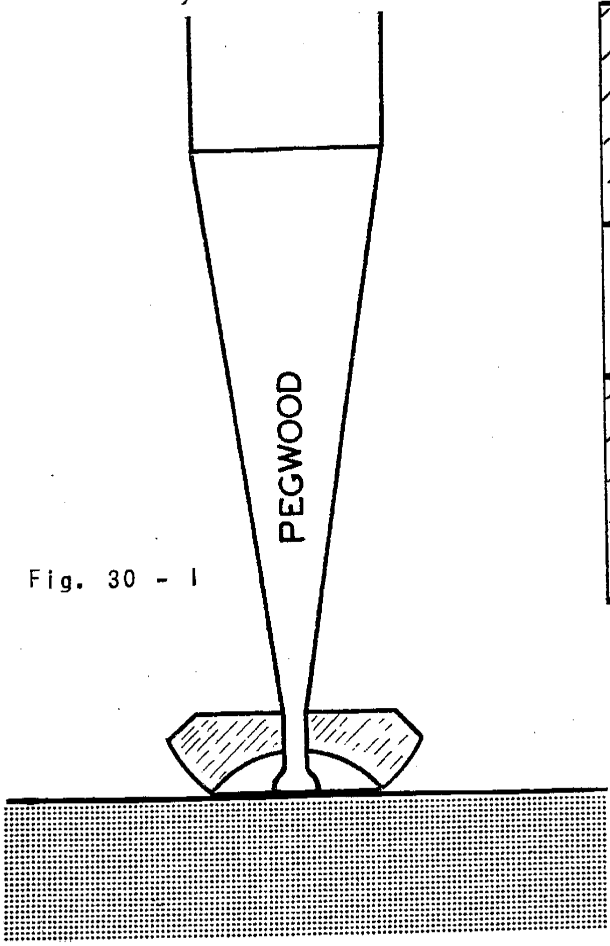


Fig. 30 - 1

2. Place brass, nickel or oreide rod in lathe chuck and center, figure 30-2.

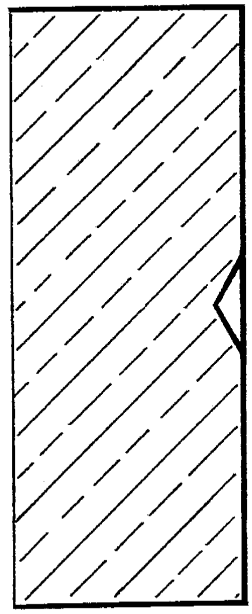


Fig. 30 - 2

3. Select a drill about 2/3 the diameter of the train jewel. Drill a hole fairly deep into the rod, figure 30-3.

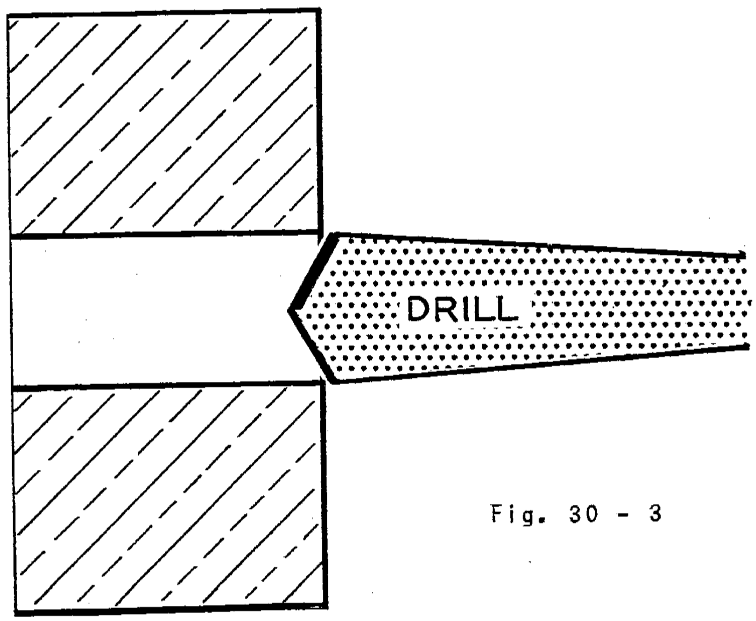


Fig. 30 - 3

4. Place seat cutting tool in position shown in figure 30-4, cut a seat by running lathe in reverse and moving seat cutting tool with left forefinger in the direction of Arrow A.

5. The train jewel is then tried into the seat, figure 30-5. The jewel should fit freely without side play and the face

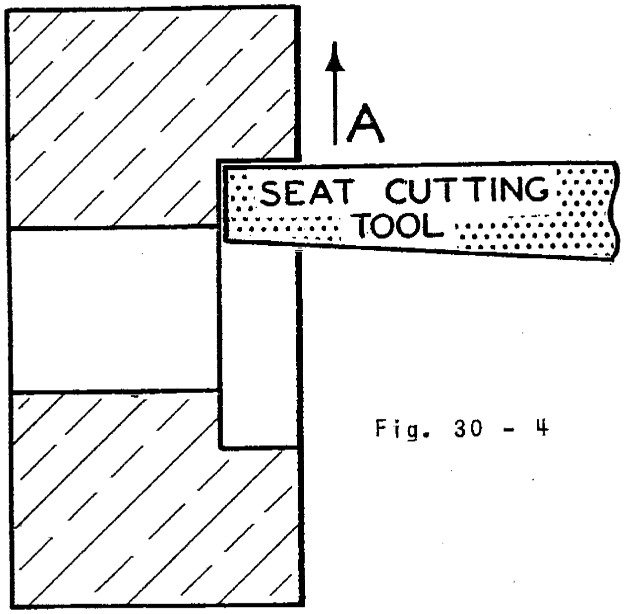


Fig. 30 - 4

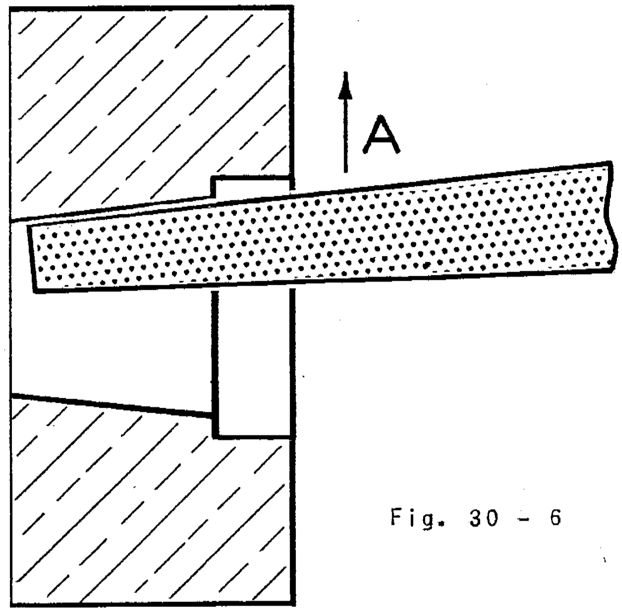


Fig. 30 - 6

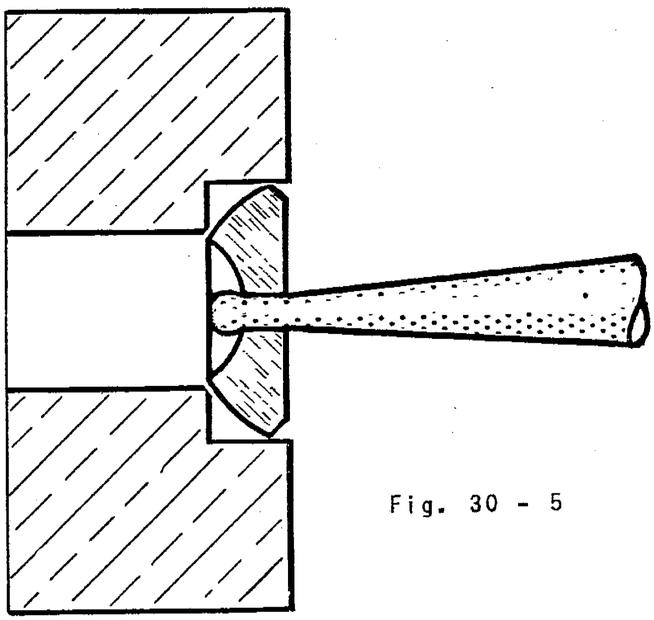


Fig. 30 - 5

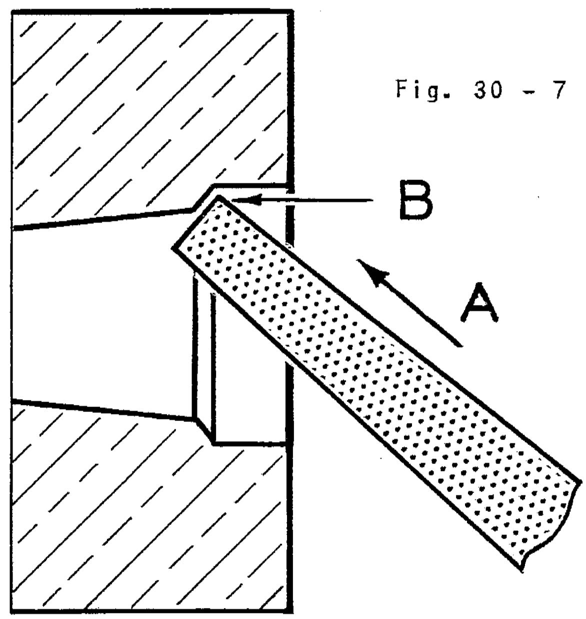


Fig. 30 - 7

of the jewel should be just below the surface.

6. Open the back of hole with seat cutting tool, running the lathe in reverse and moving the tool in direction of Arrow A, leaving a small shoulder, as shown in figure 30-6.

7. Bevel the corner of shoulder B with seat cutting tool, moving tool in direction of Arrow A, as illustrated in figure 30-7. This will allow the curved portion of train jewel on side of oil cup to rest securely in place. Face off rod until the jewel is just below the surface. It is now ready to be burnished in place.

8. With a square graver or a long pointed stripping tool, make a small cut to the edge of the hole as in figure 30-8. This is called the bezel.

9. Place train jewel in seat, place tweezer over face of train jewel and extract pegwood. A very small amount of beeswax applied to jewel before placing in hole will help keep jewel in place until burnished.

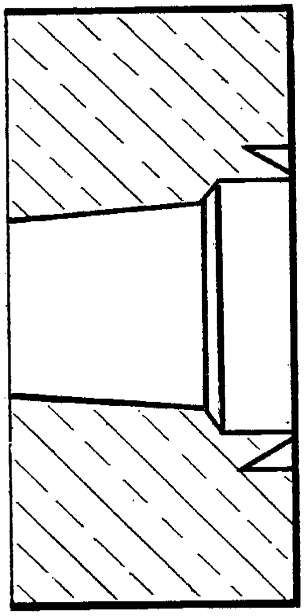


Fig. 30 - 8

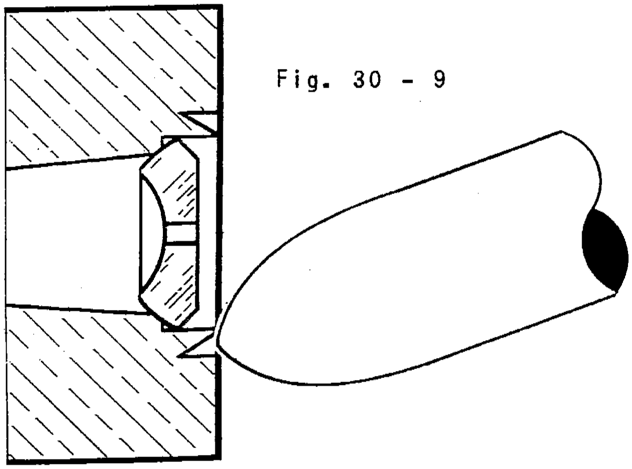


Fig. 30 - 9

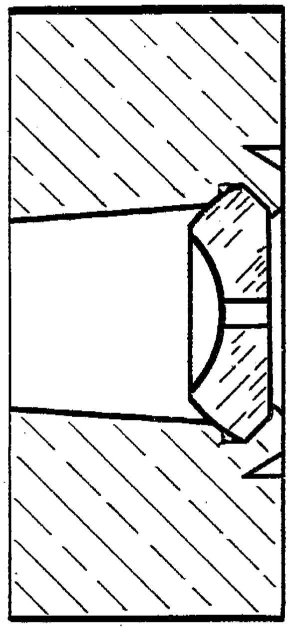


Fig. 30 - 10

10. Place burnisher in bezel, figure 30-9, and roll bezel over train jewel while running the lathe forward. Face off rod until jewel is slightly below surface and jewel will appear as in figure 30-10.

11. Figure 30-11 illustrates the train jewel in place and the burnisher held in position to burnish the edge of metal over the jewel without a cut bezel.

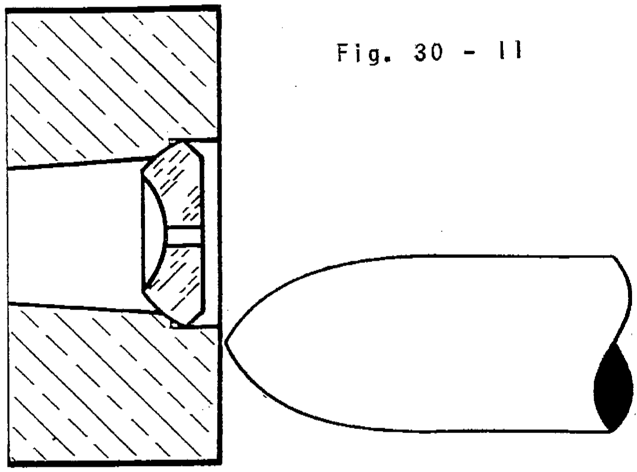
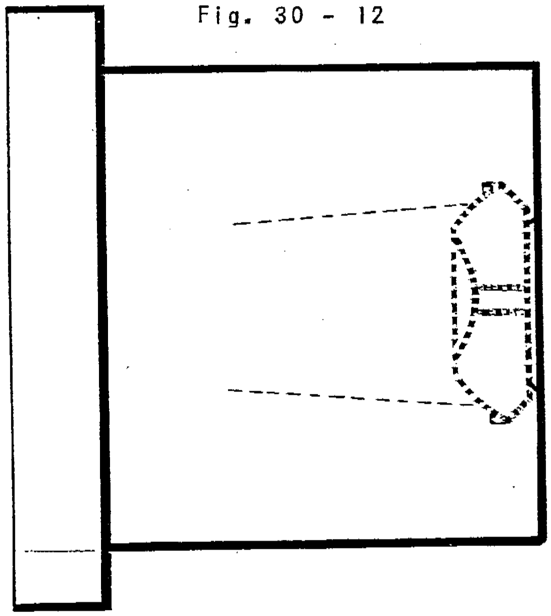


Fig. 30 - 11

12. Cut diameter of rod to preselected diameter, figure 30-12.

Fig. 30 - 12



13. Cut square shoulder on end of stock to correct depth and diameter as in figure 30-13.

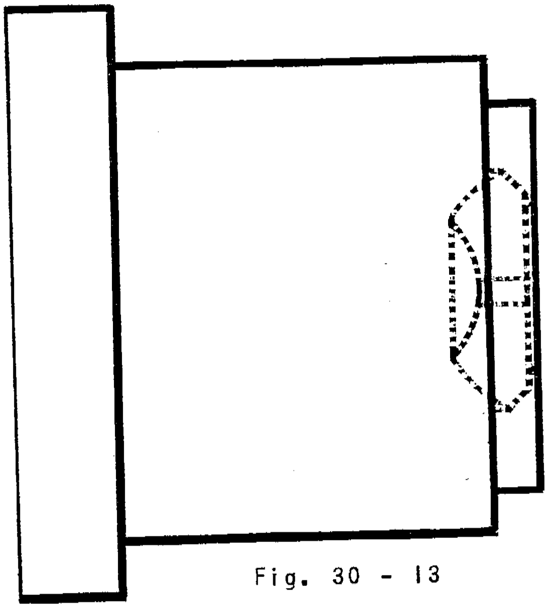
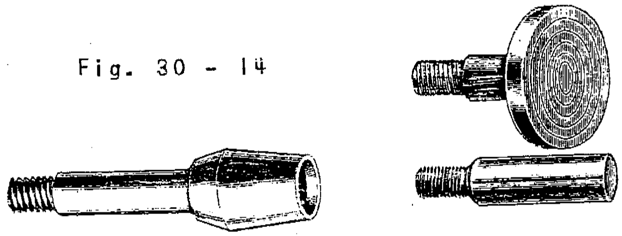


Fig. 30 - 13

Fig. 30 - 14



SCREW CHUCK CEMENT BRASSES

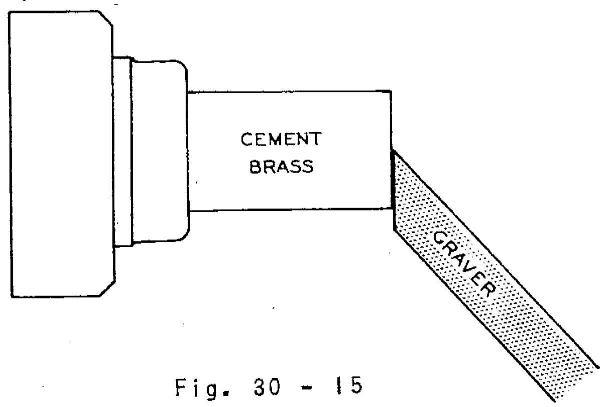


Fig. 30 - 15

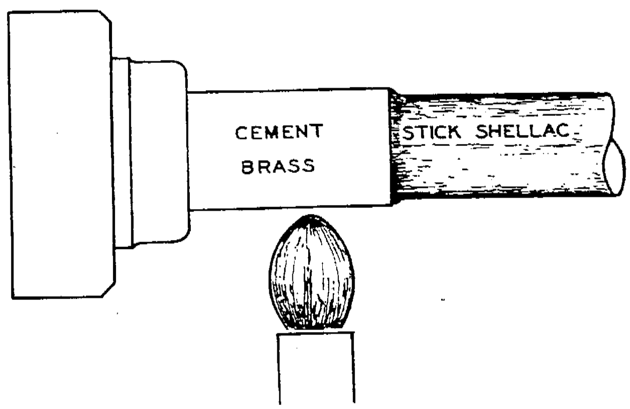


Fig. 30 - 16

SEC. 502 -- Steps in Stripping a Train Jewel Setting

Figure 30-14 illustrates a screw chuck. The screw chuck is made up of a steel chuck tapped to receive the threaded end of a cement brass. These come in assorted diameters. The face of the cement brass should be faced off. This will insure a true flat surface upon which to cement and center the jewel setting. The best cement to use is pure orange shellac in stick form. Be careful not to overheat or burn the shellac as it loses its adhesive qualities. In case this happens, remove burned cement and start over.

1. Figure 30-15 illustrates the method used to face off a cement brass prior to cementing a jewel. Be sure that the cement brass has been screwed securely into the chuck. Before proceeding any further, it might be well to make a little experiment. Heat the end of your stick shellac with the flame of an alcohol lamp and quickly press against the face of the cement chuck. It will be seen that the cement does not adhere to the cold metal, thus illustrating clearly that the metal must be heated to a temperature which will melt the cement before it will adhere properly.

2. In figure 30-16, the flame of the alcohol lamp is held directly beneath the cement brass. With the lathe turning, hold the stick shellac against the face of the cement brass until the cement melts and covers the face of the cement brass.

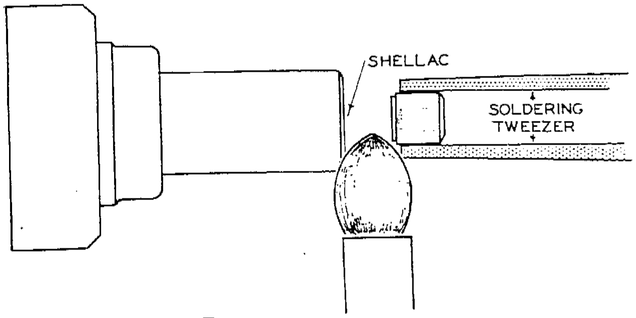


Fig. 30 - 17

3. Hold the jewel setting with a pair of soldering tweezers as illustrated in figure 30-17 and with the flame of the alcohol lamp placed in the position shown, keep the cement brass warm while heating the jewel setting. When the jewel setting has been heated, push it against the face of the cement brass and pull away. If the cement adheres to the face of the setting, the cement is of the proper temperature.

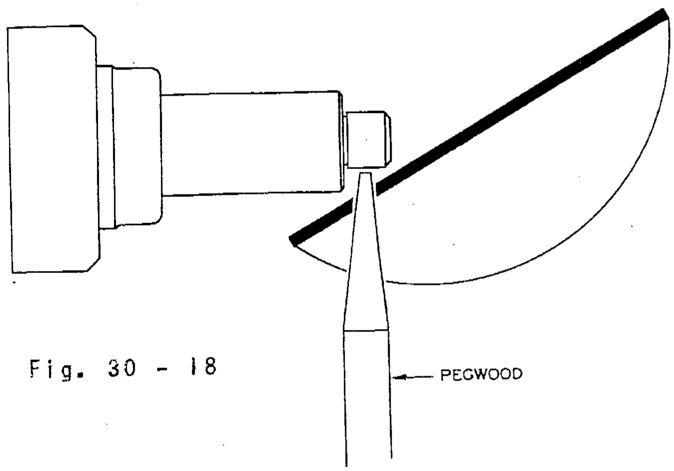


Fig. 30 - 18

4. Set jewel setting on cement chuck and set T Rest as close to the cement brass and setting as possible, as shown in figure 30-18. With a piece of pegwood in position shown, true the setting up by running the lathe forward and holding the pegwood lightly against the side of the jewel setting. If it does not adhere properly or run true, warm the cement brass again and repeat the truing process until your setting runs absolutely true. The setting should now appear on the face of the cement chuck as shown in figure 30-19. With a stripping tool, which has had the edge polished with a 4/0 emery buff, place in the position shown in this figure and face off the setting to the proper thickness.

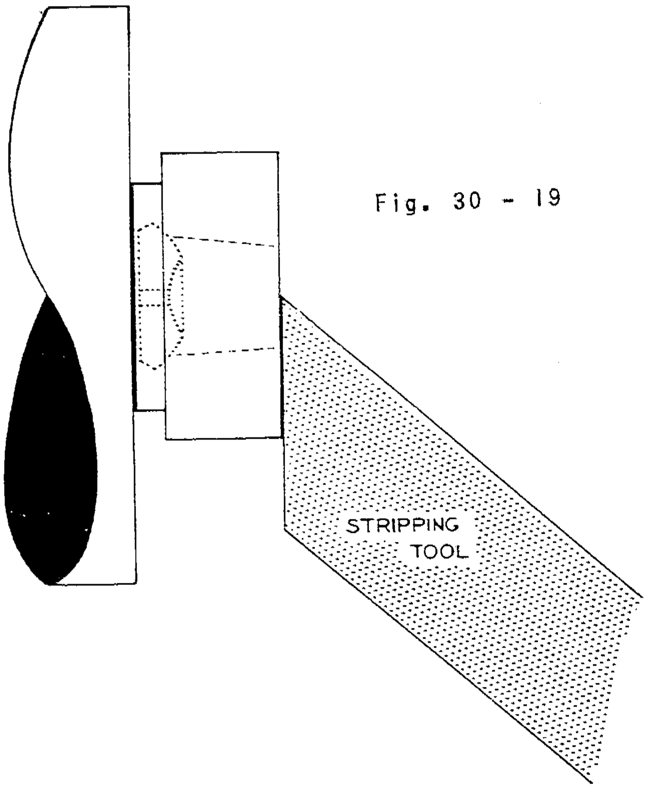


Fig. 30 - 19

5. Place the stripping tool in the position shown in figure 30-20 and open

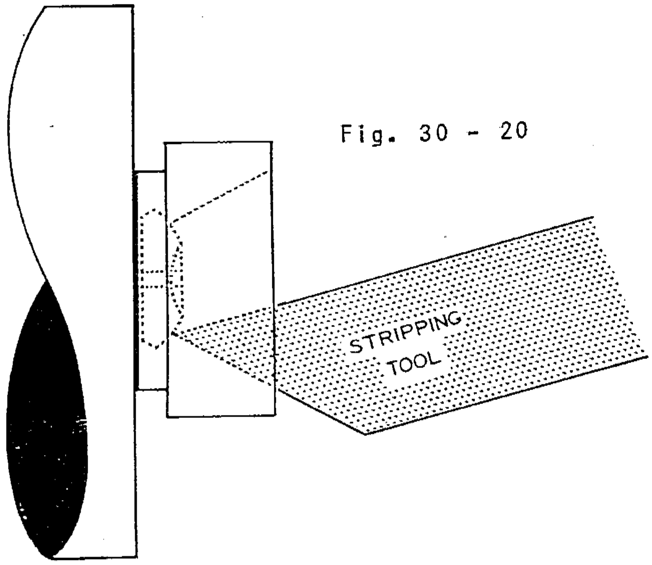


Fig. 30 - 20

up the hole leaving a small rim around the top of the setting. The finished setting should appear as shown in the cross section view in figure 30-21.

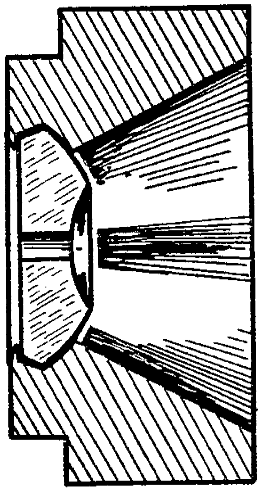


Fig. 30 - 21

SEC. 503 -- Cleaning Cement from Jewel Settings

Put the jewel or jewels to be cleaned in a small bottle about half full of alcohol. This bottle should have a screw cap, figure 30-22, through which a hole has been drilled. Place the bottle in a boiling pan about half full of water, and heat carefully over flame of alcohol lamp until alcohol has boiled violently for several minutes. It is not necessary for the water to boil. Remove setting from bottle and place between two pieces of pithwood which have been wet with alcohol,

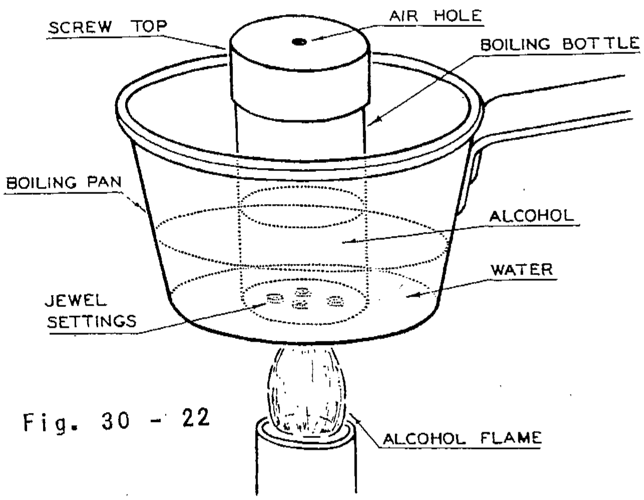


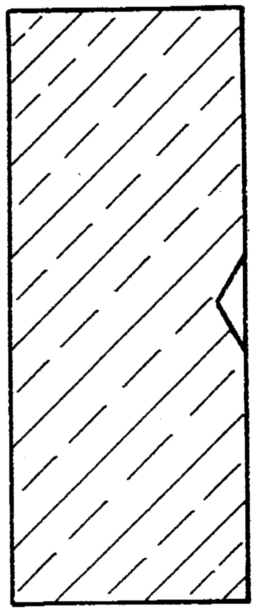
Fig. 30 - 22

and twist pithwood back and forth. With a piece of pegwood wet in alcohol, clean hole in jewel.

SEC. 504 -- Steps in Setting a Balance Hole Jewel

1. Select balance hole jewel to be set. The balance hole jewel is held with pegwood as illustrated in figure 30-26.
2. Center stock as in figure 30-23.

Fig. 30 - 23



3. Select drill about 2/3 the diameter of the balance hole jewel and drill hole into rod as shown in figure 30-24.

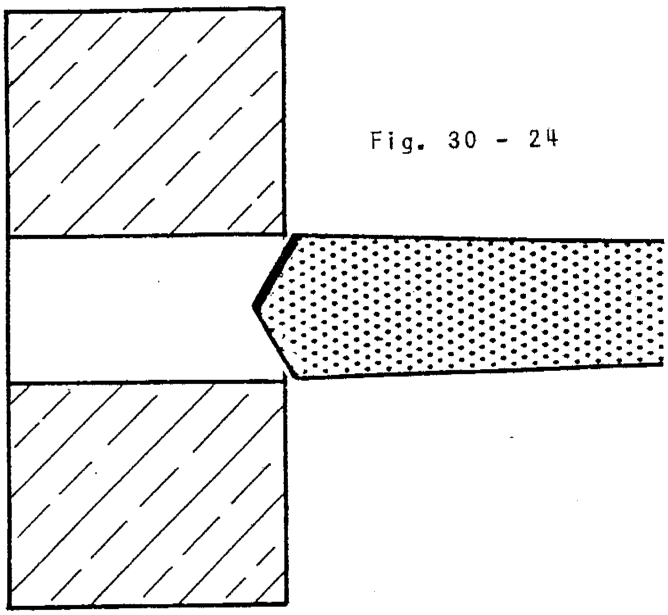


Fig. 30 - 24

4. Place seat setting tool in position as shown in figure 30-25. Cut seat for balance hole jewel.

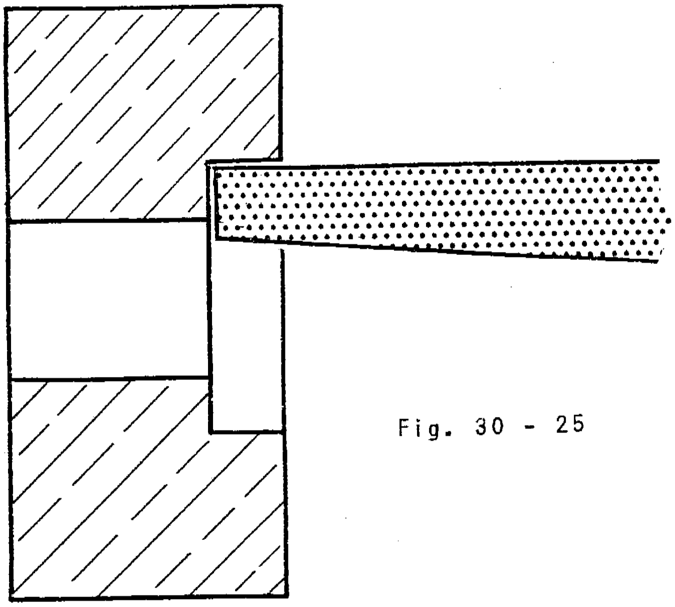


Fig. 30 - 25

5. The jewel should fit freely without side play and just below the surface of the rod as illustrated in figure 30-26.

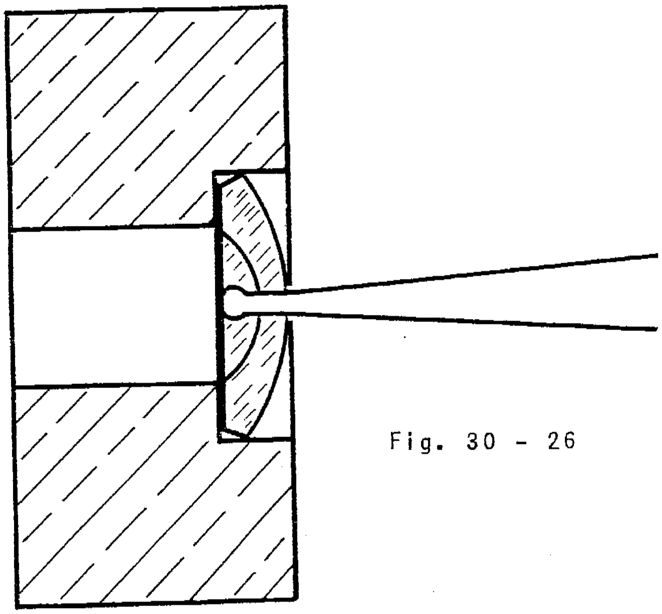


Fig. 30 - 26

6. Open the back of the hole with seat cutting tool as in figure 30-27, leaving a small shoulder as illustrated. Do not cut off the corner!

7. With a square graver or long pointed stripping tool, cut bezel as shown in figure 30-28.

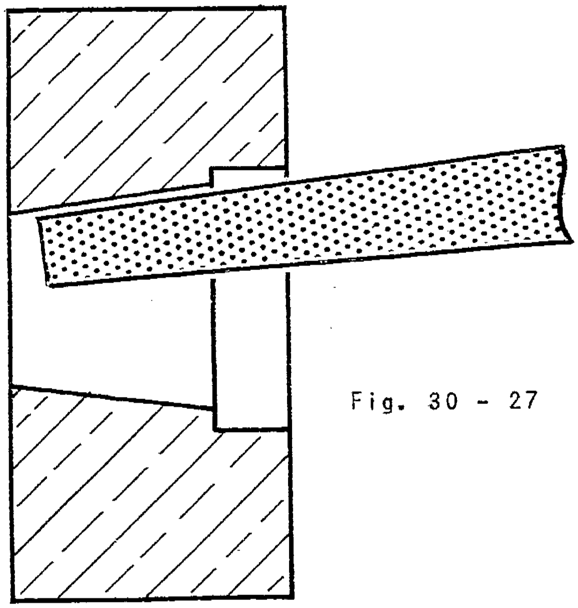


Fig. 30 - 27

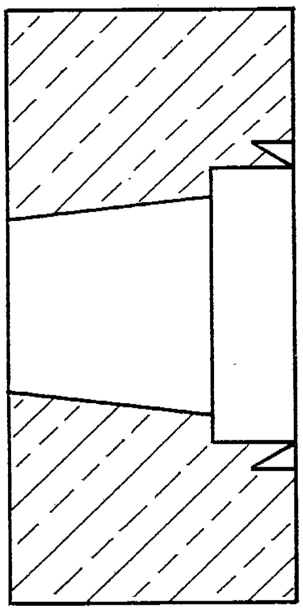


Fig. 30 - 28

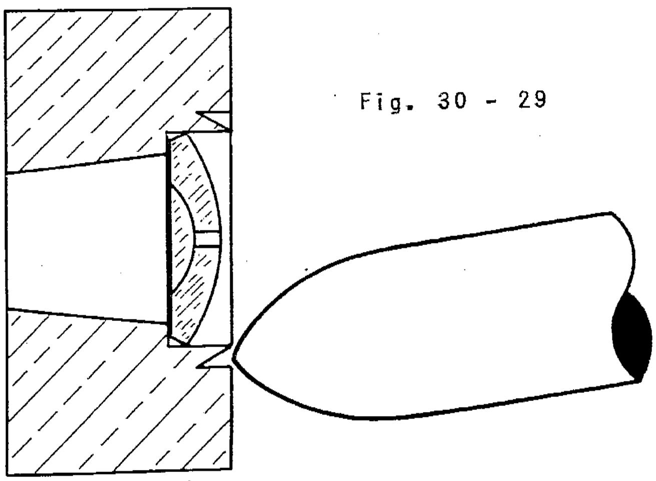


Fig. 30 - 29

8. Place balance hole jewel in position and holding tweezers over face of hole jewel, extract pegwood. Burnish bezel over face of balance hole jewel as shown in figure 30-29. The jewel should now appear as in figure 30-30.

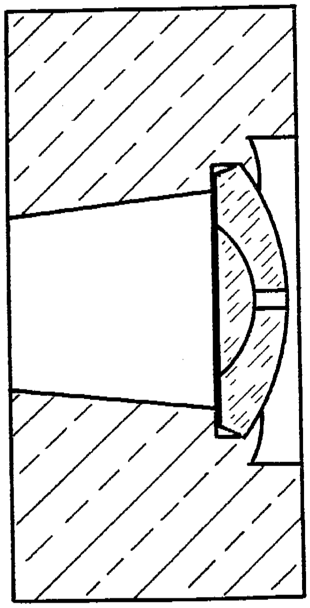


Fig. 30 - 30

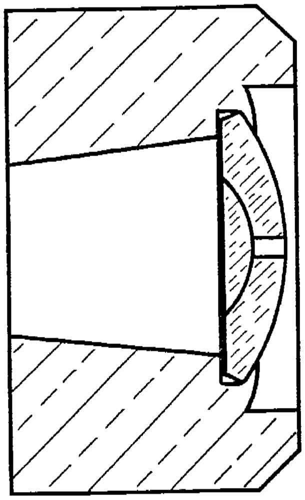


Fig. 30 - 31

9. Face off rod until the face of the balance jewel sets just below the surface as shown in figure 30-31. Turn outside diameter to correct dimension.

10. Bevel corner of setting as shown in figure 30-31.

SEC. 505 -- Stripping a Balance Hole Jewel

The balance hole jewel is secured to cement chuck in the same manner as is a train jewel as explained in Sec. 502.

1. Face off setting to proper thickness, figure 30-32. With a square graver, cut shoulder on setting as shown in figure 30-33. In most cases there is not very much stripping on a balance hole jewel setting but it is accomplished by holding the stripping tool in position as shown in figure 30-33.

2. Figure 30-34 illustrates a cross section of a finished balance hole jewel setting. Notice that the corner has been beveled slightly at A. This makes for a finished job.

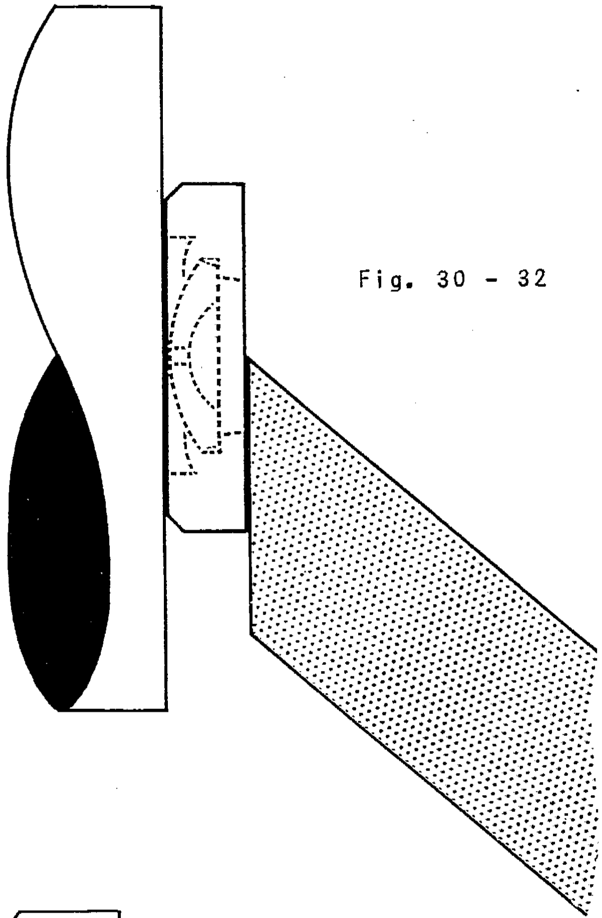


Fig. 30 - 32

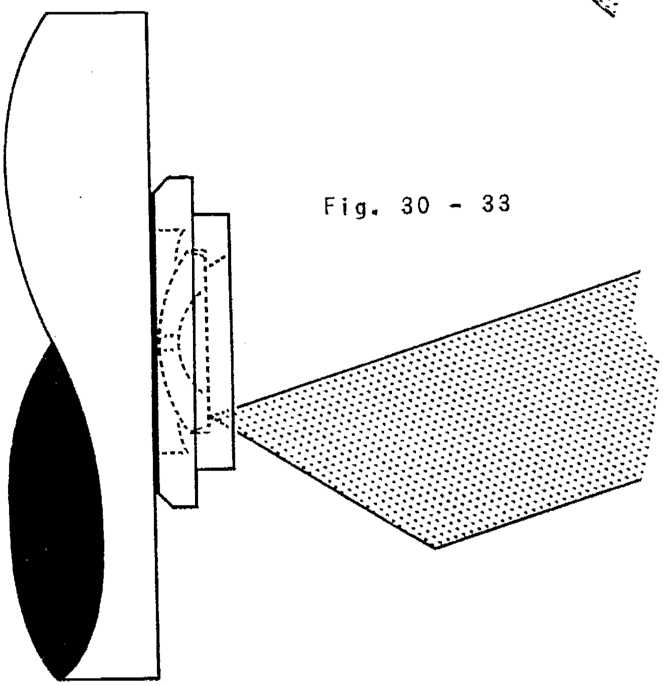


Fig. 30 - 33

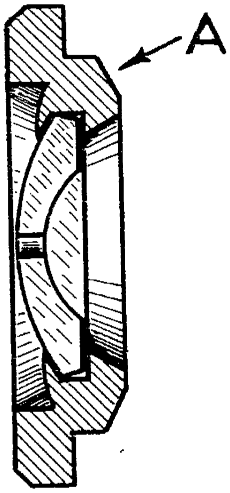


Fig. 30 - 34

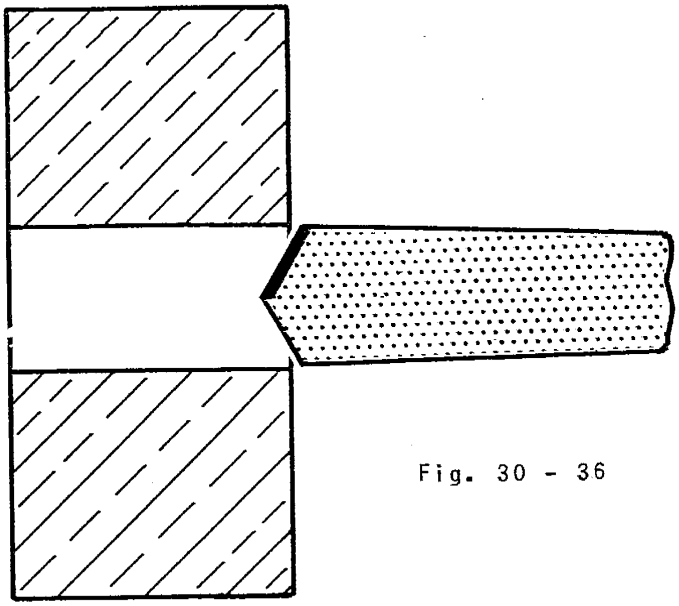


Fig. 30 - 36

SEC. 506 -- Steps in Setting a Cap Jewel

1. Select cap jewel to be set. Put a small amount of beeswax on a piece of pegwood and place against the flat side of cap jewel, figure 30-38. If the cap jewel has a curved surface, the procedure is identical to that for setting a train jewel. If the cap jewel is flat instead of being curved on the upper surface, it is set the same as a balance hole jewel.

2. Place stock in lathe chuck and center, figure 30-35. Select drill about 2/3 the diameter of the cap jewel and drill hole into stock as in figure 30-36.

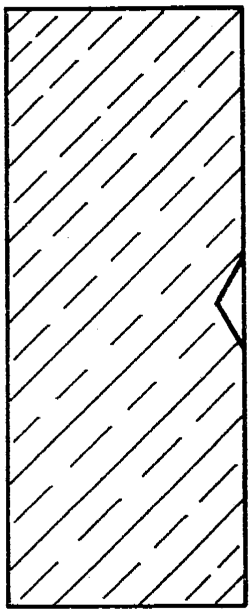


Fig. 30 - 35

3. Place seat cutting tool in position shown in figure 30-37 and cut seat while running the lathe in reverse.

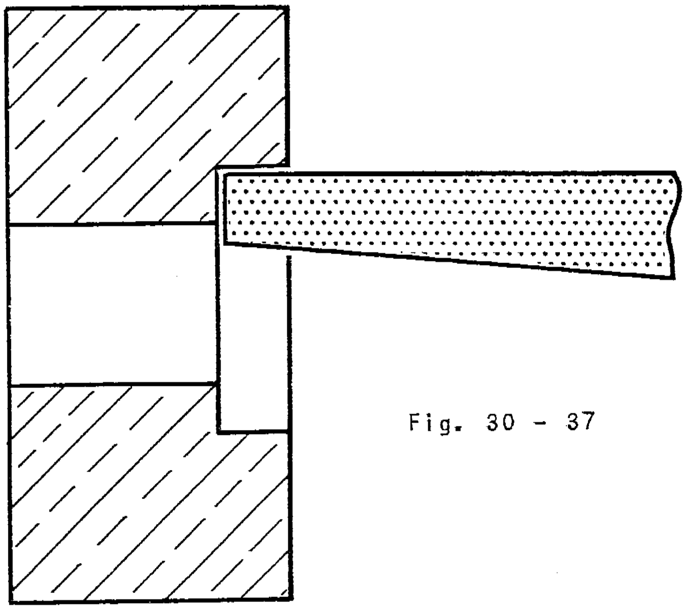


Fig. 30 - 37

4. The cap jewel can be tried as in figure 30-38. The jewel should fit freely without side play and the face of the cap jewel should be just below the surface.

5. Open the back of the hole with seat cutting tool as shown in figure 30-39.

6. Bevel corner as in figure 30-40.

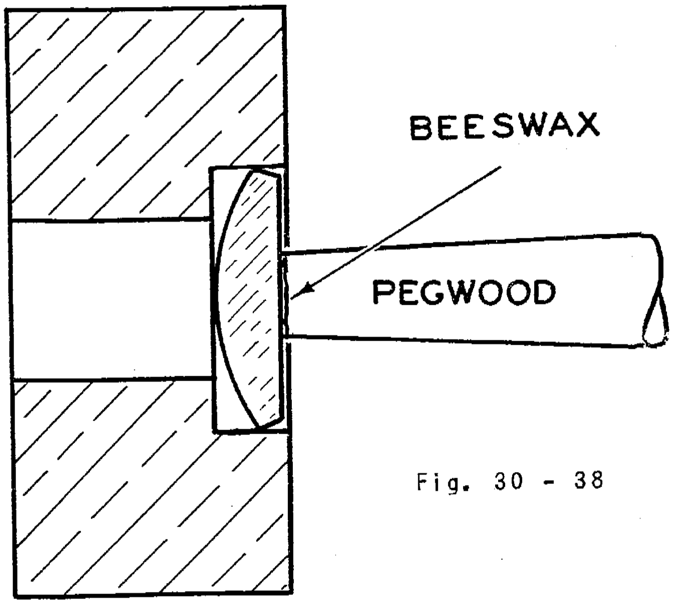


Fig. 30 - 38

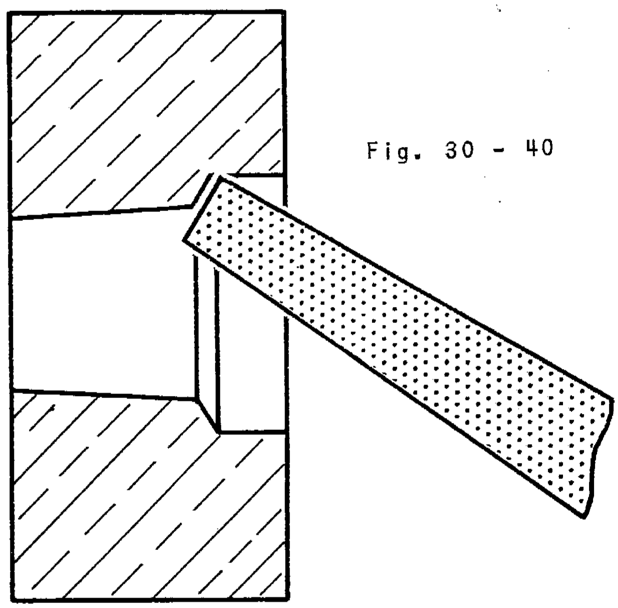


Fig. 30 - 40

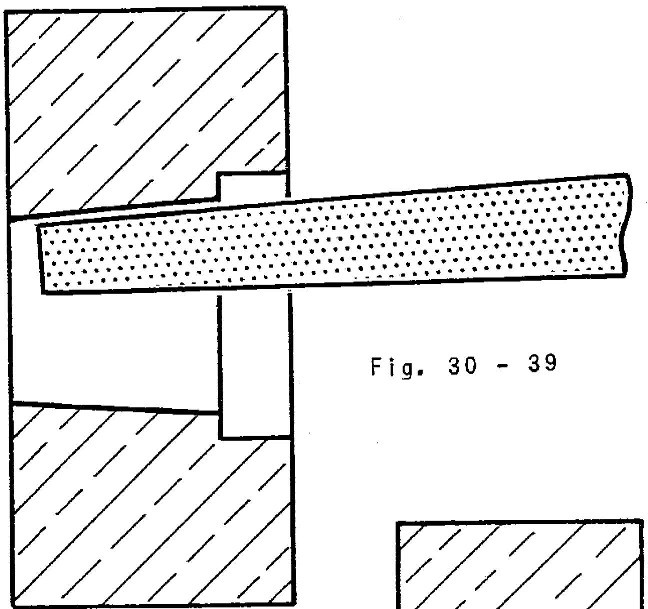


Fig. 30 - 39

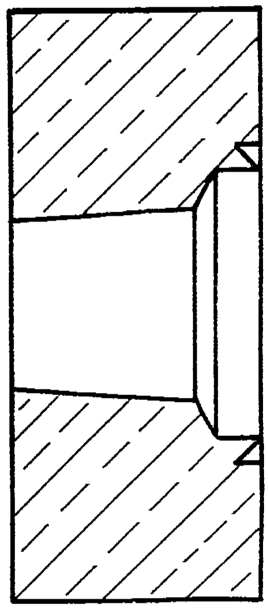


Fig. 30 - 41

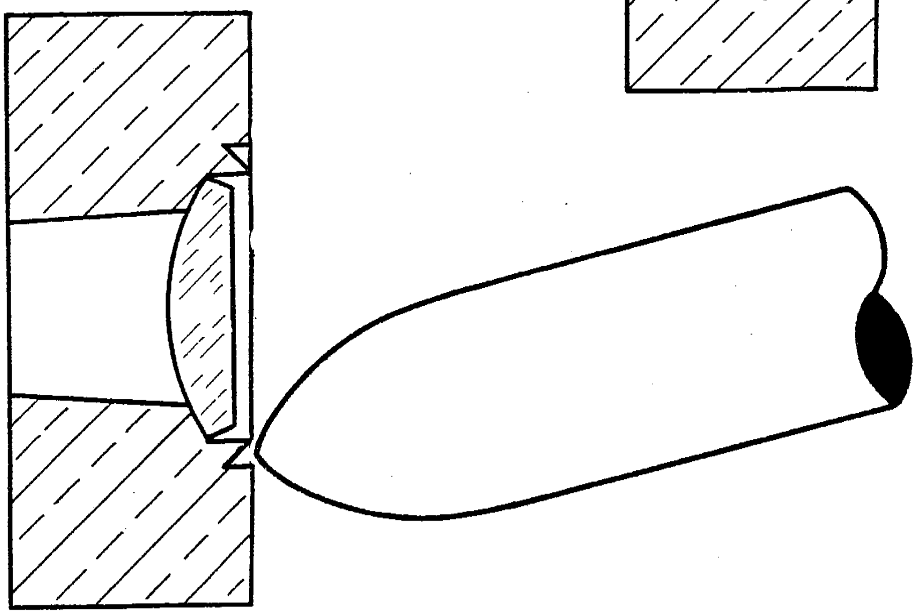


Fig. 30 - 42

7. Cut bezel as in figure 30-41.

8. With cap jewel in place as shown in figure 30-42, burnish bezel over cap jewel as shown in figure 30-43.

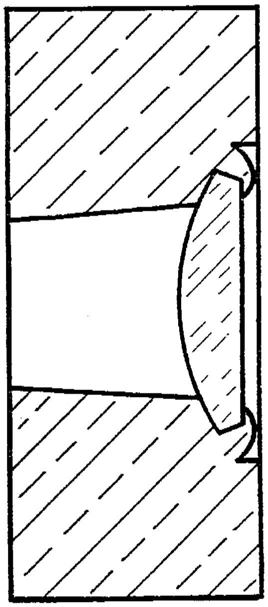


Fig. 30 - 43

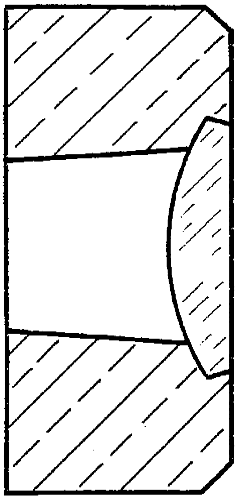


Fig. 30 - 44

9. Face off setting so that the face of cap setting is flush with rod as shown in figure 30-44.

10. Bevel corner of setting as shown in figure 30-44.

SEC. 507 -- Steps in Stripping a Cap Jewel

The cap jewel setting is cemented to a cement brass as previously explained and then faced off to the proper thickness as in figure 30-45. It is then stripped out as illustrated. Figure 30-46 illustrates a cross section view of a cap jewel in setting.

SEC. 508 -- Setting Train Jewels in Watches

1. Measure pivot and select train jewel, allowing .02 mm for side shake.

2. Cut diameter of stock to fit plate or to the diameter of old setting.

3. Set train jewel (Steps 2, 3, 4, 5, 6, 7, 8, 9, and 10, of Sec. 501).

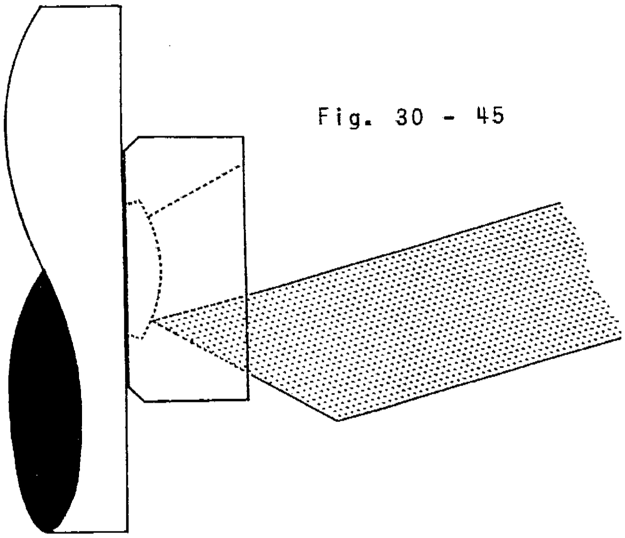


Fig. 30 - 45

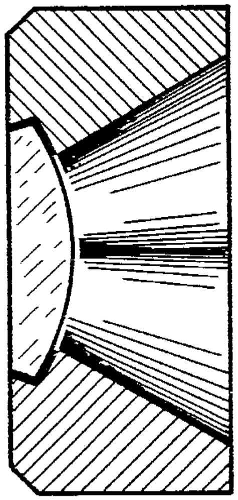


Fig. 30 - 46

4. Cut shoulder to proper diameter and depth. As this depth determines the correct amount of end shake, it can be compared with the old setting as in figure 30-47.

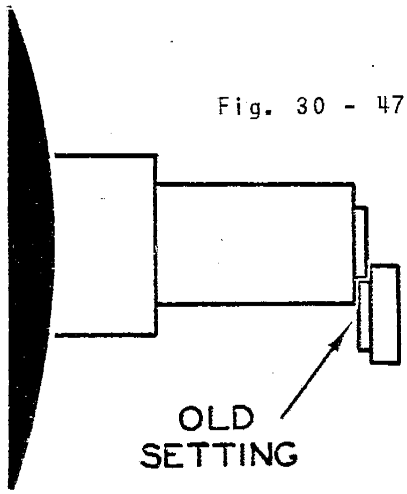


Fig. 30 - 47

5. Place bridge or plate on rod as far as it will go. With graver cut a notch which will end at the point of contact between the setting and the upper edge of bridge or plate, figure 30-48. Cut off setting.

6. Cement and face off to proper thickness. Strip as in Step 5 of Sec. 502.

7. Clean jewel setting in alcohol (Sec. 503).

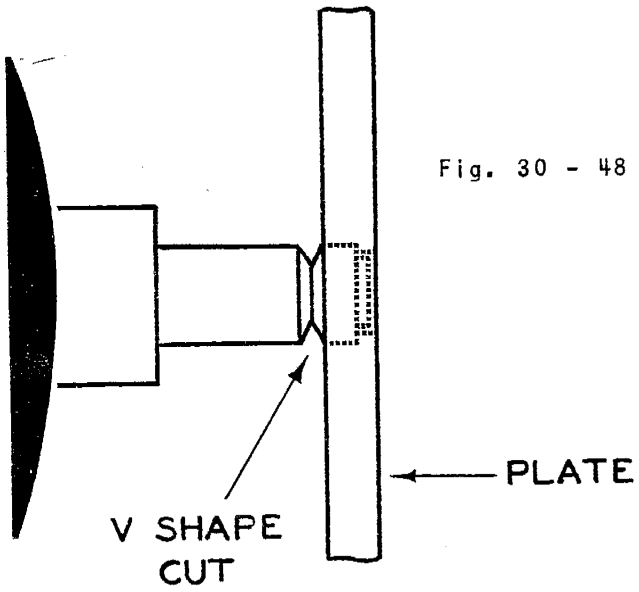


Fig. 30 - 48

SEC. 509 -- Countersinking Jewel Screw

Figure 30-49 is an illustration of a jewel screw countersink with a centering pivot. The centering pivot is used as a guide when countersinking the jewel setting as in figure 30-50. It is best to place one jewel screw in position as at

Fig. 30 - 49

JEWEL SCREW COUNTERSINK

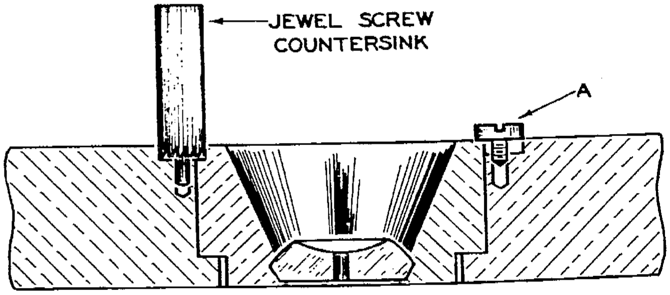


Fig. 30 - 50

A, figure 30-50, and countersink the opposite side. Then replace jewel screw in hole, which has just been countersunk, and countersink side at A. The jewel screws should be flush with the plate.

SEC. 510 -- Steps in Rebushing a Worn Pivot Hole

There are times when a pivot hole becomes worn so badly that it is impossible to close it satisfactorily or to locate the center in order to fit a friction jewel. This is a common occurrence in seven jewel watches. Figure 30-51 illustrates such a hole. The actual center

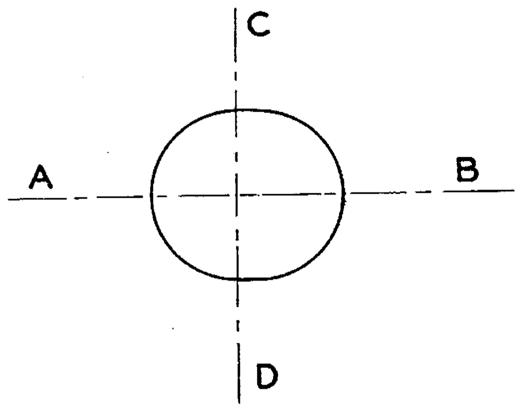


Fig. 30 - 51

is at the intersection of lines AB & CD. When a worn pivot hole has been uprighted and rebushed properly, the wheel and pinion will have the proper depthing and the pinion will be perpendicular to the hole in the bushing or jewel. For this purpose we use a face plate, figure 30-52. The face plate is made up of three moveable jaws secured to a circular plate

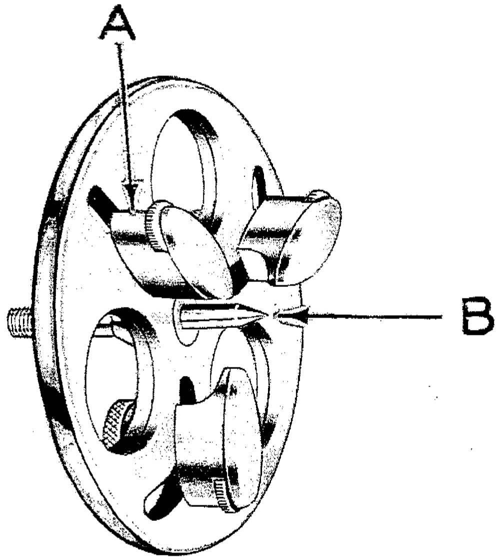


Fig. 30 - 52

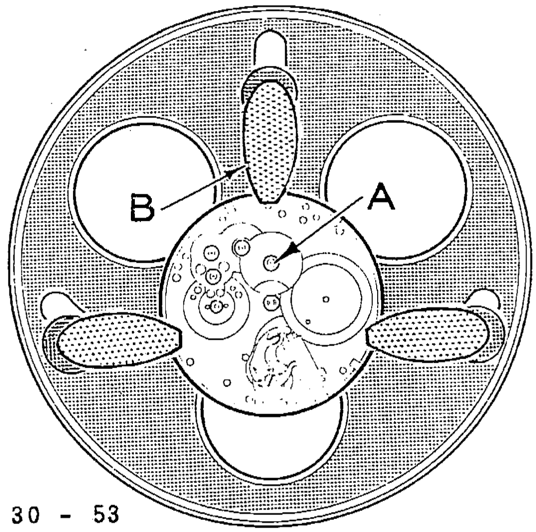


Fig. 30 - 53

and used in a watchmakers lathe. Notice that the jaw at A moves in a straight slot while the remaining two jaws move in curved slots. The pump center at B is used as a guide in locating the approximate center of the pivot hole which is to be uprighted. In uprighting a pivot hole in a bridge or upper plate of a watch, proceed as follows:

1. Place pillar plate with pivot hole A directly in line with center jaw B, figure 30-53, and place the other two jaws just over the edge of the pillar plate. The center of the pivot hole is located over the pump center, which is not visible in this view. Now remove pump center and tighten jaws with nuts A, figure 30-54, enough to hold plate in place. The knurled nuts at B are adjusted to keep the jaws parallel.

2. Figure 30-54 is a side view of the pillar plate held in position in the face plate with the T Rest set as close as possible and parallel to the face plate.

3. Place a long piece of pegwood as shown in figure 30-54 in pivot hole and rest on the T Rest. Now turn face plate slowly and pegwood will move up and down as illustrated by dotted pegwood. When the pegwood is at its lowest point A, figure 30-54, tap the top edge of pillar plate with a brass hammer. This will bring the pivot hole nearer to dead center. Continue turning the lathe and watching the low point of your pegwood while gently tapping the top edge of pillar plate until the end of the pegwood at

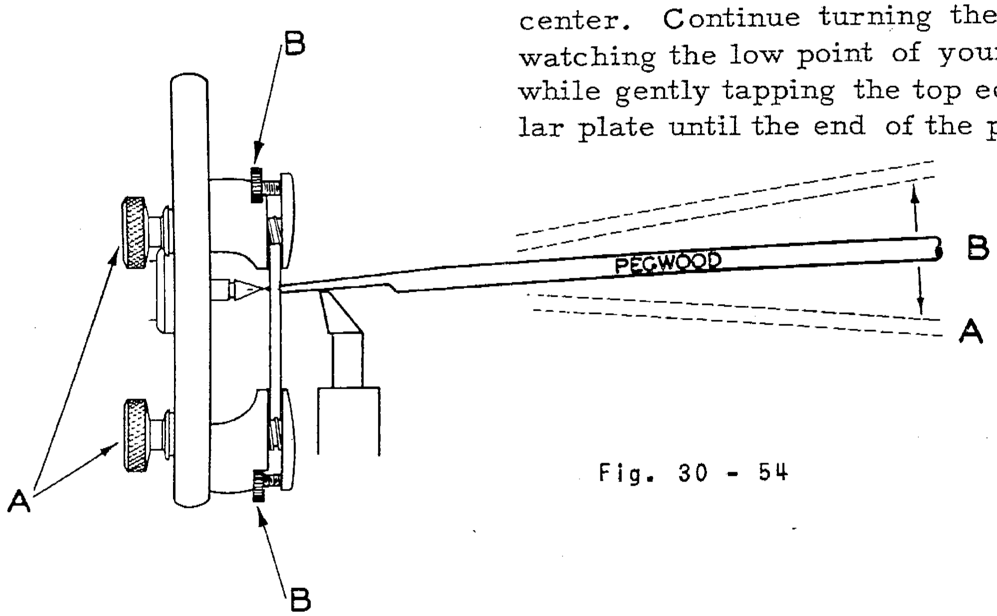


Fig. 30 - 54

B remains stationary. Tighten thumb nuts A. The pivot hole is then centered. Now screw the bridge in place on the pillar plate and bore out a hole for the new bushing. This hole can be of any convenient diameter. The bushing is made from a piece of brass rod turned to a diameter approximately 1/100 mm larger than the hole in the bridge. This bushing should be centered and the pivot hole made a trifle smaller than the diameter of the pivot for which it is intended. The bushing is then stripped out and pressed into position either with a friction jeweling tool or a staking tool. Broach pivot hole to fit pivot.

If the hole in the pillar plate was the one which needed to be rebushed, we would start off by uprighting the corresponding pivot hole in the upper bridge or plate; and after it was centered properly, remove the bridge and bore out a hole in the pillar plate and rebush as previously explained.

The most modern method today is to use a friction jewel instead of a bushing after a plate or bridge has been uprighted.

SEC. 511 -- Plugging Swiss Bridge

Although this method of replacing a jewel in a Swiss Bridge has been outmoded in favor of friction jeweling, there may be times in your career as a watchmaker when it is the most practical method to use.

1. Open bezel, using a cutting broach from the upperside of our bridge, as illustrated in figure 30-55. Do not cut any larger than necessary; just cut out old bezel.

2. Turn down a piece of rod on a very slight taper until bridge will just start over end of rod as in figure 30-56.

3. Select jewel to fit pivot. Set in rod and push bridge securely on rod, figure 30-57.

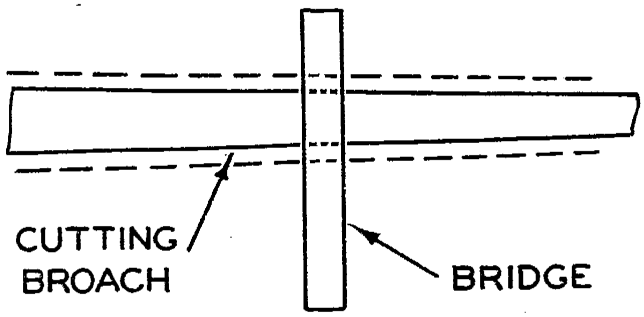


Fig. 30 - 55

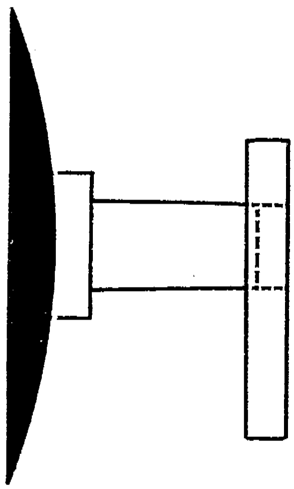


Fig. 30 - 56

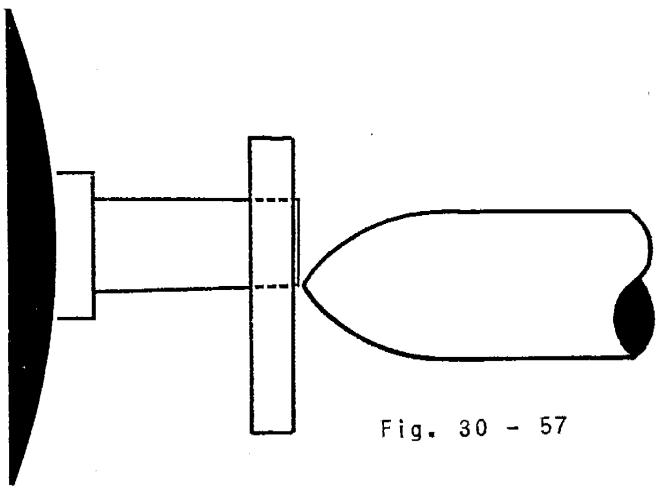


Fig. 30 - 57

4. Burnish edge of brass over setting and face off flush with bridge, figure 30-58. Cut a slot as at A, figure 30-59, and saw off. The jewel and setting are now burnished into the bridge. To finish, cement bridge to cement brass truing to hole in jewel as in figure 30-60, and strip along dotted lines, figure 30-60. Remove and clean with alcohol.

SEC. 512 -- Setting Balance Jewels in Watches

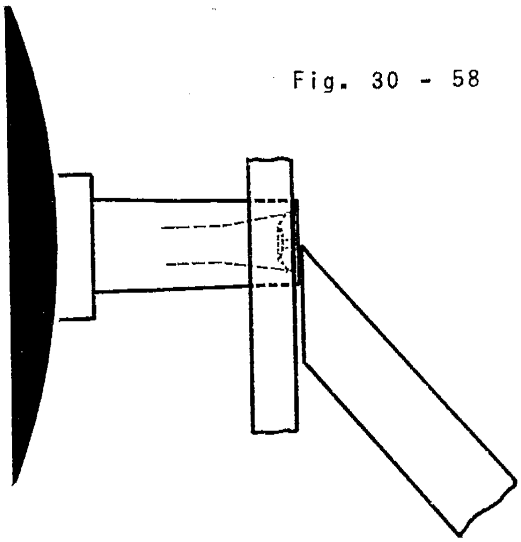


Fig. 30 - 58

1. Select balance hole jewel to be set allowing .01 mm for side shake. Always try the jewel on the pivot as you will frequently find a slight variation in the hole sizes. The balance pivot should extend through and above the top of the jewel approximately the thickness of the pivot as shown in figure 30-61. Pivots should always be polished, if necessary, before selecting the jewel to be set.

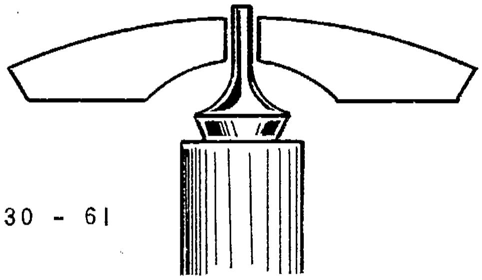


Fig. 30 - 61

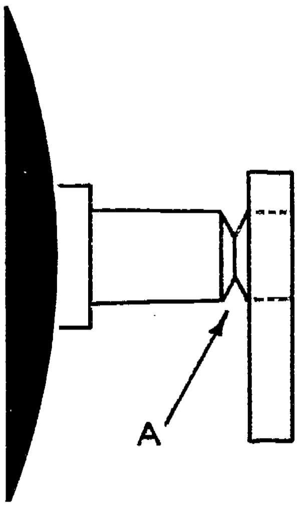


Fig. 30 - 59

2. Turn stock to the diameter of the old setting or until it fits hole in cock or plate snugly.

3. Set balance jewel (Steps 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, Sec. 504).

4. Cut off setting, gauging the thickness by comparing with old setting.

5. Cement setting to cement chuck and face off to the proper thickness, using the old setting as a guide.

6. Cut square shoulder, using the old setting as a guide, figure 30-62. The thickness of the setting at A is very im-

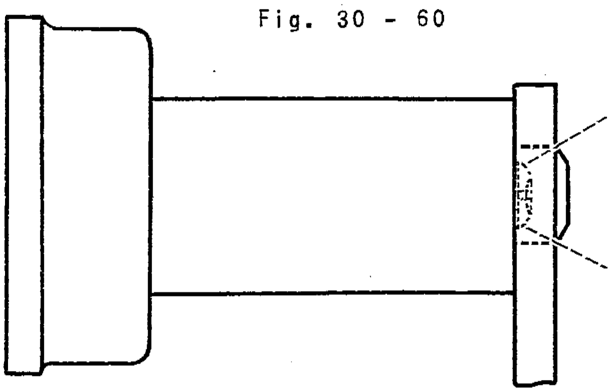


Fig. 30 - 60

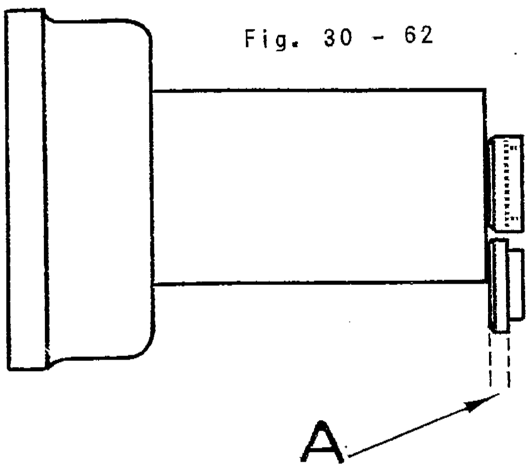


Fig. 30 - 62

portant and must be correct.

7. The diameter of the shoulder can be slightly smaller than the opening in the cock or plate and does not have to fit snugly.

8. Strip, remove and clean thoroughly.

SEC. 513 -- Setting Cap Jewels in Watches

1. Select cap jewel.
2. Cut diameter of stock to fit plate or to the diameter of the old setting.
3. Set cap jewel as in Sec. 506 and face off. Face setting flush with the face of cap jewel.
4. Cut off, using old setting as a guide for thickness.
5. Cement and face off to proper thickness, using old setting as a guide, and strip out setting.
6. Place cap and balance jewel in cock or plate and countersink jewel screws as in Sec. 509.

Figure 30-63 illustrates a cut away view of the cap and balance jewels in settings and their relative position in the cock or plate.

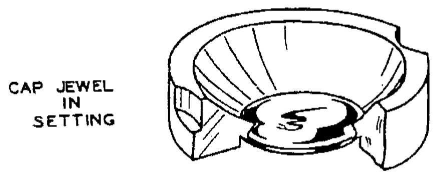
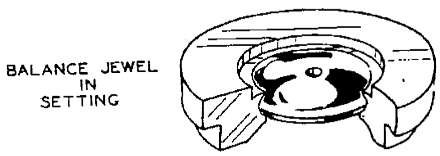
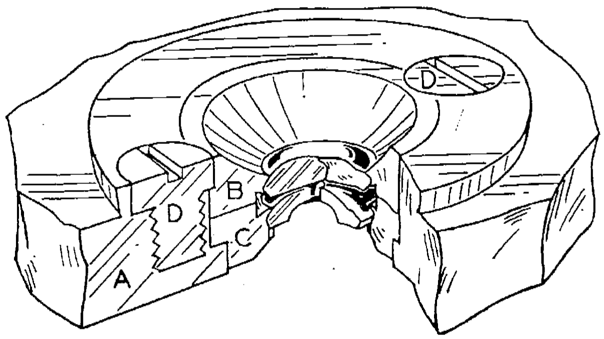


Fig. 30 - 63





A - Balance Cock
B - Cap Jewel In Setting
C - Balance Jewel In Setting
D - Jewel Screws

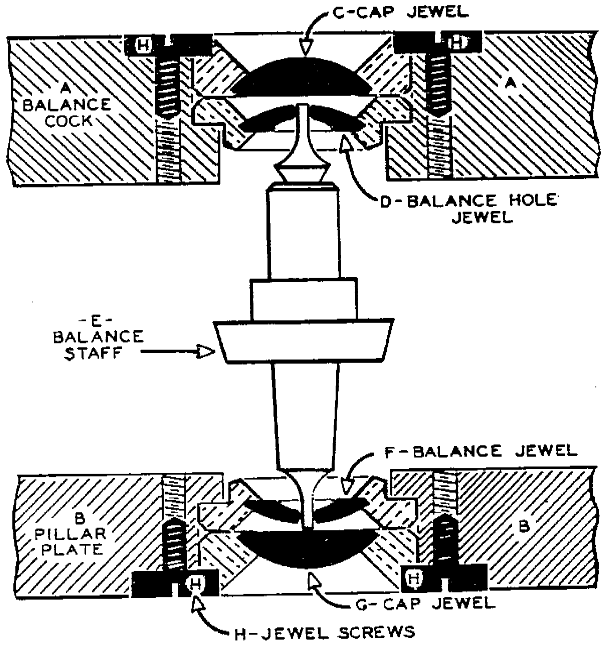


Fig. 30 - 64

Figure 30-64 is a cross section view of the balance cock and pillar plate with a balance staff placed in position. Notice that the lower pivot rests on the lower cap jewel and that the upper pivot is even with the top of the upper balance hole jewel. The space between the upper pivot and the upper cap jewel is the "end shake". This space is always determined by the fact that the balance hole jewel is set slightly below the surface of the balance jewel setting while the cap jewel is flush with the cap jewel setting.

SEC. 514 -- Raised Settings

Train jewel settings and cap jewel settings are found at times raised above the surface of the cock or plate. Figure 30-65 illustrates two types of raised settings. The one at A requires the countersinking of the jewel screws to the level of the bridge or cock. The one at B does not require countersinking but the bottom of the shoulder should be flush with but not below the level of the bridge or plate.

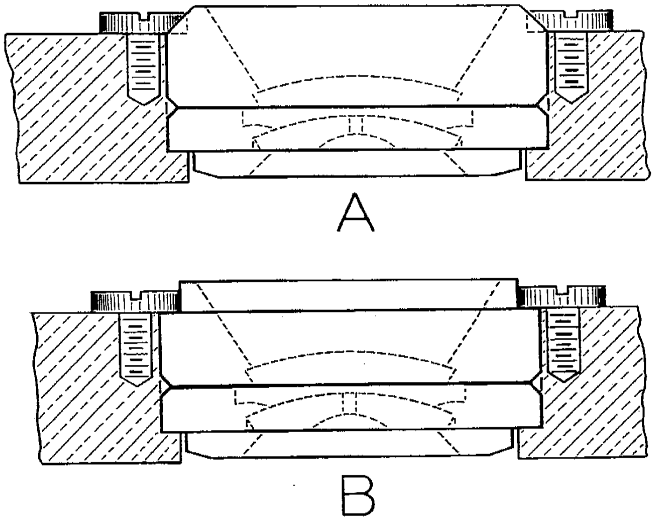


Fig. 30 - 65

SEC. 515 -- Replacing a Regulator Key, Swiss Style

1. Place in lathe a piece of brass rod which is thicker than the width of the regulator key at the thickest part, figure 30-66.

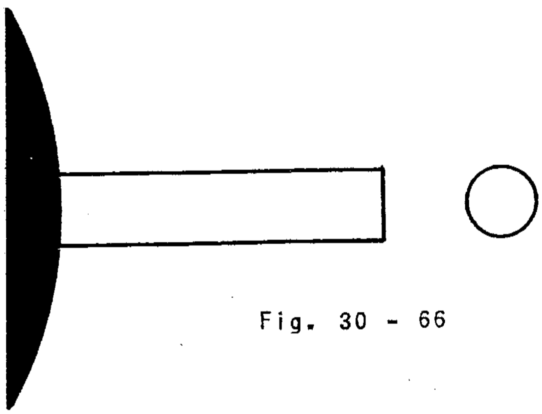


Fig. 30 - 66

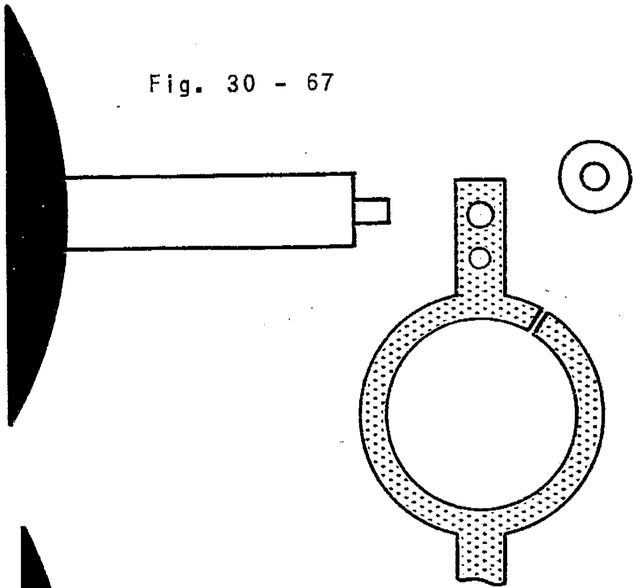


Fig. 30 - 67

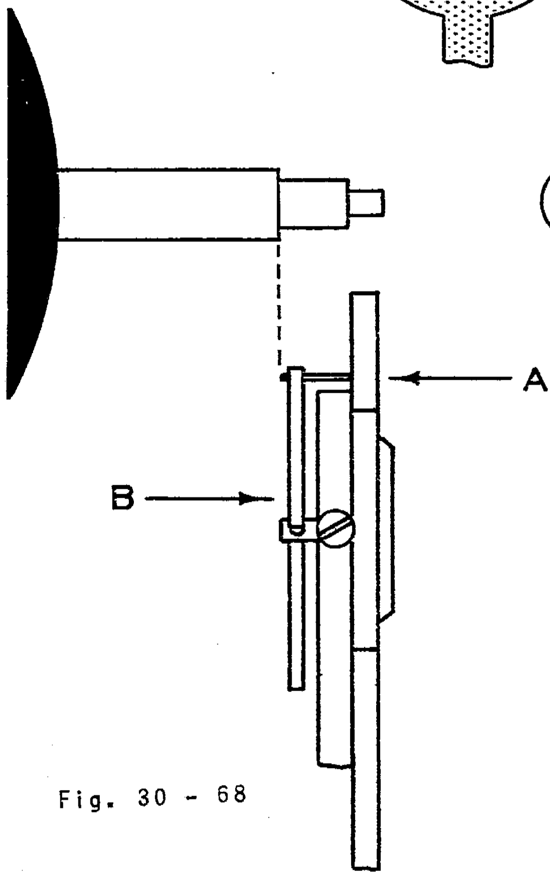


Fig. 30 - 68

2. Turn square shoulder to fit hole in regulator key, figure 30-67, the length to be slightly longer than the thickness of the regulator.

3. Turn another square shoulder, figure 30-68, the length of which is determined as shown in the drawing directly beneath it in which A represents the regulator and B the hairspring held in place by the stud. Notice that this shoulder is slightly longer than the distance from the underside of the regulator to the underside of the hairspring.

4. File the sides flat, figure 30-69.

5. Cut off regulator key as in figure 30-70. Finish the end.

6. Rivet in place with staking tool punch, figure 30-71.

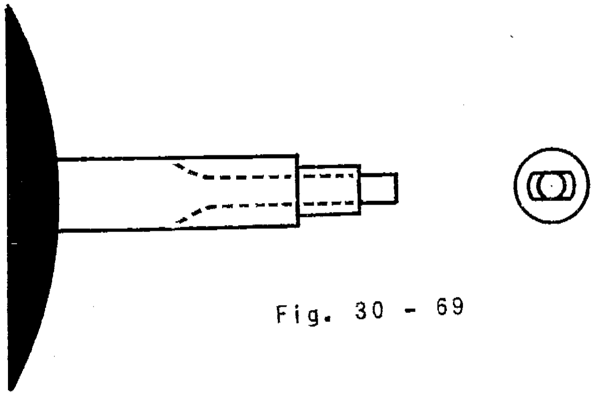


Fig. 30 - 69

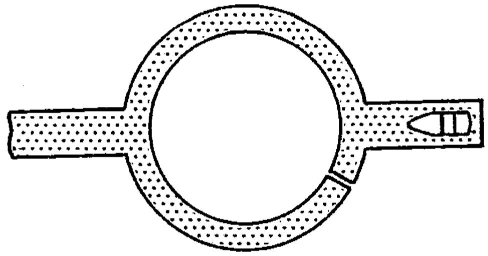


Fig. 30 - 72

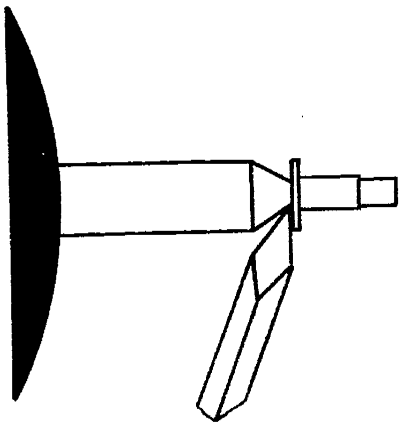


Fig. 30 - 70

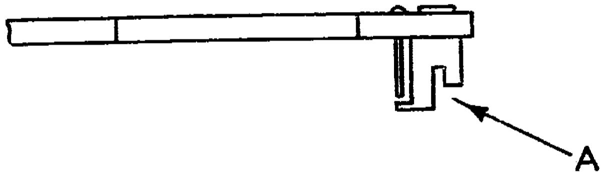
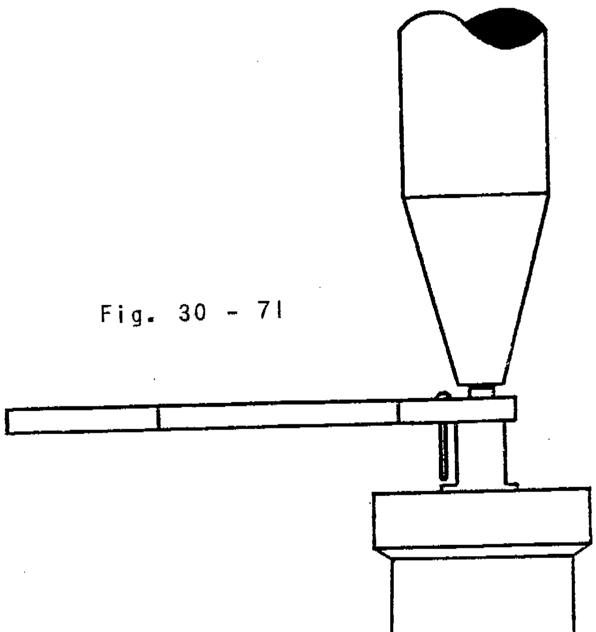


Fig. 30 - 73

Fig. 30 - 71



7. Shape key with file as in figure 30-72.

8. With screw head file, put slot in key at A, figure 30-73.

Although you may find variations from the methods described in these lessons, you can accept our methods as practical and correct. Each has been proved in practice.

On all watch work, do not, as said before, be content with doing a job once. In order to be proficient you should practice at every opportunity. Work Sheets are used with these lessons to give you this practice and the work laid out on these sheets should be reviewed from time to time. If you are working on staffs, make it a point to review your jewel setting work from time to time. If you are working on jewels, brush up on the escapement. Each time you review a lesson, you will be greatly benefited.

CHECK YOURSELF

Progress Check 30 — A Self Test Review of Lesson 30

Study Sections 500 through 514 before answering these questions. See if you can answer without looking back. DO NOT SEND THIS TEST FOR GRADING. You'll find answers later in the lesson. If you miss any questions, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The base metals most used in watchmaking are __________ and __________.	500
2. While setting a train jewel, the jewel is held with __________.	501
3. The drill used for the jewel setting should be about __________ the diameter of the jewel.	501
4. In making a jewel setting, the next tool used after the hole has been drilled is a __________.	501
5. The tool used to fix the jewel in place is called a __________.	501
6. In applying stick shellac to a cement brass, heat is applied to the __________.	502
7. The hole in a jewel setting is opened up with a __________ __________.	502
8. Cement is cleaned from jewels with __________.	503
9. The seat for a balance hole jewel does not need to be __________.	504
10. The procedure used in setting a cap jewel is determined by its __________.	506
11. Train jewels and balance jewels are set __________ the surface while cap jewels are set __________ the surface.	501 504 506
12. The amount of end shake for a train jewel being set in a watch is determined by the depth of the __________.	508
13. To set a jewel screw flush with the plate, a __________ __________ is used.	509
14. Worn pivot holes can be corrected by uprighting and __________ or by use of a __________.	510
15. When cap jewels are replaced, a useful guide is the __________ __________.	513

ANSWERS TO PROGRESS CHECK 30:

1. brass
   nickel
2. pegwood
3. 2/3
4. seat cutting tool
5. burnisher
6. cement brass
7. stripping tool
8. alcohol
9. beveled
10. shape
11. just below
    flush with
12. shoulder
13. jewel screw countersink
14. rebushing
    friction jewel
15. old setting

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 30

Name: No.: Date:

Circle ONE correct answer:

SUBJECT: Lathe Work

1. What is the main reason for using oreide, nickel or brass in setting jewels as described in this lesson?

   Readily obtained | Less expensive | Easily worked | Easily polished

2. In jewel setting, how large should the drill be in proportion to the diameter of the jewel?

   1/4 | 3/4 | 1/3 | 2/3

3. After drilling the hole in the material in which the jewel is to be set, the next step is to:

   Bevel the corner | Make the bezel | Burnish | Cut the seat

4. How deep in the face of the setting should the train jewel be set?

   Just below the surface | Just above the surface | Flush with the surface | Half the depth of jewel below surface

5. What is meant by stripping a jewel setting?

   Cutting the seat | Cutting the bezel | Opening and finishing setting | Burnishing in the jewel

6. The first step in cementing a jewel is to:

   Cut to correct length | True the setting | Apply cement to cement brass | Face off cement brass

7. How does setting a balance jewel differ from setting a train jewel?

   Drill used for balance jewels is larger in proportion | Shoulder of balance jewel seat has no bevel | Balance jewel is set cup out | Balance jewels are set deeper in setting

8. How does setting a cap jewel differ from setting both train and balance jewels?

   Seat is cut in different manner than either | Setting is faced off flush with jewel | Drill used must be smaller | No bezel is cut in cap jewel setting

9. In setting train jewels in watches, how can we best get correct end shake?

   Measure shoulder of old setting with MM gauge | Measure shoulder of new setting with micrometer | Compare shoulder of new setting with shoulder of old | Keep cutting shoulder and trying until correct

10. The lathe attachment used in rebushing a worn pivot hole is called a:

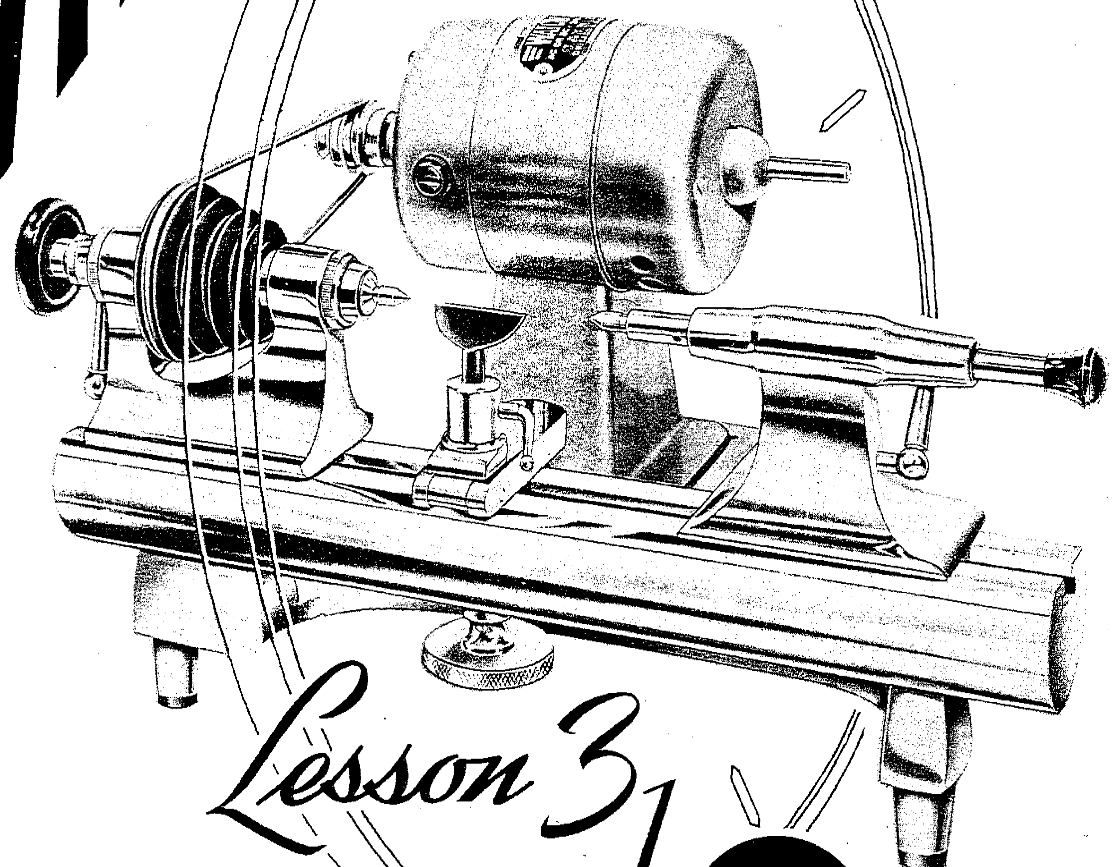
    Face plate | Rebushing tool | 3-jaw chuck | Clamp attachment

11. When selecting train and balance jewels to fit watches, how many hundredths of a millimeter larger than the pivot should the jewel hole be?

    .02 for balance jewels, .01 for train jewels | .02 for train jewels, .01 for balance jewels | .03 for balance jewels, .04 for train jewels | .03 for train jewels, .02 for balance jewels

-Detach page or cut along this line — and send to the School for grading.-

Master Watchmaking



Lesson 31

LATHE WORK

CHICAGO SCHOOL OF WATCHMAKING *Founded 1908 by* THOMAS B. SWEAZEY

Printed in the United States of America

KEY POINTS OF LESSON ASSIGNMENTS 103, 104, 105, 106, 107, 108, 109, 110, 111, 112:

- How to make square shoulder and cone pivots.
- How to straighten bent pivots.
- How to make a balance staff.
- Making balance staffs with and without a sample.
- How to make timing washer punches.
- How to use carboloy gravers.
- Replacing pinions and pallet arbors.
- Making a stem with and without a sample.
- Repivoting.
- Rebushing a train wheel.
- Replacing a hook in a barrel.
- How to calculate lost wheels and pinions.
- How to calculate train wheels.
- How to calculate a dial train.
- How to fit new cylinder plugs.

ASSIGNMENT NO. 103: Study Sections 520 and 521.

Study Questions:

1. After a piece of hardened and tempered steel is placed in the chuck, what is the first step?
2. How do you compute the length of the pivot?
3. What is the name of the grinding powder to be used? Polishing powder?
4. How much should you allow for polishing?
5. How do you grind pivots?
6. In which direction do you run the lathe when grinding a pivot?
7. How do you polish pivots?

Recommended Practice:

1. To prepare a piece of steel for the work in this lesson, use a piece of 1.6 mm drill rod. Insert in chuck with end projecting slightly and turn end flat and smooth. Rechuck, leaving about 30 mm projecting from chuck. Polish with your emery buffs, starting with the coarsest grit and continuing with all buffs to the finest. Use the point of graver and cut rod about half way through 25 mm from the end. Do not break off. Coat with boric acid powder and harden. Heat a portion of the rod back of the groove first; then heat outer portion, being sure there are no dark areas in the part to be hardened. Stop at this point and test for hardness, being careful not to break off rod at groove. When you are satisfied that it is correctly hardened, break off at groove for hardness test. Rod should break at groove as easily as a fine pencil lead and without bending. Polish entire hardened piece, handling only with tweezers. Stop at this point and anneal with alcohol lamp to a blue.

2. New pivot burnishers are rarely in proper condition for use, as they are too coarse. Draw the burnisher crosswise on medium coarse, well-worn emery buff until fine lines appear running crosswise of entire surface of burnisher. The other side may be prepared in the same manner. Then finish to a finer surface on a medium fine, well-worn emery buff. Now we have two different surfaces or "cuts" on the square shoulder burnisher. Emery paper of proper grit cemented to a plate glass used instead of a buff insures a very flat surface. Never use grinding compound or diamantine on a burnisher. Wiping with light oil prevents rust and keeps the burnisher in good condition.

3. When turning tempered steel, a sharp, well-shaped graver is necessary for good work, especially on hardened blued steel, and it will be necessary to sharpen gravers more often. It is best to resharpen your graver while it is still cutting well, as if it becomes so dull the work slides past the edge, a shell is burnished on the surface that is very difficult to remove without spoiling the entire piece you are working on.

4. These are the diameters in hundredths of a millimeter of square shoulder pivots for practical work of Lesson 31:

Diameters	.50	.40	.30	.20	.10
Lengths					

Calculate the length of each pivot. Grind and burnish end of stock.

ASSIGNMENT NO. 103 (Continued):

5. Start your practice work on the .50 mm pivot. Do not remove from lathe for inspection. It is very difficult to make your stock run true once it has been removed from the lathe. If the shoulder is not cut square by the graver, it will be practically impossible to grind it square. Rounded shoulders will quickly wear the edge off the grinding slip. Burnish all surfaces of the pivots with a properly prepared burnisher after polishing with diamantine. Cut off 6 mm long, exclusive of the length of pivot. Make four other pivots in sizes given above.

ASSIGNMENT NO. 104: Study Section 522

1. What is the first step in making a cone pivot?
2. How is the length of a cone pivot calculated?
3. Are grinding and polishing done the same way as for square shoulder pivots?
4. What determines the shape of the cone?

Recommended Practice:

1. Prepare 1.6 mm steel for making cone pivots the same as for square shoulder pivots.

2. Make 6 cone pivots with pivot and cone sizes as shown below in hundredths of a millimeter:

Pivot Diameters	.13	.12	.11	.10	.09	.08
Cone Diameters	.75	.71	.67	.63	.59	.55

The diameters of the cones and lengths of the oil cuts are ordinarily made to fit a specific watch. For your practice work in this assignment, make the cone diameters as above. Establish the length of the cones and oil cuts by multiplying the diameter of the pivot by 7-1/2 and dividing this length into three equal parts: 1/3 for pivot, 1/3 for cone, and 1/3 for the oil cut.

3. Some workmen prefer to use a round graver for shaping the cones of pivots.

You may make one out of a piece of 2 mm round drill rod. File to a 45 degree angle. Polish and harden. Next polish and draw to a very pale straw color. Sharpen at the same angle as a square graver. File the tang square and to a point, and fit into a handle.

4. Grind and burnish end of stock and make cone pivots as instructed in Section 522.

5. A round-edge burnisher is used for cone pivots. It must be prepared as per instructions previously given for square shoulder pivot burnisher. If the curve of the round edge does not conform to the pivot, correct the curve on your large oil stone. After pivot is ground to size and polished with diamantine, the entire pivot should be burnished with the properly prepared burnisher. Use the smoothest side for finishing. The practice gained in use of the burnisher in this lesson will be put to good use in refinishing pivots in actual watch repairing.

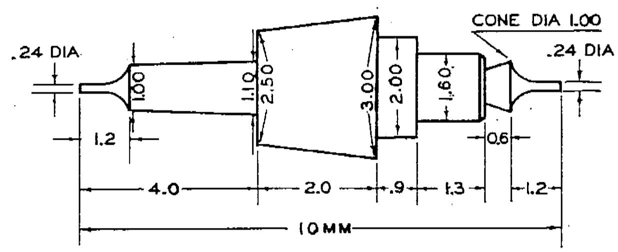
ASSIGNMENT NO. 105: Study Sections 523 and 524

1. Is it advisable to straighten pivots?
2. What are the principal reasons for polishing pivots?
3. What lathe accessory can be used for this purpose?

ASSIGNMENT NO. 106: Study Section 525

Recommended Practice:

1. Make two oversize staffs, one of brass and one of soft steel to dimensions below:



ALL DIMENSIONS GIVEN IN MILLIMETERS

Brass staff: Do not grind the ends of stock. Turn smooth, flat and burnish. Make to dimensions above, following steps shown in lesson through paragraph 13, except the allowance for grinding and polishing. Turn the brass

ASSIGNMENT NO. 106 (Continued):

staff to finished size as smoothly as possible. Polish edge of graver on 4/0 emery buff for brass work. Turn the staff end to proper length and burnish instead of grinding. Leave in chuck and finish roller seat and pivot with graver. Because of its size, it will not be practical to place the brass staff in cement chuck for finishing.

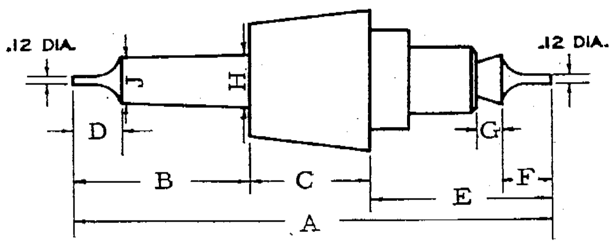
Soft steel staff: Make this staff according to all steps from paragraph 1 through 14. Do not cement soft steel staff for finishing for reason noted above. All dimensions are the same as diagram. Finish roller seat and pivot in #16 chuck with graver.

2. Make two balance staffs to fit your practice balance wheels and collets. (Sec. 525). You may use collets from your practice hairsprings.

   These balance staffs are to be made of hardened and tempered steel. A cement chuck should be used to make and finish the roller seat ends.

   The 2 mm drill rod used for making balance staff must be polished, hardened and tempered by the same steps and processes as the material used for square shoulder pivots.

   Use these dimensions for these balance staffs:



Dimensions for Large Balance Wheel (16s):	Dimensions for Small Balance Wheel (6s or 0s):
A = 6.00	A = 4.12
B = 2.20	B = 1.82
C = 1.50	C = .30
D = .60	D = .60
E = 2.30	E = 2.00
F = .60	F = .60
G = .30	G = .30
H = .65	H = .55
J = .62	J = .52

The diameter of the balance seat is determined by the hole in balance arm. (Paragraph 3, Sec. 525, Lesson 31.)

The diameter of the collet shoulder is determined by the hole in collet. (See paragraph 8, Sec. 527, Lesson 31.)

Follow steps on making staff, paragraphs 1 through 14, Sec. 525.

Center cement chuck and test center with a needle. This is very important, as the staff will not be true unless the cement chuck is true. Test the center of cement chuck before each staff is cemented.

Follow steps from paragraphs 15 through 23. Remember to grind and polish the collet shoulder before making undercut (paragraph 7).

The entire surface of the staff must be ground after turning and be given a high polish.

Rivet staffs into balance wheels.

ASSIGNMENT NO. 107: Study Section 526.

Recommended Practice:

Remove hairspring, roller and staff from a movement 6s or larger. Cut away hub of staff when removing. (Sec. 526) Proceed as in Section 526. Take measurements of sample staff, but the final fitting of balance wheel, roller and jewels should be done by trying them in place BEFORE REMOVING WORK FROM LATHE. Do not attempt to fit balance jewel on pivot with the cap jewel in place while work is in lathe. Try end shake of staff before riveting into balance wheel. Replace roller, true and poise wheel, replace hairspring, and put movement in beat.

ASSIGNMENT NO. 108: Study Section 527.

1. What should be checked before making a balance staff without a sample?
2. How do you establish the overall length of the staff?
3. How are the other dimensions found?

ASSIGNMENT NO. 109: Study Section 528 through 531.

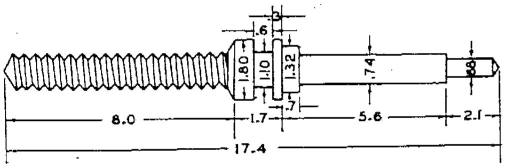
1. How are punches made for timing washers?
2. What is the advantage of carboloy gravers?
3. How can pinions be made, if necessary?
4. What are some types of pallet arbors?

ASSIGNMENT NO. 110: Study Section 532.

Recommended Practice:

1. Make a slot cutting graver (Figure 31-54) from your 3 mm square steel. Make the tip 10 mm long. Polish, harden, and temper the same as your jewel setting tools.

2. Make a Swiss stem, taking measurements from drawing below. Use any size hole on your screwplate which is smaller than hub dimension given for threaded portion.



3. Follow steps 1 through 14, except paragraph 4. On stems the size of the above and smaller, it is somewhat easy to damage or bend threaded portion; therefore, you may place LARGEST diameter of stock in chuck to cut to correct length.

ASSIGNMENT NO. 111: Study Sections 533 through 536.

1. How can you make a stem without a sample?
2. How can you repair a pinion or balance staff?
3. How can train wheels be trued up?
4. In replacing a hook in a barrel, how is the center for the hook found?

ASSIGNMENT NO. 112: Study Sections 537 through 541.

1. How can you find the number of teeth for a center wheel?
2. How can you calculate a missing third wheel and pinion?
3. How can you figure a missing fourth wheel and pinion?
4. How can you find the teeth for a fourth wheel in an 18,000 train watch?
5. How do you calculate a missing escape pinion?
6. What is the rule for calculating a train of wheels?
7. How do you calculate a dial train?
8. How are cylinder plugs replaced?
9. What are some useful lathe accessories?

NOTES: Making a Stem without a Sample. Watches with badly worn stem openings in the plates, and some very high grade watches for which no material is available are the repair jobs where making a stem without a sample is sometimes necessary.

Fitting Pinion to Watches, Making Pallet Arbors, Repivoting, Rebushing a Train Wheel, Replacing a Barrel Hook, and Fitting New Cylinder Plugs may be undertaken as the occasion demands. No special training is needed as you have already been instructed in the operations used on these projects and need only apply your knowledge of hardening, tempering, centering, turning, grinding, polishing, drilling, threading, and filing.

REQUIREMENT:

➧ Answer all Test Questions for Lesson 31 and return for grading.

You may hear it said that today with interchangeable parts and the low cost of watch material it is a waste of time to make parts such as stems and balance staffs. But there are many old watches you will handle where it is impossible to obtain the correct material, and even on some newer watches not all repair parts fit perfectly. To justify the term Watchmaker, you must be able to repair all makes and models of watches, and your success as a Watchmaker depends upon your ability to make or alter the required parts for the watches you are repairing.

SEC. 520 -- Making a Square Shoulder Pivot

It is best to harden and temper your own material for practice. Select a piece of drill rod, harden, polish, and temper it to a deep blue. This is the color required for pivot and staff work.

1. Place hardened and tempered rod in chuck allowing it to extend approximately 6 mm. Grind the end with a Hard Arkansas slip, keeping it at right angles to the work and moving it rapidly back and forth as illustrated by arrows in figure 31-1.

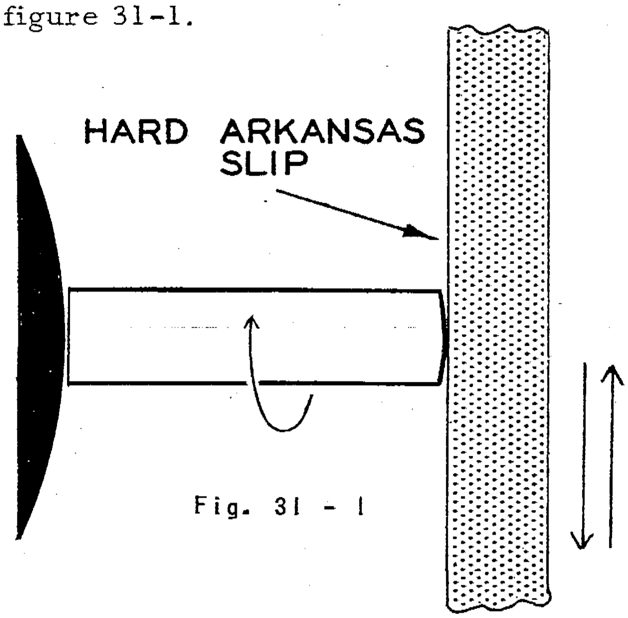


Fig. 31 - 1

2. Burnish end of rod with hardened steel pivot burnisher, figure 31-2.

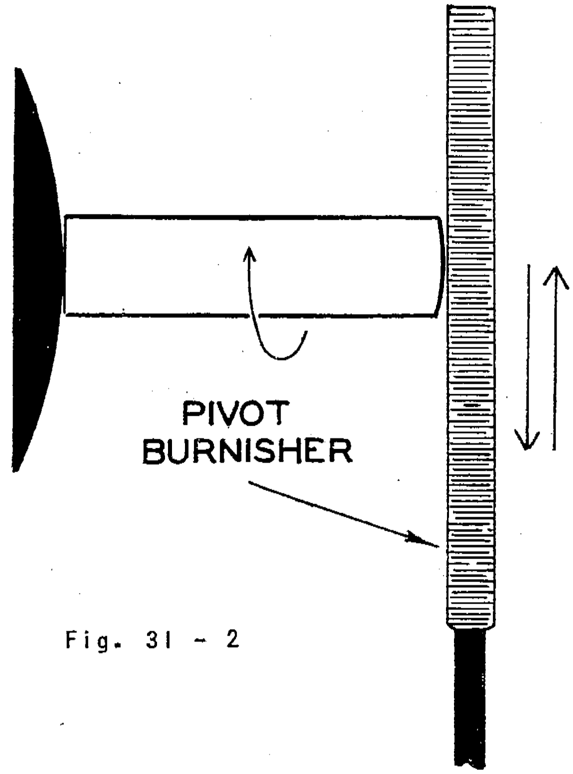


Fig. 31 - 2

3. Turn a square shoulder on end of rod approximately 4/100 mm larger than the diameter of the finished pivot, figure 31-3. This will allow for grinding and polishing.

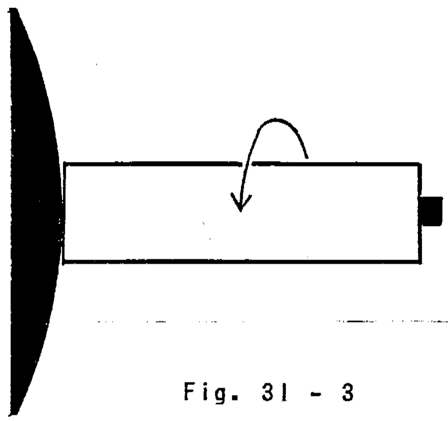


Fig. 31 - 3

4. Cut square shoulder back to a length of approximately 3 times the <u>finished diameter</u> of pivot figure 31-4.

Example: Diameter of finished pivot to be .3 mm.
.3 mm multiplied by 3 equals .9 mm, the length of the pivot.

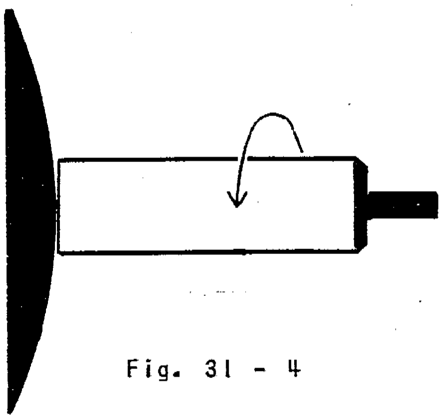


Fig. 31 - 4

5. Bevel corner, figure 31-4. This is a square shoulder pivot in the rough and it now must be ground and polished. Grinding the pivot will reduce its diameter slightly. Therefore, we allow about 3/100 of a millimeter for grinding and 1/100 millimeter for polishing, depending on the finished diameter. Not much grinding will be required if you are careful to cut a straight, smooth surface.

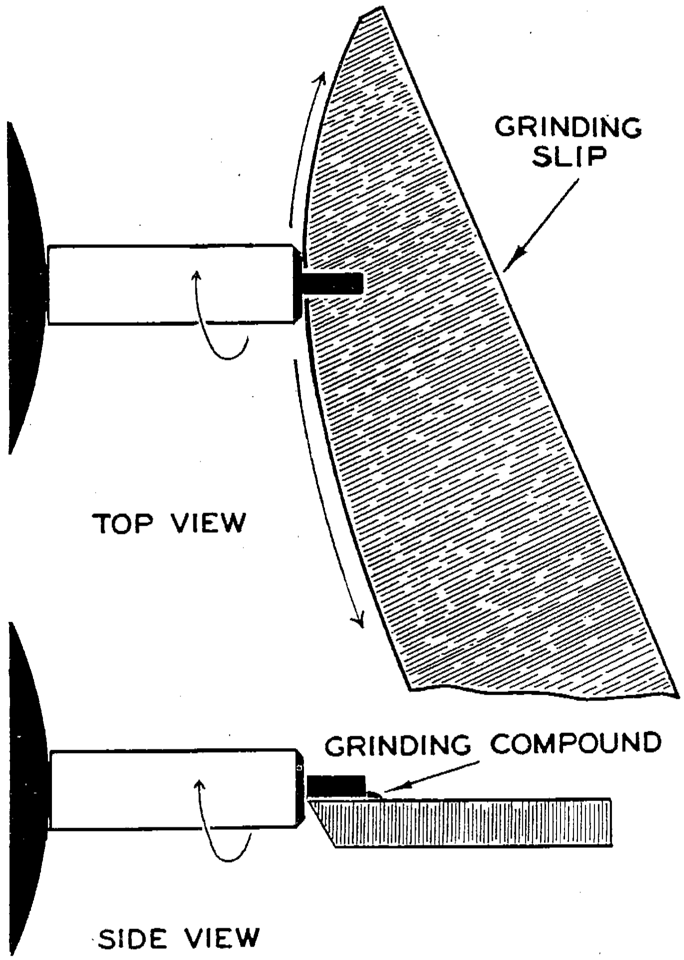


Fig. 31 - 5

SEC. 521 -- Grinding and Polishing

There are several methods of grinding and polishing pivots. The method we will use is oilstone powder with the iron grinding slip, which we made in Lesson 27. For polishing we will use Diamantine with a boxwood slip.

1. Mix a small quantity of oilstone powder with oil until it is the consistency of thick cream. Place a little of this compound along the curved edge of the grinding slip and place slip on the underside of pivot as shown in figure 31-5. Run the lathe in reverse.

2. Move grinding slip rapidly backward and forward until pivot attains a dull gray finish. The grinding compound can be removed with pithwood in order to examine the work. Insufficient grinding will not leave a smooth surface. Excessive grinding will round the corner. Grind to within 1/100 mm of the finished diameter. This will allow for polishing.

3. Figure 31-6 illustrates a boxwood slip which has been impregnated along the top edge with Diamantine #2. Run your lathe at high speed when polishing and in the direction of arrow, figure 31-6, until you have a high polish.

4. Figure 31-7 illustrates the finished pivot.

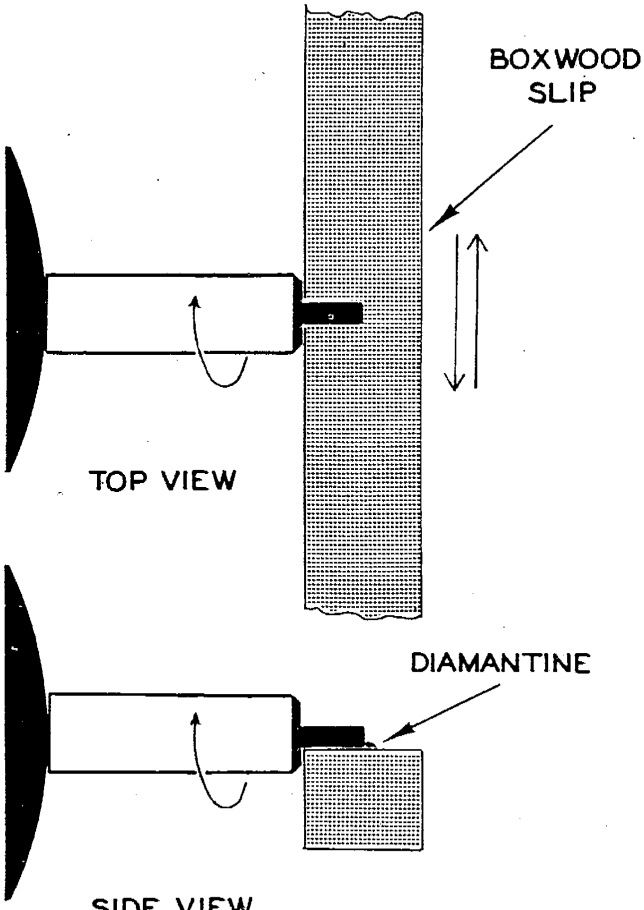


Fig. 31 - 6

You should be thoroughly familar with the function of the square shoulder pivot from your previous lessons, and as a good workman you should examine each square shoulder pivot in every watch you repair. Do this before cleaning the watch and if, under a double loupe, a pivot is found to be scratched or rough, it should be refinished in the manner described. Never overlook this fact and if in doubt, polish the pivot with Diamantine or pivot burnisher.

SEC. 522 -- Making a Cone Pivot

The first step in making a cone or balance pivot is to grind and burnish the end of the wire.

1. Grind end with an oilstone or Hard Arkansas slip, figure 31-8.

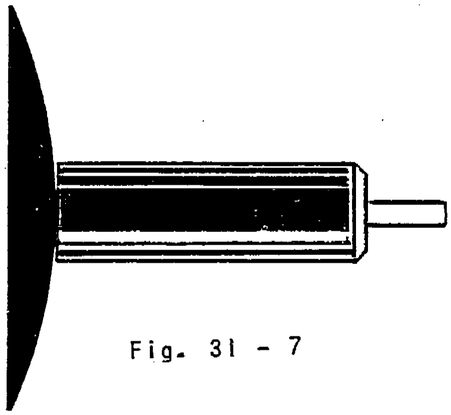


Fig. 31 - 7

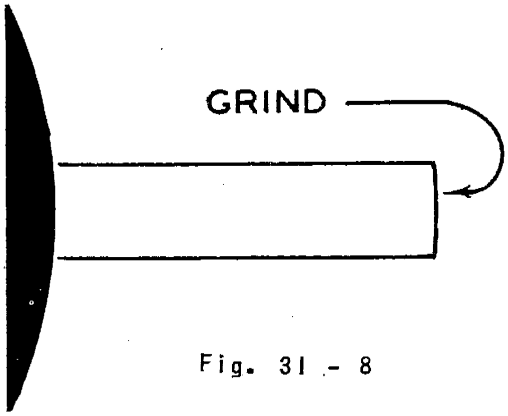


Fig. 31 - 8

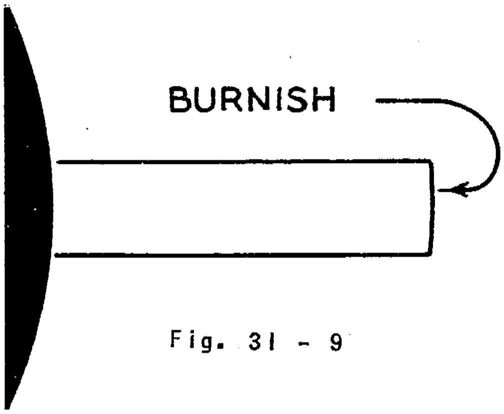


Fig. 31 - 9

2. Burnish end with pivot burnisher, figure 31-9. The lathe is run at high speed and the burnisher held squarely against the metal.

3. Turn a square shoulder on the end of the rod approximately 3/100 millimeters larger than the finished diameter of pivot, figure 31-10.

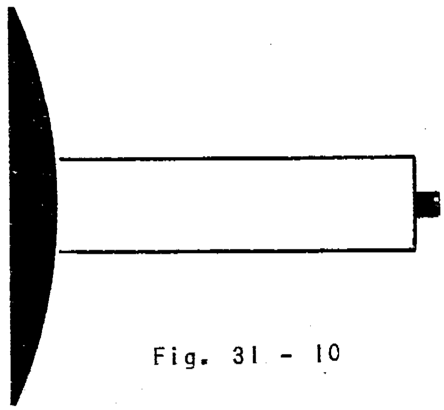


Fig. 31 - 10

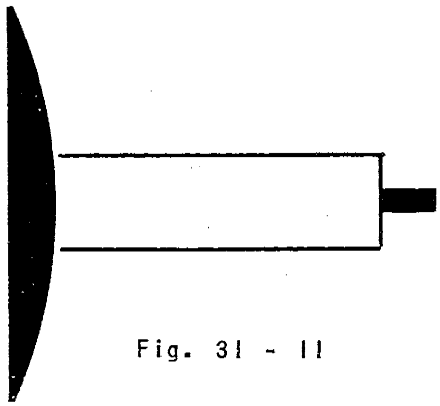


Fig. 31 - 11

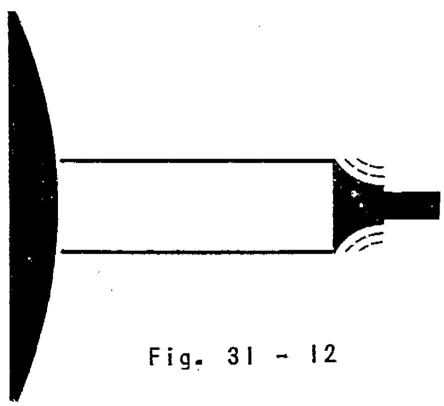


Fig. 31 - 12

4. Cut back and make a square shoulder pivot 2-1/2 times as long as the diameter of the finished pivot, figure 31-11.

Example: Diameter of finished pivot to be .12 mm
.12 mm multiplied by 2.5 equals .3 mm, the length of the pivot.

5. The cone of the balance pivot is cut after you have made a square shoulder pivot. Do not try to cut the pivot and cone at the same time. The dashed lines in figure 31-12 illustrate the shape of the cone as it is being formed. Some workmen use a round graver for this purpose. The length of the cone is left to the discretion of the watchmaker but is approximately the same length as the pivot.

6. The oil cut in figure 31-13 is left to the discretion of the watchmaker but keep it about the proportion shown. Bevel corner, figure 31-13.

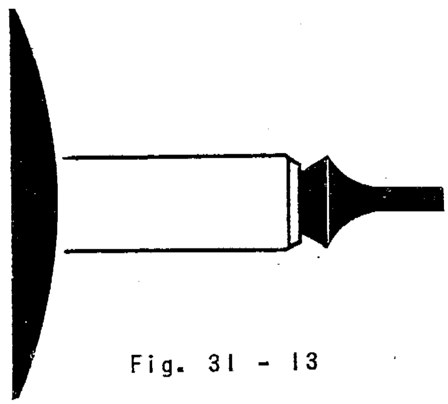


Fig. 31 - 13

7. Round the straight edge of the iron grinding slip slightly by draw filing at A, figure 31-14.

8. Place oilstone powder mixed with oil on grinding slip and while holding in position B, figure 31-15, run lathe in reverse moving grinding slip forward and backward rapidly. The cone is determined by the angle at which you hold the grinding slip. A, figure 31-15, illustrates the angle which will give a longer cone. B illustrates a shorter cone. It is only by practice that you will be able to grind the pivot and cone at the same time. If pivot is properly cut, it will not require much grinding.

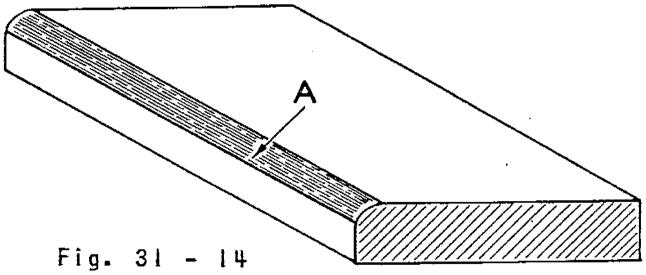


Fig. 31 - 14

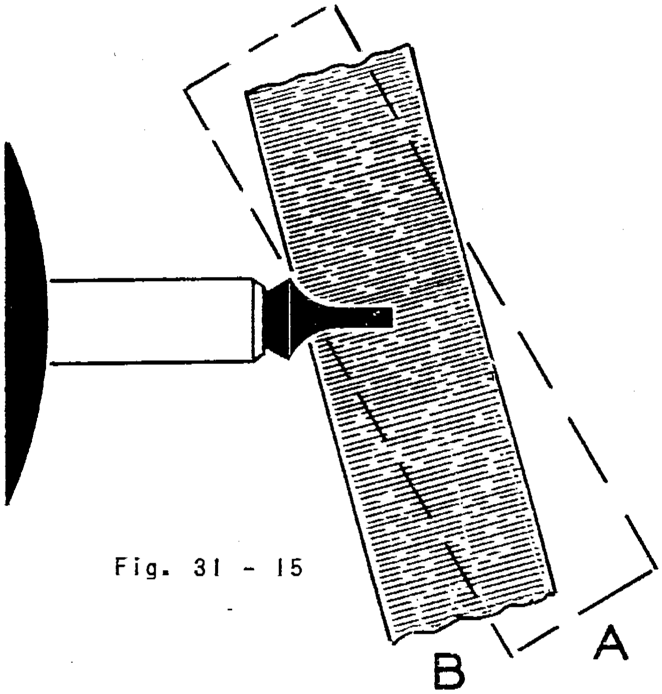


Fig. 31 - 15

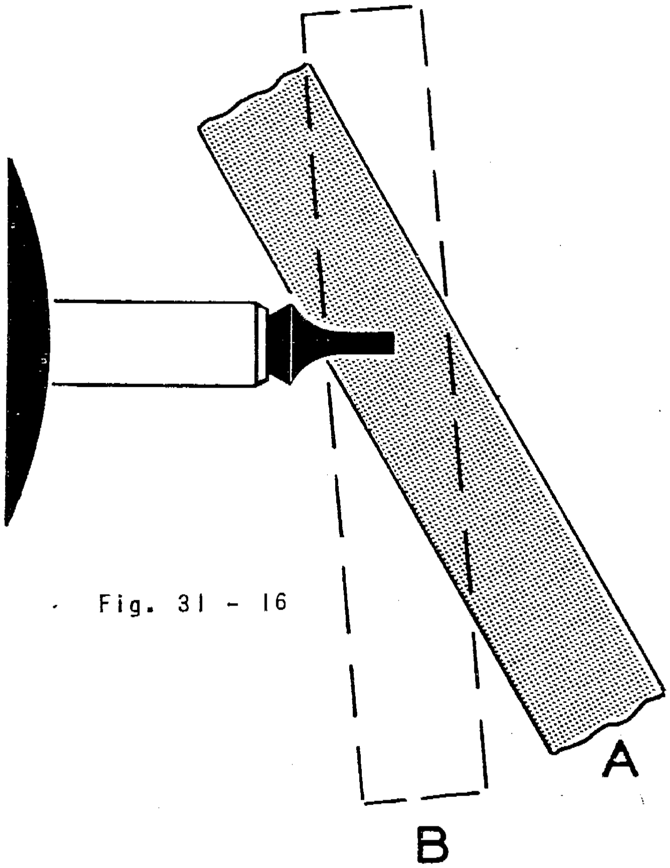


Fig. 31 - 16

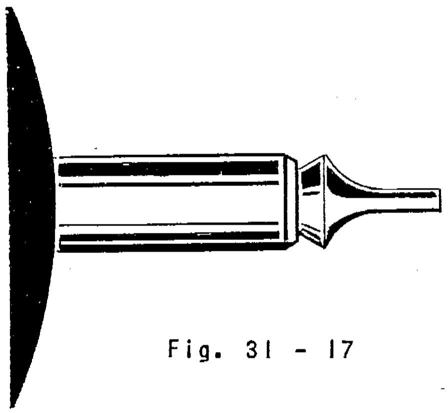


Fig. 31 - 17

9. Polishing is done with a boxwood slip impregnated with Diamantine to which a little rouge may be added, figure 31-16. Move boxwood slip rapidly back and forth as in figure 31-16. In order to polish the pivot and cone at the same time, shift the boxwood slip to different positions as at A & B, figure 31-16. This will give a high polish to the pivot.

Figure 31-17 illustrates the finished pivot.

Figure 31-18 illustrates a pivot which is too short.

Figure 31-19 illustrates a pivot with too short a cone.

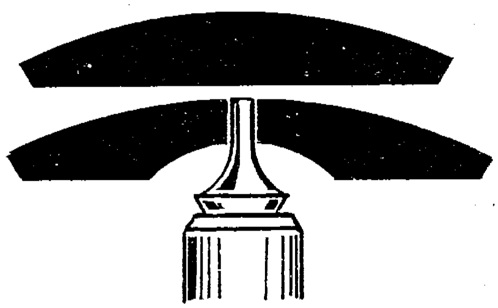


Fig. 31 - 18

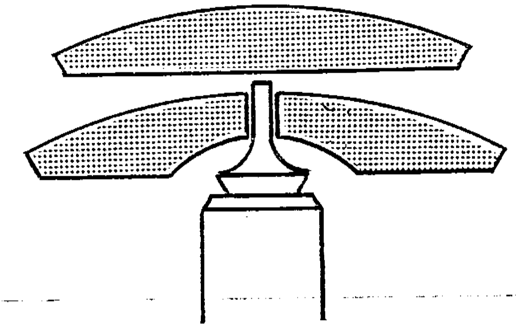


Fig. 31 - 19

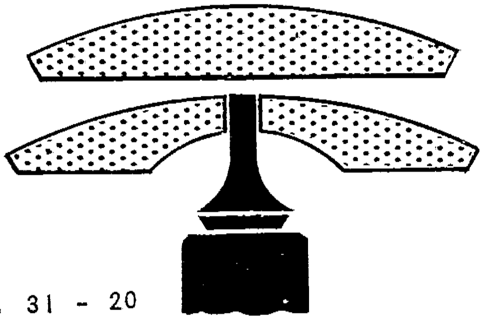


Fig. 31 - 20

Figure 31-20 illustrates a pivot which is too long.

SEC. 523 - Straightening Pivots

In former years, a watchmaker took a great deal of pride in his work, especially when called upon to make a balance staff for a repair job. Factories seemed to delight in seeing which one could make the hardest balance staff, much to the dismay of a poorly trained workman. An exceptionally hard balance pivot broke more readily than a soft one. A soft one would bend in most cases before it would break. Balance staffs in modern watches are not generally as hard as the ones used formerly.

At times you will be able to straighten bent pivots, and if properly executed, straightened pivots will give good service. For this purpose, an old pair of tweezers ground to the shape shown in figure 31-21 will prove very

Fig. 31 - 21

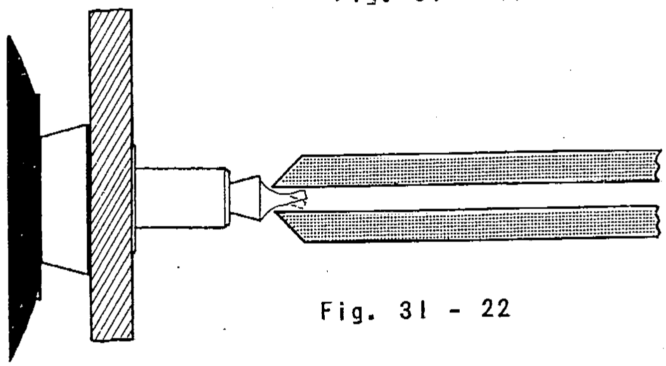


Fig. 31 - 22

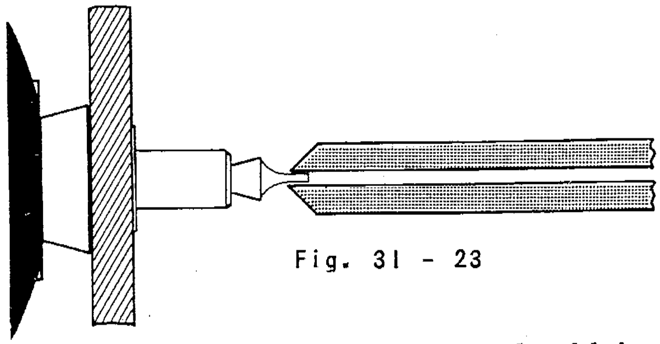
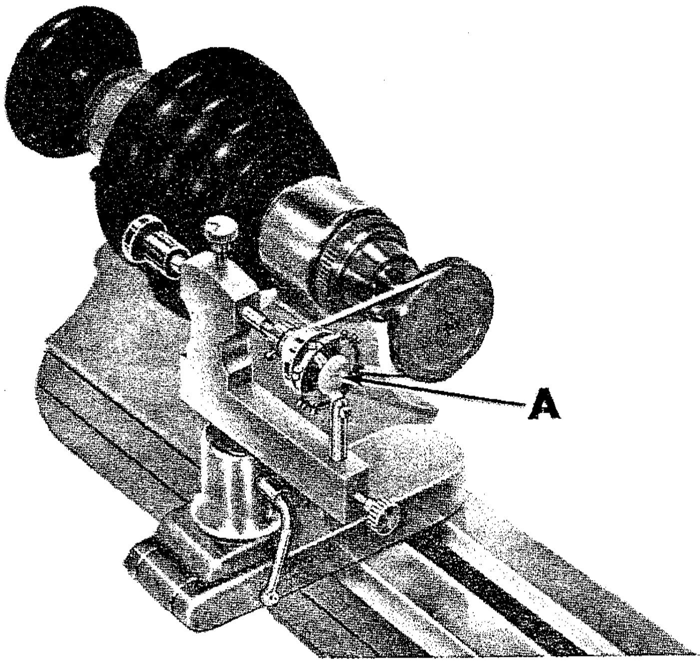


Fig. 31 - 23

satisfactory. The tweezers should be hardened and tempered to dark straw and the inside of the jaws highly polished. To be able to straighten balance pivots it is necessary to have a large selection of chucks. It is not always necessary to remove the roller table if the roller table has been fitted tightly. Figure 31-22 illustrates a pivot that is bent slightly. To straighten, place tweezers high upon the cone parallel with the balance staff, figure 31-22. Be sure the staff is running true. Reverse the lathe motor and run it at fairly high speed. Close jaws of tweezers until you reach the position shown in figure 31-23. If it straightens immediately, the chances of the pivot functioning properly are good. Do not feel badly if the pivot breaks as it will be a constant cause of trouble if the pivot does not run true. After straightening, the pivot must be burnished on the end and repolished. Train pivots are straightened in the same manner.

SEC. 524 - Reasons for Polishing Pivots

In the general repair of watches, cleaning, etc., it is good practice to burnish the ends and the sides of all balance pivots. The highly polished balance pivot decreases friction and, in most instances, the watch to be repaired will take a better motion. Most factory material is precision made and the majority of staff replacements can be made quickly and easily with genuine material. In replacing a factory balance staff, it is good practice to carefully check the pivots and be sure they are burnished and polished before replacing in the watch.



COURTESY OF THE NORTH AMERICAN WATCH TOOL AND SUPPLY CO., CHICAGO, ILLINOIS

Fig. 31 - 24

The pivot polisher illustrated in figure 31-24 is an excellent tool for burnishing and polishing cone shaped pivots. The T Rest has been removed and the pivot polisher inserted in its place. The drive pulley is mounted in a #50 wire chuck and a small rubber belt is used to connect the drive pulley and the pulley on pivot polisher. The small thin plate at A is one of several interchangeable plates required to accommodate different sized pivots. The plate is thin enough to allow the pivot to extend through the hole, the cone resting on the inner side of the plate. A small, hardened steel burnisher is used to finish the end and side of the pivot. Some watchmakers fasten the pivot polisher to the bench and operate it with a bow.

SEC. 525 - Making a Balance Staff

The ordering and replacing of a balance staff in a modern watch is done quickly and easily because of the standardization of watch material. At times you will find it necessary to make alterations on a new factory made staff. It may be that the balance shoulder, collet shoulder or roller post are too large. It is seldom that you will find a staff needing all of these corrections but in order to have the "know how", it is necessary to practice making balance staffs. There are times also when you will be called upon to make a balance staff for a watch, usually one for which no material is obtainable.

The difference between making a practice balance staff, a balance staff with a sample, and a balance staff without a sample varies only in the method in which the dimensions are obtained. Balance staffs are always made from high quality steel wire or drill rod, which has been hardened and tempered to a deep blue.

1. Place wire in chuck and let it extend a little more than the length of the finished staff.

2. Grind the end with a Hard Arkansas slip. Burnish end with hardened steel burnisher, figure 31-25.

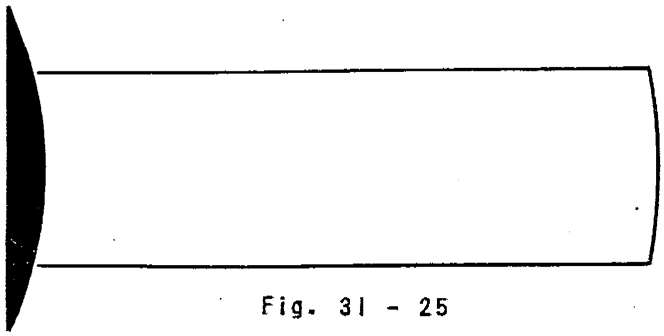


Fig. 31 - 25

3. Cut a square shoulder on the end of wire for the balance shoulder, figure 31-26. It is good practice to use the balance wheel for this diameter. As we must grind and polish each section of the balance staff, it is advisable to allow approximately 4/100 millimeters for this purpose (pivots excepted).

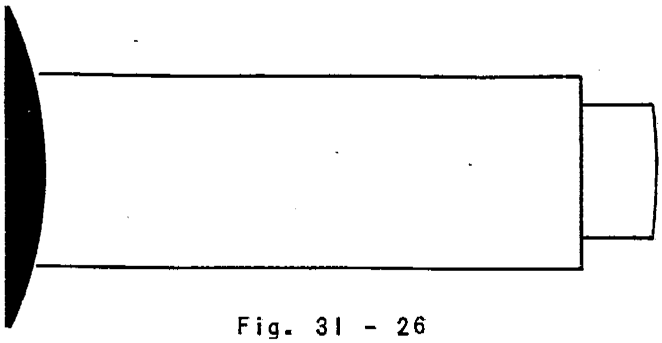


Fig. 31 - 26

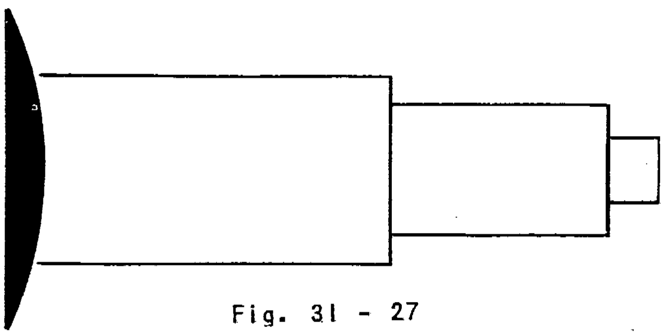


Fig. 31 - 27

4. Cut this shoulder back to proper length as in figure 31-27. This length and all lengths given in this section are obtained with a millimeter gauge from measurements given on your master work sheet.

5. Cut a square shoulder on end of wire for collet as in figure 31-27.

6. Cut collet shoulder back to proper length, figure 31-28. This length is actually determined by the thickness of the arm of the balance wheel, as there must be enough metal left up and above the arm of the balance wheel to allow for riveting as indicated by the dotted line in figure 31-28.

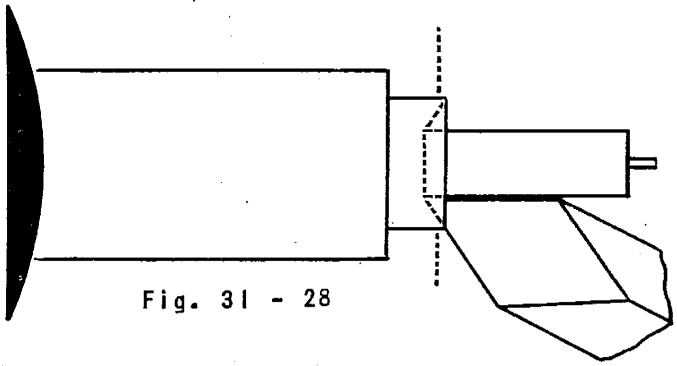


Fig. 31 - 28

7. The undercut is made, after the collet shoulder has been ground and polished, by holding the graver in position as shown in figure 31-28.

8. Cut a square shoulder pivot on end of wire, which is 2-1/2 times as long as the finished diameter of the pivot, in figure 31-28. Remember to allow approximately 2 or 3/100 mm for grinding and polishing.

9. Cut cone and oil cut and grind and polish pivot as shown in figure 31-29.

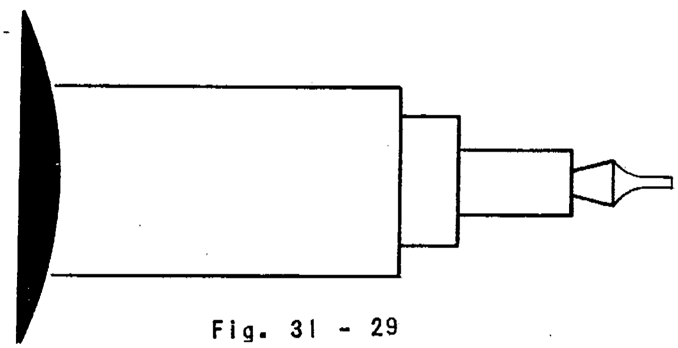


Fig. 31 - 29

10. Bevel corner of collet post as shown in figure 31-30.

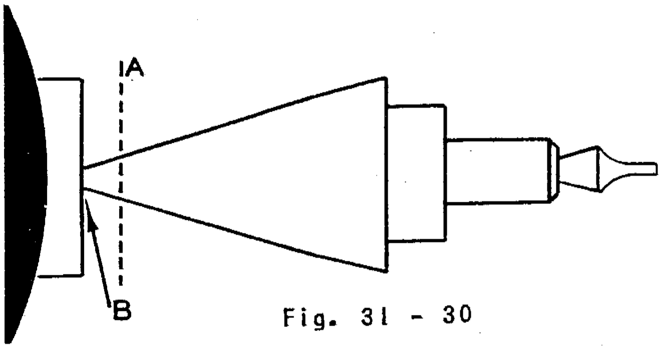
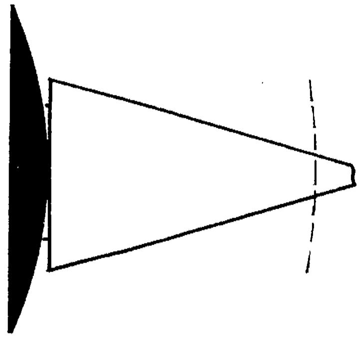


Fig. 31 - 30

Fig. 31 - 31



11. Make a tapered cut as shown in figure 31-30 so that we may break the staff off from the wire. The dotted line at A is the length of the finished staff measured from the end of the finished pivot. Notice that the cut extends beyond dotted line A, figure 31-30.

12. Break off unfinished staff at B, figure 31-30. The next step is to finish the end to the correct length of our balance staff. This method requires the workman to have a complete range of chuck sizes.

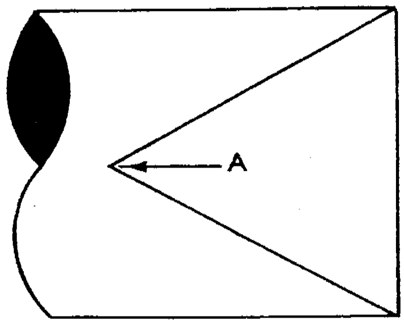
13. Catch the balance shoulder in the chuck of the proper size as in figure 31-31. Relieve the tension in the draw-in spindle of the lathe and while running the lathe in reverse hold the middle finger on a T rest and true the balance staff. Quickly grab the draw-in spindle with the left hand, which will tighten chuck on balance shoulder.

14. With a Hard Arkansas slip or oilstone, grind off the end of the unfinished staff to the proper length as illustrated by dotted line in figure 31-31. Burnish end. This may necessitate removing the staff from the chuck several times in order to measure the length with a micrometer.

It is impractical to use wire chucks to make this end of the balance staff because the staff will not run true. In order to have the staff run true, use a cement chuck which has been hollowed out.

15. Place cement chuck in lathe and make a deep cone shaped cut as in figure 31-32. The center of the cone indicated by Arrow A must be tested with a needle in order to insure this point being absolutely centered. Do not proceed until it is correct.

Fig. 31 - 32



16. Heat the cement chuck with an alcohol lamp and fill hollow with shellac. Then warm balance staff by placing it in warm shellac until the cement adheres to the balance staff, figure 31-33, the same way as it did the jewel settings in Lesson 30.

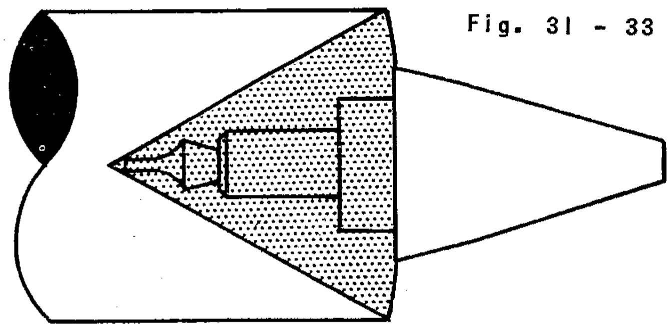


Fig. 31 - 33

17. Place T Rest as close as possible to balance staff and while cement chuck is still warm, true end of staff using peg-wood or fingernail. Let cool.

18. Turn a square shoulder on end for roller post as illustrated in figure 31-34 and mark the length of roller post as illustrated by dotted line.

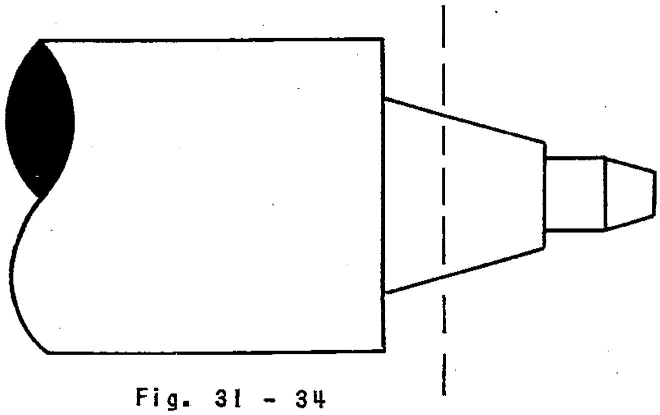


Fig. 31 - 34

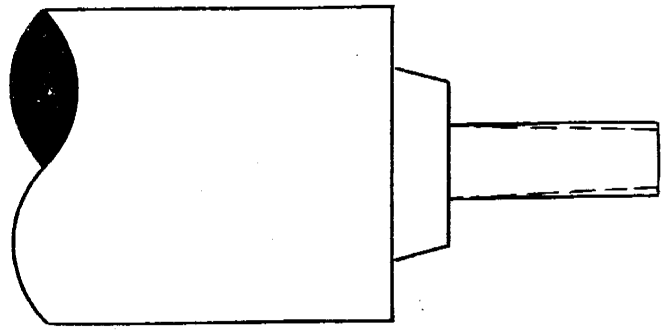


Fig. 31 - 35

19. Finish cutting roller post with a slight taper which should measure approximately 2/100 mm from front to back, figure 31-35. It is possible to use a micrometer if you know the exact measurement but in balance staff work, it is much better to try the roller table on the end of roller post and grind and polish the post until the roller table fits approximately one-half of the thickness of the roller table from the base of the hub as indicated by arrows in figure 31-36.

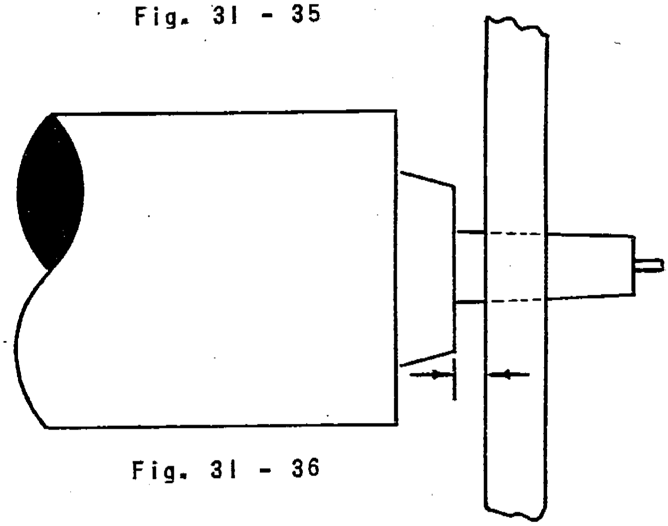


Fig. 31 - 36

20. Grind and polish hub.

21. Cut square shoulder pivot on end of roller post 2-1/2 times the diameter of the finished pivot allowing approximately 2/100mm for grinding and polishing, figure 31-36.

22. Cut cone, grind and polish pivot as in figure 31-37.

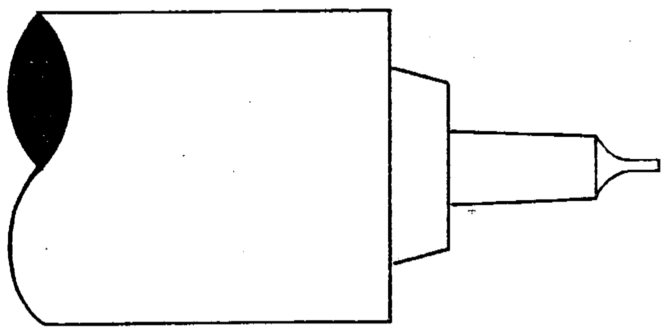


Fig. 31 - 37

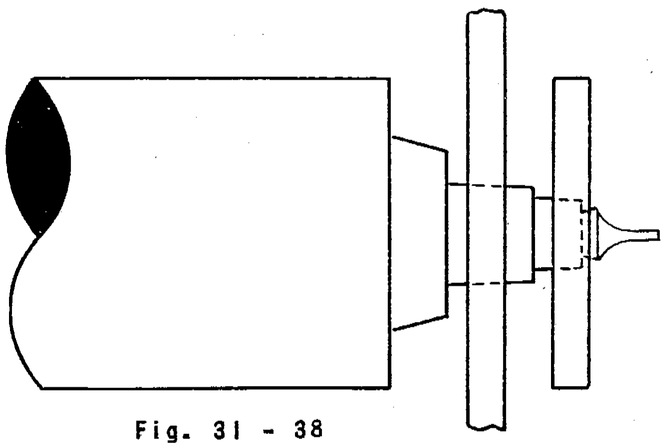


Fig. 31 - 38

23. Warm cement chuck with alcohol lamp, remove balance staff, and clean in alcohol. In fitting a combination roller, the same procedure is used as in figure 31-36- In fitting a two-piece double roller, two shoulders have to be cut as in figure 31-38 and both the impulse roller and the safety roller should fit to within one-half of the thickness of each roller from the shoulders, figure 31-38. The above instruction was given without mentioning any grinding or polishing except for the balance pivots. Remember it is necessary to grind and polish the balance shoulder, the collet shoulder, and the roller post. Therefore, you must allow approximately 3 or 4/100 mm for grinding and polishing.

SEC. 526 - Making Staff to Sample

Figure 31-39 illustrates the proper method of removing the balance staff from the balance wheel by cutting away the hub and then undercutting. Use this method on all watches which have riveted staffs in order not to mar the balance arm.

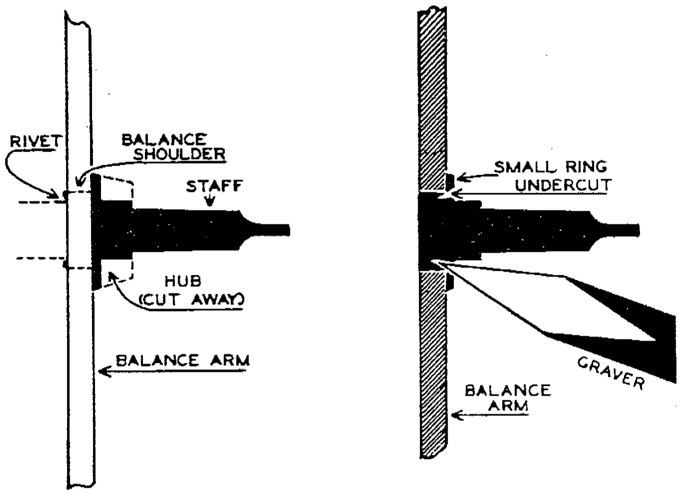
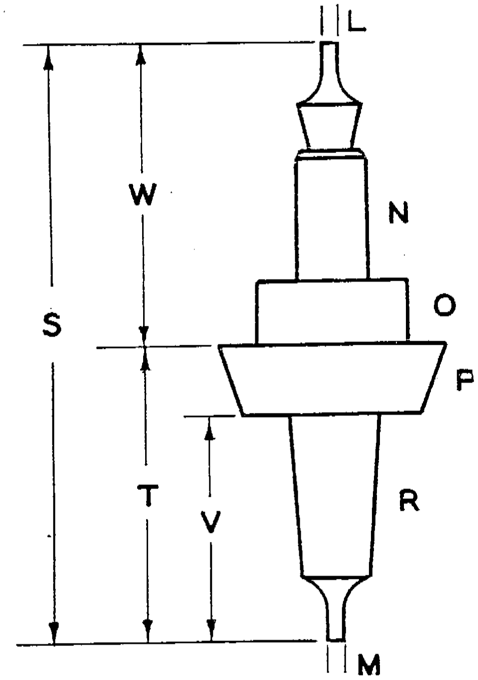


Fig. 31 - 39

In making a balance staff to a sample, make a sketch as in figure 31-40 and fill in the dimensions of the pivots, balance



L UPPER PIVOT -----MM
M LOWER " ------MM
N COLLET SEAT ------MM
O WHEEL " ------MM
P HUB ------MM
(The diameter of the hub should be less than the width of the balance arm)
R ROLLER SEAT ------MM
S LGTH. OVERALL------MM

Fig. 31 - 40

shoulder, collet shoulder and roller post. To determine the correct length of balance staff with broken pivot, allow approximately 3/10 mm for each broken pivot. This will give you the total length overall.

1. Select wire, place in chuck, and proceed as in Section 525. Grind and burnish end of wire.

2. Hold sample balance staff in position shown in figure 31-41. The dotted line A represents the distance from the end of the pivot to the balance wheel shoulder.

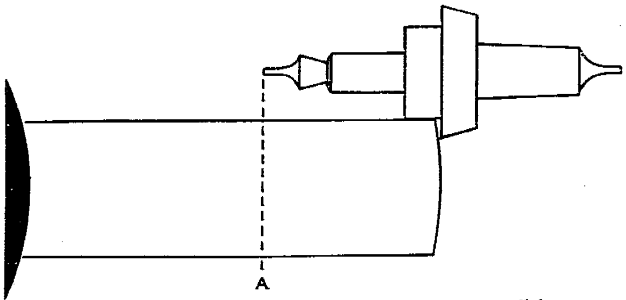


Fig. 31 - 41

3. Turn balance wheel shoulder. Grind and polish.

4. Turn collet shoulder allowing enough metal to extend through the arm of the balance wheel for riveting. Grind and polish.

5. Undercut balance shoulder.

6. Turn cone shape pivot and oil cut. Grind and polish.

7. Cut off staff as in Step 11, Sec. 525.

8. Grind to proper length, Step 14, Sec. 525.

9. Cement staff in cement chuck.

10. Hold sample balance staff in postiion shown in figure 31-42. The dotted line A represents the distance from the end of the pivot to the roller table shoulder.

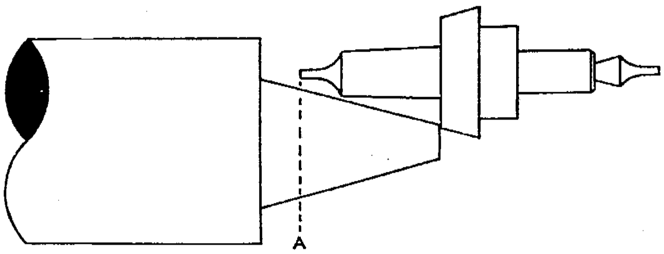


Fig. 31 - 42

11. Cut roller post. Grind and polish. Fit roller.

12. Grind and polish hub.

13. Cut pivot, grind, and polish.

14. Remove from cement chuck and clean in alcohol.

SEC. 527 - Making Balance Staff Without a Sample

Making a balance staff without a sample is an accomplishment enjoyed by all good watchmakers. The actual process of making a balance staff is the same as given in Sec. 525. It is advisable to make a sketch the same as in Figure 31-40 and fill in the dimensions as you obtain them. Before ascertaining the dimensions, make sure the upper and lower balance jewels and cap jewels are correct and the balance cock is not bent up or down but is parallel with the pillar plate.

To obtain the different dimensions proceed as follows:

Use a millimeter gauge or a degree gauge which measures in hundredths of a millimeter.

1. To get the overall length of a balance staff, measure from the outside of the upper cap jewel to the outside of the lower cap jewel A, figure 31-43. Subtract the thickness of both cap jewels, B and C, figure 31-43, which will give the over-all length of the balance staff exclusive of endshake, which can be adjusted later. This is written as LOA (Length Over-All). Mark the result on your sketch.

2. Measure the distance between the center wheel and the pallet bridge D, figure 31-43 (or the upper plate and balance bridge in case of a full plate

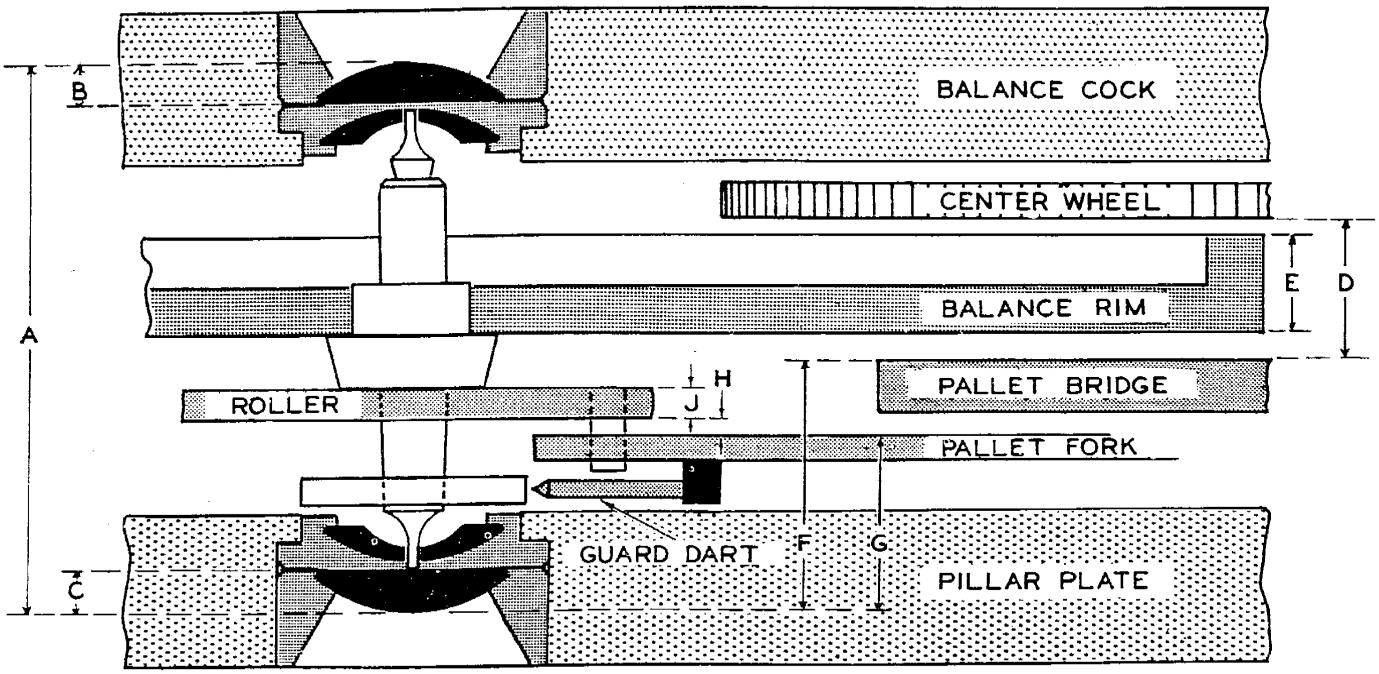


Fig. 31 - 43

movement). Measure the thickness of the balance rim E, figure 31-43. The difference between the measurements D & E divided by two will give the clearances between the lower edge of the balance rim and the top of the pallet bridge, and the top of the balance rim and center wheel, (or the lower edge of the balance rim and the upper plate, and the top of the balance rim and balance bridge in case of a full plate movement).

The remainder of the instructions will use, as an example, a three-quarter plate or bridge model movement, and measurements will be taken with the cap jewels in place.

3. Using the sketch you made of the balance staff, mark in the measurements as you determine them. From the outside of the lower cap jewel to the top of the pallet bridge, F, figure 31-43, plus one-half the difference between the thickness of the rim of the balance wheel and the space between the center wheel and the pallet bridge, (result of Step 2), minus the thickness of the lower cap jewel, C, figure 31-43, equals the length of the balance staff from the end of the lower pivot to the balance seat, T, figure 31-40.

4. From the outside of the lower cap jewel to the top of the pallet fork, G, figure 31-43, plus one-half the thickness of the impulse roller for clearance, H, figure 31-43, plus the thickness of the impulse roller, J, figure 31-43, minus the thickness of the lower cap jewel C, equals the length of the lower half of the balance staff from the end of the lower pivot to the underside of the balance hub, V, figure 31-40.

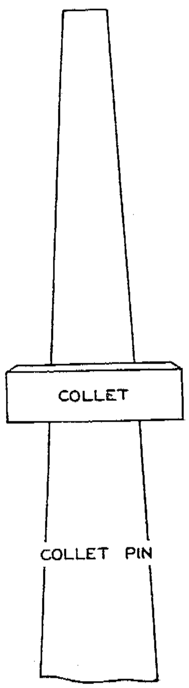
5. Subtract the result obtained in Step 3, T, figure 31-40. from the L O A of the balance staff, S, figure 31-40, and the result will be the length of the balance staff from the end of the upper pivot to the balance shoulder, W, figure 31-40.

6. The difference between W and V, figure 31-40, equals the thickness of the hub, P, figure 31-40.

7. Determine the diameters of pivots by measuring the jewel holes with a jewel hole gauge or balance pivots which fit correctly. Make the straight part of the pivot 2-1/2 times as long as the diameter, the cone the same length, and the back cut at your discretion. Back cut may be made extremely short if necessary to leave the collet seat long enough. Diameter of the back cut should be slightly less than the diameter of the collet seat.

8. Drop the collet on a tapered pin and mark the location, figure 31-44. Measure the diameter of pin at this point with a micrometer and multiply the result by the constant 1.05. This result will be the finished diameter of collet seat.

Fig. 31 - 44



9. The roller seat should have a slight taper (taper toward the lower pivot) and have a finished size that will permit the impulse roller to be pushed within half the thickness of the roller.

10. After all dimensions are obtained and entered on the sketch, proceed to make balance staff (Section 525).

SEC. 528 - Making Punches for Washer

At this time we will make punches to be used in poising balance wheels. As you proceed with watch repair work, make these punches to fit different size balance screws as you encounter them. The following dimensions are suitable for a 16 size Elgin Watch:

1. Turn down a square shoulder about 4/100ths mm larger than the threads of the balance screw, figure 31-45.

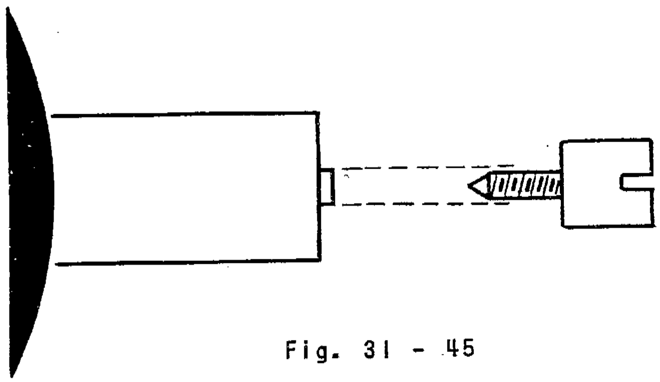


Fig. 31 - 45

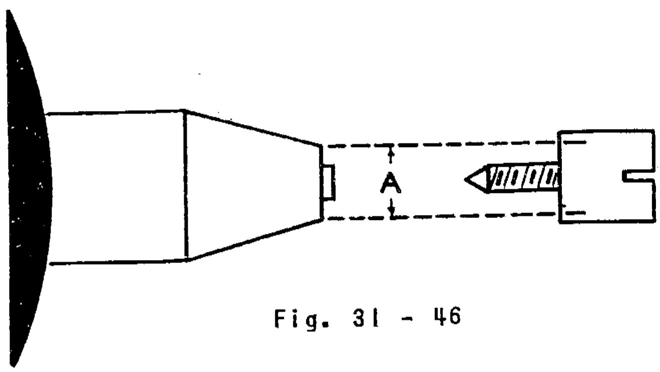


Fig. 31 - 46

2. Bevel corner of rod so that diameter illustrated at A is slightly smaller than the head of the balance screw. figure 31-46. Cut off pilot as shown in figure 31-47. Harden and temper to a straw. The shorter the pilot the less trouble you will have in removing the washers. Obtain a small lead block or melt some lead in a small material can. Punch washers from very thin material such as dial washers, figure 31-48.

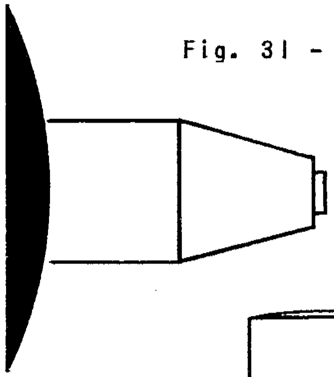


Fig. 31 - 47

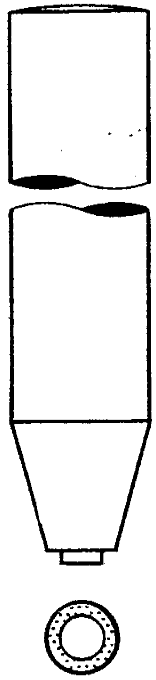


Fig. 31 - 48

These washers are slipped under the heads of the balance screws when poising wheel. At times, when we are undercutting screws, it is a good policy to add washers to the opposite screws in order to keep the weight of the balance more equal, and you will not have to make as many adjustments when bringing the watch to time. These punches can be made in any size you desire and a workman may make his own timing washers. In some cases where a pair of heavy washers is needed for a bracelet watch, thin gold or platinum can be used. Because platinum is the heaviest metal known, washers made of this metal will have greater effect upon slowing up a watch. Keep these punches handy and use the washers when poising a balance wheel or regulating a watch.

SEC. 529 - Carboloy Gravers

Carboloy is the hardest metal made by man. It is a very useful tool for the watchmaker. A carboloy graver will cut the hardest of balance staffs or stems. It is extremely useful in removing a balance wheel by cutting away the old hub, figure 31-39. This method is without a doubt the safest and most practical way of removing the balance wheel from the staff. Before the advent of the carboloy graver, the watchmaker was confronted at times with a balance staff which was too hard to be cut with an ordinary graver. At times he would have the hub cut half way through and discover that in the cutting process the steel had become burnished making a great deal of extra work in sharpening the graver or drawing the temper in the staff. With the carboloy graver you can disregard the hardness. Keep your carboloy gravers sharp and use them only where it is impractical to use the ordinary graver. The carboloy graver illustrated in figure 31-49 has a removable handle. Carboloy gravers must be sharpened with a diamond charged lap or wheel. Remember that because of the extreme hardness of the carboloy graver the point will break quite easily. Therefore, do not force the graver when cutting.

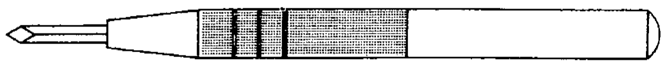


Fig. 31 - 49

SEC. 530 - Fitting Pinions to Watches

It should be an easy matter by now to replace a pinion in a watch. We are not often compelled to make a pinion from pinion wire as most pinions can be obtained in the finished form from a material house.

Although the average finished pinion ordered from a material house should fit there are times when the pivots have to be ground and polished to fit the bearings or jewels. Some pinions may have a square shoulder pivot on one end and a cone shape on the other. Figure 31-50 illustrates the end of a blank pinion. Blank pinions come with any number of leaves desired such as 6, 7, 8, 9, 10, and 12. The diameters are gauged by a Stubs Gauge.

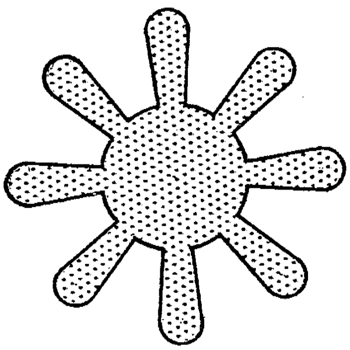


Fig. 31 - 50

Pinions to fit watches can be cut from pinion wire as follows:

1. Select a blank pinion with the same number of leaves as the sample and the same diameter as measured with a Stubs Gauge.

2. Obtain over-all length.

3. Obtain height of wheel shoulder.

4. Turn pinion wire to fit wheel.

Figure 31-51 illustrates the pinion leaves cut down to a tapered shoulder on which the train wheel is to be driven friction tight.

Figure 31-52 illustrates the pinion leaves cut down for a wheel which requires rivetting. The shoulder protrudes through the wheel enough to be rivetted after undercutting.

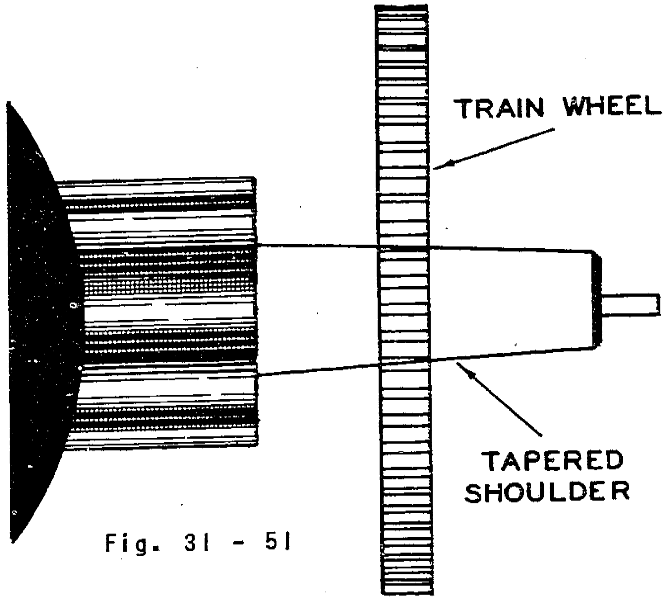


Fig. 31 - 51

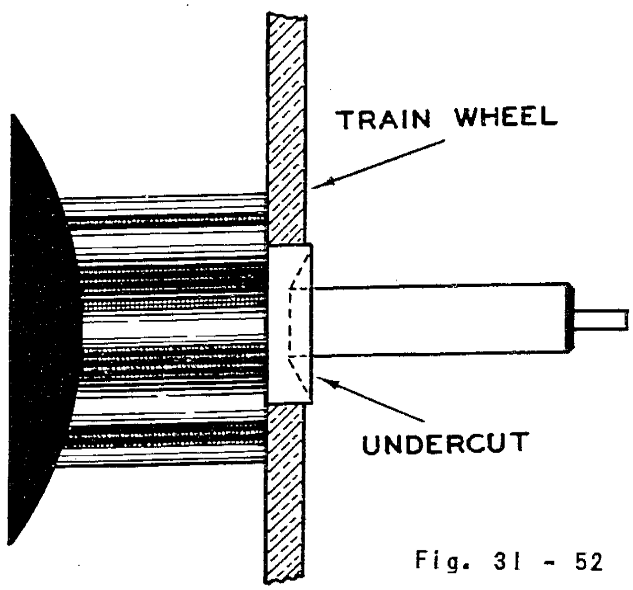


Fig. 31 - 52

5. Cut through leaves to match length of sample pinion.

6. Cut, grind, and polish pivots.

7. Replace wheel.

SEC. 531 - Pallet Arbors

Figure 31-53 illustrates two types of pallet arbors. A is a friction type having a tapered shaft which is driven into pallet fork. B represents a screw type

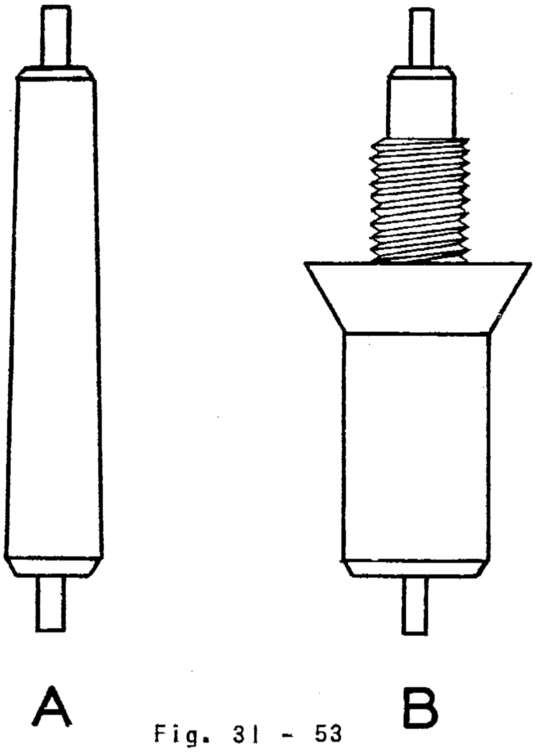


Fig. 31 - 53

pallet arbor. This is screwed into pallet fork and is easily removed by catching pallet arbor in a chuck and holding head of lathe with left hand, carefully turning pallet fork toward you. In replacing pallet arbors, it is necessary to ascertain the correct one to be used, using a micrometer. Any alterations of pallet arbor are made the same as for pinion or balance staffs using square and/or cone shaped pivots.

SEC. 532 - Making a Stem from a Sample

For stem work it is desirable to have a good slot cutting graver as illustrated in figure 31-54. This graver can be made from a regular graver #0, the tip to measure approximately .50 mm. It is also possible to make a graver from a piece of square drill rod. However, a carboloy graver is recommended in preference to all others.

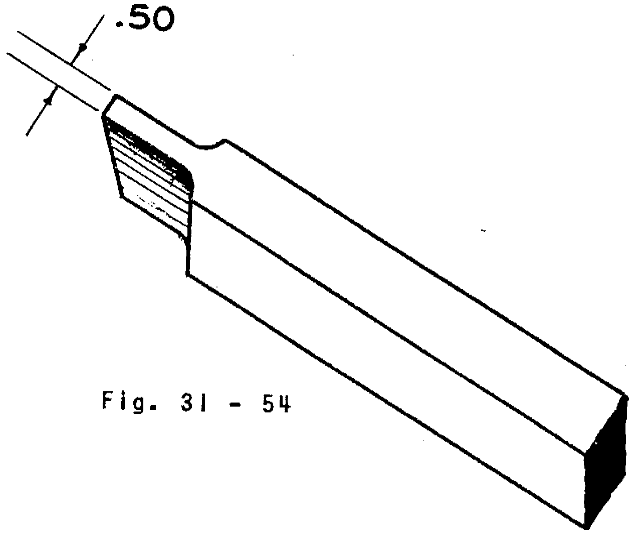


Fig. 31 - 54

1. Select a piece of drill rod slightly larger than the diameter of the finished hub of the sample stem.

2. Cut off as in figure 31-55, the length over-all to be slightly longer than the length of the finished stem.

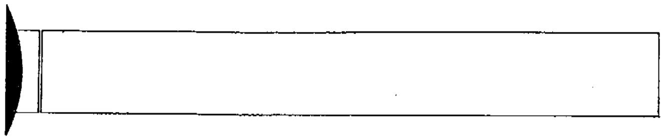


Fig. 31 - 55

3. Place in lathe and cut thread (Lesson 29, figure 29-34). This thread should be slightly longer than the sample, figure 31-56, and of the same tap size as crown to be used.

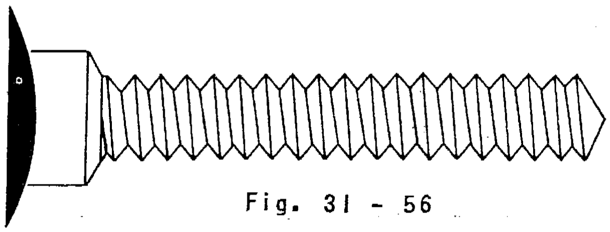


Fig. 31 - 56

4. Place threaded portion in lathe chuck and cut off to correct length using sample for length A, figure 31-57.

5. Remove, harden, and temper to a blue.

6. Place threaded portion in lathe chuck, figure 31-58, and turn outside diameter to the diameter of the hub.

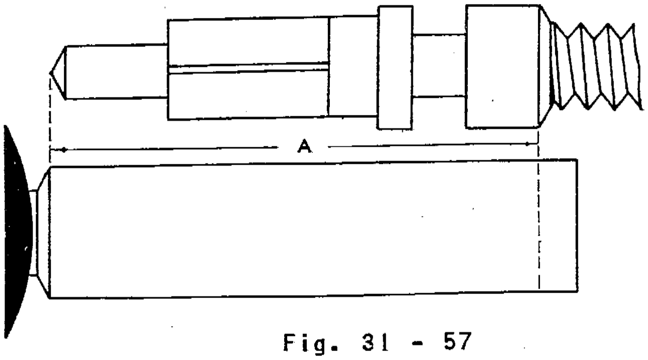


Fig. 31 - 57

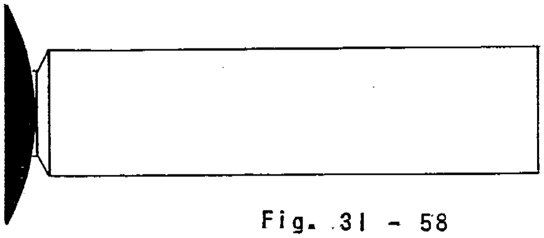


Fig. 31 - 58

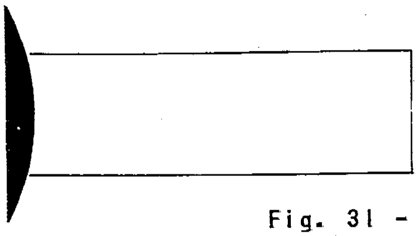


Fig. 31 - 59

7. Remove from lathe and place hub section in lathe chuck allowing the length required for the winding pinion shoulder to extend from chuck, figure 31-59.

8. Turn pilot, figure 31-60, using old stem pilot as guide for length.

9. Turn diameter for winding pinion using old stem as guide to length, figure 31-61.

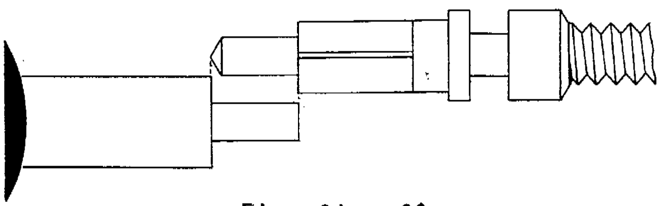


Fig. 31 - 60

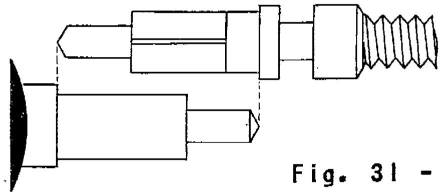


Fig. 31 - 61

10. Measure the width of the square on the old stem and multiply by the constant 1.39. The result is the diameter to turn for the winding square. This constant can be used for any size winding square. To find the exact diameter of a circle circumscribed about a given square, multiply the length of one side of the square by the constant 1.41. However, for our purpose, we use the constant 1.39 which will allow the corners of the square to be slightly rounded as in figure 31-62.

Example: Length of one side of square equals .95 mm. .95 multiplied by constant 1.39 equals 1.32 mm.

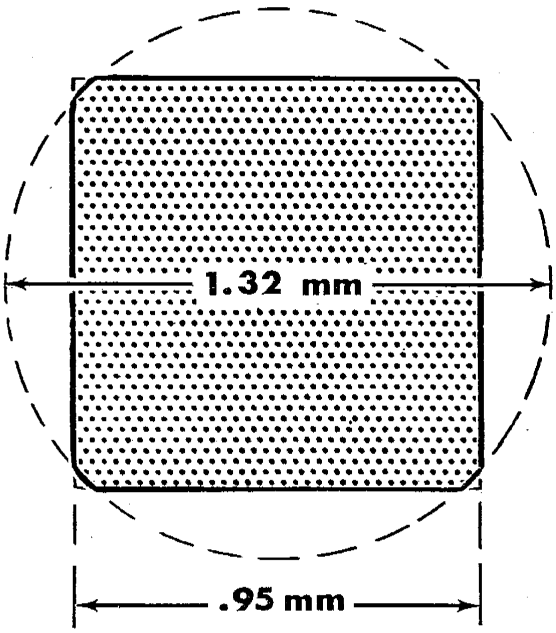


Fig. 31 - 62

11. Turn clutch shoulder to diameter using old stem as a guide for length, figure 31-63. Polish all surfaces finishing with 4/0 emery buff.

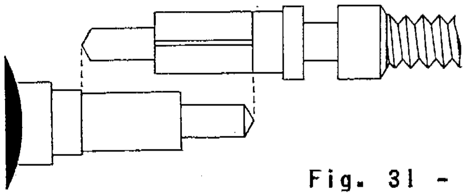


Fig. 31 - 63

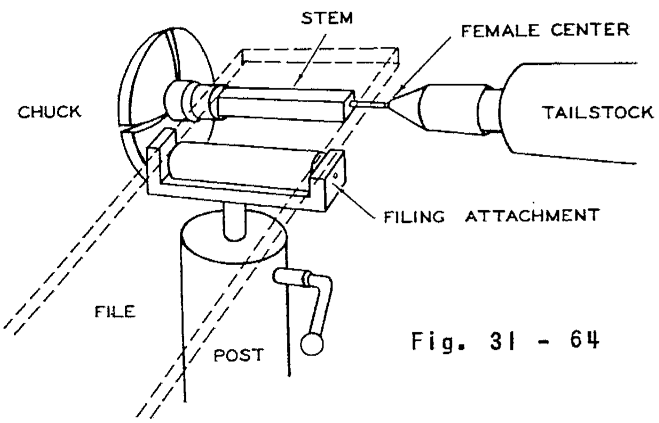


Fig. 31 - 64

12. File square on stem. This can be done using a file attachment as illustrated in figure 31-64. Figure 31-65 illustrates the four end positions of the stem as the square is turned using the index plate in the head of the lathe as a guide. The square can be measured with a micrometer and left several hundredths of a millimeter larger than the finished square. To finish draw file square to proper thickness. Remove from lathe, placing winding pinion shoulder in lathe chuck and cut slot, figure 31-66.

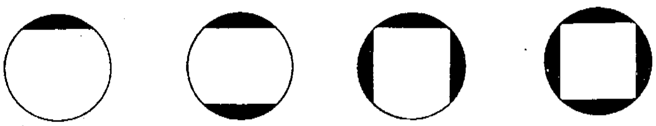


Fig. 31 - 65

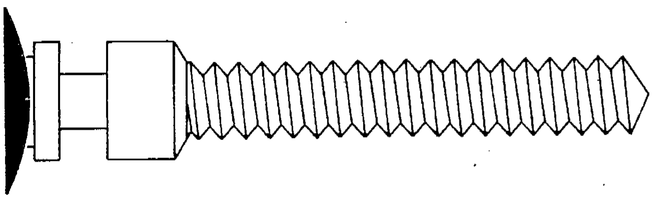


Fig. 31 - 66

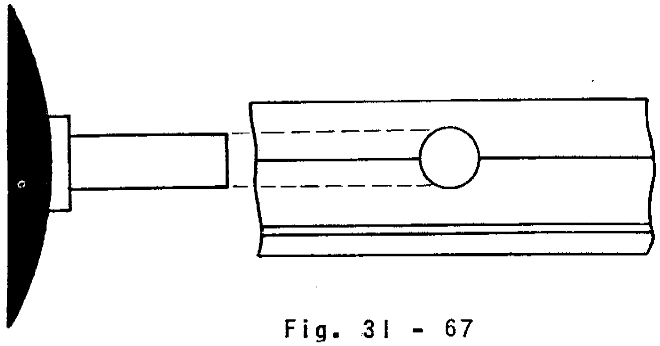


Fig. 31 - 67

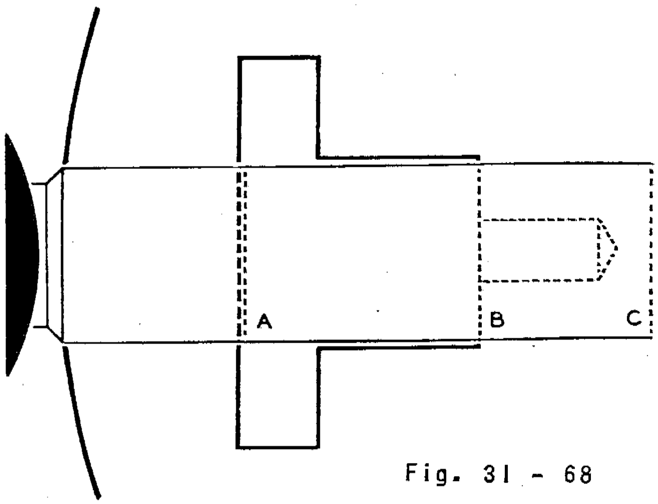


Fig. 31 - 68

SEC. 533 - How to Make a Stem Without a Sample

1. Turn down a metal plug until it just enters hole in plate, figure 31-67. At times it is necessary to round up the hole in the plate with a broach before making this plug.

2. Select a piece of drill rod slightly larger in diameter than the plug and of sufficient length for a complete stem.

3. Thread the end of stock the same tap size as the crown to be used and long enough to extend outside the watch case.

4. Remove from chuck and place threaded portion in a chuck of correct size. Hold pillar plate in position shown in figure 31-68 with the outer edge of pillar plate at the base of thread. Make

a mark with the point of your graver as indicated by dotted line A. This will be the winding pinion seat. Make a mark with the point of your graver as indicated by dotted line B. This will be the pilot seat. Allow sufficient length from this mark for the length of the pilot and cut off as at C, figure 31-68.

5. Remove, harden, and temper to a blue.

6. Place threaded portion in a chuck and turn the outside diameter to the diameter of the plug or until it fits the hole in plate snugly, figure 31-69.

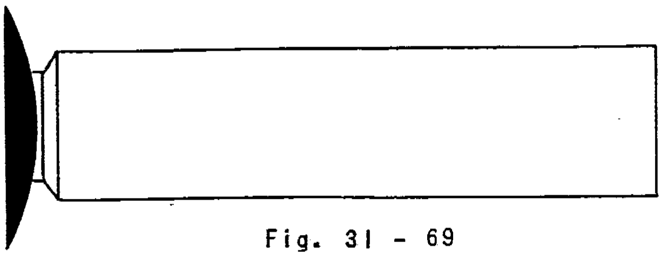


Fig. 31 - 69

7. Remove stem from lathe and catch up on full diameter of hub, figure 31-70.

8. Turn pilot to correct diameter and length, figure 31-70. If necessary, a plug can be made to ascertain the diameter of the hole in plate for pilot.

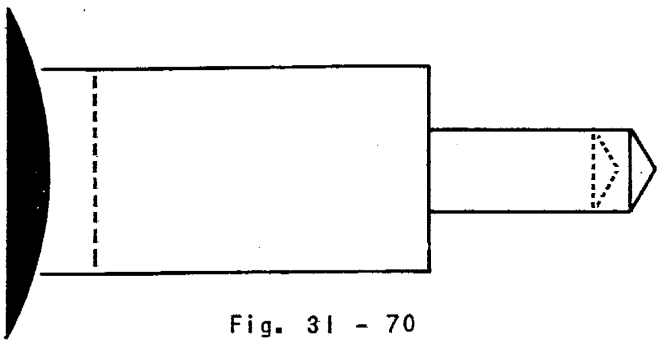


Fig. 31 - 70

9. Turn down winding pinion shoulder until winding pinion will just go on, figure 31-71.

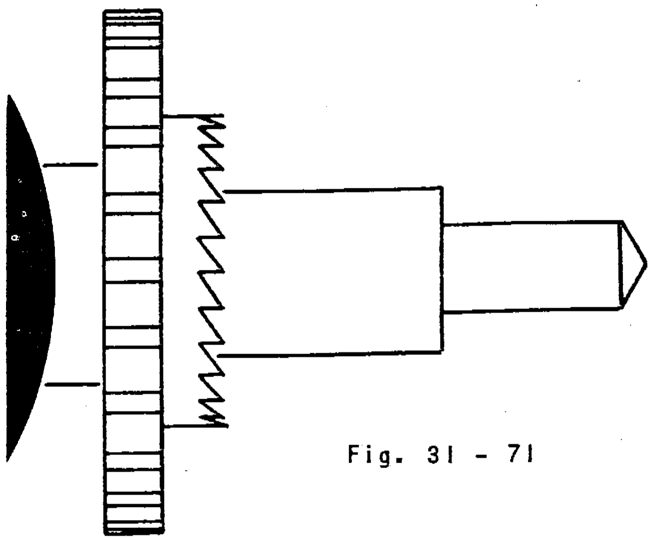


Fig. 31 - 71

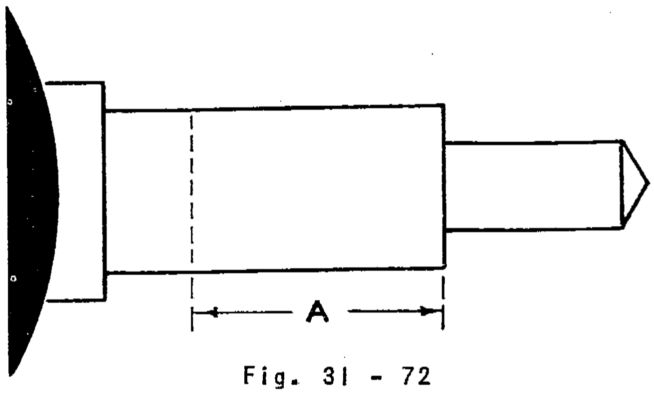


Fig. 31 - 72

10. Slide the clutch over a taper pin and measure the diameter with a micrometer at the point where the hole contacts the pin. Multiply this result by the constant 1.39. This result will give the diameter of section A, figure 31-72, from which the square is to be filed.

11. File square on stem.

12. Cut slot in stem. To locate slot insert stem into plate and with the winding and setting parts in place and in the winding position place a mark on either side of the point of contact between the setting lever pin and the unfinished stem. Be certain that the slot in stem is wide enough and deep enough to allow a minimum of play when set lever screw is tightened.

SEC. 534 - Repivoting

It is not often that we are called upon to repivot a pinion or a balance staff. This, however, was considered an accomplishment by the old master watchmaker but with today's standardized material it is more practical and profitable to purchase a new staff or pinion. At times you may find it profitable to repivot a pinion, especially in clock work.

1. Draw temper in pinion. Figure 31-73 illustrates the method by which a copper wire is crimped on to the pinion and heated until the pinion turns to a light blue.

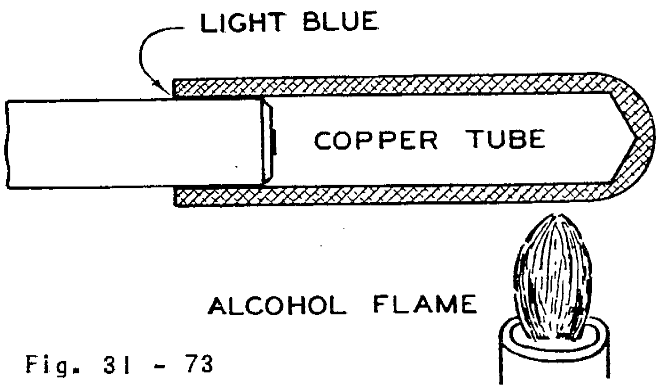


Fig. 31 - 73

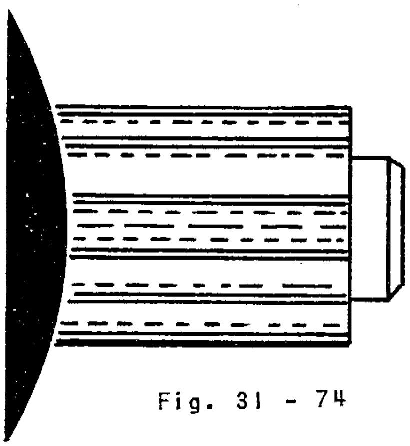


Fig. 31 - 74

2. Place pinion in lathe chuck and make certain it is running absolutely true, figure 31-74. If necessary, cement in a hollow cement chuck.

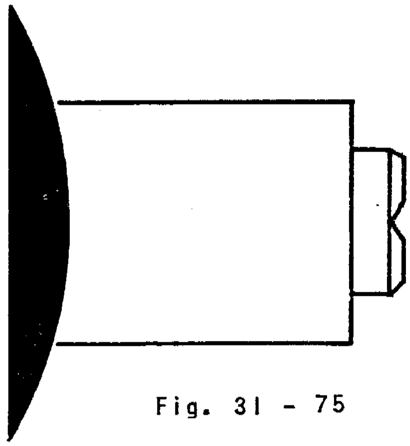


Fig. 31 - 75

3. Center, figure 31-75.

4. Drill hole slightly larger than the diameter of the finished pivot, figure 31-76.

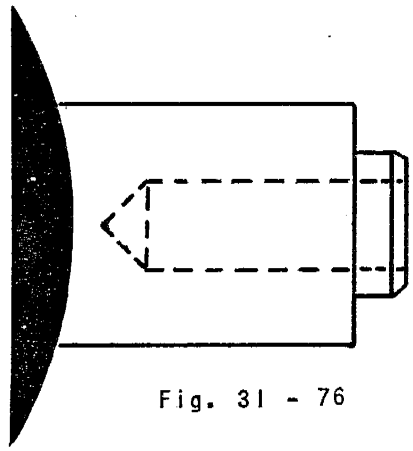


Fig. 31 - 76

5. Remove from lathe and take a blued pivot wire slightly larger than the finished pinion and chuck up the lathe. Turn down the diameter of this wire, figure 31-77, until it just starts into hole.

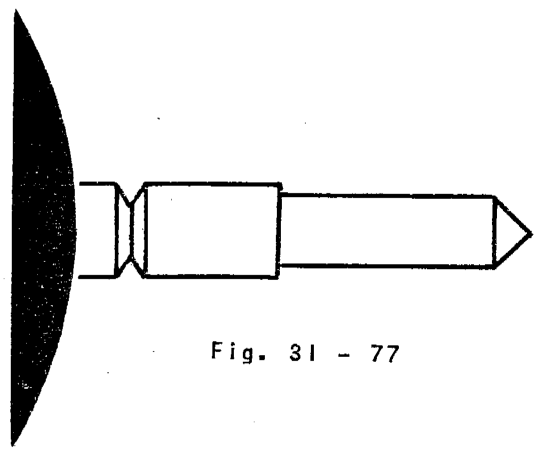


Fig. 31 - 77

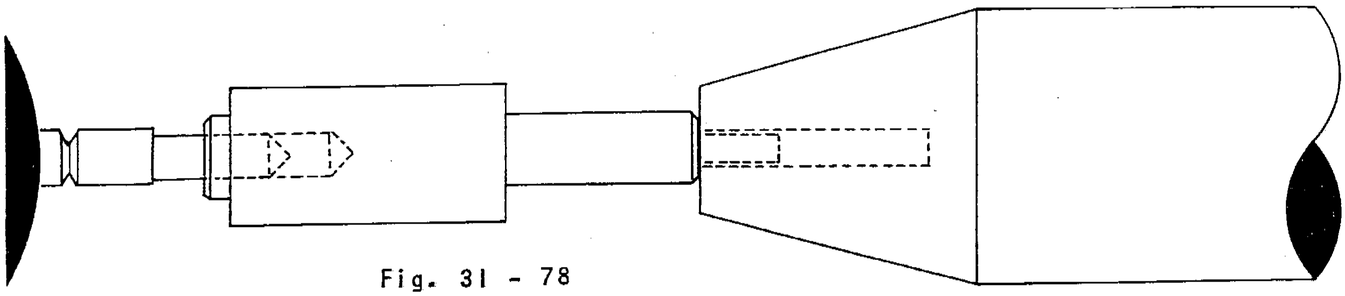


Fig. 31 - 78

6. Drive pinion into wire as in figure 31-78 using a flat face hollow staking tool punch. At times, it is necessary to reverse this process and drive the pivot wire in the pinion.

7. Remount pinion in lathe, figure 31-79, and finish pivot to the proper diameter and length, figure 31-80.

The same process is used to repivot a balance staff.

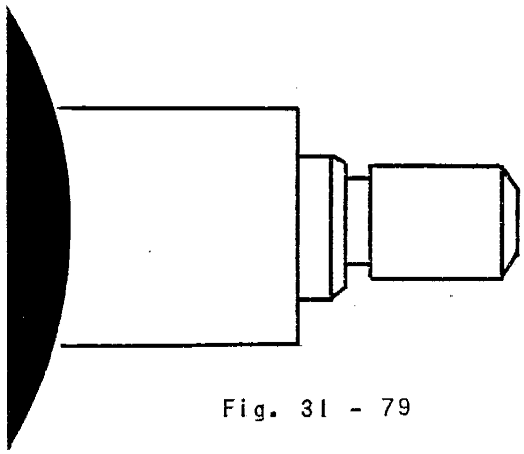


Fig. 31 - 79

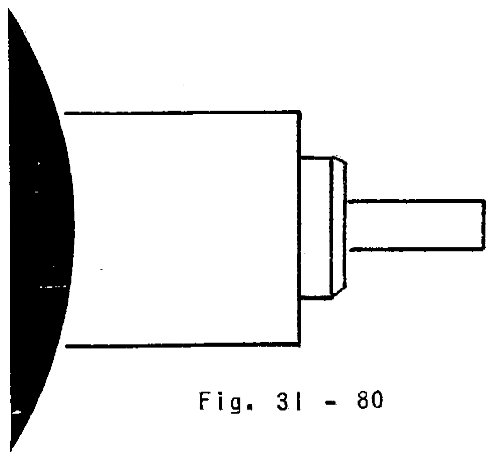


Fig. 31 - 80

SEC. 535 - Rebushing a Train Wheel

At times a train wheel which is out of true can be corrected with a rounding up tool and cutter. The rounding up tool which is used to round up the teeth in the wheel after the wheel is riveted to the pinion, is not used much by the watchmaker's craft here in the United States.

One of these tools is shown in figure 31-81. The wheel to be operated upon is placed upon a small table at A between two vertical runners with guard-pivot centers. The cutter is fixed at B to a suitable arbor chuck in a small head C, which is turned by hand-wheel D, a supplementary pulley E taking all strain off the axis. The three milled-headed nuts seen at F; G, and H are for adjusting; F for moving the lathe-head so that the cutter is in the same plane as the axis of the runners, a position which is determined by the pointer D; G for advancing the wheel against this cutter; and H for setting the plane of the wheel to pass through the axis of the lathe-head as indicated by the index K. The tool is accompanied by a number of cutters to suit the various sizes of teeth as well as of tables to support wheels of different dimensions.

An enlarged view of the mill cutter is shown in figure 31-82. Section A-B of the circumference is cut away and replaced by guide C-D made of spring steel and fixed to coincide with the edge

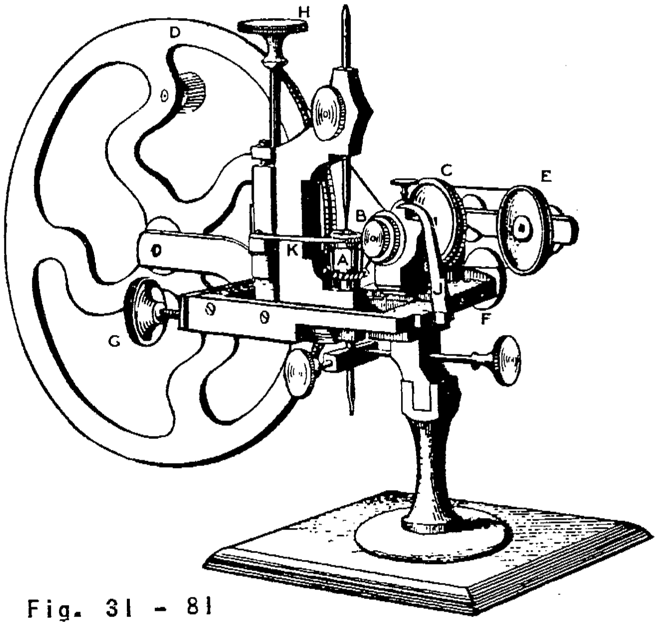


Fig. 31 - 81

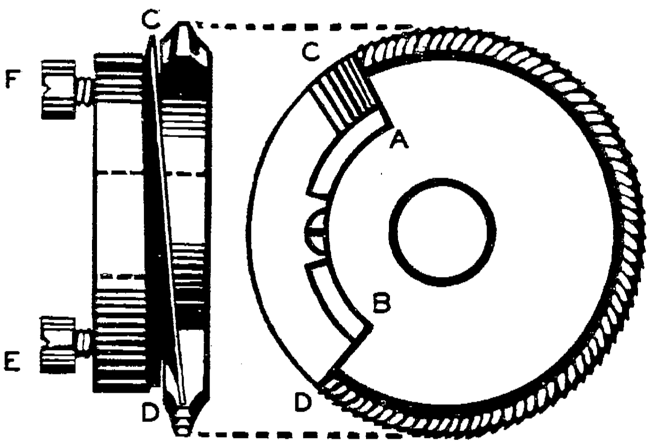


Fig. 31 - 82

of the cutter at D and inclined at C in order to compel the cutter to pass at each rotation into consecutive spaces of the wheel. Two screws are provided, E for setting the guide opposite the edge of the cutter, and F for placing the free end of the guide opposite to the space between teeth.

For the average watchmaker, it is possible to true up a train wheel in the following manner:

1. Remove train wheel from pinion.

2. Select a cement brass slightly larger than the diameter of the train wheel. Cut out a section as in figure 31-83 so that the train wheel will fit in without any side play.

3. Cement wheel in cement chuck, figure 31-84.

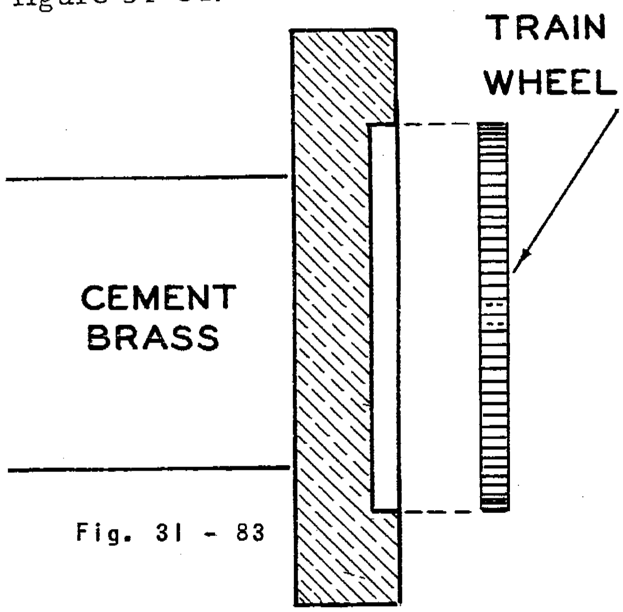


Fig. 31 - 83

4. Bore out center of wheel with boring tool, figure 31-84.

5. Remove wheel from cement chuck, boil and clean with alcohol.

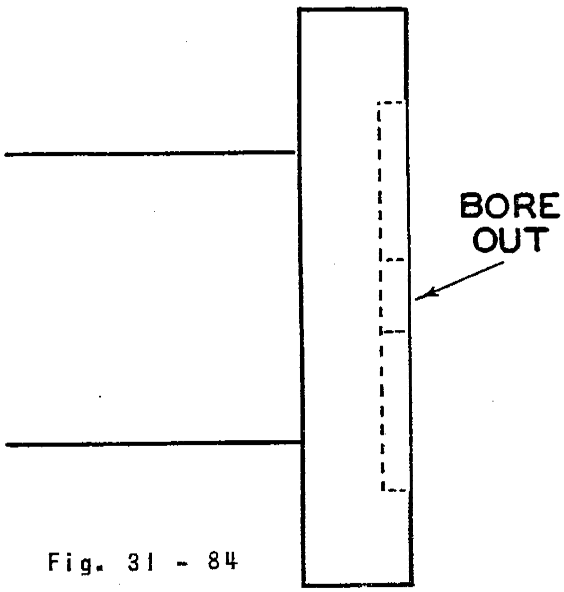


Fig. 31 - 84

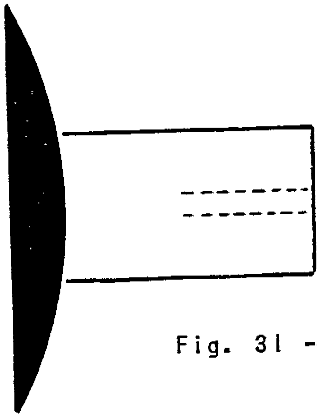


Fig. 31 - 85

6. Place a piece of brass wire in lathe, center and drill hole slightly smaller than the train pinion, figure 31-85. Turn shoulder until wheel just fits, leaving a small portion extending through wheel so that it can be riveted, figure 31-86.

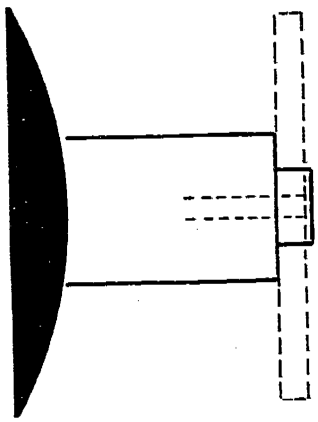


Fig. 31 - 86

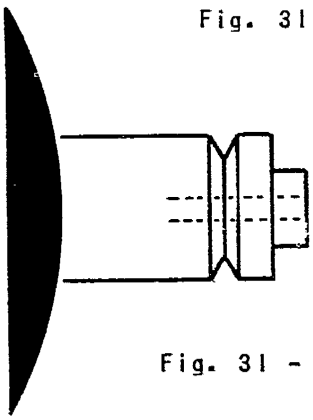


Fig. 31 - 87

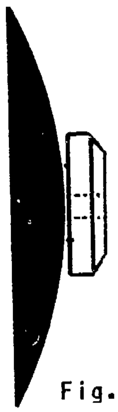


Fig. 31 - 88

7. Cut a groove leaving a short hub as in figure 31-87. Saw off, reverse in chuck of proper size and face off hub as in figure 31-88.

8. A. Stake wheel to hub as in figure 31-89. The punch used for this operation will leave indentations as illustrated by A, figure 31-90.

B. Broach out hole in wheel and replace on pinion.

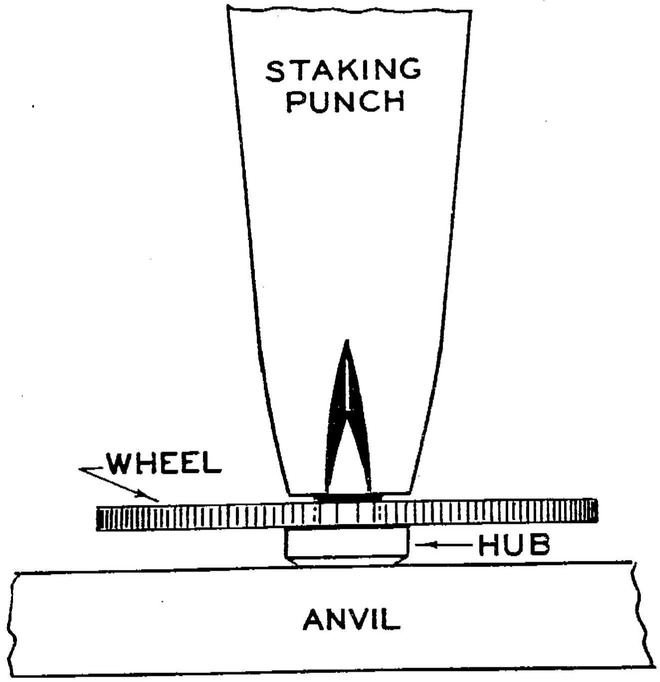


Fig. 31 - 89

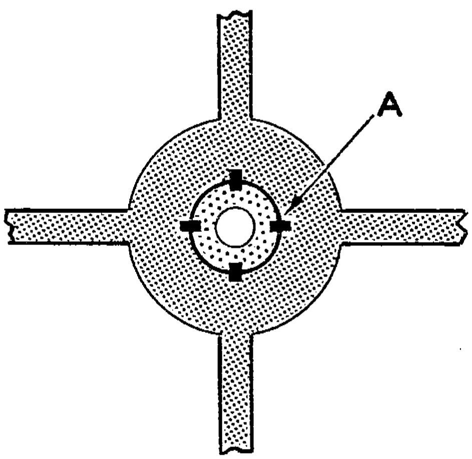


Fig. 31 - 90

SEC. 536 - Replacing a Hook in Barrel

When the hook in the barrel becomes broken or worn, the practical thing to do from the standpoint of time is to replace the barrel. At times this is impossible and it becomes necessary to replace the hook.

1. Locate center D, figure 31-91. This will be the center for the hook. It is found as follows:

$$\frac{A - B - C}{2} + B = D$$

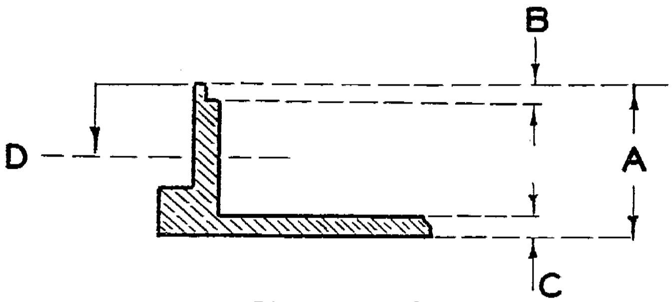


Fig. 31 - 91

2. Set a pair of dividers to this dimension and scribe a line on outside of barrel as shown at D, figure 31-92.

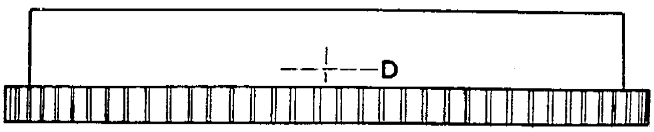


Fig. 31 - 92

3. Center punch barrel as in figure 31-93.

4. Select tap size, drill hole and tap barrel, figure 31-94.

5. Thread a piece of drill rod as in figure 31-95.

6. Turn diameter B, figure 31-95, slightly smaller than width A, figure 31-94.

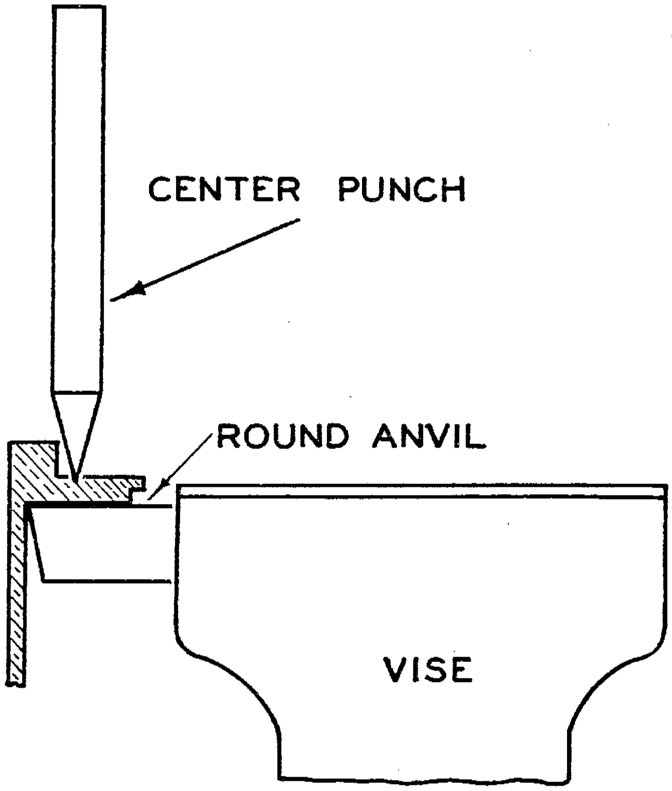


Fig. 31 - 93

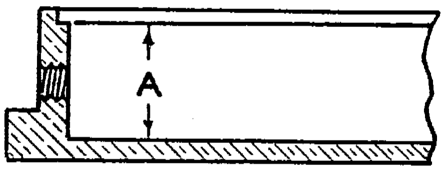


Fig. 31 - 94

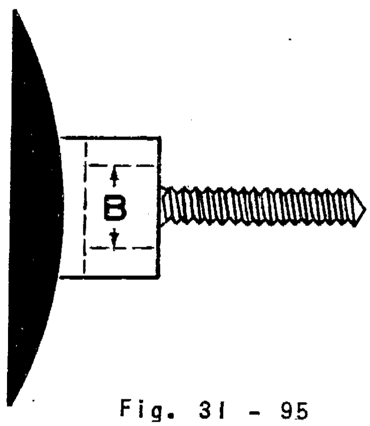


Fig. 31 - 95

7. Shape as in figure 31-96 to allow for the thickness of mainspring. The dashed lines illustrate the rim of barrel.

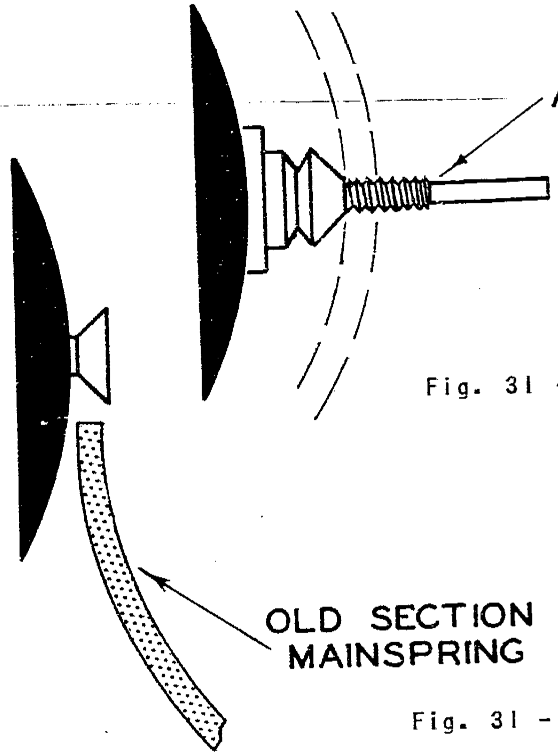


Fig. 31 - 96

Fig. 31 - 97

8. Turn off thread as indicated at A, figure 31-96.

9. Cut groove, saw off end, reverse in chuck of correct size and finish end as in figure 31-97. The hook should now be slightly longer than the thickness of mainspring, figure 31-97.

10. Screw into barrel from the inside, figure 31-98.

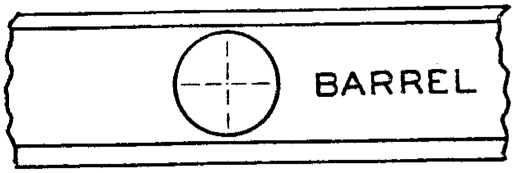


Fig. 31 - 98

11. Mark vertical and horizontal lines as in figure 31-98.

12. Remove and shape hook to fit hole in mainspring, figure 31-99.

13. Harden and temper to a blue.

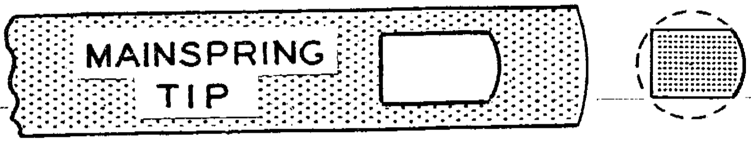


Fig. 31 - 99

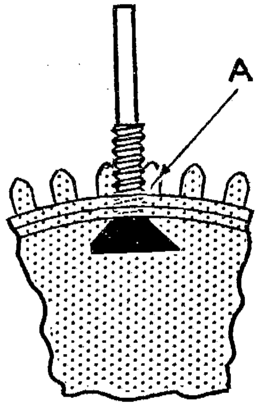


Fig. 31 - 100

14. Replace in barrel from inside. Screw in tightly and cut off excess at A, figure 31-100.

SEC. 537 - Calculating Lost Wheels and Pinions

To find the number of teeth for a center wheel. If the number of leaves in the fourth pinion goes into the number of teeth in the third wheel eight times without a remainder, the leaves of the third pinion multiplied by seven and a half will give the teeth for the center wheel.

If the leaves of the fourth pinion go into the third wheel seven and a half times without a remainder, the leaves of the third pinion multiplied by eight will give the center wheel teeth.

To calculate a missing third wheel and pinion. When the center wheel divides by eight without a remainder the quotient will be the number of leaves for the third pinion and number of leaves on the fourth pinion multiplied by seven and a half will be the number of teeth for the third wheel.

When the teeth in the center wheel divide by seven and a half without a remainder, the quotient will be the number of leaves for the third pinion, and eight times the leaves of the fourth pinion will be the number of teeth for the third wheel.

To calculate a missing fourth wheel and pinion. When the leaves of the third pinion go into teeth of the center wheel eight times without a remainder, dividing number of teeth in the third wheel by seven and a half will give the number of leaves for the fourth pinion.

When the leaves of the third pinion go into teeth of the center wheel seven and a half times without a remainder, dividing number of teeth in the third wheel by eight will give the number of leaves for the fourth pinion.

To find the number of teeth for the fourth wheel when the watch has an 18,000 train. This may be done by comparing the motion of the balance with that of another which is known to have an 18,000 train. The vibrations may be counted for half a minute or more.

An 18,000 train balance gives 300 vibrations a minute, or, if alternate vibrations are counted (which is more convenient), there will be 75 in half a minute.

When the watch is found to be an 18,000 train, multiplying the escape pinion by 10 gives the number of teeth for the fourth wheel.

To calculate a missing escape pinion. The teeth of the fourth wheel will always be divisible by either 8 or 9 without a remainder and the quotient will be the number of leaves for the escape pinion.

The number of teeth in the escape wheel will, of course, be fifteen in all modern watches.

It is seen that the calculations for the teeth and pinions in a modern watch train is a simple matter. For other trains that do not carry second hands the procedure is somewhat different.

SEC. 538 - Rule for Calculating Any Train of Wheels.

Trains are divided into two classes, simple and compound. Simple gearing consists of two or more wheels meshing directly into each other, each on its own bearings. Compound gearing consists of a series of wheels and pinions, two or more mounted on the same staff.

In simple gearing, the difference between the number of teeth in the first and last members of the train determines their respective revolutions, irrespective of the number of members or the number of teeth in the other wheels; the intermediate wheels simply transmit the motion from one to the other.

In compound gearing every member of the train enters into the calculations. To make these calculations three things are predetermined: The number of revolutions the last wheel in the train gives for one of the first; the number of members that constitute the train; the number of leaves to be given to each pinion.

Rule.--The prime factors of the product of each pinion and the number of revolutions of the last wheel, multiplied together and arranged in the number of groups corresponding with the number of wheels required, gives the number of teeth for those wheels.

For an example we will calculate the train, from the center wheel on, for an 18,000 train watch.

First operation: The number of teeth in the escape wheel is fixed at 15. Each tooth delivers two impulses to the balance; therefore, divide 18,000 by twice the number of escape teeth--30. Example:

```
30)18000(600
   180
   ---
```

The number of revolutions required of the escape pinion is, therefore, 600 per hour.

Second operation: We will select for the number of leaves in the pinions: 9 for the third; 8 for the fourth; 7 for the escape. The number 9 selected for the third is unusual. It is done for the purpose of demonstrating the adaptability of the rule to all cases.

Multiply the pinions and revolutions together:

```
     9
     8
   ---
    72
     7
   ---
   504
   600
 ------
302400
```

Ascertain the prime factors of this number:

```
2)302400
2)151200
 2)75600
 2)37800
 2)18900
  2)9450
  3)4725
  3)1575
   3)525
   5)175
    5)35
       7
```

This gives us as prime factors six 2s, three 3s, two 5s, and one 7.

We will take for our first group two 3s and three 2s:

```
  3
  3
 --
  9
  2
 --
 18
  2
 --
 36
  2
 --
 72
```

This gives us 72 teeth for the center wheel.

We will take for the next group one 5, one 3 and two 2s, which multiplied together will give us 60 teeth for the third wheel.

We now have left one 7, one 5, and one 2, which multiplied together gives 70 teeth for the fourth wheel.

This completes the train, which it will be seen is correct for the purpose required. The center wheel has 72 teeth and as the third pinion has 9 leaves the center will give it 8 revolutions. The fourth pinion has 8 leaves and as the third wheel has 60 teeth, it will give to the fourth 7-1/2 revolutions. Seven and a half times 8 being 60, the center wheel will give the fourth pinion sixty revolutions, which is correct for carrying a second hand. The escape pinion having 7 leaves and the fourth wheel 70 teeth, the fourth will cause the escape to revolve ten times. The number of revolutions will, therefore, be 10 times 60, or 600.

SEC. 539 - Calculating Dial Trains

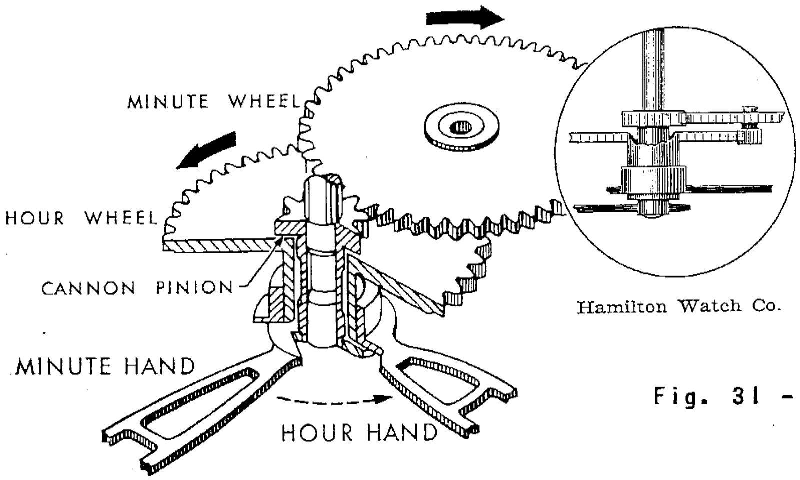


Fig. 31 - 101

The cannon pinion, minute wheel, hour wheel, and minute wheel pinion are known as the dial train.

The center staff or arbor makes one revolution in one hour. The cannon pinion is attached by friction to the center arbor and likewise makes one revolution per hour.

The cannon pinion drives the minute wheel. The pinion attached to the minute wheel is known as the minute wheel pinion and drives the hour wheel.

The teeth of the hour wheel multiplied by the teeth in the minute wheel equals the number of leaves in the cannon pinion multiplied by the number of leaves in the minute wheel pinion multiplied by 12.

The following formula is used to prove the correctness of a 12 hour dial train:

$$\frac{\text{Teeth in minute wheel x teeth in hour wheel}}{\text{Leaves in cannon pinion x leaves in minute wheel pinion x 12}} = 1$$

Substituting:

$$\frac{40\text{x}36}{10\text{x}12\text{x}12} = \frac{1440}{1440} = 1$$

If the dial train is correct, the result will always be 1

$$\frac{\text{Leaves in cannon pinion x leaves in minute wheel pinion x 12}}{\text{Teeth in minute wheel}}$$ equals teeth in hour wheel

$$\frac{\text{Teeth in hour wheel x teeth in minute wheel}}{\text{Leaves in minute wheel pinion x 12}}$$ equals leaves in cannon pinion

$$\frac{\text{Teeth in hour wheel x teeth in minute wheel}}{\text{Leaves in cannon pinion x 12}}$$ equals leaves in minute wheel pinion

$$\frac{\text{Leaves in cannon pinion x leaves in minute wheel pinion x 12}}{\text{teeth in hour wheel}}$$ equals teeth in minute wheel

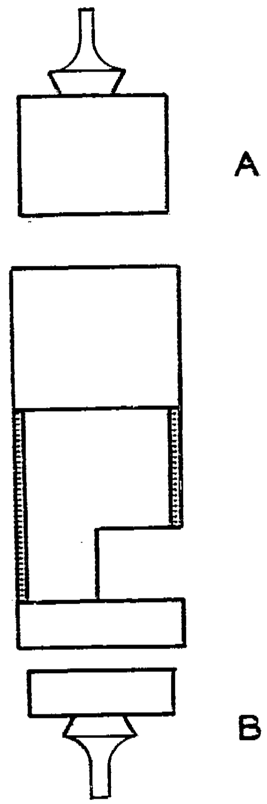


Fig. 31 - 102

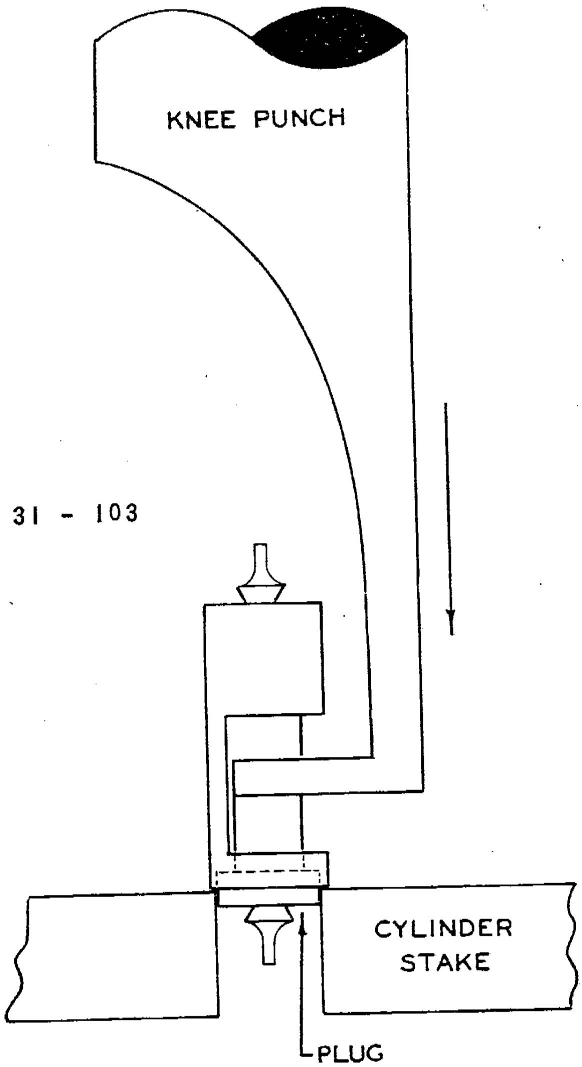


Fig. 31 - 103

SEC. 540 - Fitting New Cylinder Plugs

Figure 31-102 illustrates a Swiss Cylinder. The upper and lower pivots are made in the form of plugs A and B, which are fitted into the cylinder friction tight. The upper plug is the longer of the two and, in some cases, this plug may be driven out far enough to admit the turning of a new pivot. Cylinder plugs are driven out with a knee punch illustrated in figure 31-103. A cylinder stake or a hole in the die plate is used to hold the cylinder when removing the plug. The hole in the cylinder stake or die plate must be large enough to allow the entrance of the plug but not the cylinder. A few light taps of the knee punch is all that is necessary to drive out the old plug. The new plug must be made to fit friction tight without a taper. Use the micrometer to measure the old plug.

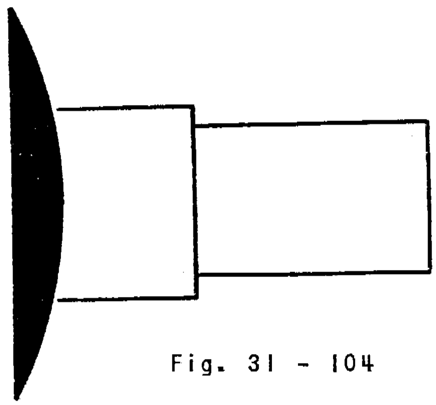


Fig. 31 - 104

1. Select a piece of blued drill rod slightly larger than the diameter of the plug.

2. Turn down outside diameter to proper dimension, figure 31-104.

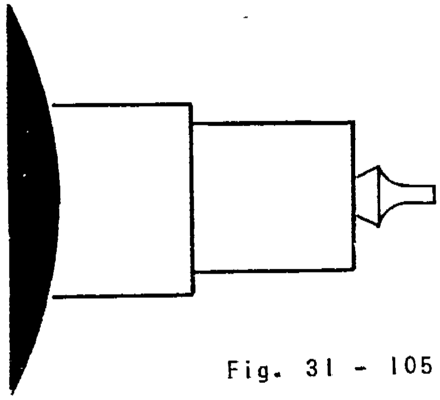


Fig. 31 - 105

3. Cut, grind, and polish a cone shape pivot on the end, figure 31-105.

4. Cut a square shoulder, the length to equal shoulder on old plug and cut off, figure 31-106.

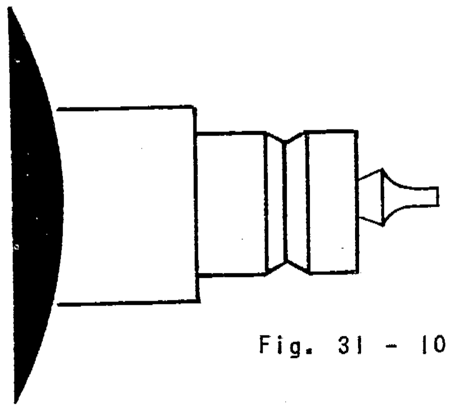


Fig. 31 - 106

5. Turn plug around in lathe and finish end, figure 31-107

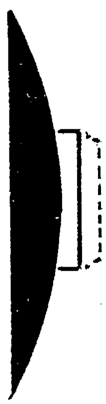


Fig. 31 - 107

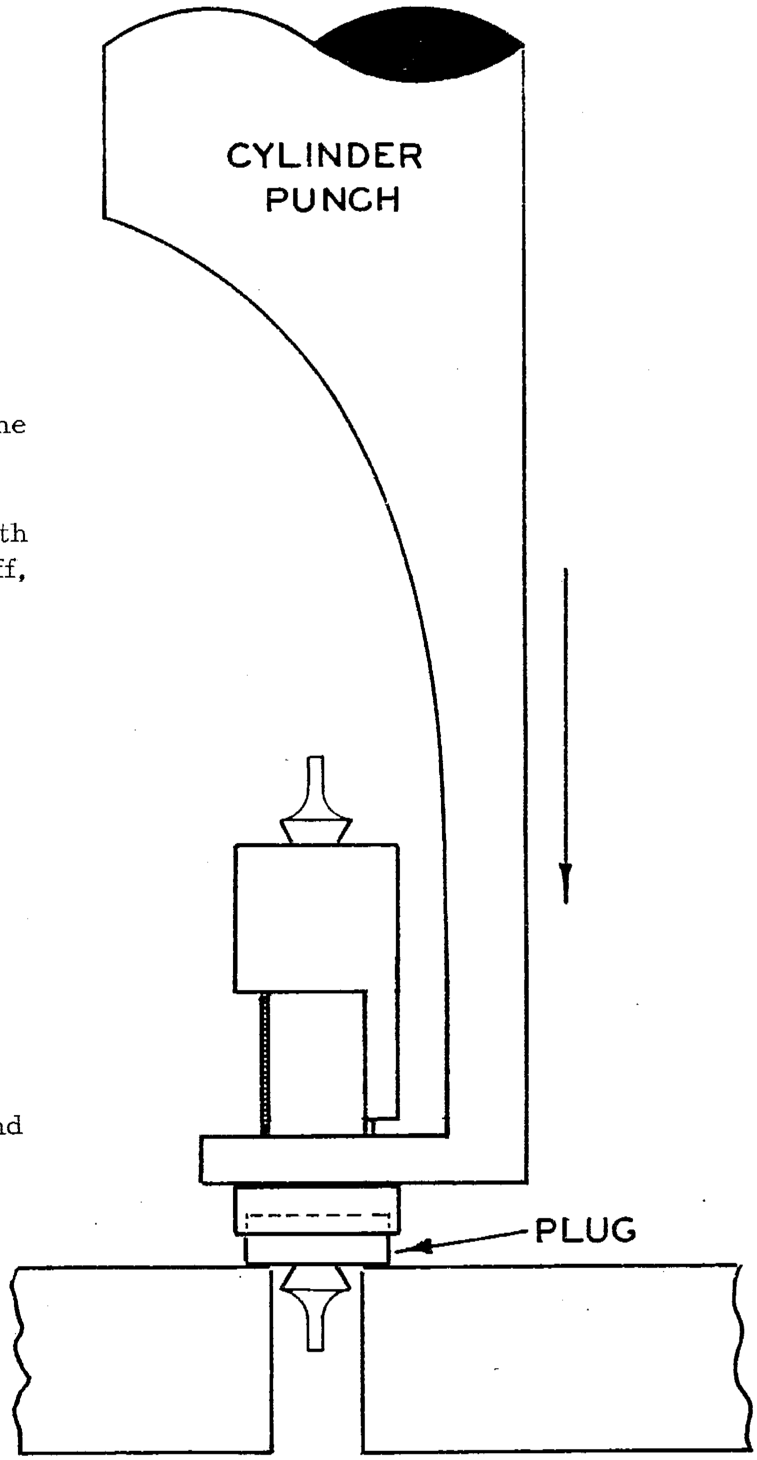


Fig. 31 - 108

6. Place plug in die plate of staking set or cylinder stake and with a punch shown in figure 31-108 placed across the inside walls of the cylinder, press plug into place.

SEC. 541 - Additional Tools

There are any number of additional tools used in watchmaking by men who have been at the bench a good many years. As you progress with your practical experience you too, will acquire additional tools. New tools will be developed and manufactured which will aid you in your work. You will become aware of other tools and material systems through the catalogues of the supply houses. Other watchmakers will recommend tools.

You should read magazine articles and acquire a good reference library of old and new books.

Illustrated here are a few other lathe accessories not previously described in Tools of the Trade manual.

Figure 31-109 illustrates a balance chuck sometimes known as a "ballon" chuck. The pivot projects through convex face of chuck and a hardened steel burnisher can be used to finish end and sides of pivot.

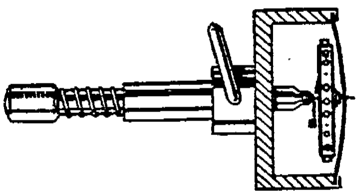


Fig. 31 - 109

Figure 31-110 illustrates a pivot drill chuck used with the regular taper chuck.

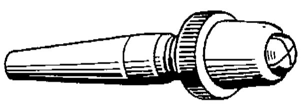


Fig. 31 - 110

Figure 31-111 illustrates a drill chuck for a watchmaker's lathe. It has a capacity up to 1/4".

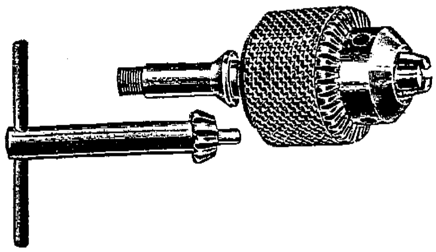


Fig. 31 - 111

Figure 31-112 illustrates a stepping device. It is used in the head stock of a lathe with a wire chuck. It affords a back seat in chuck for a jewel setting or other small pieces that lack thickness and require a shallow seat to set in.

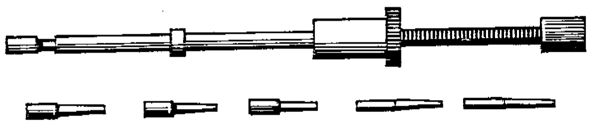


Fig. 31 - 112

Figure 31-113 illustrates a wheel cutting, grinding and drilling attachment.

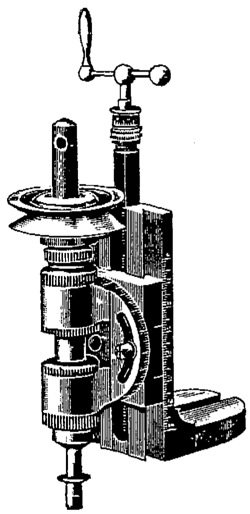


Fig. 31 - 113

Figure 31-114 illustrates the wheel cutting attachment bolted to a slide rest, adjustable to any conceivable position.

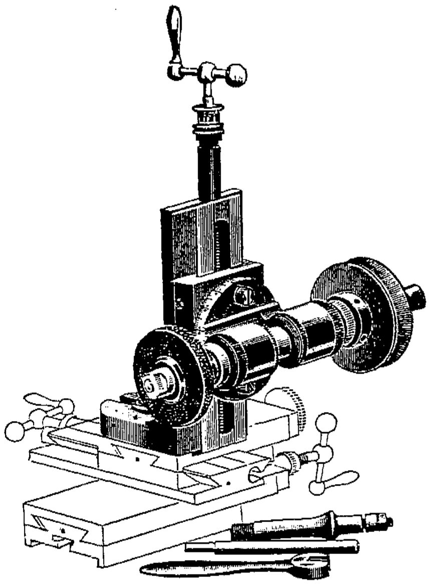


Fig. 31 - 114

Figure 31-115 illustrates an index for wheel cutter with index holes up to 360.

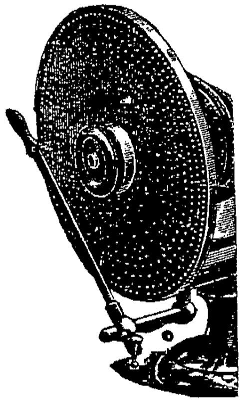


Fig. 31 - 115

CHECK YOURSELF

Progress Check 31A

A Self Test Review of Lesson 31

Study Sections 520 through 529. Then see if you can answer these questions without looking back. DO NOT SEND THIS TEST TO THE SCHOOL FOR GRADING. You'll find answers later in the lesson. If you miss a question, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces.	Section Ref.
1. The drill rod used for making pivots and staffs should be tempered to a ______________.	520
2. In making a square shoulder pivot, an allowance of ______ mm is made for grinding and ______ mm for polishing.	520
3. For grinding, we use an iron grinding slip and ______________ while for polishing we use a boxwood slip and ______________.	521
4. When grinding and polishing a pivot, the lathe is run ______________.	521
5. Polishing is always done at ______________ speed.	521
6. In making a cone pivot, the first step after grinding and burnishing the end of the wire is to cut a ______________.	522
7. Some common errors in making cone pivots is to make them too ______________, too ______________, or with a too short ______________.	522
8. Bent pivots can sometimes be straightened with a properly prepared ______________ with the staff held in a chuck of proper size.	523
9. The purpose of polishing pivots is to ______________.	524
10. The only difference in making an oversize balance staff, a staff with a sample, and a staff without a sample is in the method of obtaining the ______________.	525
11. The overall length of a balance staff made without a sample is found by measuring from the outside of the ______________ to the outside of the ______________ and subtracting the thickness of ______________.	527
12. Timing washers of gold or platinum are sometimes used where ______________ weight is desired to ______________ a watch.	528
13. Very hard balance staffs are cut with a ______________ ______________.	529

CHECK YOURSELF

Progress Check 31B — A Self Test Review of Lesson 31

Study Sections 530 through 540. Then see if you can answer these questions without looking back. DO NOT SEND THIS TEST TO THE SCHOOL FOR GRADING. You'll find answers later in the lesson. If you miss a question, review the section on which the statement is based.

DIRECTIONS: Complete the following statements by writing the correct word or words in the blank spaces. — Section Ref.

1. In making a pinion from pinion wire, it is necessary to check the number of ____________________ and measure the diameter with a ______________________ guage. — 530

2. In making a stem, the size of the winding square is determined by use of the constant: __________________. — 532

3. Fitting a new pivot to a pinion or balance staff is called ________________________. — 534

4. Truing up a train wheel in the round can be done with a ____________ __________________ tool, but this can also be done by other means. — 535

5. When a barrel hook is broken or worn, it is most practical to replace the ________________________. — 536

6. a. To find the number of teeth in a missing center wheel, divide the teeth of the __________________ wheel by the leaves in the ___________________ pinion. If the result is 8 without a remainder, multiply the leaves of the _________________ pinion by __________ to get the answer.

   b. If the result of the first step in a above is 7-1/2 without a remainder, multiply the leaves of the ________________ pinion by _______ to get the number of teeth in the missing center wheel. — 537

7. If a center wheel divides by 8 without a remainder, the result is the number of leaves for the _______________ pinion. In that event, the number of leaves on the _______________ pinion should be multiplied by _______ to get the number of teeth in the third wheel. — 537

8. To find the number of teeth in a fourth wheel in an 18,000 train watch, multiply the ___________________________ by ________. — 537

9. A missing escape pinion is calculated by dividing the teeth of the _________________ wheel by 8 or 9 without a remainder. — 537

10. Only the first and last wheels are considered in calculating a _______________________ train. — 538

11. All members of a train must be considered when calculating a _______________________ train. — 538

12. Cylinder plugs are fitted _______________________ and are driven out by use of a ____________________________. — 540

ANSWERS TO PROGRESS CHECK 31A:

1. dark blue
2. 3/100
   1/100
3. oilstone powder
   diamantine
4. in reverse
5. high
6. square shoulder
7. long
   short
   cone
8. tweezers
9. reduce friction
10. dimensions
11. upper cap jewel
    lower cap jewel
    both cap jewels
12. more
    slow up
13. carboloy graver

ANSWERS TO PROGRESS CHECK 31B:

1. leaves
   Stubs
2. 1.39 mm
3. repivoting
4. rounding up
5. barrel
6. a. third
      fourth
      third
      7-1/2

   b. third
      8
7. third
   fourth
   7-1/2
8. escape pinion
   10
9. fourth
10. simple
11. compound
12. friction tight
    knee punch

HOW TO ALTER A BALANCE STAFF

Tools, Equipment and Supplies:

Lathe
Cement Chuck
Lathe Cement

Alcohol Lamp
Grinding Slip
Oilstone Powder

Boxwood Slip
Diamantine
Burnisher

PROCEDURE:

A. TO REDUCE THE DIAMETER OF A CONE PIVOT:

1. Chuck or cement work in lathe.
2. Make certain it runs true.
3. With a pivot burnisher, burnish end of pivot. Do this lightly, as two or three wipes is generally all that is necessary.
4. Grind pivot and cone with iron grinding slip and oilstone powder to desired diameter.
5. Polish with boxwood slip and diamantine to finished diameter.

B. TO REDUCE THE LENGTH OF A CONE PIVOT:

1. Chuck or cement work in lathe.
2. Make certain it runs true.
3. Grind end of pivot with hard Arkansas oilstone slip. Allow at least .02 mm for burnishing.
4. Burnish end of pivot lightly.
5. Reshape cone.
6. Polish pivot with boxwood slip and diamantine.

C. TO REDUCE DIAMETER OF COLLET SEAT:

1. Chuck or cement work in lathe.
2. Make sure it runs true.
3. Reduce diameter with graver if more than .05 mm.
4. Finish with iron grinding slip and oilstone powder.

(Continued)

D. TO REDUCE DIAMETER OF ROLLER SEAT:

1. Chuck or cement work in lathe.

2. Make certain it runs true.

3. Grind with grinding slip and oilstone powder on a slight taper to dimensions.

4. It is not necessary to polish.

Detach page or cut along this line — and send to the School for grading

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 31

Name: No.: Date:

Circle ONE correct answer:

SUBJECT: Lathe Work

1. The steel used in the pivot and balance staff work of this lesson is hardened and drawn to what color?

Purple	Deep blue	Dark straw	Pale straw

2. In pivot making, what is the first work done after hardening and tempering steel?

Grind and burnish end of steel	Mark off length of pivot	Turn pivot to finished diameter	Turn pivot to approximately 4/100 larger than finished diameter

3. The oilstone powder used when grinding pivots is placed on the:

Boxwood slip	Grinding slip	Emery buff	Burnisher

4. Assuming that a bent pivot was not worn or rough, which of the following should be done after straightening pivot?

Grind end	Leave as is	Reduce diameter	Burnish

5. After grinding and burnishing the end of steel from which a balance staff is to be made, the next step will be to cut the:

Roller post	Pivot	Collet seat	Balance seat

6. How is a balance staff finished to correct length?

Make shoulders, pivots, oil cut, and hubs to measurement, so total of all will be correct length	Break off after finishing upper end and tapering lower end; catch in chuck, grind to correct length and burnish	Finish with both pivots too long; then grind pivots until staff is correct length	Make one pivot too long; then shorten it until staff is correct length

7. When making a balance staff to fit a movement, the roller post should be ground and polished until the roller table can be pushed how close to the base of the hub?

1 millimeter	1/2 millimeter	1/2 thickness of roller	Thickness of roller

(Please turn over)

8. When making a balance staff without a sample, how is size of collet shoulder determined?

Make shoulder same size as hole in collet	Make shoulder about 1-1/4 times the size of hole in collet	Measure hole in collet with taper pin and determine size by figuring	Try collet on shoulder while in lathe

9. Carboloy gravers are best used:

Only where impractical to use ordinary graver	For all work in watchmaking	For all steel work; not on brass	For all tempered steel

10. When should the stock for making a stem be hardened and blued?

After all work except filing is finished	After entire stem is finished	Before cutting threads	After cutting threads

11. When making a stem without a sample, how do you determine the diameter to turn stock for winding square?

Measure hole in clutch diagonally	Measure width of hole in clutch and figure diameter	Leave oversize and file to fit square hole in clutch	Find a stem with square to fit clutch and determine size

12. Trains being divided into two classes, simple and compound, which of the following is true?

Simple gearing is the term used where all the wheels have same number of teeth	Simple gearing is the term used where the pinion drives the wheel	Compound gearing is a series of wheels and pinions, two or more on same staff	Compound gearing is where two or more wheels mesh directly into each other, each on its own bearing

Master Watchmaking

MODERN SHOP METHODS

LESSON

32

PRACTICAL JOB METHODS

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by THOMAS B. SWEAZEY

KEY POINTS OF LESSON ASSIGNMENTS 113, 114, and 115:

- How to estimate and make repairs efficiently.
- How to time, rate and regulate watches.
- Organizing your work area.
- Principles and use of ultrasonic cleaning machines.
- Principles and use of infrasonic cleaning machines.
- Using Miracle plastic lubricant.

ASSIGNMENT NO. 113: Study Sections 562 through 563, Chart A in this lesson, and the Estimating portion of the Modern Shop Check List.

Study Questions:

1. What is a watchmaker?
2. What is estimating?
3. What is the purpose of the numbers and letters given to the repairs listed on Chart A?
4. What should you look for when estimating?
5. How does the watchmaker set his prices?

Recommended Practice:

Seize every opportunity to estimate repairs on the movements you come across. The more estimates you make, the more quickly you'll be able to do them. Wherever possible, verify your initial estimate by making the actual repairs, as in the next two assignments.

ASSIGNMENT NO. 114: Study Sections 564 through 566, the Repairing and Reassembly portions of the Modern Shop Check List, and the previously issued booklet: Aids in Estimating and Repairing.

1. What are the advantages of a standard sequence for making repairs?
2. When is the recommended time for making repairs?
3. What are the steps in disassembly?
4. What methods of cleaning are recommended?
5. What do you look for as you assemble the watch?

Recommended Practice:

Use a 6s or larger American movement and a Check Sheet from the Modern Shop Check List.

1. Enter job number at top of Check Sheet.

2. Print your name in space provided.

3. Enter date job is started.

4. Let down power and remove movement from case.

5. Enter a description of movement and case in space marked "Register". Enter movement numbers and case numbers. If no numbers are on movement or case, write "None" in the space. Do not leave these spaces blank.

6. Estimate the repairs to be made (Section 562). On the back of a watch tag, write down the numbers designating these repairs. (You'll find these numbers on Chart A.) For example, if you find a broken mainspring and the watch is a 15 jewel watch, you would write 23A. If it needs a new winding pinion, you would write 25. If the watch is magnetized, you would write 19, and so on.

7. Make all necessary repairs (Steps 1 through 42, Section 564). Clean watch (Step 43, Sections 564 and 565).

8. Assemble and oil watch according to instructions through Step 5, Sec. 566. STOP. Initial your Check Sheet at (A) when you are satisfied with the recoil.

9. Replace pallet bridge and balance (without hairspring or pallet fork and arbor) and test. (Steps 6, 7, 8, and 9, Section 566) STOP. Initial your Check Sheet at (B).

10. Replace pallet and test. (Step 10, Section 566)

11. Replace balance without hairspring for escapement test. (Step 11, Section 566) STOP. Initial your Check Sheet at (C).

12. Replace hairspring (Lesson 20), put watch in beat (Lesson 26), and wind watch. Check motion (Lesson 11). Enter number of turns (Lesson 11) in three positions and enter on Check Sheet under (D) Dial Up, (E) Dial Down, and (F) Balance falling toward fork.

ASSIGNMENT NO. 115: Study Sections 567 through 570.

1. What is regulation? Timing? Rating?
2. What are the limits of accuracy for a railroad watch?
3. How do you time a watch?

Recommended Practice:

NOTE: Watches repaired for this lesson should be rated and timed without use of timing machines.

1. Replace dial and hands on your practice watch (Sections 280 and 281) and recase.

2. Wind watch fully. Set second hand of watch to correspond with second hand of master clock, watch or electric clock which is known to keep accurate time. Remove back and stop balance with a camel's hair brush or pegwood, letting watch start when second hands synchronize. Always synchronize second hand and check time at same position on dial, preferably at 60. Because of innacuracy in manufacture, some dials may vary a second or more at different points. Use an eye loupe, if necessary.

3. When second hands are synchronized, set minute and hour hands to correct minute and hour. Be sure the minute hand is directly over or points to the minute mark when the second hand is at 60. (Or, if the second hand is at 30, the minute hand should be exactly between the minute marks.)

4. In watches without a second hand, use an eye loupe and set minute hand to register as second hand of regulator timepiece reaches 60. By using a loupe and checking at same point on watch dial, it is possible to detect a variation of approximately 15 seconds at a time.

5. Rate in Dial Up, Dial Down and Pendant Up positions (Section 569).

6. Calculate loss or gain for a 24-hour period (Section 272, Lesson 11) and record on back of watch tag.

   NOTE: This is known as the apparent 24-hour (daily) rate of the watch. It is based on observation of the rate in each position for only a portion of the 24 hour period with the rate for the full period obtained by calculation.

   For example, if the watch gains five seconds in a two hour period, the calculated rate would be 60 seconds gain for 24 hours:

$$\frac{24 \text{ hours}}{2 \text{ hours}} \times 5 \text{ seconds} = 60 \text{ seconds}$$

   Similarly, an eight second loss in three hours would mean a 64 second loss for 24 hours.

   The watch should maintain this approximate rate of gain or loss for its total 24 hours running time.

   To determine the actual 24-hour (daily) rate of a timepiece, you would have to compare it with your standard time source for a full 24 hours.

7. Transfer the calculated or apparent rates you have recorded on back of the watch tag to your Check Sheet (G, H and J).

8. When satisfied with the rates obtained in Dial Up, Dial Down, and Pendant Up (Pendant Down for wrist watches) positions, bring the watch to time in the Pendant Up position (Pendant Down for wrist watches). (Sections 567, 568 and 569.)

9. Bringing the watch to time (adjusting) is done by moving the meantime screws in or out, or by adding washers to or removing weight from the balance screws. Each one of a pair of meantime screws should be moved an equal amount to avoid throwing the balance out of poise (Lesson 11). Do not move the regulator until the plus or minus rate is within a few seconds a day.

10. When the watch has been brought to time, the regulator should not be noticeably off the center of index.

11. The final check of time should be a 24 hour trial, Pendant Up (Pendant Down for wrist watches) with watch fully wound. When the watch shows a close rate of time (Section 567), enter rates in spaces provided on Check Sheet.

12. Enter on Check Sheet the total number of clock hours spent on this job and the date finished.

Recommended Additional Practice:

Repeat the practical work of Assignments 114 and 115 with a Swiss watch, 10-1/2 lignes or larger. Also, practice on any other available watches until you are thoroughly familiar with this sequence of estimating and repairing.

ASSIGNMENT NO. 115A: Study Sections 571 through 574.

Study Questions:

1. Why is it important to set out your tools in a definite arrangement?
2. What is ultrasonic cleaning and how is it done?
3. What is infrasonic cleaning and how is it done?
4. What alternate method of lubricating watches is now available?

Recommended Practice:

1. Study your work layout and put the suggestions in Section 571 into use.
2. If you have access to an ultrasonic or infrasonic cleaner, try it out to see how it compares with hand cleaning and ordinary machine cleaning.

REQUIREMENT:

➧ Answer the Test Questions for Lesson 32 and send in for grading.

SEC. 562 - Practical Job Methods

The term "Watchmaker" has come down through the years to mean one who makes watches. But in the true sense of the word, the watchmaker of today is a repairman, one who has the ability to repair watches no matter who made them. He is judged by his customers on his ability to make their watches keep accurate time, the kind of time his customers can depend on.

A watchmaker can be considered a master only when he is able to make all of his watches keep time.

From now on, in your career in watch repairing, you know that you must not neglect any repairs necessary to put the train, the balance and hairspring, and the escapement in first class condition but you must also see that the watch keeps time.

In this lesson, we want to show you how to make your repairs in a systematic manner. System makes for better work and increased profits. The methods outlined here have been used profitably by many watchmakers. If you will follow them, you will shortly develop an efficient system of handling repairs that will become second nature.

SEC. 563 - Estimating

The first important step when you have taken in a watch for repair is to estimate what needs to be done. Try to have the customer leave the repair job in order that you can make an accurate estimate. When you estimate, you figure the material and the time it takes to make the necessary repairs. You base your charges upon your estimate. Check the following items carefully and note the repairs required and material needed. Add to this the time the job takes and you will have an idea of how much to charge.

1. Check case and band. (Lessons #1 and #3)

2. Check crystal. (Lesson #3)

3. Check crown, stem, sleeve, bow, and mainspring. (Lessons #2, #5 and #6)

4. Check hands. (Lessons #8 and #11)

5. Condition of dial. (Lesson #8)

6. Check cannon pinion. (Lessons #8 and #11)

7. Check hairspring. (Lessons #18, #19 and #20)

8. Check balance staff. (Lesson #15)

9. Check roller jewel. (Lesson #13)

10. Check balance jewels. (Lesson #13)

11. Check pallets and escapement. (Lesson #26)

12. Check the train. (Lessons #8 and #10)

13. Observe general condition of oil, screws, etc. (Lessons #10)

See the <u>Modern Shop Check List</u> in this lesson for additional guidance.

SEC. 564 - Making Repairs

Unless you have special equipment, (sections 572 and 573), you should make your repairs first and then clean, assemble, oil, and bring the watch to time. You save time by doing everything while the watch is apart.

The order of steps which follows has proven very practical when making repairs. In looking over the watch for mechanical troubles, follow these steps in the order given. Make your repairs as soon as you find the trouble. For example, if the watch is magnetized (step #5), demagnetize it right away. When you check the roller jewel (step #21) and find it loose, reset it properly at this time. As you use this sequence time after time, you'll find it develops speed in repairing and saves you doubling back to fix something you should have taken care of earlier.

1. Test winding and setting. (Lessons #2 and #9)

2. Remove watch from case. (Lesson #1)

3. Make all necessary repairs such as crowns, stems, sleeves, bows, and crystals. (Lessons #2 and #3)

4. Polish and clean case. Assemble and put to one side. (Lessons #1 and #10)

5. Check for magnetism. (Lessons #11)

6. Check loose cannon pinion with pegwood pushed against minute hand. (Lessons #8 and #11)

7. Remove hands and dial, and tighten dial screws. Replace screws if necessary. (Lessons #2 and #8)

8. Check dial and dial feet. (Lessons #8 and #29)

9. Fit new hands if necessary. (Lesson #11)

10. Check teeth in hour wheel. (Lessons #8, #10 and #11)

11. Remove cannon pinion - tighten if necessary. (Lessons #8 and #11)

12. Check hairspring for center. Place regulator in center of index. (Lesson #20)

13. Check hairspring for level. (Lesson #20)

14. Release stud screw. (Lesson #8)

15. Remove balance cock and separate balance from cock. (Lesson #8) Tighten stud screw.

16. Check regulator pins, adjust or replace. (Lessons #11 and #20)

17. Place balance in truing caliper and check hairspring in round and flat. (Lesson #18)

18. Remove hairspring. (Lesson #15)

19. Replace hairspring in balance cock and recheck for center and level. Check outside terminal coil to see if it is circled correctly. (Lessons #8 and #20)

20. Remove hairspring from bridge and tighten stud screw.

21. Check roller jewel. (Lesson #13)

22. Check for broken balance or cap jewels. Replace if necessary. (Lessons #13, #14 and #30)

23. Burnish and polish balance pivots. (Lesson #31) Fit new balance staff if necessary. (Lesson #15) When polishing the upper balance pivot, it is permissible to catch the balance up on impulse roller. Use a chuck of proper size and make certain the staff runs true before endeavoring to polish the pivot. If roller will not hold, remove

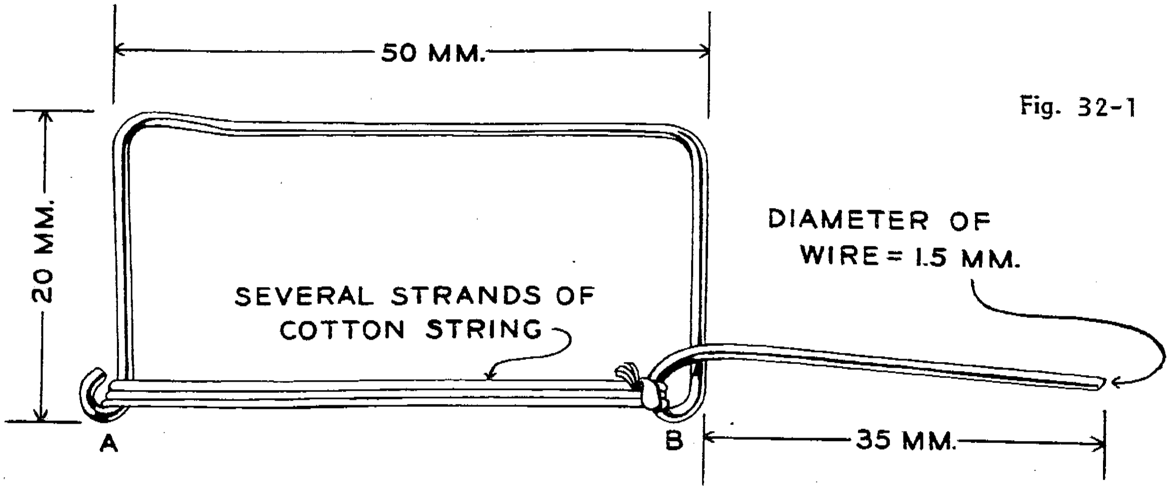


Fig. 32-1

roller (Lesson #15) and catch up on roller post. To polish lower pivot, catch up on collet post. In either case, if the pivots do not run true, it is best to use a pivot polisher as shown in figure 31-24, Lesson #31. Burnish end of every balance pivot lightly with smooth pivot burnisher, grind with grinding slip if necessary, and polish with boxwood slip and diamontine.

24. Replace balance, check endshake and sideshake. (Lesson #13)

25. Check guard action. (Lesson #26)

26. Remove cap jewels, replace balance jewels, and jewel screws. (Lesson #10)

27. Polish balance wheel rim if necessary. To polish between the screws of a balance wheel, make a small bow of brass wire. Approximate dimensions are given in figure 32-1. Wind two or three loops of cotton store string from A to B, keeping it taut. Wet the string with alcohol and rub across a stick of rouge. Balance screws and rim of wheel are then polished as in figure 32-2. Brush balance with cleaning solution to remove all rouge.

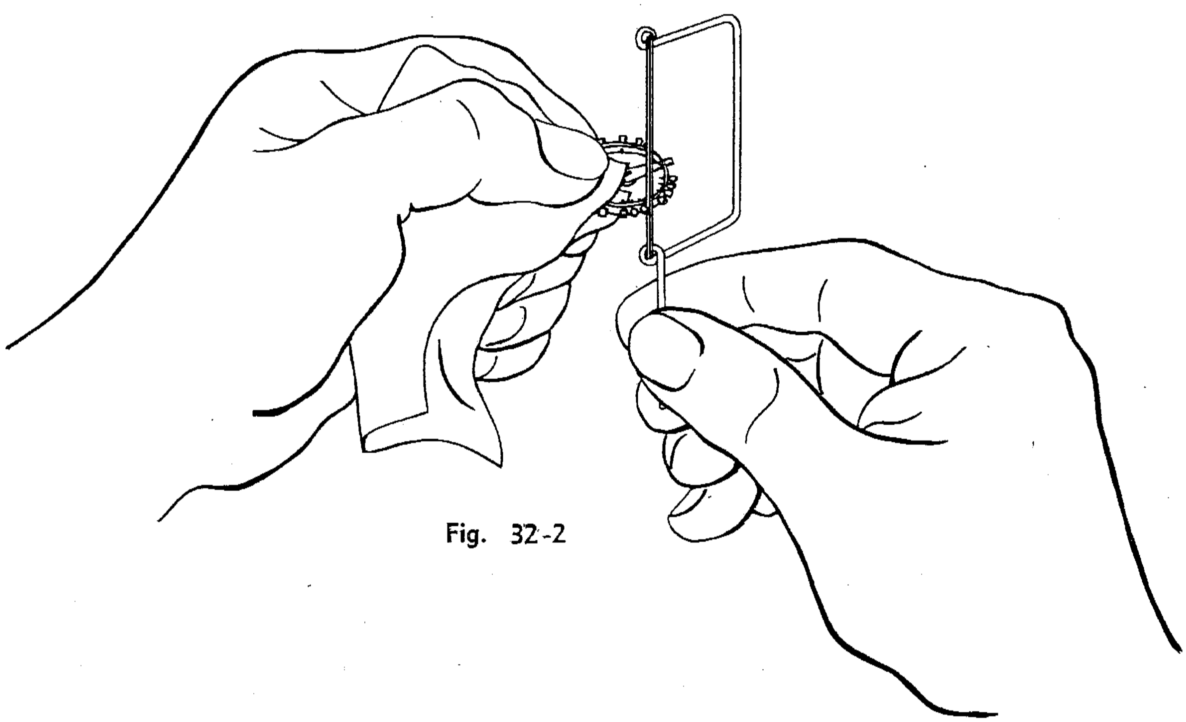


Fig. 32-2

28. True and poise balance wheel. (Lessons #16 and #17)

29. Check lock, drop and slide; also, sideshake of pallet arbor. (Lesson #26)

30. Let down power. (Lesson #5)

31. Remove fork and examine pallet stones and guard dart. (Lesson #26) Polish pallet arbor pivots if necessary. (Lesson #31) Make necessary escapement adjustments. (Lesson #26)

32. Check train wheels to see if they run true. Check lower 4th pivot for trueness.

33. Disassemble movement. (Lesson #8)

34. Dip each wheel and pinion in benzine or trichloroethylene and push leaves and pivots into pithwood.

35. Remove rust from pinion leaves. (Lesson #10)

36. Polish or burnish pivots if necessary. (Lesson #31) When polishing train pivots, place arbor or pinion leaves in chuck, making certain that the pivot runs true. If impossible to catch on arbor or pinion leaves, place wheel in a wheel chuck or cement to a flat face cement chuck, which has been hollowed out, making certain that the pivot runs true. Never place a pivot in a chuck as it will mar or distort the shape of the pivot. Lightly brush the ends of the pivot with a smooth pivot burnisher. Grind pivot with grinding slip, if necessary, and polish with boxwood slip and diamontine.

37. Check and peg out all pivot holes. Close holes if necessary. (Lesson #17) Replace broken jewels. (Lessons #12, #14 and #30)

38. Check endshake in barrel arbor. (Lesson #5)

39. Clean teeth in mainspring barrel using a stiff brush. (Lesson #10)

40. Remove mainspring, replace if necessary, check hook in barrel, and on barrel arbor. Polish bearing surfaces on arbor, barrel and cap if necessary. (Lessons #5 and #6)

41. Check and repair winding and setting parts. (Lesson #9)

42. Fit all new material. All repairs should have been completed by now.

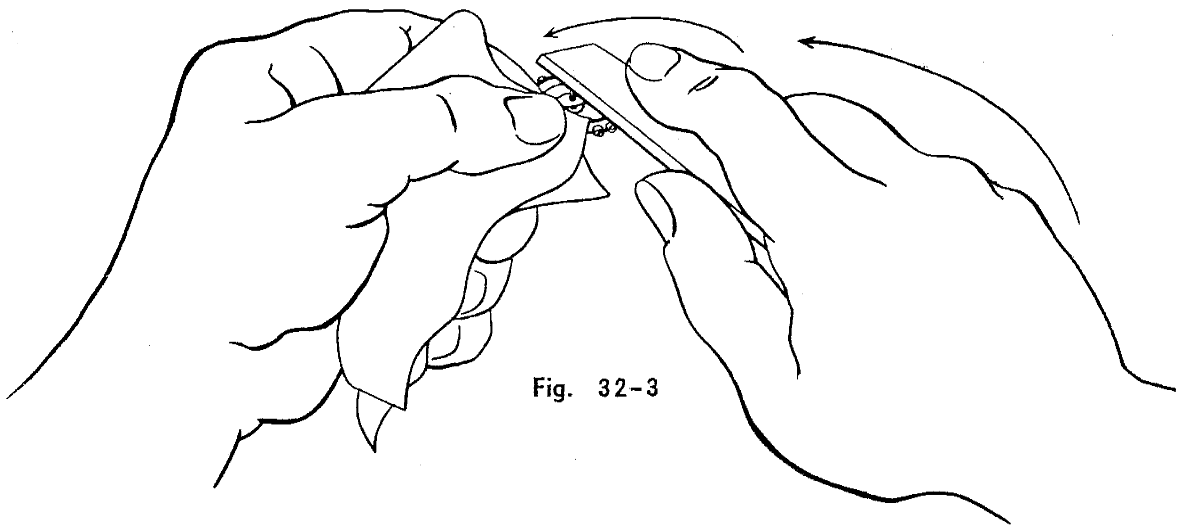


Fig. 32-3

43. Clean and dry all parts of watch. (Lesson #10) Repolish top of balance rim using small chamois buff and rouge. After the balance has been thoroughly cleaned and dried, polish the upper side of rim with a circular motion as in figure 32-3. The buff can be either chamois or leather and the wheel should be held between the fingers with watch paper. Do not use any pressure. Remove traces of rouge with soft dry brush.

SEC. 565 - Review of Cleaning Methods

Hand cleaning is entirely adequate for students and hobbyists who are not usually concerned with how fast a job must be completed. Those who begin to work professionally, where competition and time are important factors in delivery and profit, usually shift to machine cleaning at first opportunity.

The ordinary shop method of machine cleaning uses three jars and commercial solutions. Jar #1 contains the cleaning solution while jars #2 and #3 have the rinsing solution. These solutions are free of acids which might attack the plates if left too long in any of the solutions. Hence, it is unnecessary to brush all parts with naptha or benzine before putting them in the cleaning machine. But you should run them somewhat longer in each solution to make up for this.

Assemble the parts in a cleaning basket, figure 32-4. Put bridges, plates and barrel into the largest compartment C. Place in compartment B all screws, levers, train wheels, and the like, which you know will not slip through the basket. Place the pallet fork and balance in compartment A. Clean the hairspring separately, as given below.

NOTE: If you are cleaning a water resistant watch, DO NOT place stem and crown in cleaning basket. Most cleaning solutions will soften or dissolve the waterproof crown gasket. If necessary, clean stem with pithwood.

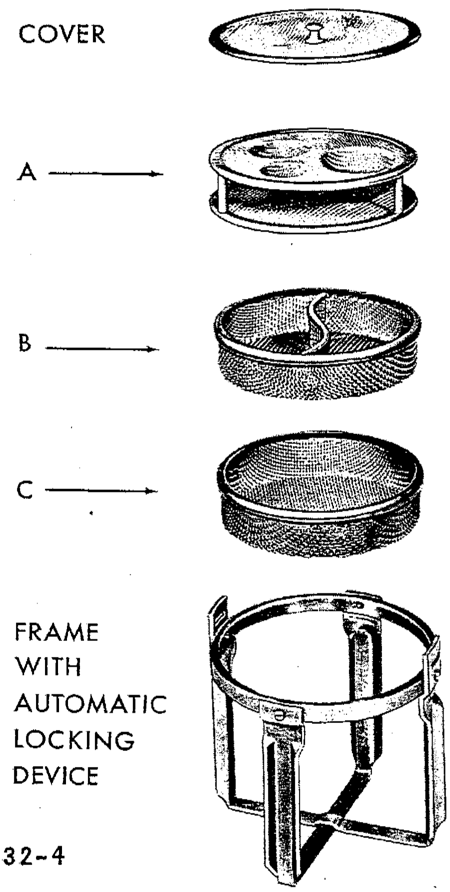


Fig. 32-4

Cover the basket and place in cleaning machine. Run slowly in solution #1 (cleaning) for two to three minutes. Spin off surplus solution in upper half of jar #1. Rinse in solution 2 for another two or three minutes. Spin off surplus and rinse again in jar #3 for two more minutes. Dry for three to five minutes over heater in cleaning machine depending upon how efficient the dryer is.

Clean the hairspring separately. A small jar with an airtight screw top containing naptha or benzine should be kept handy for cleaning the hairspring or you can use a commercial solution, such as One Dip. Dry with a soft watch brush or blower. It is a good idea to warm the hairspring slightly to make certain that all the cleaning solution has been evaporated.

Newer machine cleaning methods are ultrasonic and infrasonic cleaning. See Sections 572 and 573.

SEC. 566 - Assembling

1. Replace mainspring, oil barrel arbor and mainspring. (Lessons #5 and #6)

2. Replace winding and setting parts, and oil. (Lessons #9 and #10)

3. Replace and oil all balance hole and cap jewel combinations. (Lesson #10)

4. Replace train wheels and oil pivots. (Lessons #8 and #10)

5. Check the train carefully by winding the mainspring, and in most cases the train wheels will run down and the escape wheel will come to a stop and then reverse its direction. This is called train recoil and generally speaking, the train is in top notch condition if this recoil takes place. (Lesson #8)

6. Place balance in watch with pallet bridge in place and place movement dial down.

7. With a small brush or pointed piece of pegwood, test balance by flicking it with brush. Not fast. Carefully observe the reaction. The balance should revolve freely and slow down gradually!

8. Repeat this operation Dial Up position. When you are certain that the action is free in both positions, the balance is in good order.

9. Turn balance pendant up and test. In most cases, the balance will slow down more rapidly in this position than in the D U (Dial Up) or D D (Dial Down).

10. Replace pallet fork (remember to oil escape wheel teeth) and wind the stem 5 or 6 turns. Test lock, drop, draw, slide and endshake. (Lesson #26)

11. Replace balance without hairspring and check roller and safety action. (Lesson #26) Many of the high grade pocket watches will run on half time. When the balance (without a hairspring) continues to oscillate from impulses imparted to the roller jewel by the fork, it is referred to as running on "half time". A watch capable of running on "half time" in the Dial Down position should also run on "half time" in the Dial Up position or vice versa.

If all of the above conditions have been met, the watch can be adjudged to be in good condition.

12. Replace hairspring (Lesson #20) and put watch in beat (Lesson #26)

13. Check motion. (Lesson #11, Sec. 269)

14. Replace cannon pinion, hour wheel, dial and hands.

15. Check motion.

SEC. 567 - Timing and Regulation

Rating is the observation and comparison of the daily rate of a watch when it is being adjusted.

Timing is the operation required to bring a watch to time after it has been repaired and rated.

Regulation refers to the regulator adjustment of a watch to its owner's personal routine and habits.

This lesson could be extended into volumes if we were to consider all the theories advanced and operations required in temperature and position adjusting. In this lesson, we will consider three positions first as these three positions are most important in the majority of watches in use today. Facts, theories, and problems regarding temperature and position adjusting are contained in many good books and the student should endeavor to do a certain amount of study and practice from recommended books.

SEC. 568 - Limits of Accuracy

First, we, as watch repairmen, have to consider that the factory which made the watch has made the necessary adjustments regarding temperature and position errors and we, therefore, are only expected to repair the watch as well as it was when it left the factory. Consequently, we are primarily interested in:

1. Putting the watch in first class shape.

2. Making the watch keep accurate time within certain limits. 30 seconds a week is the maximum error for a quality grade pocket watch. With careful regulation you should get greater accuracy.

The average wrist watch should keep time within 90 seconds per week more or less. Again, closer accuracy is possible. Fast beat (36,000) watches and Accutron can be brought to within one minute a month.

The principal factors to consider before trying to adjust and time a watch are:

a. The train must be free, cleaned, and oiled properly.

b. The escapement must be free and have snap.

c. The balance must be in first class condition.

d. Hairspring - true and centered. Regulator pins adjusted properly.

e. Pivots polished.

f. Endshakes and sideshakes at a minimum.

g. Wheel true and poised.

If these conditions have been met, we should have good motion.

3. Dial Up and Dial Down the motion should be the same, 1-1/2 turns. (Lesson #11)

4. Pendant Up the motion should be about 1-1/4 plus turns. (Lesson #11)

In watches with a Breguet hairspring, the regulator pins should be parallel and be adjusted with a minimum amount of play. (Lesson #20) This is also true with flat hairsprings but the amount of clearance is greater in most cases than the Breguet Spring, (Lesson #20).

SEC. 569 - Rating and Timing Records

When all of the above conditions have been met, we will make three preliminary tests and keep a record of each test. Set the second hand of the watch you are timing with a regulator having a known rate. Of course, the best possible regulator is a short wave radio set which sends time signals on different wave lengths 24 hours per day. Other methods include regular radio tone beats, chronometers, clocks, etc.

Set the second hand on your watch to correspond exactly with the second hand on your regulator and place your watch in a Dial Up position. All rates are based on a 24 hour period. Wind the watch fully. It isn't necessary for us to let the watch run the full 24 hours before making further checks as that slows down the process of adjusting. For example: Let us say we let our watch run for 3 hours in the Dial Up position. At the end of this 3 hour period, calculate the loss or gain over a 24 hour period and make a note of it. Place watch in Dial Down position and calculate the loss or gain over a 24 hour period, and make a note of it. Now run watch in Pendant Up position and calculate the loss or gain over a 24 hour period and make a note of it. The Dial Up and Dial Down position should be the same. The Pendant Up may vary some but should be within a reasonable amount of loss or gain. When these calculations have been made and found to be correct, it is only a matter of adding weight to or subtracting weight from the balance wheel in order to bring the watch to time.

If we are timing a pocket watch, we will make the adjustment necessary to bring the watch to time in the Pendant UP position as this is the position in which the customer will carry his watch in the greater portion of time he will wear it. A wrist watch is brought to time in the Pendant Down position for the same reason.

It is better to have pocket watches gain from 5 to 10 seconds per day average and then have the customer return for regulating to his personal habits.

A wrist watch should have about 10 to 15 seconds per average day gain for the same reason.

For final check, compare rate a full 24 hours in each position. Regulating a watch when the rate is known can be accomplished by the meantime screws. (Lesson #11). Turning them in will cause the watch to gain: turning them out will cause the watch to lose. Adding timing washers will cause the watch to lose and removing washers or weight from balance wheel will cause it to gain.

SEC. 570 - Timing Machines

Many shops now use an electronic watch rate recorder to speed up timing, rating and regulation. These machines do a faster -- not better -- job than bench timing because they give an immediate result--30 to 60 seconds. They are simple to operate but the record they make takes a little study and this will be the subject of the next lessons.

Some students believe that timing machines will make their repair analysis for them and be a "cure-all" for watch troubles. Actually, the machine is nothing more than a check on their craftmanship and not a substitute for it.

Before the watch is placed in the machine, it must be in good running order. This means that all repairs have been made. By following the modern shop outline, the good craftsman locates and corrects the trouble as he checks each part. The machine does not make repairs nor is it a short cut to making repairs. It tests the job that has been done and shows up work that may have been slighted. If you have properly repaired the watch according to the Modern Shop outline, it is unlikely that the machine will ever indicate errors such as dirty balance jewels, magnetism, loose roller jewels, bent regulator pins, wheels out of poise and so forth. The good watchmaker will have already found and corrected these errors. He does not need a machine for this purpose.

The main advantage of an electronic timing machine is a saving in time for the watchmaker when rating, timing and adjusting. With it he can bring watches to time more quickly than without it. This means better service for his customer. But depending on the machine to show up errors in workmanship encourages slip-shod repair habits. There is then less saving as the repair work must be done over before the watch can be brought to time.

SEC. 571 - Organizing Your Work Area

Another means for increasing your repair output is a good work layout. It costs nothing and can help you repair one or two more watches a day.

Each time you begin work, set out your tools in the same way with those you use most nearest at hand. You'll work faster and get less tired.

In time you'll find you can almost automatically pick up a tool and put it back in place without looking. Every efficiency you can introduce into your work will pay off in faster work and added profit. Here is a suggested work layout from the now discontinued Bulova Digest:

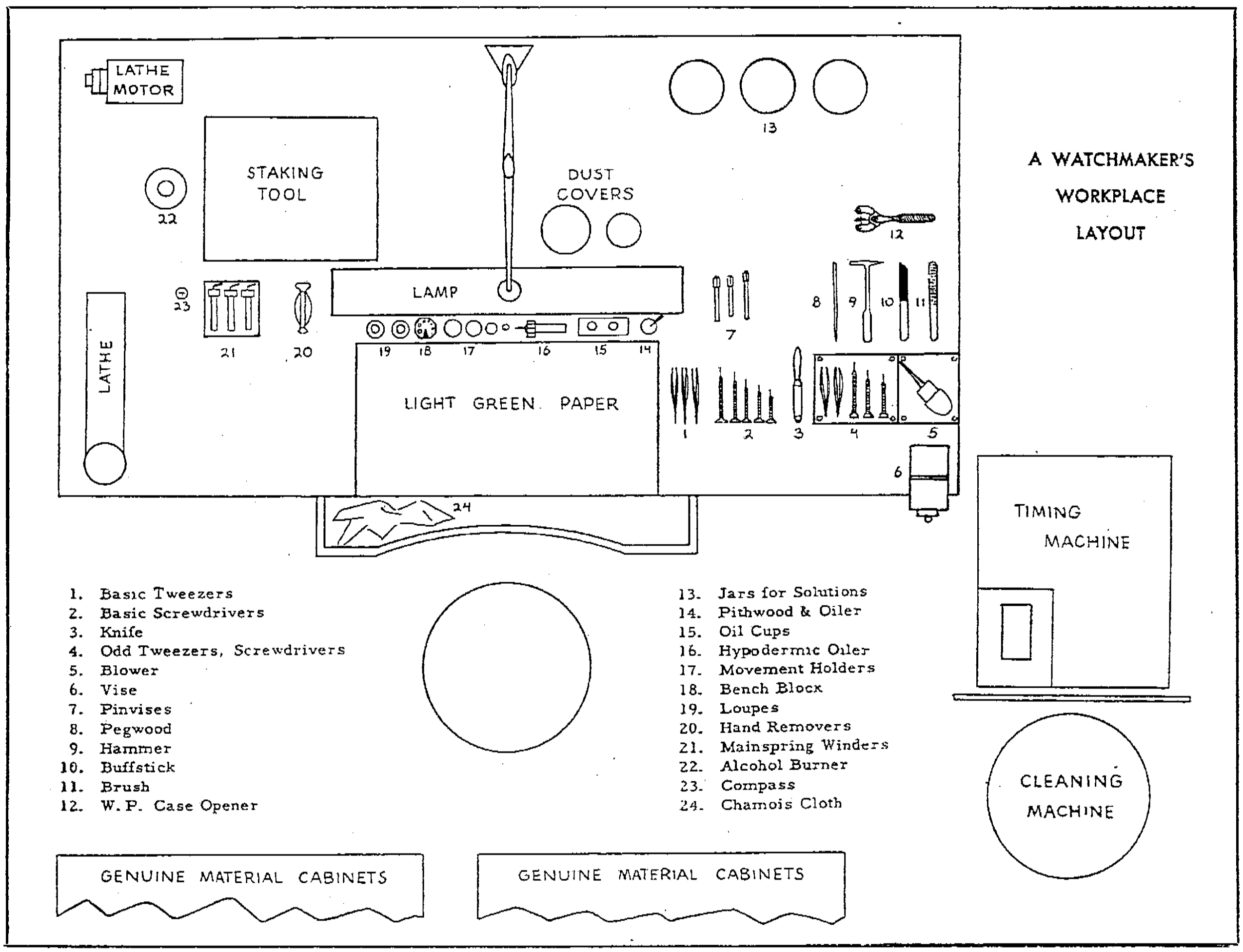


Fig. 32-5

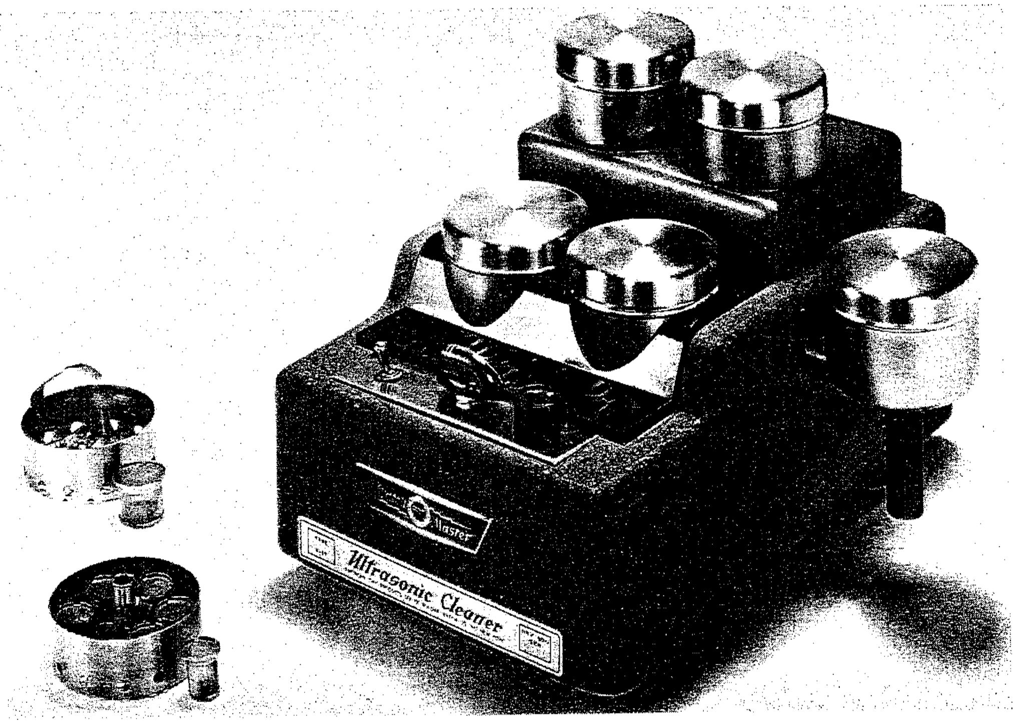


Fig. 32-6

SEC. 572 - Ultrasonic Cleaning

A more recent method of machine cleaning uses sound waves and is known as ultrasonic cleaning. These machines do a fantastic cleaning job and are particularly suitable for newer type watches, such as Accutron and electric. Since more and more shops are equipping their repairmen with this type of cleaner, we'll examine it now in some detail.

Ultrasonic means "beyond sound". Sound is caused by vibrations and when these vibrations or sound waves increase in speed per second, they soon reach a point where the human ear cannot hear them. For most people the top limit is about 19,000 vibrations per second. Animals, however, can hear beyond this range and this is the basis of the silent dog whistles. They are pitched at frequencies higher than the human ear can hear, but dogs and certain other animals can hear them and respond.

Similarly, ultrasonic cleaners use a variety of frequencies from about 20,000 vibrations per second to megacycles (one million vibrations per second).

Ultrasonic cleaners come in a variety of shapes and sizes, but all work on the same principle. They use a generator or transmitter to create the fast sound waves, a transducer, which expands and contracts and thus changes these electrical impulses into mechanical energy of the same frequency, and a cleaning tank to hold the cleaning solution. The vibrations produced by the transducer travel rapidly through the solution and create millions of tiny bubbles or cavities. These bubbles grow and then collapse inward or implode. Gas from the destroyed bubbles escapes and forms new ones. This process is called cavitation.

When a bubble collapses, the solution around it rushes into the vacuum thus created. The resultant pressure and local agitation is so strong that the collapsing bubbles act like millions of tiny scrub brushes against the surfaces of the objects immersed in the solution. These bubbles are so microscopic that they penetrate every corner and crevice and quickly remove all dirt and oil. Detergent in the cleaning solution holds the impurities in suspension while the solvent disintegrates the greasy matter. The job is completed by rinsing and warm air drying. The rinsing agent evaporates completely.

With clean solutions and proper use, the ultrasonic cleaners will remove all oil and foreign matter from even the tiniest recesses of a fully assembled watch, including cap jewels still in place on the bridge. This makes it possible to clean a watch without taking it apart. But since the parts need to be re-oiled, we find it useful to partially disassemble the watch before cleaning so the re-oiling can be done as you reassemble the watch.

Unless your initial inspection shows you need to go further, this is as far as you have to disassemble: Remove hands and dial, hour wheel, minute wheel, cannon pinion, balance wheel and bridge, and the mainspring barrel. We take the spring from the barrel, although not everyone does. Remove cap jewels on train bridge or plates. On most watches, you can leave the train wheels in place as well as the setting parts. (However, if setting parts are rusty, remove them and clean the rust off with a soft steel brush or brass brush. Replace parts which are pitted from rust.) This limited disassembly enables you to oil all pivots and setting parts when reassembling.

CAUTION! Most cleaning solutions will soften or dissolve waterproof crown gaskets. If you are cleaning a water resistant movement, it is best to remove the stem and crown entirely and not place them in the cleaning basket.

If the stem needs cleaning, insert it into a piece of pithwood. Then be sure to re-oil the square of the stem.

On direct sweep second watches you will have to remove the train bridge so the center wheel can be oiled on the upper pivot and the lower sweep second bearing (see Job Sheet J12, Lesson 9).

When you have disassembled to the extent needed, place the pillar plate and larger parts in the largest compartment of the cleaning basket and the balance assembly and any train wheels in the smaller ones. Clean 2 to 5 minutes in the cleaning solution, rinse for 1 to 2 minutes in each rinse, and dry. Drying will take about 5 minutes in most machines.

When you remove the watch from the baskets, examine all the jewels with a loupe to be sure there is no oil left on the jewel surface. If your solutions are clean, you should find the jewels free of all film and the jewel holes very dry. You must be sure to re-oil the pivot holes. There is a special type oil made for ultrasonically cleaned watches, but we find a good bracelet watch oil works well. However, you should oil with a fine capillary oiler so you won't smear the oil on the bridges, as happens with a dip oiler. Use an oil pusher on the balance hole and cap jewels as shown in Fig. 10-18, Lesson 10.

Change your cleaning solutions often, particularly when you find they no longer remove old oil from the jewels. Use a solution specifically designed for ultrasonic cleaners. Those we have used -- L&R, Bulova, Zenith -- all do a good job. Solutions are available in quart or gallon sizes from your material dealer.

SEC. 573 - Infrasonic Cleaning

Infrasonic cleaning is fairly new in the U.S.A., but has been used in Europe for some years. It is a vibratory process like ultrasonic, but uses mechanically caused vibrations. Whereas ultrasonic vibrations are above the level of human hearing, infrasonic vibrations are below -- around 20 cycles per second.

The mechanical vibrations produced by infrasonic cleaners are stronger than ultrasonic vibrations and cause greater agitation of the cleaning liquids. As a result, the manufacturers claim this type of machine will clean assembled movements better than an ultrasonic cleaner. User reports tend to confirm this.

Infrasonic cleaners work best with assembled movements, which are clamped vertically in a special holding device. Three to six movements at once are the usual capacity for individual repairmen. Larger capacity machines are available for production cleaning, as in factories or trade shops.

The movements are completely exposed to the fluid's action, which cleans all parts inside and out by shaking them in all directions. Since sideshakes and endshakes of pivots, jewels, and the like, are very small and the liquid itself acts as a cushion, no damage results and the parts are thoroughly cleaned. The normal machine cleaning process is used with any non-water based cleaning solution and quick drying rinse. Movements are dried in a hot air chamber.

Regular infrasonic cleaning machines are available or an infrasonic device alone can be purchased as an attachment for an ordinary cleaning machine. Illustrated is the German-made Elma, marketed in the U.S.A. by Zenith. It gives you a choice of cleaning assembled movements by vibration or disassembled ones without vibration.

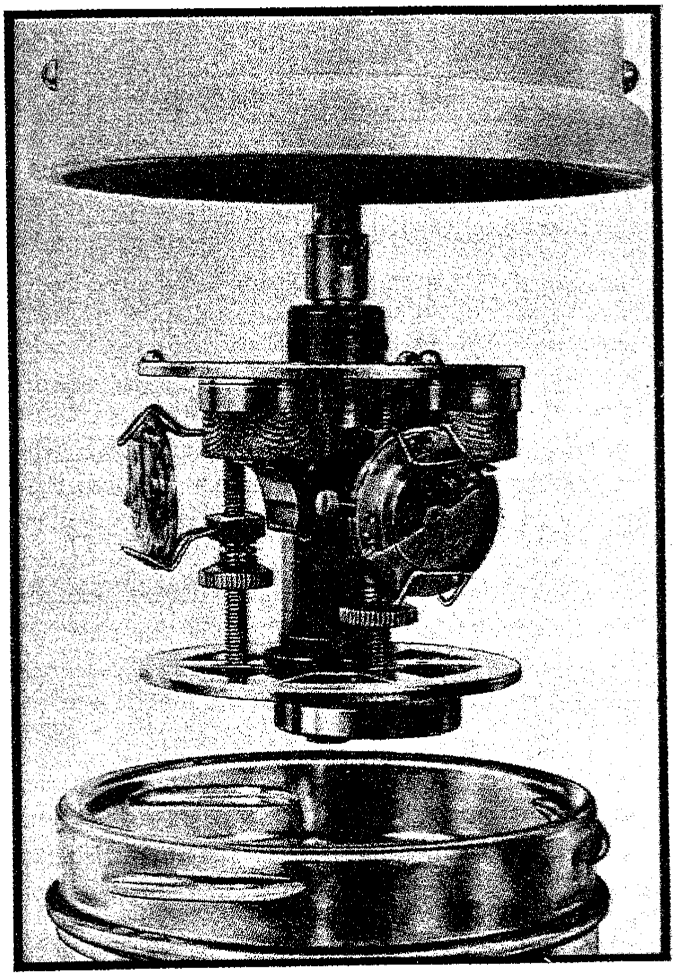


Fig. 32-7

Figure 32-7 shows a unit with capacity for 3 wrist watches plus 3 baskets for any small parts you may have dismantled. Figure 32-8 shows a six watch unit. A different type holding device is used for very small movements.

The unit can be fitted in seconds to the motor shaft of an ordinary cleaning machine by tightening the set screws in the collar (1), Figure 32-7.

This collar is fastened to and balanced by a counterweight (2) to prevent strain on the motor shaft. The counterweight is needed because the collar is offset from the center axis to provide an eccentric motion and agitate the cleaning solution in all directions.

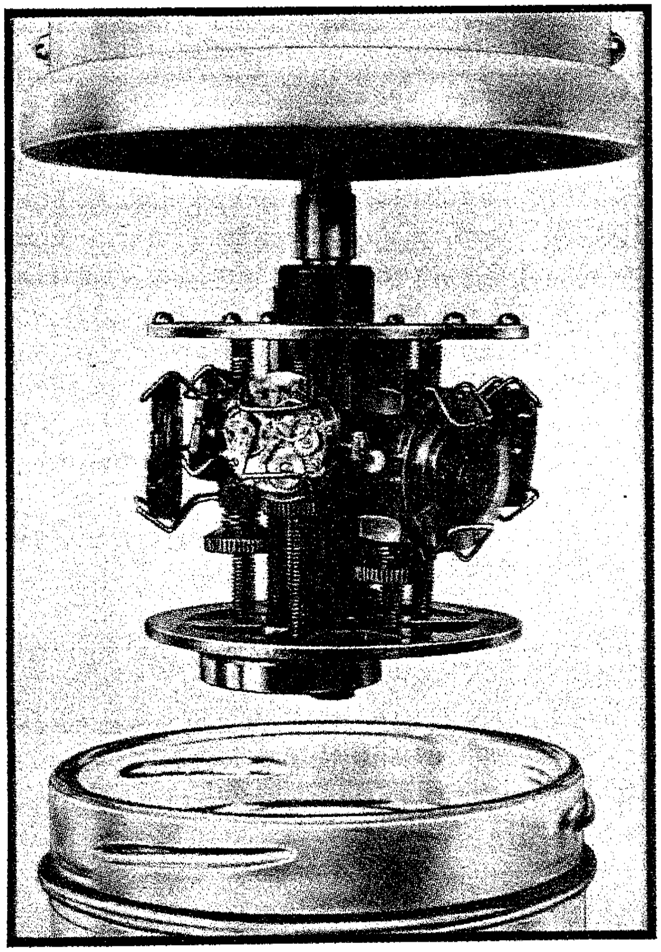


Fig. 32-8

Inside the center post (3) are two ball bearing units which enable the rest of the device or cage (4) to turn freely around the rod or axle which connects collar and counterweight. When the machine motor spins, the collar and counterweight move with it while the cage trails along much more slowly and moves in a sharp elliptical path. When the device is lowered into the solution, the liquid exerts a drag on the cage and further slows its movement. This results in full eccentric vibration combined with a very slow rotation.

As soon as the cage is lifted for spin-off (which should be at top motor speed), the resistance caused by the liquid ends and the cage then follows the speed of the motor.

To prepare an assembled movement for cleaning, first remove the dial and hands. Tighten screws, including dial feet. Let down the power of the mainspring. Put the stem in the setting position.

CAUTION! Remember that we told you that most cleaning solutions will soften or dissolve waterproof crown gaskets. Play safe, therefore, and remove stem and crown from water resistant watches. If necessary, clean the stem by inserting it into pithwood. Be sure to re-oil the square of the stem.

Now fasten the small cleaning baskets in their holders, which are permanently fixed on the upper cage plate. Clamp movements to be cleaned in their holders and replace all movement holders, whether occupied or not. From this point on, follow the normal machine cleaning cycle.

When cleaning is ended, disassemble as you wish for oiling.

Some repairmen combine this device with an ultrasonic cleaner and feel they get an even better result. If the cleaner used has an automatic reverser, this must be disconnected. Otherwise, the slowdown, stop and reverse of the motor will reduce the number and force of the mechanical vibrations as well as the efficiency of the action.

SEC. 573A - The Portescap FRU System

A later type of infrasonic cleaner is a portable one not yet available in the United States of America. It has been in use in Europe and is made by Portescap in Switzerland. This cleaner is one part of a 3-part system known as the Portescap FRU or Fast Repair Unit. The system is intended to give individual watch repairmen the advantages of the fast work methods used by volume repair centers.

In large service centers, watches are sorted as they come in and put into groups according to the kind of work needed. They are then sent to specialized work stations where they are handled as a group rather than one by one.

For some time individual repairmen have tried to adapt some of this procedure in order to speed up their own work. They also group watches for the day according to the work to be done; that is, all staff and stem jobs go together, general overhauls form another group, and so on.

Instead of completely taking down and repairing one movement at a time, they do the same work in turn on all the watches in the group. For instance, they uncase all watches while they still have their case opener in hand. Then off come bands and crystals. Next, they remove the hands from each watch and drop them directly into their cleaning basket. They loosen all dial screws before taking off the dials and setting them aside. As they continue disassembly, whatever can go directly into the cleaning basket goes there as it is taken off. The idea is to do as much as you can with the tool in hand before you lay it down.

This approach does organize and speed up the work. It also takes a fair amount of room for parts trays, movement covers and multiple cleaning baskets. Moreover, conventional cleaning creates something of a bottleneck.

In the preceding section we pointed out that infrasonic cleaners work best for fully assembled movements. The FRU system is based on this fact. You clean first, then disassemble, repair and re-oil as needed.

This outfit has three major parts, all portable, which can be set up in 5 minutes for either store or home use. These parts, called sets, are:

1. A cleaning set
2. A repair set
3. An arm rest set

Each set is contained in its own carrying case, about the size of a small attache case.

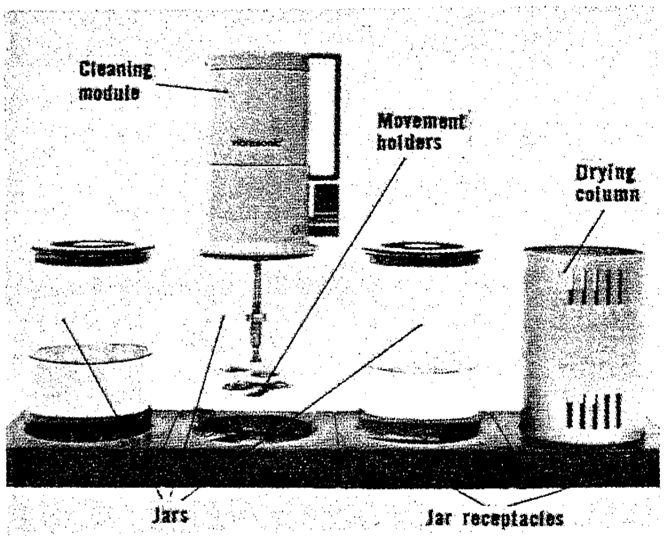


Fig. 32-9

THE CLEANING SET

The cleaning set, figure 32-9, contains the infrasonic cleaner, cleaning jars and drying column and two movement holders for 3 movements each in sizes from 5 to 13 lignes. There is also a container for tiny pieces, a movement holder spacer and a fluid gauge.

The infrasonic cleaner works on the principles already discussed in section 573 except that you must move it by hand from one jar to the next. You follow the regular cleaning, rinse and drying cycle, using any cleaning solutions which will dry without leaving a deposit. No heat is used for drying. Drying is by evaporation caused by rapid rotation (1500 revolutions per minute).

THE REPAIR KIT

The repair kit, figure 32-10, has two slideways which are dovetailed together. A parts storage tray and a movement work tray are set inside the slideways and dust covers placed over all this. The dust covers serve as hand rests while you are working and are slightly tinted to avoid reflections and eyestrain.

The movement tray contains 5 movement holders which take any size movement, round or shaped, up to 32 mm.

The 15 compartments of the storage tray are set on three levels to make it easier to distribute and locate parts. The bottom of these compartments are curved so that small parts, such as screws, will roll to the rear and large parts will rest on only a few points, making them easier to pick up.

The tool holder, set behind the slide, also has three levels. The top level is lined with pithwood into which you can stick tweezers, screwdrivers, and the like.

THE ARM REST SET

The arm rest set, figure 32-11, has two specially designed foam covered pieces. You can clamp these to any work bench or table not thicker than 6 cm. A work table between them assures the proper interval. It serves also as an additional tool holder and to catch any dropped parts.

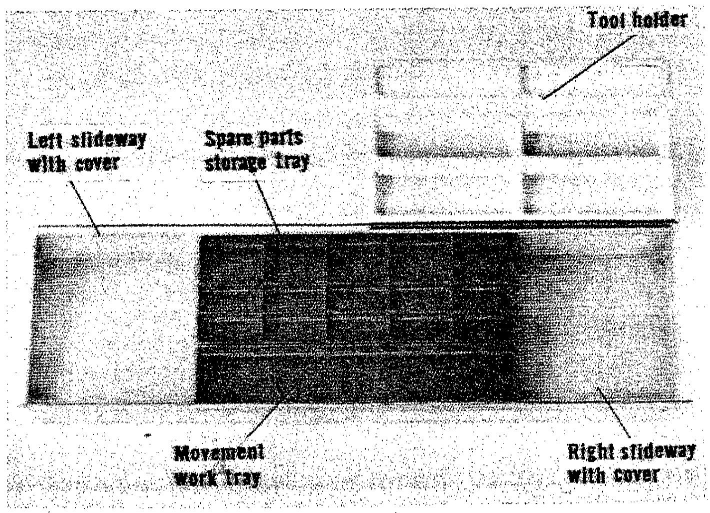


Fig. 32-10

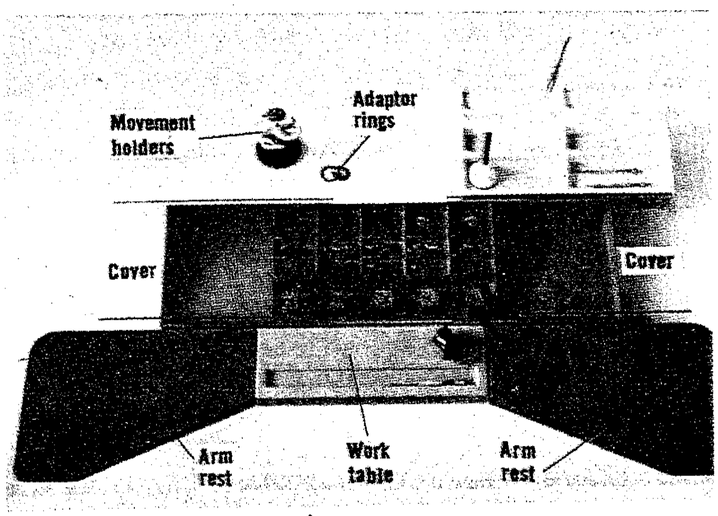


Fig. 32-11

SEC. 574 - Miracle Plastic Lubricant

In 1969 a dry lubricant called "Miracle Plastic Watch Lubricant" was introduced. When added to the cleaning cycle of an ultrasonic or infrasonic cleaner, it enables the repairman to clean and oil a watch movement without disassembly other than dial, hands, balance and bridge, except as necessary for needed repairs.

The lubricant covers all parts of the watch, does not attract dirt or dust and will not dry up in watches in stock or in use. You oil only the balance jewels in the usual way.

This not only saves time with ordinary watch and clock movements, but is particularly advantageous for autowinds and chronographs, which normally require extensive disassembly to permit re-oiling. Even the cleaning of pin lever watches can be profitable.

However, this plastic lubricant should not be used on electric and electronic watches.

One kit of lubricant will service about 500 movements at a cost of about 5¢ each. You can clean, dry and lubricate a watch in about 10 minutes.

The lubricant comes in two bottles. The first is inhibiter, which prepares the surface during the first rinse to accept the lubricant. The second bottle contains the actual lubricant and when mixed becomes the final rinse. Each bottle is added to one gallon of ultrasonic rinse.

These two solutions can also be obtained in premixed solutions, ready to use.

Here is the procedure:

1. Remove dial and hands and examine movement to see how much disassembly is needed.

2. Make all necessary repairs and reassemble the watch before cleaning, except for dial and hands. (You may prefer to remove balance and bridge before cleaning and clean in the conventional manner.)

3. Demagnetize the movement before cleaning.

4. Place the assembled watch in the cleaning basket, securing it carefully to keep the staff from breaking if left in place.

5. Run the movement through a regular cleaning solution and spin off the excess.

6. Rinse in the solution containing the inhibiter and spin off the excess solution.

7. Rinse in the solution with the lubricant and extend this spin off time to get rid of as much rinse with lubricant as you can.

8. Dry thoroughly in hot air (a hot air chamber is best) to cure the lubricant.

9. After cleaning and drying, remove balance and bridge (if not already removed.) Dip the completely assembled balance and bridge into any good hairspring cleaner (One Dip, etc.). This is to remove the lubricant from hairspring, which may stick unless lubricant is removed. Hold balance and bridge firmly together with tweezers while cleaning. Dry in warm air or in sawdust.

10. Oil the upper and lower balance hole jewels with regular, good grade watch oil. DO NOT oil any other part of the watch.

11. Replace balance and bridge in movement. (Note - Some watch repairmen omit steps 9 through 11 on pin lever watches.)

12. Time the watch in your usual way. Normally, little adjustment will be required.

When servicing is needed again, the cleaning process will remove all trace of the dry lubricant.

Some watchmakers prefer to first clean and dry the assembled movement in the regular way, using ultrasonic solutions, before using the plastic solutions. They do a number of watches at a time.

They then remove the balance and bridge and run the movements again through the ultrasonic rinse solutions containing the plastic lubricant and dry in hot air as already indicated.

After this, they follow steps 10 through 12 above.

Their purpose in using this variation is two-fold: 1. It keeps the plastic solutions cleaner much longer, and 2. There is no need to clean the hairspring separately with hairspring cleaner as in step 9 for it is already absolutely clean from the first run through. It also avoids the possibility of any trace of plastic lubricant remaining on the hairspring after it has been dipped in hairspring cleaner.

You should also be aware that not all watchmakers favor the use of this plastic lubricant.

After the original plastic lubricant appeared on the market, other companies quickly brought out their own versions so it is available under a number of trade names and also in a single solution added only to the final rinse.

SUMMING UP

In this lesson you have studied various ways to speed up your work. Some require nothing more than an efficient procedure: orderly work habits and good work layout. Others require additional equipment, which you should obtain only as your volume of work requires it. When you add time-saving devices, be sure you understand their use. A machine is no help unless you operate it properly.

Remember, speed alone is not your aim. It is entirely possible to work fast but carelessly. That's what the botchmaker does. As a Master Watchmaker you must work rapidly but with precision.

If you are not already doing so, you should now begin to read books in the field of watch and clock repair. Almost all of these are written for the practicing repairman. They often skip over details which they take for granted you know. Now that you know these details, you can read with better understanding.

You should also read some of the trade magazines in the watch and jewelry field. The most useful of these are the <u>American Horologist and Jeweler</u> and <u>Jewelers Circular-Keystone.</u> These magazines will help to keep you informed on new developments, new tools, and new ways of working.

CHART A

This chart is for use with the Modern Shop Check List and Check Sheets.

In order to speed up the estimating of repairs necessary to put a watch in first class order the most common repairs are listed below, preceded by a number and followed by letters which designate special work. Estimate job carefully and enter by number or number and letter in space for estimate on check list. Example: Demagnetize-Mainspring (17 jewel)-Clean, Oil and Regulate would be entered 19, 23-B, 4.

1. PIVOTS
   - A. Polish
   - B. Straighten

2. HAIRSPRING
   - A. True in round
   - B. True in flat
   - C. Center
   - D. Level
   - E. Overcoil

3. BALANCE WHEEL
   - A. True
   - B. Poise

4. CLEAN, OIL, REGULATE

5. WATCH GLASS
   - A. Round
   - B. Fancy
   - C. Military Bend

6. NO-BREAK
   - A. Round
   - B. Fancy

7. SPECIAL CRYSTAL
   - A. Color
   - B. Extra Heavy
   - C. Special

8. BALANCE STAFF

9. DIAL
   - A. Refinish
   - B. Replace

10. SPRING BARS

11. CORD

12. STRAP

13. HAND
    - A. Plain
    - B. Luminous
    - C. Seconds
    - D. Sweep Seconds

14. HANDS - Pair
    - A. Plain
    - B. Luminous

15. CROWN
    - A. Regular
    - B. Waterproof
    - C. Snap

16. STEM
    - A. Regular
    - B. Oversize
    - C. Snap

17. SLEEVE

18. CROWN AND STEM
    - A. Regular
    - B. Special

19. DEMAGNETIZE

20. CASE
    - A. Joint
    - B. Catch
    - C. Lugs

21. REMOVE RUST

22. CLICK SPRING

23. MAINSPRING
    - A. 7 to 15 jewel
    - B. 17 to 19 jewel
    - C. 21 to 23 jewel

24. JEWELS
    - A. Cap
    - B. Balance
    - C. Roller
    - D. Train
    - E. Center
    - F. Pallet

25. WINDING PINION

26. MAINWHEEL

27. HAIRSPRING, New
    - A. Flat
    - B. Overcoil

28. SETTING SPRING

29. WHEELS
    - A. Center
    - B. 3rd
    - C. 4th
    - D. Escape
    - E. Balance

30. BOW
    - A. White
    - B. Yellow

31. CLUTCH

32. SHIPPER SPRING

33. SET LEVER SCREW

34. CANNON PINION

Modern Shop Check List

The purpose of this check list is to give you additional guidance by refreshing your memory on points to be observed when making an estimate or when making repairs.

WHAT TO LOOK FOR WHEN YOU MAKE AN ESTIMATE (Section 563)

1. CASE STRAP CORD OR BAND — Do any of these need replacement? Is the case dented so it causes pressure on parts of the movement? If the case has stones, are any missing or chipped? Are they all tight?

2. CRYSTAL — Does the crystal fit tightly or does it allow dirt to seep in? Is it chipped, cracked or broken? Is it badly scratched or discolored? (Suggest a new one for better appearance.)

3. CROWN STEM SLEEVE BOW WINDING SETTING — Is the crown secure? Does it match the case in color? Is the knurling worn, making it hard to turn? (Recommend a new one.) Is the stem the right length, allowing the crown to just clear the case? Is the bow worn or loose? Does the sleeve have good snap-action?

   Wind the watch. Is the mainspring broken? Or are other winding parts broken or loose? (Endless winding usually means a broken mainspring, but if the crown jumps back as soon as released, the click spring is probably broken. If there is little resistance and no sound of the click on the ratchet wheel teeth, you may have a broken winding pinion, a loose or broken crown wheel, or a loose or broken ratchet wheel or screw.) Does the watch wind stiffly? (Winding parts may be rusted.) Does the crown unscrew when turned backwards?

   Pull out the crown to test the setting. Does the mechanism jump back to the winding position? (This usually means a broken set bridge.) Do the hands turn in the set position? (If they do not, you can look for broken teeth in the minute wheel, clutch or setting wheel.) If you now can set the hands, but the watch did not wind before, you may have a broken setting spring.)

4. HANDS — Do the hands match? Are they the proper length? Is the minute hand parallel to the hour hand? Is the end of the minute hand bent down slightly so as not to rub the crystal? Turn the hands completely around the dial? Do the hour and minute hands clear each other? Does the hour hand clear the second hand? Does the second hand clear the dial when making a complete turn? Does the second hand fit the pipe snugly? If the hands are a luminous type, do they need refilling? If the numerals are raised, do the hands clear them?

5. DIAL	Remove crystal and bezel and check the dial. Is it dirty or discolored? Is it badly scratched? Is it dull or badly tarnished? (Suggest refinishing.) If it is a luminous dial, is the luminosity still good?
6. CANNON PINION	Push against the minute hand with pegwood. Is the tension correct on the cannon pinion?
7. HAIR-SPRING	Remove the movement from the case. Is the regulator in center of index? Is the hairspring level? Is it centered? Does the outside coil or overcoil pass through the regulator pins correctly? Is there rust on the hairspring? Do any coils touch each other? Is there any oil on the hairspring? If coils touch but are dry, check for magnetism.
8. BALANCE STAFF	Test end shake of balance with tweezers. Is it broken? Are pivots bent? Is there proper endshake? Is the balance true in flat and round? Does balance clear pallet bridge and center wheel?
9. ROLLER JEWEL	Move balance gently back and forth. If pallet fork moves, roller jewel is OK.
10. BALANCE JEWELS	Are they cracked? Rough? If rough, remove and examine closely.
11. PALLETS AND ESCAPE-MENT	Are the pallet stones loose? Does the escapement appear out of order in any other way?
12. TRAIN	Release the power so you can check each pinion for endshake. Does any part of the train appear to be out of order? If so, you may have to dismantle the movement further to check it out.
13. GENERAL	Are there any missing screws? Signs of rust? Has the oil dried?

WHAT TO LOOK FOR WHEN YOU MAKE REPAIRS (Section 564)

The following check list is concerned only with the <u>additional</u> points to observe that were not evident when you made your estimate. The numbers correspond to those in Section 564.

2. CASE	Are the case screws satisfactory? Does the movement fit the case?
4. CASE	Should the case be buffed? Is it necessary to remove the crystal for buffing? Will only washing of the case be satisfactory?

8.	DIAL FEET	Are the dial feet located so the hole in the dial centers over the hour wheel pipe ?
10.	HOUR WHEEL	Are any teeth bent or burred? (You can check wheels easier if you hold them up to the light.)
12.	HAIR-SPRING	Remember if the regulator was set toward fast or slow when you bring it back to center of the index.
13.	HAIR-SPRING	Is the body of the hairspring level with the arms of the balance ? Is the overcoil level with the bridge ?
14.	STUD SCREW	Does the thread on the stud screw seem to hold in the balance cock ?
16.	REGU-LATOR PINS	Are regulator pins parallel and free from burrs and roughness ?
17.	HAIR-SPRING	In checking the round, do the coils spiral evenly toward the collet? In checking the flat, do the coils remain in the same plane ?
18.	HAIR-SPRING	Does the collet fit snugly on the balance staff? Is it cracked?
19.	HAIR-SPRING	Does the outside coil of the hairspring now lie between the regulator pins ? Is the collet over the center of the balance cock? Is the body of the hairspring parallel with the balance cock?
21.	ROLLER JEWEL	Is the roller jewel of correct length? Does the roller jewel fit the fork slot correctly? Is the roller jewel cemented firmly? Are the edges and face of roller jewel clean of all cement? Is the roller table tight on the staff?
23.	BALANCE STAFF	Are the pivots of the balance staff straight? Do the sides of the pivots appear parallel? Do the pivots appear pointed? Is the pivot about $2\frac{1}{2}$ times as long as its diameter, exclusive of the cone ? Do the balance pivots fit the hole jewels correctly? Do the ends of pivots need burnishing? Have you polished the pivots ? Is the balance wheel riveted tightly to the staff?
24.	BALANCE	Have you tightened the balance cock screw? Are the endshake and sideshake correct? Does the balance wheel clear the pallet bridge and center wheel?
25.	GUARD ACTION	Is the guard action correct? Hold the balance wheel with the roller outside the fork horns. Place light pressure on the fork. Does the guard pin keep the fork from moving to the other side and from unlocking the escapement?

26. CAP AND BALANCE JEWELS	Did you find any pits or other defects after you cleaned the old oil and other foreign matter from cap and balance jewels? Do any jewel screws need replacement?
27. BALANCE	Does the balance rim need polishing? Are balance screws, except meantime screws, turned all the way in? If some of the balance screws had timing washers previously added, did you check that they did not protrude above the rim of the wheel?
28. BALANCE WHEEL	If you found it necessary to true the wheel, did you check afterward that it would clear the pallet bridge and center wheel in dial up and dial down positions? If you found in Step 12 above that the regulator was toward the "F" side, did you remember to remove weight in poising? If the regulator was toward the "S" side, did you add weight in poising?
29. ESCAPEMENT	Are lock, slide and drop correct and equal on both stones?
31. PALLET ARBOR	Are the pivots straight? Do they need polishing? Are the pallet stone faces in good order? Did you check the guard pin for burrs?
32. TRAIN	Does the train run freely? Are all wheels true? If you detect too much friction on any of the wheels or pinions, did you note which ones so you could polish them?
33. DISASSEMBLY	Have you placed parts in separate categories: train wheels together?
34. WHEELS AND PINIONS	After cleaning, did you recheck that pivots were straight? Have you checked that there are no bent teeth? Did you note which pivots might need polishing?
35. RUST	Did you determine whether it is more practical to remove the rust or to replace the pinion?
36. PIVOTS	Did you polish all pivots if you were in doubt as to which needed it?
37. PIVOT HOLES	Did you check the bearing surface of all pivot holes, whether jeweled or not? If you closed any pivot holes or replaced any jewels, did you replace the wheel and pinion and test endshake and sideshake?
38. BARREL ARBOR	When checking endshake, did you detect any roughness or scratching? If so, did you polish the bearing surfaces as soon as you removed the arbor?
39. MAINSPRING BARREL	Are any of the teeth bent?

40.	MAIN-SPRING	Is the mainspring set? If broken and in need of replacement, have you checked the correct size by movement identification or by measuring the old one?
41.	WINDING AND SETTING	Check for signs of wear on the stem. Is the hub of stem worn? Is the pilot of stem worn? Is the hole in plate worn? Are the teeth of clutch and winding pinion free of rust, excess wear or foreign matter? Is there any sign of excess wear or damage on crown wheel and ratchet wheel teeth? Are the crown wheel screw and ratchet wheel screw in good order? Do you know which is which so you can replace them properly?
42.	NEW MATERIAL	Do all the parts you have replaced fit properly?

WHAT TO LOOK FOR AS YOU REASSEMBLE THE MOVEMENT (Section 566)

1.	MAIN-SPRING	Did you oil the arbor? Did you oil the mainspring? Are you sure the mainspring is properly hooked? Is the cap snapped down all around? Did you test the endshake of the barrel arbor?
2.	WINDING PARTS	Did you oil the square on the stem? Did you oil the teeth on the winding clutch which contact the teeth on the winding pinion? Did you oil the point of contact between the set lever and clutch lever?
3.	BALANCE HOLE AND CAP JEWEL	Did you make sure the screws are "set"? Did you oil each combination?
4.	TRAIN	Did you oil the upper and lower center, 3rd, 4th, and escape wheel pivots?
5.	TRAIN	Is the train free and showing proper recoil?
6. 8.	BALANCE DIAL DOWN	Does the balance turn freely in the Dial Down position?
8.	BALANCE DIAL UP	Does the balance slow down in the Dial Up position the same as in the Dial Down?
9.	BALANCE PENDANT UP	Are you satisfied the balance is free in all three positions?

10. PALLET FORK	Did you oil 3 or 4 teeth on the escape wheel? Did you lightly oil the pallet arbor pivots? (Note: Some authorities do not oil pallet pivots.) Does the pallet have end shake and feel free? Is there safe lock on both stones? Does the pallet fork snap quickly to the banking pin, showing it has draw? Does the pallet snap back and forth, indicating the escapement is working properly?
11. BALANCE ROLLER	Does the roller jewel clear the guard dart? Does the roller table clear the pallet fork? Is there safe guard action on both sides?
12. HAIR-SPRING	Is the regulator in the center of the index? Is the hairspring level with the bridge and neither dished nor umbrella-shaped? If this is a Breguet hairspring, is the overcoil clear of the balance cock in the Dial Up position? Does the outside coil pass through the regulator pins? When looking at the hairspring over the balance cock, do the coils seem equally spaced? Is the hairspring stud screw "set"? Is the balance cock screw "set"? Is the watch in beat?
13. MOTION	Dial Up -- $1\frac{1}{2}$ turns and the same as Dial Down. Dial Down -- $1\frac{1}{2}$ turns and the same as Dial Up. Balance falling toward the fork -- 1-1/4 turns.
14. CANNON PINION, HOUR WHEEL	Is the cannon pinion tight? Are dial screws "set"? Is the opening in the dial centered over hour wheel and fourth pinion? Are the hands free and parallel? Is the end of the minute hand bent down slightly on the end? Do the hands register correctly?
15. CASING	Is the case clean? Have you removed all fingermarks from both case and movement? Is the crystal clean and properly sealed? Is the case properly sealed? (Especially important for waterproof models.) Does the watch wind and set properly? Do the hands clear the crystal?

MODERN SHOP CHECK SHEET

Job Number ....

NAME ....

DATE STARTED .... FINISHED ....

REGISTER

.... Name of watch | Size | No. of jewels

.... Movement No. | Description of case—14k—18k—RGP Number etc.

ESTIMATE

METHOD OF CLEANING

☐ Hand ☐ Machine

A .... Train Recoil
B .... Balance Test without hairspring
C .... Escapement Test without hairspring

PRELIMINARY MOTION TEST

D .... Dial Up
E .... Dial Down
F .... Balance falling toward fork

TIMING

Apparent Rates		24-hour Final Check
G Rate	Dial Up	.... Rate
H Rate	Dial Down	.... Rate
J Rate	Pendant Up	.... Rate
K Rate	Pendant Down	.... Rate

Remarks ....

....

....

....

....

....

TOTAL CLOCK HOURS ....

Do not write in this column.

Balance Wheel and Staff
- True ....
- Poise ....
- Polish Pivots ....
- ....

Hairspring
- Round ....
- Flat ....
- Center ....
- Level ....
- Overcoil ....
- ....

Escapement
- Guard Action ....
- Roller Action ....
- Lock ....
- Drop ....
- Draw ....
- Slide ....
- ....
- ....

Cleaning
- Finger Prints ....
- ....
- ....

Oiling
- Excess ....
- Lack ....
- ....

Jewels—Pivot Holes
- ....

Wheels and Pinions
- ....

Train Pivots
- Polish ....
- Straighten ....

Rust
- ....

Case
- Stem ....
- Crown ....

Winding
- ....
- ....

Setting
- ....
- ....

Mainspring
- ....
- ....

Cannon Pinion
- Loose ....
- Tight ....

Regulator Pins
- Replace ....
- Too Far Apart ....
- Too Close Together ....

Screws
- ....

Hands
- Tighten Hour ....
- Tighten Minute ....
- Tighten Seconds ....

Motion
DU DD PU PD

GRADE ....

MODERN SHOP CHECK SHEET

Job Number ....

NAME ....

DATE STARTED .... FINISHED ....

—REGISTER—

Name of watch .... Size .... No. of jewels ....

Movement No. .... Description of case—14k—18k—RGP Number etc. ....

—ESTIMATE—

METHOD OF CLEANING

☐ Hand ☐ Machine

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PRELIMINARY MOTION TEST

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TIMING

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Remarks ....

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Cleaning
- Finger Prints ....

Oiling
- Excess ....
- Lack ....

Jewels—Pivot Holes

Wheels and Pinions

Train Pivots
- Polish ....
- Straighten ....

Rust

Case
- Stem ....
- Crown ....

Winding

Setting

Mainspring

Cannon Pinion
- Loose ....
- Tight ....

Regulator Pins
- Replace ....
- Too Far Apart ....
- Too Close Together ....

Screws

Hands
- Tighten Hour ....
- Tighten Minute ....
- Tighten Seconds ....

Motion
DU DD PU PD

GRADE ....

MODERN SHOP CHECK SHEET

Job Number ....

NAME ....

DATE STARTED .... FINISHED ....

REGISTER

....
Name of watch   Size   No. of jewels

....
Movement No.   Description of case—14k—18k—RGP Number etc.

ESTIMATE

METHOD OF CLEANING

☐ Hand   ☐ Machine

A .... Train Recoil
B .... Balance Test without hairspring
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D .... Dial Up
E .... Dial Down
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K Rate	Pendant Down	.... Rate

Remarks ....
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Setting
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Screws
....

Hands
- Tighten Hour ....
- Tighten Minute ....
- Tighten Seconds ....

Motion
DU   DD   PU   PD

GRADE ....

MODERN SHOP CHECK SHEET

Job Number ....

NAME ....

DATE STARTED .... FINISHED ....

REGISTER

....
Name of watch — Size — No. of jewels

....
Movement No. — Description of case—14k—18k—RGP Number etc.

ESTIMATE

METHOD OF CLEANING

☐ Hand ☐ Machine

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Screws
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Hands
- Tighten Hour ....
- Tighten Minute ....
- Tighten Seconds ....

Motion
DU DD PU PD

GRADE ....

MODERN SHOP CHECK SHEET

Job Number ....

NAME ....

DATE STARTED .... FINISHED ....

REGISTER

Name of watch .... Size .... No. of jewels ....

Movement No. .... Description of case—14k—18k—RGP Number etc. ....

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Remarks ....

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- Polish ....
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- Stem ....
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Winding ....

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Screws ....

Hands
- Tighten Hour ....
- Tighten Minute ....
- Tighten Seconds ....

Motion

DU DD PU PD

GRADE ....

MODERN SHOP CHECK SHEET

Job Number ....

NAME ....

DATE STARTED .... FINISHED ....

REGISTER

.... Name of watch .... Size .... No. of jewels

.... Movement No. .... Description of case—14k—18k—RGP Number etc.

ESTIMATE

METHOD OF CLEANING

☐ Hand ☐ Machine

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Remarks ....

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....

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Train Pivots
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Case
- Stem ....
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Cannon Pinion
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- Too Far Apart ....
- Too Close Together ....

Screws
....

Hands
- Tighten Hour ....
- Tighten Minute ....
- Tighten Seconds ....

Motion
DU DD PU PD

GRADE ....

Detach page or cut along this line and send — to the School with your work for grading

CHICAGO SCHOOL OF WATCHMAKING

Proficiency Exam No. 6

A test of your Master Watchmaking Shop Skills.

Student number ________________ Date ________________

Name	
Address	
City State Zip Code	

This examination reviews the practical work for:

Lessons 1 through 34

You may send in this examination any time after you have completed study of the lessons above, up to 3 years from your date of enrollment.

YOUR GRADE: ________________

Certificate Awarded: ________________

PURPOSE OF THIS EXAMINATION: To review and test your ability to do the practical work you have learned in these lessons.

THIS REVIEW EXAMINATION IS REQUIRED of all students desiring a DIPLOMA and who have not satisfactorily completed Proficiency Examinations 1, 2, 3, and 4. Students who have SATISFACTORILY COMPLETED these earlier examinations are NOT REQUIRED to do this one and may request their Final Examination as soon as they have satisfactorily completed the written Test Questions 32, 33, and 34.

NOTE: Your Final practical examination requires you to send in two good grade watches ahead of time so your instructor can prepare them for the work you are to do.

( ) Check here if you wish to use for your Final Examination the same two watches you are using here for this review examination.

If your two watches are satisfactory, your instructor will prepare them before he returns them to you.

YOU WILL NEED FOR THIS EXAMINATION:

One 16s or 12s American-made pocket watch, either open face or hunting case, with 17 or more jewels, OR an equivalent size foreign make pocket watch, OR one 17 jewel wrist watch.

One cased Swiss-make wrist watch with jeweled lever escapement. Either ladies or mens style is acceptable.

Two balance wheels and staffs fitted with one flat and one overcoil hairspring. (Use the wheels, staffs, hairsprings, and collets sent with Lessons 15 through 20.)

Pack these watches and wheels carefully, each in the separate envelopes furnished with this shipment. Mark them as your property. Also mark the envelopes "For Proficiency Exam 6". When sending in watches, slip a small piece of paper under the balance so as to stop the motion. This many times prevents bent pivots when you send watches through the mail. Where possible, send via insured mail and include return insurance fee.

(Please turn over for required work.)

IDENTIFY THE AMERICAN MOVEMENT: POSSIBLE SCORE: 35

Make ____________ Size ____ No. of Jewels ______
Model or
Movement No. ________ Description of Case ______

Less points lost for errors indicated below:

WORK TO BE PERFORMED:

1. Completely disassemble, clean, oil, and reassemble this watch without damage to parts. Follow steps in Secs. 564 and 566, Lesson 32. Make the specific repairs indicated below: (See Proficiency Examinations 1, 2, 3, and 4 for check points.) (Up to -20 for errors other than repairs specified at left.) ____

   (Sec 564)

Step 21: Remove and reset the roller jewel.	$(-\frac{1}{2})$	____
Step 23: Fit new balance staff.	(-5)	____
Step 31: Remove and reset pallet stones.	(-1)	____
Step 37: Remove and replace upper fourth train jewel.	$(-\frac{1}{2})$	____
Step 40: Remove mainspring from barrel and replace.	(-2)	____

2. How did you clean this watch? ( ) Hand ( ) Machine

3. After you have finished the above, follow sections 568 and 569 and enter the following information:

   A. Motion of balance when fully wound in each position. (-6) ____

   DIAL UP ____ turns. DIAL DOWN ____ turns.

   DIAL FALLING TOWARD THE FORK ______ turns.

   B. Enter the amount of gain or loss in 24 hours in each of these positions:

   DIAL UP ____________ DIAL DOWN ________
   PENDANT UP ____________

4. Bring watch to time. YOUR SCORE: ____

ERRORS NOTED: ( ) None. Splendid work. Damaged parts:

( ) Case and crystal: ____________ ____________
( ) Winding and setting: ____________ ____________
( ) Mainspring: ____________ ____________
( ) Train assembly: ____________ ____________
( ) Cleaning and oiling: ____________ ____________
( ) Dial, hands and cannon pinion: ____________ ____________
( ) Jewels -- Roller, 4th train, other: ____________ ____________
( ) Balance wheel: ____________ ____________
( ) Balance staff and pivots: ____________ ____________
( ) Hairspring: ____________ ____________
( ) Regulator pins: ____________ ____________
( ) Escapement and pallet stones: ____________ ____________
( ) Other: ____________ ____________

Suggestions for improvement: ____________________________

____

 Name Student No.

Detach page or cut along this line and send — — to the School with your work for grading

IDENTIFY THE SWISS MOVEMENT: POSSIBLE SCORE: 35

Make __________ Size _____ No. of Jewels _____
Model or
Caliber No. __________ Description of case _____

Less points lost for errors indicated below:

WORK TO BE PERFORMED:

1. Completely disassemble, clean, oil, and reassemble this watch without damage to parts. Follow steps in Secs. 564 and 566, Lesson 32. Make the specific repairs indicated below: (See Proficiency Examinations 1, 2, 3, and 4 for check points.)

(Up to -20 for errors other than repairs specified at left.)

(Sec. 564)		
Step 3: Fit a new stem.	($-\frac{1}{2}$)	____
Step 21: Remove and reset the roller jewel.	($-\frac{1}{2}$)	____
Step 22: Remove and reset a balance and cap jewel.	($-\frac{1}{2}$)	____
Step 23: Fit a new balance staff.	(-5)	____
Step 31: Remove and reset pallet stones.	($-\frac{1}{2}$)	____
Step 40: Remove mainspring from barrel and replace.	(-2)	____

2. How did you clean this watch? ( ) Hand ( ) Machine

3. After you have finished the above, follow sections 568 and 569 and enter the following information:

   A. Motion of balance when fully wound in each position: (-6) ____

   DIAL UP _____ turns. DIAL DOWN _____ turns.

   DIAL FALLING TOWARD THE FORK _____ turns.

   B. Enter the amount of gain or loss in 24 hours in each of these positions:

   DIAL UP __________ DIAL DOWN __________
   CROWN DOWN __________

4. Bring watch to time.

YOUR SCORE: [ ]

ERRORS NOTED: ( ) None.

Damaged parts:

( ) Case and crystal: __________
( ) Winding and setting: __________
( ) Mainspring: __________
( ) Train assembly: __________
( ) Cleaning and oiling: __________
( ) Dial, hands and cannon pinion: __________
( ) Jewels -- Roller, balance, other: __________
( ) Balance wheel: __________
( ) Balance staff and pivots: __________
( ) Hairspring: __________
( ) Regulator pins: __________
( ) Escapement and pallet stones: __________
( ) Other: __________

Suggestions for improvement: __________

WORK TO BE PERFORMED ON THE TWO BALANCE WHEELS:

1. Stake the staffs to the balance wheels. (Lesson 15)
2. True the wheels in flat and round. (Lesson 16)
3. Poise the wheels. (Lesson 17)
4. Collet the hairsprings and true in flat and round. (Lesson 18)
5. Leave one hairspring flat. Raise overcoil on other, using either knee bend or gradual bend, as you wish.
6. Circle the overcoil to follow the 3rd coil and be level with the body of the hairspring.

POSSIBLE SCORE FOR EACH WHEEL:

Wheel with flat hair-spring	Wheel with over-coil hair-spring
13	17

ERRORS NOTED:

		Less points lost for errors noted:	
( ) Staked incorrectly.	(-2)	______	______
( ) Arm of balance not down against hub.			
( ) Not riveted firmly.			
( ) Wheel not true.	$(-1\frac{1}{2})$	______	______
( ) Wheel not poised.	$(-1\frac{1}{2})$	______	______
( ) Pivots bent.	$(-\frac{1}{2})$	______	______
( ) Pivots broken.	$(-\frac{1}{2})$	______	______
( ) Hairspring not colleted correctly.	$(-1\frac{1}{2})$	______	______
( ) Pin not cut close to collet.			
( ) Elbow incorrectly formed.			
( ) Pin not tight.			
( ) Hairspring not true in flat.	(-2)	______	______
( ) Hairspring not true in round.	(-2)	______	______
( ) Body of spring distorted or bent.	$(-\frac{1}{2})$	______	______
( ) Flat hairspring outer coil:			
( ) Not level with body of spring.	$(-\frac{1}{2})$	______	
( ) Not smoothly formed.	$(-\frac{1}{2})$	______	
( ) Overcoil:			
( ) First bend in wrong location.	$(-\frac{1}{2})$		______
( ) Bent out of spiral.	$(-\frac{1}{2})$		______
( ) Not raised high enough.	$(-\frac{1}{2})$		______
( ) Raised too high.	$(-\frac{1}{2})$		______
( ) Second bend in wrong location.	$(-\frac{1}{2})$		______
( ) Not level to end of spring.	$(-\frac{1}{2})$		______
( ) Third bend in wrong location.	$(-\frac{1}{2})$		______
( ) Touching first coil as it passes over.	$(-\frac{1}{2})$		______
( ) Not following directly over 3d coil.	(-1)		______
	Each wheel:	______	______

YOUR SCORE: [ ]

End of Proficiency Examination No. 6.

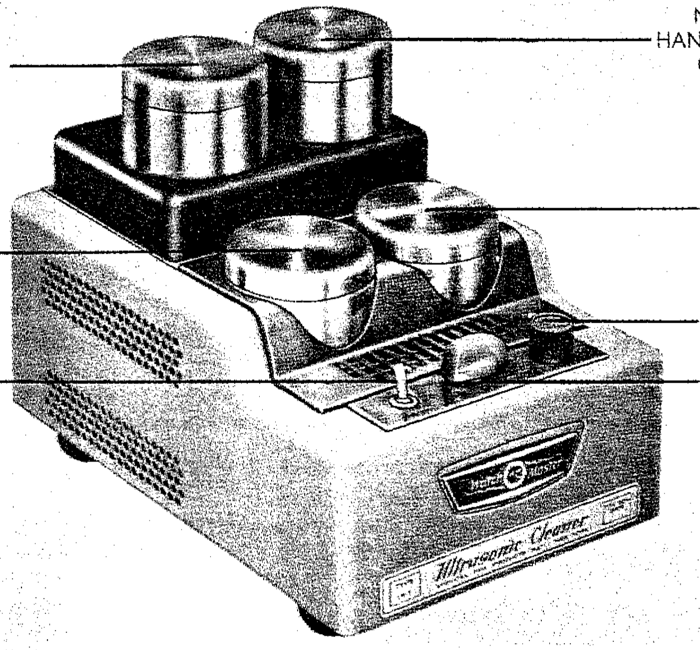
LESSON	32
ULTRASONIC CLEANING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L32-J1



HOW TO CLEAN WITH A WATCHMASTER ULTRASONIC WATCH CLEANER.

The WATCHMASTER Ultrasonic Cleaner cleans watch movements and other small precision parts to the highest degree possible. The degree of cleanliness achieved, however, depends entirely on the care exercised in the use of the equipment. The following requirements must be carefully met if good results are to be uniformly obtained.

1. The apparatus must be kept scrupulously clean, and all of the solutions used must be fresh, clean and appropriate for the work. Any contamination in the cups or the solutions will contaminate the work and reduce the quality of the finished job. *A WATCH CANNOT BE CLEANER THAN THE FLUID OUT OF WHICH IT COMES.*

2. The basic cleaning process uses a wash-solvent to remove soil and to brighten the work. All trace of this solvent with its load of removed soil must be *completely rinsed* from the work if final cleanliness of a high order is to be achieved.

3. The *rinsing* solution must be capable of removing all of the cleaning solution residue and the last rinse should dry at a reasonably fast rate.

One operating procedure which has been found to produce high quality work is outlined below:

a) When putting the cleaner into operation for the first time and periodically thereafter, clean the inside and outside of all cups with watch-cleaning solution and follow this with watch rinsing solution. *This is important to prevent re-contamination.*

b) Fill the #1 or wash cup with fresh *watch-cleaning* solution to a depth of at least 1⅜", or about ⅛" to ¼" above the top of the basket. Fill the #2 and #3 rinse cups with appropriate *rinsing* solution to the same depth. (See *SOLUTIONS*)

c) Prepare movements for cleaning by removing dials, hands, mainspring barrels and barrel bridge. Tighten dial screws or put them in the thimble, as ultrasonic action will take out any loose screws. If desired, the barrel bridge may be refastened to the movement.

d) Put stems in "setting" position. Place movements in the slots having parallel sides, as close to the center post as possible. Small parts such as hour wheel, barrel arbor, etc., should be put into the thimble baskets. The thimbles should be put into the triangular sections of the large basket.

All compartments of the large basket are numbered on the outside: 1, 1A, etc., to 6A. The first movement goes into partition 1 and its thimble into 1A and so on. Parts large enough not to fall through the bottom mesh of the large basket should be placed alongside the movement or alongside the thimble.

Continued

Small barrels, ratchet wheels and similar *solid* small parts are placed in the thimble in edge position, not in flat position. The arbor and cannon pinion should be removed and placed in the thimbles. The mainspring remains in the barrel unless you have decided to replace it with a new one. Leave the balance in the movement. Put all *Incabloc* or similar spring-mounted cap and hole jewels into the thimbles. Regular cap jewels and all other jewels should remain in place.

OPERATION

The right-hand knob controls wash and rinse. The left-hand "on-off" switch controls the spin-dry mechanism. The timer acts as a master switch. When the timer is off, the entire machine is off. Keep ultrasonic cups covered, but keep hand rinse and spin-dry cups uncovered, during work.

1. Ultrasonic Wash—L & R #111—for from 3-6 minutes. Sometimes 3 minutes is too short and 6 minutes too long. The exact time is measured by the back of the fingers against the sides of the tank. It should feel good and warm. It should *not* feel hot. If the wheels or steel parts change color, it is too hot. Once the correct duration is established, it usually holds good until seasonal changes take place. If you have a thermometer, the shut-off temperature is 115–125°F.

2. Drip off and blot against a clean cloth or paper napkin, using long-nose pliers against the hollow center-post of the large basket, to keep your fingers dry.

3. Switch on the spinner for pre-heating. Put basket into ultrasonic rinse tank containing ZENITH *SuperSonic Rinse* (blue label), for $2\frac{1}{2}$–3 minutes. Use the back of your fingers to establish the proper duration (thermometer shut-off temperature 115–125°F.)

4. Drip off and blot as in #2 above.

5. Turn right-hand knob to "OFF."

6. Place basket into hand-rinse tank, containing *Triclene "D"* or *Chlorothene*, move up and down, and twirl.

7. Transfer basket dripping wet into the pre-heated spin-dry cup as quickly as possible so as to reduce contact with cool air to the absolute minimum. Spin dry for six minutes.

8. ZENITH *SuperSonic Rinse* can also be used for the hand rinse. The plated surfaces will be clean but less brilliant. However, when using this or any other oil-based solution for the hand rinse, it must be dripped off and blotted as in #2 and #4 above, prior to transferring basket to spin-dry unit to prevent liquid from dripping into circuitry as it does not dry as quickly as *Chlorothene* or *Triclene "D."* Spin-dry action must also be increased from 6 to 9 minutes.

9. If you intend to use the machine again immediately, turn on the timer for five minutes, with the spinner switch and the right-hand knob both in "OFF" position. This five-minute action of the blower will free the mechanism of trapped vapors and prevent over-heating of the next run. If you don't intend to use the machine for the next half-hour, just leave the timer at "OFF."

10. Solutions should be disposed of as follows:
    Empty #1 cup. Pour rinse from #2 cup into #1, and empty #1 cup. Pour rinse from #3 cup into #2, and then from #2 cup into #1, and again empty #1 cup. Wipe all cups thoroughly with a clean cloth, including all surfaces, recesses and interiors.

SOLUTIONS

L & R #111 and ZENITH *SuperSonic Rinse* are available nationally from material houses. Sometimes, one single, extra-dirty movement ("stinkers and clunkers") can turn fresh #111 Wash to a dark bottle-green color. When that happens, the wash should be discarded, the cup wiped clean, and the wash done all over again with fresh solution.

Chlorothene is manufactured by Dow Chemical Co. *Triclene "D"* (Trichlorethylene) is manufactured by Du Pont. The latter is more effective and less expensive, but has a more pungent odor. Both may be obtained from industrial chemical distributors. (See your classified telephone directory.) They should come packed in 1-gallon glass jugs, or 5-gallon welded steel drums. The 1-gallon tin-can packing is not recommended because these cans are soldered, and the solder and traces of flux react unfavorably with the contents.

You may find other locally or nationally distributed or produced fluids equally satisfactory. Before you try them, we suggest that you use the fluids we recommend for a week. This will then give you a solid basis for comparison, based on experience.

How often to renew fluids? Unlike mechanical machines, disposal of used fluids in the WatchMaster Ultrasonic Cleaner does not involve pints or quarts; only ounces. A careful watchmaker doing first-class, well-paid work will use a fresh set of fluids after each batch of six movements, emptying and wiping clean all cups before refilling. Let your experience be your guide. The end result will be in relation to your cleanliness of operation. Remember: *A watch cannot be cleaner than the fluid out of which it comes!*

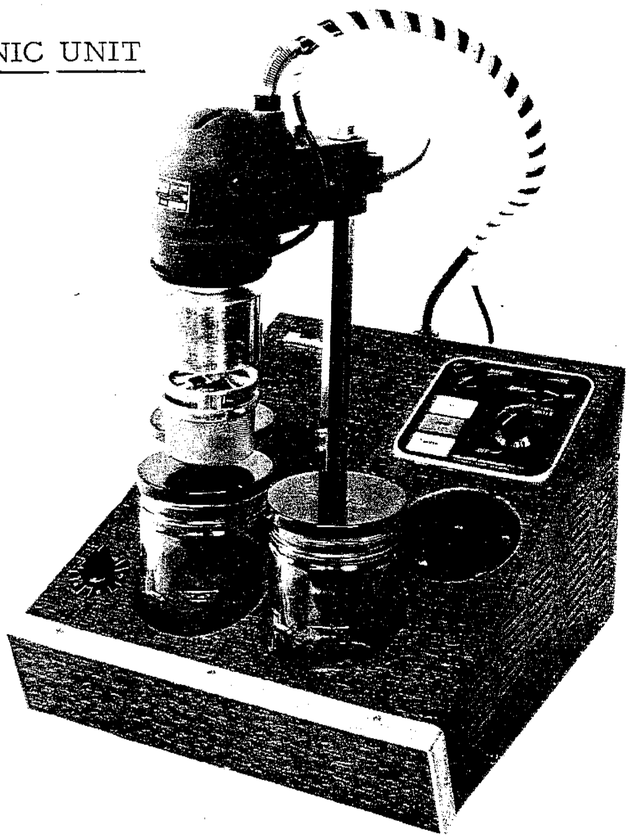
LESSON	32
ULTRASONIC CLEANING	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET
L32-J2

HOW TO CLEAN WITH AN L&R ULTRASONIC UNIT



Introductory Information:

Many workmen prefer to combine the ultrasonic action with the conventional cleaning method. They feel the combination gives a result superior to either method alone.

Either the L&R Console Cleaner (shown here) or the L&R Ultrasonic Unit attached to any L&R Master, Mastermatic or Automatic cleaning machine provides this result.

Use ultrasonic solutions and regular cleaning procedures:

PROCEDURE:

1. Prepare the watch as in Sec. 572.

2. Fill all three jars with solution 1/8 inch above raised letters "L&R" on the jar. Too much solution will overflow or make spin-off impossible. Too little will cause insufficient or no contact with the transducer and can result in its damage. The transducer must be in direct contact with the solution and should be immersed for at least 1/8 inch. Never operate the transducer unless it is in solution.

3. Clean, rinse and dry in the regular way but keep the basket speed fairly low. High speed may let air into the solution. This will act as a muffler for the sound waves and hinder the ultrasonic action.

4. On Master model machines, reverse the machine frequently.

5. Use a 3 minute cycle in each jar. After you become familiar with ultrasonic cleaning, you can shorten the time for cleaning and rinsing. However, not less than 3 minutes drying time is recommended for proper drying.

Detach page or cut along this line and send to the School for grading

CHICAGO SCHOOL OF WATCHMAKING

Test Questions **Master Watchmaking** *Lesson No. 32*

Name: No.: Date:

Circle the ONE BEST answer: SUBJECT: Modern Shop- Practical Job Methods

1. The first important step when you have taken in a watch for repair is:

Cleaning	Repairing	Estimating	Regulating

2. After removing dial from movement or hairspring from the balance bridge, the next step should be to immediately:

Continue to disassemble the movement	Tighten dial screws or hairspring stud screws	Clean dial or hairspring	Clean the movement

3. When repairing a watch, the truth and poise of a balance wheel should be checked:

On all repair jobs	On small watches only	Only when a new staff has been fitted	Only if the watch does not have a good rate in positions

4. When necessary to polish or burnish train pivots, if impossible to catch up with chuck on arbor or pinion leaves, it is best to:

Not polish or burnish the pivot	Polish as well as possible without use of lathe	Catch the pivot in chuck	Use a wheel chuck or hollowed out cement chuck

5. A watch is said to be running on half time when:

The mainspring is wound half way	The balance is taking one-half turn of motion	The balance continues to oscillate without the hairspring	It is running at a very slow rate

6. An average wrist watch should keep time within:

90 seconds a week	60 seconds a week	30 seconds a week	15 seconds a week

(Please turn over)

7. When bringing a watch to a close rate of time, which of the following is not absolutely necessary?

A timing machine always available	A source of correct time for regulation	Balance and train in very good order	Hairspring trued, leveled and centered properly

8. Ultrasonic cleaning machines clean by:

Immersion	Mechanical vibrations	Chemical action	Cavitation

9. Infrasonic cleaning machines clean by:

Immersion	Mechanical vibrations	Chemical action	Cavitation

10. Miracle plastic lubrication can be used:

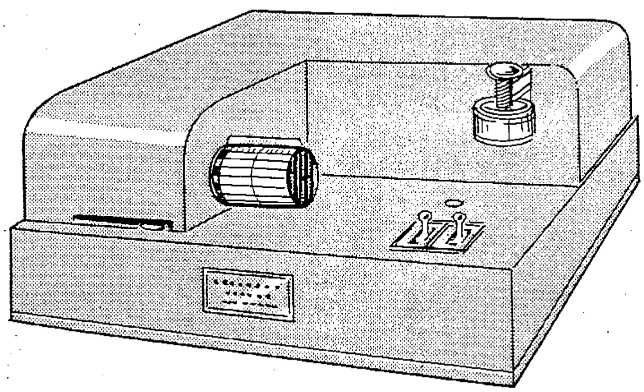
On all watches	Only on spring-driven watches	Only on pin lever watches	Only on complicated watches

Master Watchmaking

MODERN SHOP METHODS

LESSON

33



Electronic Timing Machines

(Watch-Master and Vibrograf)

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by THOMAS B. SWEAZEY

Printed in the United States of America

Sections 576 through 583A (Figure 33-25) are reprinted from the Watchmaster Handbook with the permission of American Time Products, Inc., (now Watchmaster Products). Additional illustrations, starting with Fig. 33-28 are courtesy of the same firm.

INTRODUCTORY INFORMATION

The advent of electronic watch rate recorders has greatly speeded up the rating and regulating of watches. These next assignments deal with some of the many machines that have been developed. The basic text of this and the next lesson is concerned with two early types of recorders from which most later types have evolved. An understanding of them not only prepares you to understand the changes that have occurred, but enables you to take advantage of the low price at which these early machines are now being offered. They are bulkier than later machines and somewhat limited, but save you several hundreds of dollars over the cost of later models of recorders.

The watch rate recorder is a useful device when properly used. But a machine is only as good as the one who operates it. The one who learns to rate, adjust, and regulate watches properly without a machine will benefit most from its use.

Watches rated on timing machines are handled in the same general way as watches at the bench, except that uncased rates are obtained before putting dial and hands on the watch. When the necessary positions have been rated on the machine, all watches should be bench-timed for 24-hour periods to check the rate over an elapsed period of time. This rate may be entirely different from the rate obtained on a timing machine. These machines record only 30 to 60 seconds out of 24 hours. (It is obviously impractical to record a full 24 hours on tape.) So it is a mistake to accept this brief record as final.

These machines will give you a calculated apparent rate in the shortest possible time. This enables you to bring the rate well within the scope of the regulator. But the final check and adjustment of the regulator should still be made over a 24-hour period. Even then it may be necessary to further regulate the watch to the personal habits of the wearer.

When you buy a timing machine, you will usually get a booklet on the care and oiling of the machine. Be sure to use the quality and amount of oil specified.

KEY POINTS OF LESSON ASSIGNMENTS 116, 117, 118, 119:

- Construction and use of the WatchMaster and Vibrograph Watch Rate Recorders.

ASSIGNMENT NO. 116: Study Sections 575 through 577.

Study Questions:

1. How does a WatchMaster Watch Rate Recorder operate?
2. How do you read the record it makes?
3. Can "odd beat" movements be recorded on a WatchMaster?

ASSIGNMENT NO. 117: Study Sections 578 through 582.

1. Why is a two-position average used when rating wrist watches?
2. How will an out-of-poise balance show up on the record?
3. What is meant by the "isochronous error" of a watch?
4. How do hairspring defects show up?
5. What kind of patterns do mechanical faults make?

ASSIGNMENT NO. 118: Study Sections 583 and 583A.

1. Why do odd beat movements usually record as multiple lines?
2. Which of these multiple lines can be used?
3. When is it necessary to establish the "time slope" of an odd beat movement?
4. How is this done?
5. What are the advantages of having small watches beat six times per second rather than 5?

   NOTE: A more recent and complete listing of odd beat watches and clocks and how they are recorded with current models of timing machines is contained in the booklet "Watches with Odd Vibration Rates" by Henry B. Fried. It is available from the American Watchmakers Institute, P.O. Box 11011, Cincinnati, Ohio 45211.

ASSIGNMENT NO. 119: Study Section 584.

1. Do later models of WatchMaster record the same as the early models?
2. How do the Vibrograph Watch Rate Recorders differ from WatchMaster?

REQUIREMENT:

➧ Answer the Test Questions for Lesson 33 and send in for grading.

SEC. 575—Introduction

This lesson has been prepared for the purpose of assisting the student watchmaker in utilizing the WatchMaster Watch-Rate Recorder to its best advantage. The relationship between the record and the watch is explained in some detail as a means of simplifying the interpretation of unusual records. No attempt has been made to reproduce exact records which are entirely indicative of a specific watch but rather the principles of diagnosis are illustrated.

NOTE: The frequency control referred to in Section 576 is achieved by means of a tuning fork in the WatchMaster.

SEC. 576—General Description

The WatchMaster Watch-Rate Recorder is a device which has been designed to record every tick of a watch or clock on calibrated chart paper in a manner which will give the maximum information in the shortest practical time. The calibration of the chart paper and the speed of its movement have been chosen to make an error of one second per twenty-four hour day, the minimum which can be distinguished in a period of thirty seconds, and at the same time, keep the recorded indication of instantaneous variations, due to watch irregularities, to a readable extent.

These principles take practical form in the WatchMaster by wrapping the chart paper around a drum which is rotated exactly five times per second by a motor controlled by a very accurate constant frequency. Since the escapement in a normal watch operates exactly five times per second when keeping correct time, a mark made on the chart paper every time the watch escapement operates would fall in exactly the same place for successive ticks. In order to distinguish between successive marks and hence successive ticks, the recording mechanism is advanced from left to right approximately the width of a mark every revolution of the drum. Therefore these conditions produce a line of marks on the paper which develop from left to right on the drum and exactly parallel to its axis when the rate of the escapement action and the rate at which the drum rotates are identical. A watch which is gaining produces marks which come slightly in advance of a complete revolution of the drum **between successive ticks** and hence produce a line of dots which slant in the direction of drum rotation as the recording is produced. This produces a line of dots which slopes upward from left to right as the record is viewed. Conversely, a watch which is losing produces marks which come slightly behind a complete revolution of the drum **between successive ticks** and hence produce a line of dots which slopes downward from left to right. The chart paper is calibrated directly in seconds error per twenty-four hour day, and the departure of the watch rate from correct time is read directly from the chart paper.

SEC. 577—The Record and How to Read It

The size of the recorded marks has been chosen to be approximately the minimum which can be readily seen by the unaided eye and still be positive in its production. A line of such marks immediately adjacent to each other requires about thirty seconds of recording time to be dependably readable to one second in twenty-four hours when the instantaneous errors which exist in many watches are to be recorded.

The chart is ruled horizontally with parallel lines which are the equivalent of five seconds in twenty-four hours apart when the full width of the two inch recording represents a twenty-four hour day. When the record slopes the distance of one space between any two of these lines while covering the full two inch width of the paper, the watch is indicated to be five seconds in twenty-fours hours off time. When the record slopes the distance between two divisions, the error is indicated to be ten seconds in twenty-four hours, and so on in units of five seconds for each space covered. When the watch is very nearly correct, errors of one second can readily be distinguished.

For convenience in reading large errors, every sixth line has been made of double width and the distance between the double width lines is hence read as an error of thirty seconds or one half minute per twenty-four hour day. For further assistance in reading large errors, the chart is also ruled lengthwise to divide it in two equal parts. This divides the observation time by two and errors observed in either half represent the twelve-hour performance and must be doubled to obtain the twenty-four hour rate.

Figure 33-1 shows samples of typical records illustrating the method of reading charts. Record **A** represents a watch which is in exact agreement within the frequency standard. The record is exactly parallel with the lines on the chart. Record **B** represents a watch which is gaining at the rate of twenty seconds in twenty-four hours. Four five-second spaces are covered in the full width of the chart. Record **C** repre-

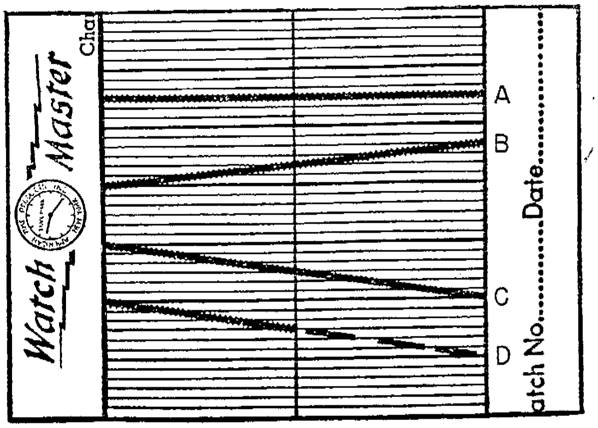


Fig. 33-1

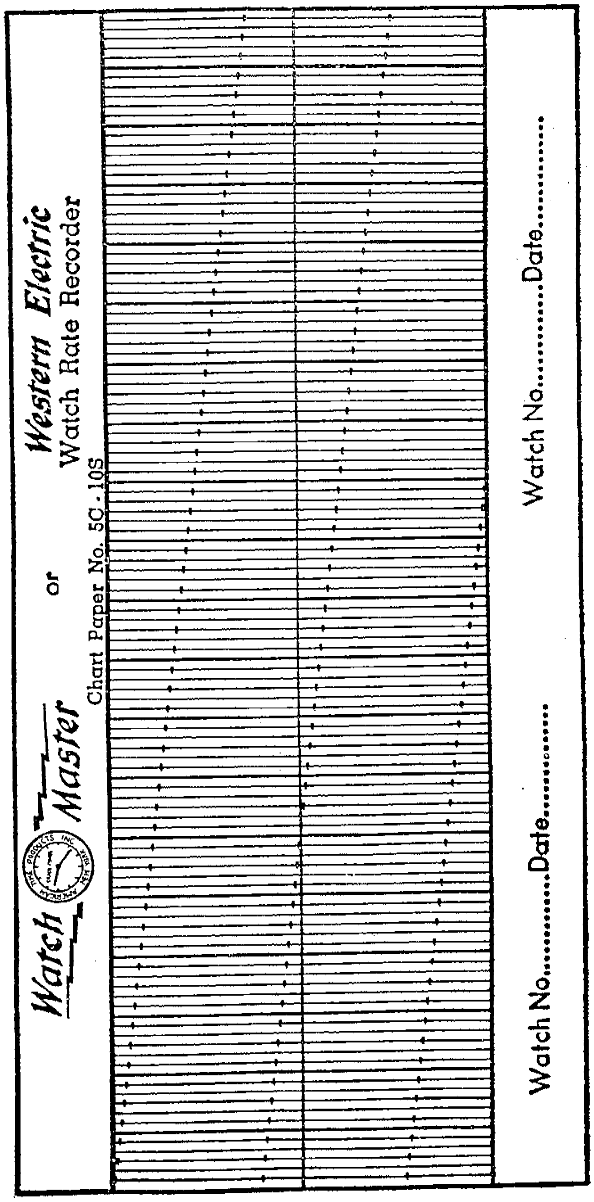
sents a watch which is losing at the rate of thirty seconds in twenty-four hours. Six five-second spaces, or the space between two heavy lines, are covered in the full width of the chart. Record **D** represents the use of the length-wise ruling. The left half of the chart covers three five-second spaces but since the half chart is a twelve hour indication, the error must be doubled making this error thirty seconds in twenty-four hours. By extending this record to the full chart width as indicated by the dashed line, the similarity with Record **C** is shown. The errors indicated by records **C** and **D** are identical.

Watches will occasionally be found which are running very fast or very slow in one or more positions. Records which indicate such rates may make one or more complete spirals around the drum. The size of the drum has been chosen to include exactly one hundred twenty five-second spaces, hence a record which made one complete spiral in the full width of the chart would indicate an error of ten minutes per day. Two spirals would represent twenty minutes per day and so on. Any incomplete spirals are read on the basis of five seconds for each division in the usual way and added to the error represented by the number of complete spirals in the record. For example, figure 33-2 represents a watch which is gaining at the rate of twenty-six minutes per day. The record makes two complete spirals plus twelve large (or seventy-two small) divisions.

There are also many watches made which do not operate five times per second when keeping correct time. Many inexpensive watches and most clocks operate only four times per second while many small ladies' watches operate up to six times per second. While the WatchMaster is primarily designed to record the action of watches which operate five times per second, it will produce usable records from these other so-called "odd beat" movements as well.

For example, a watch or clock which operates only four times per second will make only four marks for every five complete revolutions of the drum. This means that one and one-quarter revolutions of the drum occurs between succesive ticks. Hence, the first, fifth, ninth, thirteenth, etc., ticks will produce marks at the same position on the drum. The second, sixth, tenth, etc., ticks will produce marks in the same position and one-quarter revolution behind the first. The third, seventh, eleventh, etc., will produce marks on the other side of the drum and the fourth, eighth, twelfth, etc., will be three-quarters of a revolution behind the first. The effect of this condition will be to record four separate lines of dots on the drum. They will all be parallel and any one

Fig. 33-2



been closed to the point where the action of the hair-spring between them was proper. This, of course, has the effect of making the watch run faster in all positions but the change in the vertical position rates is greater than the change in the horizontal rate. This has had the effect of bringing the position error for this watch within acceptable limits.

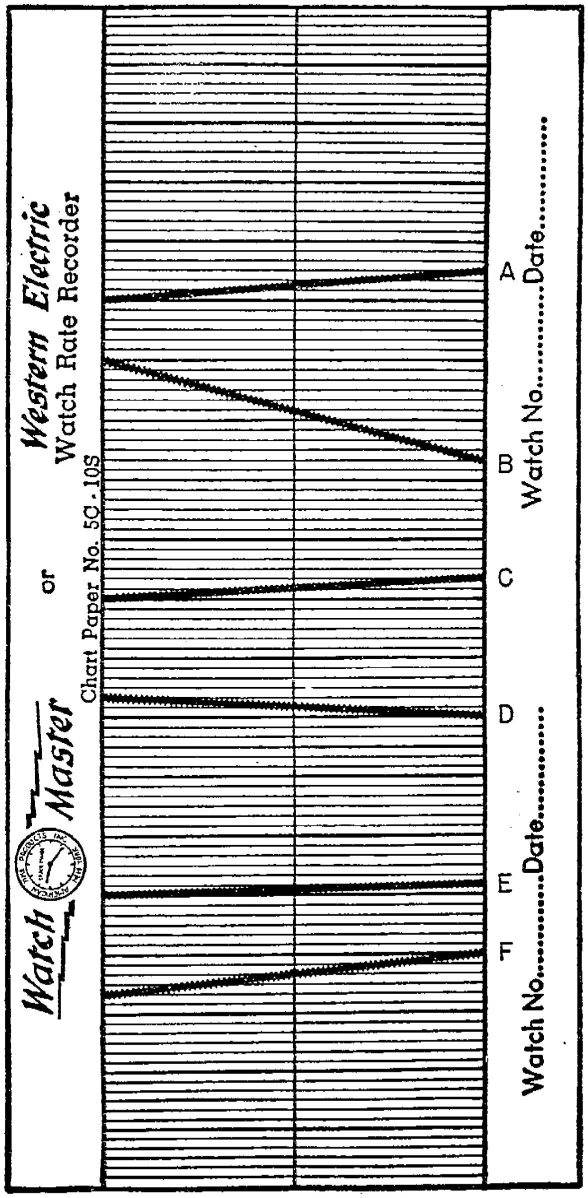


Fig. 33-11

A Dial up—full wound
B Dial up—24 hrs down
C Dial up—full wound
D Dial up—24 hrs down
E Dial up—full wound
F Dial up—24 hrs down

SEC. 580—Isochronism

Isochronism in a watch may be roughly defined as the relationship between the rate and the arc of balance motion in any position. The isochronous error may then be defined as the difference between the rate of the watch full wound and the rate at the end of the normal period between windings. This is generally 24 hours. This is most easily measured by taking the rate with the main-spring wound an amount equivalent to that after 24 hours of running and then measuring the rate in the same position with the mainspring fully wound. The difference between these two rates is the isochronous error of a watch in the position tested.

Figure 33-11, Records **A** and **B,** shows the full-wound and 24-hour down rates of a watch with a flat hairspring which, of course, has no isochronal correction and always runs slower as the motion decreases. Figure 33-11, Record **C** and **D,** shows a comparable watch having a hairspring with an over-coil which does not fully compensate the rate with decreased motion and figure 33-11, Records **E** and **F,** shows another watch in this same classification in which the over-coil over-compensates for decreased motion, thereby making the watch run faster as it runs down.

From an inspection of these three records, a quick method for correcting excessive isochonal errors in watches having over-coils suggests itself, which may be also used advantageously in bringing the horizontal and vertical rates closer together without resorting to the undesirable method of altering the shape of the balance pivots. For example, a watch having a hairspring with an over-coil runs somewhat slower in all of the vertical positions than it does in the horizontal positions. It may be assumed to have an excessive isochronal error which should, of course, be roughly checked in the manner explained above.

When the wound-down rate is found to be considerably slower than the full-wound rate, the correction is made by re-shaping the over-coil slightly to have the straight part in the center section of the coil slightly closer to the staff. If this correction is over-done the watch will run faster as the motion decreases. However, a position for this over-coil section is easily reached where the isochronous error of the watch is reduced to a tolerable value, in which case a watch in good condition will have vertical rates extremely close to the horizontal rate.

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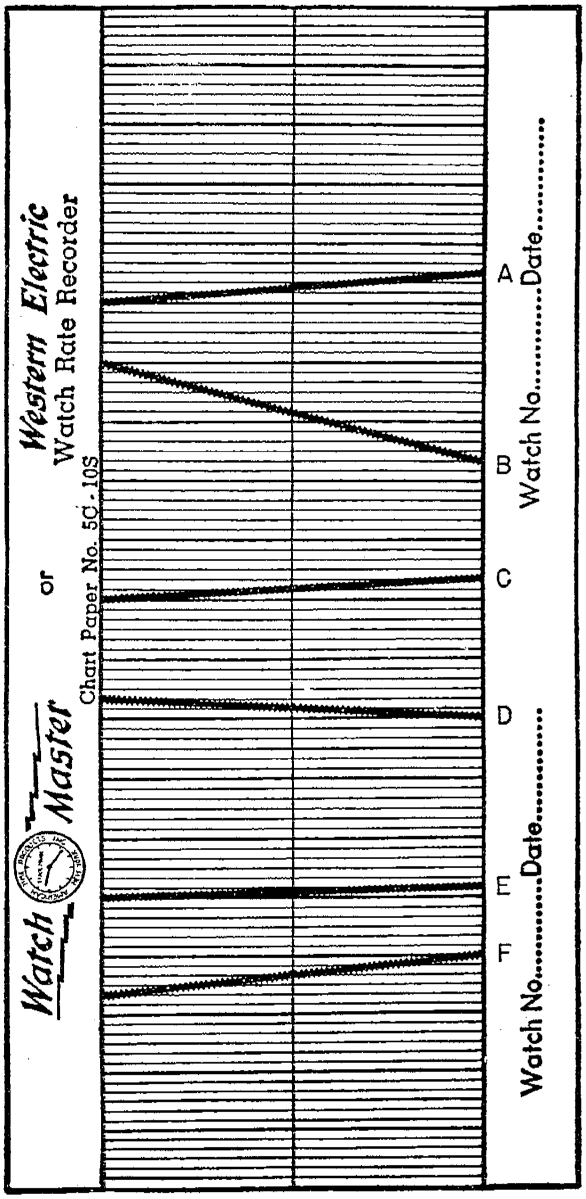

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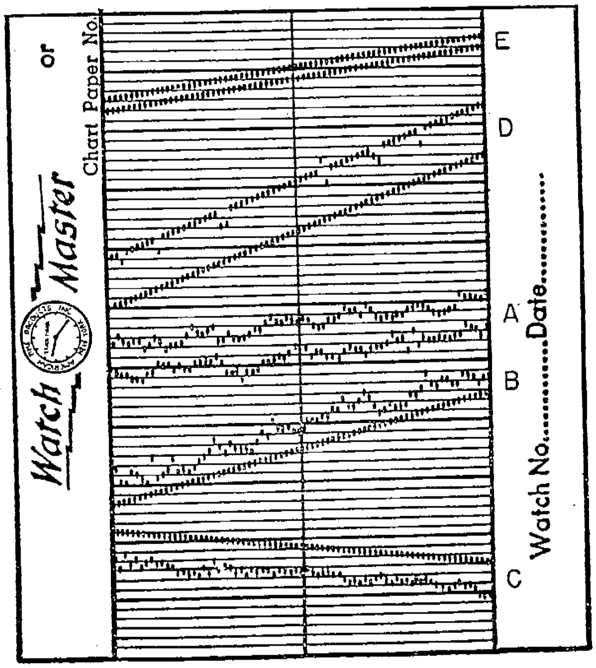


Fig. 33-12

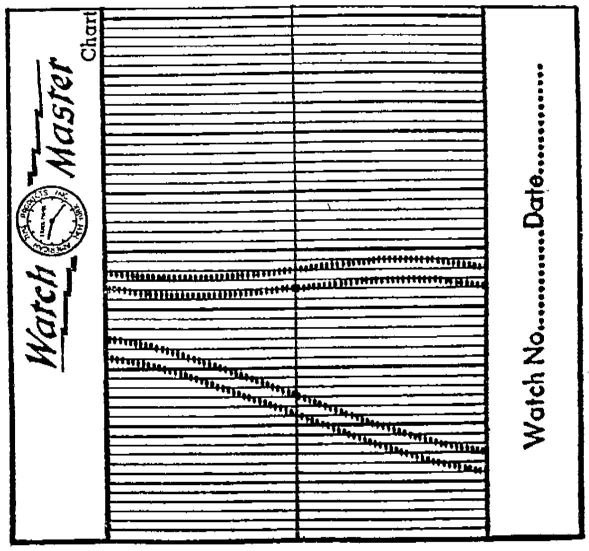


Fig. 33-13

SEC. 581—The Hairspring

The adjustment of the hairspring in the watch is the greatest single factor which contributes to the watch performance. Faulty adjustment of the hairspring and its relationship to the regulator pins can be the source of most of the erratic time-keeping which a watch in otherwise excellent mechanical condition will exhibit. Variations in rate in the vertical positions may occur when the spring is improperly centered or when it is given insufficient support in one position, thus allowing it to sag and producing an apparent out-of-poise condition. Variations in rate between dial-up and dial-down may occur when the regulator pins are not parallel. Variations in rate between the horizontal and vertical positions may occur when the over-coil is improperly formed or when the regulator pins are too far apart. Generally erratic behavior may be experienced when the spring is not centered between the regulator pins so that the restrictive effect of the two pins is unequal. Record **E**, figure 33-12, is indicative of this condition when the watch is in perfect beat statically. The effect is further exaggerated by bending one of the pins away from the spring at an angle. In addition to indicating a greater departure from perfect beat, one line of the record exhibits a slightly ragged tendency, due to spring hitting the pin at an angle and sliding an unequal amount on succesive oscillations. Record **D** is indicative of this condition which can also be caused by lack of parallelism between the pins in the direction of the staff.

Record **A** is representative of a hairspring which is not flat. This causes the flat sides of the spring to hit the pins at an angle and produces a tendency for it to slide on the pins unevenly and also causes the spring to move unevenly in the direction perpendicular to its plane. Records **B** and **C** are very common types and are indicative of trouble at only one pin. In general, a ragged upper line may be traced to the outer pin and a ragged lower line to the inner pin. None of these should be tolerated as they all are indicative of faults which make an otherwise good watch a poor timekeeper.

SEC. 582—Mechanical Faults

Many of the common mechanical faults produce characteristic records on the Watch-Master. Some of these are occasioned by the fact that most watches have some isochronal error and hence the rate changes as the power delivered to the balance changes. For instance, figure 33-13 shows two consecutive records for a watch having a defective fourth wheel. The fourth wheel revolves once per minute and as a consequence, when it is out of round, or has a bent arbor, the power delivered to the escape wheel will vary over the period of one minute and will be accompanied by a rate change as the power varies. A second hand which binds or drags on the dial on one side and not on the other is a common cause of this trouble.

Similarly, an escape wheel which is out-of-round or has any mar or bur on its pinion will cause a change ten times per minute (15-tooth escape wheel). Figure 33-14, Records **A, B** and **C,** shows the typical records for these conditions. When the wheel, itself, is out-of-round or not

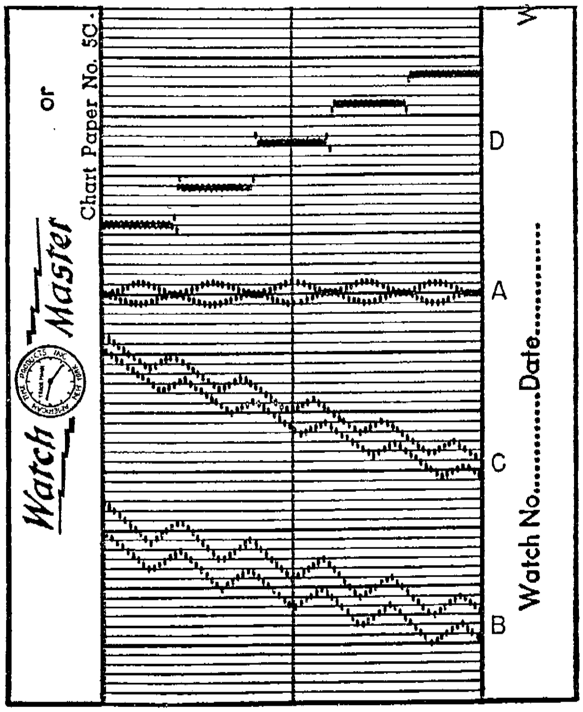


Fig. 33-14

exactly centered on the arbor, the locking of the escapement will vary as the wheel rotates and, while there may be slight changes in rate, the characteristic pattern consists of a periodic widening and narrowing of the space between the two recorded lines. This may also take the form of a single line which widens to a double line and returns to the single line at the rate of ten times per minute or five full cycles in the full 30 seconds of the WatchMaster Record. Figure 33-14, Record **A,** shows this condition.

When the pinion alone is defective, the power changes as the wheel rotates but the escapement is not affected. The record then shows a change of rate without change of pattern. Figure 33-14, Record **B,** shows this condition. When the pivot or arbor is at fault, the power transmitted usually varies and the escapement locking changes as the wheel rotates. This condition produces a record which changes rate and pattern both as shown on Figure 33-14, Record **C.**

In addition to these escape wheel faults, occasionally watches are found with a mutilated escape wheel tooth. This may result in the failure of the escapement to lock on one or both sides as this tooth presents itself to the pallet. Figure 33-14, Record **D,** shows the effect of this condition in a watch which is well adjusted in all other respects.

Occasionally, watches will produce records which indicate one or more of these escape wheel faults and upon examination, the fault

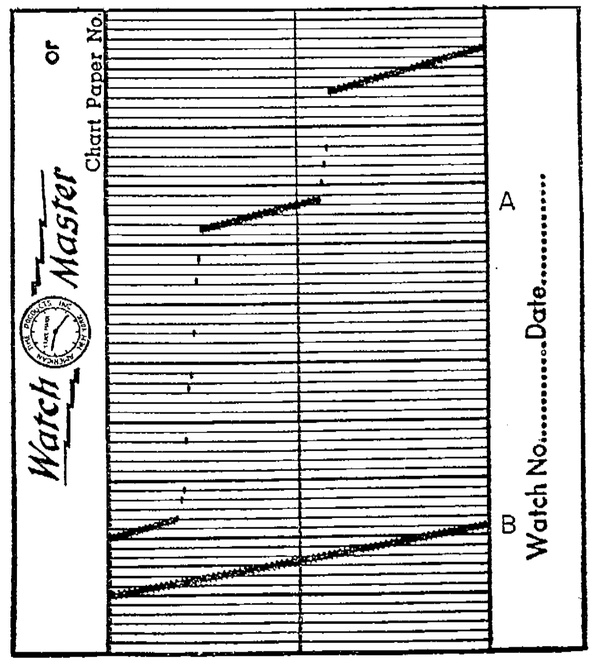


Fig. 33-15

cannot be found. This trouble will then be generally traced to a magnetized escape wheel. This is particularly true of a so-called non-magnetic watch which nevertheless has a steel escape wheel. When this condition exists the magnetism exerts a variable influence on the hairspring and the watch records a pattern which is similar to the escape wheel fault records of Figure 33-14.

Figure 33-15A is representative of watches in which the balance motion is excessive. This usually occurs after the watch has been put in first-class condition with the majority of its errors eliminated or greatly reduced. The trouble is ordinarily called "over-banking" and is caused by the roller jewel unlocking the escapement by hitting the pallet on its back side. The proper correction for this trouble consists in reducing the strength of the mainspring rather than by increasing the friction, by flattening the balance pivot ends. Figure 33-15B shows the same watch after the mainspring had been replaced.

Watches which have low motion of the balance wheel are generally unsatisfactory timepieces and are apt to be very troublesome in service. While the eye is a fairly good judge of the extent of the balance arc, the WatchMaster record gives a definite indication of the effect of the particular motion in question on the performance of the watch. In general, low motion which affects watch performance produces records which are unsteady in direction and are very characteristic of this condition. Figure 33-16 shows a record of this type. Watches which produce records having these characteristics are almost certain to be troublesome and should never be delivered until the condition is corrected.

All of the foregoing charts are indicative of watch faults which are correctable by adjustment and manipulation. These corrections are part of the finishing and timing procedure after the watch has been repaired.

There are, however, a certain number of specific faults which might be overlooked in the repairing process which produce records indicative of their existence. Such things as loose or cracked jewels, loose banking pins and loose or improperly set roller jewels produce ragged records which in some cases are similar to records produced by certain types of hairspring faults, but in general they will not vary between positions as the hairspring records do. In any event ragged, double records represent watch faults which should not be tolerated and the records furnish a clue to their correction although more than one part may contribute to the fault.

In addition to these specific faults excessive slide in the escapement has the effect of producing a ragged record when it begins to cause trouble in the watch. This may exist in one or both lines of the record and is an indication of which side to reduce the slide on. In many older watches in which the balance pivots have become slightly worn the separation between the lines vary as the watch is moved through the vertical positions. The lines will be closest together, in general, in that position where the balance is over the pallet and escape wheel, and the separation will be greatest in the position directly opposite that point with the records in the horizontal positions somewhere in between. When this condition exists, it is well to make all adjustments to the escapement in the position which brings the lines on the chart closest together. It is then likely that all other positions will be satisfactory.

In order to compensate for the wear existing in the balance pivots, it is sometimes possible to reduce the slide on one side of the escapement and increase it on the other and thus arrive at a compromise which will produce a satisfactory operating condition in all positions without interference. Figure 33-17, Records **B** and **A**, represents pendant-up and pendant-down for a watch having somewhat worn balance pivots and which has been adjusted to have a good escapement action in a horizontal position. It is noted that interference is encountered in the pendant-up position which makes an extremely erratic record and in the pendant-down position the lines have separated considerably.

The slide in this watch was then adjusted in the pendant-up position until it was optimum, and the results are shown in figure 33-18. Note that the records for the various positions have been brought very close to the same separation and the action is extremely good in all positions. This is accomplished without the necessity of replacing the staff and possibly the jewels in the watch.

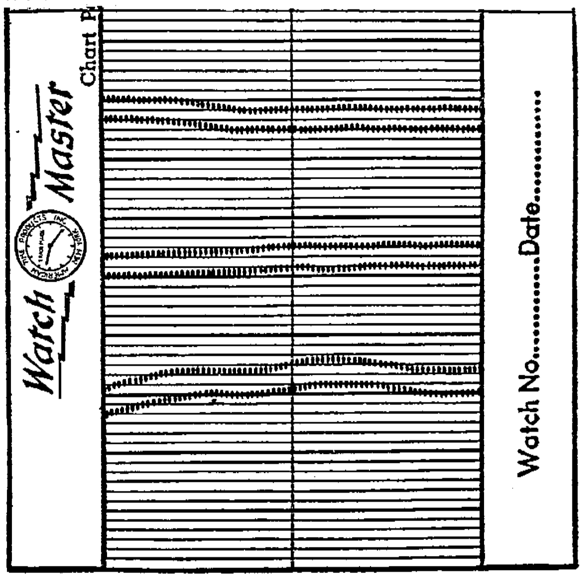


Fig. 33-16

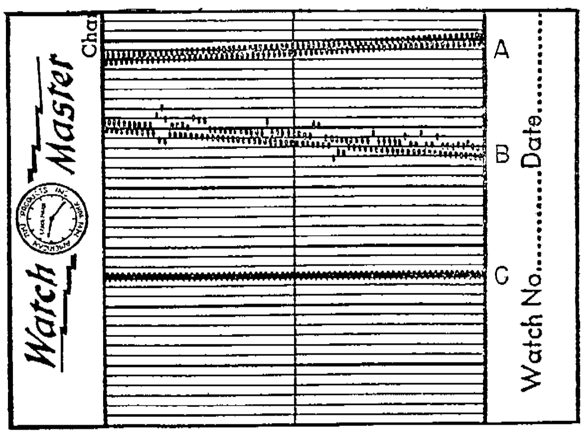


Fig. 33-17

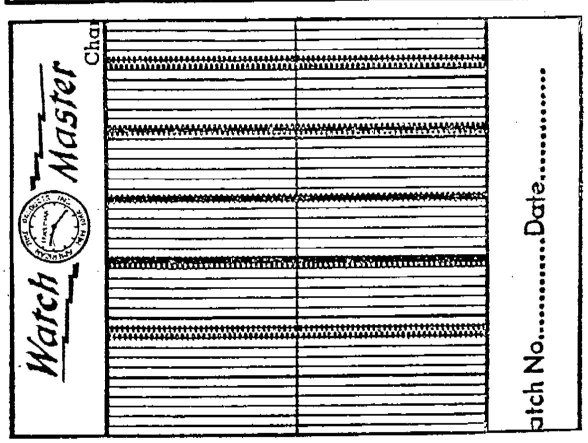


Fig. 33-18

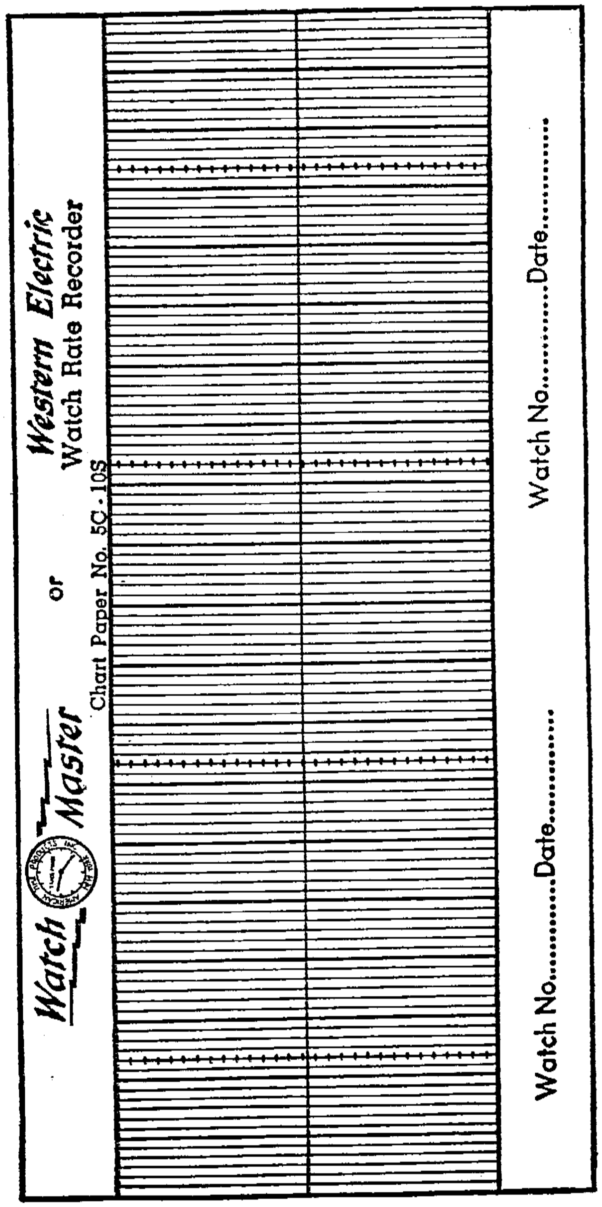


Fig. 33-3

of them may be used to read the rate in the same manner as the complete line is used for five-beat watches. Figure 33-3 represents a four-beat movement which is keeping correct time.

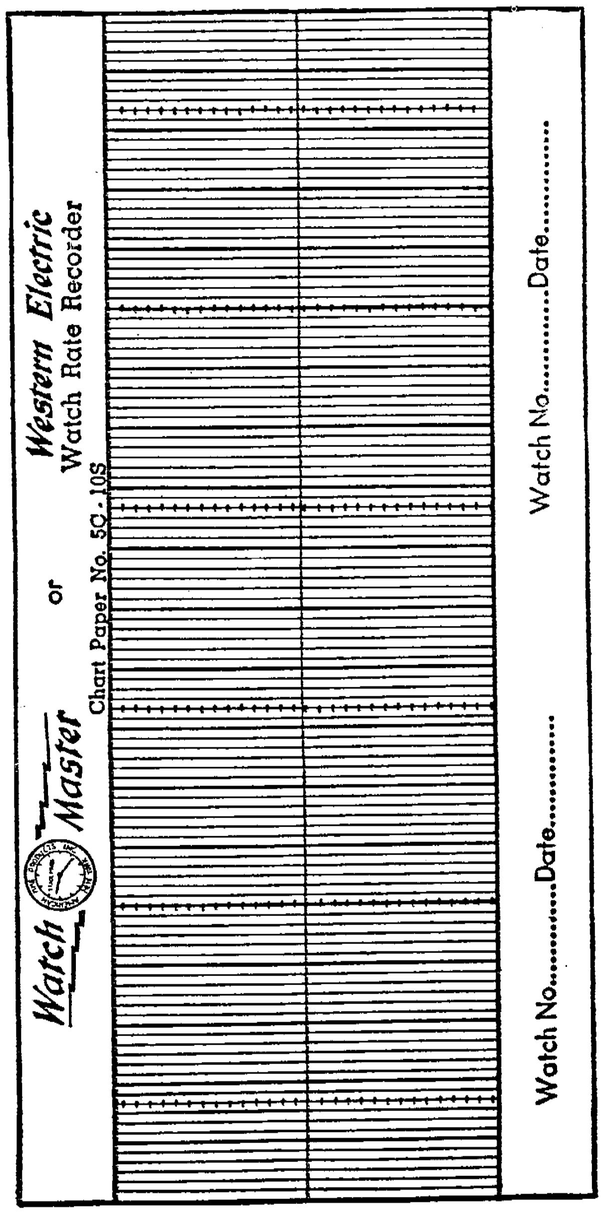
The manner in which the record from a six-beat movement is produced is similar except that six marks are produced for every five revolutions of the drum. In this case five sixths of a revolution occurs between successive ticks. This results in six separate lines of dots any one of which is usable in the regular manner. Figure 33-4 represents a six beat movement which is keeping correct time.

There are a number of other odd beats frequently encountered. Records from these movements are produced in a similar manner and all are usable in the same way. Typical records for most of the odd beat movements are shown at the rear of this lesson, together with a list of most common makes and sizes using each beat.

SEC. 578—Wrist Watches

When the WatchMaster is used for timing wrist watches of average commercial grade, it is generally unnecessary to make the complete 30-second record in each position. This is due to the fact that very few wrist watches will repeat their instantaneous rates exactly from one minute to the next and the average rate must be used. The dial-up and crown-down positions control the performance of a wrist watch when worn and the average between the rates in these

Fig. 33-4



positions is a satisfactory basis for wrist watch timing. This two-position average is obtained by placing the watch in the holder with the dial up and the crown either to right or left.

The WatchMaster is started in the usual manner and when the record reaches the longitudinal dividing line, the watch is turned to the crown-down position without stopping the instrument. Each half of the record represents the twelve-hour rate in the respective positions used and when the chart is read for its full width, the twenty-four hour average is obtained. Record **A,** figure 33-5, shows a wrist watch which has been timed in this manner. The dial-up rate is 10 seconds per day slow and the crown-down rate 80 seconds per day slow. The twenty-four hour average is read as 45 seconds per day slow.

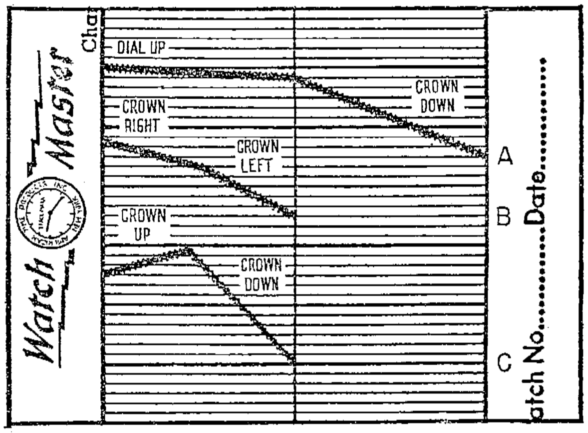


Fig. 33-5

In order to make certain that a serious rate error does not exist in one of the other positions, it is desirable to quickly check the crown-right and crown-left positions before bringing the watch to time. Record **B,** figure 33-5, shows the crown-right-and-left rates for same watch and illustrates the method used in making these quick checks. The rates are similar to the crown-down rate indicating a satisfactory condition. Record **C,** figure 33-5, shows a similar watch in which the balance is out of poise in a manner which does not affect the crown-down rate. This watch could not be expected to keep good time when worn and the error must be corrected before bringing to time.

The watch represented by Records **A** and **B** of figure 33-5 is in satisfactory adjustment for timing and the dial-up, crown-down average rate is 45 seconds per day slow. Since wrist watches generally run slightly slower when worn than they do when perfectly stationary, this watch should be adjusted somewhat more than 45 seconds per day faster. One position only is necessary for this operation although quick position checks are desirable to make certain that other errors have not been introduced by the timing operation.

Figure 33-6 shows the steps followed in regulating the watch and the use of short records to obtain an indication of the extent of the adjustment. Record **A** shows the result of the first attempt. This record represents a rate

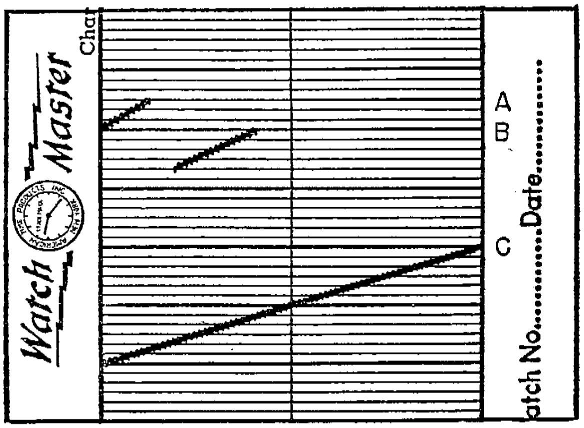


Fig. 33-6

approximately two minutes fast. Record **B** represents the next attempt—about 90 seconds fast. After a further adjustment the full record is made and the watch found to be one minute fast in the dial-up position. This should be about right for this particular watch as the average would then be about 30 seconds fast which allows for the amount the watch will run slow when worn and still have it gain slightly. This is the desirable condition to achieve as a slightly slow watch is unsatisfactory.

All of the records shown up to this point are representative of watches in good mechanical adjustment where the time from "tick" to "tock" is exactly the same as the time from "tock" to "tick" and hence are in perfect beat. Any departure from this time relationship is evidenced by a double line of dots as shown in figure 33-7. The separation between the two lines is a direct measure of this "time" difference and hence the amount the watch is out of beat dynamically (when it is running).

When the watch has been placed in beat statically, by visual inspection of the roller jewel with respect to the line of centers of the balance staff, pallet, and escape wheel arbors, there are at least two more factors which contribute to the dynamic beat condition. The first of these is the relative amount of angular travel the pallet makes on either side of center, (pallet travel is determined by the banking pin adjustment), and should be exactly the same on both sides of center in order that the time of balance swing on each side should be the same. The second contributing factor is the relationship between the hairspring and the regulator pins. It is vitally important that the spring be centered between the pins at rest and that both pins have the same restricting value on the spring at all motions normally encountered.

When all of these conditions have been met, the balance and hairspring combination are in the best condition to oscillate freely and be least affected by variable mechanical influences. The existence of this state of adjustment is evidenced by a single line record which is clean and does not show changes of time between succeeding ticks or ticks and tocks. In wrist watches of ordinary commercial grade, it may be impractical to attain this true state of dynamic beat due to the miscellaneous mechanical imperfections normally present. With watches of this type a compromise adjustment which will produce a double line record with a clear separation not to exceed one small chart division may be assumed to be acceptable. Record **B,** figure 33-7, is representative of such a compromise which may be assumed to be satisfactory although obviously not perfect.

Most watches have balance and hairspring assemblies which are out of true dynamic poise even though the balance wheel itself has been carefully poised before adding the spring. Part of this effect is due simply to lack of symmetry of the collet and inner spring termination and it can be reduced by counterpoise. A further contribution to the apparent out-of-poise condition is made by the tendency of the spring to sag when improperly supported.

SEC. 579—Out of Poise

In a carefully designed watch, the hairspring pinning points have been chosen to provide the most support to the spring in the positions which are most important. Most support is given in the pendant-up position and the least in the pendant-down. A sagging spring has the same general effect as an out-of-poise balance and the position which is affected the most is located in the same manner. When all other conditions are normal, this will generally be found in the pendant-down position. A slight movement of the inner regulator pin in the direction of the spring body away from the stud will be found effective in affording more support in the pendant-down position with a slight improvement in the pendant-right and left rates.

The principles involved in locating the effective heavy side are as follows:

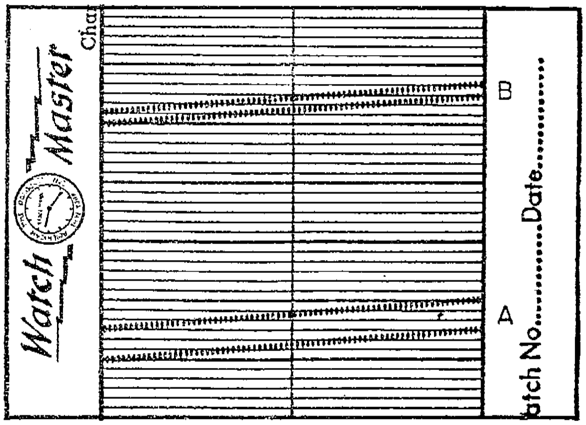


Fig. 33-7

Figure 33-8 shows the rates in one horizontal and four vertical positions in a watch which has the balance somewhat out-of-poise but is otherwise in good condition. The heavy spot on this balance is directly down with the pendant-up and the balance at rest in dead center. This is the position with respect to the out-of-poise condition of the balance which produces the fastest rate and the slowest rate is found directly opposite, in this case with the pendant-down. The pendant-right and left positions are not appreciably affected by this out-of-poise condition and remain close to the rate of the watch in the horizontal position.

Figure 33-9 shows the rate of the same watch in the same positions as in figure 33-8 with the heavy spot on the balance moved half

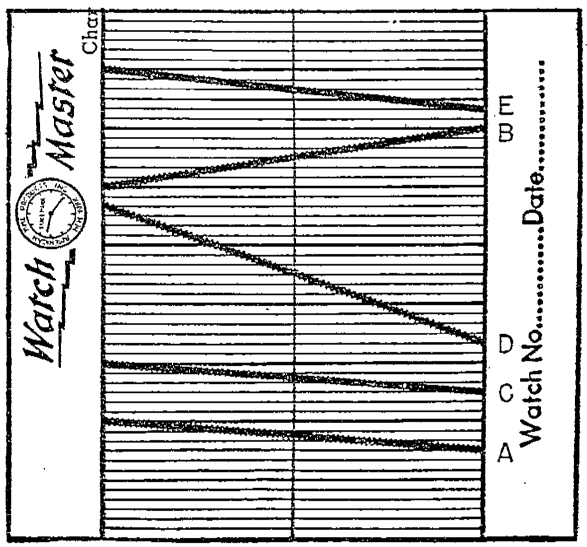


Fig. 33-8

E Pendant right
B Pendant up
D Pendant down
C Pendant left
A Dial up

way between the six and the nine on the dial with the pendant-up and the pendant-left rates are now fast and the pendant-right and pen-

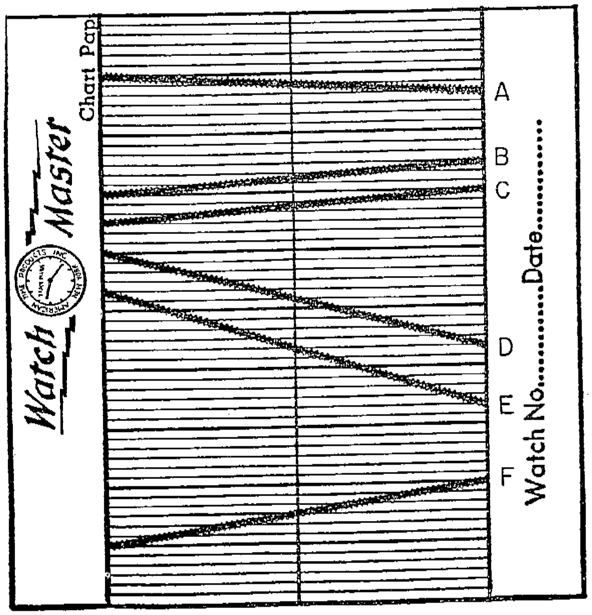


Fig. 33-9

A	Dial up	D	Pendant down
B	Pendant up	E	Pendant right
C	Pendant left	F	Pend. Half left

dant-down rates are slow, the errors in each case being less than the maximum errors indicated in Figure 33-8.

A comparison between figure 33-8 and 33-9 indicates that the fastest rate on the watch in the condition of figure 33-9 would be expected with the pendant moved half-way left, (in other words, the position corresponding to the 1½ on the dial uppermost). Figure 33-9, Record **F**, shows the rate in this position and this rate checks exactly with the pendant-up rate with the watch in the condition as shown in figure 33-8.

Figures 33-8 and 33-9 indicate the method to be followed in determining the balance poise error in any watch and offer a ready means of making a correction which will bring the watch within acceptable limits for its particular grade in a minimum of time. For example, the watch used in obtaining Records in figures 33-8 and 33-9 has its balance arbitrarily thrown out of poise by the addition of a single timing washer under one balance screw.

The effects of lack of poise are the same regardless of the cause. When the obvious mechanical conditions of wheel poise and collet center poise and pin support have been fulfilled and an out-of--poise condition is still apparent, the trouble will generally be found in the manner in which the spring develops. This is corrected by slightly altering the spring so that it develops in a direction away from the apparent heavy spot as located above.

Many watches, particularly of the cheaper grades, will be found with the regulator pins spread too far apart in order to correct the horizontal rate while leaving the regulator in the center of its scale. The most serious error caused by this manipulation appears to be the increased position error encountered.

Most of the error encountered through this condition is truly isochronous in that a difference in rate accompanies a change in motion. In this case the effect of the pins is reduced as the motion falls off in the vertical position, thereby making the full length of the spring to the stud effective for a greater part of the time and thus making the watch very much slower at the reduced motion encountered in the vertical positions.

Figure 33-10, Records **A, B and C,** show three positions of a watch having regulator pins excessively far apart. The horizontal rate is approximately correct, the pendant-down-and-up rates are very slow.

Figure 33-10, Records **A¹, B¹** and **C¹**, show the same three positions after the regulator pins had

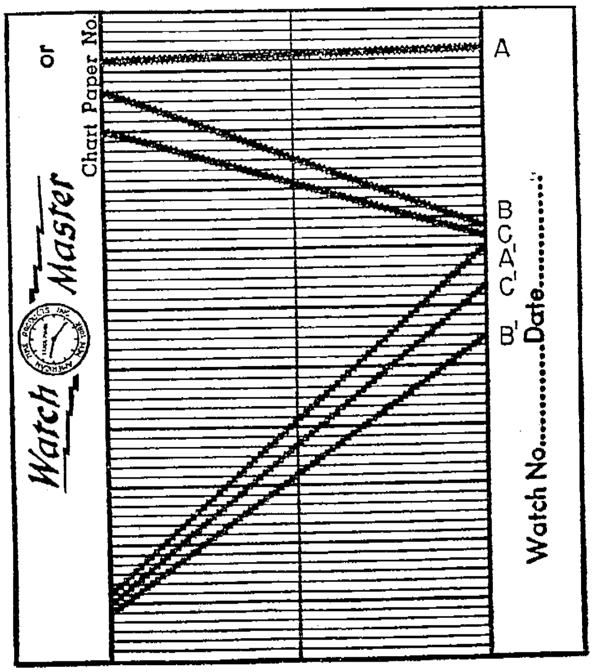


Fig. 33-10

A *Dial up*
B *Pendant up*
C *Pendant down*
A¹ *Dial up*
C¹ *Pendant down*
B¹ *Pendant up*

SEC. 583—Odd Beat Movements

The WatchMaster is primarily designed to record the action of watches having 18000 beat per hour trains. This means that the drum turns at exactly 18000 revolutions per hour and the comparison between the watch rate and the machine rate is read directly from the chart. However, the very nature of the WatchMaster design insures an adequately readable record for any other beat up to at least double the normal rate, or 36000 per hour. Most of these so-called odd beats record multiple line records around the drum, any of which are usable in the regular manner. This condition exists for all beat rates that are reducible to a small common fraction of the drum speed. For example, a watch which beats only four times per second will make four dots in five revolutions of the drum. This means that one and one quarter revolutions of the drum will be made between beats and every fifth beat will record at the same position on the drum. The intervening beats will record at evenly spaced intervals around the drum, one-quarter revolution apart. Thus, a four beat movement will record a pattern of four lines all equally spaced and parallel to the drum when on time. From this fact, it may be shown that any beat which bears a common fraction relationship to the rate of the drum with a difference of one between the numerator and denominator will record a multiple record parallel to the drum. The following table lists these odd beats which will produce lines parallel to the drum when on time.

Beat	Ratio to 18000	Lines	Ratio to 18000	Beat
14400	4/5	4	4/3	24000
15000	5/6	5	5/4	22500
15428	6/7	6	6/5	21600
15750	7/8	7	7/6	21000
16000	8/9	8	8/7	20571
16200	9/10	9	9/8	20250
16363	10/11	10	10/9	20000
16500	11/12	11	11/10	19800
16615	12/13	12	12/11	19636
16714	13/14	13	13/12	19500
16800	14/15	14	14/13	19384
16875	15/16	15	15/14	19285
16941	16/17	16	16/15	19200
17000	17/18	17	17/16	19125
17052	18/19	18	18/17	19058
17100	19/20	19	19/18	19000

The maximum number of lines which can be read is nineteen. Any beat which is closer to 18000 than the beats which produce nineteen lines is read as one line with an off-time slope. Any beats which are other than the exact ones shown on the above chart produce the number of lines shown for the nearest exact beat but will have a slope which is representative of the difference between the beat of the watch and the nearest beat shown. The amount of this slope is determined by subtracting the value of the nearest beat shown from the beat of the watch, dividing this difference by the exact beat shown and multiplying by 86400, the number of seconds in one day. This product will represent the slope of the record for the beat in question when keeping correct time. The sign of the answer will determine whether the indicated record is gaining or losing. Plus represents a gain and minus a loss. For example, 20222 is a relatively common beat for medium small size Swiss ladies' watches. The nearest exact beat shown is 20250, which produces nine lines. The correct time slope is determined as follows:

$$\frac{\text{Beat of watch under test (20222)} - \text{Nearest exact beat (20250)}}{\text{Nearest exact beat (20250)}} \text{ X } \begin{matrix}\text{No. of}\\ \text{second per}\\ \text{day}\end{matrix}$$

$$\frac{20222 - 20250 \text{ X } 86400}{20250} = \frac{28}{20250} \text{ X } 86400 = -120 \text{ seconds per day}$$

The correct record for a watch which is designed to beat at the rate of 20222 per hour is therefore nine lines evenly spaced around the drum at a slope of 120 seconds or 2 minutes per day slow.

SEC. 583A —Typical Odd-Beat Charts

The following charts have been included to show the on-time record for most of the common types of odd beat movements. In reading a watch rate of this type only one line is used and the watch is fast or slow by the amount the record departs from the on-time record shown. Any watches having beats other than those shown may be checked by referring to the method outlined above.

Perfect Record — 14,400 Beats Per Hour

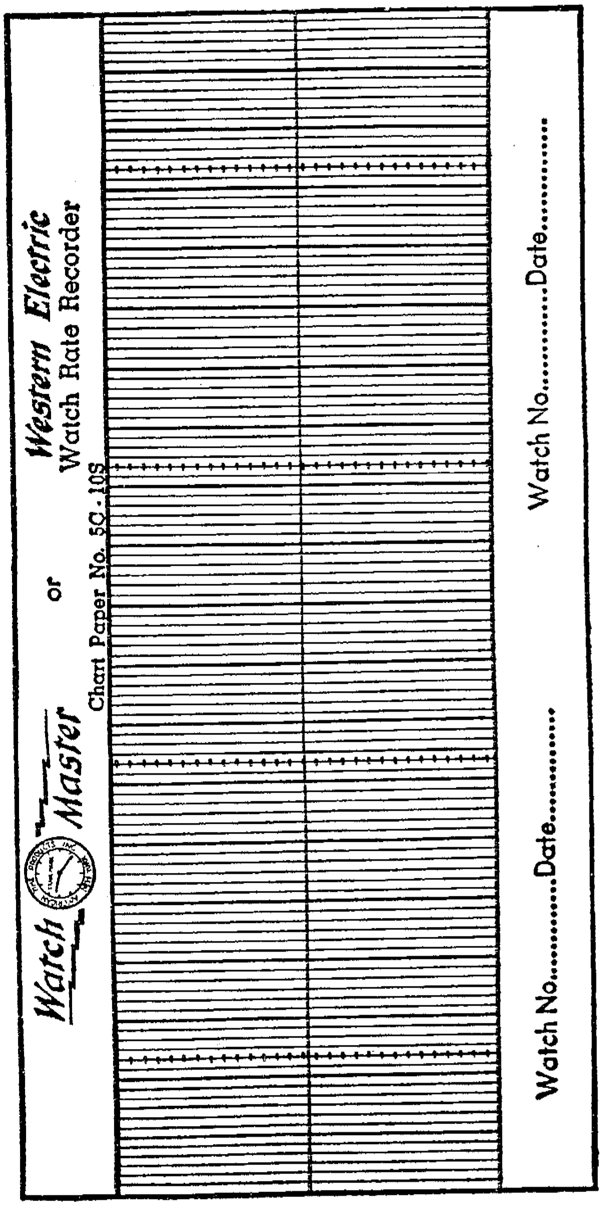


Fig. 33-19

4 lines — Horizontal

The rate can be easily determined in the manner described in the introduction to this section.

This beat is common in cheaper watches and alarm clocks.

Perfect Record — 19,800 Beats Per Hour

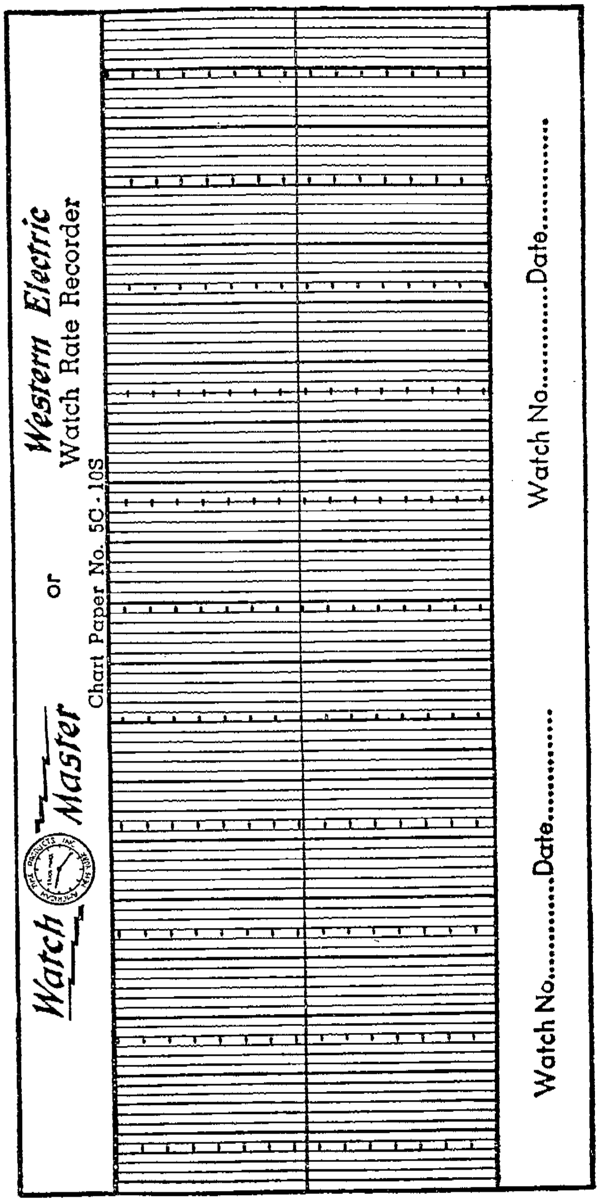


Fig. 33-20

11 lines — horizontal — indicates a correct rate.

If the lines slope upward, the rate is fast—if the slope is downward the rate is slow. (The same as for 18,000 beat per hour movements.)

Manufacturer	Model or Size
Elgin	Baguette
Omega	5½ ligne oval
Concord	5½, 7¾ ligne and "R. Cart"

Perfect Record — 20,160 Beats Per Hour

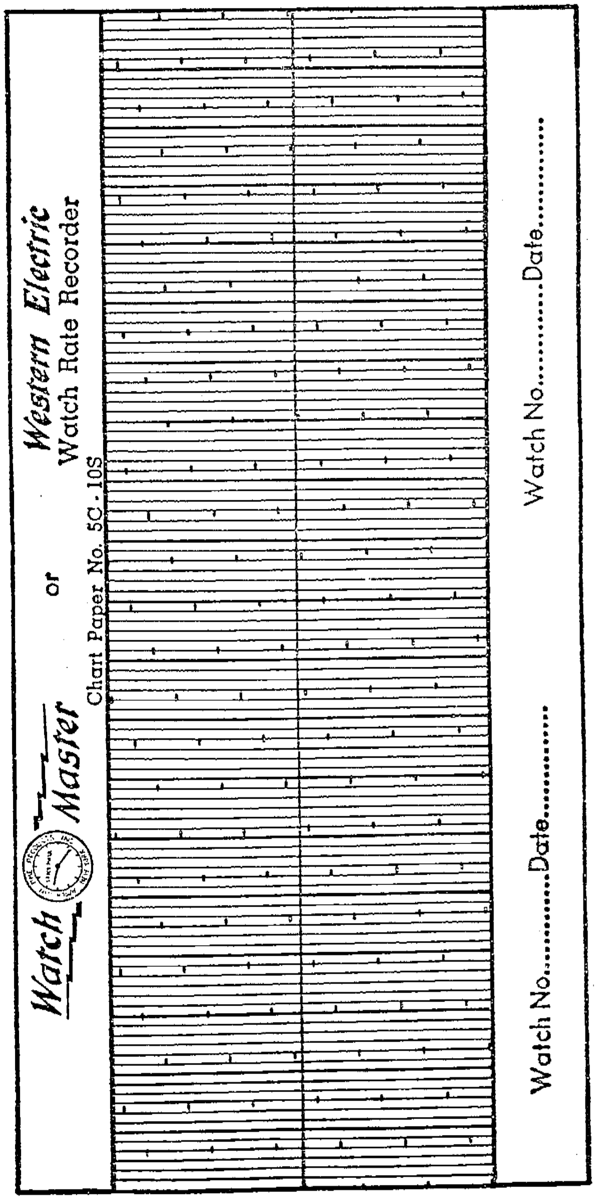


Fig. 33-21

9 lines— 6 min. 24 sec. "SLOW" — indicates a correct rate.

If the lines do not slope downward as much as this, or if they slope upward, the rate is fast—also if the slope downward is more than this, the rate is slow.

The rate can be easily determined in the manner described in the introduction to this section.

Manufacturer	Model or Size
Huguenin	5½ ligne
Gruen	Most small Models

Perfect Record — 20,222 Beats Per Hour

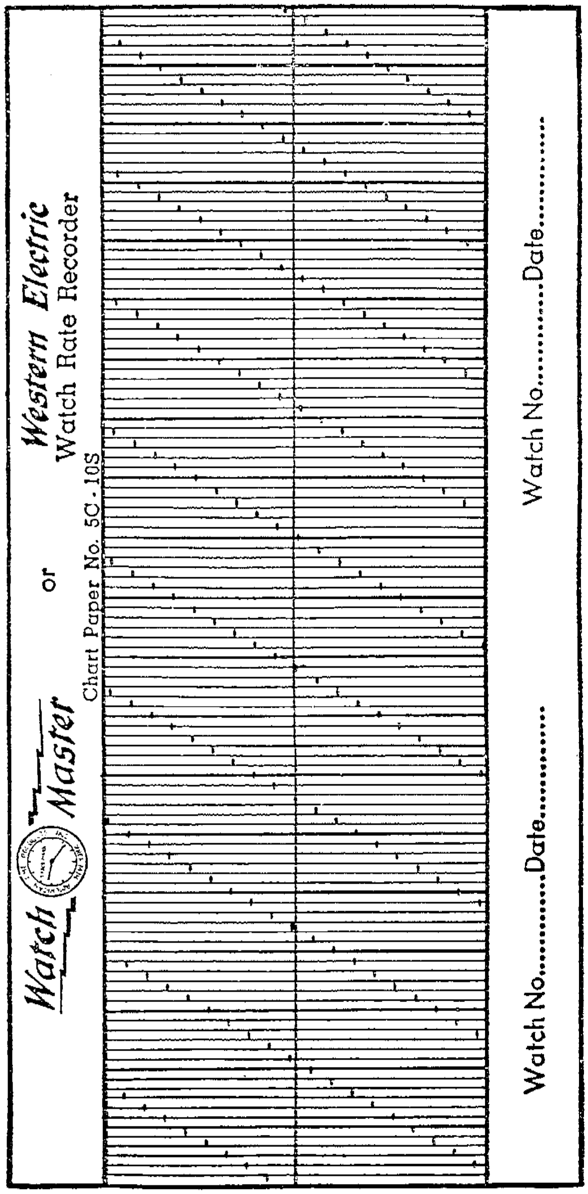


Fig. 33-22

9 lines — 2 min. "SLOW" — indicates a correct rate.

If the lines do not slope downward as much as this, or if they slope upward, the rate is fast—also if the slope downward is more than this, the rate is slow.

The rate can be easily determined in the manner described in the introduction to this section.

Manufacturer	Model or Size
Agassiz	8 ligne (8PCV)
Meylan	7 and 8 ligne
Haas	8 ligne round
Gruen (old)	105, 840, 845

Perfect Record — 20,944 Beats Per Hour

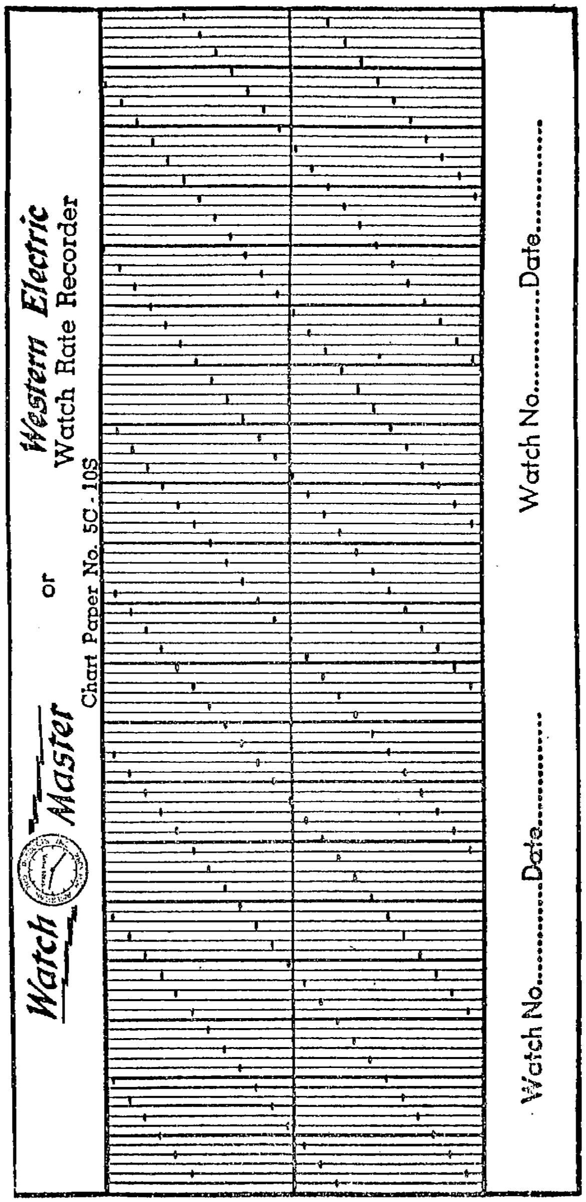


Fig. 33-23

7 lines — 3 min. 50 sec. "SLOW" indicates a correct rate.

If the lines do not slope downward as much as this, or if they slope upward, the rate is fast—also if the slope downward is more than this, the rate is slow.

Manufacturer	Model or Size
Vacheron and Constantine	7 ligne oval
Agassiz	7 ligne (PCV, AO, Z)
Meylan	7 and 8 ligne
Nardin	7 ligne round
Merrimont	7 ligne oval
Gruen (old)	839, 847

Perfect Record — 21,000 Beats Per Hour

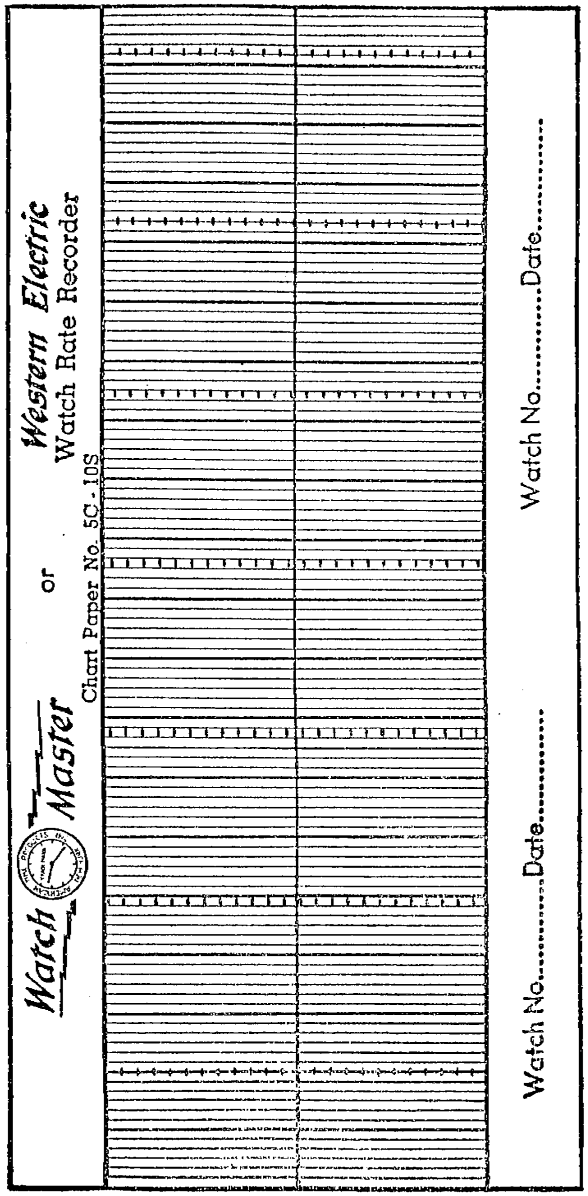


Fig. 33-24

7 lines — horizontal — indicates a correct rate.

If the lines slope upward the rate is fast—if the slope is downward the rate is slow. (The same as for 18,000 beat per hour movements.)

Manufacturer	Model or Size
Touchon	4 ligne Rect.
Patek Phillipe	Baguette
Audemars Piquet	8 ligne Rect.
Omega	Baguette
Cartier	Some Models

Perfect Record — 21,600 Beats Per Hour

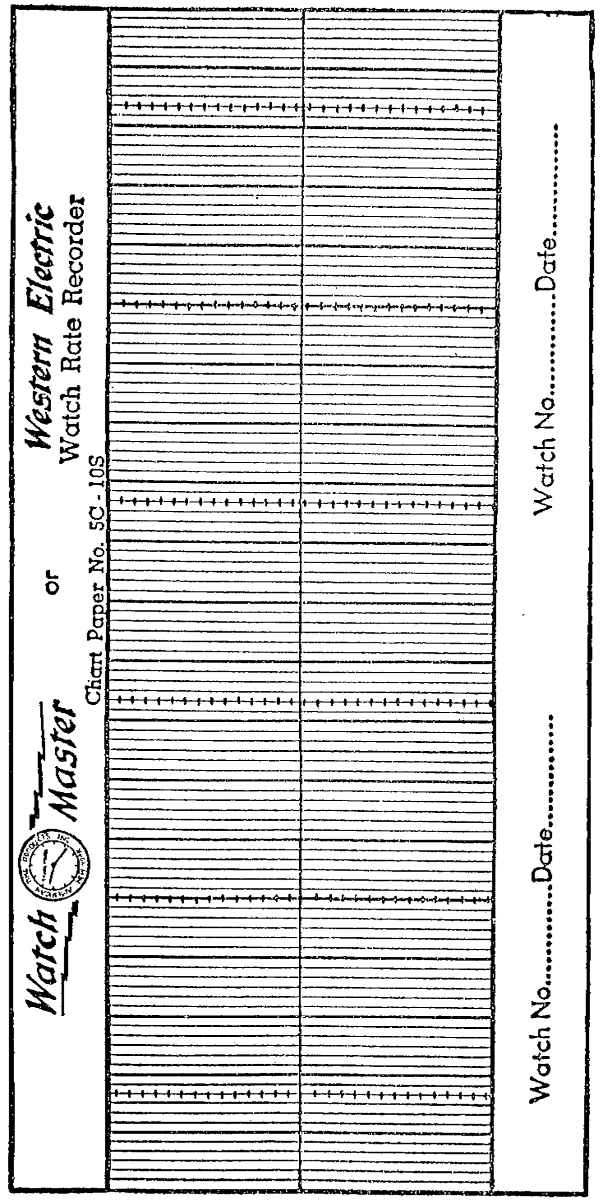


Fig. 33-25

6 lines — horizontal — indicates a correct rate.

If lines slope upward the rate is fast—if the slope is downward the rate is slow. (The same as for 18,000 beat per hour movements.)

Manufacturer	Model or Size
Agassiz	8 ligne (8AC)
Waltham	Baguette (400)
Cartier	Some Models

SUPPLEMENTARY INFORMATION

FAST TRAIN WATCHES

Introductory Information:

This information bulletin was published by Longines-Wittnauer some years ago. It mentions only specific models in use at that time. However, nearly all ladies watches, 6-3/4 ligne and smaller, are now of this fast beat type and the general information applies to all of them.

MOVEMENT SIZE—21,600

Longines 13.50
Longines 119

A fast train watch is one whose balance oscillates faster than five times a second (300 vibrations per minute, 18,000 VPH). Two principal advantages of the faster train as found in ladies watches such as the Longines and LeCoultre models above will be appreciated by a superior watchmaker.

1. Longer periods between servicing requirements.
2. Closer regulation and better timekeeping.

The first advantage is due to the increase in power and increased speed of the moving parts. In very small five beat movements the hairsprings are delicate and weak, with the faster balance the hairspring is stiffer and stronger.

It is obvious that every dust particle or bit of foreign matter presents a relatively large obstacle to the tiny gears. The smaller the watch, the larger the dust particles become by comparison. In a fast train watch the gears go faster and override small obstacles that would ordinarily stop them. The same benefits apply to the escapement, in a fast train watch the balance performs the unlocking action with greater speed and more positive assurance. The escape wheel and the train wheels move much faster during the action of lift and drop and more easily ride past minor obstructions. The fast train watch should run for longer periods before service is required.

The closer regulation possible with fast train watches is appreciated with a little study. The loss of one tick in a watch beating five times per second is obviously greater than the loss of a tick to a watch beating six times per second. In both instances, moving the regulator brings a proportionate change in speed. With a faster balance, any movement of the regulator is comparatively small and more critical regulation is possible.

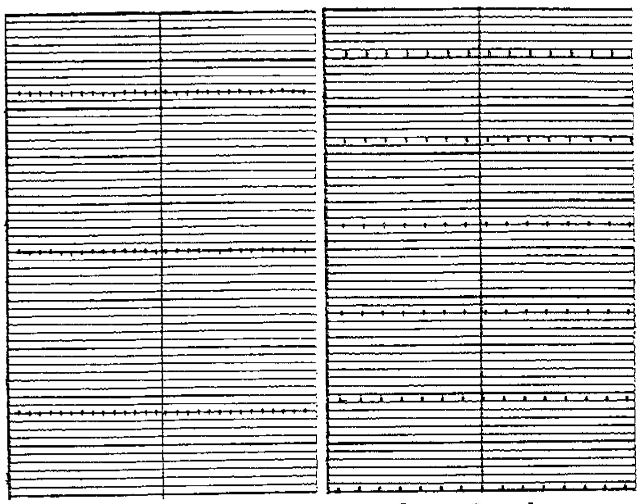
MOVEMENT SIZE—19,800

Longines 14.16 Longines 19.4
Longines 13.15V LeCoultre 812 Automatic

Easier servicing is another advantage to the watchmaker in the fast train watch. In the small five beat movements, because the hairsprings are delicate and weak, they are often damaged. The stiffer and stronger hairspring of the fast train watch is more resistant to accidental damage, tangling or kinking.

In the past, some fast train watches have been produced with odd numbers of vibrations per hour. However, the Longines and LeCoultre fast-train watches beat either 19,800 VPH which is 10% faster than the normal 18,000; OR 21,600 VPH or 20% faster than the normal. Consequently, these movements can be checked with any type of timing machine—new or old—and will print a straight line.

The graphs below show the type of pattern produced by the 19,800 and 21,600 VPH movements, on both the machine with the revolving drum (Watchmaster) and with the continuous tape type such as Vibrograph or Paulson.



Correct Record 21,600 *beats per hour*   *Correct Record* 19,800 *beats per hour*

Fig. 33-26

Sec. 584 - Later Developments

SEC. 584.1 - The WatchMaster G-47

The early timing machines, including the G-11 discussed in this lesson, were rather large. In 1955, American Time Products brought out a new model, the G-47, figure 33-27. This was considerably smaller (8-1/2 x 13 x 6-3/4 inches) and lighter in weight (17-1/2 pounds). It operates basically the same as the machine already discussed, but had a new gear shift lever which produced single line records for the common odd beat movements.

The watch holder is detached and accommodates either cased or uncased movements. The holder is made of non-magnetic metals throughout. This holder can also be used as a hairspring vibrator with a quick adjustment. The microphone unit can be removed from the holder to test clocks, watches on customer's wrists, new watches in trays or just received in stock. The machine has nylon gears which need no oiling.

Another company made a plastic recording drum which fitted this model of WatchMaster and eliminated the need for the chart paper. The record could simply be wiped off.

Early models of the G-47 had the gear shift lever on top of the machine. In later versions, figure 33-28, this lever was moved next to the center knob (chart knob).

SEC. 584.2 - The WatchMaster G-57

The G-57, a tape model recorder, was also produced for a time. On this model, the calibrated chart paper moved

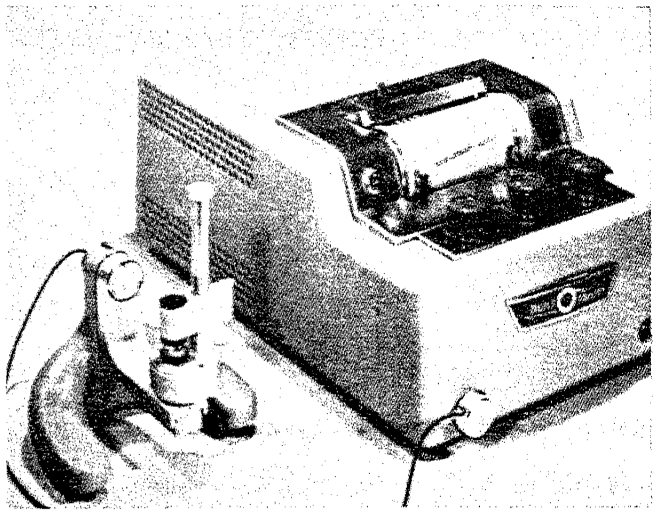


Fig. 33-27

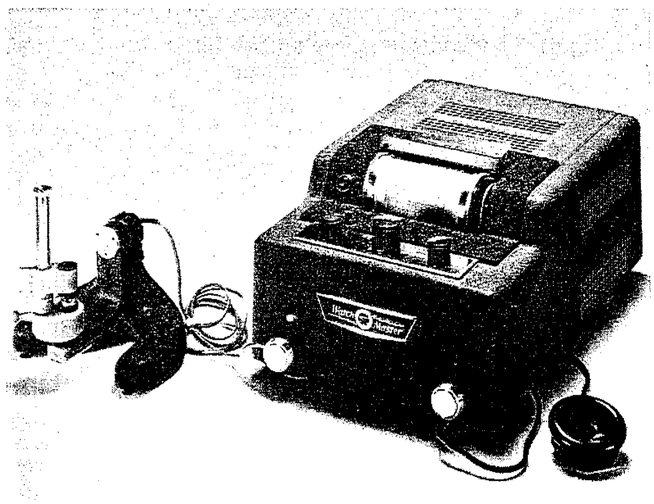


Fig. 33-28

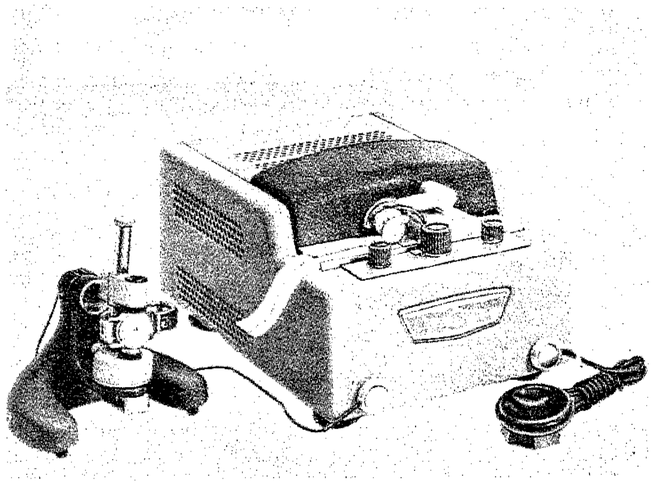


Fig. 33-29

across the front of the machine, figure 33-29, and gave a continuous visible record. Unlike the drum type recorders, the G-57 did not use ink or ribbon but printed by a helix, the spiral shape shown at center front. The helix had a thin printing strip on its outer diameter which marked like a pencil when a printer bar pressed it against the chart paper. Recording followed the same pattern as the drum models and the gear shift lever allowed odd beat movements to record as one line.

This machine is no longer in production as a change to the Vibrograph recorder made the G-57 unnecessary.

SEC. 584.3 - The Vibrograph

In 1960 American Time Products became a division of Bulova Watch Company under the name of Watchmaster Products. Efforts to modify existing machines in anticipation of the the forthcoming Accutron were not wholly satisfactory. Watchmaster therefore became the exclusive U.S.A. distributor of the Vibrograph recorder, made by Portescap, a Swiss company.

SEC. 584.4 - The Vibrograph B-100

The standard model Vibrograph, the B-100, figure 33-30, replaced the G-57. The B-100 was smaller, (8-5/8 x 11-1/2 x 5 inches high) and uses plain paper tape rather than calibrated chart paper. It is a push button model, which produces single line records from regular and odd beat watches with these beats: 10800, 12000, 14400, 17280, 18000, 19800, 21600, 36000, and multiples of these. The rate is read through an adjustable, calibrated scale. The B-100 uses a quartz crystal frequency standard rather than a tuning fork.

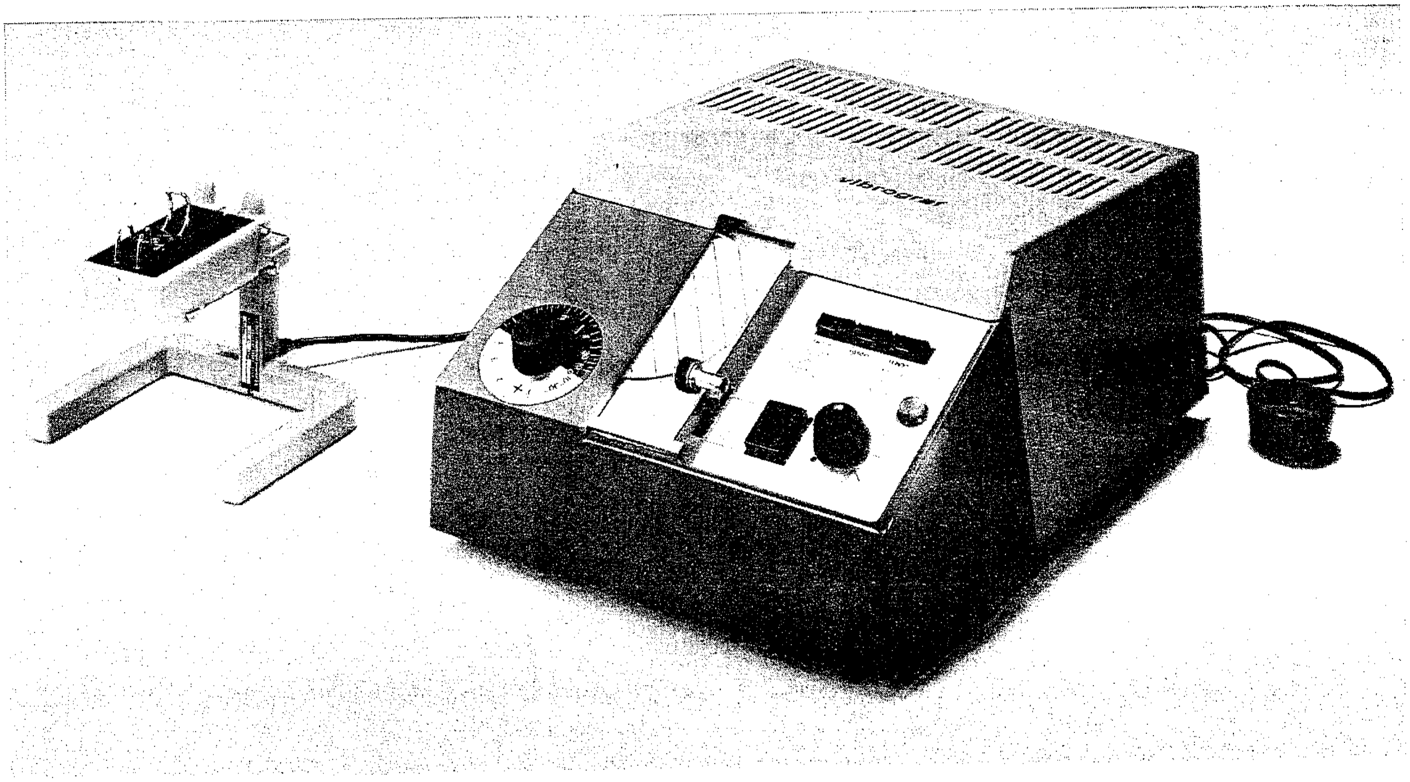


Fig. 33-30

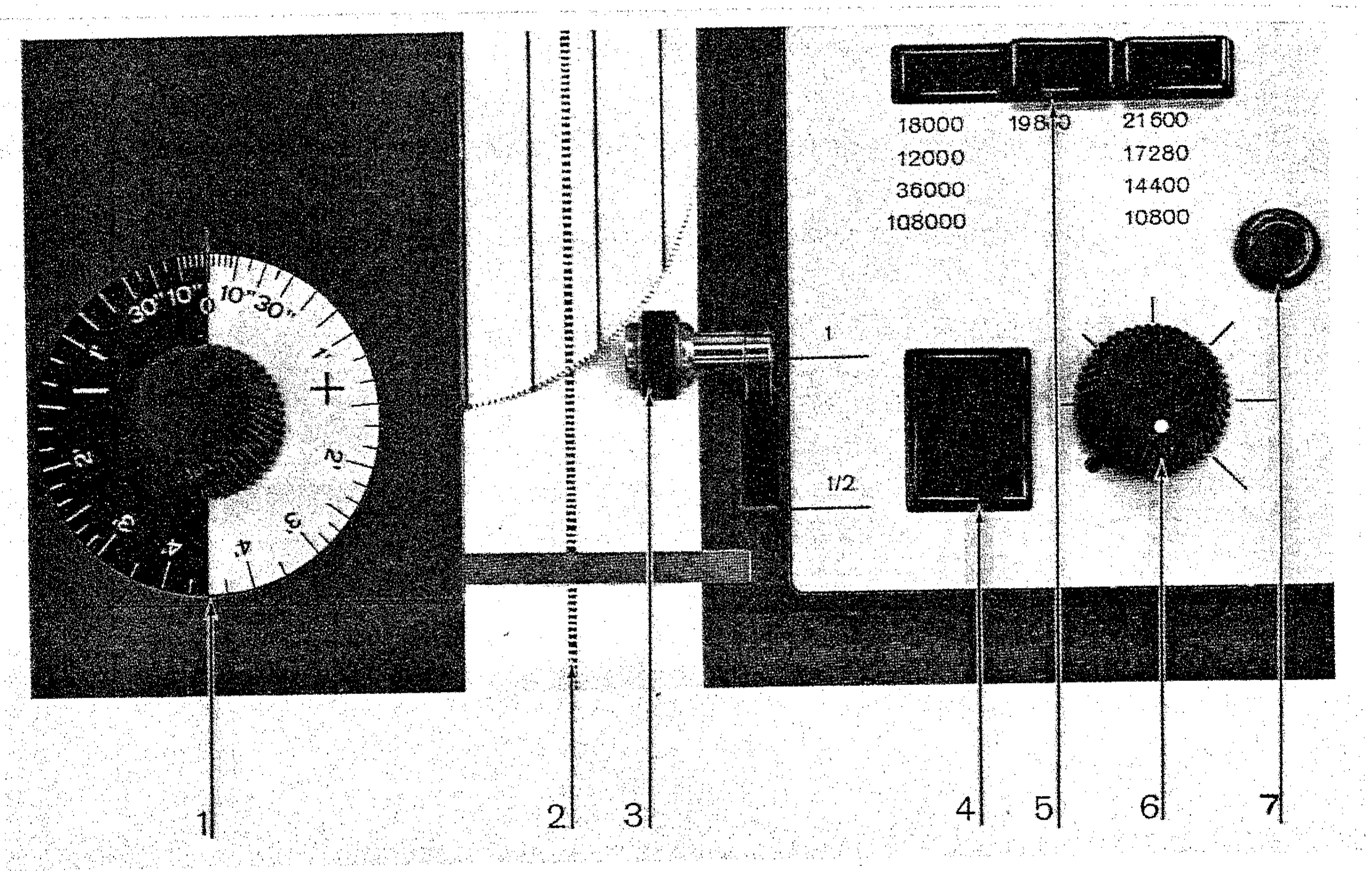


Fig. 33-31

1. Movable dial to read accurately the gain or loss of the watch's timing in seconds and minutes.

2. The printed recording on paper. Provides a visual check on the precision of the watch and any faults.

3. Paper speed control lever. The slow speed is for observations over a long period of time thereby doubling the precision of the reading.

4. Push button system for starting and stopping the paper movement.

5. Push button system for selecting the right frequency.

6. Knob for starting the machine and for regulating volume.

7. Pilot light to show machine is on.

Continuous tape machines like this one operate like the Time-O-Graf and others described in the next lesson. The lines on the transparent dial are lined up with the printed record and the gain or loss in seconds is read directly on the calibrated dial.

The printed record is vertical rather than horizontal as on the WatchMaster. A perfect beat shows a straight up and down line while lines sloping left show a slow rate and lines sloping to the right show the watch is gaining. Records for other faults are similar to those shown in Lesson 34.

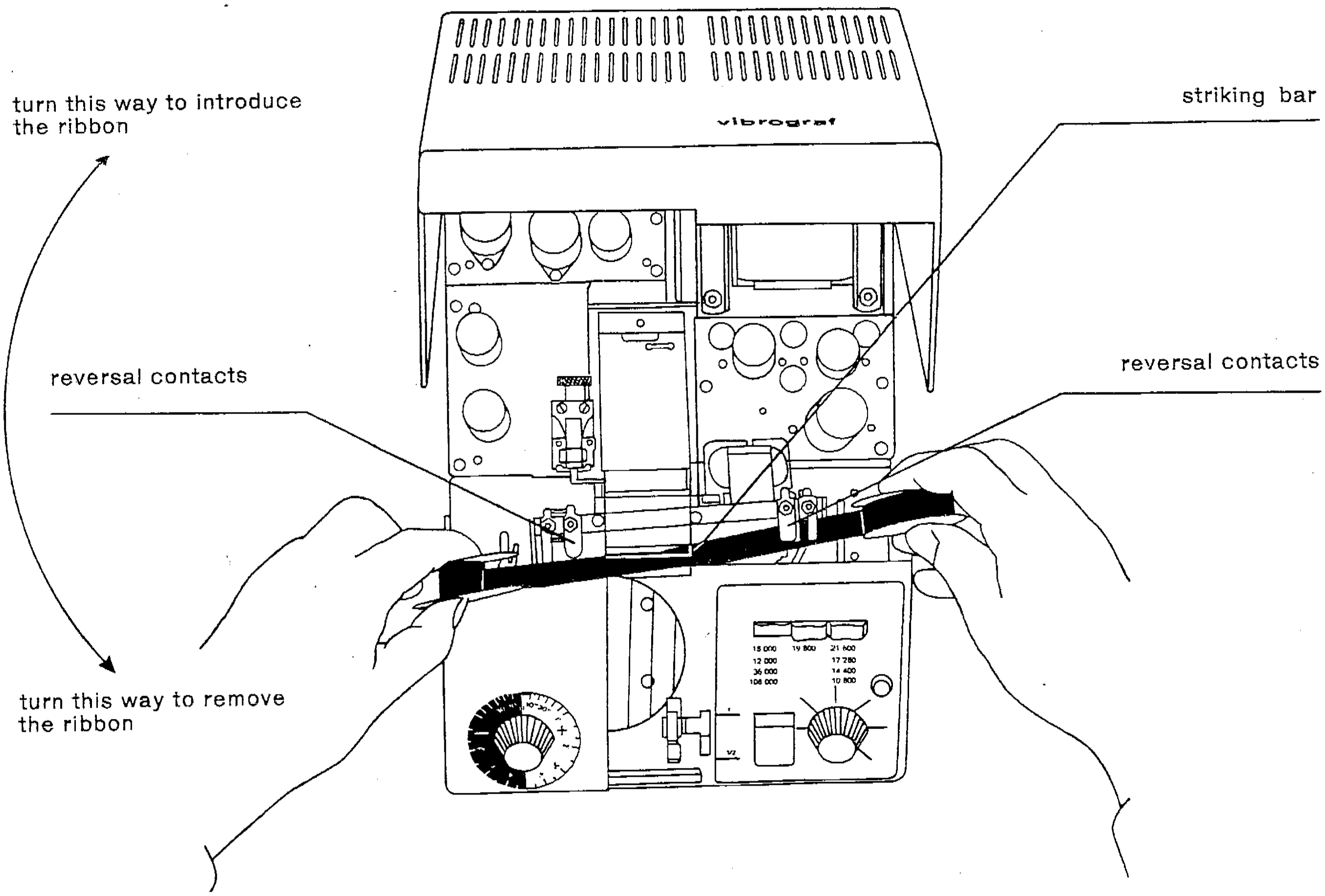


Fig. 33-32

SEC. 584.5 - Changing the Ink Ribbon

It is best to change the ribbon when one of the ribbon spools is almost empty. In any case, first remove the roll of paper.

To remove the ribbon, first remove the retaining ring from the axle of the spool with a small screwdriver. Then hold the left spool with your left hand and the right spool with your right hand as shown in figure 33-32. Keep the ribbon taut as shown and slide it out of its guide track. Reroll the remainder of the ribbon onto the spool with the most ribbon so one spool is empty.

Fasten the end of the new ribbon on the empty spool. Roll it a few turns making sure the ribbon will unroll from underneath. Hold both spools as you did when you took them off. Keeping the ribbon taut, slide it under the striking bar and under the two sets of contacts located on both sides of the guide track, figure 33-32. Place each spool on its axle, being sure it is properly in position. Replace the roll of paper.

The automatic ribbon reversal is done electro-magnetically. To insure smooth operation, clean these contacts regularly by inserting a thin sheet of paper between them. You can do this without disconnecting the machine as the current on the contact is only 10 volts.

SEC. 584.6 - Replacing the Paper Roll

For easier insertion cut the beginning of the tape on an angle as shown in figure 33-33. Put the roll of paper on the spindle and then into position. Be sure the free end of the paper is on top of the roll.

Slide the paper tape into the striking mechanism as in figure 33-33. Lead the paper under the transparent reading disk and then under the moving lever by pulling the lever between position 1 and 1/2. Make sure the paper passes underneath the paper guide.

SEC. 584.7 - The Vibrograph B-100A

With the coming of the Accutron, the Vibrograph was modified to give a single line record for Accutron and regular watches without switching. It also times electric watches. This model, figure 33-34, is the B-100A.

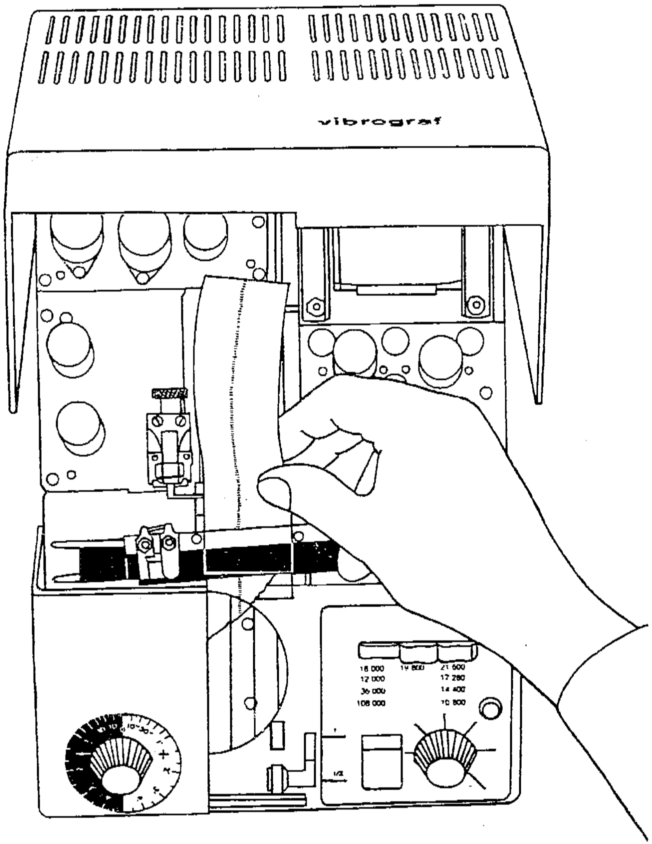


Fig. 33-33

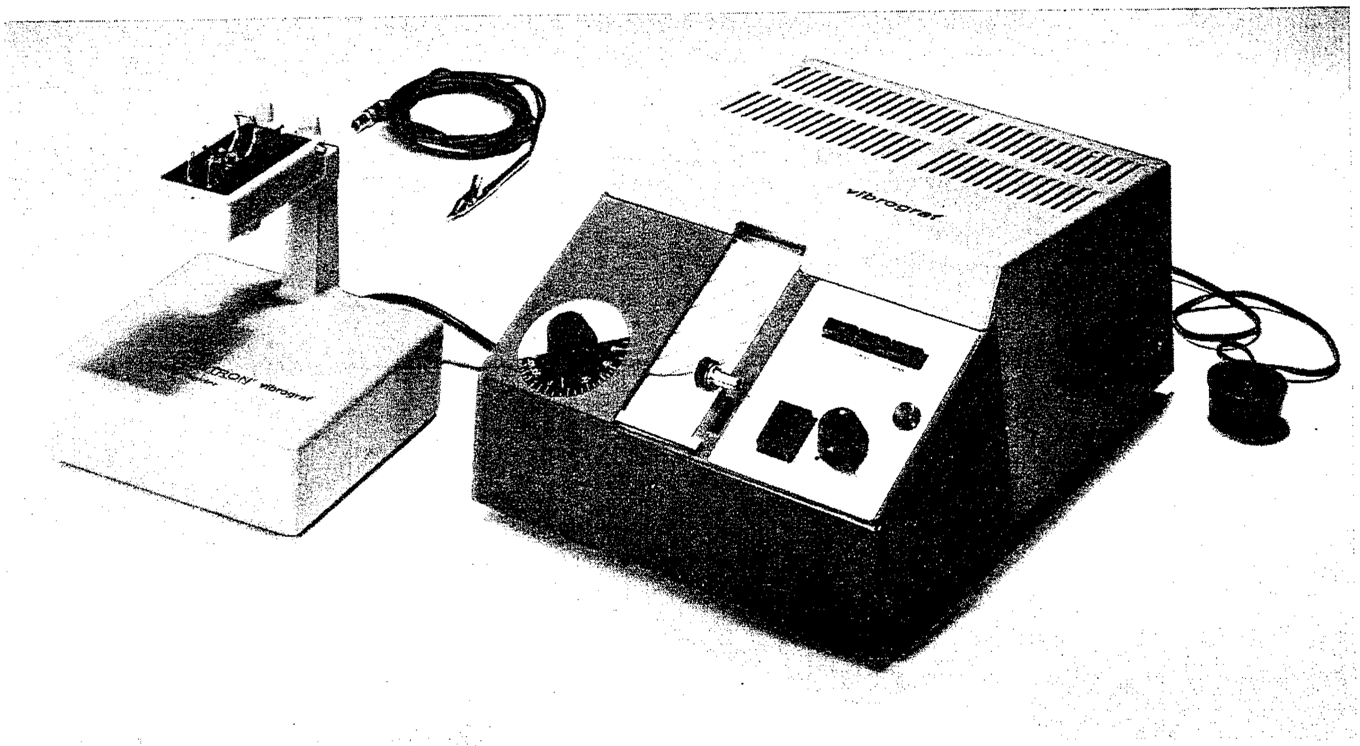


Fig. 33-34

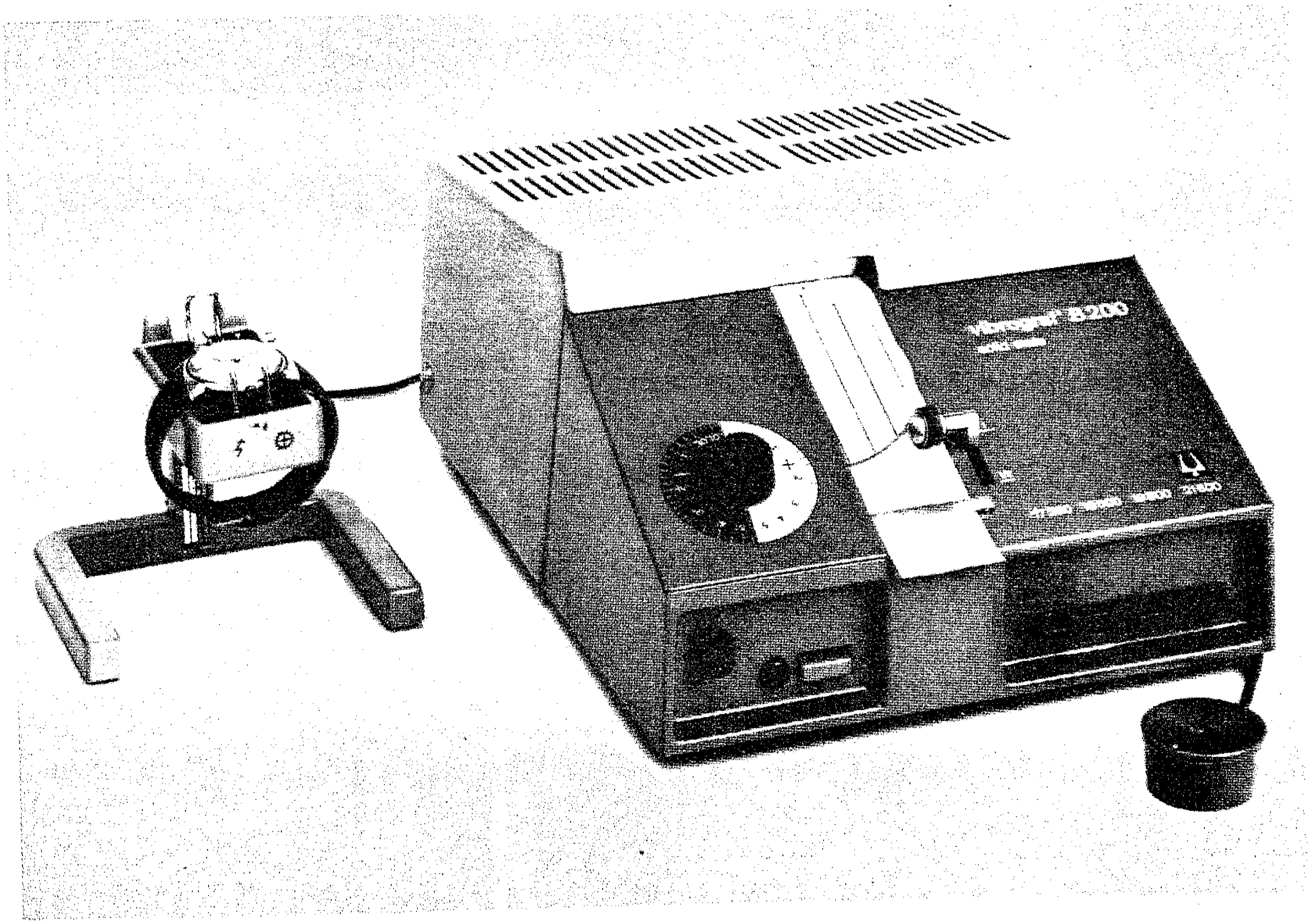


Fig. 33-35

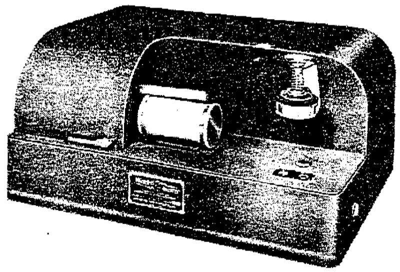
SEC. 584.8 - The Vibrograph B-200A

Later modifications produced the solid state transistorized B-200A Vibrograph, figure 33-35. Notice that the controls are on the front end rather than above. No warm up is required on transistorized models. The machine starts recording as soon as the watch is placed on the microphone. Pressure sensitive recording paper is used instead of the former ink ribbon. The B-200A gives instant single line records for these primary beats: 17280, 18000, 19800, 21600, 36000 or any multiple or sub-multiple of these.

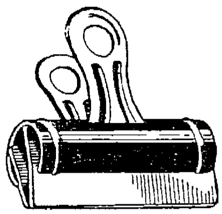
HOW TO USE THE G-7 or G-11 WATCHMASTER WATCH RATE RECORDER.

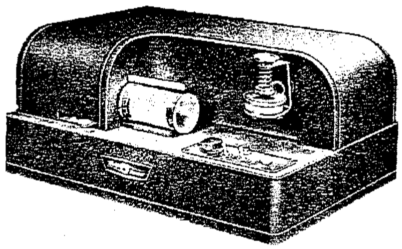
Introductory Information:

This is the machine discussed in this lesson. When rating uncased movements on it, it is advisable to use a clip type holder (shown below) for the movement to prevent it from being seriously damaged by the microphone pickup, by falling, and so on. Later model machines provide for holding uncased movements.



G-7





G-11

Use a spring clip of suitable size to hold the movement and place the handles of the clip in the microphone. As the jaws of spring clips will mar the fine finish of a watch movement, cover them with some suitable material, such as Scotch tape or masking tape. Or you can cement a strip of chamois skin on each jaw. Keep your clip in a clean envelope when not in use to avoid transferring any dirt or dust to the movement.

PROCEDURE:

1. Turn the ON-OFF switch to the ON position. This warms up the machine and takes 15 to 20 seconds.

2. Place watch on microphone. Let the watch run 15 seconds in each position before the rate is taken. This enables the watch to assume or "settle down" to its rate in that position and insures the correct rate during the entire run of that position.

3. Now turn the LISTEN-RECORD switch to RECORD. Start the drum by pressing handle all the way down, move to left as far as it will go, and release handle. Drum will now rotate and machine will record rate of watch.

4. When finished rating, turn switch to LISTEN position, leaving other switch in ON position. This keeps the machine ready for immediate re-use. Keep-

in ON position. This keeps the machine ready for immediate re-use. Keeping the second switch at LISTEN avoids wearing out or breaking the sapphire tip of the recording stylus. Ordinary room sounds would needlessly activate the recording mechanism if it were left on RECORD.

Where the timing machine is used continuously or very often, the control switch can be left turned to the ONposition during working hours, so it will only need to be turned to RECORD while rating a watch. This saves time, as it keeps the machine warmed up and ready for immediate use. At the end of the day or whenever the machine will not be used for some time, the control should be turned to the OFF position. ALWAYS CHECK TO SEE THAT THE SWITCH IS IN THE OFF POSITION BEFORE REPLACING THE DUST COVER ON A TIMING MACHINE. Also, unless your shop has a master switch which is pulled at the end of each day and cuts off all current, take the added precaution of removing the extension cord of the machine from the electrical outlet.

HOW TO USE THE G-47 WATCHMASTER.

PROCEDURE:

1. Set the Beat Selector Switch for the beat of the watch being tested.

2. Turn the Volume Control clockwise to "High".

3. Place a running watch or movement in the Watchholder, with the stem in the hole of the movable jaw and the edge of the watch in the saddle of the pickup.

4. Turn the Master Control knob to "Listen". When you hear the ticking of the watch in the microphone, the machine will be ready for operation.

5. Move the Master Control knob to "Record". The drum will automatically rotate for the beat selected and stop when stop automatically when the knob has rotated its dot clockwise back to the starting point.

6. When the drum stops, turn Master Control knob back to "Listen". Rotate drum, preferably to rear, and inspect record.

LESSON	33
Vibrograph	

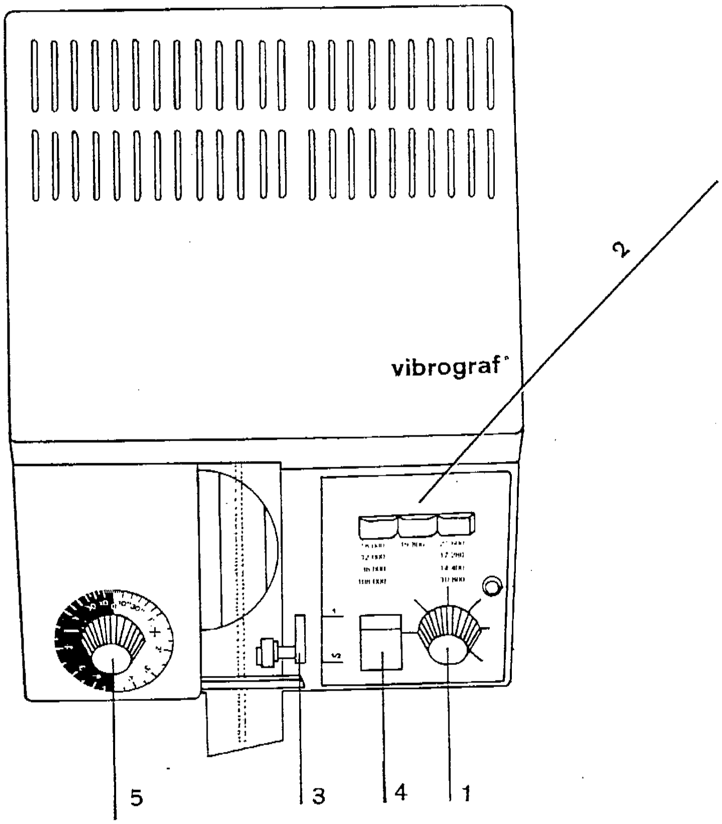
Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L33-J3

HOW TO OPERATE THE B-100 VIBROGRAPH



Vibration groups

18 000	19 800	21 600
3 600	9 900	3 600
4 320		4 320
5 400		4 800
6 000		5 400
7 200		7 200
9 000		8 640
10 800		9 600
12 000		10 800
13 500		14 400
36 000		17 280
54 000		
72 000		
108 000		
180 000 (6 traces)		

PROCEDURE:

1. Place a watch on the microphone. Start the machine by turning the volume control knob 1 to the right until you hear a slight noise. Wait for 15 seconds.

2. Push one of the three buttons 2 - 18000, 19800 or 21600 - corresponding to the beat of the watch being tested.

3. Set the paper lever 3 at the desired speed, either 1 or 1/2.

4. Push down the starting button 4 until the paper begins to roll.

5. To control volume, turn knob 1 to the right. The vibrogram may zig-zag slightly and the beat indication may appear excessive. This means not enough amplification. Increase amplification until you get a good reading.

6. Knob 5 controls the reading device. When the lines of the transparent reading disk are parallel with the vibrogram on the tape, you can read the rate of the watch over 24 hours on knob 4., If the speed control is at 1/2 position, the rate shown on knob 5 is twice the actual reading.

7. Stop the printing by pressing lightly on button 4.

LESSON	33
Vibrograph	

Master Watchmaking

CHICAGO SCHOOL OF WATCHMAKING

JOB SHEET

L33-J4

HOW TO OPERATE THE ACCUTRON-VIBROGRAF B-100A.

Introductory Information:

Recording is done the same as for the B-100. The difference between these two models is in the special Accutron-Vibrograf Watchholder, which enables you to time the Accutron timepiece, standard beat or odd beat spring-driven watches, or electric watches without changing or switching the pickup.

A. Recording the Accutron Timepiece:

1. Place the timepiece in the Watchholder clamps with the band or strap encircling the pickup. The Watchholder clamps should grasp the timepiece at the three and nine o'clock positions on the dial.

2. Depress the 18000 Beat Selector Button and advance the Volume Control approximately one-half of its rotation in a clockwise direction or until a regular five beat per second sound is detected from the printing mechanism.

B. Recording the Accutron Movement in a movement holder:

1. Place the movement holder containing the Accutron movement in the Watch holder clamps. Hold the tuning fork cups 90° from the clamping pins. The tuning fork length should be parallel to each pair of clamping pins.

2. Advance volume fully clockwise or until regular five beat sound is heard from the printing mechanism.

C. Recording Spring Driven Watches:

Select the correct beat and record as for the B-100.

PRECAUTIONS

1. To insure proper operation, be sure to use a three wire grounded outlet or a grounded two prong adaptor, if a three wire receptacle is not available.

2. The Accutron-Vibrograf Watchholder has a high degree of electrical sensitivity. Keep it at least 6 inches away from the B-100A. The electrical field emitted from any transformer will energize the printing mechanism and produce erratic records. You can avoid or eliminate this by simply moving the Watchholder far enough away from the source of the electrical field.

3. Never place the Watchholder on top of the B-100A since heat is harmful to the components inside.

CHICAGO SCHOOL OF WATCHMAKING

Test Questions — Master Watchmaking — Lesson No. 33

Name: No. Date:

Circle ONE correct answer. SUBJECT: WatchMaster and Vibrograph Rating

1. What is the source of standard time in a WatchMaster Rate Recorder?

   A synchronous electric clock | A quartz crystal | A tuning fork | A master clock

2. What is the source of standard time in a Vibrograf Rate Recorder?

   A synchronous electric clock | A quartz crystal | A tuning fork | A master clock

3. What kind of printed line will a slow watch make on the WatchMaster?

   A double line | An uneven line | A line sloping downward | A line sloping upward

4. What kind of line will a slow watch make on a Vibrograf Recorder?

   A line sloping downward | A line sloping upward | A line sloping to the right | A line sloping to the left

5. What name is usually given to watches which do not beat 5 times per second?

   Obsolete watches | Odd beat watches | Chronometer watches | Special watches

6. What kind of record will the watches referred to in Question 5 make on a G-11 WatchMaster?

   Printed record must be cali-brated | Cannot be rated on machine | Print several lines irregu-larly spaced | Usually print more than one line

7. When rating ordinary wrist watches, which positions are used for the two-position average rate?

   Dial Up Crown Left | Dial Up Crown Right | Dial Up Crown Up | Dial Up Crown Down

8. If a watch runs faster as it runs down, what is your conclusion?

   It has an isoch-ronal error | It is out of poise | It has a mech-anical fault | Balance pivots should be re-shaped

Detach page or cut along this line - - and send to the School for grading

(Please turn over)

9. How does an out of poise condition show on the WatchMaster record?

One or more positions will show ragged lines	One or more positions will record very slow	One or more positions will record very fast	One or more positions will show fast; opposite positions show slow

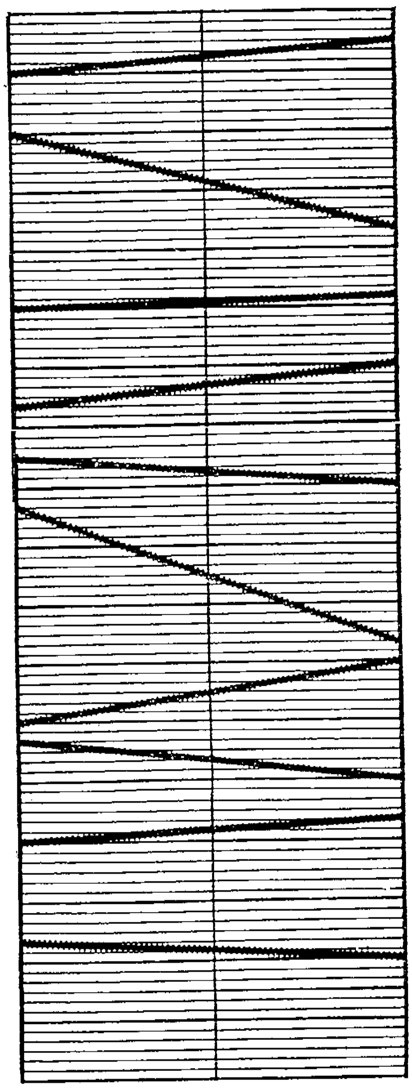
10. Where would you look for trouble if you get a double line record and one line prints ragged while the other line is straight?

Regulator pins	Balance	Hairspring	Escape wheel

DIRECTIONS: In the remaining questions, enter the rate in seconds for each numbered line of the record and indicate whether fast or slow by circling the appropriate word. For example:

5 seconds fast slow

11.
12.
13.
14.
15.
16.
17.
18.
19.
20.



11. ____ seconds fast slow

12. ____ seconds fast slow

13. ____ seconds fast slow

14. ____ seconds fast slow

15. ____ seconds fast slow

16. ____ seconds fast slow

17. ____ seconds fast slow

18. ____ seconds fast slow

19. ____ seconds fast slow

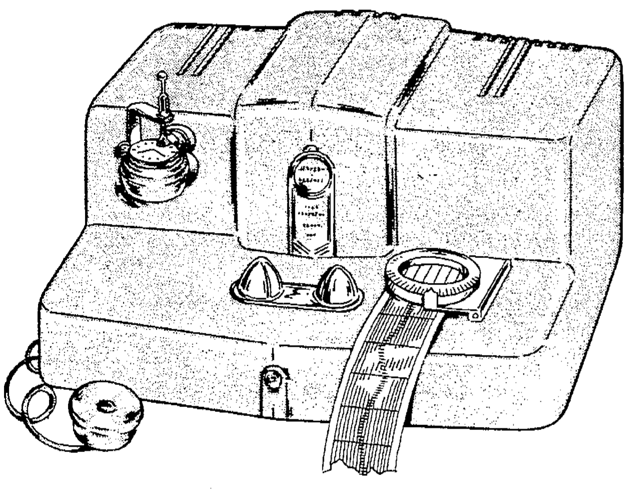
20. ____ seconds fast slow

Master Watchmaking

MODERN SHOP METHODS

LESSON

34



Electronic Timing Machines

(Time-O-Graf and Others)

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by THOMAS B. SWEAZEY

Printed in the United States of America

34

Sections 586 through 596 are reprinted
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Figures 34-38 through 34-43 are
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CHICAGO SCHOOL OF WATCHMAKING

Assignments for Master Watchmaking Home Study Course

LESSON 34 Electronic Timing Machines (Time-O-Graf)

KEY POINTS OF LESSON ASSIGNMENTS 120, 121, 122, 123:

- Construction and use of the Time-O-Graf Watch Rate Recorder.
- New developments in timing machines.

ASSIGNMENT NO. 120: Study Sections 585 through 590.

1. How does the Time-O-Graf operate?
2. What are the major differences in construction between a Time-O-Graf and a WatchMaster?
3. What is the purpose of the Rotary Precision Dial on the Time-O-Graf?

NOTE: The Time-O-Graf is used as follows: Turn the right hand knob to the ON position and let the machine warm up for 15 to 20 seconds. Place watch on microphone. Let it run 15 seconds in each position before starting to take rate. Turn right hand knob to RECORD position. Machine will now record rate of watch. When finished with rating, turn right hand knob back to ON position, which leaves the machine ready for immediate re-use. As indicated for the WatchMaster, the control switch can be left turned to ON during working hours to keep the machine warmed up and ready for use.

ASSIGNMENT NO. 121: Study Sections 592 through 594.

Will the same error record the same way on both a WatchMaster and Time-O-Graf?

ASSIGNMENT NO. 122: Study Sections 595 and 596.

1. What is involved in poising and adjusting from a timing standpoint?
2. How will odd beat movements record on the Time-O-Graf?

ASSIGNMENT NO. 123: Study Secs. 597-8.

How do these newer timing machines differ from the WatchMaster or Time-O-Graf?

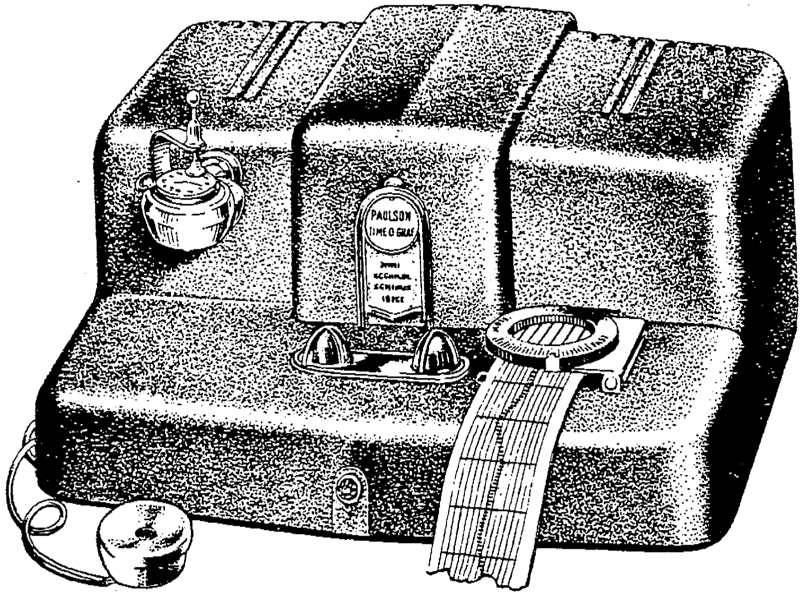
Recommended Practice:

If you have access to a watch rate recorder, you should rate various available watches as instructed below:

1. Complete all repair work, cleaning and oiling before starting to rate watch on timing machine. (See Lesson 32, Sections 564 through 570.)
2. Before putting dial and hands on watch, take the uncased rates in these positions: Dial Up, Dial Down, Pendant Up, Pendant Right, and Pendant Left for pocket watches. Rate wrist watches Dial Up, Dial Down, and Pendant Down. Dial Up and Dial Down should be the same. If there is any appreciable variation in pendant rates or between dial rates and pendant rates, STOP. Correct any faults and rate again in position. When all rates are equal, bring to close time, Pendant Up for pocket watches, Pendant Down for wrist watches.
3. Replace dial and hands and recase watch. Rate again in all positions with movement in case.
4. Bench time the watch for 24-hour periods, starting full-wound, Pendant Up for pocket watches, Pendant Down for wrist watches.

REQUIREMENT:

- Answer the Test Questions for Lesson 34 and send in for grading.



SEC. 585—Introduction

Manufacture of the Paulson TIME-O-GRAF was discontinued some years ago. However, many of these machines are still around and since they can be adapted for odd beat movements and Accutron rating, they will probably still be in use for some years to come.

Like other timers, it may be used to determine such factors as rate, position errors, isochronal errors, and faulty actions of the movement. Again, it is not a substitute for the skill and knowledge of the watchmaker, but it does give a clear, accurate, printed record of the watch under test and upon which the watchmaker's skill and knowledge may apply.

As with any other precision instrument, you should know as much as possible about the machine to take full advantage of its potentialities.

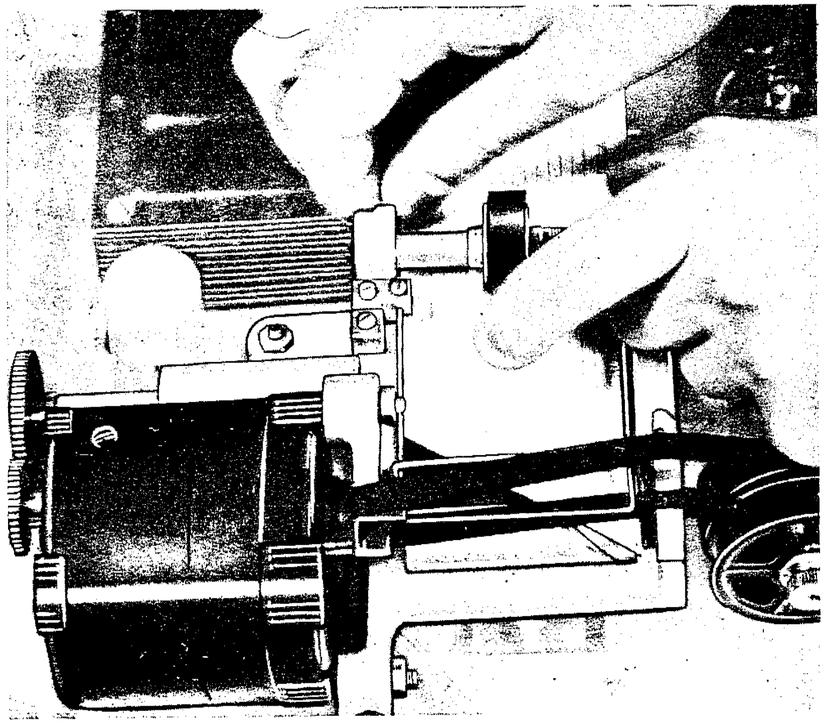


Fig. 34-1

SEC. 586—Threading the Printer Tape

Figure 34-1 shows the threading of the printer tape. Cut the end of the paper tape to about a 45 degree angle; place the roll on its roller in position and thread the end of the tape between the 3/32" diameter rod and the top surface of the cast aluminum printer frame.

DO NOT LIFT UP ON THE PRINTER BAR when threading the paper tape beneath the inked ribbon.

Connect the rubber covered cord to a source of 110-120 volt, 50-60 cycle alternating current and turn the right hand knob to the "ON" position and let the machine warm up for at least 30 seconds. Then, turn the knob to the "RECORD" position. As the machine then starts you will start the paper tape forward in between the rubber roller and the knurled driving roller. Let the motor feed it on through, and with a piece of pegwood guide the tip of the tape under the inked ribbon and over the spiral roller.

Let the machine run until the tip of the paper tape just extends beyond the inked ribbon, then turn the knob back to the "ON" position.

Remove the knob from its post and lower the cover of the machine into place.

Place both knobs on their respective posts.

Then, turn the right hand knob to the "RECORD" position, and as the paper tape feeds through, use a piece of pegwood and guide it through the window in the case and under the paper cutter bar.

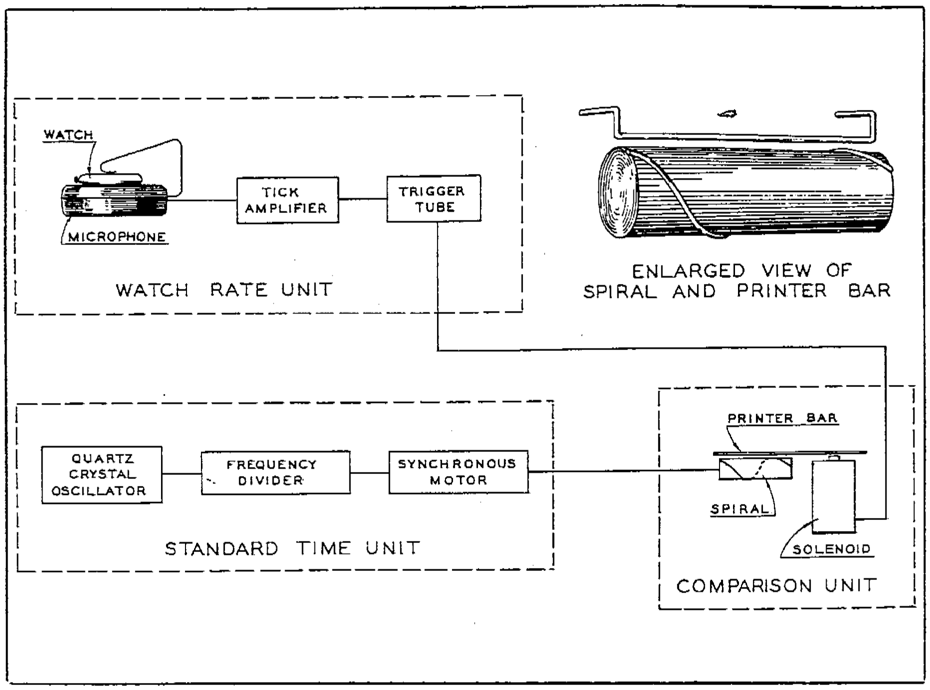
Place a watch under the clamp of the microphone with the watch crystal making contact with the metal button in the center of the microphone and with the right hand knob in the "Record" position, the printer tape should start to emerge. Turn the volume control about 2/3 of the way on and then the printer bar should pull down with an easily heard click with each tick of the watch.

SEC. 587—Construction and Theory

The TIME-O-GRAF is a time differentiating watch rate recorder. Its basic principle is the comparison of the rate of the watch under test with an accurately measured interval of time and the printing of this comparison on a paper tape so that the rate may be ascertained therefrom or may be obtained by reference to a calibrated dial.

IMPORTANT: It must be clearly understood by every watchmaker that any watch rate recorder will indicate the rate of the watch during the period of the test only, hence it is impossible to predict the full 24 hour rate of

Fig. 34-2



a watch from any test covering less than that amount.

The method by which the TIME-O-GRAF makes the comparison between the rate of the watch on test and the standard time is shown in Figure 34-2. The unit which furnishes the source of standard time consists of a quartz crystal controlled oscillator which generates a high-frequency voltage of exceptional stability and a frequency divider which divides this frequency to a value which permits it to be used to drive the synchronous motor of the comparison unit. The armature shaft of this motor, running at a speed of 2700 revolutions per minute or 45 revolutions per second, carries a metal drum which has a raised spiral on its surface.

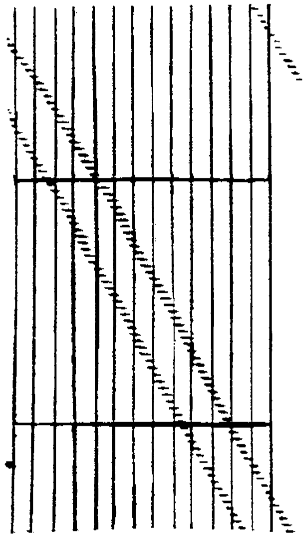
The watch rate unit consists of a microphone which picks up the tick of the watch under test, an amplifier which amplifies this tick, and a trigger tube which operates or "fires" once for each tick of the watch and energizes a solenoid in the comparison unit. This solenoid pulls a printer bar downward against an inked ribbon and a paper tape which rest lightly on the spiral previously mentioned. Inasmuch as the printer bar can strike the spiral at only one point, each stroke produces a dot on the tape, the location of the dot depending on which part of the spiral is under the printer bar at the moment of contact.

It can be seen that if the spiral is made to rotate at a constant rate of speed, the point at which the spiral and the printer bar make contact will move at a uniform rate across the tape. In the TIME-O-GRAF the spiral, which has a lead of two inches, is made to rotate at 45 revolutions per second which causes the point of contact to move from right to left across the tape at a rate of 90 inches per second. If each tick of the watch occurs EXACTLY one-fifth of a second later than the preceding one, the spiral will make exactly nine revolutions between ticks and each dot on the tape will fall on top of the last one. If, however, the watch is running slow, the spiral will turn slightly more than nine revolutions between ticks and each dot will fall to the left of the one preceding it. If the watch has a losing rate of 43 seconds per day, each tick will occur one ten-thousandth of a second later than it should, and consequently each dot on the tape will fall nine-thousandths of an inch to the left of the preceeding one. If provision is now made to advance the tape at a uniform rate, the dots will also progress along the long axis of the tape, forming a line thereon. In the TIME-O-GRAF this motion of the tape, which amounts to six inches per minute, is obtained by a reduction gear and friction roller driven by the same synchronous motor which drives the printed spiral.

Note that this line of dots may fall anywhere from the right side to the left side of the paper. Where it occurs depends entirely upon the time relationship between the motor spiral and the balance wheel in the watch. Thus, the location of the line (to the right or left side of the paper) is no indication of the rate of the watch.

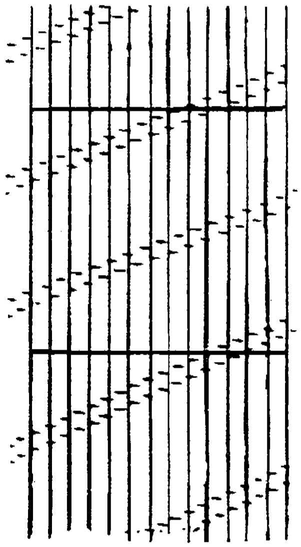
The rates of the watch and the actions of the escapement are determined by the slopes and variations in the line.

Hence, from the above, we see that if the watch is running slow the line of dots will slope to the left, as in figure 34-3, and if the watch is running fast the line of dots will slope to the right, as in figure 34-4.



Losing about 52" per day

Fig. 34-3



Gaining nearly 4' per day

Fig. 34-4

If one desires to calculate the rate of a watch directly from the line of dots on the tape, without using the Rotary Precision Dial, one may proceed as follows:—

Using the printed tape we find reference lines are printed on this tape, figure 34-5—one set spaced $1\frac{1}{2}$ inches apart and the other set spaced $\frac{1}{8}$ inch apart. The physical constants of the TIME-O-GRAF are so chosen that a rate of error of one second per day will cause the printed record to travel $\frac{1}{8}$ inch across the tape while traveling 12 inches along the tape. Thus a record which travels $\frac{1}{8}$ inch across the tape while traveling $1\frac{1}{2}$ inches along the tape indicates an error of 8 seconds per day. The rate may be calculated by the following formula:

$$R = \frac{A \times 96}{B}$$

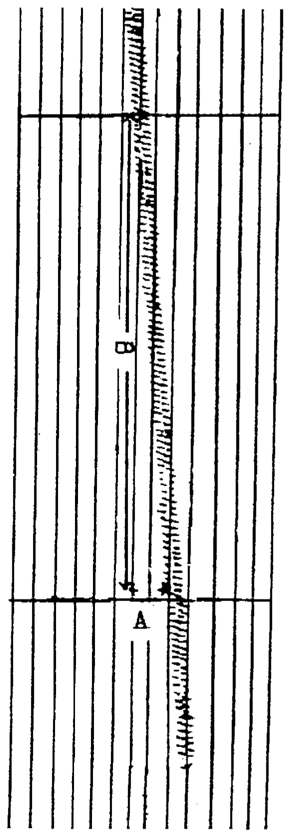


Fig. 34-5

Where **R** is the rate of the watch in seconds per day, **A** is the distance in inches which the record has travelled across the tape, while **B** is the distance in inches which the record has travelled along the tape.

SEC. 588—Crystal Control Assures Accuracy

Crystal Control: Nothing in the wide world has the accuracy of the quartz crystal control, your absolutely accurate, dependable time comparison. To depend upon anything but accurate time comparison is time wasted.

The U. S. Government uses crystal control for accuracy. The U. S. Bureau of Standards can tell you of the accuracy of crystal control. The world renowned clock at Greenwich, London, England, universally famous for continued accuracy, is under Crystal Control.

The Crystal Control is "natures own," scientifically ground and set; natures vibrations "like natures own" keeps in step with the stars for accuracy.

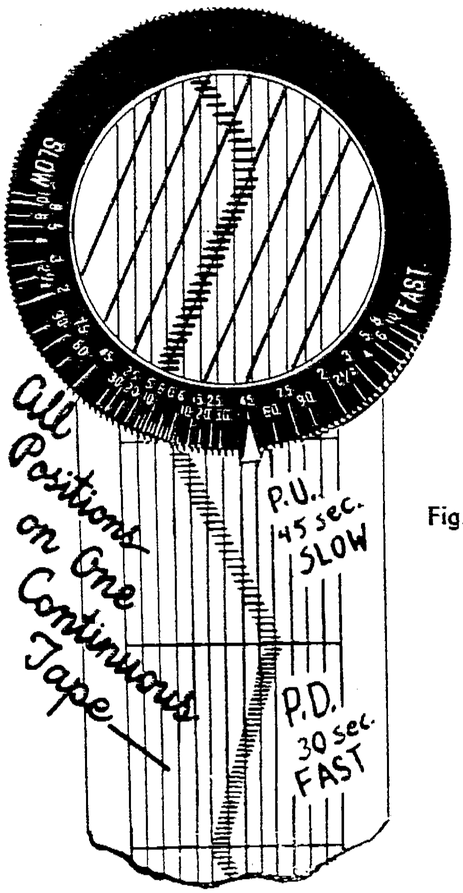


Fig. 34-6

SEC. 589—Instant Reading of Rates

The ROTARY PRECISION DIAL, under which the tape moves is calibrated in seconds per day, gain or loss, and enables the user to read the rate directly instead of having to measure the angle of the printed line and calculate the rate.

The rotary precision dial on the TIME-O-GRAF is illustrated in figure 34-6. It consists of seven parallel lines and is turned so that these parallel lines become parallel to the angle made by the line of dots issuing from the machine. Then the second marks on the dial show instantly the exact number of seconds per day, gain or loss. When using the rotary dial exclusively to ascertain the rates, it is not necessary to use the calibrated paper tape inasmuch as ordinary adding machine paper tape will suffice for the printed record under these circumstances.

SEC. 590—Operation

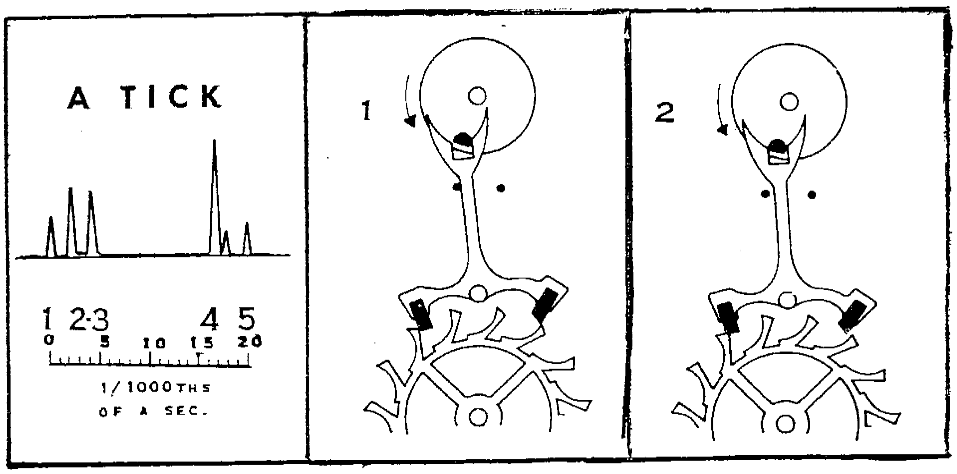
To use the TIME-O-GRAF intelligently it is first necessary to understand the sequence of sounds produced by the escapement in a watch. We know that the sounds in a watch which we call the "tick" and the "tock" occur as the result of the escapement action. These sounds are caused by the parts of the escapement striking or rubbing one another. An analysis of the escapement action will clearly show that not one but several sound impulses occur each time the escapement action ("tick" or "tock") occurs.

A watch "TICK" consists primarily of five major sounds. These sounds all occur within about 1/200th of a second. Figure 34-7 is a graph showing the sequence of these sounds, the height of the curve showing their comparative volumes.

The first sound, though not the loudest one, occurs when the roller jewel comes around and strikes the fork slot as in figure 34-7, No. 1.

The next sounds we hear are Nos. 2 & 3. When we have an escapement model and move the parts slowly, apparently the escape wheel tooth begins pushing on the pallet stone face

Fig. 34-7



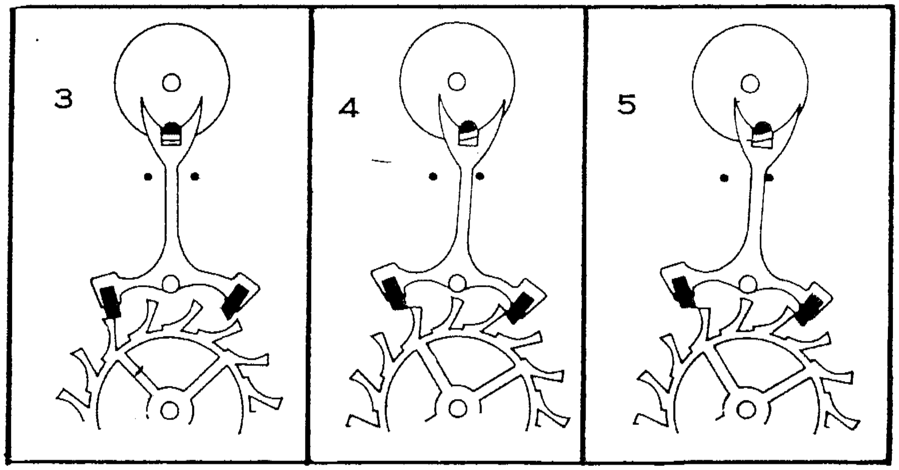


Fig. 34-7 (Cont.)

immediately after the unlocking action causing the fork slot to strike the roller jewel and push on it. But in actual practice it does not work that way because the pallet stone, having a certain amount of draw, forces the escape wheel to move backward a slight amount when it is withdrawn from the locking face of the tooth, and, inasmuch as the pallet stone is practically jerked out of that position (due to the speed at which the roller jewel is traveling at the time), it throws the escape wheel backwards slightly. Then, by the time the escape wheel overcomes its inertia and starts forward again the toe of the tooth may strike the pallet stone perhaps a third of the way down its impulse face, the impulse action actually beginning at that instant. The loudest sound is depicted in No. 4 when the escape wheel tooth drops onto the locking face of the other pallet stone. There is a slight rebound to that which is followed by the last sound as depicted in No. 5 when the lever falls against the banking pin.

For an accurate watch rate record it is necessary for the printed dot to come from a clearly defined part of the "Tick." The most exact point on a watch "Tick" and the most clearly defined point is the point designated in No. 1.

The trigger tube selects the part of the tick from which the dot is printed. The exact part of the tick that fires the trigger tube depends upon the loudness of the tick. If the trigger tube does not fire with the first (No. 1) part of the tick, then it will fire with the next part that is sufficiently loud to operate the tube. Since the ticks of different watches vary in loudness, it becomes necessary to adjust the volume control on the machine so that it will pick up the No. 1 sound at all times yet not have the volume on full enough to pick up unnecessary sounds as the picking up of unnecessary sounds only serves to confuse the action of the trigger tube, likewise the printed record. Therefore, if the machine is to be used for diagnostic purposes, the picking up of the No. 1 sound will give a continuous record from which a quite complete diagnosis may be made.

We then take this continuous record and by analysing the position of the dots, the lines they form, etc., consecutively and relatively, we are able to determine the condition of the escapement in detail and the rate of the watch throughout as long a run as we may desire.

SEC. 591—Diagnosis of the Printed Record

The methods of determining the overall rates of the watch under test have been described in Section 587 and Section 589.

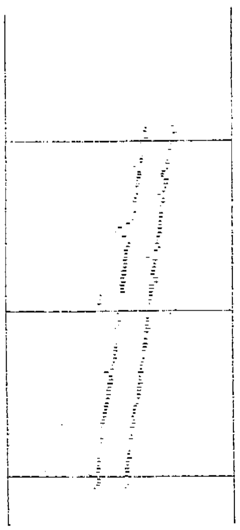
Now we present a few notations on the readings and diagnoses of irregularities found in the dots on the tape.

SEC. 592—Examples of Records

Before submitting any watch to the timing machine for analysis, the watchmaker should have made certain that the watch is in good mechanical order throughout.

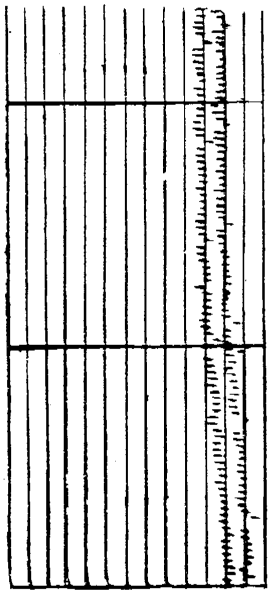
Many defects may be heard in the ear phone and such should be corrected before any attempt is made to obtain a good printed record.

Pivots should be in good condition and jewels fitted correctly, otherwise the printed pattern will be irregular. The end-shake of the balance especially must be correct in the smaller wrist watches and the escapement



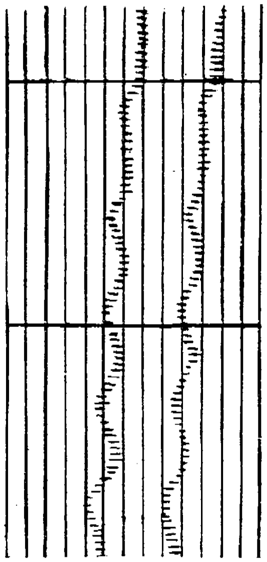
Loose Roller Jewel

Fig. 34-8



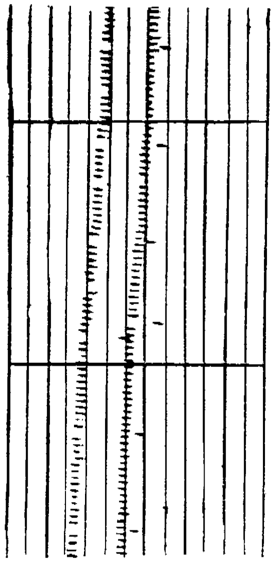
Loose Pallet Stones

Fig. 34-9



Escape Wheel Out of Round

Fig. 34-10



Bent Tooth in Escape Wheel

Fig. 34-11

PROPERLY oiled in order to obtain a readable record.

A loose roller jewel may be detected by visual inspection, but at times one may be so slightly loose as to have escaped notice.

Figure 34-8 is the record made by a 11¼ ligne watch with a roller jewel very slightly loose.

Loose pallet stones may also usually be detected by a visual inspection, yet one often finds that pallet stones which are apparently tight (visually) will show to be loose, giving a record similar to figure 34-9. A small amount of stone cement is the remedy.

Quite often we will find watches about 6¾ ligne in size that apparently keep time, but which refuse to make a legible record on the TIME-O-GRAF. An examination of many of these will disclose a hairspring which is out of flat and a balance staff which has too much endshake. The out of flat hairspring causes the balance staff to dance up and down or endwise in its pivot holes and the timing machine will pick up the sounds of that in preference to the sound of the roller jewel striking the fork slot (as in figure 34-7, No. 1). The obvious remedy is to true the hairspring and eliminate the surplus end-shake in the balance staff.

The left hand line of dots is usually the record of the action caused by the receiving pallet stone—likewise the right hand line of dots is usually the record of the action caused by the discharging pallet stone.

The escape wheel in the ordinary 18,000 beat watch makes one revolution in six seconds, or ten revolutions per minute. Hence, errors in the escape wheel may be easily recognized by the fact that they should repeat themselves every six seconds, or ten times per minute (ten times per six inches of paper travel). The line caused by an escape wheel which is out of round due to its either being bent itself or having a bent pivot will be curved, a complete cycle showing every six seconds. (Figure 34-10) A bent or damaged tooth in an escape wheel will show a single displaced marked similar to that shown in Figure 34-11, occurring every six seconds. A damaged leaf in the escape pinion will make a record showing an error of much longer duration, the duration of the error being nearly one second in length, and it also repeating every six seconds.

A bent fourth wheel or a fourth wheel out of round will show as an error every 60 seconds or every minute. This can be found only on a machine that runs for a full minute or more, such as the TIME-O-GRAF.

Presume now that we have a defect that occurs once in every 60 seconds. If it be curved, similar to that in figure 34-12, we would assume that the fourth wheel or one of its pivots was bent, as the record clearly shows it to be out of round. If, instead of the record showing a clearly cut curve, it shows defects of moderate time duration, spaced at intervals of 60 seconds apart, we may then examine further. When

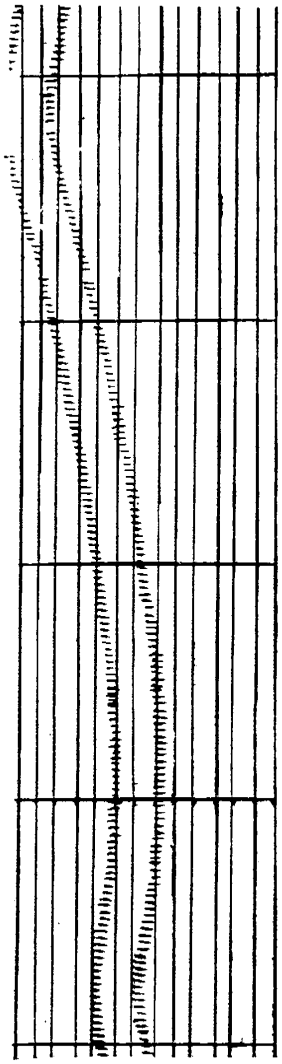


Fig. 34-12

Train Wheel
Out of Round

the length of the record of the defect in a fourth wheel is about ½ inch of paper travel, we could assume that it was a defective tooth in the fourth wheel. If the length of the defect consumed about 10 seconds of travel of the paper, we would say that it was a defective leaf in the fourth wheel pinion. That is easily understood as the pinion leaf requires a longer time to pass than does a single wheel tooth.

Likewise, defects in the center seconds mechanism of chronographs are easily located with the TIME-O-GRAF. For example, we may take a chronograph and with the center seconds hand in its neutral or zero position, bring the watch movement to time. We then push the plunger which starts the center seconds hand into action and observe if the watch records any variation in rate. If so, we know there is some defect in the action of the center seconds hand mechanism when it is in action. We then may push the plunger which stops the center seconds hand, and any change in the rate of the watch at this point indicates a defect in the braking or locking mechanism of the center seconds hand.

MAGNETISM never affects two watches in the same manner. Hence, we cannot present any "typical" record showing magnetism. Watchmakers are supposed to look for magnetism in a watch with their compass.

PRESSURE applied to the movement, or to the train bridges of many of these thin watches will cause a noticeable variation in the rate of the watch.

We presume that the watchmaker has properly cleaned and oiled the mainspring, replacing it if necessary; but if he has not, he cannot be assured of a good rating of the watch. A dry mainspring will seize, then release, giving an uneven delivery of power to the train wheels. (See figure 34-13). CAUTION: A mainspring that is slightly too wide for the barrel will rub the barrel or the cap, and cause an irregular rating of the watch.

If the movement of the watch shows a record as keeping time, and the hands of the watch

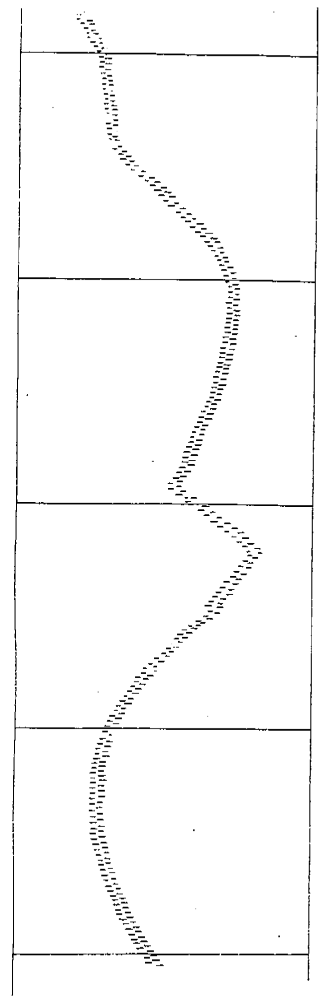


Fig. 34-13

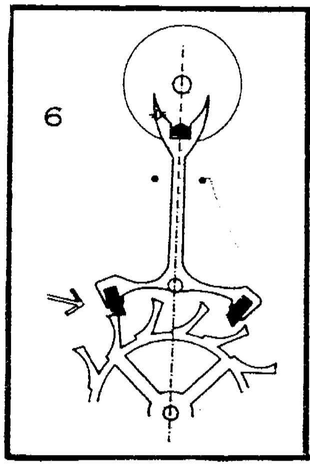
Uneven Power
Caused By a
Dry Mainspring

indicate a loss of time,—look well to the canon pinion friction, and see that the setting bridges do not bind on either the minute wheel or other dial wheels. Also see that the minute hand does not bind onto the hour hand, and the pipes do not rub the holes in the dial in any position.

SEC. 593—Putting an Escapement in "Beat"

The general rule for putting an escapement "in beat" is to so place the hairspring collet that when the escapement is at rest, the roller jewel lies on the line of centers. See figures 34-14 and 34-15.

To be sure that we have it in beat, we release the power from the train, even to the extent of removing the ratchet wheel. Then we carefully adjust the position of the hairspring collet so that when the escape wheel is moved forward, the toe of the escape wheel tooth will drop onto the receiving pallet stone about the center of its impulse face, (See figure 34-14), and likewise, the toe of the escape wheel tooth will drop onto the discharging pallet about the center of its impulse face or a little beyond. See figure 34-15. When that condition exists the escapement may be said to be very closely "in beat." Thus, when the hairspring collet is adjusted to that position, if we "bank the escapement to drop," (the escapement being otherwise in mechanically good order), we will find that the TIME-O-GRAF will give us a record composed of apparently almost one line, the two lines being practically superimposed upon each other. See figure 34-16.



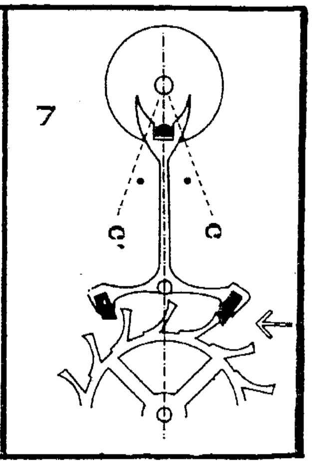


Fig. 34-14

Fig. 34-15

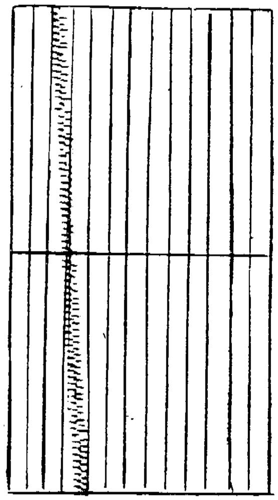


Fig. 34-16

SEC. 594—The "Double" Line

PLEASE NOTE: In practically all small Swiss watches and in many other watches due to variations in escapement design, it is practically impossible to obtain a reading of a "single line" as in figure 34-16.

The workman must be his own judge as to when the watch is in "passable" condition.

A double line on the record may be caused by numerous things, including the improper setting of a pallet stone, loosely fitting pivots in the members of the escapment, as well as the improper setting of the hairspring collet.

However in an escapement wherein the pallets are properly set, the roller jewel properly set and the escapement otherwise in good order, a double line indicates that the roller jewel is striking the fork slot on one side at a greater distance from the line of centers than on the other side. Turn to Escapement drawing No. 1, figure 34-7. If we move a banking pin out a little for example, the one on the left hand side of the figure, it will allow the lever to lay over a little farther to the left which means that the roller jewel will strike the fork slot on that side, which in this case is the receiving side, a little sooner or if you please, a little farther from the line of centers on that side which causes the machine to record the No. 1 sound on that side in a new position or sooner as shown by the appearance of the line of dots a bit away from their previous position. Following is an example of how this may apply:—

In figure 34-17 we have the record of a 16 size Elgin first with the escapement properly adjusted. At "A" we opened the banking pin which controls the slide on the receiving stone.

Here you will note the immediate appearance of the line of dots made by the receiving side moving over to a new position. Coincident with this you will note that the increment of the slide on the receiving stone of an escapement tends to slow down the rate of a watch slightly. Returning the banking pin to its proper position at "B," the line of dots produced by the receiving side return to their former position, and the watch resumes its former rate. Likewise, we may open the banking pin which controls the slide on the discharging pallet stone. This will cause the line of dots made by the discharging stone to assume a new position as at "C." Here we note that giving the discharge stone more slide, we tend to speed the rate of the watch slightly. Returning this banking pin again to its proper position, the line of dots controlled by the discharging side return to their former position, and the rate of the watch again returns to its former rate as at "D."

It is desirable to bring the two lines as closely together as possible with the slide adjusted to a minimum with safety on both sides.

SEC. 595—Poising and Adjusting

Much has been written in the past years on the matter of poising the balance wheel in a watch, and great theories have been expounded on the subject.

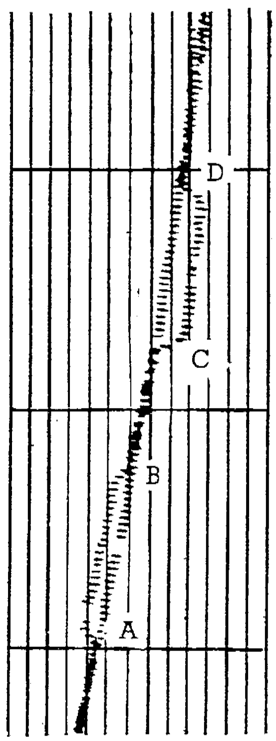


Fig. 34-17

The great majority of these are well founded, but one notable fact becomes increasingly evident: many textbooks, yes, even instructors in watchmaking, do not agree on even the fundamentals of hairspring work.

Not until the advent of the TIME-O-GRAF with its continuous tape with instant reading have we been able to solve these problems in a practical manner.

The RATE of a balance can only be changed by some force which gives an impulse tending to turn or retard its turning one way or the other.

When the balance is at rest and the hairspring idle, we may say that it is in the NEUTRAL POSITION.

The FUNDAMENTAL RULE on rates is: A push toward the neutral point speeds it up; a push away from the neutral point slows it down. This is true for either direction of the balance swing.

Let us see how this fundamental rule shows the effects of a balance which is out of poise. (See figure 34-18). If the heavy part of the balance is at the bottom in the neutral position, and the motion is less than one turn, the push of the heavy point is always toward the neutral point making the watch gain. Conversely, if the heavy part of the balance is at the top in a neutral position, and the motion is less than one turn, the push of the heavy point is always from the neutral point making the watch lose.

If the heavy point is at the side, the amount of gain and the amount of loss may counteract each other.

In figure 34-18 the balance is making a swing of over one full turn. The heavy point in going up from Z to the top on either side causes a gain, but in going beyond the top to X or Y the push of the weight is away from the neutral point and causes a loss. One might think that as in the figure, as the upswing from Z to the top of greater length than the swing from the top to either X or Y, the gain would be greater than the loss. It does not work out that way, for the travel from the top to either X or Y is nearer the end of the swing and errors which show that near the end of a swing of a balance are far more effective than errors near the middle of the swing. Mathematicians have shown that if the arc from the top to X and from the top to Y are each 40 degrees, and the heavy point being at Z, the loss from the top to X will offset the gain from Z to the top. Hence, for a swing of

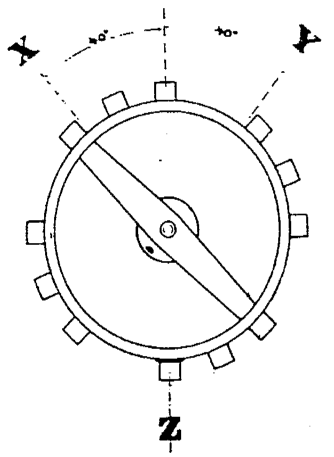


Fig. 34-18

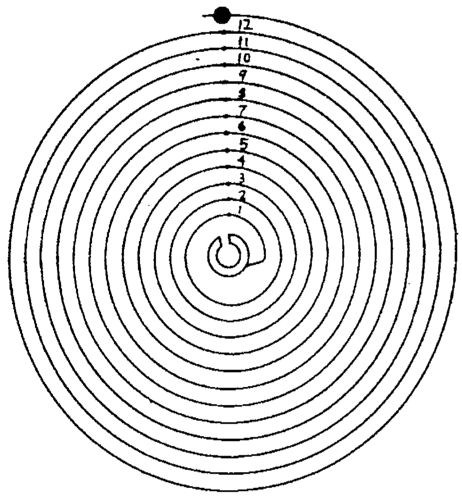


Fig. 34-19

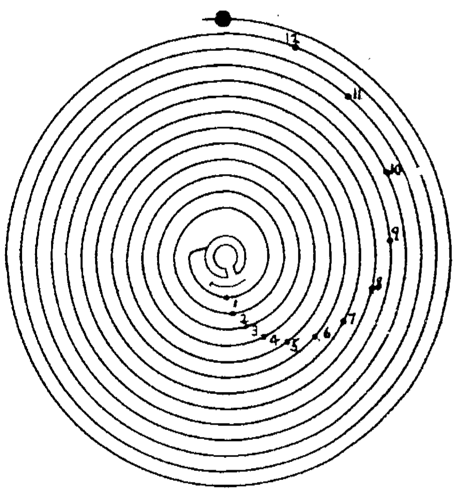


Fig. 34-20

220 degrees on a side, a poise error in the spot indicated will not affect the rate. However, should the arc of swing vary, either more or less, the poise error will show itself causing the rate to vary in turn.

Many watchmakers accept the statement that all watches, even those with an overcoil hairspring, have what they call a "natural error" of losing some 20 seconds per day, in some one of the vertical positions, which one it may be depends on the position of the pinning point of the hairspring to the collet.

There is nothing mysterious or occult about the workings of a watch or adjusting it. There is no such thing as an inexplainable "Natural Error." There is a definite reason for any and all errors and combinations of errors.

We may poise a balance wheel as carefully as we please on the poising tool and oft times we put it in the watch and the watch behaves as though it were out of poise. True, the fact that we have poised the wheel only, does not mean that we have poised the wheel with all its accessories, some of which move in whole or in part with the balance in the watch. We all know that we poise the wheel, and after that we apply the hairspring to it. In figure 34-19 we have a hairspring at rest with 12 little dots on the coils. Notice the dots are in a straight line. When that hairspring collet is turned a half turn, as it must when the balance carries it, notice the new position of the dots, and suppose the collet is turned a half turn in the opposite direction, the dots would arrange themselves in a similar pattern on the opposite side.

What occurs there, as you will notice, is that an unpoised mass, namely about half of the inner terminal of the hairspring plus certain portions of the succeeding hairspring coils, has been added to that balance staff. In other words, we have introduced and added to that balance an unpoised mass of material which is simply, as the balance moves to and fro, wagging back and forth.

In connection with this, please bear in mind that your hairspring must be true in the round and in the flat. The least error in the inner coil of the hairspring throws the entire timing of a watch into a condition where it is almost impossible to adjust. The hairspring must be

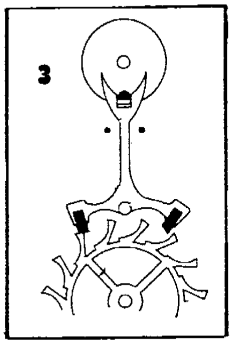


Fig. 34-21

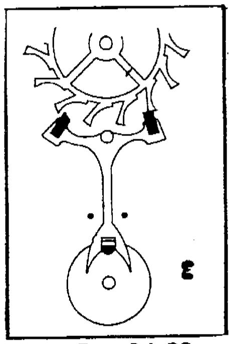


Fig. 34-22

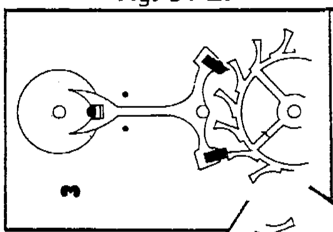


Fig. 34-23

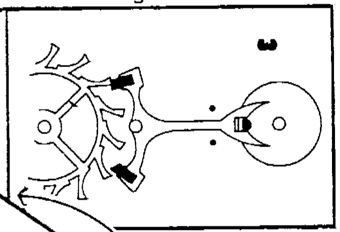


Fig. 34-24

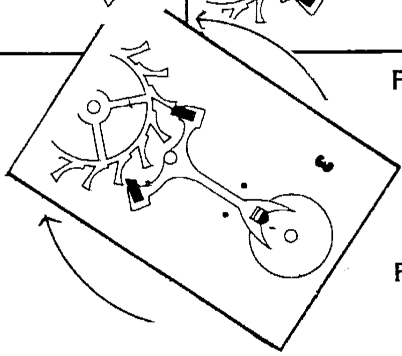


Fig. 34-25

true. Yes, the rates of a watch can be altered by tampering with the outer coil of the hairspring before or after it passes through the regulator pins, but inasmuch as the watch factories themselves do not agree on the proper shape for an overcoil, we shall not set forth any definite form that it should take. You can raise or lower the outer coil of a hairspring with the point of a tweezer, screw driver, tooth pick or anything else, call that operation anything you please, but if you adjust the outer coil of the hairspring in accordance with the well known rules of isochronism, it cannot be improved upon by any new tricks or methods.

Also theorists will tell us that the center of gravity of the hairspring shifts from side to side, up and down, or through any intervening angle, depending upon the position of the watch, and the shift of that center of gravity will affect the timekeeping, True, but it does so in an infinitesimal manner. Likewise the "sag" of a hairspring has but a very slight practical affect on the timekeeping. Even the unpoised pallet fork may introduce a slight position error.

The pallet fork may be considered as being practically "in poise" when the assembly finds itself in the positions depicted in figures 34-21 and 34-22. It is definitely out of poise in the positions depicted in figures 34-23 and 34-24. In the position shown in figure 34-23 the weight of the lever adds to or detracts from the power delivered to the roller jewel, depending on whether it is moving upwards (against the force of gravity) or downwards (being accelerated by the force of gravity). NOTE that when the watch is turned 180 degrees, so that we find the lever in the position as depicted in figure 34-24, the conditions described in figure 34-23, as to power delivered are exactly reversed. Concurrently, we must bear in mind that in practical usage, the lever finds itself in every conceivable angular position (figure 34-25) between the above described positions, hence, the "out of poise" element contributed by it, has every conceivable variation with positions.

Sometimes these small variations or errors will tend to offset each other, and sometimes they compound.

Thus we see that poising a balance wheel on the poising tool, while quite necessary, only suffices to place that one unit of the escapement in a condition which may be described as "static poise." That is quite insufficient—as it is imperative, for good timekeeping, that we consider the cumulative effects of the additional elements of the escapement. In other words, we must bring this entire "mobile unit," and by "mobile unit" we mean the completely assembled and running escapement, with its accumulated plus and minus errors—we must bring this entire "mobile unit" into a condition that shows it to be in poise WHILE RUNNING.

We can do this only with the use of the TIME-O-GRAF, as on it we can observe the entire accumulation, summation or whatever you wish to call it, continuously from one position to another, of all these infinitesimal errors, and correct them in one simple gesture.

First, we know that if we have a balance with a good motion, a motion with an arc of (See figure 34-18) over 220 degrees on a side, it will be very easy to detect the heavy side of the balance by locating the position of the watch when it has the greatest loss of time. We place the watch in the microphone of the TIME-O-GRAF pendant up, and rotate the watch slowly while the machine is running. The TIME-O-

GRAF immediately tells us on the continuous tape which position that watch is in when it has the slowest rate. We know that in that position, were the balance to be at rest, the heavy side of the balance assembly would be down. Your attention is called to the fact that when you rotate that running watch in the microphone of the timing machine, you have found the heavy side of the entire mobile unit, that is, of the balance, hairspring, all the other cumulative errors, some of which are very slight. However, you have absolutely and correctly located the heavy side of the mobile unit simply, effectively and without delay. This is the only method available today for the watchmaker to make a poise test on a running watch so that he may know at once where to make the necessary adjustments. Suggestion: If the watch has an over all losing rate, remove a little from the heavy side of the balance, or if it has an over all gaining rate, weight may be added to the lighter side. By these means in a very short time you can take a watch that is in good mechanical order and bring all of your vertical positions up to within a variation of less than 3 seconds in 24 hours in a good grade of pocket watch.

To summarize: The rates of a watch in the vertical positions can be adjusted very closely and rapidly by making use of the TIME-O-GRAF to determine the poise errors.

SEC. 596—Tapes from Odd Beat Movements

The watchmaker will occasionally encounter a watch beating other than 18,000 beats per hour (five beats per second).

Herewith is a list giving the beat of some of the currently found odd beat watches.

BEATS PER HOUR

Agassiz, 8PCV	20,222
Agassiz, PCV, AO, Z	20,944
Agassiz, 8AC	21,600
Audemars, 8'''	21,000
Concord 5½''', 7¾''', and "R. Cart"	19,800
Elgin, "Slow Train"	16,200
Elgin, 26/0	19,800
Gruen, some of the 124, 125, 176, 177	19,440
Gruen, 151	19,332
Gruen, 455, 457, 459, 465, 467, 469	19,800
Gruen, 106, 107, 109, 130, 133, 137, 139, 155, 159, 161, 169, 181, 183, 306, 307, 327, 328, 329, 331, 520	20,160
Gruen, 105, 333, 840, 841, 845, 857	20,222
Gruen, 305, 837, 839, 847, 863	20,940
Haas, 8''' round	20,222
Huguenin, 5½'''	20,160
Meylan, 7''' and 8'''	20,944
Meylan, 8'''	20,222
Nardin, 7'''	20,944
Omega, 11.5	21,300
Omega, 13.5 and 17.8	21,600
Omega, 30.10	19,800
Patek-Phillippe, 4'''	21,000
Touchon, 4'''	21,000
Vacheron & Constantin, 7''' oval	20,944
Waltham, 18 size, old models	14,400
Waltham, 18 and 16 and 14 size, "Slow Train"	16,200
Waltham, "400"	21,600

All of these odd beat watches can be rated on the TIME-O-GRAF, although in most cases the record for a watch with a zero rate will not consist of a single line, nor will it run straight down the tape.

In determining the pattern made by any odd beat watch, two constants of the machine must be known. These are the scanning speed and the rate of paper feed. The motor in the TIME-O-GRAF runs at EXACTLY 2700 revolutions per minute or, 45 revolutions per second. The lead on the printing spiral is exactly 2 inches. Thus, the scanning speed is exactly 45 r.p.sec. x 2" which equals 90 inches per second. The paper speed is exactly 6" per minute.

Some of the very early Roxbury made Walthams were 14,400 beats per hour, or 4 beats per second.

In this case the revolutions of the spiral per beat are 45/4, or 11¼ revolutions.

As ¼ revolution of the spiral equals one half an inch of scanning speed, this watch when running on time will print four lines of dots one half an inch apart, straight down the tape. Figure 34-26.

If the escapement is slightly out of beat, the record will appear somewhat like figure 34-27, the lines being "paired off."

Some of the early "Slow Train" Elgins and Walthams employed a 63 tooth fourth wheel and a 7 leaf escape wheel pinion, giving these watches a beat of 16,200 per hour, or 4½ beats per second.

In this case the revolutions of the spiral per beat are 45/4½, or 10 revolutions.

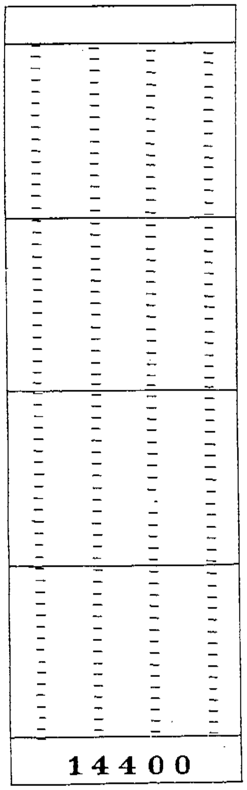


Fig. 34-26
A 14,400 Beat

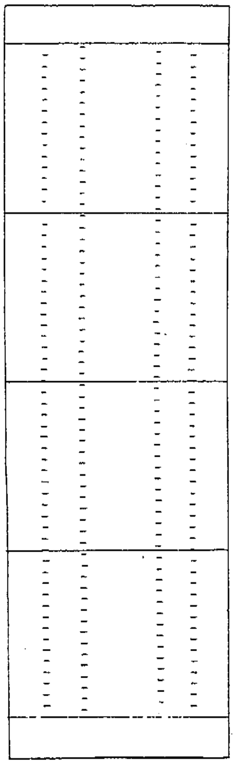
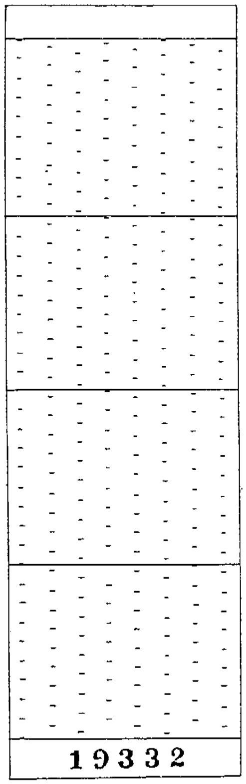
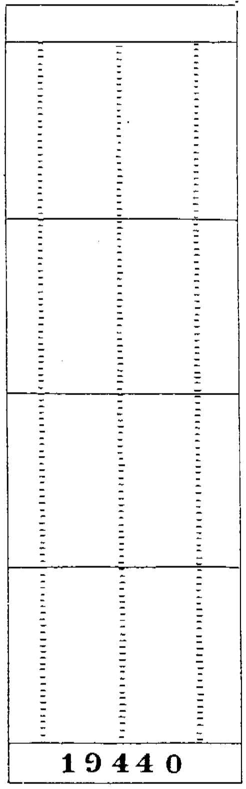


Fig. 34-27
A 14,000 Beat, when "Out of Beat"



A 19,332 Beat
Fig. 34-28



A 19,440 Beat
Fig. 34-29

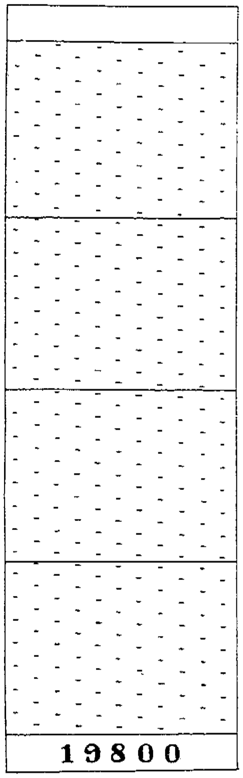


Fig. 34-30
A 19,800 Beat

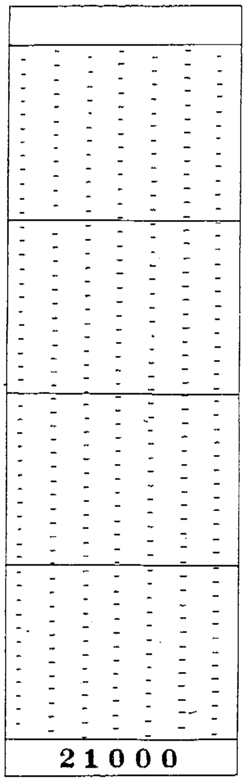


Fig. 34-31
A 21,000 Beat

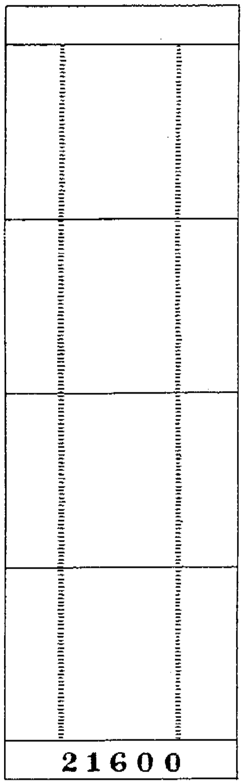
Thus, this 16,200 beat watch when running on time will print exactly in line straight down the tape very similar to the line made by an 18,000 beat.

Similarly, we find that the watches having 19,332 beats per hour, allow the spiral to make 8⅜ revolutions per beat, thus, these 19,332 beat watches when running on time will print 8 lines of dots straight down the tape, the lines being ¼ inch apart, figure 34-28.

The 19,440 beat watches allow the spiral to make 8-1/3 turns per beat, thus, the 19,440 beat watches when running on time will print three lines of dots straight down the tape 2/3 of an inch apart, figure 34-29.

The 19,800 beat watch will allow the spiral to make 8-2/11 turns per beat, thus the 19,800 beat watches when running on time will print 11 lines straight down the tape 2/11 of an inch apart, but it is rather difficult, on account of the scattered position of the dots comprising these lines, to arrive at a quick diagnosis of the watch, unless the watch is almost on time. The appearance of the correct record made by one of these watches is shown in figure 34-30.

The 21,000 beat watches, similarly, when running on time, will make a record of 7 lines straight down the tape, figure 34-31.

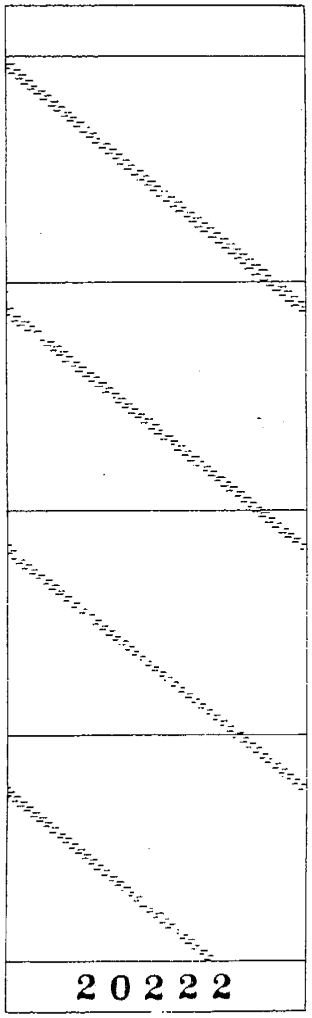


A 21,600 Beat

Fig. 34-32

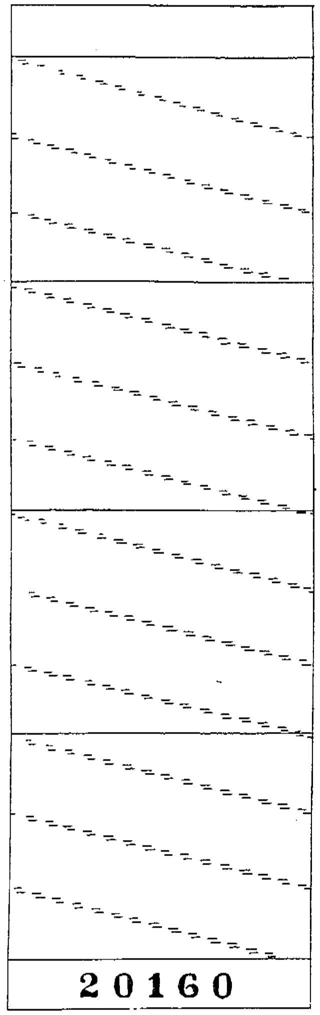
The 21,600 beat watches, similarly, when running on time, will make a record of two lines one inch apart, straight down the tape, figure 34-32.

Now, for those who like mathematics, let us look at a watch having 20,222 beats per hour, which is 5.61720555 per second. We see immediately that this watch will not print a straight line. $\frac{45}{5.61720555}$ equals approximately 8 and 1/100 revolutions of the spiral per tick. Now we can see that this one will print like a normal 5 beat watch **except** that since the spiral will make slightly more than an even number of turns between ticks, the line will slope to the left. Let us determine to what extent the line slopes. The time between ticks is 3600/20222 or .178024 seconds. Then .178024 x 90" per second (the speed of the spiral) equals a travel of 16.02216" per tick. As 8 turns equals 16" scanning, then 16.02216 minus 16 equals 0.02216' that each dot is displaced to the left of the previous dot. So, dividing the 2" of travel by this .02216 we get 90.25 ticks for the printed line to travel once across the 2" width of the paper. In time, this is equal to 90.25 x .178024 which equals 16.06666 seconds.



A 20,222 Beat

Fig. 34-33



A 20,160 Beat

Fig. 34-34

And $\frac{16.06666 \times 6''}{60 \text{ (sec.)}}$ equals 1.606" of paper travel while the dots move two inches to the left. We take a piece of paper and with a scale measure carefully 2" across the paper from a point and then up the paper 1.6" and make another point, then draw a line connecting these two points, giving us a pattern of what the record of this 20,222 watch should look like when the watch is running on time, figure 34-33.

With the paper travel of 1.6" while the line of dots crosses the 2" width of the paper, we may also lay out the position of the line by obtaining its angle by trigonometric functions.

The 20,160 beat watches, when running on time will make a record resembling that in figure 34-34.

SEC. 597 - Other Types of Timers

THE PRECISE TIMER

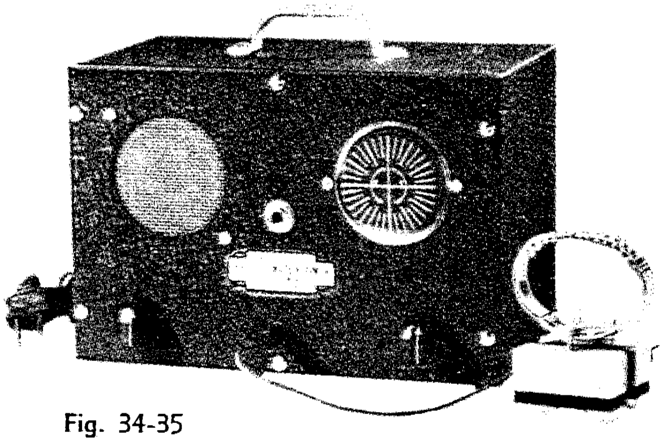


Fig. 34-35

The enthusiastic acceptance of the early timing machines quickly led other manufacturers into the field. Here are three low priced machines from the 1950's which used sound and visual records only. The Precise Watch Timer, figure 34-35, and the HR Watch Timer, figure 34-36, both operated on 110-120 volt, 60 cycle AC current. The transistorized Watch Meter, figure 34-37, was powered by two mercury batteries with capacity for 420 hours of rating time. None of these machines used printing records and none could time anything other than standard 300 beat watches.

THE WATCH METER

Other manufacturers stayed with the established chart type machine using a quartz crystal control. The trend became one of smaller machines, variable speeds for single-line recordings of odd beat watches, modifications or accessories for electric and electronic watches, faster scanning speeds, improved printing methods, transistorized solid state models with automatic stop-start and no warm up needed. The use of preprinted chart paper was largely abandoned in favor of plain paper with the rate still read by means of a timing dial as on the Time-O-Graf.

THE HR WATCH TIMER

Fig. 34-36

Fig. 34-37

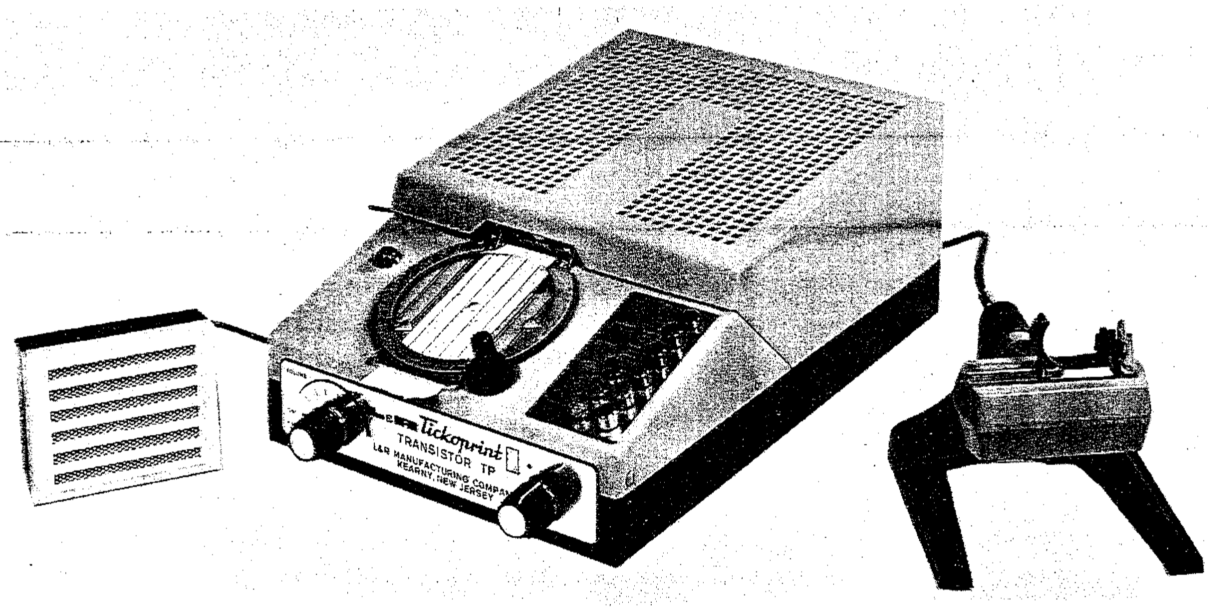


Fig. 34-38

SEC. 598 - L&R and Greiner

The Vibrograf, which you studied in the previous lesson, is typical of these newer machines as is the L&R Tickoprint TP46-5, figure 34-38. But there are many others.

THE L&R TICKOPRINT

The Tickoprint TP46-5 measures all mechanical, electric or electronic watches with greater precision than earlier models. An "electronic lens" magnifies the scale reading 5 times, which increases the precision rating also by 5. A fine alignment control on the rotary dial allows a more precise reading of the actual recording. It also uses a loudspeaker for the audio signal instead of an earphone. The microphone is the automatic start-stop type. Rating begins when the watch is placed on it and stops when the watch is removed.

L&R is also the U.S.A. distributor for Greiner timing machines.

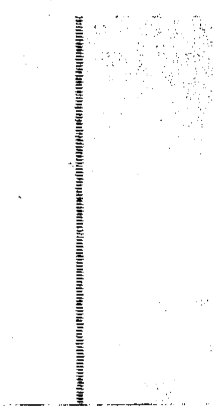
THE CHRONOGRAPHIC JUNIOR

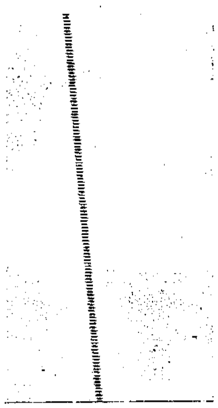
The Swiss made Greiner timing machines have always ranked high in the field. Their Chronographic Junior, figure 34-40, of the mid 1950's, was probably the smallest machine of its type in use at that time. It used only four tubes. It was also unique in using an electronic frequency divider instead of a mechanical gear shift for different beats and a spark printing arrangement rather than the common printing bar. Spark printing was discontinued in later machines.

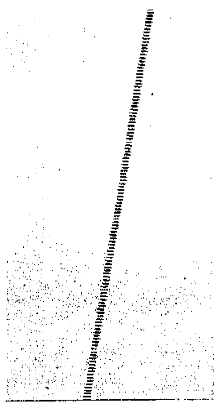
THE MICROMAT

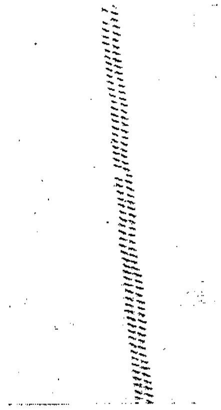
Figure 34-41 shows the Micromat, a current model by Greiner, which uses a paper tape print out. It is very small and measures only 8-7/8" x 6" x 4". It will time regular watches, electric and electronic, some quartz movements and electric clocks without requiring further units.

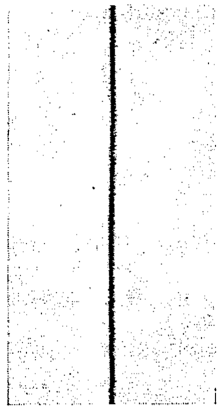
TYPICAL DIAGRAMS MADE BY AN L&R TICKOPRINT:

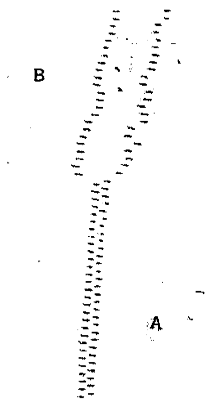

Deviation: 0


Deviation: –

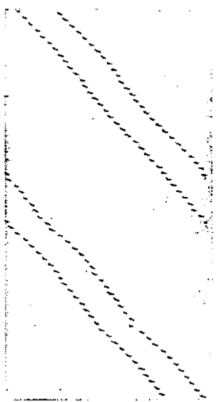

Deviation: +

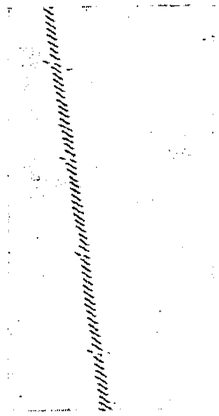

Hamilton Electric
Deviation: – 10 secs./day

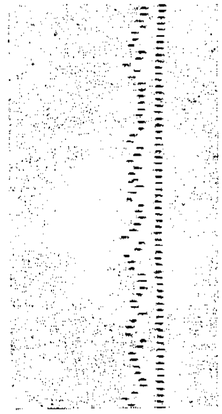

Accutron
Deviation: 0



17 Jewel Movement
Deviation: — 5 secs./day
A 1:1
B 1:5 Electron lens


Off beat
Deviation: – 2 min. 40 secs./day


One escape wheel tooth damaged
Deviation: – 25 secs./day


Entry pallet damaged

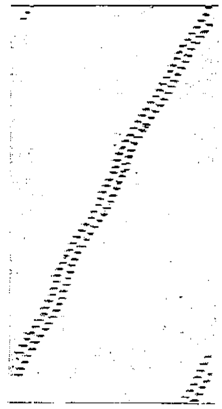

Power unevenly transmitted
Deviation: + 1 min. 32 secs./day

Fig. 34-39

THE CHRONOGRAPHIC JUNIOR

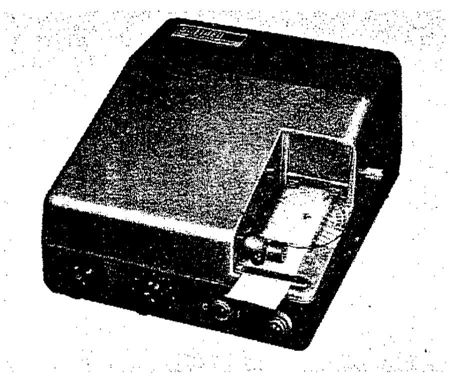


Fig. 34-40

THE MICROMAT

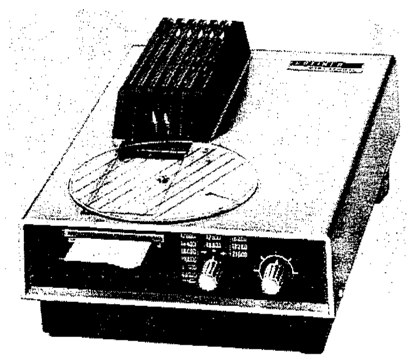


Fig. 34-41

THE PRECICHECK

Another small (9" x 7-1/2" x 4-1/4") Greiner machine is the Precicheck, figure 34-42. It recalls the earlier visual timers, figures 34-35 and 34-37, but is much more versatile. This silent visual indicator shows fast or slow rates and out of beat errors for all currently available mechanical watches as well as electric and electronic watches. It uses only 5 watts power and no paper or ink ribbons so there are no diagrams to interpret. Watches can be quickly adjusted while mounted on the microphone.

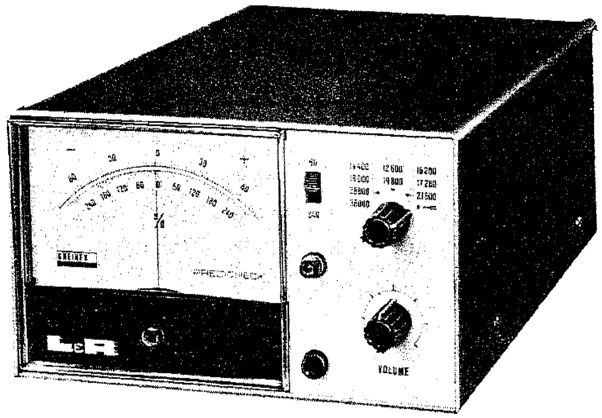


Fig. 34-42

THE QUARTZ-TIMER

The only radical change in recorders is the development of a digital display timing machine. Greiner's entry, figure 34-43, is the Quartz Timer. This solid state machine is designed to record all present watches of whatever type and all future quartz watches. It automatically selects all frequencies of electronic watches and clocks (quartz crystal and tuning fork) between 1 and 812-2/3 cycles as well as all beats for existing mechanical watches.

Of course other companies are active in the digital display field also. In 1969, National Time Corporation, of Denver, Colorado, announced a Watch Computer digital display machine for mechanical watches and Accutron. In 1972, the A. Y. A. Timatron Company, of Newton, Mass., began to market its Timatron 501, which can measure watch or clock rates from 1,000 to 360,000 beats per hour. The beat can also be heard audibly.

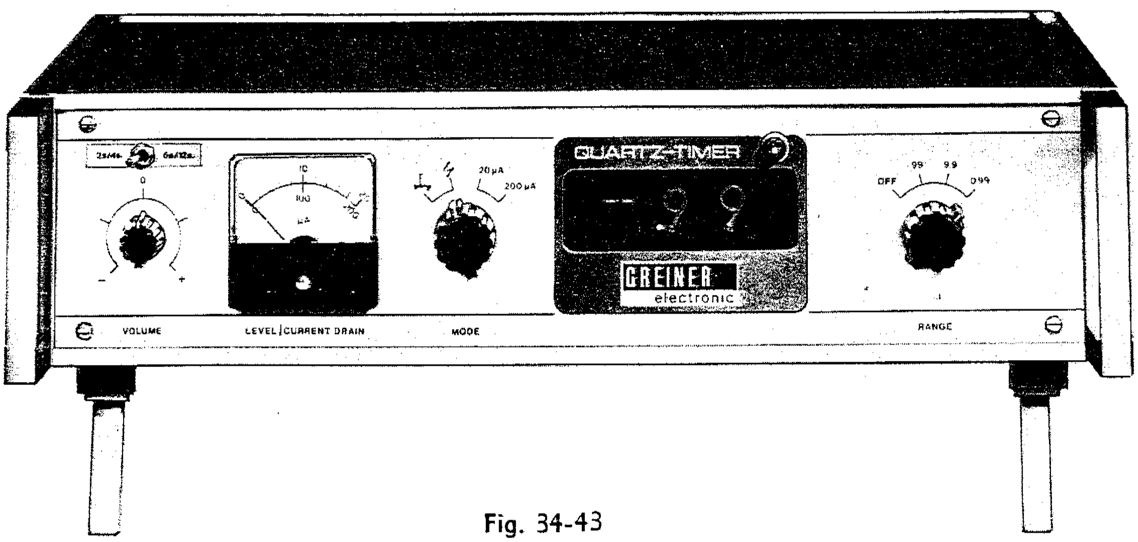


Fig. 34-43

Test Questions — Master Watchmaking — Lesson No. 34

Name: No.: Date:

Circle the ONE BEST answer: SUBJECT: Time-O-Graf and Others

1. The unit of the Time-O-Graf Electronic Timing Machine which furnishes the source of standard time is:

A tuning fork	A quartz crystal oscillator	A master clock	A synchronous electric clock

2. The line on a Time-O-Graf tape shows the rate of a watch by:

The space between the dots forming the line	The width of line or space between lines	The slopes and variations of the line	The location of line on the left or right of tape

3. How many major sounds are in a watch tick?

6	5	4	3

4. Which one of the following happenings is NOT LIKELY to be caused by a dry mainspring?

Mainspring might break	Mainspring might rust	Watch might have excessive motion	Uneven power delivered to train

5. Which is the proper method of putting an escapement in beat?

Put stud directly above arm of balance	Put stud directly above mark on rim of balance	Test on timing machine; then make corrections	Let down power and check pallet stones and escape teeth

6. What effect has pressure or strain on the movement of a watch?

The watch will vary in rate	The watch will lose	The watch will gain	No effect on watch in good condition

7. How would magnetism in a watch affect its printed record?

Will not show on the printed record	Will show a fast rate	Will show a slow rate	Rarely affects two watches the same way

8. How do the printed records made on late model timing machines differ from those made on early models?

No ink ribbons required for newer machines	No interpretation of printed record needed on newer machines	Odd beat watches record as single line	Record needs magnification for easy reading

Detach page or cut along this line — and send to the School for grading

Master Watchmaking

MODERN SHOP METHODS

333

Problems and Solutions

Questions and Answers Illustrated

CHICAGO SCHOOL OF WATCHMAKING

Founded 1908 by THOMAS B. SWEAZEY

70-35 REVISED 1960 Printed in U.S.A.

This review manual serves two purposes: 1. It will refresh your memory on important points covered in the Master Watchmaking course. 2. It will acquaint you with the kind of questions asked on state license and other examinations.

The questions and answers herein are not arranged in any definite order. But they are grouped together below so you can quickly go over just certain parts of the course or certain subject matter. A few questions do not fit readily under the headings we are using, so they are grouped under a Miscellaneous heading at the end as they do come up on examinations.

In a few cases, answers may vary from what you have learned in the lessons. There are several reasons why this happens. We may have been talking about a specific watch while the answer here covers the matter in general or the other way around. Also, some subjects can be covered from various viewpoints and this gives rise to conflicting opinions. A few terms are not ones we use but are some used by other watchmakers. If you keep this in mind, you'll not get mixed up by these variations.

UNIT W-1 - Fundamentals, Casing, Stems, Crystals, Nomenclature:

Questions 201, 202, 200, 1, 205, 208, 203, 204, 2, 66, 238, 309, 226, 271, 272, 311, 232, 269, 270, 3, 306, 4, 57, 5, 7, 50, 8, 166, 295, 333, 225, 193, 6, 69, 71, 72, 330, 206, 255, 55.

UNIT W-2 - Mainsprings:

Questions 38, 31, 37, 39, 9, 35, 40, 41, 10, 293, 29, 43, 42, 284, 332, 54, 55, 36, 242, 285, 11, 14, 46, 34, 30, 12, 13, 16, 33.

UNIT W-3 - Assembly and Disassembly, Winding and Setting Mechanisms, Cleaning, and Timing:

Questions 275, 255, 229, 69, 268, 67, 257, 15, 238, 233, 273, 312, 260, 45, 246, 274, 248, 294, 253, 254, 258, 61, 62, 64, 63, 65, 68, 70, 261, 277, 212, 213, 214, 329, 187, 230, 265, 264, 299, 303, 304, 305, 234.

UNIT W-4 - Jeweling:

Questions 307, 16, 227, 276, 259, 17, 176, 18, 283, 172, 173, 158, 146, 175, 298, 291, 310.

UNIT W-5 - Factory Balance Staffs and Truing and Poising Balance Wheels:

Questions 19, 188, 181, 190, 20, 21, 198, 174, 175, 189, 22, 185, 182, 183, 184, 191, 177, 23, 245, 252, 316, 317, 318, 319, 321, 320, 315, 186, 24, 322, 243, 25, 194, 265, 192, 171, 219, 26.

UNIT W-6 - Hairsprings and Calculation of Watch Trains:

Questions 229, 209, 211, 196, 197, 221, 222, 27, 217, 179, 210, 296, 297, 58, 52, 235, 51, 53, 59, 60, 170, 199, 215, 218, 216, 328, 213, 214.

UNIT W-7 - The Escapement:

Questions 159, 76, 158, 82, 156, 155, 151, 150, 145, 116, 97, 92, 89, 28, 75, 104, 107, 103, 106, 108, 149, 148, 147, 81, 110, 111, 112, 80, 117, 79, 163, 90, 286, 138, 140, 142, 139, 78, 132, 137, 134, 133, 135, 136, 119, 120, 93, 94, 95, 96, 99, 114, 115, 118, 105, 109, 113, 126, 129, 125, 127, 130, 128, 123, 124, 84, 164, 165, 144, 143, 169, 161, 168, 160, 162, 91, 88, 153, 154, 256, 152, 121, 122, 167, 157, 86, 131, 83, 98, 100, 101, 102, 141, 77, 87.

UNIT W-8 - Use of the Watchmaker's Lathe and Calculating Wheels and Pinions:

Questions 26, 241, 292, 236, 278, 279, 234, 305, 288, 302, 289, 181, 198, 174, 175, 180, 326, 266, 331, 56, 301, 44, 296, 297, 47, 48, 49, 50, 32, 75.

UNIT W-9 - Modern Shop Methods and Electronic Timing Machines:

Questions 69, 255, 71, 72, 73, 228, 249, 250, 300, 313, 281, 74, 238, 67, 262, 287, 187, 230, 264, 265, 243, 314, 322, 323, 324, 251, 325, 178, 326, 267, 85, 286, 77, 51, 53, 170.

MISCELLANEOUS:

Clocks: 240, 255, 239, 224, 290, 247, 237, 207.

Dials: 280, 244.

Special Feature Watches: 231, 308.

Unclassified: 263, 223, 282.

WHEN IS A MAN A WATCHMAKER?

Time and time again we read or hear the definition of a watchmaker. It is said by some that a man must have years of experience behind him. Some states require a watchmaker to pass an examination, and upon meeting their requirements, will issue a certificate to that effect. Certain associations have set up a standard by which the aspiring watchmaker can take an examination and upon paying a fee be issued a certificate stating in large captions that he is a watchmaker. Schools issue diplomas stating that the recipient has completed his course in a satisfactory manner. Men who learned their trade in the old country declare that the best watchmakers come from the particular country in which they were apprenticed. Some state that a good watchmaker must have an electric timing device and only then can he be a good watchmaker. There are always those who will condemn something or other whether or not they are qualified to do so. Many so-called eminent watchmakers who a few years back condemned watch cleaning machines now regard them as a valuable asset to their shops.

Without much doubt it can be said that because of lack of educational facilities, watchmaking or watch repairing has not progressed as rapidly as it should have. The watchmaker must meet the problems of the future as soon as they are presented. He must be alive to new ideas. He must be on the lookout for new tools that will help him do a better job. He must not become "old fashioned." He must strive to do better work -- not strive to see how much he can "get away with." He should put himself in his customers' place and treat them accordingly. He should do everything possible to elevate himself and his associates. His pay should rank with that of the highest tradesmen. In short, a watchmaker is one who can conscientiously turn out a first class job with a personal feeling of a job well done. His success will depend upon his desire to be of service to his customers and an asset to his community.

To meet the conditions which prevail in some states and for those who are desirous of taking an outside horology examination, this review of your elementary training in watchmaking is put in the form of questions and answers. One of the best ways to cram for an examination is to write out each question several times and then write the answer several more times. This is the most effective method for the majority of the students. The majority of the following questions are similar to those given by state boards and other associations which have written test questions. Although some of the answers given may conflict with the opinions of others, they are, in most cases, generally accepted for written examinations.

QUESTION	ANSWER
1. To avoid fingerprints on the movement or dial we ...... ?	1-A. Handle the movement by the edge of the pillar plate and use watch paper.
2. Is it necessary to oil the stem on a pocket watch case and, if so, at what point?	2-A. It is advisable to oil the stem at the point of contact with the sleeve.

QUESTION	ANSWER
3. What is the difference between an open face movement and a hunting movement?	3-A. An open face winds at 12; a hunting winds at 3.
4. Give the name used in horology which describes the series of gears and which transmits the power from the mainspring to the pallets.	4-A. Train.
5. What material are pinions made from?	5-A. Steel.
6. What controls the rate of a timepiece through the regularity of its oscillations?	6-A. The balance assembly.
7. How many revolutions does the center wheel and pinion make in an hour?	7-A. One.

8. How many revolutions does the fourth wheel and pinion make in one hour?

8-A. Sixty.

9. What is the minimum number of steady pins found on each bridge?

9-A. Two.

10. How many hours should an average watch run with one winding?

10-A. 32 to 36.

11. Is the metric or the Dennison Gauge the more accurate for measuring the width and strength of a mainspring?

11-A. The metric.

12. To get the best results of the area between the outside of the arbor and the inside shell of the barrel how much of the area should be occupied by a mainspring with 11 coils?

12-A. One half.

13. How much should be occupied by one with 13 coils?

13-A. One half.

14. The Metric Micrometer gives us readings in ..?

14-A. 1/100 of a millimeter.

15. What is the purpose of the clutch lever?

15-A. To move the clutch from winding to setting.

16. Will a 7 Jewel and a 21 Jewel watch of the same size and model require mainsprings of different strength?

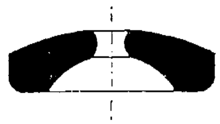
16-A. Yes.

17. Name the jewels in a 17 Jewel Watch which are not used as bearings for a wheel and pinion?

17-A. R. Stone (Receiving Stone)
L. Stone (Let-Off Stone)
Roller Jewel

18. What is the advantage of an olive hole jewel?

18-A. It has a smaller bearing surface.

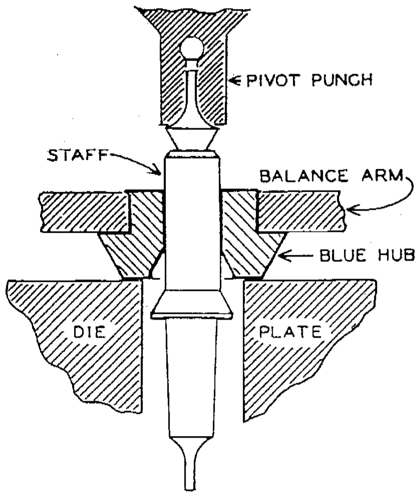


19. What does the term "genuine" watch material mean?

19-A. The material was made by the factory that made the watch.

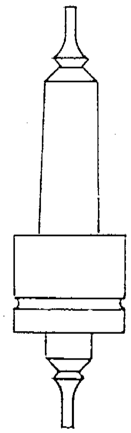
20. How do you recognize a Waltham friction staff?

20-A. By the blued hub on the balance wheel.



21. Some Hamilton watches use another type of friction balance staff which may be recognized by ...... ?

21-A. A groove cut in the staff.



22. The main purpose of truing and poising the balance wheel is ...... ?

22-A. To be able to properly adjust and bring the watch to time.

23. The balance screws in a compensating balance wheel have been placed in their respective positions by the factory for ...... ?

23-A. Temperature adjustment.

24. What is the general cause of a balance wheel which seems to run true in the caliper but not in the watch?

24-A. Most likely the pivots are bent.

25. In poising a balance wheel, would you generally remove or add weight if the regulator was as far toward the "fast" as possible?

25-A. More weight is removed than added.

26. Is it practical to do watch repairing without a lathe?

26-A. No.

27. The word Isochronism means?

27-A. Equality of time.

28. How many impulses does the pallet receive from an escape wheel with 15 teeth in 1 revolution?

28-A. 30.

29. What is the proper way to put a mainspring in a barrel?

29-A. With a mainspring winder.

30. How much space should a mainspring occupy in the barrel?

30-A. One half the remaining area with the barrel arbor in place.

31. Name the three kinds of barrels used in watches.

31-A. Motor Barrel; Going Barrel; Fuzee Barrel.

32. If a barrel has 80 teeth and the Center Pinion has 10 leaves, how many revolutions does the barrel make in 24 hours?

32-A. Three revolutions.

SOLUTION:

Teeth in barrel divided by leaves in center pinion equals time for 1 turn of barrel.

Substituting, $\frac{80}{10}$ equals 8

Hours watch runs divided by time for 1 turn of barrel equals number of turns of barrel.

Substituting, $\frac{24}{8}$ equals 3

33. What is the effect of putting a mainspring in a watch that is:
   A. Too thick?
   B. Too thin?
   C. Too wide?
   D. Too narrow?

33-A.
   A. It will exert an excess of power.
   B. It will not have enough power.
   C. It will cause friction between the barrel cap and the bottom of the barrel.
   D. It may cause buckling and will lack power.

E. Too short?

E. It would not run a sufficient length of time.

F. Too long?

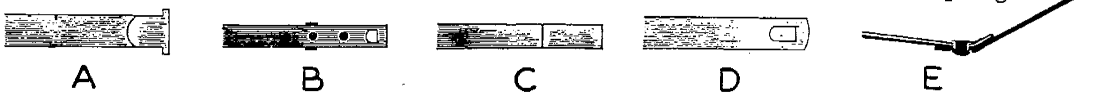
F. It would not run a sufficient length of time.

34. How many coils would you ordinarily find in the barrel if the mainspring is the proper length and strength?

34-A. Twelve.

35. Name the different kinds of end fastenings found on mainsprings.

35-A. (A) T-End, (B) Double Brace, (C) Tongue, (D) Hole, (E) Bridle; Slip Spring; or Tension Spring



36. What is a Motor Barrel?

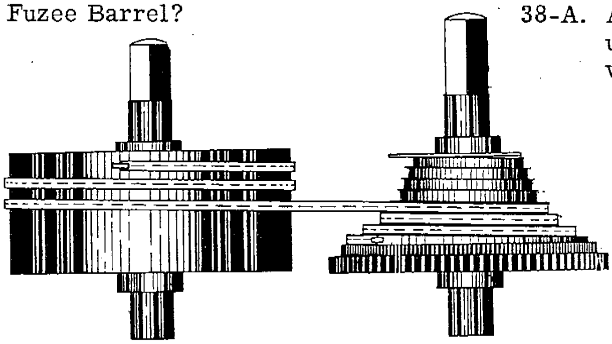
36-A. A Motor Barrel remains stationary. Its only purpose is to confine the mainspring. The great wheel, or first wheel, revolves independent of the barrel.

37. What is a Going Barrel?

36-A. The Going Barrel contains the teeth of the great wheel or first wheel and revolves as it drives the train.

38. What is a Fuzee Barrel?

38-A. A barrel which contains the mainspring and upon which the fuzee chain winds as the watch runs down.

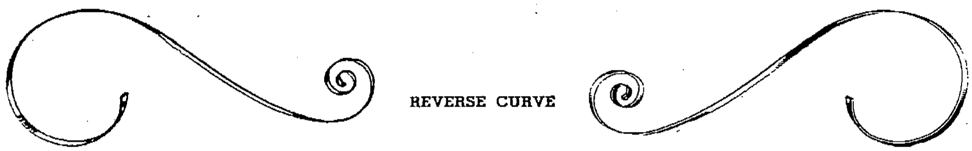


39. What is a Suspended Barrel?

39-A. A Suspended Barrel is one which is supported only from the upper plate.

40. What is a reversed curve mainspring?

40-A. A spring which is reversed to the direction which it is wound. It does not have a tendency to set as quickly and it possesses greater elasticity.



41. What is a cross curve mainspring?

41-A. One with a concave surface.

42. If a barrel head is loose, how do you tighten it?

42-A. With a barrel contractor.

43. What are the safeguards used when winding in a mainspring?

43-A. Clean the new mainspring thoroughly to dissolve the protective coating. Dry carefully. Oil lightly by passing spring through tissue with small amount of oil. Wind spring in with a mainspring winder. Use an arbor of the proper size, make certain that the pin on the winding arbor isn't any longer than the thickness of the mainspring. Insert mainspring in barrel and oil with watch or clock oil.

44. How would you fit a new hook in a barrel Explain.

44-A. Locate center from barrel head shoulder to bottom of barrel on the outside of barrel. Drill hole proper size and tap. Then take piece of brass wire slightly tapered and thread with same size die from which tap was made. Screw into barrel the proper amount after which cut off on the outside and finish flush with barrel. File slot on the proper side of the hook.

45. What risks would you take by not removing the mainspring every time you clean a watch?

45-A. The cleaning fluid would probably ruin the mainspring. The cleaning fluid would also ruin the lubricating properties of the oil.

46. How do you determine the strength of a mainspring?

46-A. The strength of the mainspring may be determined by dividing the inside diameter of the barrel by 100. For very small watches add 1/100th of a millimeter.

47. What is the ratio of the center wheel to the third pinion?

47-A. 8 to 1.

SOLUTION:

$$\frac{\text{Number of teeth in center wheel}}{\text{Number of leaves in 3rd pinion}}$$

Substituting: $\frac{80}{10}$ equals 8 Ratio is 8 to 1

48. What is the ratio of the 3rd wheel to the 4th pinion?

48-A. 7-1/2 to 1

SOLUTION:

$$\frac{\text{Number of teeth in 3rd wheel}}{\text{Number of leaves in 4th pinion}}$$

Substituting: $\frac{60}{8}$ equals 7-1/2 Ratio is 7-1/2 to 1

49. What is the ratio of the center wheel to the 4th pinion?

49-A. 60 to 1.

SOLUTION:

$$\frac{\text{Number of teeth in center wheel X number teeth in 3rd wheel}}{\text{Number of leaves in 3rd pinion X number of leaves in 4th pinion}}$$

Substituting: $\frac{80 \times 60}{10 \times 8}$ equals 60 Ratio is 60 to 1

50. What is the time of one revolution of the third wheel?

50-A. 7-1/2 minutes.

SOLUTION:

$$\frac{\text{Number teeth 3rd wheel}}{\text{Number leaves 4th pinion}} \text{ X Number turns 4th pinion makes in 1 minute}$$

51. Name five different kinds of trains.

51-A.

Slow	14,400	vibrations per hour
Medium	16,200	" " "
Fast	18,000	" " "
Quick	19,800	" " "
Extra Quick	21,600	" " "

52. How do you calculate the number of vibrations a watch with a second hand makes in one minute?

52-A. The number of teeth in the 4th wheel multiplied by twice the number of teeth in the escape wheel, divided by the number of leaves in the escape pinion.

EXAMPLE:

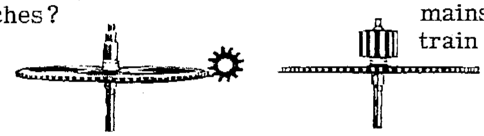
$$\frac{60 \text{ X } 30}{6} \text{ equals 300 vibrations per minute}$$

53. What is usually meant by a quick train watch?

53-A. Two Common Quick Train Watches are 19,800 vibrations and 21,600 vibrations per hour.

54. What is the purpose of a safety pinion on the center staff of some watches?

54-A. The Safety Pinion will unscrew when the mainspring breaks, thereby relieving the train of the excess strain.



55. What is the center staff?

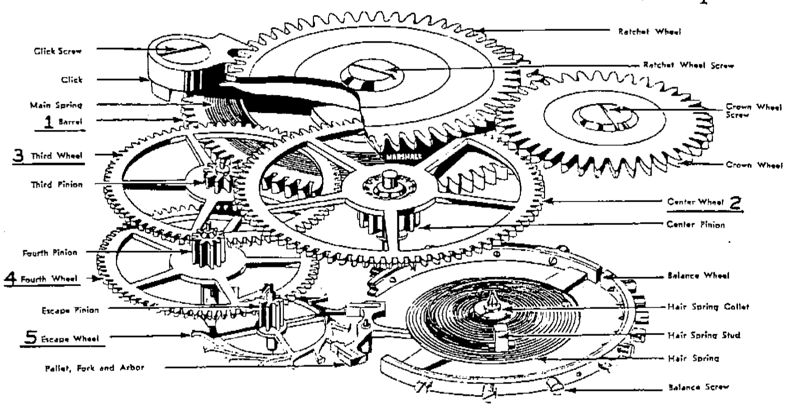
55-A. The arbor attached to the center wheel, which carries the minute hand.

56. If you had a train wheel that was out of round, how could you correct it?

56-A. The wheel must be recentered usually by cementing to a cement chuck and then re-bushed, or it may be corrected with a rounding up tool.

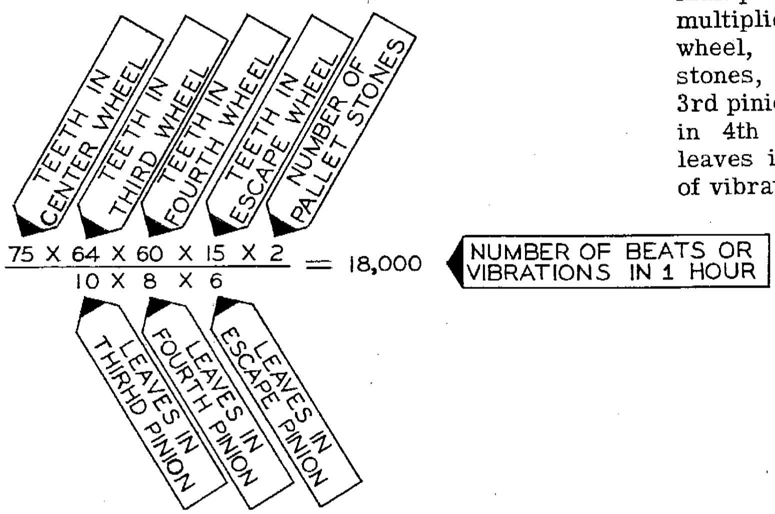
57. Name the wheels in a watch train.

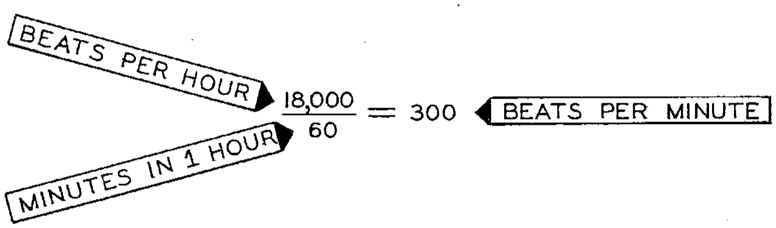
57-A. Barrel, No. 1; Center Wheel, No. 2; Third Wheel, No. 3; Fourth Wheel, No. 4; and Escape Wheel, No. 5.



58. How do you calculate the train of a watch?

58-A. The number of teeth in the center wheel, multiplied by number of teeth in 3rd wheel, multiplied by number of teeth in 4th wheel, multiplied by number of teeth in escape wheel, multiplied by number of pallet stones, DIVIDED BY number of leaves in 3rd pinion, multiplied by number of leaves in 4th pinion, multiplied by number of leaves in 5th pinion, EQUALS the number of vibrations or beats per hour.





59. How do you figure a Quick Train?

59-A. All trains are calculated in the manner shown in the answer and question #58. Because of the different ratio between the center wheel and 4th wheel the number of vibrations can be other than 300 vibrations per minute.

EXAMPLE:

$$\frac{64 \times 66 \times 60 \times 15 \times 2}{8 \times 8 \times 6} \text{ equals } 19{,}8000$$

60. How do you figure on Extra Quick Train?

60-A. At times you will find a watch train with an additional train wheel and pinion. Do not let this confuse you but in figuring the number of vibrations place the number of teeth in the extra wheel and the number of leaves in the pinion in proper sequence.

EXAMPLE:

$$\frac{42 \times 42 \times 35 \times 35 \times 12 \times 2}{7 \times 7 \times 7 \times 7} \text{ equals } 21{,}600$$

61. How do you tighten the cannon pinion friction on a watch with a Center Pin?

61-A. By driving the cannon pinion against the end of the center pinion pivot.

62. What causes an ordinary Cannon Pinion to stay in place?

62-A. Usually a small depression in center staff, into which the center punch mark or spring snaps in place.

63. Do you oil a Cannon Pinion?

63-A. Yes, sparingly.

64. How much friction is considered necessary for the Cannon Pinion?

64-A. Sufficient to carry the hands safely.

65. If a Cannon Pinion works up slightly when setting a watch, what can you do?

65-A. Set center punch mark up higher on the cannon pinion.

66. What direction do you turn the dial screws when releasing most Swiss Dials?

66-A. To the right.

67. What is the proper way to center a dial if the holes do not center with cannon pinion and second bit?
Should the balance be taken out?

67-A. Place a piece of wood against the edge of the dial and tap the edge.

The balance should be taken out.

68. If a watch continues to run and the hands do not move, what might be the trouble and how would you remedy same?

68-A. The trouble might be a loose cannon pinion. Tighten the Cannon Pinion.

69. Name the Dial Train.

69-A. Hour wheel, minute wheel, cannon pinion, minute pinion.

70. How do you tighten a loose cannon pinion?

70-A. Use a Cannon Pinion tightener, or insert tapered brass wire into cannon pinion and use center punch.

71. What is the Hour Wheel?

71-A. The Hour Wheel is the wheel which turns on the cannon pinion once every 12 hours and carries the hour hand.

72. What is a Minute Wheel?

72-A. A wheel and pinion used to give the ratio 12 to 1 between the cannon pinion and the hour wheel.

73. What is the purpose of a dial washer?

73-A. The purpose of a dial washer is to hold the hour wheel in the proper position.

74. If a watch stops every 12 hours, where would you look for the trouble?

74-A. Examine the Hour Wheel.

75. How many revolutions does the ordinary escape wheel make per minute?

75-A. Ten.

EXAMPLE:

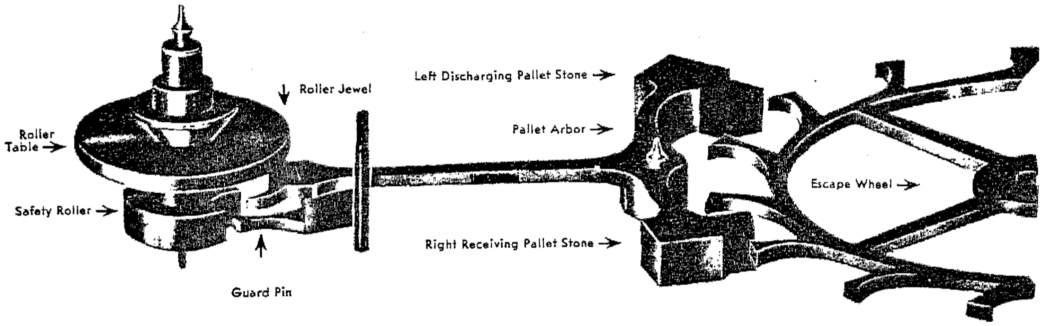
$$\frac{\text{Teeth in 4th Wheel}}{\text{Leaves in 5th Pinion}} \text{ X turns 4th wheel makes in 1 minute}$$

SUBSTITUTING:

$$\frac{60 \text{ X } 1}{6} \text{ equals } 10$$

76. Name the main group of parts of which the escapement consists.

76-A. Escape wheel and pinion; pallets; fork; roller; roller jewel.



77. How do you put an Escapement in beat?

77-A. By turning the hairspring collet until the balance escapes with equal ease on both sides or assuming that the watch is in line, bring the roller jewel to the line of center and then place hairspring in the proper position.

78. Why are the locking faces of the pallet stones placed at an angle?

78-A. To produce draw.

79. If an escapement has too much lock and slide, how do you correct it?

79-A. By pushing the pallet stone in and closing the banking pins.

80. What is meant by lock and slide?

80-A. Lock is the distance from the locking corner that the tooth drops on the pallet stone. Slide is the movement of the pallets after the lock.

81. For what purpose are the bankings in a watch?

81-A. To regulate the amount of angular motion to the Lever.

82. Name the pallet stones in a watch.

82-A. R meaning the Receiving and L the Let-Off.

83. What is meant by Corner Clearance?

83-A. The freedom between the horn of the fork at the fork slot and the face of the roller jewel.

84. Are the locking faces of the pallet stones at equal distance from the pallet center in the circular escapement?

84-A. No, but they are in an equidistant escapement.

85. What is meant by a watch rebanking? What may be the cause?

85-A. The balance takes an excessive motion, and the roller jewel hits the outside of the horns.
Caused by too strong a mainspring.

86. What would be the effect on the escapement if the let-off corner was broken off the L stone?

86-A. It would reduce or eliminate the Lock on the R. Stone due to insufficient lift.

87. In your opinion, what is the best way to test a watch for perfect beat?

87-A. By testing the let-off to see that it lets off of both pallets with equal ease with a small amount of power.

88. Name the various escapements that have been in common use for the past fifty years.

88-A. Lever, chronometer, cylinder, and duplex.

89. How many teeth does the average escape wheel have?

89-A. Fifteen.

90. When is an escapement overbanked or out of action?

90-A. When the roller jewel is out of fork slot.

91. What is meant by a Dead-Beat Escapement?	91-A. An escapement without recoil.
92. What is the recoil escapement?	92-A. One where the escape wheel moves backwards in the unlocking.
93. How many degrees lift in a lever escapement?	93-A. Average 8-1/2 degrees.
94. When does the lift occur?	94-A. Immediately after the unlocking.
95. What gives the lift?	95-A. Escape tooth passing across the impulse face of the pallet stone.
96. What is the object of the lift?	96-A. To give impulse to the roller jewel.
97. What is understood by impulse face of a pallet?	97-A. The lifting angle on a pallet stone.
98. How do you tell when impulse face is correct?	98-A. When the locking is equal.
99. How is this lift distributed in club and pointed tooth?	99-A. In club tooth it is divided between teeth and stone. In pointed tooth, it is all on stone.
100. How do you tell when pallets have right impulse face on pointed tooth?	100-A. See if it has equal lock.
101. How would you prove which pallet stone was incorrectly set on pointed tooth?	101-A. Go by the angular motion to see whether you increase one or decrease the other.
102. What would you do in case of unequal lift in pointed tooth?	102-A. Change the angle of the impulse face of one or the other stone.
103. How much drop in the lever escapement?	103-A. Approximately 1-1/2 degrees.
104. What is meant by the drop?	104-A. Space between the left off corners of tooth and stone.
105. When does the drop occur?	105-A. After the impulse.
106. What is the cause of too much or too little drop?	106-A. Pallet Stones are too thick or too thin; or escape wheel teeth are too wide or too narrow.
107. What is the object of the drop?	107-A. To give clearance.
108. Is there any bad effect in having too much drop?	108-A. Yes. It can cause wear and loss of power.
109. What is the cause of an unequal drop?	109-A. Pallet Stones are too wide apart, or too close together.
110. When is a lever watch banked to drop?	110-A. When the banking pins are moved to such a position that the tooth of the escape wheel just drops off the stone at the instant the pallet fork is arrested by the bankings.
111. What is the object of banking to drop?	111-A. To test the watch for lock and alignment.
112. Should a watch with a lever escapement be banked to drop to give good results?	112-A. No. There would be no clearance.
113. Can we have unequal drop when pallets are proper thickness and proper distance apart?	113-A. No.

114. How many degrees lock in a lever escapement?

114-A. 1-1/2 average.

115. When does the lock occur?

115-A. At the instant the escape tooth drops on the stone.

116. What is meant by locking face of pallets?

116-A. The face upon which the escape tooth drops.

117. What is the lock for?

117-A. To arrest the escape wheel while the balance performs its arc of vibration.

118. What effect would it have on the locking if the pallets were set too far from the escape wheel?

118-A. Reduce the lock.

119. What is one cause of an unequal lock?

119-A. Improper setting of pallet stones.

120. What would you do in the case of unequal lock?

120-A. Adjust one or both of the pallet stones.

121. How many degrees opening to pallets?

121-A. Sixty degrees.

122. What is understood by opening of pallets?

122-A. Angle from center of escape wheel to locking corners.

123. What is understood by equidistant lockings?

123-A. Locking faces on both stones are same distance from center of pallet.

124. What is a circular pallet?

124-A. Where the center of pallet stones is equal distance from the center of the pallets.

125. What is meant by slide?

125-A. Amount the tooth slides on the pallet.

126. Is it necessary to have slide?

126-A. Yes.

127. How much slide?

127-A. Approximately half as much as the lock.

128. When does slide take place?

128-A. Following the lock.

129. What decreases or increases slide?

129-A. Opening or closing the banking pins.

130. Can you have slide without draw?

130-A. No.

131. Would the effect be good or bad in a light locking to open the bankings a little?

131-A. Good.

132. What is meant by draw?

132-A. The angle of the locking faces of the pallets in a lever escapement.

133. How many degrees draw to the pallets?

133-A. 12 to 15.

134. When does the draw take effect?

134-A. As soon as it locks.

135. Where is the draw laid off from?

135-A. Locking Corner.

136. Would the effect of a strong draw be good or bad, and why?

136-A. Bad. Causes too much resistance to unlocking.

137. What is the object of the draw and what do you understand by the term?

137-A. Object is to hold lever against the banking to allow the balance freedom of motion.

138. When is an escapement out of line?

138-A. When the angular motion is not equal.

139. How do you test a lever watch to see if it is in line?

139-A. Bank to drop and test angular motion. Test guard freedom.

140. Name three ways of putting a watch in line.

140-A. Moving pallet stones; moving fork on two piece pallet; bending fork.

141. If the escapement was out of line and the jewel pin came to a line of centers when at rest, what effect, if any, would it have on the watch being in beat?

141-A. It would be out of beat.

142. Should the fork let off equal distance on either side of a line of centers?

142-A. Yes, if it is in line.

143. What is the ordinary length of fork as compared with diameter of escape wheel?

143-A. 2/3/ to 3/5.

144. What is the general rule for the length of fork and roller to match?

144-A. 3-1/2 to 1; or 4 to 1.

145. How do you tell when the roller is of proper size?

145-A. If the safety action is correct, the roller would be the proper size.

146. How much shake do you allow for jewel pin in fork?

146-A. Approximately 2/100 of a millimeter.

147. How do you find out when jewel pin is too far back?

147-A. Corner clearance test.

148. When should roller jewel leave the fork?

148-A. The instant before the fork is arrested by the bankings.

149. What portion of a jewel pin should be taken off or flattened when drawing an escapement?

149-A. 2/5.

150. What advantage, if any, in a double roller?

150-A. Greater safety action. Decreases friction of guard pin on roller.

151. What do you understand by double roller in lever escapement?

151-A. Large or impulse roller carries roller jewel. Small or safety roller carries the passing hollow and performs the safety action.

152. How many degrees angular motion to the lever ? What gives the angular motion?

152-A. 10 degrees. The 8-1/2 degree lift and 1-1/2 degree lock gives the angular motion.

153. What is a Cylinder Escapement?

153-A. A frictional dead-beat escapement.

154. What is the advantage of a steel escape wheel over a brass?

154-A. Lighter, strong and has better wearing qualities.

155. What is a double roller escapement?

155-A. The lever escapement in which a separate roller is employed for the guard action.

156. What is a guard pin?

156-A. A pin which prevents the watch from going out of action or overbanking.

157. Explain all that you would do in putting in a pallet stone to replace one which is lost.

157-A. If an American watch, select a stone of proper make and size and test for lock. If Swiss watch, select a stone to fit the slot and test for lock and lift.

158. What is the Impulse Pin or Roller Jewel?

158-A. The impulse pin or roller jewel is the ruby or sapphire pin of the lever escapement which, entering the notch of the lever, unlocks the escape wheel and then receives the impulse from the lever and passes out of the opposite side.

159. What is the purpose of an escapement?

159-A. The escapement is that part of the watch which changes the circular force of the escape wheel into the vibratory motion of the balance.

160. What is the straight line escapement?

160-A. A straight line escapement is one in which the pallets, lever and balance are all in a straight line.

161. What is the right angle escapement?

161-A. In a right angle escapement, we find the line of centers of the pallet and balance crossed at right angles by the line of the escape wheel.

162. What is a semi-tangental escapement?

162-A. In a semi-tangental escapement location of the pallets is a compromise between the circular and equidistant escapement.

163. What is the purpose of the horns?

163-A. Horns on the lever have no definite purpose in single roller, except that they act as a safety in case of a jar to carry the jewel pin safely across from one side of the roller to the other. In the double roller they provide the safety action after the guard pin has entered the passing hollow.

164. What is meant by the term "long fork"?

164-A. If the roller jewel will not pass out of the fork slot when the escapement is banked to drop, it is called a long fork.

165. What is meant by the term "short fork"?

165-A. If the roller jewel shake is so great as to allow the pallet stone to unlock when an escapement is banked to drop, it is called a short fork.

166. In an ordinary watch, what do you call the fifth wheel?

166-A. Escape wheel.

167. In adjusting an escapement, name the procedure.

167-A. Check your bank to drop; lock; slide; drop; draw; guard freedom.

168. What is meant by a detached lever escapement?

168-A. It is an escapement in which the balance is free from the escapement and solely under the influence of the hairspring, except when unlocking and receiving the impulse.

169. What is a poised fork?

169-A. A poised fork is a fork which has an extension on the side opposite the horns to balance or counterpoise it.

170. How many vibrations per minute does the balance make in the three different trains in American bracelet watches?

170-A. Fast Train............. 300
Quick Train............ 330
Extra Quick Train.... 360

171. How would you remove a broken screw from the rim of a balance?

171-A. Drill through the screw with drill slightly smaller then the thread of the screw, then broach the remainder.

172. What would you say is the proper amount of space between the balance and cap jewels?

172-A. 2/100 of a millimeter.

173. What do you consider the proper thickness of a balance jewel in comparison with the size of the hole?

173-A. Approximately one-half the size of the hole.

174. How long should a balance pivot be compared to its diameter?

174-A. 2 to 2-1/2 times as long as the diameter.

175. In your opinion, what is the proper amount of end shake on a balance staff for a pocket watch?

175-A. 2/100 of a millimeter.

176. What is meant by an olive balance hole jewel and what is its purpose?

176-A. The hole in an olive balance hole jewel is rounded on the inside instead of being straight. The purpose is to reduce friction.

177. What is the purpose of a compensating balance?

177-A. To compensate for loss or gain in heat or cold.

178. If the end of a balance pivot is flat and you make it slightly round, will it cause a slower or faster rate on that pivot?

178-A. Slower.

179. Name two kinds of hairsprings and explain the difference.

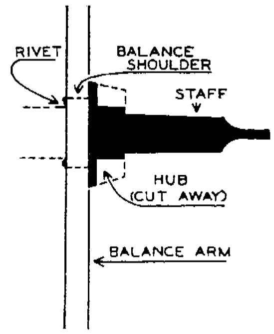
179-A. Breguet or overcoil and flat.

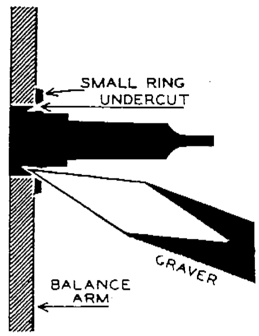
180. If, in putting in new balance staff, your nearest selection has pivots a trifle too large, explain fully how you reduce their diameter.

180-A. Grind with oilstone powder or crocus and polish with diamantine.

181. How do you remove a balance staff from a balance wheel of ordinary construction?

181-A. Chuck it up in the lathe and undercut the rivet, or turn away the hub.





182. Why are some balances made of two metals and cut?

182-A. To compensate for changes in temperature.

183. Why are two metals used in a compensating balance?

183-A. Because of their difference in expansion and contraction.

184. Why are steel and brass used?

184-A. Brass has a greater coefficient of expansion than steel.

185. What do you understand by a composition balance?

185-A. A balance made of alloyed metal.

186. How do you true a balance?

186-A. With a good truing caliper. First level the arms, then raise the lower segments until true in the flat. In the round, check to see that the arms are both the same length, then bring the rim in or out to conform with the edge of rim at end of arm, until both sections are true in the round.

187. How much of an arc should the balance make when the watch is in good condition?

187-A. 1-1/2 arcs or 540 degrees.

188. How do you select a balance staff?

188-A. You select a balance staff for the make of watch, size, length of staff, diameter of pivots, proper diameter of collet and roller shoulders.

189. Explain how you fasten a balance staff to a balance wheel of ordinary construction.

189-A. By first staking with a round face hollow and a flat face hollow staking punch.

190. Name the two other kinds of staffs and explain the difference.

190-A. Waltham Friction Taper Shoulder Staff, and Hamilton two-piece Friction Staff. The part which is the hub is staked into the balance arm permanently. The broken staff may be driven out and the new one driven in friction tight.

191. What is a compensating balance?

191-A. A compensating balance is a bimetallic balance consisting of approximately 2/5 steel and 3/5 brass.

192. What is the usual time value of a pair of balance screws?

192-A. A pair of regular sized screws added or removed from the balance of a pocket watch will vary the time approximately one hour per day. Some factories make screws known as heavy, medium, and light. Other companies make a line of timing screws for their watches, each pair having a specifically stated time value.

193. What is the purpose of the balance?

193-A. The vibratory wheel of a watch which in conjunction with the mainspring controls the progress of the hands.

194. Name the different kinds of screws that may be found on a balance.

194-A. Full head balance screws; timing screws; meantime screws.

195. Why are threads on some balance screws longer than others?

195-A. Those with long threads are fitted friction tight, and are called meantime screws. Moving a pair in will cause the watch to run faster.

196. What is Invar?

196-A. Nickel steel alloy containing approximately 36% nickel.

197. What is the most important property of Invar?

197-A. The expansion in the ordinary temperature range is negligible.

198. Explain how you take the staff measurements on a watch.

198-A. Overall length from outside of balance jewel settings. Then from outside of lower balance jewel setting to top of pallet bridge, and from outside of lower balance jewel setting to top of fork. The balance of the measurements may be computed from these three measurements.

199. If the hairspring of an 18,000 beat train was vibrated two beats per minute fast, how much would the watch gain in 24 hours?

199-A. 9 minutes and 36 seconds.

SOLUTION:

2 beats per minute equals 2/5 sec.
2/5 sec. x 60 minutes equals 24 (the number of seconds fast in 1 hour)
24 sec. x 24 hrs. equals 576 (the number of seconds fast in 24 hours)
576 divided by 60 (the number of seconds in one minute) equals 9.6

SUBSTITUTING:

$$\frac{.4 \times 60 \times 24}{60} \text{ equals } 9.6$$

200. Name two springs used in a hunting case.

200-A. Lift and lock.

201. What are the principal parts of an open face pocket watch case?

201-A. Frame or center, bezel, back, pendant, crown, bow.

202. What is the difference between an Open Face Watch and a Hunting Case Watch?

202-A. An open face watch has no cover or back. A hunting case watch has a cover protecting the glass. This cover is referred to as the front back.

203. What is the probable trouble with an American Pendant Set Watch when you pull the stem out to the setting position and it neither winds nor sets?

203-A. The sleeve may be in too far.

204. If the stem pulls out easily on an American Pendant Set Watch so that it occasionally gets in the setting position itself, what is usually wrong?

204-A. Usually a worn or broken sleeve.

205. What is a stem of a watch?

205-A. The stem is also known as the winding arbor.

206. What is the clutch?

206-A. A sliding pinion which shifts from winding to setting, or vice versa.

207. What is meant by Maintaining Power?

207-A. A mechanism for driving a watch or clock while being wound.

208. How do you take the excess shake out of a stem?

208-A. The shake in stem is generally due to the hole in between the plates being worn. In order to overcome excess shake in stem caused by wear, fit new stem with oversized hub.

209. What is the purpose of the balance spring?

209-A. To regulate the time of vibrations of the balance.

210. Why is the Breguet Spring superior to a flat one?

210-A. The action is more concentric and more susceptible to adjustment for Isochronism.

211. Is a cylindrical spring superior to all others?

211-A. Yes.

212. What do you understand by the word curb pins?

212-A. Regulator pins.

213. Should the hairspring vibrate between the curb pins?

213-A. On a flat spring, yes.
On a overcoil spring, no.

214. What is the proper distance between the curb pins?

214-A. Approximately twice the thickness of the spring.

215. In vibrating a flat hairspring, where should the point of vibration be placed?

215-A. About half way between stud and regulator pins.

216. About how many coils should a Breguet spring have?

216-A. Fourteen or fifteen.

217. Which way do you insert pin in collet and is it best to have pin flattened slightly?

217-A. Insert same direction as spring enters collet. No, it is not best to flatten pin.

218. About how many coils should a flat spring have?

218-A. Fourteen or fifteen.

219. If you were fitting a hairspring to a watch and you found it necessary, where would you add or take off weight?

219-A. You make your change on the balance within 1/3 from the solid end.

220. What is the hairspring?

220-A. It is frequently termed balance spring, and is a small coiled spring which vibrates the balance.

221. What is Elinvar?

221-A. Elinvar is the same as Invar with 12% chromium added, replacing a like amount of iron.

222. What is the most important property of Elinvar?

222-A. The elastic strength does not change in the ordinary temperature range.

223. What is known as a free spring?

223-A. A balance spring with no provision for regulating by curb pins. Marine Chronometers, and occasionally very fine watches, have no curb pin regulator in them. Regulation is effected by meantime screws in the balance rim.

224. What is the effect in increasing the weight of a pendulum bob?

224-A. No effect, except if increased too much, it will stop. As long as impulse will throw it, no effect.

225. How many millimeters are there in an inch?

225-A. 25.4.

226. How many millimeters are there in a Ligne?

226-A. 2.26.

227. Name materials used for making watch jewels.

227-A. Garnet, ruby, sapphire, and sometimes a diamond.

228. What is the difference between regulating a watch and adjusting a watch?

228-A. Regulating a watch is timing it so it doesn't gain or lose.
Adjusting a watch is manipulating it so that it will keep equal time in different positions and temperatures.

229. How do you remove the hands from a watch with a metal dial so as not to mar the dial?

229-A. With a hand remover and a dial protector.

230. If a watch should suddenly gain considerable time, name all the causes you can think of that might be the trouble.

230-A. Balance screw lost; balance out of true; oil on the hairspring; hairspring tangled.

231. What are each of the following:
a. Chronograph Watch?
b. Repeater Watch?
c. Calendar Watch?

231-A.
a. A Chronograph Watch is a recording time piece.
b. A Repeater Watch is one that strikes the time.
c. A Calendar Watch is one that records the date.

232. What is a:
a. Bezel?
b. Pendant?
c. Bridge?
d. Crown?
e. Click?

232-A.
a. A bezel is a grooved rim into which the watch glass or crystal is fitted.
b. A pendant is that part to which a bow is attached.
c. A bridge is the standard secured to the plate by means of screws and in which a pivot works.
d. A crown is the part you grasp when winding a watch.
e. A click is a dog or pawl which falls into a ratchet wheel and prevents it from turning backwards.

233. How often should the ordinary pocket watch be cleaned?

233-A. Every 12 to 18 months.

234. If you were fitting a second hand and found the hole in the socket too large, how would you close the hole to fit pivot?

234-A. Close hole in socket by placing in chuck and tightening draw in spindle.

235. In an 18,000 beat train, what fraction of a second does the second hand advance with each beat of the balance wheel?

235-A. 1/5 of a second.

236. To what temper do you draw stem wind wheels?

236-A. Dark Blue.

237. How do you put the alarm hand on an alarm clock so as to have the clock ring at the time indicated?

237-A. Turn hands until cam drops, then put alarm hand on at the time hour and minute hands indicate.

238. Name at least two causes for a watch winding hard after being put together.

238-A. Lack of oil under crown wheel, or not aligned with stem in case.

239. How do you regulate a pendulum bob?

239-A. By raising or lowering.

240. What clock will keep the best time, one driven by mainspring power or one driven by weight?

240-A. The one driven by weight keeps the best time because the power is more constant.

241. How may you prevent steel from being oxidized when hardening?

241-A. Cover with powdered boracic acid or soap.

242. Explain the advantage of a recoil click.

242-A. The recoil click prevents winding the mainspring too tightly.

243. When a watch varies in the pendant positions, what may be some of the troubles?

243-A. Balance out of poise; hairspring out of true or out of center; curb pins open.

244. If you had to enlarge the hole in a porcelain dial, how would you do so without chipping?

244-A. Use a tapered broach charged with diamond powder.

245. What are the chief causes of variations in different temperatures?

245-A. Expansion and contraction of balance wheel; lengthening and shortening of the hairspring.

246. What are the most important qualities required for good watch oil?

246-A. Must remain liquid when exposed to intense cold.
Must evaporate slowly under intense heat.
Must not corrode on metal.
It must not become gummy.
It must not creep.

247. What time of day would it be when a ship or marine clock strikes eight bells?
Five bells?
One bell?

248-A. When it strikes eight bells, it is 12, 4 or 8 o'clock.
When it strikes five bells, it is 2:30, 6:30 or 10:30.
When it strikes one bell, it is 12:30, 4:30 or 8:30.

EXAMPLES:

1 Bell	12:30	4:30	8:30
2 Bells	1:00	5:00	9:00
3 Bells	1:30	5:30	9:30
4 Bells	2:00	6:00	10:00
5 Bells	2:30	6:30	10:30
6 Bells	3:00	7:00	11:00
7 Bells	3:30	7:30	11:30
8 Bells	4:00	8:00	12:00

248. What parts of a watch do you oil?

248-A. The winding wheels, the mainspring, all pivots, the center post, the escape wheel teeth; in other words, where there is friction. Do not oil roller or hour and minute wheels.

249. What is meant by adjustment of a watch?

249-A. Manipulating the balance, its spring and staff for the purpose of improving the time keeping qualities of the watch. Adjusting to position, isochronism and temperature.

250. What is meant by position adjustment?

250-A. The manipulation of the hairspring, curb pins, and balance so that the movement keeps time in the different positions.

251. What is meant by adjusting to Isochronism?

251-A. The manipulation of the hairspring so that the long and short arcs of the balance are performed in the same time.

252. What is meant by adjusting a watch to temperature?

252-A. Manipulation of the balance screws to cause a watch to rate the same in heat and cold.

253. How do you test a watch for magnetism?

253-A. By the use of a small compass, preferably with the magnetism removed.

254. What is the effect of magnetism on a watch?

254-A. It causes the watch to run erratically.

255. Define the following parts; dial; bob of a clock; cannon pinion.

255-A. A Dial is a graduated face of a time piece.
Bob of a clock is the metal weight at the bottom of a pendulum.
Cannon Pinion is the pinion to which a minute hand is attached.

256. What is a Marine Chronometer?

256-A. A chronometer hung in gimbals for use at sea.

257. What is a potance?

257-A. A lower bridge, or hang down bracket fastened on the under side of the upper plate of an 18 size watch.

258. What is a Demagnetizer?

258-A. A device used to remove magnetism from parts of watches.

259. Name the jewels in a 21 jewel watch.

259-A. 2 Balance hole jewels
6 Cap jewels
2 Pallet jewels
1 Roller jewel
2 Pallet arbor hole jewels
2 Escape pinion hole jewels
2 Third pinion hole jewels
2 Center pinion hole jewels
2 Fourth pinion hole jewels

260. When cleaning a watch, do you remove the mainspring from the barrel?

260-A. Yes.

261. What is a regulator of a watch?

261-A. The part to which the curb pins are attached.

262. How do you remove a broken screw from a plate?

262-A. Dissolve screw out in solution of alum water, or one part of sulphuric acid to 9 parts of water. If plate should discolor in either of these solutions, immerse in cyanide solution to restore finish.

263. What is Solar Time?

263-A. Sun time.

264. After placing a staff in a watch, and you find that the watch runs 2 or 3 minutes fast, explain how you would bring that watch to time.

264-A. If watch was running fast, turn the meantime screws out. If watch is running slow, turn the meantime screws in. If watch was running slow, in absence of meantime screws, reduce weight of balance by undercutting screws. If watch was running fast in absence of meantime screws, add weight in form of timing washers.

265. What are meantime screws?

265-A. Screws usually placed at quarters. Often called quarter screws. Threaded friction tight so they can be moved in or out. The purpose of meantime screws is to bring the watch to time without the use of the regulator.

266. How do you make a Swiss stem?

266-A. Select a piece of steel as large as the hole through the plate. Turn pivot, locate slot, fit winding pinion and clutch. Cut off proper length and thread for crown. Harden and temper to a blue.

267. If you flatten the ends of the balance pivots, what effect would it have in regard to rate?

267-A. By flattening the ends of the balance pivots, you would increase the friction, which would reduce the arc of the balance, and thereby increase the rate in the dial up and dial down positions.

268. Name the most important steps when taking a watch apart for cleaning and oiling and reassembling.

268-A.
1. Remove hands, dial and dial train.
2. Remove balance and bridge, being very careful with the hairspring.
3. Press back click and release the power slowly with the stem or bench key.
4. Remove pallet bridge and fork.
5. Remove winding wheels.
6. Remove bridges, barrel and train.
7. After cleaning all parts thoroughly, put mainspring and arbor in the barrel and oil.
8. Assemble balance hole jewels and cap jewels and oil.
9. Assemble barrel, train and pallet in watch oil, commencing at center.
10. Place balance in watch.
11. Check to see that hairspring is true in the round and flat and centered.
12. Oil center staff and replace cannon pinion.
13. Complete oiling at all points of friction including three of four teeth of escape wheel.
14. Complete assembly by replacing dial and hands.

269. What is a full plate watch?

269-A. In a full plate watch the balance and balance bridge are above the plate.

270. What is a 3/4 plate watch?

270-A. A 3/4 plate watch is where the balance is in the movement or below the surface of the plate.

271. Name the different kinds of crystals used in open faced watches.

271-A. Mi-concave; lentile; lentile chevee.

272. What is the name of the crystal used in hunting case watches?

272-A. Geneva.

273. How often should bracelet watches be cleaned?

273-A. Bracelet watches should be cleaned every 9 to 12 months. Very small watches should be cleaned every 6 to 9 months.

274. How would you transfer oil from your bottle to the oil cup and why?

274-A. Use a clean glass rod so that you do not contaminate your oil supply, or keep your oil in a hypodermic needle.

275. What is a floating or self centering stud?

275-A. It is the type of stud which when free allows the spring to seek its centered position, and which is held firmly in place with a small plate, which is held in position by two screws.

276. Name or illustrate eight kinds of jewels.

276-A. Regular cap; balance; plate; friction cap; friction balance; friction plate; roller jewel; pallet jewels; barrel arbor jewels.

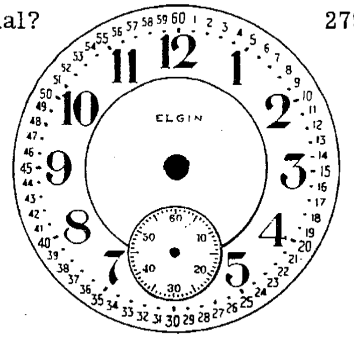
277. What is a patent regulator?

277-A. It is a type of regulator which makes possible a micro-meter adjustment.

278. What is a double sunk dial?

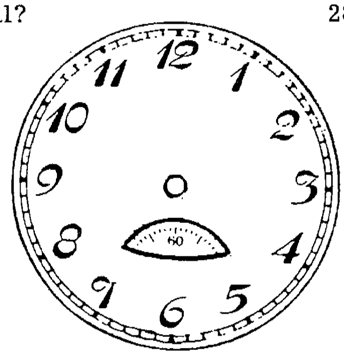
278-A. A dial which is in three parts before being assembled, each portion at a different level.

279. What is a Montgomery dial?



279-A. It is a dial showing numbers 1 to 60 on the margin, indicating minutes.

280. What is a Secometer Dial?



280-A. A secometer dial has an aperture through which the rotating second dial may be seen.

281. Where would you look for the trouble if a watch stops every five minutes?

281-A. The trouble may be caused by the cannon pinion if 12 leaf, or by the center pinion if 12 leaf.

282. What is Epilame process?

282-A. Pivots or plates are dipped in a liquid solution which prevents oil from creeping away.

283. Where are conical pivots found other than on the balance staff?

284-A. Conical pivots are found wherever the hole jewel is capped.

284. Where is the stop works found in a watch?

284-A. The stop work mechanism is usually found on the under side of the mainspring barrel.

285. What two different systems of measurements are used for Mainsprings?

285-A. Metric and Dennison.

286. Does Re-Banking mean the same as Over-Banking?

286-A. Re-Banking is caused by excessive motion. Over-Banking, providing the watch is correct in every other way, is caused by faulty guard pin, which action means the guard pin is too far away from the roller or too short.

287. What do you consider good timing qualities for a high grade watch? What should be the limit of error per week?

287-A. Within thirty seconds per week.

288. What is a depthing?

288-A. Distance between centers. It is the amount which a wheel will engage into a pinion.

289. In what way may a depthing be defective, and how is this to be remedied?

289-A. A depthing could be remedied by uprighting. Faulty depthing is usually corrected with a rounding up tool.

290. What is the length of the pendulum on a second beat clock?

290-A. 39 and a fraction inches.

291. What allowance is made between diameter of the reamer and the diameter of a friction jewel to obtain a friction fit?

291-A. 1/100 millimeter.

292. Name the different temper colors.

292-A. Light straw, yellow straw, light brown, dark brown, purple, dark blue, light blue, gray.

293. Name the three different lengths of running time on watches with one winding.

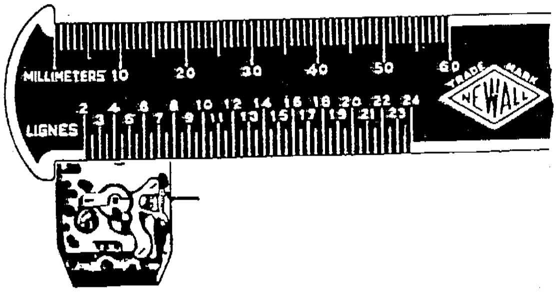
293-A. The ordinary watch should run 36 to 40 hours, 60 hours, or eight days.

294. How do you clean dials?

294-A. Cyanide Potassium solution is an excellent tarnish remover. Rinse in cool water.

295. How do you measure a watch for size?

295-A. Use watch gauge, or a millimeter gauge, and measure diameter of pillar plate on the dial side.



296. What is a simple train?

296-A. Where the teeth of one wheel engage the teeth on another wheel.

297. What is a compound train?

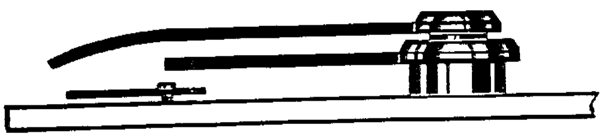
297-A. Where wheels depth into pinions.

298. What is meant by friction jeweling?

298-A. Jewels are placed into the proper position in a watch friction tight. The proper friction is obtained by pressing the jewel into a hole in the plate or bridge, and the hole is approximately 1/100 of a millimeter smaller in diameter than the jewel.

299. How do you adjust the hands on a watch?

299-A. The hands should be parallel with the dial.



300. What is required to attain a good regulation?

300-A. The barrel must be free from faults. The mainspring must be of the right dimensions, the train free, the escapement properly adjusted, proper fit of balance pivots and proper end shake, balance true and poised, hairspring true, flat and centered, and the curb pins in the proper position.

301. What is the purpose of a Rounding Up Tool?

301-A. A rounding up tool is used for touching up the teeth of a wheel or reducing the diameter very slightly.

302. What is a Depthing Tool?

302-A. An adjustable tool used to determine the distance between centers.

303. How do you close the socket in an hour hand?

303-A. The socket of an hour hand is closed with a taper mouth punch used in the staking tool.

304. How do you close the hole in a minute hand?

304-A. The hole in a minute hand may be closed by using a round edge punch which is slightly larger than the hole, which when tapped lightly with a hammer, will reduce the diameter of the opening.

305. How do you close the pipe or tube on a second hand?

305-A. By placing it in a chuck in a watchmaker's lathe and tightening the Draw-In Spindle, which closes it the entire length.

306. How may the moving parts in a watch movement be classified?

306-A. Winding parts; motive parts; transmitting parts; distributing parts; regulating parts; setting parts; time showing parts.

307. What is the use of jewels in a watch movement?

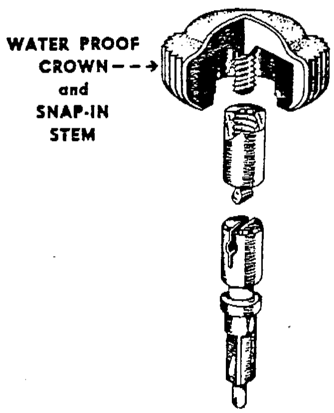
307-A. To reduce wear and friction of the moving parts to a minimum. Oil sinks in the jewels provide for adequate storage of oil.

308. What is the difference between Sport Timers and Chronographs?

308-A. Sport Timers do not tell time.

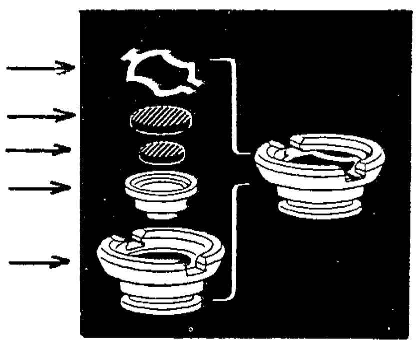
309. On what type watches are snap-in crowns and slotted stems used?

309-A. On waterproof watches.



310. What do you understand by Incabloc assembly?

310-A. The assembly consists of the balance jewel cap jewel and spring, the purpose being to absorb shock when the watch receives a blow or is dropped.



311. When replacing a strap on a strap watch case, is the buckle end placed at 12 or 6?

311-A. 12.

312. Explain your method of cleaning and oiling a watch correctly.

312-A. The two methods of cleaning a watch are known as hand method and cleaning by machine method. Both methods require the use of a cleaning fluid which will remove the dirt and old oil and brighten the watch parts, after which all parts are thoroughly rinsed before drying. Regardless of the method used, all pivot holes should be thoroughly pegged before the watch is assembled.

313. If a watch was handed to you for repair, how would you go about examining it?

313-A. First examine to see if the case is tight,, after which test the winding and setting. Then remove the movement from case, remove hands and dial and balance from the watch. Examine carefully and proceed to estimate the necessary repairs.

314. What is the difference between Static Poise and Dynamic Poise?

314-A. A balance is static poised on a poising tool. When the balance is in perfect static poise, it must come to rest and remain at rest in any position it may be placed.
Dynamic poise refers to conditions which arise when the balance of the watch is in motion, which in turn effects the rate of a watch.

315. When is a watch adjusted to temperature?

315-A. When proper adjustments have been made on balance for heat and cold.

316. If a watch gains in heat, what is the action and which way would you move the screws?

316-A. Balance expands in heat, and for that reason screws must be brought nearer arm, away from cut end.

317. Why are gold and platinum screws sometimes used?

317-A. For appearance and weight.

318. What is the first thing to be done in adjusting to heat and cold?

318-A. Get difference in rate between heat and cold.

319. What are the extreme temperatures used when adjusting to heat and cold?

319-A. 45 to 90 degrees.

320. Should a watch always remain in one position while being adjusted to temperature and why?

320-A. Yes, so as to eliminate position error.

321. How is temperature adjustment obtained?

321-A. When a watch is adjusted to temperature, it is run 24 hours dial up in a temperature of 90 degrees F, and its rate compared with a standard. It is then run 24 hours dial up in a temperature of 40 degrees F. If it then shows a gain in the 40 degrees temperature as compared with the running in the 90 degree, it is said to be under compensated. This is remedied by moving screws nearer the free ends of the rim.

322. What effect in timing to position would it have if the balance was out of poise?

322-A. Make vertical positions variable.

323. What is plus action and what is minus action?

323-A. Plus means gain; minus means a loss; although some writers reverse the signs.

324. Is the balance ever put out of poise in timing to position?

324-A. Sometimes done. Not recommended.

325. What effect does a thick hole jewel have on the rate of timing?

325-A. You would make vertical position slow.

326. Should the pivot be made flat on the end to equalize the friction?

326-A. No.

327. When is a watch in Isochronal condition?

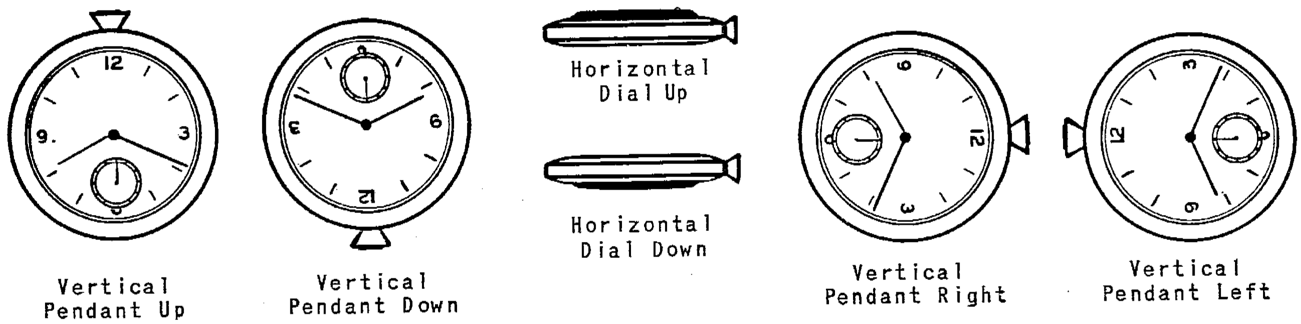
327-A. A watch is Isochronal when the short arcs of the balance have the same time value as the long arcs.

328. Is the pinning of a hairspring to a collet usually above or below the line of centers and why?

328-A. Usually above. It is pinned below when seeking a slower rate in pendant up position.

329. Name the 6 different positions to which a watch is commonly adjusted.

329-A. Dial up; Dial down; Pendant up; Pendant down; Pendant right; Pendant left.



330. What do the letters P F & A stand for?

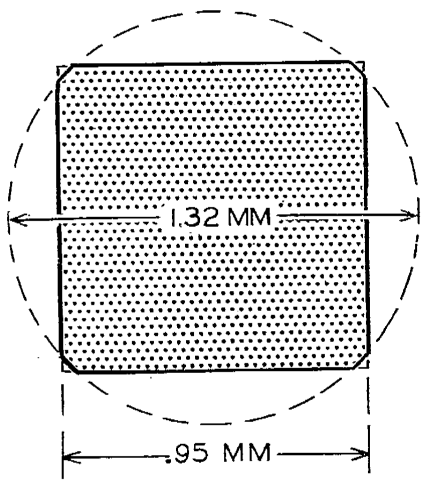
330-A. Pallet Fork and Arbor.

331. How do you determine the diameter of the round section from which you will mill or file the square for the winding clutch?

331-A. Multiply one side of the square by the constant 1.39.

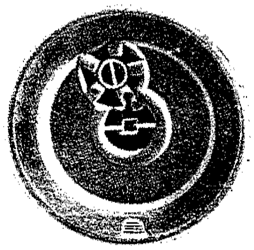
Example:

.95 MM Multiplied by 1.39 equals 1.32 MM



332. What is the purpose of the Stop Works?

332-A. The Stop Works prevent the mainspring from being wound up completely and also prevents it from running down entirely. It utilizes that portion of the mainspring which is most uniform in its delivery of power.



333. Many books containing tables of American Watch sizes list the measurement of an 18 size pillar plate at 44.87 mm. This is not correct. What is the correct diameter?

333-A. 45.7 mm.

Solution:

Measure one.

The following chart is a standard of points for grading repairs made. It is included here to give the student the point values placed on practical repairs to make a perfect grade.

1.	Function of winding	4	Points
2.	Function of setting	2	"
3.	Clearance and fit of hands	5	"
4.	Condition of jewel settings and screws	5	"
5.	Motion - dial up	4	"
6.	Motion - dial down	4	"
7.	Motion - Pendant down	4	"
8.	Freedom of train	3	"
9.	Condition of lock, drop and slide	10	"
10.	Jewel Pin Shake	4	"
11.	Guard Pin Shake	4	"
12.	Endshake of balance staff	4	"
13.	Sideshake of balance staff	4	"
14.	Trueness of balance wheel	7	"
15.	Condition of balance pivots	5	"
16.	Centering and condition of hairsprings	5	"
17.	Flatness and trueness of collet	5	"
18.	Condition of overcoil	5	"
19.	Condition of regulator pins	2	"
20.	Condition of cleaning	4	"
21.	Condition of oil	4	"
22.	Condition of all steel parts	4	"
23.	General appearance	2	"
	Total	100	Points

Sizes of American Watches

One Inch = 25.4 MM.

SIZE	MM	SIZE	MM
18	45.7	6/0	25.4
16	43.1	8/0	23.7
14	41.5	10/0	22.0
12	39.8	12/0	20.31
10	38.1	14/0	18.6
8	36.4	15/0	17.8
6	34.7	16/0	16.9
4	33.0	18/0	15.2
0	29.6	20/0	13.5
3/0	27.9	21/0	12.7
4/0	27.09	22/0	11.8
5/0	26.2	26/0	8.5

Sizes of Swiss Watches

One Ligne = 2.258 MM.

LIGNES	MM	LIGNES	MM
3	6.77	11¾	26.51
3¼	7.38	12	27.07
3½	7.87	12¼	27.63
3¾	8.42	12½	28.20
4	9.03	12¾	28.79
4¼	9.59	13	29.33
4½	10.15	13¼	29.89
4¾	10.72	13½	30.45
5	11.28	13¾	31.02
5¼	11.84	14	31.58
5½	12.40	14¼	32.15
5¾	12.97	14½	32.71
6	13.53	14¾	33.27
6¼	14.10	15	33.84
6½	14.66	15¼	34.40
6¾	15.23	15½	34.98
7	15.79	15¾	35.53
7¼	16.35	16	36.09
7½	16.92	16¼	36.66
7¾	17.48	16½	37.22
8	18.05	16¾	37.78
8¼	18.61	17	38.35
8½	19.17	17¼	38.91
8¾	19.74	17½	39.48
9	20.30	17¾	40.04
9¼	20.87	18	40.60
9½	21.43	18¼	41.17
9¾	21.99	18½	41.73
10	22.56	18¾	42.30
10¼	23.14	19	42.86
10½	23.69	19¼	43.42
10¾	24.45	19½	43.99
11	24.81	19¾	44.55
11¼	25.38	20	45.12
11½	25.94		