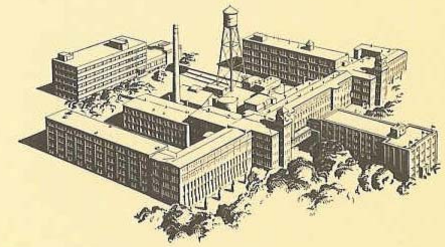
Service and Repair of the

HAMILTON *Electric* WATCH

Service and Repair of the HAMILTON *Electric* WATCH



HAMILTON WATCH COMPANY, Lancaster, Pa.
Creator of the World's First Electric Watch

Published May, 1959

Printed in the United States of America

Preface

January 3, 1957 was a great day in the history of American horology.

That was the day the Hamilton Watch Company of Lancaster, Pennsylvania, U.S.A., announced the completion of "Project X" and the introduction of the World's First Electric Watch.

After more than ten years of intensive research and development, which had been carried on in utmost secrecy, the first really new portable timepiece in nearly 500 years was ready for the marketplace.

The time was indeed propitious. The fine watch industry was suffering from over-production and under-consumption. Jewelers were finding it hard to hold their own under the pressures of competition, not only within their own field, but from a host of other industries which were taking a larger and larger share of the consumer's expendable income for gifts as well as self-purchases.

What the retail jeweler needed was something new — new in concept, new in styling — to capture the imagination and conquer competition on its own ground.

The Hamilton Electric was the answer, and almost overnight it was like a shot in the arm to the declining sales in many watch departments. People came to look and stayed to buy — so many that, for the first two years, even steadily increasing production could not keep pace with the demand.

But the strange and the new is usually mysterious — and there were still many jewelers and watchmakers who felt that they were not ready for such a radical departure from the conventional. Much about the electric watch (but not all) had to be learned, and learning is a slow process.

To the cause of learning this book is dedicated. For it has been proven that with increased knowledge of the Hamilton Electric comes increased confidence, both at the sales counter and at the watchmaker's bench.

We firmly believe that the electric watch is here to stay — that it will play an increasingly important part in the jeweler's watch business — and that the sooner it is understood, the sooner it can start making substantial contributions to the jeweler's watch sales and service profits.

—*Hamilton Watch Company*

Contents

Page

A New Concept in Timekeeping 1

Section one

Disassembly, assembly
and cleaning procedure

Nomenclature of Parts 10
Energy Cell Clamp 12
Energy Cell 14
Case Ring 16
Upper Shunt Bridge 18
Lower Shunt Bridge 20
Contact Spring, Trip Spring and Bridge .. 22
Balance Bridge 24
Balance Assembly 26
Train Bridge 28
Index Wheel and Pinion 30
Fourth Wheel and Pinion 32
Third Wheel and Pinion 34
Center Wheel 36
Stop Lever and Spring 38
Cleaning Procedure 41

Section two

Function and adjustment

Balance and Contact Assembly 44
Electrical Circuit 46
Electrical Contact 48
Balance Assembly 51
Motion Limiter Mechanism 52
Impulse of the Balance 54
Starting the Electric Watch 57
Setting the Electric Watch 59
How the Train Is Driven 60
Checking and Adjusting the Electrical Contact System ....63 to 83

Section three

Trouble shooting —procedure and equipment

Putting the Electric Watch in Beat 86
Poor Balance Motion 88
Failure of Watch to Start 91
Power Movement Holder 92
Use of the Multimeter 93
Use of the Oscilloscope 100
Timing Machine Rates 106
Cements 106

A new concept in timekeeping

Most of this volume is of a technical nature intended for the watchmaker, but this first chapter is for those who buy and who sell fine watches. WHY was the electric watch developed? WHAT are its advantages and its future? HOW should it be—and can it be—sold?

A new concept in time-keeping

WHY an electric watch

Since 1511 when Peter Henlein installed the first, crude coiled spring in his "Nüremberg Egg," the source of power for all portable timepieces has been the mainspring. This spring and the basic mechanism which it actuated have had a steady flow of refinements over the years, but have undergone no basic changes. Today's spring-driven watch — either manually wound or self-winding — is generally believed to have reached its highest stage of development, and further advances can only be achieved through a completely new approach.
The electric watch was developed to fill this need: the need for a watch as modern as today . . . a watch that fits into the world of automatic elevators, toasters, washing machines, radar control, missiles, automatic pilots and many other servants of man which have built-in protection against human frailties.
The electric watch is the world's first carefree watch. One does not have to learn or remember to wind it, nor give it the agitation required by a self-winding watch. Compressed into the tiny energy cell, no larger than a shirt button, is sufficient power to keep it running for a year or more without attention.

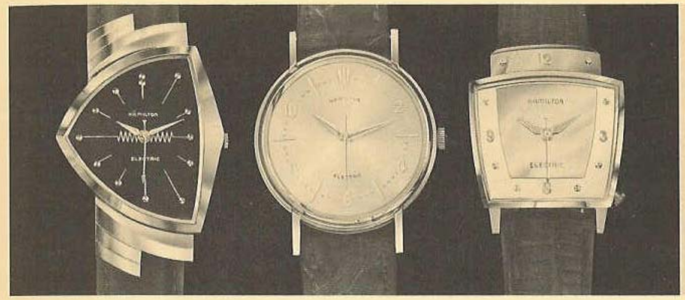
WHAT is it

The electric watch is actually a miniature electric motor, finely made and carefully adjusted to run at a pre-determined speed. Power is transmitted directly to the hands, effecting an economy of parts over its predecessor and eliminating many of the friction points in a spring-driven watch, where the power of the mainspring strains through the train seeking release at the point of escapement.
The Hamilton Electric is a true electric watch and is not to be confused with an *electronic* watch. The general form of the electric watch is approximately the same as the conventional watch, and, as further chapters in this manual will clearly demonstrate, the watchmaker can quickly learn to handle normal servicing and repair. It contains no transistors or electronic circuits which require specialized knowledge for servicing.

HOW to sell

The concept of watches powered by electricity is so new and revolutionary that the Hamilton stylists felt the watch deserved to be equally spectacular in the outer case design.

Accordingly, as the electric watch concept broke the time barrier, so did it also break the style barrier and launch a new series of spectacular watch styles far beyond anything available in current markets. The consumer response



The world's first electric watch was the trend-setting VENTURA, left. Subsequent designs, such as ATLANTIS, center, and EVEREST, have had wide acceptance.

to this new styling was instantaneous, and those who buy watches for retail sale are cautioned not to under-estimate the growing preference for this type of styling, particularly when associated with the electric watch.
Most consumers are intensely curious about the new Hamilton Electric even though they may not be at the moment in the market for a new watch. It takes many, many years for the entire public to become even aware of something so new and different, and we must never forget that for a long time to come, even the mention of an electric watch will be "news" to many people.
Once the consumer is aware of it, the jeweler should make it as easy as possible for him to satisfy his curiosity. Identifying displays in the window, in the showcase and on top of the showcase will often start a conversation which can end in the making of an unanticipated sale. The successful salesman follows through all the way to *wearing* the electric watch himself. It is doubly convincing to the customer to hear an enthusiastic testimonial based on the salesman's personal experience and to see the electric watch on the salesman's wrist.
In talking about and explaining the electric watch, it is as important not to oversell as it is not to undersell. The Hamilton Electric opens a new era of accurate timekeeping, but, like any other precision mechanical device, it requires care, and sometimes adjustment and servicing. Properly informing your customers of what they may expect from the new Hamilton Electric Watch will insure their satisfaction, minimize your sales problems and go a long way toward maintaining good customer relations.

A few words about energy cells

The miniature energy cell or battery which powers the Hamilton Electric is one of the miracles of our times. Without it, the electric watch could never have been developed. And, unless it is continually available to electric watch owners, the watches cannot continue to run.

This cell is guaranteed to function for a minimum of one year. And one of the pleasant and profitable aspects of this new timepiece is that it automatically requires the owner to stop in at his jeweler's once a year for a replacement. This not only builds store traffic, but also it offers the jeweler an opportunity to perform a service and strengthen his relations with the customer . . . *provided he has the energy cells on hand and can make the replacement promptly.* If he does not have it in stock, the effect on the customer can be reversed and result in irritation and dissatisfaction.

We cannot urge too strongly that all jewelers selling the Hamilton Electric keep a supply of energy cells on hand at all times. They can be secured by writing to the Hamilton Watch Company, Material Sales Department, Lancaster, Pa. The dealer cost at this writing is $1.25, and the recommended selling price is $2.00, plus a small additional installation fee if you think it advisable. (Excessive charges for energy cell replacement cannot help but reflect discredit and cause resentment.)

Energy cells may be stored for as long as a year without dangerous deterioration. Even after being in stock for 12 months, they may be safely guaranteed for an additional year. They may be stored wherever there is a normal, even temperature — preferably on the cool side. Excessive heat causes energy cells to deteriorate more rapidly. For this reason electric watches should not be subjected to extreme heat, either in the showcase or in the window, for continued exposure to excessive heat will undoubtedly shorten the life of the cell.

It is recommended that all electric watches be displayed in a non-operating condition — with the stem out — to conserve the power of the energy cell.

Special Note: For self-protection, it is strongly recommended that the date be scratched on the flat surface of the energy cell when the watch is sold or put into use.

Here are some of the questions your customers are asking about the electric watch and the answers you can give.

Answers to questions frequently asked

Q. *How does this watch differ from conventional watches?*

A. It contains no mainspring, the traditional source of watch power for nearly 500 years. Therefore, it cannot be wound — either manually or automatically.

Q. *How does it get its power?*

A. A tiny energy cell replaces the mainspring and is the sole source of power. It is about the size of a shirt button.

Q. *How long does the energy cell last?*

A. It is guaranteed for a full year from the date of purchase and in actual wear tests many energy cells have lasted 16 months, some even longer. To insure continuous performance, we suggest marking your calendar to have a new cell installed one year from date of purchase. This also gives your watchmaker an opportunity to check lubrication and make other minor adjustments that may be necessary.

Q. *What is involved in replacing the energy cell?*

A. The energy cell can be replaced in a few minutes by a jeweler. New cells cost about $2.00, plus a nominal service charge.

Q. *How will I know when the energy cell needs replacing?*

A. The energy cell will operate the watch at full power up to the last few days of its life. When the watch suddenly begins to operate erratically, it is time to replace the energy cell.

Q. *How do you start the Hamilton electric watch?*

A. Remove the small plastic energy guard inserted between case and crown. The crown is now pulled out, and no electric contact is made. To start, firmly snap the crown straight in. If the watch does not start, pull out crown and repeat, twisting the watch quickly if necessary.

Q. *How do you set the Hamilton electric watch?*

A. As in any other watch, pull the crown out, turn the hands to the time, and snap the crown in. If the second hand spins, no harm is done: merely repeat the process. For split-second setting, to a standard time signal, pull out crown and stop the watch when the second hand is at 12. Then set the minute hand in advance of the signal. On signal, push in crown to start.

Q. *Should I pull out the setting stem to "shut off the power" when not wearing my electric watch?*

A. You can if you choose, but consider the inconvenience of resetting the watch to the correct time when you put it on again. Current drain on the energy cell is so slight that you would not prolong its life by much — if at all — even if it were "shut off" for as long as a week.

Q. *In setting the electric watch, does it matter which direction the hands are turned?*

A. No, but make certain that you do not twist the setting crown as you snap it back in position. If it is not snapped in *straight*, the hands will spin and must then be re-set.

Q. *Are Hamilton electric watches shock-resistant, anti-magnetic?*

A. All models use conventional shockproofing systems and are also anti-magnetic. Exposure to X-ray machines, fluoroscopes, and other conventional medical laboratory equipment will not harm the watch. Some models are also waterproof.

Q. *How many jewels are there in the electric watch?*

A. Because of its radically different design and simplified construction, the electric watch requires but 12 jewels. For a watch of this type, this is fully jeweled.

Q. *When will Hamilton offer a lady's electric watch?*

A. Research and development on the lady's electric watch is continuing, but it is unlikely that it will be ready for the market for some time. The biggest limiting factor is the size of the present energy cell and the problems in adapting it to a lady's small watch movement design.

Q. *How accurate is the electric watch?*

A. The electric watch is a remarkably accurate portable timepiece. (It should not be compared with an electric clock which is set or controlled throughout the day by the power company.) If a minor gain or loss of seconds is observed, the cumulative error after an extended period can be corrected by resetting the hands.

section 1

Disassembly, assembly and cleaning procedure of the HAMILTON ELECTRIC WATCH

Disassembly, assembly and cleaning procedure

How to use section one of this book

To service the Hamilton Electric, follow in order the 14 parts discussed in Section One. Each part is illustrated separately and as it appears in the movement.

To disassemble: To disassemble the Hamilton Electric, follow the procedure outlined on pages 12 through 40. Remove Part No. 1 first, then Part No. 2, etc., until the last Part No. 14, is removed. Before removing each part, read the disassembly procedure and hazards in disassembly. Note: It is advisable to use an anti-magnetic tweezer when working on this watch.

To assemble: To assemble the Hamilton Electric, the parts must be replaced in the reverse order in which they were removed. Thus, Part No. 14 is the first part to be replaced, then Part No. 13, etc., until the last, Part No. 1, is replaced. Before replacing each part, read the assembly procedure, hazards in assembly, the oiling, and function of the part.

IMPORTANT

Thoroughly check the electrical contact system of every Hamilton Electric that comes in for repair. To do this, follow the eleven steps set forth in Section Two on pages 63 through 83.

REMOVING THE MOVEMENT FROM ITS CASE

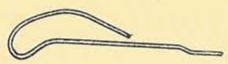
The electric watch movement is removed from its case in the same way an ordinary watch is removed. Proceed as follows:

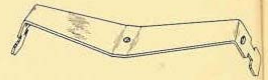
1. Remove the case back.
2. Loosen detent screw and remove stem and crown.
3. Using energy cell clamp and tweezers, lift the movement out of its case, being careful not to damage the delicate contact and trip springs.

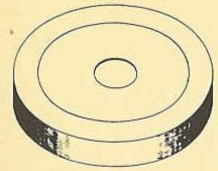
TYPE OF OIL AND GREASE RECOMMENDED

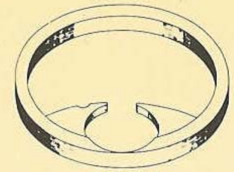
Throughout this manual Hamilton consistently recommends the use of Hamilton PML Grease and Hamilton PML No. 79 Oil. These are recommended because we can insure that both are free of volatile components which could cause contact deterioration and failure. While this is true of many synthetic watch oils, we have not been able to completely test all of the known synthetic oils now on the market and must therefore insist that we can insure performance only with proven lubricants. Non-spreading oil characteristics are also of singular importance because many of the components in the electric watch are to be oil-free and a "creeping" oil can cause serious problems.

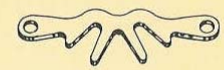
Nomenclature of parts

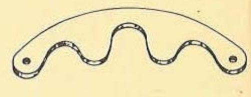

ENERGY CELL CLAMP—MODEL 500

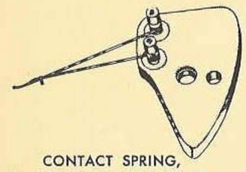

ENERGY CELL CLAMP—MODEL 501

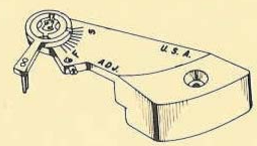

ENERGY CELL


CASE RING

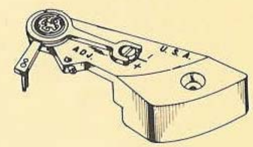

UPPER SHUNT BRIDGE


LOWER SHUNT BRIDGE

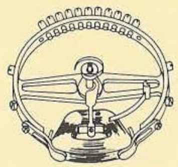

CONTACT SPRING,
TRIP SPRING AND BRIDGE

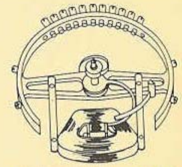


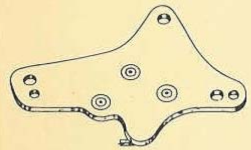
BALANCE BRIDGE—MODEL 500

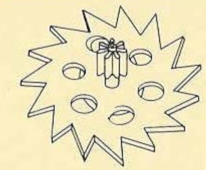


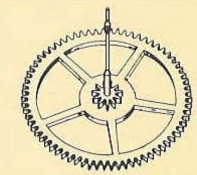
BALANCE BRIDGE—MODEL 501

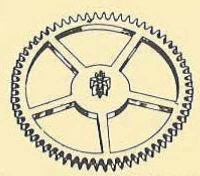

BALANCE ASSEMBLY—MODEL 500

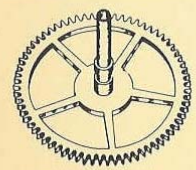

BALANCE ASSEMBLY—MODEL 501

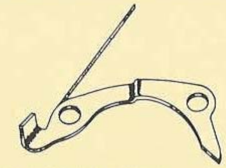

TRAIN BRIDGE

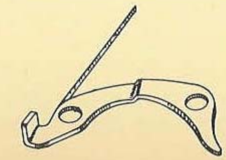

INDEX WHEEL AND PINION

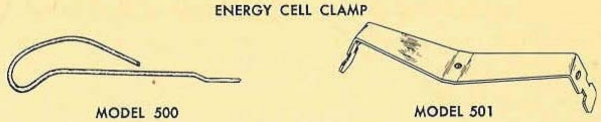

FOURTH WHEEL AND PINION


THIRD WHEEL AND PINION


CENTER WHEEL


STOP LEVER AND SPRING—MODEL 500


STOP LEVER AND SPRING—MODEL 501



Disassembly procedure: To remove the energy cell clamp of Model 500, unhook the end "C" of the clamp from the post on the pillar plate. Then lift up this end until the clamp is in an upright position. Now turn the clamp in a counterclockwise direction to unlock it from the post "B" on the plate.

1 ENERGY CELL CLAMP

On the Model 501, either end of the spring may be removed by slightly depressing and removing its T-shaped end from the slot in the pillar plate. Both techniques above release the energy cell which is replaced as detailed in [2] on page 14.

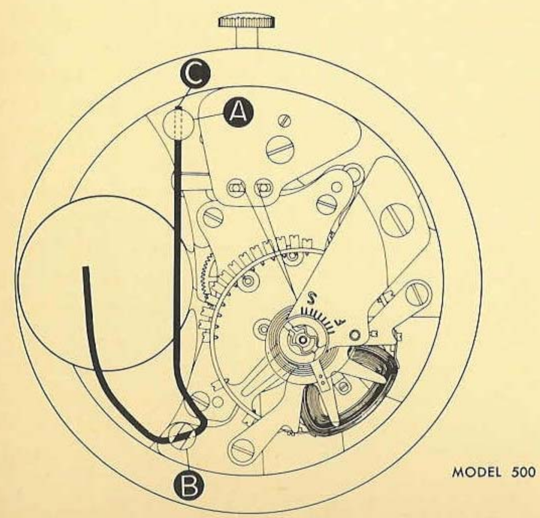
Assembly Procedure: On the Model 500, hold the clamp in an upright position and place the proper section of the clamp into the slot of post "B". While the clamp is still in an upright position, turn it in a clockwise direction to lock the clamp in this post. This done, lower the end "C" of the clamp and hook it in post "A". On the Model 501, simply replace the clamp in the appropriate slots.

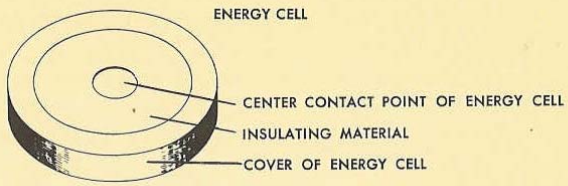
At this point the watch should be started. This is done by pulling out on the crown to setting position and pushing it back in again. As the crown is depressed, the balance should immediately start oscillating and its motion should increase until it reaches a minimum of 1¼ turns in the dial position. If the watch does not continue to run, it may be that the energy cell is not making proper contact with the energy cell lead. To check on this, it would be necessary to remove the dial and examine the contact of the energy cell through the energy cell peep hole on the dial side of the watch. If the energy cell lead is making

proper contact with the energy cell, replace the old energy cell with a new one. If there is any further trouble, we must assume that the error is elsewhere. In such a case, each part of the watch must be checked over carefully. Start with checking the contact and trip springs, as trouble is most likely to occur there. See pages 63 through 83 for information pertaining to the adjustment of these two springs.

Function: The function of the energy cell clamp is to hold the energy cell in proper position. Also, when the electrical contact is made, the current flows through the "ground" to the energy cell clamp, back to the energy cell.

Oiling: The energy cell clamp should *not* be oiled.





2

ENERGY CELL

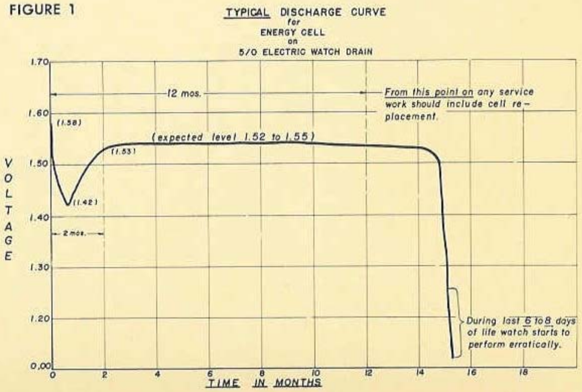
Disassembly procedure: To remove the energy cell, turn the watch over and the cell will fall out.

Assembly procedure: Place the energy cell on the bench with the flat side up. Now grasp the top edge of the cell with your fingers and place it in the case ring recess. The cell can also be held with tweezers to replace it; however, care must be taken not to short the energy cell by having the tweezer contact the center and metal cover.

Function: The cell supplies the energy to run the watch. It supplies 1.5 volts. The energy cell takes the place of the mainspring found in conventional timepieces.

Remarks: Cells are guaranteed to run the watch for 12 months from the date of activation. In order to insure

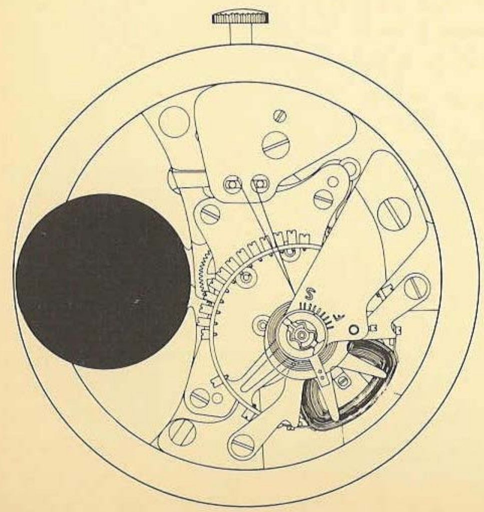
FIGURE 1

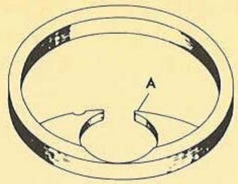


customer satisfaction it is suggested that all energy cells be changed after 12 months of operation. The date of sale should be lightly scratched on the back of the energy cell. This will insure or guarantee against servicing a watch as the cell approaches its 14th or 15th month, and unknowingly returning it to the customer with an almost exhausted energy cell.

Your attention and the customer's is directed to Fig. 1 which shows the typical discharge curve of the energy cell in the Hamilton Electric. The short dip in the early months of its activation will not affect the watch's timekeeping. As indicated, the watch maintains a constant voltage to or about the 14th month, at which time it falls off rather rapidly. This is why we urge cell replacement from the 12th month on.

Oiling: The energy cell should *not* be oiled.





CASE RING

3 CASE RING

Disassembly procedure: The case ring is merely frictioned on to the movement. The case ring is removed by forcing the movement out of it. To do this, grasp the edge of the case ring with the fingers of both hands in such a way that the thumbs can be used to push the movement out of the case ring. Now apply pressure on the side of the crown with the left thumb and at the base of the balance bridge with the right hand thumb.

Having removed the case ring, remove the following parts in the same way that these parts are removed from an ordinary watch.

1. Sweep second hand
2. Minute hand
3. Hour hand
4. Dial
5. Hour wheel
6. Cannon pinion

Assembly procedure: Before replacing the case ring, the following parts should be replaced in the same way that these parts are replaced in an ordinary watch.

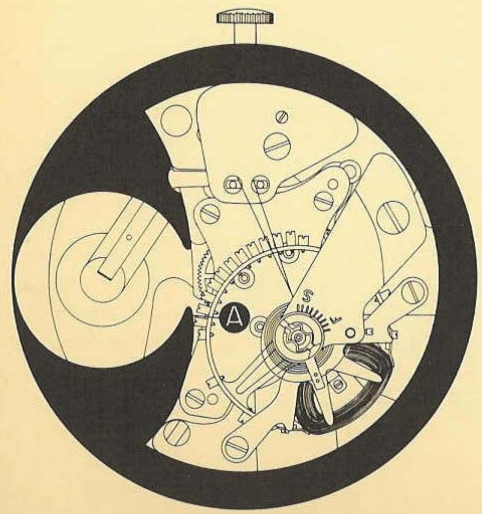
1. Hour wheel
2. Dial
3. Hour hand
4. Minute hand
5. Sweep second hand

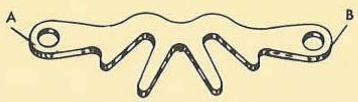
To replace the case ring, grasp the crown of the watch with the right hand and support the dial side of the movement with the fingers of the same hand. Now with the left hand, place the case ring over the movement with the slot in the case ring over the tube of the crown. Care must be taken that the portion of the case ring that forms the recess for the energy cell is in proper position so that section "A" of the case ring will clear the balance. Now from the dial side, press the movement into the case ring.

Function: The case ring of *Model 500* forms a recess to hold the energy cell. In addition, it serves the same purpose as does the case ring in an ordinary watch. Under no condition should the case ring touch the energy cell lead.

The *Model 501* movement is held in the case by case screws. In certain case styles this movement is secured in a movable case ring with the same type screws. By aligning the cutaway portion of the screw head with the case shoulder, the movement can be removed from either case or case ring.

Oiling: The case ring should *not* be oiled.





4 UPPER SHUNT BRIDGE

Disassembly procedure: Remove the two screws that hold this bridge in place. End "B" of the bridge can now be lifted from its post and swung out (using location "A" as a pivoting point) from between the hairspring and balance. The other end, "A" can then be lifted from its post. (To remove this part, it may be necessary to raise the hairspring stud in the balance bridge.)

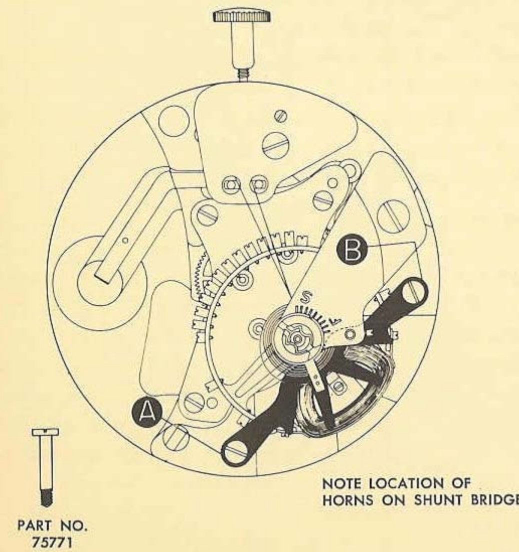
Hazards: Care must be taken that the shunt bridge is kept as level as possible when removing it. In this way, no damage will occur to the hairspring or coil.

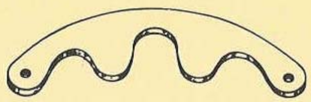
Assembly procedure: Place the end "A" of the upper shunt bridge over the proper supporting post on the pillar plate. Now place the forefinger of your left hand over end "A" to hold this end down on the post. This bridge can then be swung (using point "A" as a pivoting point) in between the hairspring and balance until the hole in end "B" is fitted over the other post in the pillar plate. The fillister head screws No. 75771, can then be replaced. These screws are screwed into the lower shunt bridge. (To replace this part, it may be necessary to raise the hairspring stud. Then after the shunt bridge is replaced, the stud can be lowered to level the hairspring.)

Hazards: Care must be taken that the upper shunt bridge is kept as level as possible when pivoting it into position to prevent damage to the hairspring or coil.

Function: See page 54 for information pertaining to the function of the upper shunt bridge.

Oiling: The upper shunt bridge should *not* be oiled.





LOWER SHUNT BRIDGE

5

LOWER SHUNT BRIDGE

Disassembly procedure: The lower shunt bridge is now being held in place only by the permanent magnets. To remove this part, simply lift it out of place with tweezers.

Assembly procedure: Place the lower shunt bridge in its proper position as shown. This part will be held in place by the permanent magnets.

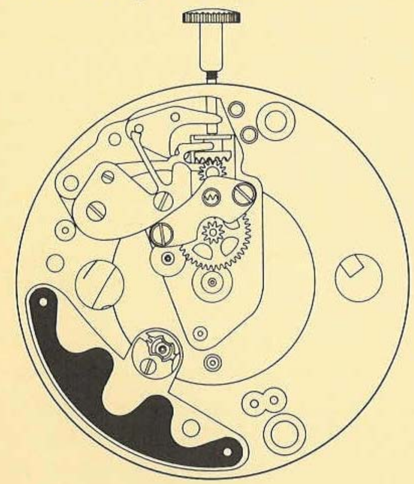
Function: See page 54 for information pertaining to the function of the lower shunt bridge.
The screw holes in the lower shunt bridge are for the screws that hold the upper and lower shunt bridges in place.

Remarks: The magnets in this watch are made from a platinum alloy. They are so strong they will support 215 times their own weight. The hairspring in this watch is non-magnetic and is not permanently affected by magnetic fields.
The second hand on this watch *must be* of non-magnetic material so that it will not be attracted to the permanent magnets. For this reason it is advisable, whenever replacement hands are needed, to order only genuine hands and no substitutes.

Oiling: The lower shunt bridge should *not* be oiled.

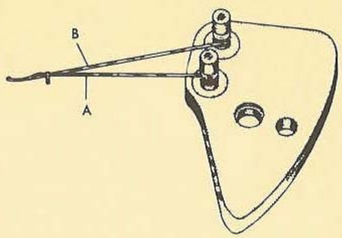
18,000 Beat Watch

Although the balance in this watch makes 18,000 vibrations per hour, as does the balance in most ordinary watches, the train is driven only on alternate vibrations. For this reason, the sweep second hand will advance two-fifths of a second each time it moves or make five advances in two seconds, which makes it land on the second line scale of the dial every two seconds.



DIAL SIDE

CONTACT SPRING, TRIP SPRING AND BRIDGE



6

CONTACT SPRING, TRIP SPRING AND BRIDGE

Disassembly procedure: The contact spring, trip spring, and bridge are removed as a single unit. Remove the screw that holds this assembly in place. As the screw is being removed, the bridge may be forced upward by the pressure of the energy cell lead "F" against the contact spring post. Now raise the bridge to clear the detent screw "C" and lift this assembly out of place, being careful not to damage the contact and trip springs while slipping them out from under the hairspring.

Hazards in disassembly: Care must be taken in removing this part, as the trip spring and contact spring are very delicate and easily bent. Also, be careful when setting this part on the bench or in an assembly tray that no stress is placed on the two springs. Rest assembly on work bench with the engraved side down.

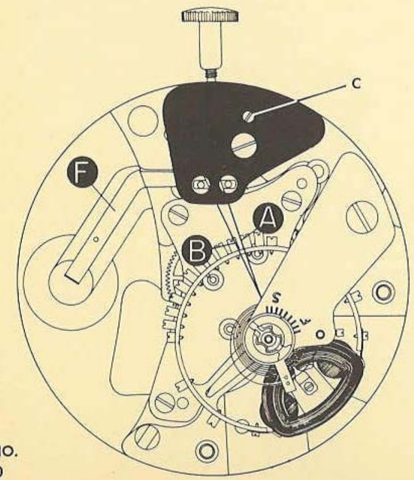
Assembly procedure: Pull into setting to move trip jewel. Carefully insert the contact and trip springs under the hairspring and then with a piece of pegwood push down on the contact bridge to seat it properly and replace fillister head screw No. 75760. As previously mentioned, the contact and trip springs are very delicate and must be handled with care to prevent damage to the springs.

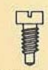
Function: The actual electrical contact is made through the contact spring "A". However, the trip spring "B" works in conjunction with the contact spring to make the electrical contact possible. See pages 63 thru 83 for full information pertaining to the adjustments of these two springs.

Remarks: To prevent a short in the electrical system, the following parts of this watch are insulated from the 'ground' parts:

1. Post to which the contact spring "A" is attached.
2. Post to which the trip spring "B" is attached.
3. Gold tab that leads to the coil on the balance.
4. Energy Cell Lead "F".

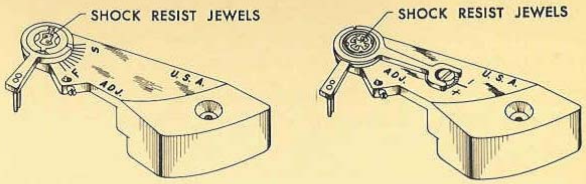
Oiling: The contact spring, trip spring and bridge should *not* be oiled.





PART NO.
75760

BALANCE BRIDGE



MODEL 500 MODEL 501

7

BALANCE BRIDGE

Disassembly procedure: Loosen the stud screw and push the stud out of the stud hole in the bridge. Make certain the hairspring is free of the curb pins. The balance bridge can now be removed in the same way that the balance bridge is removed from an ordinary watch.

Assembly procedure: Replace the balance bridge in its proper position so that the top balance pivot can enter the jewel hole in the bridge. Replace the fillister head screw No. 75762 to hold the bridge in place. Now loosen the stud screw and work the stud into the stud hole in the bridge, making sure the hairspring enters between the curb pins. Raise the stud to the proper height to level the hairspring and tighten the stud screw.

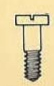
If desired, the balance assembly can be attached to the balance bridge before assembling. This is an accepted procedure used in the trade and the same method can be used. In assembling the balance bridge and balance in this manner the lower balance pivot will be attracted by the permanent magnets, making it necessary to guide the balance into position by using the index finger of the left hand.

Having replaced the bridge, check the balance to see that it oscillates freely. If the balance will not oscillate, due to its movement being restricted in one direction only, it is most likely that the finger block which is located on the lower side of the balance assembly is not in its proper position; see page 26. To correct this condition, the balance bridge must be removed and the finger block turned to a position that will keep it from jamming the balance.

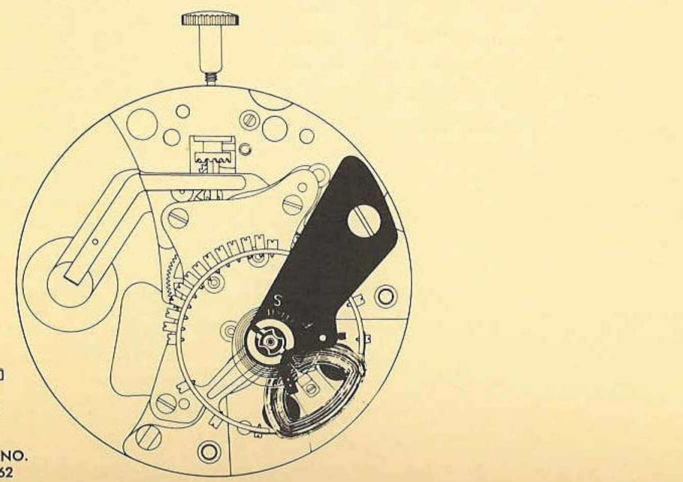
Function: This bridge serves the same purpose as does the balance bridge in an ordinary watch. It supports a regulator and provides a bearing for the upper balance pivot. In addition, the balance bridge carries the current from the hairspring to the pillar plate through which the current flows back to the energy cell.

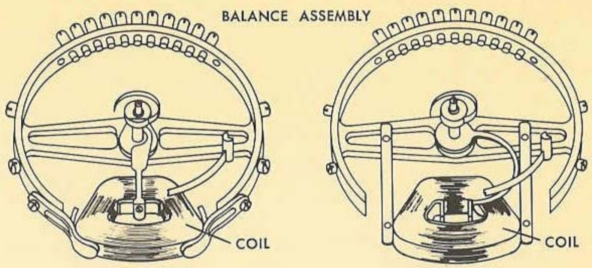
Remarks: A tailless regulator is fitted to the Model 500. This provides a great range of regulation. When regulating the watch the position of the regulator slot is compared to the markings on the balance bridge. Moving the regulator one space on the balance bridge markings is equal to about $2\frac{1}{2}$ minutes per day. It is not necessary to alter the balance screws or add washers for regulation. The Hamilton Model 501 electric is equipped with a two-piece regulator employing an eccentric adjustment. The graduations on the eccentric dial represent 10 seconds and the regulation should be less tedious than with the tailless type regulator.

Oiling: The shock resist jewels should be oiled in the same way that these jewels are oiled in an ordinary watch. Use PML No. 79 oil. Note: Do not oil the finger block.



PART NO.
75762





Disassembly procedure: To remove the balance assembly, lift it out of place as you would a balance assembly in an ordinary watch. In removing the balance do not grasp the coil with tweezers, as this may damage it.

8 BALANCE ASSEMBLY

Assembly procedure: Before replacing the balance assembly, the finger block (Fig. 2), which is located on the lower side of the balance, must be checked to see if it is free. To do this, check the finger block as follows:
Shift the balance from one flat position to the other to see if the finger block falls freely from one collar to the other, as shown in Fig. 2 and 3. Notice in Fig. 2 that the finger block is against the lower collar and in Fig. 3 (the balance turned over) the finger block is against the upper collar. When making this test, if the finger block does not fall freely from one collar to the other, it is most likely that foreign particles or oil on the finger block are causing it to bind. In such a case, reclean the balance assembly. The finger block must pass the test illustrated in Fig. 2 and 3, otherwise the motion of the balance will be affected.
To replace the balance assembly, first move the finger block 180 degrees from the actuating pin. This will place the finger block in a position that will permit the balance to oscillate freely after it and the balance bridge are replaced. This done, replace the balance in the watch. In handling the balance, do not grasp the coil with tweezers as this may cause irreparable damage to it.

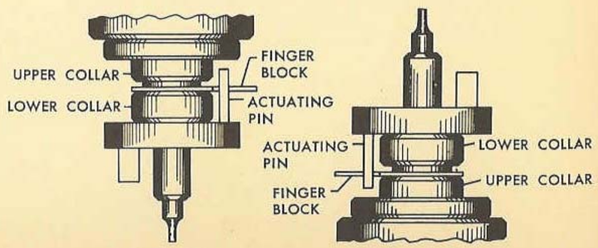
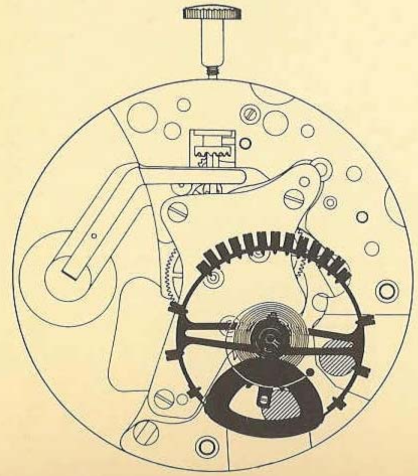
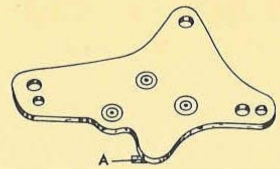


FIGURE 2. FIGURE 3.

Function: The balance assembly in this watch, as usual, is the timekeeping element. This assembly differs in function, however, from the balance assembly in ordinary watches in that it drives the train of the watch instead of the train driving it. Information pertaining to the function of the components of the balance assembly is explained in Section Two of this book.

Oiling: The shock resist jewels must be oiled and replaced in this watch before the balance assembly is replaced. Use PML No. 79 oil.





TRAIN BRIDGE

9
TRAIN BRIDGE

Disassembly procedure: This bridge is removed in the same way that a train bridge in an ordinary watch is removed.

Assembly procedure: This bridge is replaced in the same way as a train bridge in an ordinary watch is replaced. As always, care must be taken that each pivot enters its respective jewel hole before the three bridge screws, No. 75760, are screwed down tight. (These screws are identical.) After replacing the bridge, the train cannot be checked to see if it spins freely. The permanent magnet acting on the index wheel will prevent this. Thus it is necessary to carefully check each wheel individually to make certain that there is no binding and that each wheel has proper endshake.

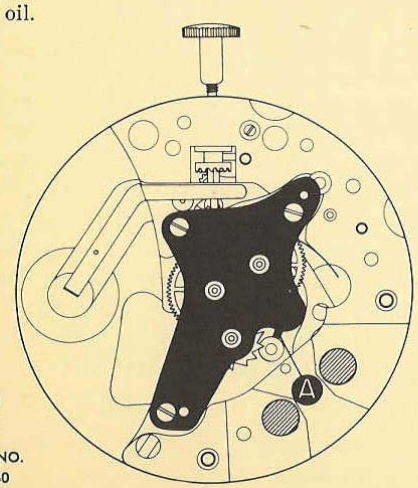
Important: Press on the cannon pinion to force it against the center hole jewel when checking the endshake of the fourth wheel. If this is not done, you will be checking the combined endshake of both the center and fourth wheels instead of the fourth wheel itself. If the fourth wheel endshake is found to be insufficient, there are two methods to increase this endshake:

1. Decrease the center wheel endshake by beveling the edge of the hole on the lower side of the cannon pinion. (Do not, of course, decrease the center wheel endshake unless it is excessive.)

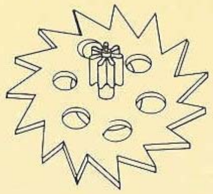
2. Move the fourth wheel or center wheel jewel bearings.

Function: This bridge provides a bearing for each of the train wheels. The guard pin "A" affixed to this bridge is provided to prevent the balance from taking an excessive motion. If the balance motion becomes excessive, a finger block on the balance staff will contact the guard pin "A" and prevent the balance from traveling beyond its limits. See page 53 for full information.

Oiling: After replacing the train bridge, all the pivots of the train should be *slightly* moistened with oil. Use PML No. 79 oil.



PART NO.
75760



INDEX WHEEL
AND PINION

Disassembly procedure: To remove the index wheel, simply lift it out of place as you would a train wheel in an ordinary watch.

10
INDEX WHEEL AND PINION

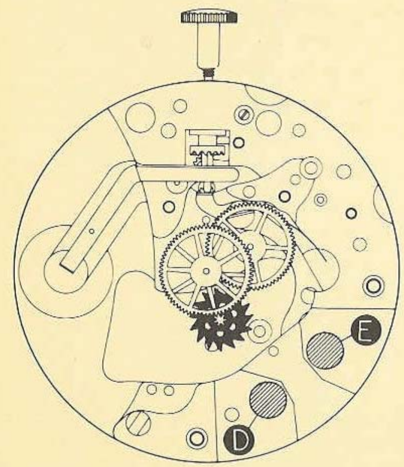
Assembly procedure: To replace the index wheel, place this wheel in the watch with the pinion leaves up. The leaves of the pinion mesh with the teeth of the fourth wheel. When placing this wheel in the watch, keep it as far as possible from the magnets "D" and "E"; otherwise it may be drawn out of the tweezers to the magnets.

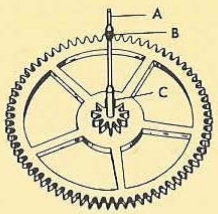
Remarks: This train could have been disassembled and assembled another way. It is up to the individual to discover which way is best for him. In this book we adopted the disassembly and assembly procedure of the train in the order that these wheels intermesh with one another. This is standard procedure as it guides the watchmaker and makes it apparent whether a pinion on a wheel goes up or down. Another procedure that can be tried by the watchmaker which has the slight advantage of making it easier to replace the index wheel is as follows:

DISASSEMBLY	ASSEMBLY
Remove fourth wheel	Replace index wheel
Remove third wheel	Replace center wheel
Remove center wheel	Replace third wheel
Remove index wheel	Replace fourth wheel

Function: The index wheel is moved one tooth for each alternate vibration of the balance. A jewel pin set in a roller on the balance moves the index wheel. This movement of the index wheel is then transmitted through its pinion to the fourth wheel. See page 60 for full information pertaining to the function of this mechanism.

Oiling: The index wheel pivots must be oiled slightly after the train bridge is replaced. Use PML No. 79 oil. *Do not oil index wheel teeth or jewel.*





FOURTH WHEEL AND PINION

11

FOURTH WHEEL AND PINION

Disassembly procedure: To remove the fourth wheel, simply lift it out of place as you would a train wheel in an ordinary watch.

Assembly procedure: To replace the fourth wheel, place the long pivot "A" in the hollow center wheel pinion and allow the wheel to "drop" into position.

Function: The function of the fourth wheel and pinion is as follows:

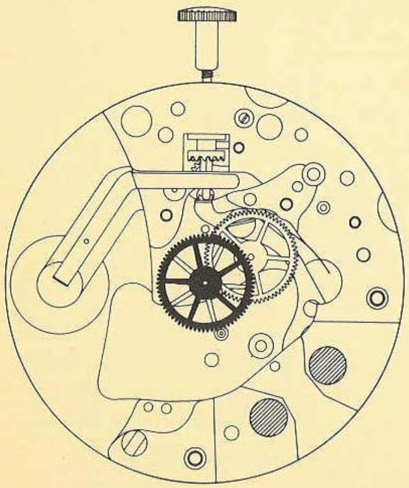
The fourth wheel and pinion transmit the movement of the index wheel to the third wheel.
This wheel makes one revolution per minute and carries the sweep second hand.

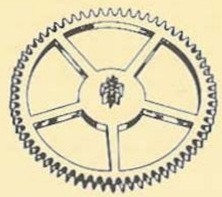
Remarks: The number of leaves in the pinions and the number of teeth in the wheels of the time train are listed below. Notice the ratio of index pinion to fourth wheel is 10 to 1, the ratio of fourth pinion to third wheel is 6 to 1, and the ratio of third pinion to center wheel is 10 to 1.

These same ratios have been used in conventional watch trains. (Index wheel has 15 teeth.)

Pinion	No. of Leaves	Wheels	No. of Teeth
Index pinion	7	Fourth wheel	70
Fourth pinion	11	Third wheel	66
Third pinion	7	Center wheel	70

Oiling: Surfaces "B" and "C" should be slightly moistened with oil. Use PML No. 79 oil.





THIRD WHEEL AND PINION

12

THIRD WHEEL AND PINION

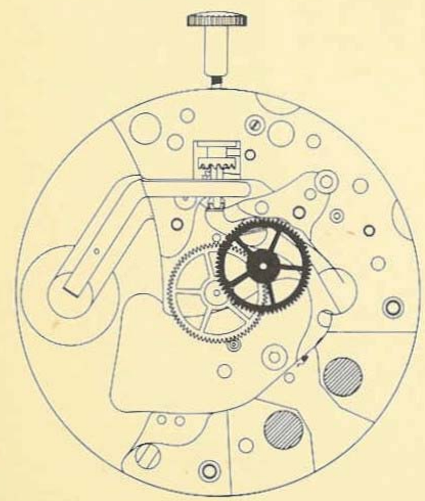
Disassembly procedure: To remove the third wheel, simply lift it out of place as you would a train wheel in an ordinary watch.

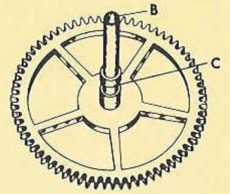
Assembly procedure: To replace the third wheel, place the lower pivot in the proper hole in the plate. The leaves of the pinion on this wheel mesh with the teeth of the center wheel.

Function: The function of this wheel and pinion is to transmit the movement of the fourth wheel to the center wheel. The third wheel and pinion in this watch merely serve as a reduction gear.

Remarks: When assembling this watch, if certain parts become magnetized by being brought within the magnetic field of the permanent magnets, do not become too concerned. The whole watch can be demagnetized after it is assembled. The factory, however, cautions against using stronger than regular demagnetizers which may partially demagnetize the permanent magnets. Regular watch demagnetizers will demagnetize the magnetized parts of the watch without affecting the platinum alloy permanent magnets. This watch cannot be checked for magnetism with the use of a compass because one end of the compass needle will always be attracted to the permanent magnets.

Oiling: The third wheel pivots should be oiled after the train bridge is replaced. Use PML No. 79 oil.





CENTER WHEEL

13

CENTER WHEEL

Disassembly procedure: To remove the center wheel, simply lift it out of place as you would a center wheel in an ordinary watch.

Assembly procedure: To replace the center wheel, place the long pivot "B" in the proper jewel hole in the plate and allow the wheel to drop into position.

Function: The movement of the center wheel is transmitted to the dial train by means of the cannon pinion. In this respect it serves the same purpose as does the center wheel in conventional timepieces. The center wheel in this electric watch differs, however, in that it does not transmit the power to keep the watch running.

Replacing the cannon pinion: After replacing the center wheel, the cannon pinion should be replaced. This is done by supporting the center wheel on a stump as shown in Fig. 4, and pressing the cannon pinion on the staff with tweezers until it is seated on the shoulder of the staff. (This cannon pinion is fitted with a lighter friction than the cannon pinions in conventional timepieces.) Having seated the cannon pinion, check the endshake of the center wheel. Do this by grasping the cannon pinion with tweezers and test the endshake. The center wheel endshake should be about .02 mm. To decrease the center wheel endshake, bevel the edge of the hole in the cannon pinion

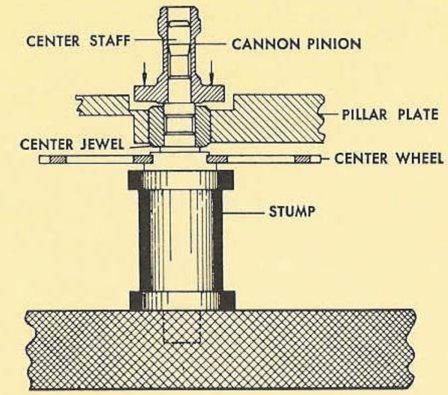
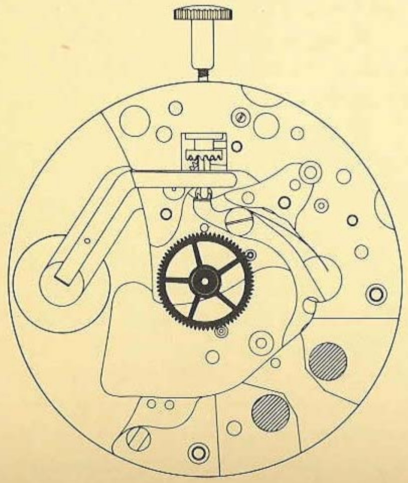
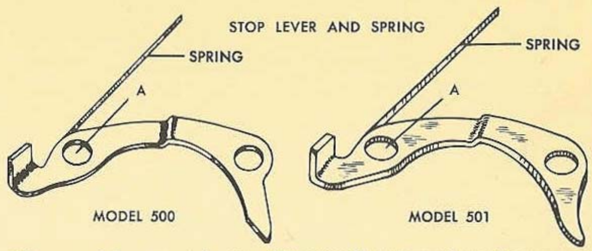


FIGURE 4

on the bottom side. This will allow the cannon pinion to go down a little further on the center staff.

Oiling: Before the center wheel is replaced, oil groove "C" in the center staff. Use PML No. 79 oil.





Disassembly procedure: First pull outward on the crown to place the watch in setting position. This will reduce the stress on the stop lever spring, making it easier to remove this part without it jumping out of place. Next, take a piece of pegwood in the left hand and place it on the stop lever to hold the lever in place while removing the screw. Having removed the screw, the stop lever can be slid on the pillar plate to release the tension of its spring. Now lift the stop lever out of place, keeping it away from the permanent magnets "D" and "E"; otherwise, the stop lever and spring may be pulled out of the tweezers to these magnets.

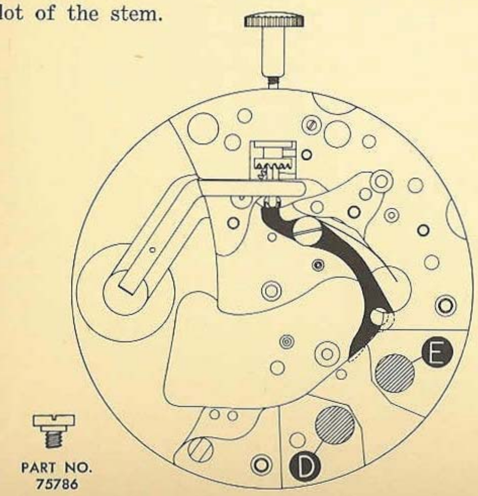
14

STOP LEVER AND SPRING

Assembly procedure: First pull outward on the crown to place the watch in setting position. This will reduce the stress that will be placed on the stop lever spring as the stop lever is moved to its proper position. Next place the stop lever and spring on the pillar plate. When doing this, keep the stop lever as far from the permanent magnets "D" and "E" as possible; otherwise, it may be drawn to these magnets. The tweezers can now be used to slide the stop lever on the pillar plate to its proper position so that the hole "A" in the stop lever is over the screw hole in the plate. Naturally, as the stop lever is moved to its proper position, the stop lever spring is forced against the side of the plate in a state of stress. Now take a piece of pegwood in the left hand and place it on the stop lever to hold it in position. This frees the right hand so that the shouldered screw No. 75786 that holds this part in place, can be picked up with tweezers and placed in its proper position to be screwed down tight. Having replaced this part, check the stop lever to see that it pivots freely under the shouldered screw. To do this, manipulate the crown in and out to see that the stop lever moves back and forth as it should. Finish by depressing the crown before proceeding with the assembly of this watch.

Function: The movement of the stop lever is controlled by the pilot of the stem acting on the stop lever as the watch is shifted into or out of setting position. When the watch is shifted into setting position, the movement of the stem permits the stop lever to be moved by its spring. This action will bring the acting end of the stop lever against a cam shaped roller on the balance staff. When the stop lever touches the roller, the balance will turn until the stop lever comes to rest on the mating surfaces of the roller. This cocks the balance so that it will start oscillating as soon as the crown is depressed, and the stop lever is forced away from the roller. This lever has the additional function of stopping the balance wheel in a position so that the contact system is open to prevent discharge of the cell. See pages 57 and 58 for complete information with illustrations on the function of the stop lever.

Oiling: The shoulder of the screw should be slightly moistened with oil. Use PML No. 79 oil. Do not oil the pilot of the stem.



Replacing the cannon pinion: To replace the cannon pinion after the movement is assembled, proceed as follows: Press the cannon pinion on the center staff as far as it will go. Then support the cannon pinion on a bench anvil over a hole that will clear the fourth wheel pivot. See Fig. 5. Next, insert a small screwdriver between the center staff hub and the fourth pinion and press down on the hub as illustrated. This will force the cannon pinion further on the center staff to its seat. At this point the center wheel and fourth wheel endshake should be checked as explained on pages 28 and 36.

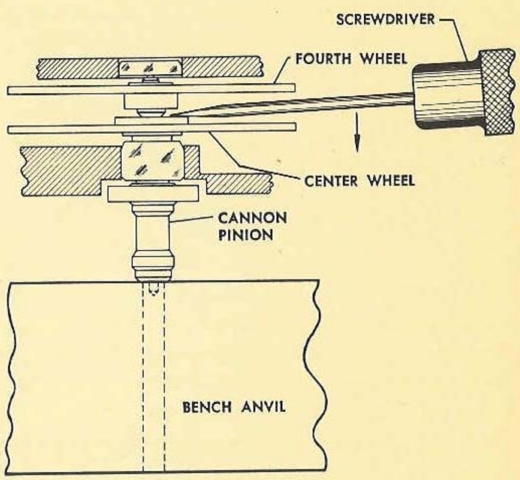


FIGURE 5

Recommended cleaning solutions:

No. 1 jar—Foaming type cleaner
No. 2 jar—Isopropyl alcohol
No. 3 jar—Isopropyl alcohol

CAUTION: *Never, under any condition, use benzene, naphtha or any other solution that contains an oily base.*

Cleaning Procedure

Cleaning of plates, train wheels, screws, etc., can be done in much the same manner as those of conventional watches. However, small steel parts should not be placed in the lower part of the basket with the pillar plate because of the magnetic attraction of the permanent magnets. The lower shunt bridge should be removed before cleaning in the machine.

The parts can be placed in the basket as follows:

Top of Basket	**Bottom of Basket**
Train wheels	Pillar Plate
Screws	Balance Bridge
Cannon Pinion	Train Bridge
	Hour Wheel
	Upper Shunt Bridge
	Lower Shunt Bridge

To prevent damage to the delicate contact and trip springs, the contact bridge assembly should be cleaned by holding in tweezers and gently agitating through solutions (same as above) which are kept separate for this purpose.

The balance wheel assembly can be cleaned in the same manner.

Dry both assemblies in the heating element of the cleaning machine by placing them in the cleaning basket. DO NOT SPIN THE BASKET. DRYING IN SAWDUST IS TO BE AVOIDED.

section 2

Function and adjustment of the HAMILTON ELECTRIC WATCH

Balance and contact assembly

Model 500

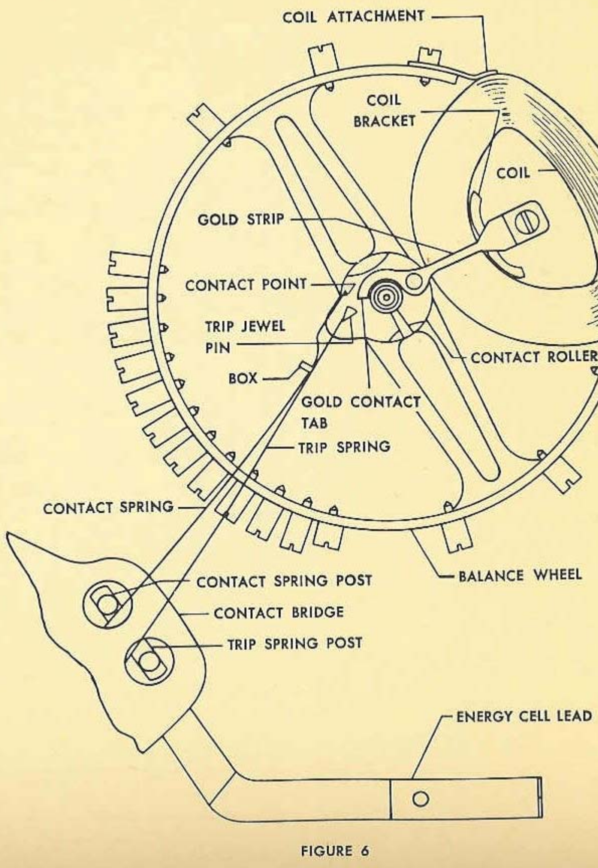


FIGURE 6

The components of the balance and contact assembly are labeled for your convenience. It is advisable for the watchmaker to become familiar with the names of these parts.

Model 501

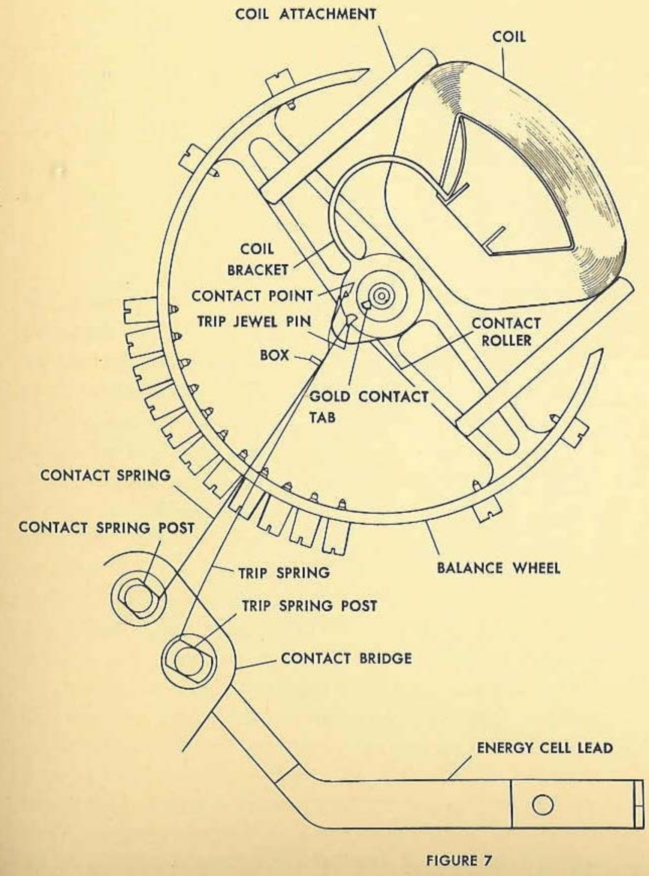


FIGURE 7

Function of balance and contact assembly

As you know, the balance in this watch is not impulsed through a mechanical mechanism whose power is derived from a spring as in conventional timepieces. The balance in this electric watch is impulsed electrically through the use of a coil on the balance working in conjunction with two permanent magnets. Naturally, to impulse the balance, the coil must be energized, and this requires a make and break of electrical contact. Since this is a standard 18,000 beats per hour watch, and the balance is impulsed on alternate vibrations, the make and break of electrical contact occurs 9000 times per hour. This electrical contact is a very critical function upon which depends the proper running of the watch. If the contact points become coated or out of adjustment, good performance of the watch cannot be expected. The function and adjustment of the electrical contact mechanism is the subject we will take up first in our studies of the Hamilton Electric Watch.

The electrical circuit

The gold tab, Fig. 8, through which current flows to the coil, is made of flat thin gold. When this tab is contacted by a silver button on the end of the contact spring, the electrical circuit is completed, and the current flows from the energy cell through the contact spring and the gold tab to the coil. Then back (via 'ground') through the balance wheel to the collet and hairspring to the plates of the watch, back to the energy cell. (Collet and hairspring are not shown in Fig. 8.) The trip jewel which is similar to the roller jewel in an ordinary watch, except for its shape, acts upon the end of the trip spring and makes the electrical contact possible, as will be explained presently.

For this mechanism to function properly, the contact spring and the trip spring must exert a force against one another. However, since the contact spring is above the level of the trip spring, a part such as the box must be provided to make this possible. The box is affixed by spot weld to the trip spring. The contact spring is held to the side of the box by the tension of the two springs. Thus through the use of the box, the springs exert a force

Coil-contact circuit

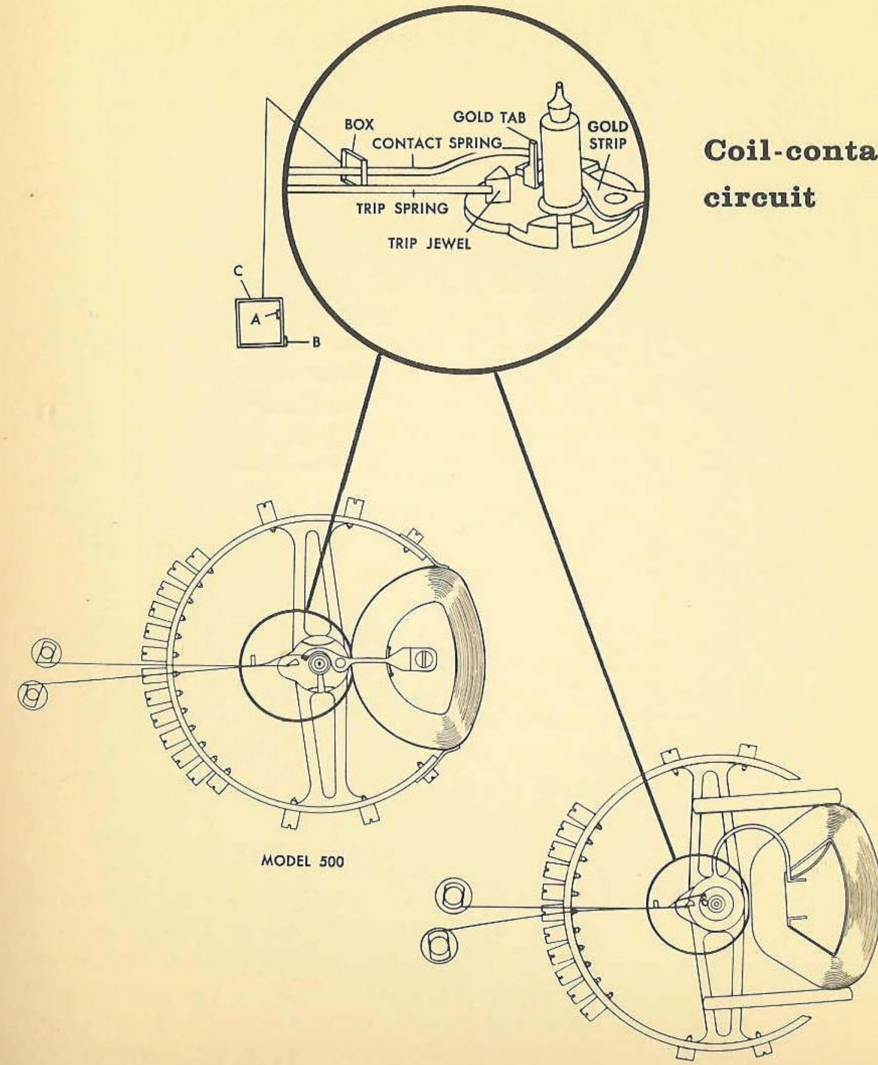


FIGURE 8

against each other. Actually, only the side of the box that touches the contact spring is used in the normal function of the watch. The main purpose for the complete box is to prevent the contact spring from being jarred out of position if the watch is bumped.

The electrical contact

Now let us examine step by step how the electrical contact occurs. Fig. 9 shows the contact roller turning in a counterclockwise direction with the trip jewel at the point of contact with the end of the trip spring. Now as the contact roller turns further in a counterclockwise direction, the trip jewel will force the trip spring to move downward as indicated by the arrow. Also, since the contact spring is exerting a force against the trip spring, the contact spring will follow the movement of the trip spring. Thus both springs move in the same direction. This movement of the springs by the trip jewel will bring the contact button in contact with the gold tab, as shown in Fig. 10, and the electrical circuit is completed.

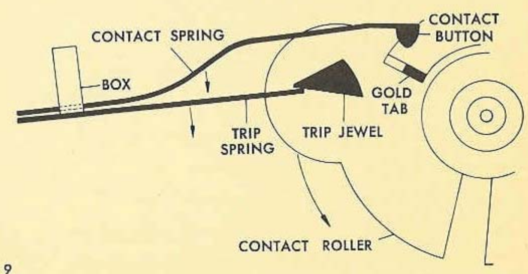


FIGURE 9

Now let us go a step further. As the trip jewel travels further counterclockwise from its position shown in Fig. 10, the trip spring will be pulled away from the contact spring. (The electrical contact and spreading apart of the springs is made possible by the trip jewel moving on a greater radius than the tab, and the contact spring being longer than the trip spring.)

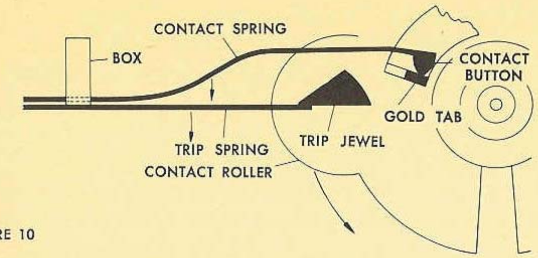


FIGURE 10

In Fig. 11, we show the springs spread apart, which makes the contact spring independent of the trip spring to the extent that it can exert its full pressure in maintaining a good electrical contact with the tab. The separation of these springs begins with the position shown in Fig. 10, and becomes greater and greater as the roller turns until the trip spring drops off the trip jewel.

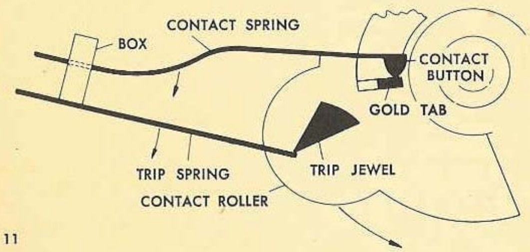


FIGURE 11

In Fig. 11 we show the springs at just about their greatest point of separation; much further movement of the trip jewel will release the trip spring. At the instant the trip spring drops off the trip jewel, it will spring back to its original position. Naturally, as the trip spring snaps back to its original position (by the box which is integral with the trip spring), it in turn will force the contact spring back to its original position, thus breaking the electrical circuit.

The balance will then continue its oscillation free of mechanical contact until the return or clockwise swing of the balance brings the trip jewel again in contact with

The electrical contact

(CONTINUED)

the trip spring. See Fig. 12. At this point the trip jewel merely trips past the end of the trip spring and no electrical contact is made, as the contact spring is kept clear of the gold tab. In Fig. 12 we show the springs at a point where any further movement of the trip jewel will release the trip spring. The dotted lines show the neutral position of the springs, which is the position the springs will return to when the trip spring drops off the trip jewel.

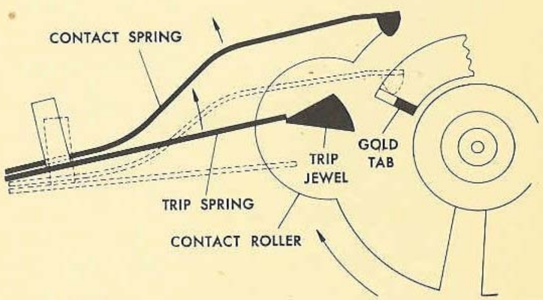
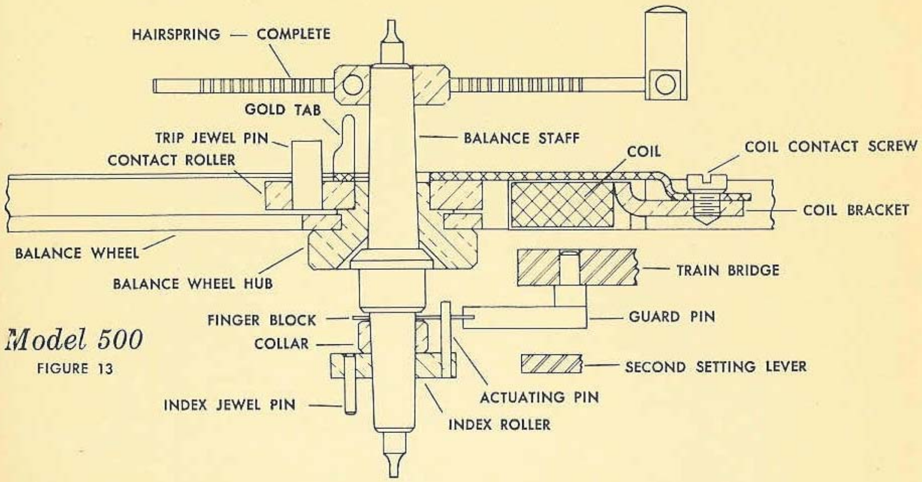


FIGURE 12

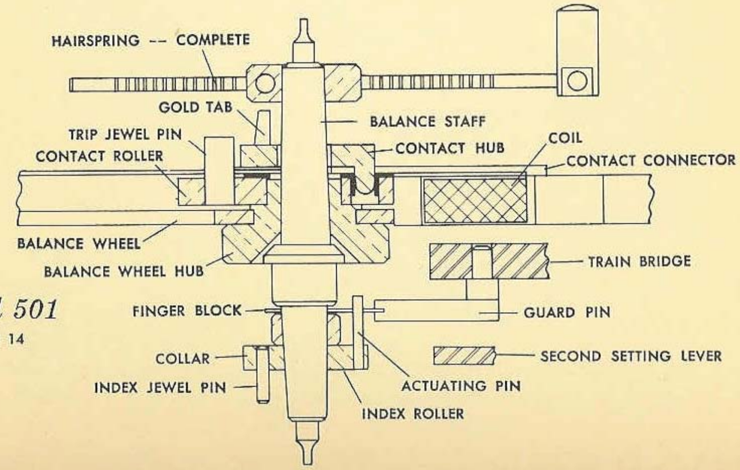
Balance assembly

The components of the balance assembly are labeled in Fig. 13 and 14 for your convenience. It is advisable for the watchmaker to become familiar with the names of these parts.



Model 500

FIGURE 13



Model 501

FIGURE 14

The motion limiter mechanism

The balance wheel motion in this watch is limited to a maximum amplitude of about 680 degrees (1⅞ turns). This limitation of the balance motion is necessary to prevent the balance from making more than one electrical contact, and the index jewel pin from moving the index wheel more than once during the counterclockwise swing of the balance. The mechanism that limits the motion of the balance consists of a finger block, an actuating pin, and a guard pin. See Fig. 15. The finger which is located on the lower side of the balance staff is not held tight, as it must pivot freely on the balance staff to function properly. The pin is frictioned into the index roller and contacts the finger to limit the motion of the balance. The guard pin projects from the underside of the train bridge to which it is attached. The function of this guard pin is to limit the movement of the finger. In Fig. 15 we show the position of the roller when the balance is at rest. At this point the pin is in direct line with the guard pin (since the finger is free to pivot on the balance staff, it can be in any position and not necessarily the position shown). Now from the position of rest as shown in Fig. 15, let us see how far the balance can be turned either clockwise or counterclockwise, and observe how the motion limiter mechanism takes effect. In this way we can get a good understanding of how this mechanism works.

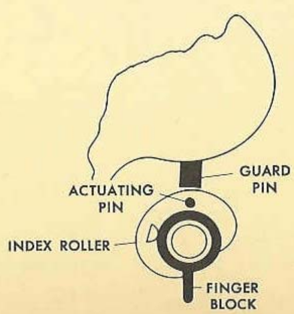


FIGURE 15

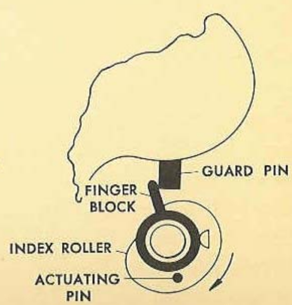


FIGURE 16

To begin, imagine the balance turning in a clockwise direction. As the balance turns, sooner or later the guard pin will be contacted by the finger, as shown in Fig. 16. However, if as illustrated, the pin has not as yet contacted the finger, the balance can turn further and the finger will slip on the balance staff and remain against the guard pin. When the balance, however, has turned far enough to bring the pin in contact with the finger, as shown in Fig. 17, the balance can turn no further in that direction. The motion of the balance is limited in the same way on the counterclockwise swing of the balance as shown in Fig. 18. Whenever the finger block is against the guard pin, and the actuating pin is forced against the finger block, the balance can travel no further.

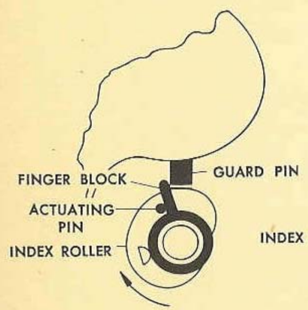


FIGURE 17

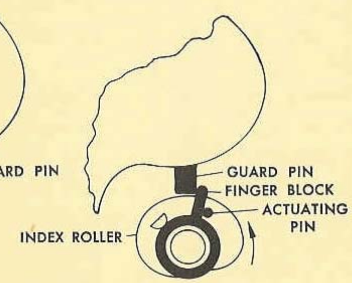


FIGURE 18

Since the finger block is continually coming in contact with the guard pin, it is imperative that the finger block be as free as possible. Even the slightest binding of the finger block will greatly affect the motion of the balance. Thus we repeat, it is imperative that the finger block be as free as possible. See page 26 for information pertaining to the method used to check the freedom of the finger block.

Impulse of the balance

The information contained on this page and subsequent page is not necessarily required to service and adjust the Hamilton Electric Watch. It is, however, included for those persons who wish to more completely understand the electrical phenomena associated with this type of motor.

Frictioned into the pillar plate of this watch are two permanent magnets which work in conjunction with the coil to impulse the balance. These permanent magnets are set to proper height to give just sufficient clearance for the balance and coil to pass over them without touching. Every magnet has a north and a south pole. These permanent magnets are set in the pillar plate so that the north pole end of one magnet and the south pole end of the other magnet are up. See Fig. 19.

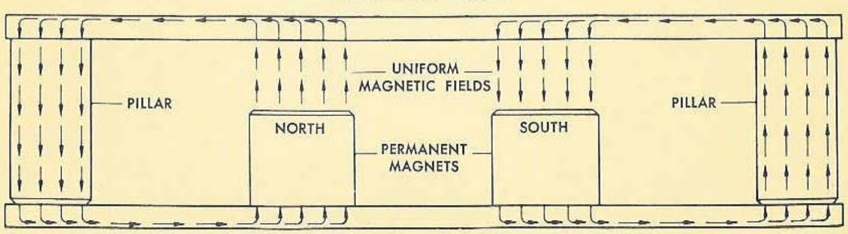


FIGURE 19

In this watch there are two shunt bridges. The lower shunt bridge is held across the lower ends of the magnets. The upper shunt bridge is supported by two pillars and is separated from the poles of the magnets by an air gap. The permanent magnets, the two shunt bridges, and the pillars comprise two magnetic circuits whose lines of force move as illustrated. This sets up a uniform magnetic field in the air gaps between the permanent magnets and the upper shunt bridge.

A coil when energized acquires similar properties to that of a magnet — in that it produces a north and a south pole magnetic field. In this watch the south pole magnetic field is generated on the top side of the coil, while the north pole magnetic field is generated on the bottom side. See Fig. 20. As illustrated, the magnetic lines of force will flow from the north pole to the south pole side of the

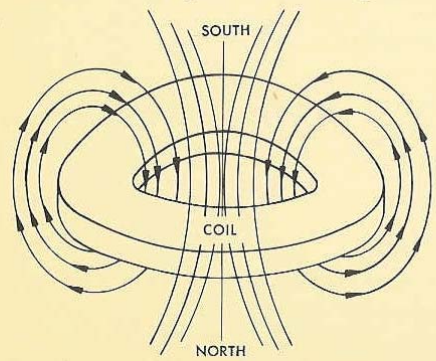


FIGURE 20

coil. Notice though that the lines of force on the right side of the coil move counterclockwise, while they move clockwise on the left side of the coil. Now let us see the reaction between the uniform magnetic field and the field set up by the energized coil.

In Fig. 21 we show a cross section of the coil in the uniform magnetic field. At points "A" and "B" the magnetic lines generated by the coil move in the opposite direction to that of the uniform magnetic field. This causes the magnetic lines to cancel out or destroy one another in that area. However, at points "C" and "D", the lines of force of the coil move in the same direction as that of the uniform magnetic field; this tends to strengthen the lines in that area. As a result, there will be a crowding of lines at points "C" and "D". Lines of force react similarly to rubber bands that are under tension; they tend to straighten out. In this way the crowding of lines at points "C" and "D" imparts a torque or impulse to the coil.

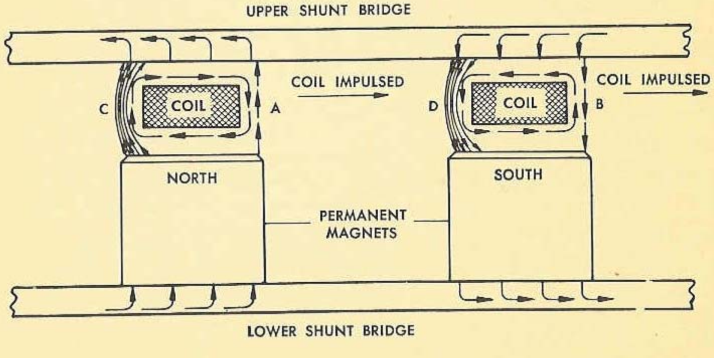


FIGURE 21

Starting the electric watch

As previously explained, the starting of the electric watch is done by shifting the watch from setting to running position. The mechanism that makes this possible is the stop lever and spring and a small cam-shaped index roller fitted to the lower side of the balance staff. When the crown is pulled out to setting position, the stop lever acts upon the index roller and brings the balance to a stop at a certain position that is slightly counterclockwise from the rest position of the balance. In this way the balance is cocked, so that as the crown is depressed and the index roller released by the stop lever, the balance will immediately start oscillating.

To illustrate this function, we show in Fig. 22 (Model 500) the roller in the position it holds when the balance is at rest. Since the crown is in running position, the roller is free of the stop lever. Now if the crown is pulled out to setting position, the stop lever will come down against the roller by the pressure of the stop lever spring. As the stop lever strikes the eccentric part of the roller, it will cause the roller to turn until the beak of the stop lever rests across the two lobes of the roller, as shown in Fig. 23.

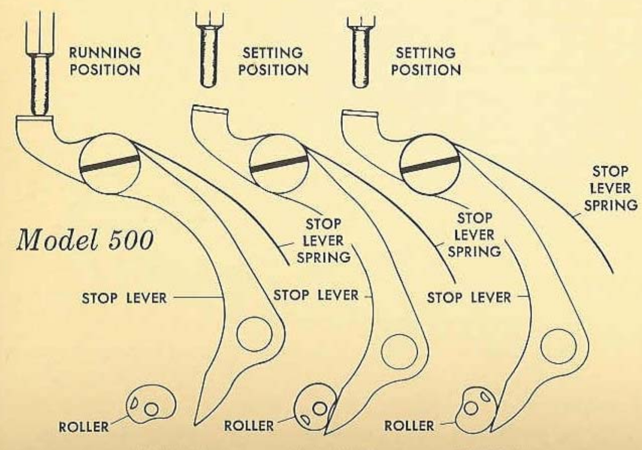


FIGURE 22 FIGURE 23 FIGURE 24

In this way, the balance is held away from its rest position, so that as the crown is depressed and the roller is released by the stop lever, the balance will begin oscillating.

With the Model 501 the same procedure is used for starting the watch as described for the Model 500. As shown in Fig. 25, 26 and 27, the index roller is changed so that the beak of the stop lever will locate in a notch on the index roller when the crown is pulled into setting position. In this position the balance is held away from its rest position. When the crown is pushed into running position, the balance is set in motion, not only by the torque of the hairspring, but also by a "kicking action" of the stop lever when it is released.

Now let us examine what happens if the crown is pulled out when the balance is not at its rest position and the stop lever strikes the concentric part of the roller as shown in Fig. 24. When this occurs, the roller will merely slide on the stop lever until the force of the hairspring returns the balance to a position that will permit the stop lever to act upon the eccentric part of the roller. Therefore, no matter where the stop lever contacts the roller, the cocking of the balance is assured.

Model 501

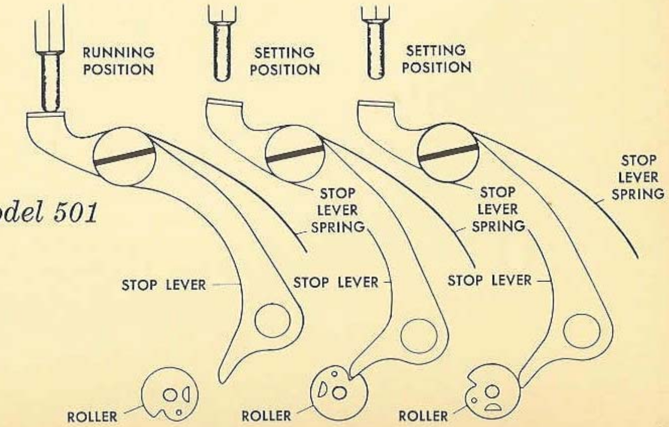


FIGURE 25 FIGURE 26 FIGURE 27

Setting the electric watch

In addition to the starting of the watch, there is another need for the roller to be held by the stop lever to a certain position. This is to prevent the train of the watch from spinning when the hands are being set. This is accomplished by the index jewel pin being brought to a position between two teeth on the index wheel. In this way the index wheel is prevented from spinning in either direction by the backing up of the train of the watch due to the hands being set.

To illustrate this we show in Fig. 28 and 29 what occurs when the hands are turned first counterclockwise and then clockwise.

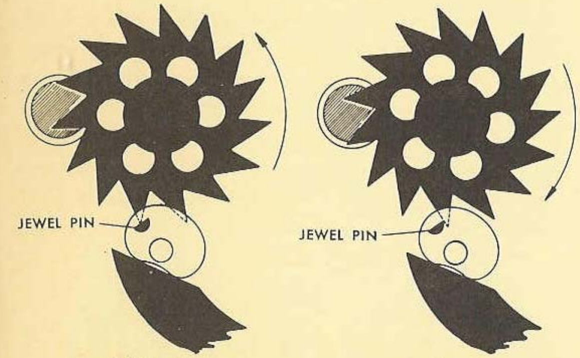


FIGURE 28 FIGURE 29

In Fig. 28 the index wheel is being forced in a counterclockwise direction which occurs when the hands are being set counterclockwise. When this happens a tooth on the index wheel hits the front face of the jewel pin and the index wheel is prevented from spinning. When the hands are turned in the opposite direction a tooth will contact the side of the jewel pin as shown in Fig. 29, and the index wheel will again be prevented from spinning. Thus you can see the necessity of employing the stop lever and cam-type index roller, as it not only serves to cock the balance, but also prevents the train from spinning when the watch is being set.

One thing remains to be explained regarding the setting of this watch. After setting the hands, do not turn the crown while depressing it. Any turning of the crown at the instant the crown is depressed may cause the hands to spin. This causes no harm; it merely means that the stop lever released the balance before the setting mechanism was disengaged. Of course when this happens the hands must be reset and the crown depressed correctly.

How the train is driven

The balance in this watch drives the train of the watch. This is accomplished through the use of the index jewel pin which is identical to the roller jewel found in ordinary watches, and is set in the index roller on the balance staff. The index jewel pin engages and moves the index wheel one tooth for each alternate vibration of the balance. Under the index wheel is a magnet, which is set in the pillar plate. This magnet serves the same purpose as does a jumper or pawl. Its function is to maintain the index wheel in proper position so that the index jewel pin can properly engage this wheel.

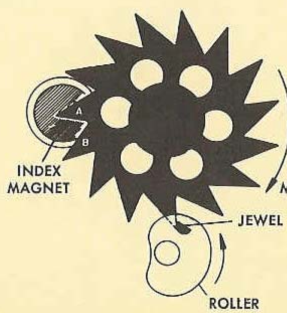


FIGURE 30

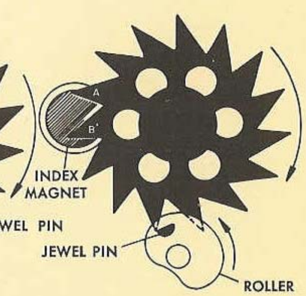


FIGURE 31

For variations in jewel pins, see page 59.

To illustrate how the train is driven by the balance, we begin in Fig. 30, by showing the roller turning in a counterclockwise direction with the jewel pin at the point of contact with a tooth on the index wheel. The tooth "A" is centered over the index magnet as the jewel pin has not as yet moved the index wheel. Now as the roller turns counterclockwise from the position shown in Fig. 30, the index wheel will be forced to turn in a clockwise direction. This will move the tooth "A" off the center of the index magnet, and will bring tooth "B" close enough to the magnet to be attracted by it. See Fig. 31.

In Fig. 31 we show the jewel pin at a point where it cannot turn the index wheel further. Notice the tooth "B" is now closer to the center of the index magnet than tooth "A". Thus it is assured that tooth "B" will be pulled directly over the index magnet to the same position tooth "A" previously held. The balance, having moved the index wheel one tooth, goes on to complete its oscillation free of contact until the return or clockwise swing of the balance brings the jewel pin again in contact with the index wheel, as shown in Fig. 32.

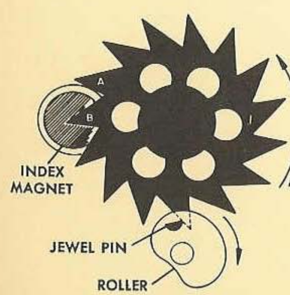


FIGURE 32

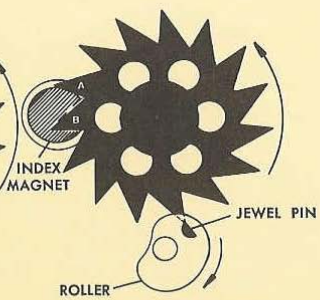


FIGURE 33

For variations in jewel pins, see page 59.

In Fig. 32, we show the jewel pin at the point of contact with a tooth on the index wheel. The index wheel has not as yet been moved by the jewel pin, and the tooth "B" is centered over the permanent magnet. Now as the turning of the roller in a clockwise direction causes the jewel pin to move the index wheel, the train of the watch will be backed up slightly. The index wheel, however, will not be turned far enough to bring the tooth "A" back over the index magnet.

In Fig. 33, we show the position of the jewel pin at a point where it cannot turn the index wheel further in a counterclockwise direction. Notice that tooth "B" on the index wheel is still closer to the center of the index magnet than tooth "A". Thus it is assured that the tooth "B" will be pulled back to the center of the magnet at the instant the index wheel is free of the jewel pin.

To conclude, the index wheel is moved one tooth for each counterclockwise swing of the balance, and on the clockwise swing of the balance, the jewel pin merely trips past a tooth on the index wheel without changing the position of this wheel.

Checking and adjusting the electrical contact system

The following is a step by step procedure outlined for checking and adjusting the contact system of the Models 500 and 501. It is well to remember that in making certain adjustments, other adjustments are affected. Therefore, after making adjustments the entire contact system should be checked step by step.

When checking and adjusting the contact system, the movement is completely assembled with the exception of the energy cell.

Step 1 *Check condition of springs and gold tab as follows:*

A. Examine the contact and trip springs carefully for twists that may be in the springs.

B. Examine the side of the box that is against the contact spring to see that it is upright.

C. Examine the box to see that it is not diamond shaped, but square or rectangular as it should be.

D. Examine the gold tab for uprightness in relation to balance staff. The gold tab may not lean to either side but may be slightly tilted toward the balance staff. The gold tab can easily be straightened with tweezers. The tab is quite soft and caution must be exercised when making adjustments.

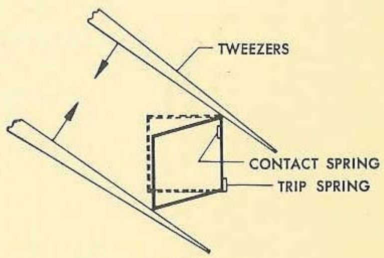


FIGURE 34

Generally speaking, the watchmaker can work on the contact and trip springs or the box to straighten them in much the same way that he works on a hairspring. However, to square up a box that is diamond shaped, it is easiest to squeeze on the corners of the box with tweezers, as illustrated in Fig. 34, to obtain the desired results.

Step 2 *Check the contact and trip springs (fig. 35) for proper level and clearance as follows:*

A. Sufficient clearance at point "A" between top of box and hairspring.

B. Sufficient clearance at point "B" between top of box and contact spring.

C. Sufficient clearance at point "C" between contact spring and top of trip jewel.

D. Sufficient clearance at point "D" between trip spring and balance, so that the coil and gold strip will clear, as they pass under the trip spring.

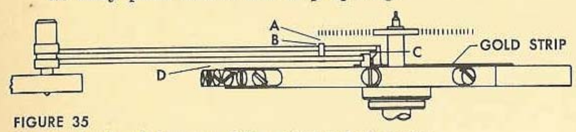


FIGURE 35
Checking level and clearance of the contact and trip spring.

To adjust the contact and trip springs for proper level and clearance, the posts to which these springs are attached can be bent. You will notice in the watch that both posts have been grooved to weaken them, so that they will bend easily at the weakened points.

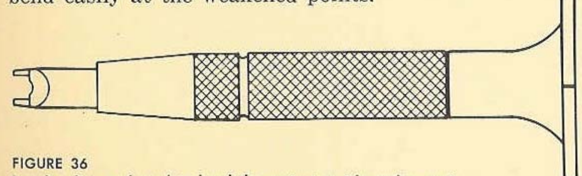


FIGURE 36
Post bending tool used to bend the contact or trip spring post.

To bend the posts, a tool such as shown in Fig. 36 can be used. These post benders may be purchased through the Material Sales Department, Hamilton Watch Company, Lancaster, Pa.

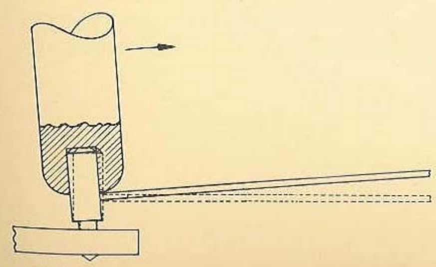


FIGURE 37
How the contact or trip spring post is bent to level a spring.

Step 3

Check contact pressure

Turn the balance 90 degrees counterclockwise from its rest position. This places the gold tab and trip jewel in the relative position shown in Fig. 38. Now with a needle or broach, move the trip spring away from the contact spring until the two springs slightly separate. (For this operation the needle should not be placed close to the base of the spring, as this would permanently bend it.) The contact spring, being completely free of the trip spring, is now unstressed. For proper contact pressure, the end section of the unstressed contact spring should be near the edge of the index hole jewel as illustrated.

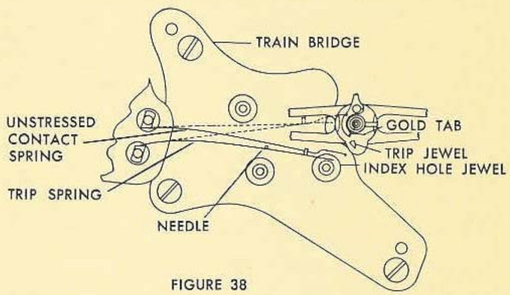


FIGURE 38

There is, however, an acceptance range in regard to the unstressed position of the contact spring. Actually, if the position of the unstressed contact spring is anywhere between the minimum and maximum positions, as shown in Fig. 39, the contact pressure will be satisfactory.

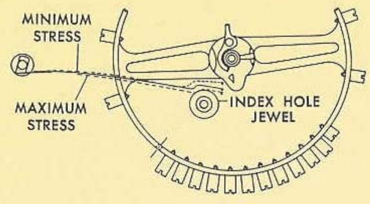


FIGURE 39

If the unstressed position of the contact spring is not within the acceptable range, then the contact pressure will be unsatisfactory. To adjust the contact pressure, the contact spring must be bent. To do this, grip the contact spring close to its post with tweezers and bend the spring in the proper direction. To bend the contact spring, do not just push or bump the side of the spring close to the post, as this will not make a permanent bend. Experience has shown that unless a definite bend is made in the spring with tweezers, it will have a tendency to creep back out of adjustment.

Caution: The contact roller is set to its proper position on the balance wheel at the factory. It is positioned so that the trip jewel is 90 degrees from the balance bars. Do not change the position of the contact roller, as certain adjustments to the contact mechanism depend upon the contact roller being in its proper position. Also, any moving of the contact roller may break loose the cement that insulates and holds the gold strip in place.

Step 4

Check trip spring pressure

As you will see later, it would be a waste of time to attempt at this point to set the trip spring pressure accurately. That will be done later. For the present, the trip spring pressure should be such that the contact mechanism will function and nothing more. In Fig. 40 and 41 we show two unsatisfactory conditions due to the trip spring pressure being incorrect. In Fig. 40 we show the trip jewel butting on the end of the trip spring. This is caused by the trip spring exerting too great a pressure against the contact spring. In Fig. 41 we show the gold tab butting on the end of the contact spring. This condition is the result of the trip spring exerting an insufficient pressure against the contact spring. For the present, any position of the springs between the positions shown in Fig. 40 and 41 will be satisfactory.

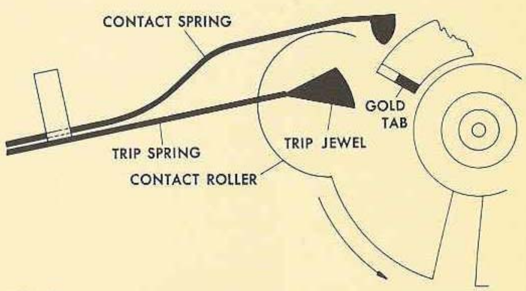


FIGURE 40
Trip spring pressure too strong. Trip jewel butts on end of trip spring.

To adjust the trip spring pressure, the trip spring must be bent close to its posts with tweezers. Again we caution against bumping the spring close to the post, as this will not make a permanent bend. Always make a definite bend in the spring with tweezers and the result will be lasting.

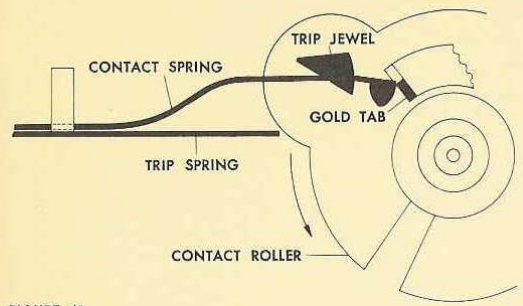


FIGURE 41
Trip spring pressure too weak. Gold tab butts on end of contact spring.

Important: When making other adjustments to the contact system, a condition such as (or similar to) those shown in Fig. 40 and 41 may be created. If this occurs, the trip spring pressure must be adjusted to correct the condition. Keep in mind that the proper trip spring pressure must be maintained at all times to keep the springs within the range in which they can function.

Step 5

Check for a bow in the contact or trip spring

In Fig. 42 we show the unstressed form of the contact and trip springs. You will notice that these springs have quite a curve in them. The location and form of the curves are such, that as the springs are made to exert a pressure against one another, they will be relatively straight.

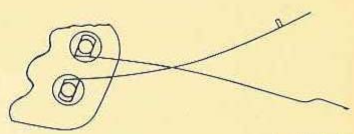


FIGURE 42
Unstressed contact and trip spring.

In Fig. 43, 44, 45 and 46 we show contact and trip springs that are in good condition and will therefore function satisfactorily in the watch. However, a bow in the springs, such as shown in Fig. 47, is unacceptable, and must be straightened.

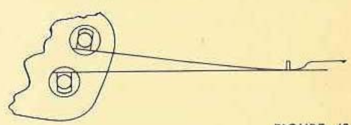


FIGURE 43
Good — Contact and trip spring are straight.

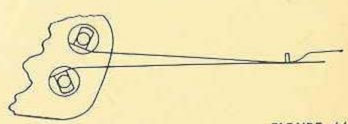


FIGURE 44
Good — Springs straight but bent inward close to posts.

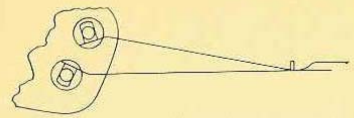


FIGURE 45
Good — Springs straight but bent outward close to posts.

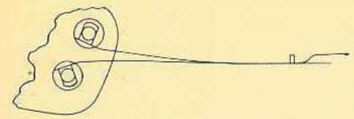


FIGURE 46
Satisfactory — Springs bowed inward.

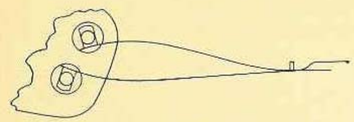


FIGURE 47
Unsatisfactory — Springs bowed outward.

Straighten a spring that is bowed

In Fig. 48 we show the method used to straighten a spring that is bowed. This is done by turning the tweezer ever so slightly and sliding it along the spring as illustrated. This method of bending a spring prevents any sharp bends or kinks from occurring. When performing this operation, keep the tweezers upright, so that a twist will not occur in the springs.

When making other adjustments to the contact system, the springs may become bowed again. If this occurs, immediately straighten them as the springs at all times must be kept straight.

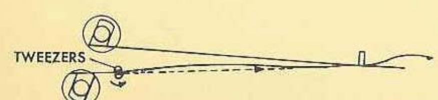


FIGURE 48
Method of straightening a bowed spring.

Check for proper lap of contact button over gold tab

Step 6

Hold the watch with the stem to your left. The contact system and balance will then appear as illustrated in Fig. 35, page 65. Turn the balance counterclockwise to bring the contact button, Fig. 49, in contact with the gold tab. At the instant the button makes contact with the gold tab, stop the balance and observe how much of the button laps over the gold tab. At the instant of contact, ¾ to ⅞ of the button should be over the gold tab as illustrated. If more than ⅞ or less than ¾ of the button laps over the gold tab at this time, the post to which the contact spring is affixed must be turned to correct this condition. You will notice that the contact spring is affixed to the side of the post. See Fig. 50. Due to this, the turning of the post will give the same effect as that of shortening or lengthening the spring. In this illustration we show the effect of turning the post in a clockwise direction. Notice how the spring is moved back from position "A" to "B", thus giving the same effect as that of shortening the spring. Naturally the turning of the post counterclockwise will give the opposite effect.

At instant of contact ¾ of button laps over gold tab.

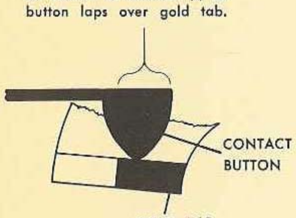


FIGURE 49

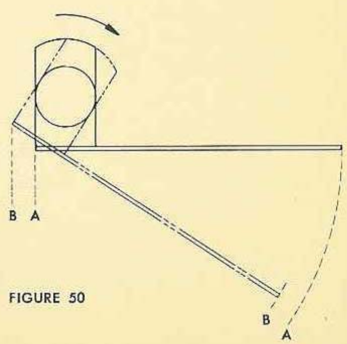


FIGURE 50

To turn the post, the post bending tool can be used as illustrated in Fig. 51.

It is important to remember that the only time the contact post is to be turned is when the contact button does not properly lap over the gold tab at the instant of contact. There is no other reason for ever turning the contact post.

When turning the contact post, the contact pressure will be changed somewhat. Therefore, after turning the contact post, the contact pressure must be rechecked and a correction made if necessary. As explained in Step 3, the contact pressure is adjusted by bending the contact spring with tweezers close to its post.

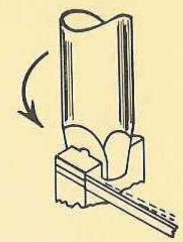


FIGURE 51

Steps 7 & 8

Make and break of the electrical circuit

The make and break of the electrical circuit must occur at precisely the correct time, so that the coil when energized will be in its proper position over the permanent magnets. In Fig. 52, we show the position of the coil over the permanent magnets at the instant the electrical circuit is completed, and the coil is energized. In Fig. 53, we show the position of the coil over the permanent magnets at the instant the circuit is broken, which naturally ends the impulse. From the make of electrical contact, Fig. 52, to the break in the electrical circuit, Fig. 53, the balance turns $22\frac{1}{2}$ degrees.

The position of the coil over the permanent magnets during the time the coil is energized is extremely important.

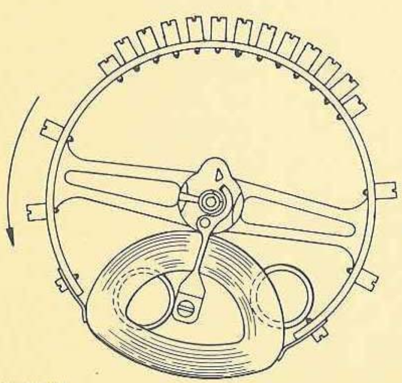


FIGURE 52
Approximate position of the coil over the permanent magnets at the instant the electrical circuit is completed.

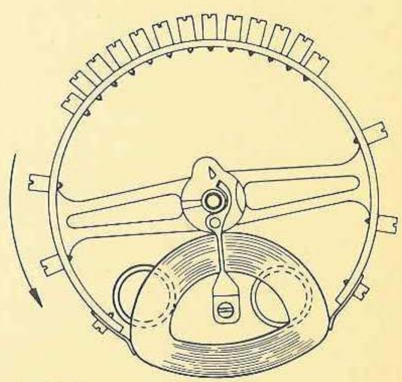


FIGURE 53
Approximate position of the coil over the permanent magnets at the instant the electrical contact is broken.

To be reasonably accurate in checking this, we will use the balance screw holes as markers, and the trip spring as an indicator. For this purpose you will notice that we have numbered the grouped screw holes in the balance. See Fig. 54. These screw holes are $7\frac{1}{2}$ degrees apart. We will begin by checking the break in the electrical contact.

Step 7

Check the break in electrical contact

The break in the electrical contact should occur when the trip spring is directly over the third screw hole as shown in Fig. 54. Notice in this illustration that the trip jewel is at a point where any further turning of the balance counterclockwise will break the electrical contact.

(continued on page 76)

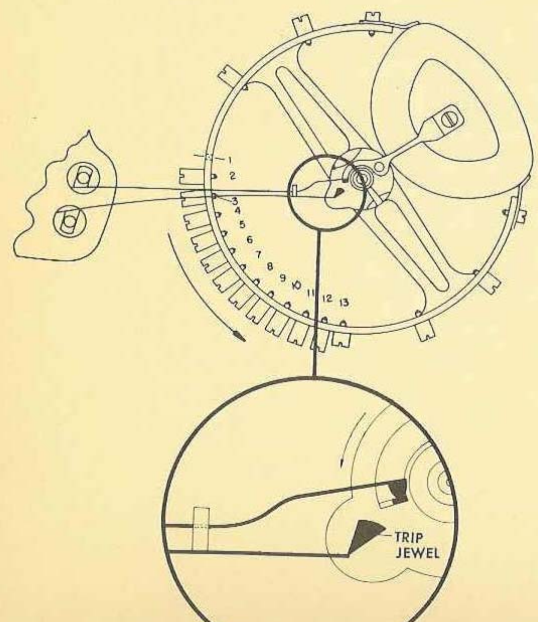


FIGURE 54

(Step 7 continued from page 75)

The position of the trip spring over the 3rd screw hole at the instant the circuit is broken must be checked very accurately. To do this, hold the watch with the stem toward you and slightly to the left. Tilt the watch so that you are looking down on the contact system. Now, move the balance slowly counterclockwise and observe when the circuit is broken. When this occurs the trip spring is released by the trip jewel and the deflecting of the trip spring is quite noticeable. Do *not* check the location of the trip spring over the balance screw holes after the spring has been deflected, but by repeating the moving of the balance through contact several times the location of the trip spring over the balance screw holes at the instant the circuit is broken can easily be determined.

In Fig. 55 and 56 we show respectively a late and an early break in electrical contact. In Fig. 55 we show the break in electrical contact occurring after the 3rd screw hole has passed by the trip spring. This indicates that the break in the electrical contact is late. To correct this condition, the trip spring post must be turned counterclockwise.

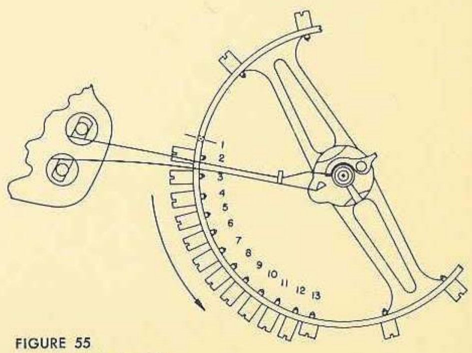


FIGURE 55
Late break in circuit.

This will decrease the penetration of the trip spring into the path of intersection of the trip jewel, and thereby cause the break in electrical contact to occur earlier. When turning the post counterclockwise, we will in addition be increasing the trip spring pressure. This must be corrected by bending the trip spring close to its post with tweezers. See Step 4. (Fig. 50 illustrates the effect of turning the contact or trip spring post.)

In Fig. 56, the break in electrical contact is about to occur, and the balance has not turned far enough to bring the third screw hole directly under the trip spring. This indicates that the break in contact is occurring early. To correct this condition, the trip spring post must be turned in a clockwise direction. This will give a greater penetration of the trip spring into the path of intersection of the trip jewel, causing the break to occur later.

We must remember that as the post is turned clockwise, the trip spring pressure will be weakened. This can be corrected by bending the trip spring close to its post.

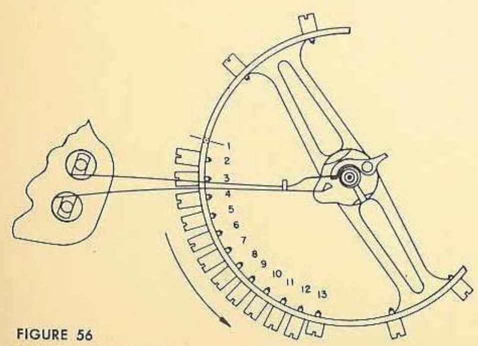


FIGURE 56
Early break in circuit.

Check the make of electrical contact

Step 8 At the instant the make of electrical contact occurs, the trip spring should be directly over the 6th screw hole, as shown in Fig. 57. Since it is rather difficult to see exactly when the electrical contact occurs, a 7-power eye loupe should be used.

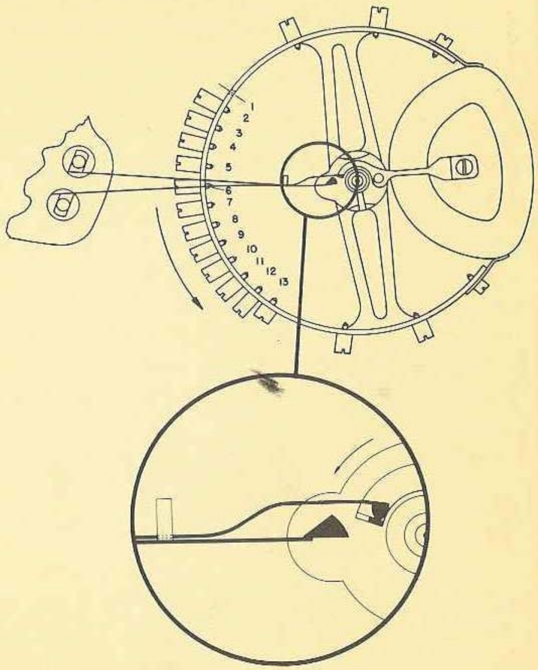


FIGURE 57

Later we will show how a multimeter can be used to show the instant the electrical contact occurs. However, if the watchmaker is careful, he can accurately determine when the electrical contact occurs with the use of a 7-power eye loupe.

It is important to have the make of electrical contact occur at precisely the correct time — that is, at the instant the 6th screw hole is directly under the trip spring. To check this, hold the watch with the stem just slightly to your left and sight in over, or just to the right of the trip spring box. Now, turn the balance counterclockwise slowly and observe the instant the contact button touches the gold tab. As soon as contact is made, stop the balance and observe the position of the trip spring over the balance screw holes. If the make of electrical contact is occurring early, such as shown in Fig. 58, the balance will not have turned far enough to place the 6th screw hole under the trip spring. On the other hand, if the make of electrical contact is late, the 6th screw hole will have passed by the trip spring before the contact button touches the gold tab.

(continued on page 80)

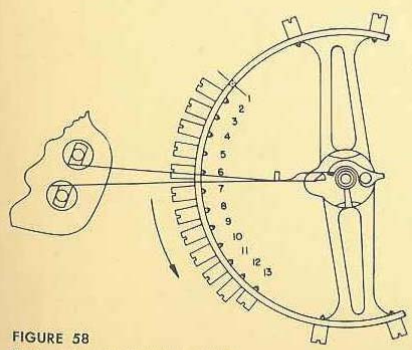


FIGURE 58
Early make of electrical contact.

(Step 8 continued from page 79)

To correct an early or late make of electrical contact, the contact spring should be bent slightly just behind the box. A pair of OO overcoil tweezers should be used to bend the contact spring. Fig. 59 shows how the contact spring is bent with overcoil tweezers to correct a late make of electrical contact. Fig. 60 shows how the contact spring is bent to correct an early make of electrical contact.

The make of electrical contact is set so that it occurs when the 6th screw hole is directly under the trip spring. The break in electrical contact is set so that it occurs when the 3rd screw hole is directly under the trip spring. This makes exactly 3 screw holes or 22½ degrees of electrical contact. It is important to remember never to exceed 22½ degrees of electrical contact, as this may cause the energy cell to run down in less than a year.

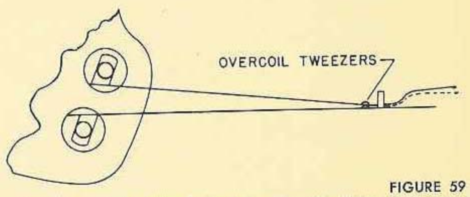


FIGURE 59
How the contact spring is bent to cause the make of electrical contact to occur earlier.

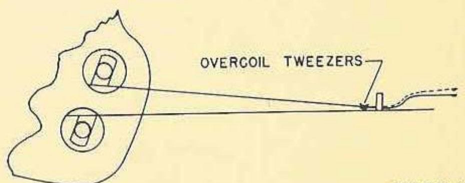


FIGURE 60
How the contact spring is bent to cause the make of electrical contact to occur later.

Step 9

Check the "Back Pick Up"

As you know, on the clockwise swing of the balance, no electrical contact occurs, and the trip jewel merely trips past the trip spring. This contact of the trip jewel with the trip spring on the clockwise swing of the balance is called "back pick up". To check this, hold the watch with the stem toward you and slightly to the left, so that it is possible to sight in along the right side of the trip spring. Move the balance slowly clockwise until the trip jewel touches the trip spring. Stop the balance at this point and tilt the watch so that you can now look down on the contact system and observe the location of the trip spring over the balance screw holes. The trip spring should now be approximate'y over the 8th screw hole as shown in Fig. 61. Now, continue moving the balance clockwise until the trip spring is released by the trip jewel. Here

(continued on page 82)

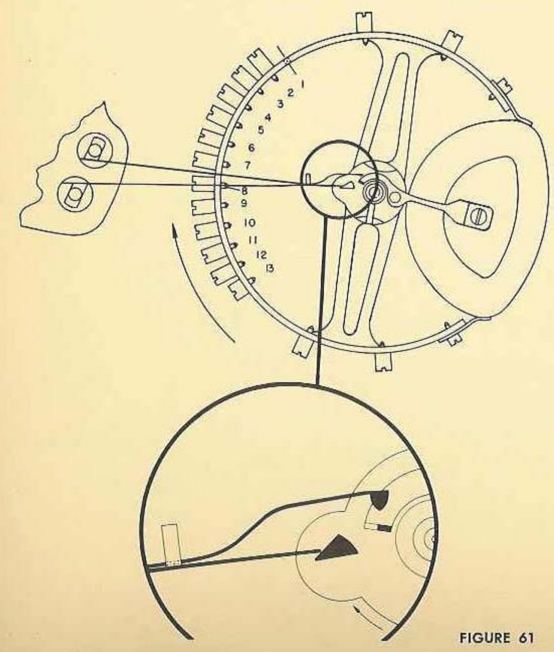


FIGURE 61

(Step 9 continued from page 81)
again, the trip spring will be deflected slightly when released. When the trip spring is just about to be released by the trip jewel the trip spring should be approximately between the 10th and 11th screw holes as shown in Fig. 62. There should be 2½ to 3½ screw holes, or 19 to 27 degrees of back pick up. The back pick up will not always start exactly on the 8th screw hole as shown in Fig. 61 or end between the 10th and 11th screw holes as shown in Fig. 62. However, there must be at least 2½ or not more than 3½ screw holes passing under the trip spring from the beginning to the end of the "back pick up" engagement.

The amount of back pick up can be adjusted by increasing or decreasing the trip spring pressure. If the trip spring

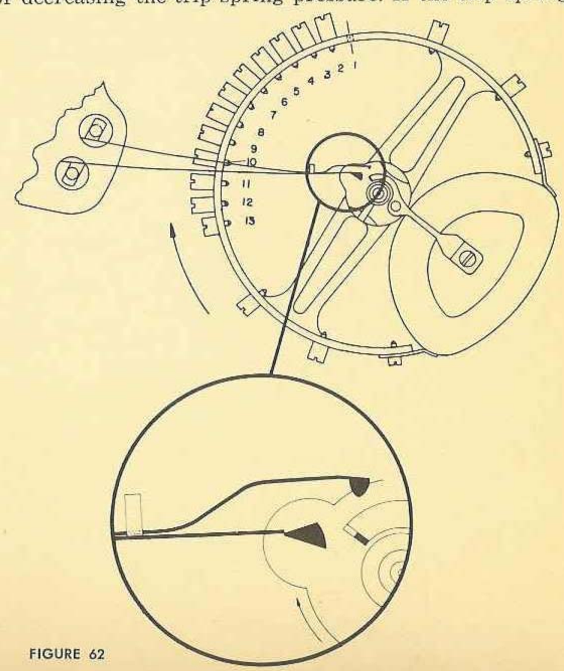


FIGURE 62

pressure is too great, the back pick up will be less than 2½ screw holes. On the other hand, if the trip spring pressure is too weak, the back pick up will exceed 3½ screw holes.

To adjust the trip spring pressure, the trip spring should be bent close to its post with tweezers. After the back pick up has been adjusted, recheck the make and break of electrical contact to be sure that everything is still set correctly.

Step 10

Check for a riding contact or trip spring

As the trip jewel moves the trip spring, there should not be any riding of the trip spring up or down on the trip jewel. A riding trip spring indicates that there is a twist in the spring close to its post. Fig. 63 shows a trip spring that is riding down, which is indicated by the dotted position of the spring. To correct this condition, the trip spring must be bent with tweezers as illustrated. Naturally if the trip spring was riding up, it would be necessary to bend the spring in the opposite direction. Similarly this applies to a riding contact spring.

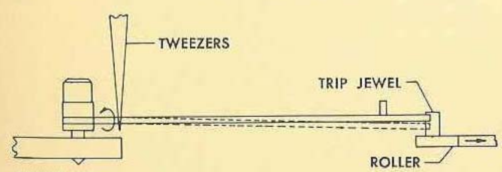


FIGURE 63

Step 11

Check the motion of the balance

The minimum motion of the balance should be 1¼ turns in the dial position and 1⅛ turns in the pendant positions.

section 3

Trouble shooting—procedure and equipment

Putting the electric watch in beat

Beat To put this watch in beat, we must first block out the train of the watch. To block out the train, we simply disengage the index wheel from the index jewel pin. This can be done by sliding a thin folded piece of paper under the index wheel, so that it will exert a light pressure against the wheel. In Fig. 64 we show the index wheel being held by the folded paper at a position that prevents the index jewel pin from contacting it.

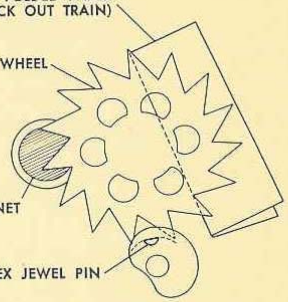


FIGURE 64
Blocking out the train with the use of folded paper.

After blocking out the train, allow the balance to come to its rest position. This done, observe the position of the gold strip screw, Fig. 65, between the horns "A" and "B" of the upper shunt bridge. When the watch is in beat, the gold strip screw will be centered between the horns. As always, the hairspring collet is turned on the staff to put the watch in beat.

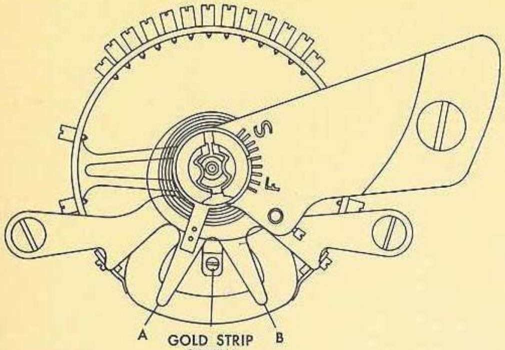


FIGURE 65
Putting the watch in beat by centering the gold strip screw between the horns of the upper shunt bridge.

Relationship of beat to self-starting

The crown of the watch should be pulled out to setting position, and then depressed to see if the watch will start itself. To make the watch self-starting, it may be necessary to make the gold strip screw favor the horn "A" (Fig. 65) of the upper shunt bridge. Although this will throw the watch slightly out of beat, it will aid in the self-starting of the watch by (1) bringing the trip jewel closer to the trip spring when the balance is at rest, and (2) causing the hairspring to be in a greater state of stress when the crown is in setting position.
However, care must be taken that the gold strip screw does not favor the horn "A" (Fig. 65) any more than is necessary to make this watch self-starting.

Poor Balance Motion

In this watch the balance motion in the dial position should be a minimum of 1¼ turns. To help locate the cause of poor balance motion, the train should be blocked out. (See page 86 for information pertaining to the method used to block out the train.) Under ordinary circumstances, blocking out the train will cause the balance motion to increase about ⅛ turn. Therefore, if the balance motion increases more than ⅛ turn, it is obvious that the error must be in the train itself. On the other hand, if the balance motion did not increase beyond ⅛ turn, this would indicate the error is somewhere other than in the train.

Assuming the cause of poor motion is not found in the train, but elsewhere, proceed as follows:

1. Recheck the entire electrical contact system. (See pages 63 to 83.) Be sure to check the contact and trip spring clearances. A slight rubbing of the contact spring on the top of the box, for instance, will affect the balance motion.

2. Check the finger block to see if it is free. (See page 26.)

3. As the balance turns, check to see that the index roller clears the stop lever. In Fig. 66 we show the index roller (Model 500) touching the stop lever. As you know, when the stem is in running position the stop lever should be held at a position that gives ample clearance to the index roller. The cause of the error illustrated is most likely to be one of the following:

- **a.** The pilot on the stem being too short.
- **b.** Improper screw in the stop lever.
- **c.** Stem not shifting properly from setting to running position.

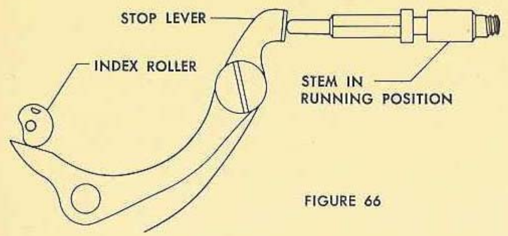


FIGURE 66

4. Check the actuating pin to see if it clears the guard pin. In Fig. 67 we show an actuating pin that is bent out of upright and touching the guard pin. Straightening the actuating pin will eliminate this error.

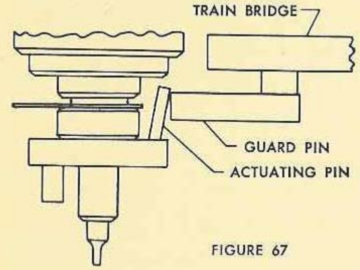


FIGURE 67

5. Examine the permanent magnets to see that there are no bits of metal on them that may rub the balance. (Bits of metal on magnets are sometimes hard to see, so examine the magnets carefully.) Cellophane tape can be used to remove any metal particles from the magnets. The same examination should be made of the index magnet.

6. Examine the contact points to see that they are clean. If there is any evidence of contamination, oxidation, or other evidence indicating a dirty contact, proceed as follows:

- **a.** Scrape the gold tab lightly and cautiously with a suitable tool for this purpose; such as shown in Fig. 68. This can be done without removing the balance from the watch.

a. Scrape the gold tab lightly and cautiously with a suitable tool for this purpose, such as shown in Fig. 68. This can be done without removing the balance from the watch.

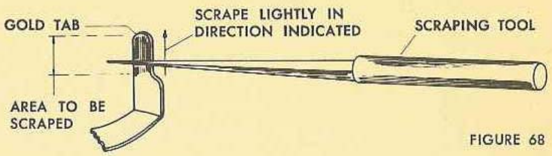


FIGURE 68

If the cause of poor balance motion is to be found in the train of the watch proceed as follows:

1. Check the endshake and freedom of the train wheels. When checking the fourth wheel endshake, push down on the cannon pinion. Keep in mind when checking endshake that the wheels in this watch should have slightly less endshake than the wheels in conventional timepieces.
2. Examine the wheels in the same way that the wheels in an ordinary watch would be examined when train trouble is evident. While doing this, remember that we have a floating train which is driven by the balance, and therefore, the slightest binding can affect the balance motion.

Failure of the watch to start

When the stem is moved from the setting position to the running position, the stop lever disengages the index roller. In the Model 500, only the action of the hairspring causes the balance wheel to rotate far enough to permit the trip jewel to engage the trip spring. In the Model 501, the balance wheel is given an additional impulse as the end of the stop lever moves out of the notch in the index roller. In either model, excessive friction between the index roller and the stop lever can cause the balance wheel to stop in an improper position, so that the watch fails to start when the stem is returned to the running position.

If the watch fails to start:

1. Check the action of the stop lever on the index roller. In the Model 500, the flat of the lever should align the lobes of the index roller. On the Model 501, the end of the lever should engage the notch in the roller. If the roller is not held in the proper position:
   - **a.** Check the stop lever to see if it is free.
   - **b.** Check the elevation of the stop lever to insure that it is riding on the index roller surface and not on the lower collar.
   - **c.** Bend the stop lever spring to exert a greater force on the stop lever.
   - **d.** Check the orientation of the roller on the balance staff.
2. If the lever engages and locates the roller satisfactorily, but the watch still will not start, check the beat position of the hairspring. (Refer to page 86.)

Power movement holder

In Fig. 69 we show a power movement holder and a 200 ohms resistor in series with a 1.57 volt dry cell. The 200 ohms resistor is employed to lower the voltage to 1.50. The motion of the balance in the dial positions should be 1¼ turns when operating on a voltage of 1.50 plus or minus .02 volts.

The power movement holder is made by screwing metal contact strips on to a 5/0 size plastic movement holder. The metal strip "A" is formed so that it will make contact with the battery lead in the watch when the movement is slipped into the movement holder. The metal strip "B" is formed to make contact with the pillar plate. The two strips should be made of a fairly resilient metal. (If a metal rather than a plastic movement holder is used, the strip "A" must be insulated from the movement holder.)

The purpose of a power movement holder is as follows:

1. To conserve the life of the small watch energy cell. For instance, improper handling of the tweezers while working on the watch can short out the energy cell and decrease its life.
2. To provide better visibility into the watch while the watch is running.
3. Oscilloscope hook up. See page 100.

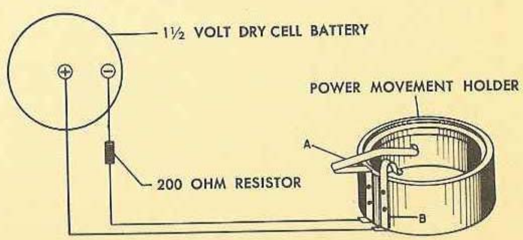


FIGURE 69

The multimeter

A multimeter (volt-ohm-milliammeter) is necessary for testing the voltage of the energy cell, coil resistance, and continuity of the circuit. The instrument is not expensive but must have 20,000 ohms per volt resistance, with a scale for accurately reading the resistance of the coil (3100 ohms plus or minus 400 ohms). The following instruments are among those suitable; see your local radio and television supply dealer:

Triplett Electrical Inst. Co.
Bluffton, Ohio
Model 630, 20M ohms/volt VΩM

Weston Electrical Inst. Co.
619 Freylinghuysen Ave.
Newark, New Jersey
Model 980, 20M ohms/volt VΩM

Simpson Electric Co.
Div. American Gage & Machine Co.
5200-5218 West Kinzie St.
Chicago 44, Illinois
Model 260, 20M ohms/volt VΩM

Hickok Electric Instrument Co.
Dupont & Williams Sts.
Cleveland, Ohio
Model 457, 20M ohms/volt VΩM

The Triplett Model 630 is referred to in this text in order to supply specific information and illustrations. Note: The points of the test prods usually must be sharpened by filing or grinding to "pencil points" for watch work.

Testing the energy cell: Set the selector switch to 3 on the DC side of the meter as shown in Fig. 70. Plug the black test lead into the COM jack and the red lead into the V-Ω-A jack as shown in Fig. 70.

Bring the negative (black) prod in contact with the center of the energy cell, and the positive (red) prod in contact with the energy cell cover. Read the voltage on the top black meter scale. From 0 to 3 volts is read on the 0 to 300 scale; therefore, the reading is divided by 100. For 1.5

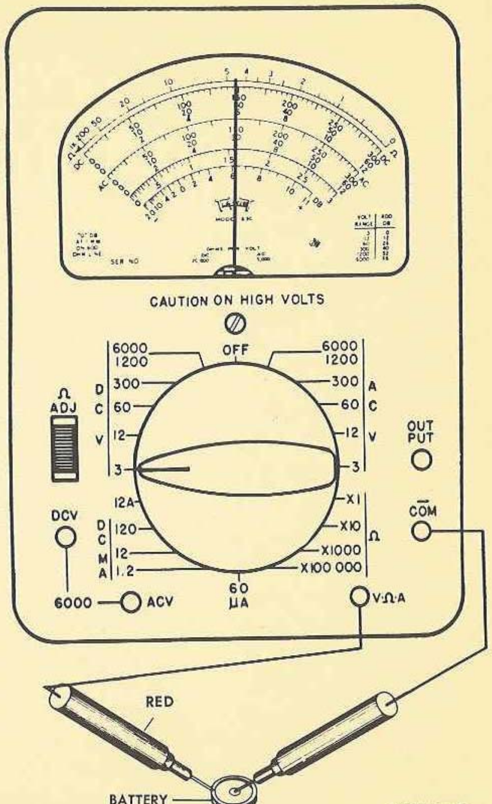


FIGURE 70

volts the reading will be 150 (150 ÷ 100 = 1.5). Cell voltage may vary from 1.4 volts to 1.6 volts at different stages of the cell life (see Page 14). This is a characteristic of the cell and any voltage reading within this margin is sufficient to operate the watch. Each scale division when

reading 0 to 3 volts is equal to 0.05 volt. A low voltage cell (less than 1.4 volts) will cause poor balance motion, erratic timekeeping and periodic stopping of the watch.

> **Caution:** *Do not use any instrument with less than 20,000 ohms per volt resistance. Otherwise the energy cell will be drained while being tested.*

Testing coil resistance: To test coil resistance, set the selector switch to X1000 as shown in Fig. 71. The test leads are plugged into the meter in the same manner as for the foregoing test for checking voltage.

Bring the test prods firmly together to see if the meter is properly adjusteu. The meter pointer should read 0 on the extreme right side of the top red scale. If the pointer is not on 0, turn the adjustor at the left side of the meter until the pointer is on 0.

Having "zeroed" the meter the resistance of the coil can then be checked. To do this, place one (either red or black) test prod on the balance wheel and the other test prod on the gold strip screw (Model 500) or on the metal core connector as shown in Fig. 71. Be sure the prod on the gold screw is not in contact with any other part of the balance assembly. Be careful not to press so hard as to dislocate the coil. Read the resistance on the top red scale. Due to the selector being set at X1000, the reading must be multiplied by 1000. Fig. 71 shows the pointer at 3 on the scale. 3 x 1000 = 3000 ohms, which is the resistance of the coil. The coil in the electric watch should show a resistance of 3100 ohms plus or minus 400 ohms. A meter reading anywhere from 2700 ohms to 3500 ohms indicates the coil is in good condition.

Coil defects will show up on the meter as follows:

1. A high or low resistance coil will simply show a reading above or below the specified tolerances mentioned above. This will result in poor balance motion, erratic timekeeping, and periodic stopping.

2. On a coil with an open circuit the pointer will remain at the far left side of the scale indicating that no current is passing through the coil and is possibly caused by a broken strand of wire within the coil. An open coil will stop the watch completely.

3. When testing the coil if the meter pointer is deflected to 0 resistance, a short circuit is evident. The short circuit may be through the coil connector. For instance, the collet or hairspring may be touching the connector.

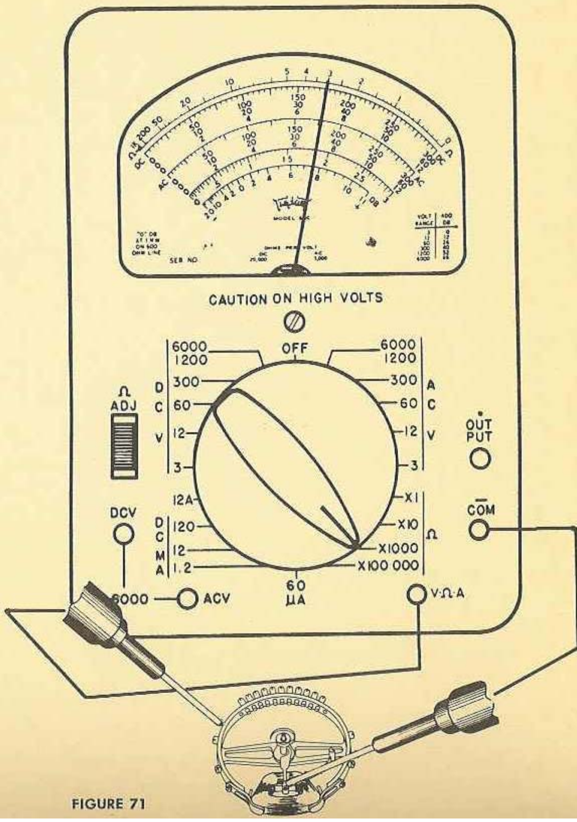


FIGURE 71

Caution: *Do not touch the coil with tweezers. This could very easily damage the coil causing an open circuit.*

Checking continuity: Set the selector switch to X1000. Place one test prod on the energy cell lead and the other on the contact spring post. See Fig. 72. The meter should read zero resistance (extreme right on the top red scale). Next turn the balance so that the contact button makes contact with the gold tab. A small folded piece of paper can then be slipped under the balance to hold it in this position. Now place one test prod on the coil connector and the other test prod on the contact spring post. See Fig. 73. The meter should again read zero resistance.

When making the above tests, if the meter pointer does not move, this indicates a break in the circuit between the points tested, thus pinpointing the trouble. When making the test shown in Fig. 73 be sure the contact button and gold strip are in contact.

In testing for a short circuit, place one test prod on the pillar plate and the other test prod on the battery lead. See Fig. 74. The pointer on the meter should remain stationary at the far left of the scale. If a short circuit exists the pointer will read zero resistance on the extreme right of the scale. The short circuit may exist through the energy cell lead, the contact spring post, or the trip spring post.

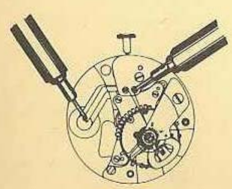


FIGURE 72

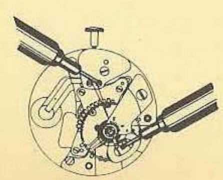


FIGURE 73

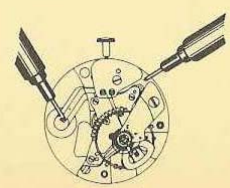


FIGURE 74

Checking the complete circuit: With the test prods in the position shown in Fig. 74, the complete circuit can be checked as follows:

Turn the balance to bring the contact button in contact with the gold tab and slip a piece of paper under the balance to hold it in this position. If the coil is good and there is neither an open circuit nor a short circuit, the meter will read the resistance of the coil. (Resistance of the coil — 3100 ohms plus or minus 400 ohms.)

This is a quick method of testing the complete circuit. However, if trouble is indicated it must be located by testing portions of the circuit as illustrated in Figures 72, 73 and 74.

Checking the make of electrical contact: To check the make of electrical contact, the multimeter can be used with the power movement holder as illustrated in Fig. 75. Since the power movement holder is also used with a $1\frac{1}{2}$ volt dry cell as illustrated on page 92, Fig. 69, alligator clips can be attached to the ends of the wires for the convenience of changing the hook up from the $1\frac{1}{2}$ volt dry cell to the prods of the multimeter. The $1\frac{1}{2}$ volt dry cell *must* be disconnected when using the multimeter in this test. Do not use the 200 ohm resistor in this hook up.

For checking the make of electrical contact, set the selector switch to X1000. Move the balance by hand in a counterclockwise direction until the contact button is just about to make contact with the gold tab. Now, watch the pointer of the multimeter and slowly continue the counterclockwise movement of the balance. At the instant contact is made the pointer will be deflected from the left side of the top red scale to approximately 3 (the resistance reading of the coil). Stop the balance at this point. The sixth screw hole of the balance should be directly under the trip spring at this time. See Fig. 57, page 78.

If adjustment is needed, refer to the section on adjusting the make of the electrical contact, page 78.

This is an alternate, quick method of checking coil resistance or continuity of the circuit.

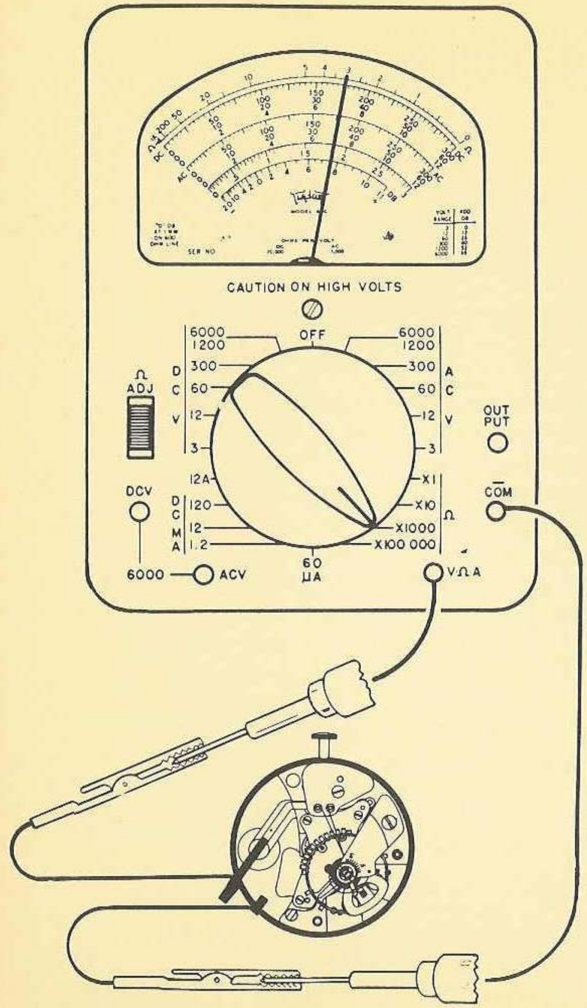


FIGURE 75

The oscilloscope

The oscilloscope is an instrument of considerable value in checking the function of the electrical contact mechanism. However as previously mentioned, if care is exercised, the checking and adjusting of the electrical contact mechanism can be satisfactorily performed without the use of an oscilloscope.

This section will point out the advantage of using an oscilloscope. The Waterman Pocketscope, Model S-14-A manufactured by Waterman Products Company, Inc., Philadelphia 25, Pa. is referred to in this section in order to give specific information and illustrations.

How to use the oscilloscope

1. Connect the power movement holder circuit as illustrated in Fig. 76. The DC input and ground on the vertical input side of the oscilloscope are connected across a 200 ohm resistor as illustrated.

2. Set controls as follows:
V ATT — set at 1 as illustrated.
SYNC-TRIG — set at 0.
H ATT — set at off position.
V GAIN and H GAIN — these controls are set at approximately 1/3 or between the 2 and 4. These adjustments may vary according to the sensitivity of the instrument.
FUNCTION — set at INT as illustrated.
V BALANCE and H BALANCE — These controls are set at the factory and should need no further adjusting.
RANGE — set at 50-500.
FREQUENCY — This adjustment may vary. Set so that the contact image will not travel across the screen. This will occur for several positions of the frequency control. For easiest viewing, the contact image should be approximately 40% of the base line. This setting corresponds to approximately 60 cycles.
V POS — set at halfway as illustrated.
H POS — set at halfway as illustrated.

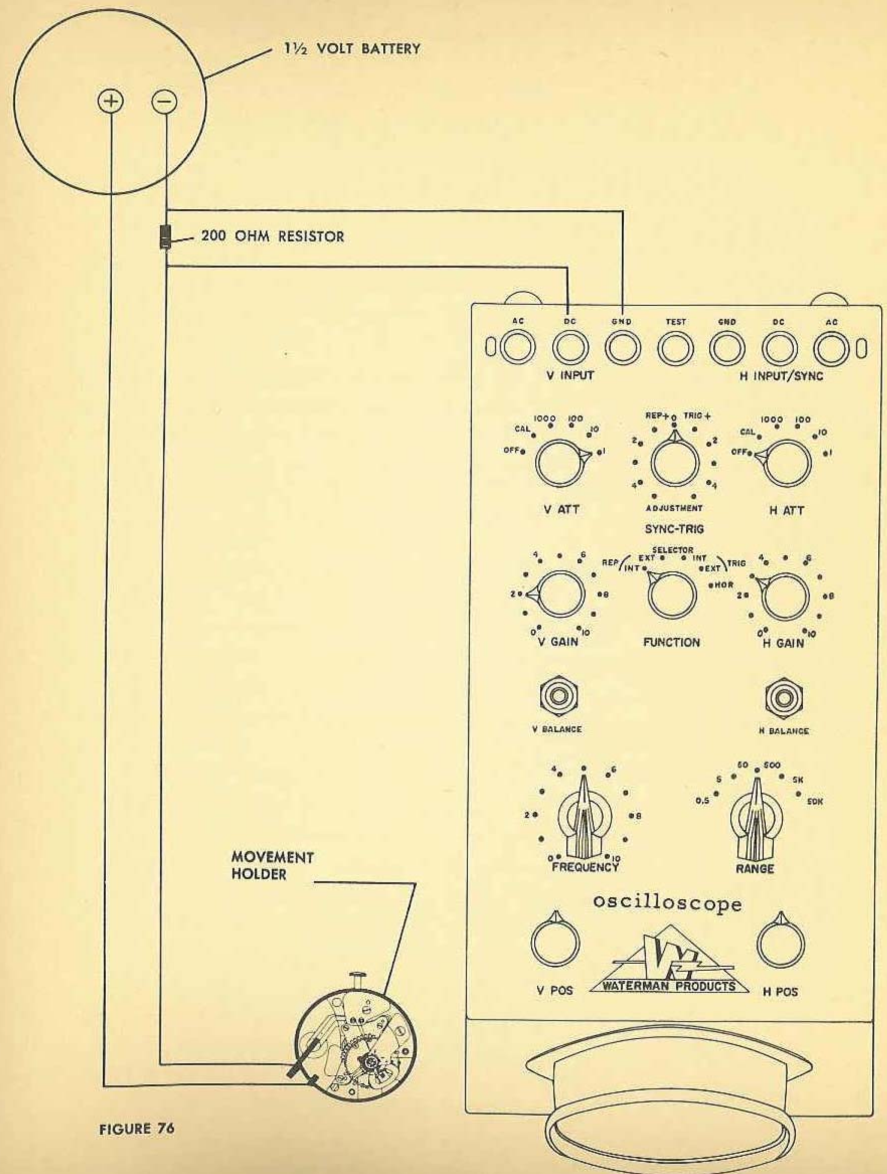


FIGURE 76

3. The oscilloscope is off when the BEAM control is turned to the extreme left or counterclockwise direction. To turn the scope on, rotate the BEAM control clockwise until the switch clicks. Wait 30 seconds for warm up.
4. Advance BEAM control in clockwise direction until the trace appears on the screen.
5. Center this line on the screen by means of the V POS and H POS controls. The ends of this line should be approximately ¼ inch from edge of screen. This can be adjusted by means of the H GAIN control.
6. Adjust FOCUS and BEAM controls for desired brightness and sharpness of trace.

With the movement in the power movement holder, the electrical contact can now be checked.

Good scope pattern

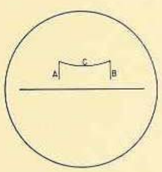


FIGURE 77

Fig. 77 shows a good scope pattern. The vertical line "A" represents the make and the vertical line "B" represents the break of the circuit. If the vertical lines are faint and narrow, this indicates a rapid make and break of the circuit. Depending upon the sensitivity of the oscilloscope these lines may or may not be visible. This is of no great importance in checking the condition of the electrical contact. We are primarily interested in the curved line "C". In Fig. 77, this line is symmetrical or level with the base line indicating the balance is being impulsed at the proper point in its swing.

Balance Motion

The greater the balance motion the shorter will be the curved line "C". With the balance motion at 1¼ turns, the linear space between the ends of the curved line "C" is equal to about 40% of the base line.

Early and late impulse of the balance

The slanted oscilloscope pattern shown in Fig. 78 and 79 indicates that the balance is not being impulsed at the proper point in its swing.

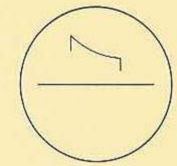


FIGURE 78

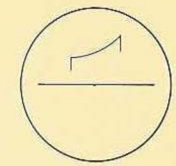


FIGURE 79

The oscilloscope pattern shown in Fig. 78 indicates an early impulse, while the pattern shown in Fig. 79 indicates a late impulse. When either of these patterns appear, recheck the position of the balance when the circuit is broken, as explained on page 75. If it is found that the break occurs at precisely the specified point, the error is most likely due to the coil being slightly off its proper position on the balance wheel. In such a case, just disregard the slant in the oscilloscope pattern. (Do not under any circumstances tamper with the coil.)

Striker

The term striker is used to denote an error in the contact system. This error occurs on the clockwise swing of the balance at the end of the back pick up, when the trip spring drops off the trip jewel. As the springs snap back to their original position they will bounce slightly. If this bounce of the springs brings the contact button momentarily in contact with the gold tab, this is a striker. (As you know, there should not be any electrical contact on the clockwise swing of the balance.) Fig. 80 shows how a striker appears on the oscilloscope screen. The long vertical line flashes on the oscilloscope screen very quickly and can be easily overlooked. If attention is directed to the frequency of the flashes, a striker is more easily detected. Normally there are three flashes per 1-1/5 seconds. More flashes than this indicate a striker.

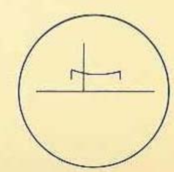


FIGURE 80

A striker can usually be eliminated by either bending the gold tab back towards the balance staff slightly, or by decreasing the back pick up through increasing the trip spring pressure.

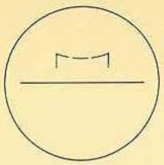


FIGURE 81

Poor electrical contact

A broken line in the oscilloscope pattern such as shown in Fig. 81 indicates that there are breaks in the electrical contact. Such a scope pattern is usually caused by oxidation or foreign matter on the contact points, or insufficient contact pressure. This in turn will cause a poor balance motion. To correct this refer to page 89 for cleaning the contact points. Refer to page 66 for checking contact pressure.

Checking make of electrical contact

The oscilloscope can be used for making a more precise check on the make of the electrical contact. With the watch in the powered movement holder, move the balance by hand in a counterclockwise direction until the contact button is just about to make contact with the gold tab. Now watch the base line on the oscilloscope and slowly continue the counterclockwise movement of the balance. At the instant contact is made the base line will move. Stop the balance at this point. The sixth screw hole of the balance should be directly under the trip spring at this time. See Fig. 57, page 78. If adjustment is needed, refer to the section on adjusting the make of the electrical contact, page 78.

Oscilloscope hookup using two power movement holders

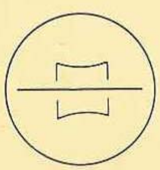


FIGURE 82

The two power movement holder hookup as shown in Fig. 83 makes possible the utilizing of one oscilloscope for two operators. When operating two watches at the same time contact images will appear on the scope as illustrated in Fig. 82. Of course, one image will appear inverted on the screen due to the polarity of the circuit. This is of no importance. Illustrations for an early or late break as shown in Figs. 78 and 79 will appear in an inverted position on the lower image.

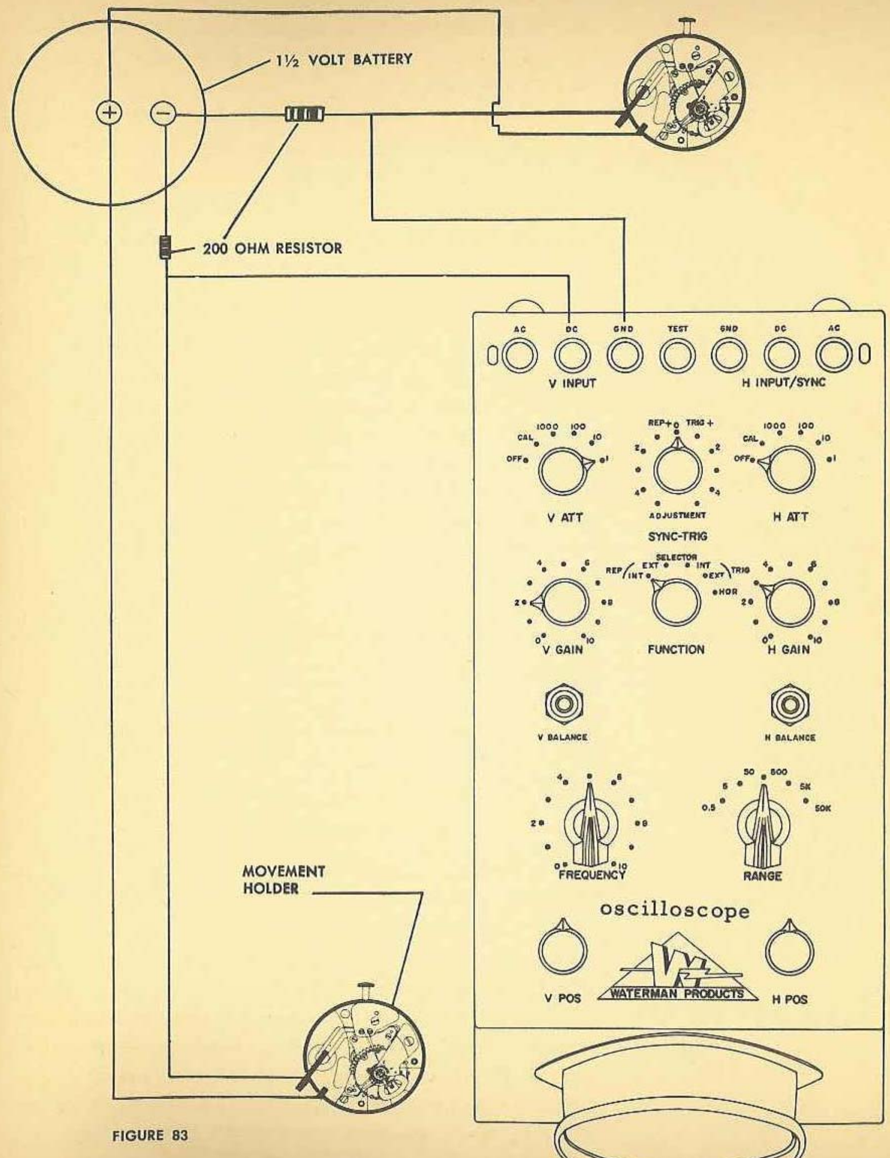


FIGURE 83

Timing machine rates

In timing the Hamilton electric watch, closer position rates should be expected than on conventional watches of comparative size.

The electrical system of the Hamilton electric watch does not produce the hard tick of conventional watches and standard rate recorders with the usual sound sensitive crystal microphones will not produce "clean" lines. In fact, such microphones will produce one-sided lines, two separated lines, or scalloped lines, depending on the sensitivity of the machine. Pay no attention to such lines. They are meaningless in the electric watch and are not an indication of its performance. Read only the direction of the line(s) for determining the rate of regulation.

Fig. 84 shows a number of acceptable type Watchmaster patterns for the Hamilton electric watch.

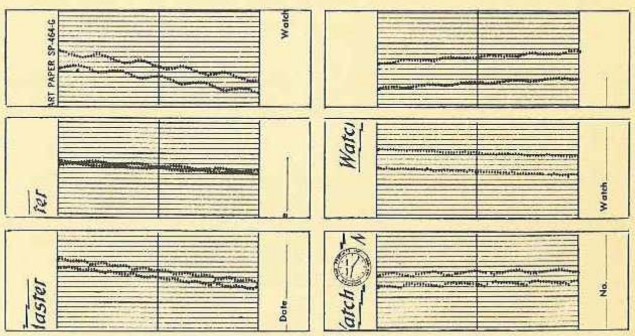


FIGURE 84

Special cements used

Cements used in the electric watch are of the epoxy resin family, and are extremely rugged. Therefore, the need to replace these cements would be unlikely. These cements require special handling in their preparation. For this reason, if the watchmaker finds that any cement in the electric watch has broken loose, it is advisable to return the necessary parts to the factory for recementing.

ADDENDUM

In order to maintain an uninterrupted flow of production of Hamilton electric watches, it was necessary to introduce an interim model. This is a relatively short production run released prior to the Model 501. Identification on the contact bridge is "Hamilton 500A."

All components of the Model 500A are the same as the Model 500 with the following exceptions, which also are incorporated in the Model 501.

1. **Energy cell clamp:** On the Model 500A the energy cell clamp is the type identified on page 12 as Model 501.

2. **Case ring:** As described on page 17 the Model 500A may be used in certain case styles where the movement is secured by case screws or by a movable case ring.

3. **Balance bridge:** The balance bridge on the Model 500A is the same as shown on page 24, identified as Model 501. This bridge employs a two-piece micromatic regulator and the Kif type shock resist jewels.