

TRAINING UNIT  
NUMBER 9A



MAINSRING BARREL ASSEMBLY  
(Power Unit)



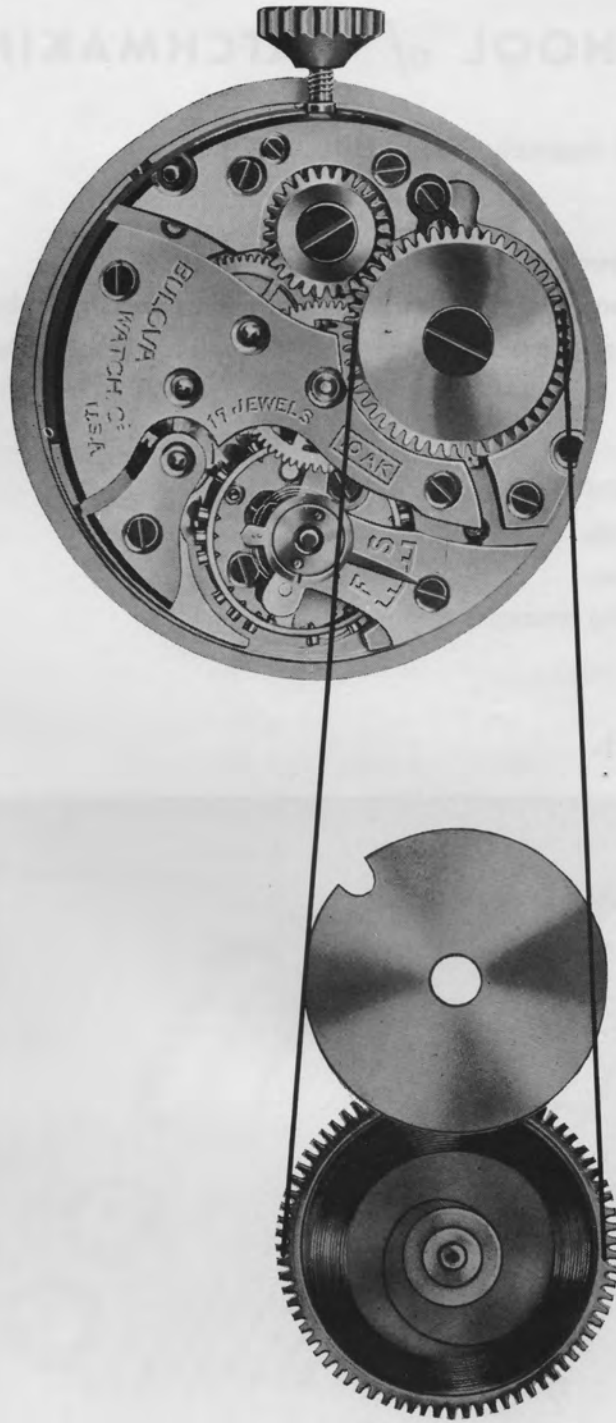
## MAINSRING BARREL ASSEMBLY

The watch like every other engine or mechanical contrivance must depend on a steady source of power in order that it may function. Through a series of evolutionary improvements, the present day mainspring and barrel assembly was developed.

Because the watch is such a minute machine, the slightest interference with the even flow of its mainspring power can readily affect its timekeeping accuracy. Experience has found considerable dissatisfaction with repaired watches because of errors in the power unit.

For this reason, mainspring barrel construction will be carefully explained with special emphasis on correct repair procedure for making replacements and adjustments.





**BULOVA SCHOOL *of* WATCHMAKING**



## BULOVA SCHOOL *of* WATCHMAKING

**Subject:**

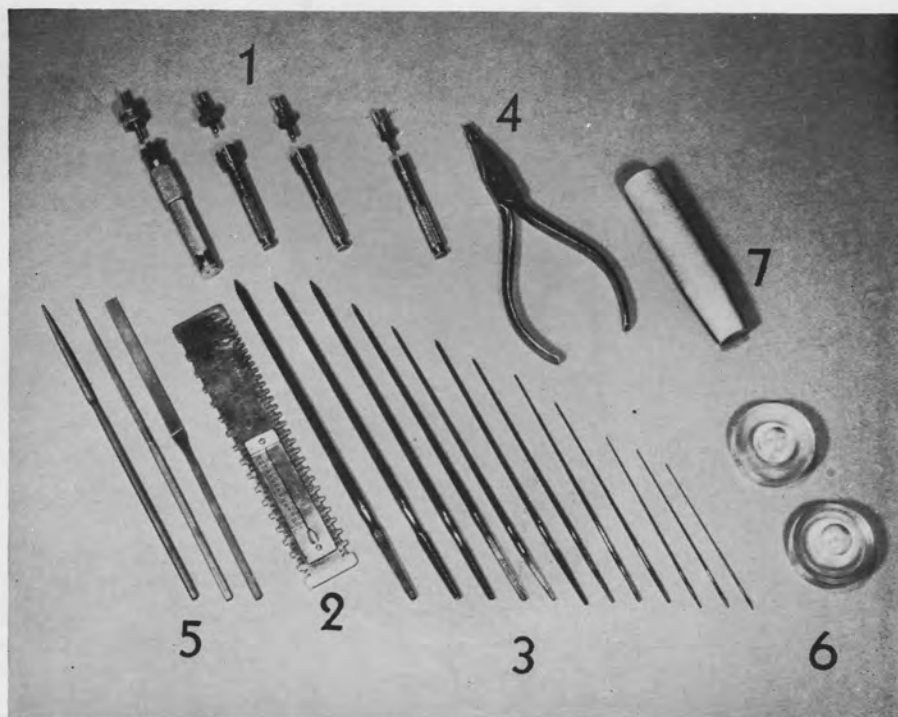
Mainspring Barrel Assembly (Power Unit)

**Objectives:**

1. To learn construction of modern watch barrel assemblies.
2. To determine and insert the correct size of mainspring in any barrel.
3. To recognize and correct common errors found in mainspring barrel assembly.

**New Tools Required:**

1. Mainspring winders.
2. Dennison gauge.
3. Set of broaches.
4. Plier for shaping mainspring inner coils.
5. Small files.
6. Plastic blocks.
7. Boxwood punch.



## MAINSRING BARREL ASSEMBLY

### Power Unit

There are three types of barrel units used in recent watch construction.

1. THE GOING BARREL.
2. THE MOTOR BARREL.
3. THE SUSPENDED BARREL.

All three will be briefly explained, with special emphasis on the most widely used going barrel.

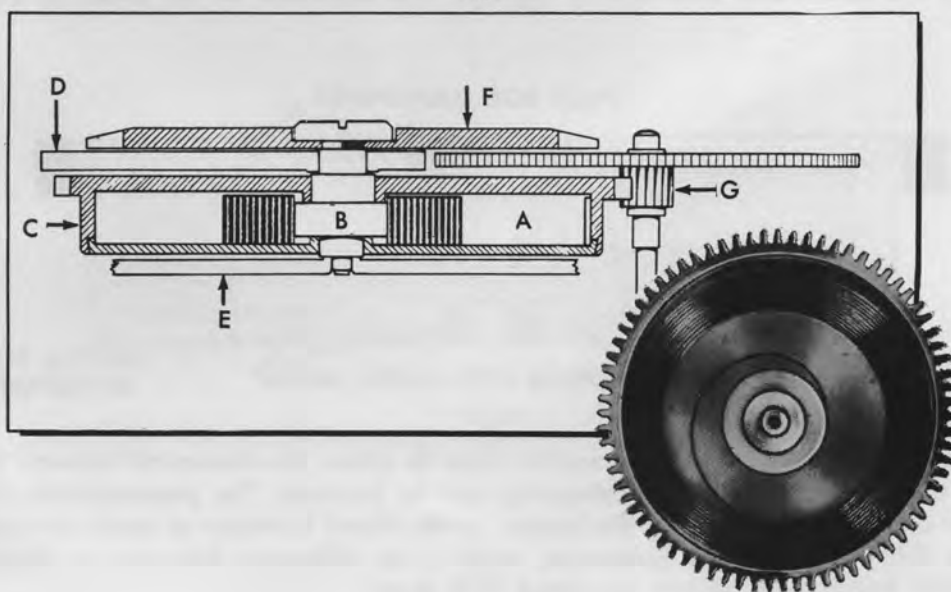
### THE GOING BARREL

Fig. 1 shows a cross section of the going barrel assembly. The mainspring (A) is wound about an arbor (B) in a barrel (C) to which is hooked the outer end of the mainspring. The arbor remains in a stationary position between the barrel bridge (D) and pillar plate (E), except during the winding process when the ratchet wheel (F) turns the arbor within the barrel. The ratchet wheel is prevented

from springing back by a click which is held against the ratchet wheel by a click spring.

The barrel which rotates about the arbor is equipped with epicycloidal gear teeth which are meshed with the center wheel pinion (G). As the spring unwinds, causing the barrel to turn, this driving action furnishes the motive power for the watch.

Fig. 1



### CONSTRUCTION OF THE MAINSPRING BARREL

The barrel which contains the mainspring is capped with a barrel cover which keeps the arbor and mainspring in their respective positions. This cover snaps on the barrel and remains firmly closed due to a slight bezel effect or back taper in the wall of the barrel which matches the taper on the cover's edge. See A and B in Fig. 2.

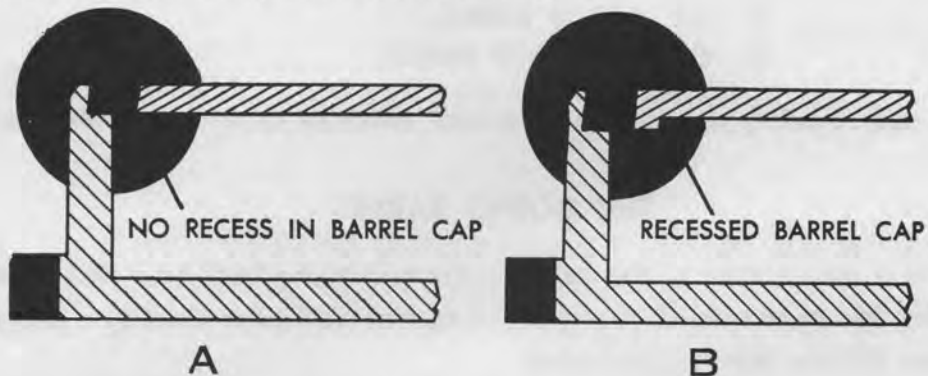


Fig. 2

Many barrel covers such as B in Fig. 2 are also recessed to accommodate part of the mainspring's width. Care must therefore be exercised to prevent the barrel cover from being bent or distorted in any way which might interfere with its remaining closed or with the free movement of the mainspring coils within the barrel.

Located at the holes of the barrel and barrel cover are the shoulders which serve as bushings for the arbor and also control the end and sideshake of the arbor in the barrel. See Fig. 3.

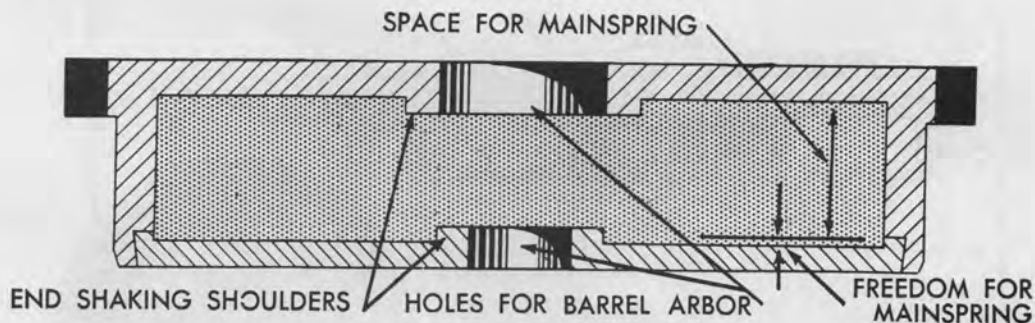


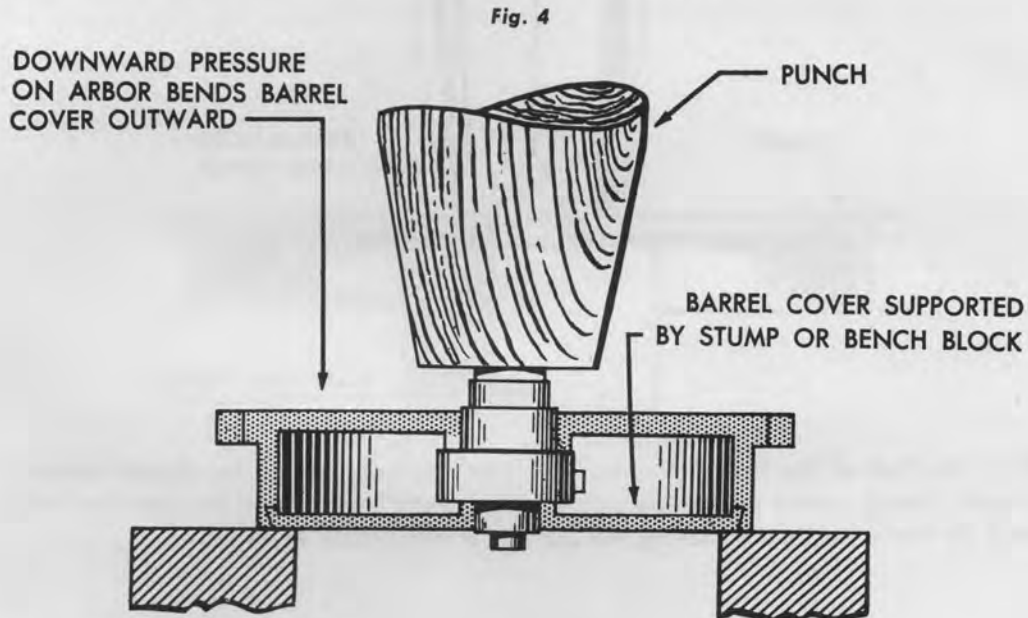
Fig. 3

Since the barrel must be free to revolve about its arbor, the clearance between these two parts must be checked before the mainspring can be inserted. The perpendicular clearance of the arbor between the cover and the bottom of the barrel is known as endshake and should be between .015 and .02 m.m. Sideshake, which is the difference between the diameters of the arbor and barrel hole, should be about .015 m.m.

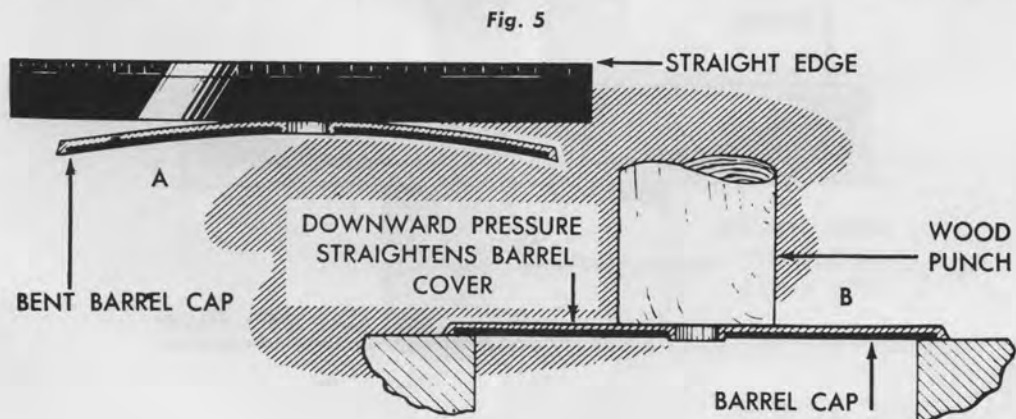


## HOW TO ADJUST ENDSHAKE AND SIDESHAKES OF BARREL ARBOR IN A GOING BARREL

1. To increase the endshake, place barrel on a bench block over a hole smaller in diameter than that of the barrel but considerably larger than the diameter of the arbor. Place a punch on arbor and tap lightly to bend the barrel cover slightly outward, thereby increasing the endshake. See Fig. 4.

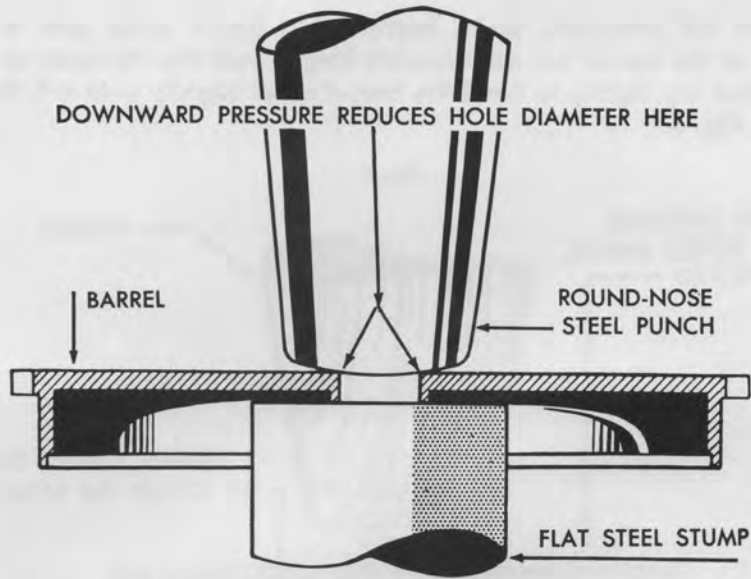


2. To decrease the endshake, determine first whether the cap or the barrel is bent too much by testing each with a straight edge (Fig. 5A). Remove outward bend by tapping a rounded piece of wood against the bent metal as in Fig. 5 (B). This will decrease the endshake.

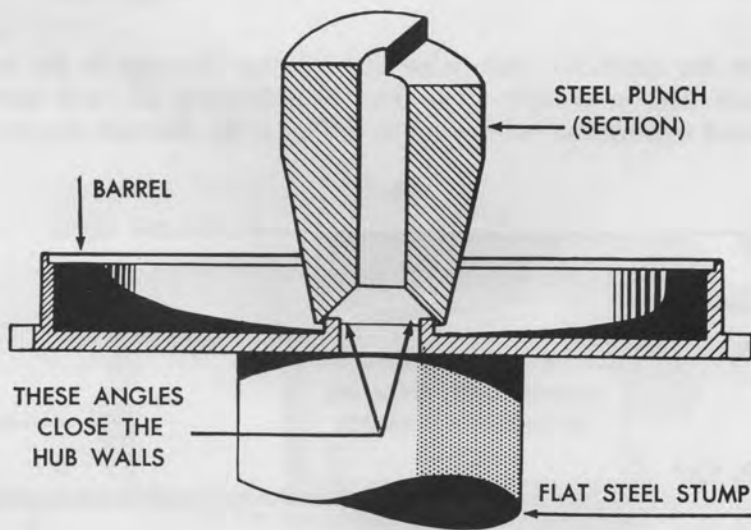


*Training Unit Number 9a*

3. A. To eliminate excessive sideshake, the hole may be slightly closed by using a rounded punch against the barrel hub which has been placed bottom up on the staking stump. See Fig. 6.



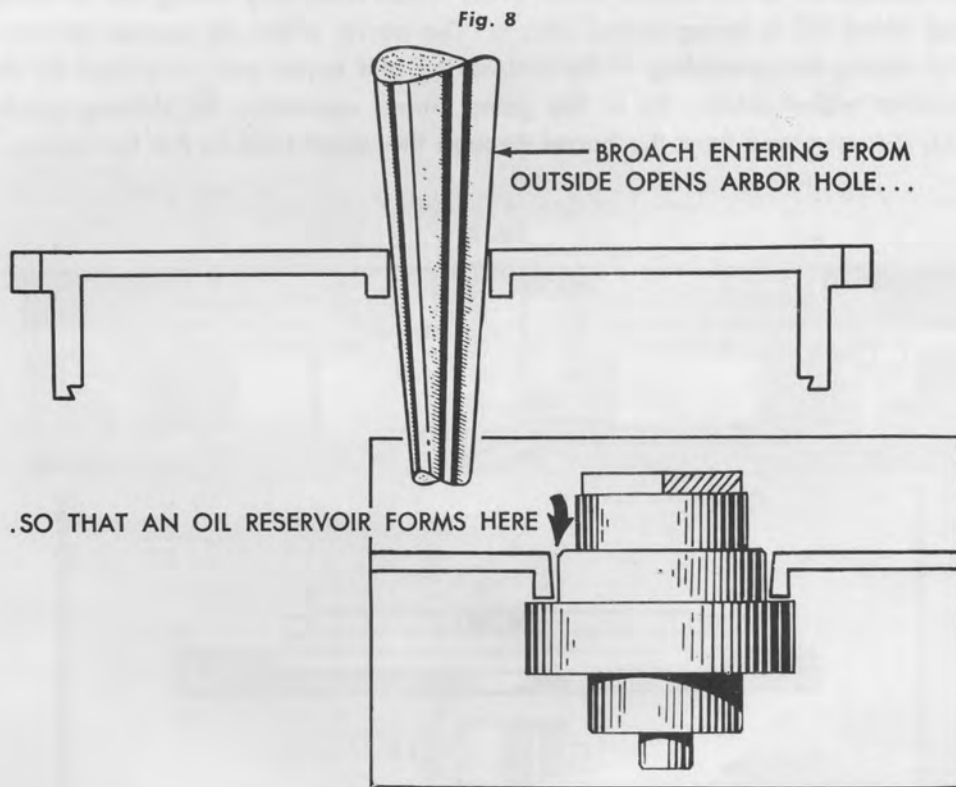
3. B. If the hub of the barrel is unusually high, the hole should be closed somewhat with a taper mouth closing punch on staking stump. The punch should tend to close the walls of the hub toward its center without touching the bottom of the barrel as in Fig. 7.





## Training Unit Number 9a

4 If the sideshake is insufficient, the hole may be slightly enlarged by using a reamer as in Fig. 8. The barrel should be reamed from the outside to keep the thrust at proper point on the pivot and to form a reservoir for the oil (insert).



In addition to establishing correct shakes, these following points must also be checked before inserting the mainspring in the barrel:

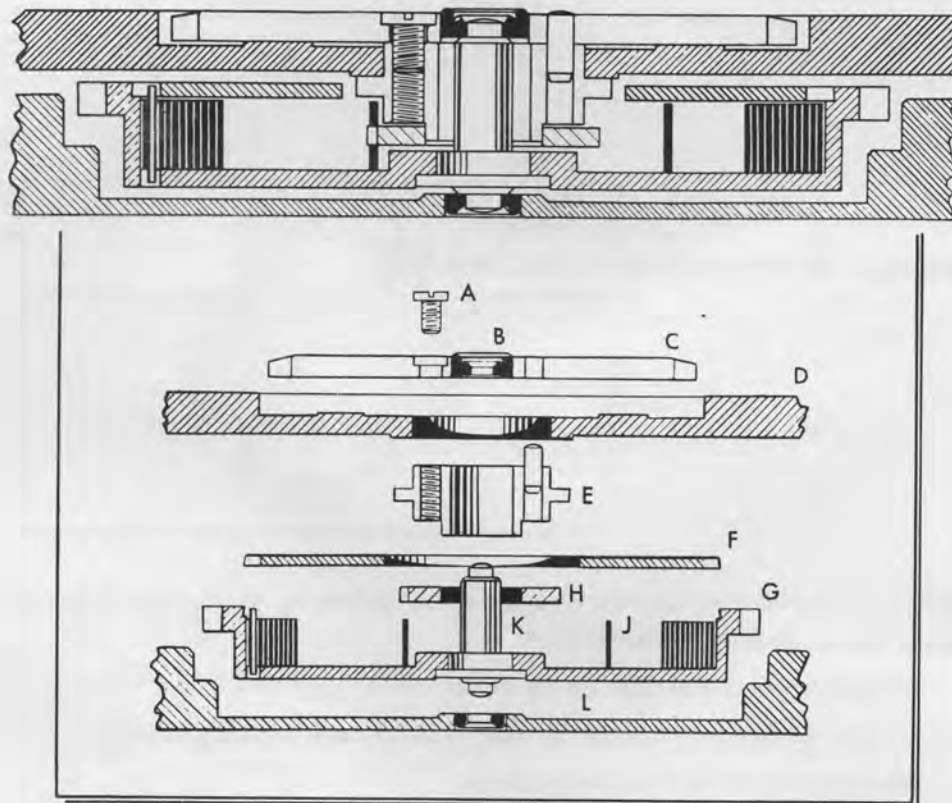
1. The barrel must run true on its arbor.
2. The barrel and cover must be flat. (Check with a straight edge.)
3. The barrel must be absolutely clean.



### MOTOR BARRELS

In the Hamilton type of motor barrel assembly shown below, there are really two arbors: the barrel arbor (Fig. 9, K) which is permanently staked to the barrel (G) and the ratchet wheel arbor (E) which fits freely over the barrel arbor. The inner terminal of the mainspring is hooked on to the ratchet wheel arbor which turns only during the winding process as the ratchet wheel (C) is being turned with it. The barrel arbor, of course, rotates with the geared barrel during the unwinding of the mainspring and serves only as a shaft for the barrel within the ratchet wheel arbor. As in the going barrel assembly, the driving power of the mainspring (J) is transmitted from the barrel through the wheel train to run the watch.

Fig. 9



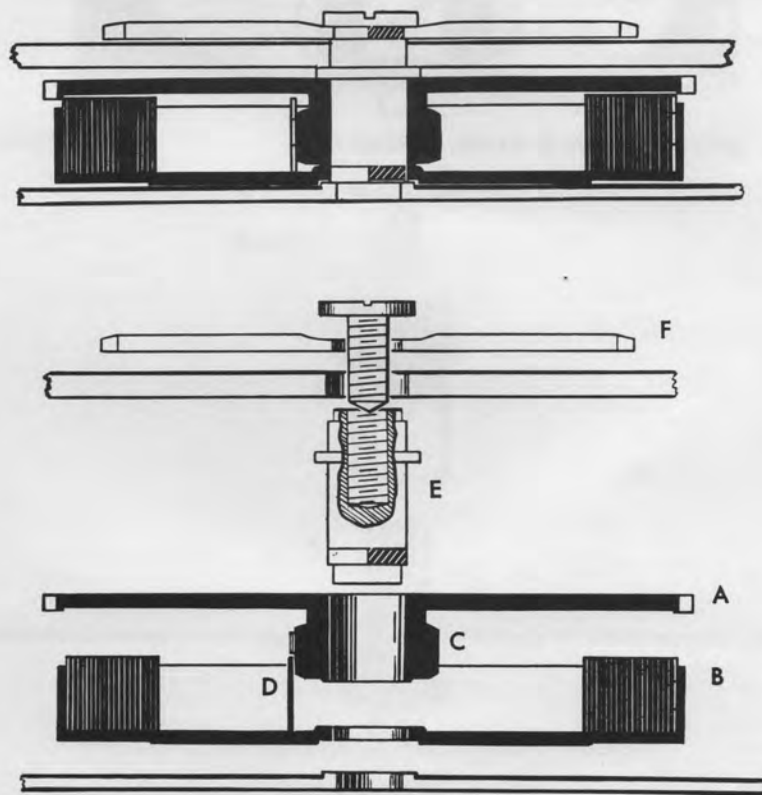
- |                                     |                   |
|-------------------------------------|-------------------|
| A—Ratchet Wheel Screw               | F—Barrel Cap      |
| B—Barrel Upper Jewel<br>and Setting | G—Barrel          |
| C—Ratchet Wheel                     | H—Mainspring Hook |
| D—Barrel Bridge                     | J—Mainspring      |
| E—Ratchet Wheel Arbor               | K—Barrel Arbor    |
|                                     | L—Pillar Plate    |



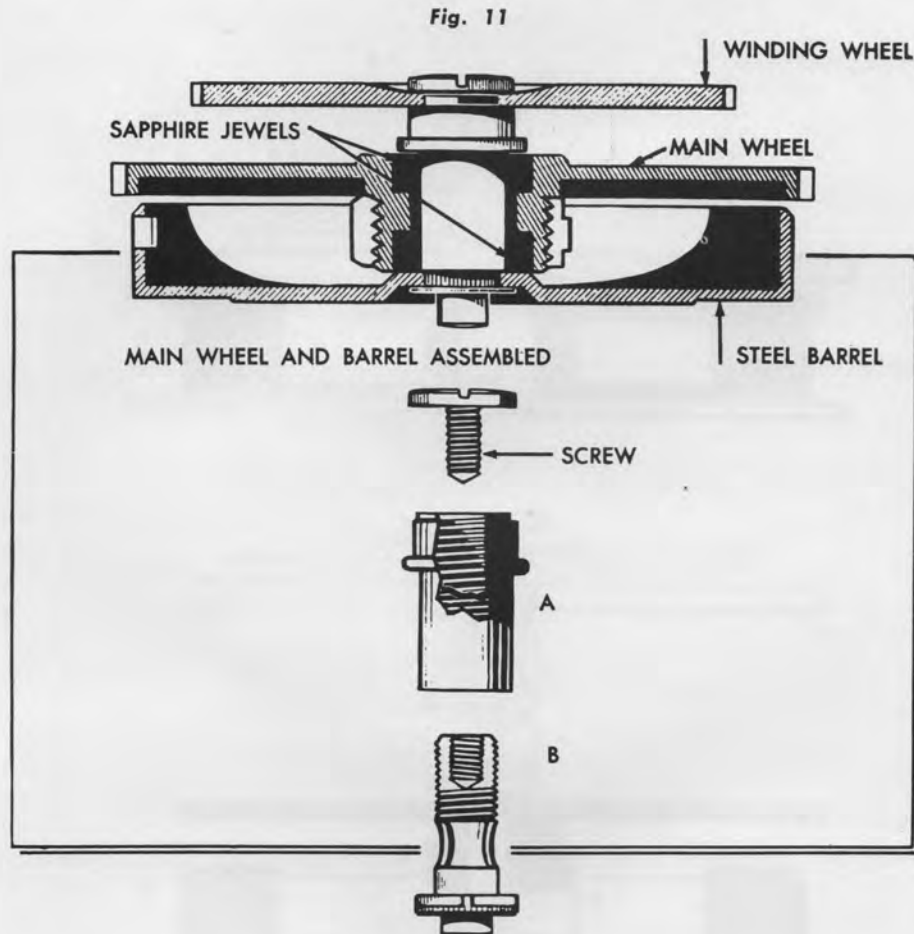
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2. In the Waltham non-jeweled type of motor barrel (Fig. 10), the geared section of the barrel known as the main wheel (A) is separated from the lower portion or shell (B). The main wheel is staked to the arbor hook (C) which fastens to the inner terminal of the mainspring (D). The arbor (E) is squared on top and bottom so as to remain fixed to the ratchet wheel and shell. When the mainspring is wound, the ratchet wheel (F) turns the arbor and shell. However, as the mainspring energy is released, these parts now remain stationary, but the main wheel, which is geared to the wheel train, delivers the driving power for the watch mechanism.

Fig. 10



3. In the Waltham jeweled motor barrel (Fig. 11), the main wheel which turns on the barrel arbor and drives the wheel train is fitted with jewels. The arbor consists of two parts, an outside member (A) and an inside member (B) which when screwed together keep the steel barrel fixed to the arbor. As in the non-jeweled Waltham motor barrel assembly, the ratchet wheel which is mounted on the top square of the arbor turns the arbor when the mainspring is wound.



When disassembling, the barrel assembly is reached by removing the ratchet wheel screw, ratchet wheel and barrel bridge. To disassemble the barrel, place the assembly in the left hand, and using the ratchet wheel as a key on the square of the arbor, turn backwards until the parts separate.

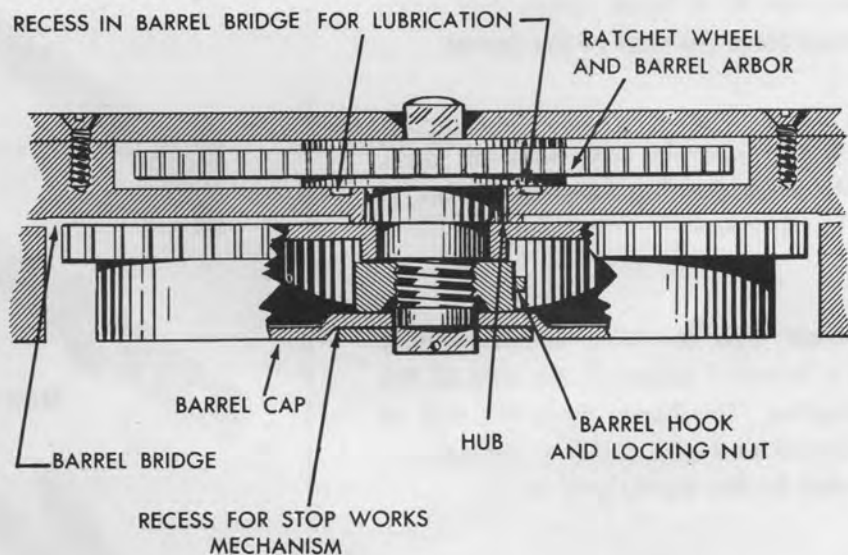


## SUSPENDED BARREL

The suspended or hanging barrel although more popular in many of the older watch models is still being utilized today in very thin Swiss watches. As illustrated in Fig. 12, the assembly of barrel, arbor, and mainspring of a suspended barrel is similar in construction to that of the much used going barrel. However, in the suspended barrel assembly, the arbor is suspended from the barrel bridge without any support at the lower end of the arbor. A solid ratchet wheel held firmly between plates on the barrel bridge keeps the suspended barrel arbor in a true upright position.

The stored up energy in the wound mainspring is delivered to the wheel train by means of the barrel rotating about its arbor, exactly as in the going barrel arrangement.

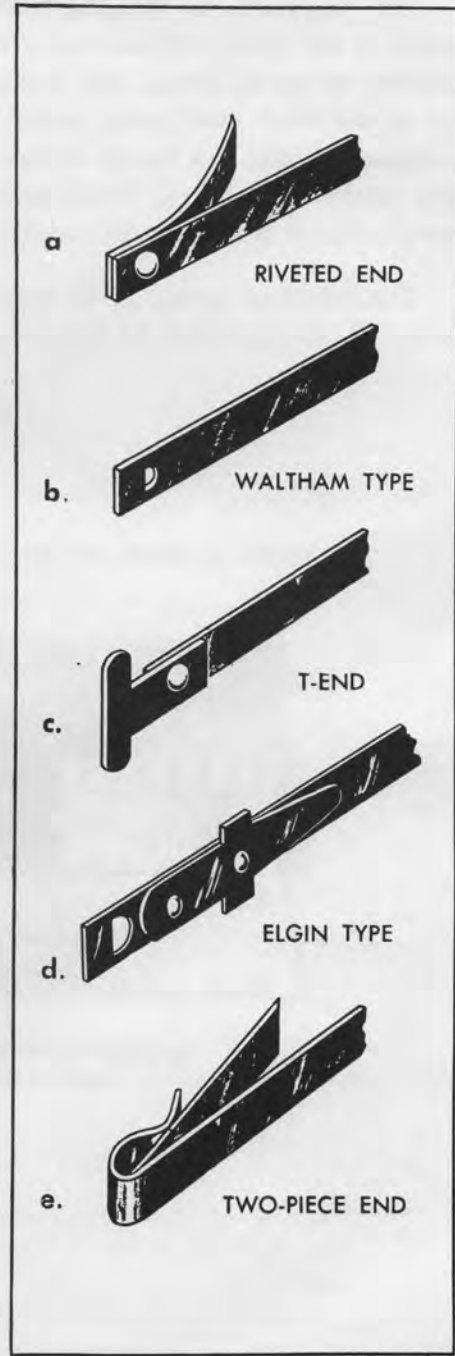
Fig. 12



### INSERTING THE MAINSPRING

When it is certain that the barrel and arbor fit together properly, the necessary size and type of mainspring must be selected for insertion into the barrel. Listed below are five of the most common types of mainspring ends for hooking on to the barrel:

- a. The turned up tongue which is a piece of spring riveted to the end of the mainspring. This sharpened tongue is arrested by a recess in the wall of the barrel.
- b. The Waltham type of mainspring wherein a small opening in the end of the spring fastens on to a hook which has been punched from the wall of the barrel.
- c. The T end wherein both ends of the T fit into corresponding holes in the barrel and barrel cover.
- d. The Elgin type consisting of an opening and a broad T brace at the end of the mainspring. This hooks on to the wall of the barrel and also fits into corresponding slots in the barrel and cover.
- e. The mainspring with an extra piece of spring inserted under its turned over end. It is this extra tongue which hooks on to the wall of the barrel.



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The thickness and width of mainsprings are measured in millimeters with a small micrometer. See Figs. 18 and 19.

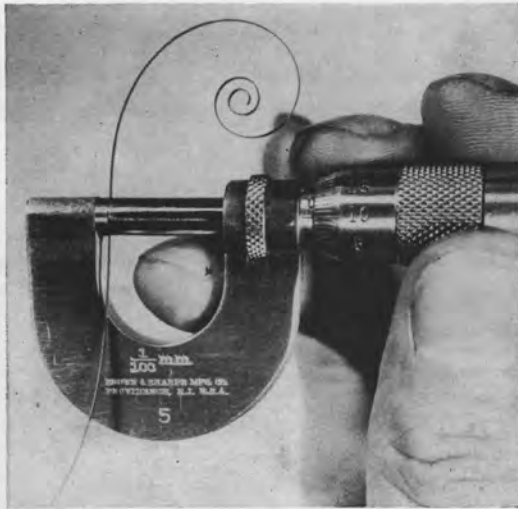


Fig. 18

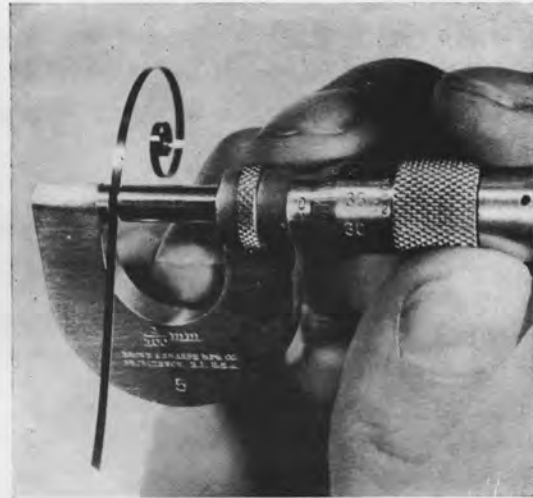
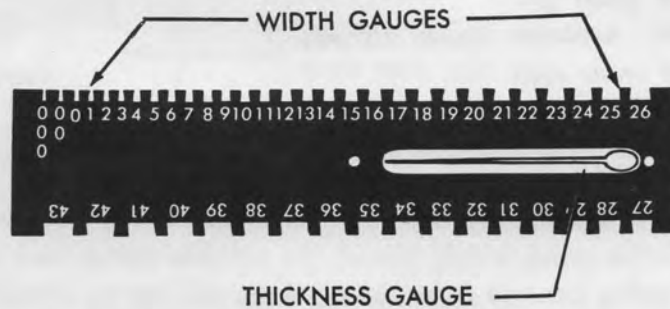


Fig. 19

If a micrometer is not available, a Dennison mainspring gauge (Fig. 20) may be used. This tool measures the width and thickness of the mainspring in terms of a numbering system which corresponds to that used on packaged mainspring replacements. For true accuracy, this method cannot compare to a micrometer measurement.

Fig. 20



When the watch is a standard make, the most dependable method is to use a genuine factory-made spring as specified by the manufacturer for the specific model. However, there will be many situations where the maker will be unknown, and a reliable method to ascertain the proper thickness and length of the mainspring for the barrel and watch must be understood.



## Training Unit Number 9a

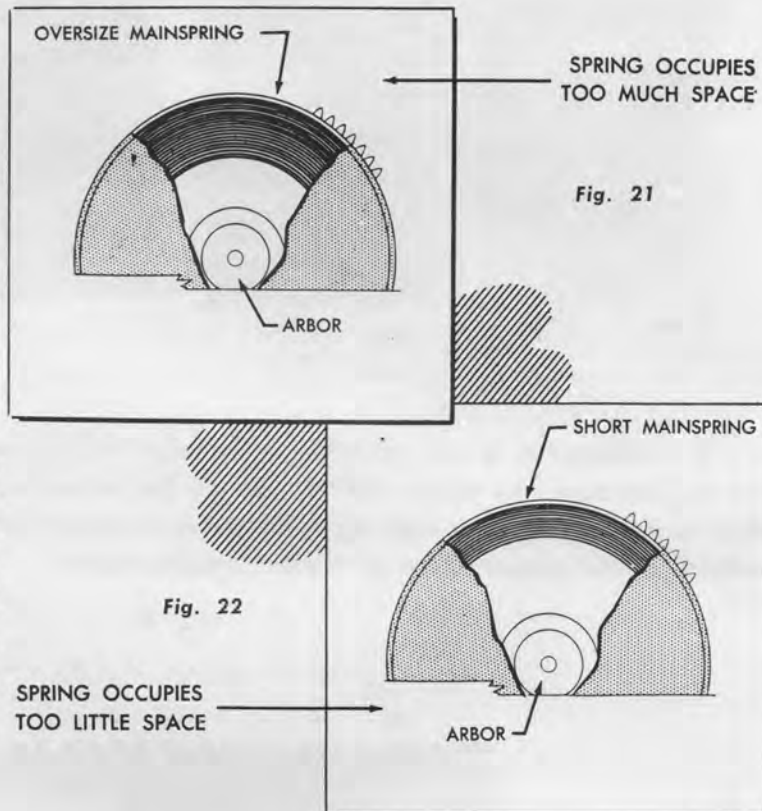
Before computing the size of mainspring, the effects of a spring too long or too short and too strong or too weak should be explained.

1. A spring that is too long will not have enough space in the barrel in which to unwind with the result that the watch will not run its maximum number of hours. In Fig. 21 is shown a barrel with a spring that is too long. Compare this with a proper sized spring as depicted in Fig. 1.

2. A spring that is too short will have insufficient coils to unwind, with the result that it will be released too quickly, and again this watch will not run its maximum number of hours. If Fig. 22 will be compared with Fig. 1, this condition will be readily apparent.

3. A spring that is too thick and therefore too strong (since the thickness of the spring determines its strength) will cause the motion of the watch to increase beyond safe limits, resulting in the banking of the jewel pin against the pallet fork. Accurate regulation of a watch under such conditions is impossible.

4. If the spring is too thin and therefore too weak, it will not have sufficient power to run the watch. When the spring is fully wound, the balance motion may at first be satisfactory, but after the weak spring has run a few hours, there will not be enough tension to maintain a good running motion of the balance wheel.





## Training Unit Number 9a

After determining the mainspring thickness, the correct length of spring to give the maximum number of barrel turns can be quickly calculated by W. Dodgion's equation as follows:

$$\frac{(B + A) \times (B - A)}{64.6 \times T} = \text{Length of mainspring in inches}$$

$$64.6 \times T$$

wherein A — arbor diameter in millimeters

B — inside diameter of barrel in millimeters

T — thickness of mainspring in millimeters

For example:

Barrel diameter = 16.8 m.m.

Arbor diameter = 5 m.m.

Spring thickness = .18 m.m.

$$\frac{(16.8 + 5) \times (16.8 - 5)}{64.6 \times .18} = \frac{(21.8) \times (11.8)}{64.6 \times .18} = 22.1 \text{ inches}$$

### HOW TO CHECK WITH "UP AND DOWN CIRCLE"

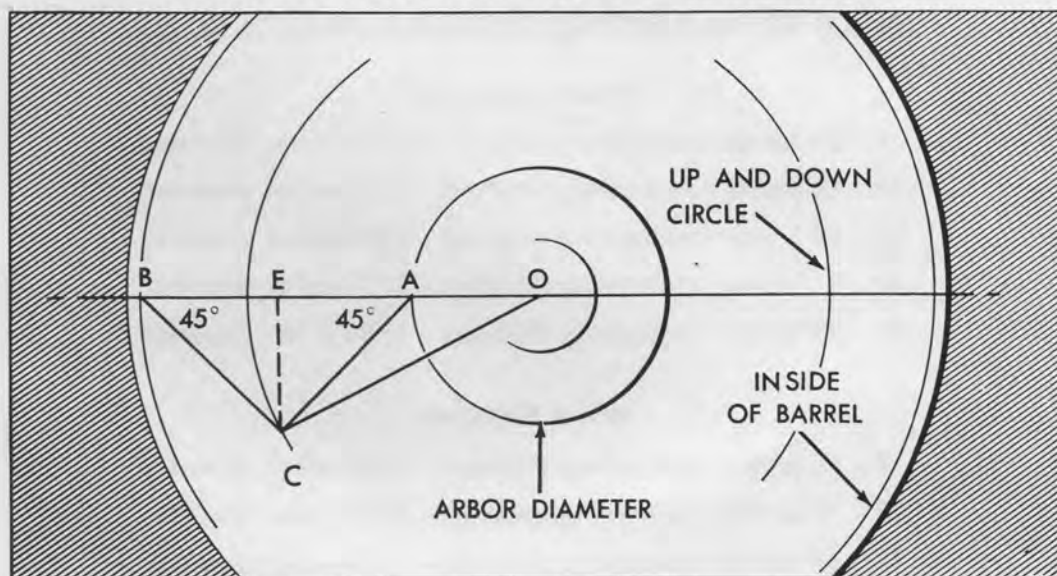


Fig. 23

1. Draw barrel and arbor diameters 10 times full size.
2. Draw horizontal diameter through point O.
3. From point A lay out AC with 45 degree triangle.
4. From point B lay out BC with 45 degree triangle.
5. Lines AC and BC will meet at point C.
6. Point C gives position of "up and down circle."
7. Draw line CO from point C to center point O.
8. Measure CO and divide by 10.
9. Set depthing tool to this size and scribe "up and down circle" in barrel.
10. Wind spring in barrel.
11. Last coil should just meet "up and down circle."



## Training Unit Number 9a

In determining the proper thickness of the mainspring for a given barrel, the following rules should apply:

1. With a given arbor diameter, the inside barrel diameter should be approximately three times as great. One half the net difference in area between the barrel and the arbor should be the area covered by the spring.
2. The number of barrel revolutions possible with a given spring is equal to the difference in the number of coils between the wound up and the run down positions of the spring.
3. For a barrel arbor of a given size, the mainspring thickness should vary from  $1/26$  to  $1/34$  of the arbor diameter, depending upon the quality of the movement. In the table that follows it can readily be seen that the better watch movement requires the weaker spring.

### GUIDE TO MAINSPRING THICKNESS PROPORTIONS

#### Pocket Watches

- 7 - 15 Jewels - mainspring thickness -  $1/26$  arbor diameter
- 15 - 17 jewels - mainspring thickness -  $1/28$  arbor diameter
- 17 - 19 jewels - mainspring thickness -  $1/30$  arbor diameter
- 19 - 21 jewels - mainspring thickness -  $1/32$  arbor diameter
- 21 - 23 jewels - mainspring thickness -  $1/34$  arbor diameter

#### Wrist Watches

- 7 - 15 jewels - mainspring thickness -  $1/28$  arbor diameter
- 15 - 17 jewels - mainspring thickness -  $1/30$  arbor diameter
- 17 - 19 jewels - mainspring thickness -  $1/34$  arbor diameter

These figures can in no way be considered as binding but will serve as a guide where data from the manufacturer may not be available. Of course, any irregularity in the depthing, poor pivots, incorrect banking, etc., will void all the proportions.

4. With a spring which occupies one-half the net difference in area between the barrel and arbor, the last coil when wound up and the first coil when down will both lie on a common circle called the "up and down circle."

5. The diameter of the "up and down circle" is approximately equal to  $3/4$  of the inside barrel diameter if, and only if, the barrel is three times the arbor diameter.



## *Training Unit Number 9a*

3. Check direction to wind the spring. (Note position of hook on arbor.) For insertion, the mainspring must be wound in a reverse direction to its position in the barrel.
4. Attach inner coil of spring to arbor of winder.
5. Wind up spring within barrel of winder.
6. Place winder over barrel so that end of spring is at hooking end of barrel. (If it is the tongue type, the tongue must be bent away from spring.)
7. Insert mainspring into barrel.
8. Lubricate mainspring and arbor with heavy oil. (A light oil would be forced from the spring by the pressure between the coils of a fully wound spring. This would cause a binding which would result in uneven power and inaccurate regulation.)
9. Snap on barrel cover with fingers after carefully lining up cover with scratch mark on side of the barrel. Note the tissue protecting the barrel from finger prints. See Fig. 26.
10. If the cover fits rather tightly, use a brush handle to apply sufficient force to snap cover into place. See Fig. 26.

Fig. 26



11. Check barrel carefully to remove dirt and fingerprints.



## Training Unit Number 9a

### INSERTING THE MAINSPRING IN ITS BARREL

With the proper thickness and length of mainspring selected and the fitting of the arbor in its barrel already checked, the mainspring is now ready for insertion into the barrel. For this operation it is necessary to use a mainspring winder. Any attempt to feed the spring into the barrel with the fingers will deform or distort the spring, rendering it unfit for reliable service.

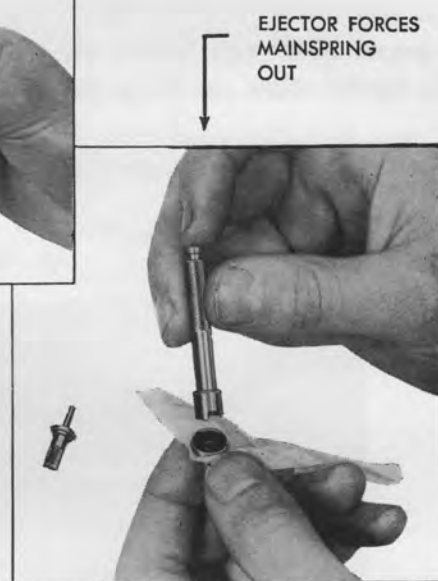
The winders are made in a range of sizes to accommodate the various sizes of mainspring barrels. Extra flexibility is provided by the movable jaws on the winder which increase or decrease the diameter of the winder's barrel to conform to the barrel of the watch.

Fig. 24



WINDING MAINSPRING  
IN MAINSPRING WINDER

Fig. 25

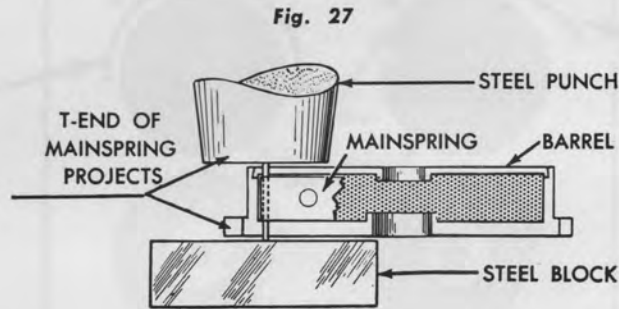


TRANSFERRING  
MAINSPRING  
TO BARREL

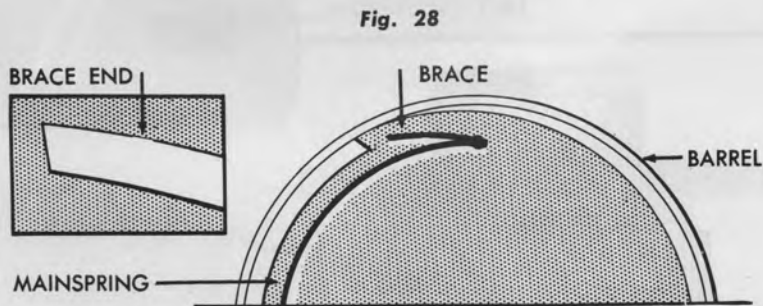
1. Select proper size mainspring winder.
2. Adjust movable jaws of the winder to the size of the barrel.



When a T brace is inserted and the ends extend out of the barrel and cover, the projections should be made flush with the barrel and head by the tapping method shown in Fig. 27 instead of by filing. As the flat punch is tapped against the projection brace, supported by a steel block, both projections will be flattened down even with the barrel and cover.

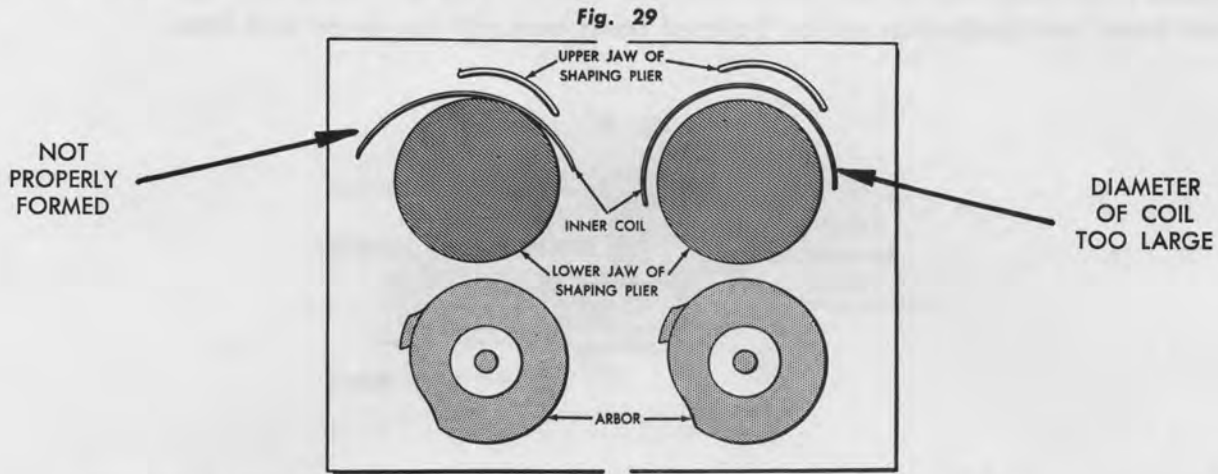


When the spring slips off the hook or slot in the barrel, it may be necessary to file the hook or brace so that the resulting angle will pull the spring tight to the barrel wall. See Fig. 28.

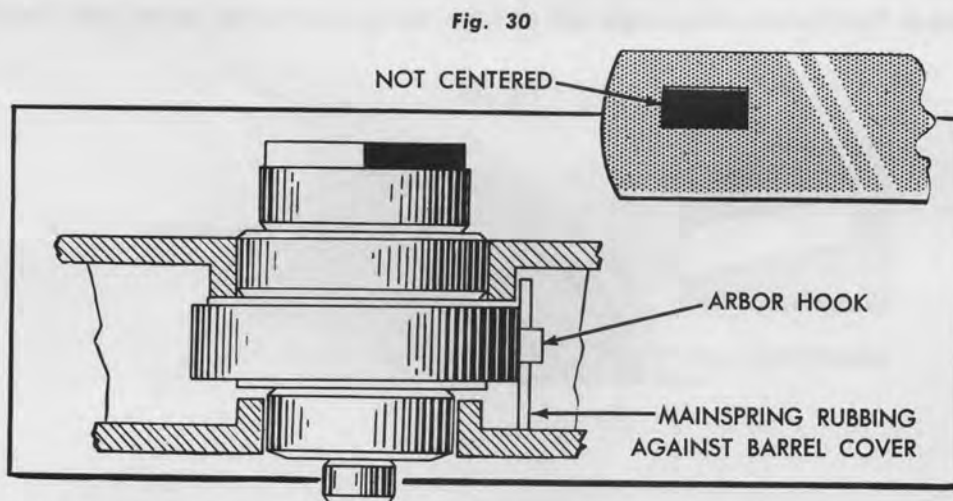


## Training Unit Number 9a

If the mainspring unhooks at the arbor, the inner coil may be improperly formed or too wide. A special shaping plier shown in Fig. 29 is helpful in bending the inner coil so that it will be circular and slightly smaller in diameter than the arbor. This will cause the spring to maintain a constant pressure on the arbor.



Sometimes, a poorly finished end of the mainspring may rub against the barrel or cover, causing poor balance motion and erratic rate. A similar condition may result if the hole in the inside end of the mainspring is not in the center of the spring. When the hole is placed over the hook on the barrel arbor, the end of the spring may rub against the barrel or cover. (Fig. 30.)



The hole in mainspring end should be in the center and slightly larger than the hook on the arbor.



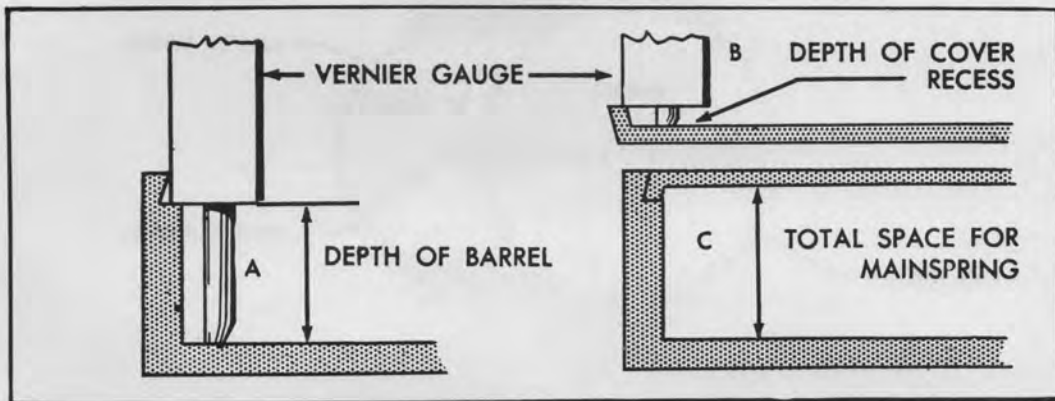
## Training Unit Number 9a

If it becomes necessary to check the depth of the barrel for proper clearance of the mainspring, this may be accomplished with the sliding Vernier gauge or ordinary micrometer.

In the Vernier method (Fig. 31), the tongue of the gauge is used in getting the depth of the barrel (A) and the depth of the cover recess (B). The two measurements, (A) and (B), are added to determine the total space for the mainspring (C). The mainspring selected should be .1 m.m. less than the mainspring space (C).

If the barrel cover is not recessed for the mainspring, then the barrel and cover depth (A) only, is gauged.

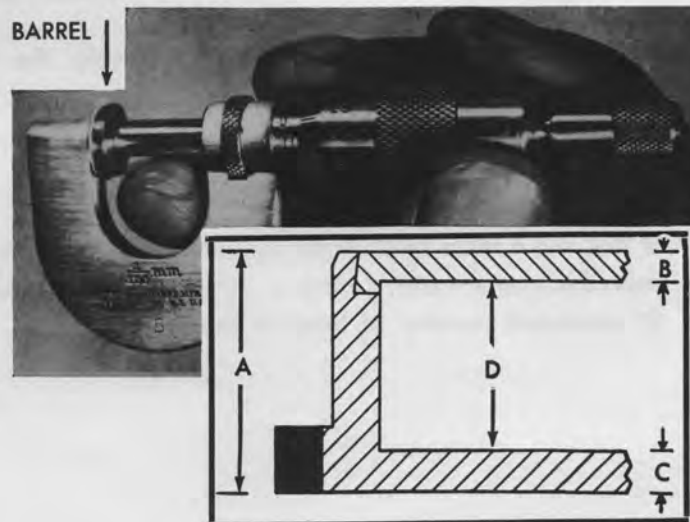
Fig. 31



In the micrometer method (Fig. 32), the thickness of the capped barrel (A) is first gauged, and from this is deducted the thickness of the barrel (C) and cover (B). The net difference less at least .1 m.m. for clearance should be the proper width of the mainspring inserted in barrel (D).

Fig. 32

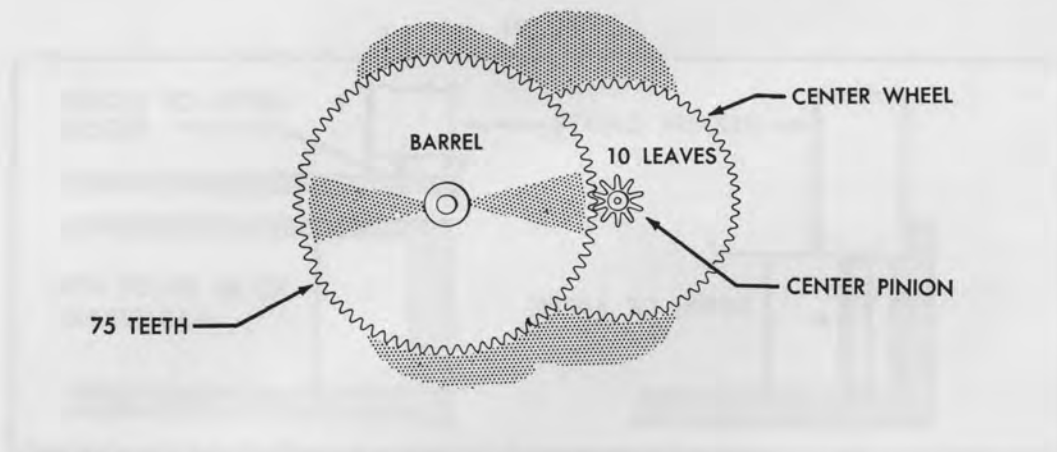
$A - (B + C) = D$   
 in which  
 A — total thickness of barrel  
 B — thickness of barrel cover  
 C — thickness of barrel bottom  
 D — space allowance for mainspring and .1 m.m. clearance



## Training Unit Number 9a

The number of revolutions of the barrel is important in so far as it becomes necessary to store sufficient energy in a spring to keep the train and balance wheel in motion for a 24 hour period and a sufficient excess to take care of irregular winding. 36 to 40 hours is the average running time of most wrist watches.

Fig. 33



In Fig. 33 it can be seen that there are 75 teeth in the barrel and 10 in the center wheel pinion, or a gear ratio of  $7\frac{1}{2}$  to 1 between barrel and center wheel. Since the center wheel which supports the minute hand rotates 24 times in a 24 hour period, the mainspring barrel will move  $10/75$  as much or 3.2 times in a full day. This would mean that a 10 AK Bulova model barrel would make about 6.4 turns for a 48 hour run.

As an over-all check on the mainspring assembly, the following simple procedure should be followed:

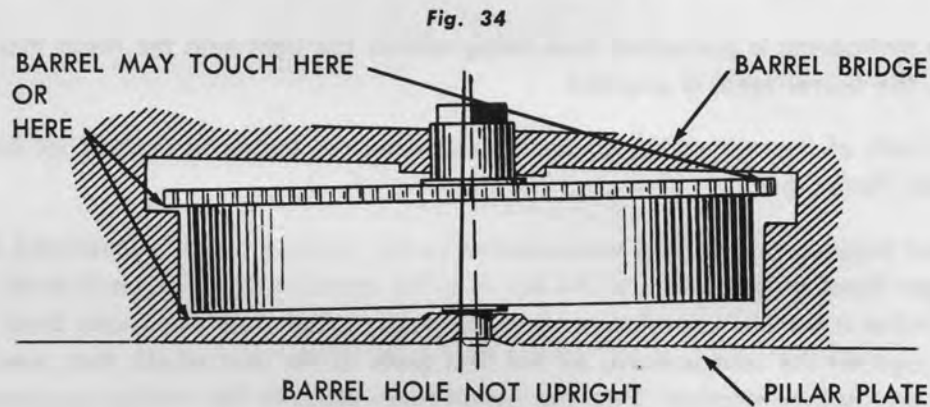
1. Tighten a pin vise to the arbor of the assembled barrel, mainspring and arbor.
2. Count the turns that the spring allows the arbor to make within the barrel.
3. If this is 6.4 turns in a 10 AK Bulova model, or at the very least, 4 turns for any other manufacturer's watch (using a different gear ratio), the spring is certain to develop its maximum number of turns in the barrel.



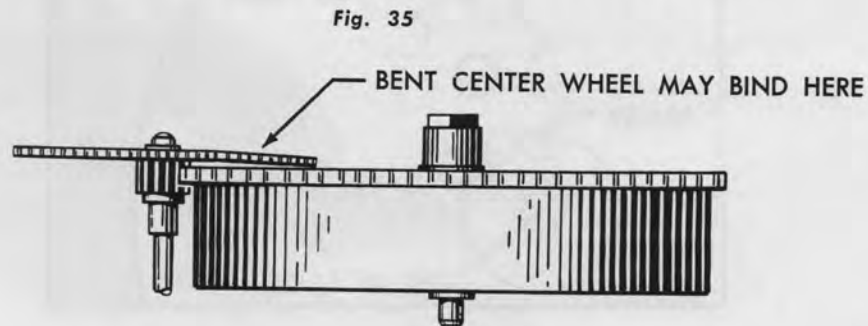


### ASSEMBLY OF BARREL BETWEEN PLATES

The mainspring assembly is now ready for mounting between the pillar plate and barrel bridge. The clearance of the arbor between the plates should be limited to an endshake of .015 m.m. and a sideshake of .015 m.m. The holes in the plates must be perfectly aligned so that the barrel will revolve in a plane parallel with the pillar plate and bridge. If the barrel is not true on the arbor, it will wobble or rise and fall. If the arbor is out of upright in the plates, the barrel won't wobble but will turn in a plane which is not parallel to the plates. Either condition may result in a binding of the barrel against the bridge or plate as illustrated in Fig. 34.



Before putting mainspring bridge into position, it will be necessary at this point to insert the setting lever screw into its proper position. The adjoining parts such as center, 3rd and 4th wheels must be carefully checked to insure that they do not rub against the barrel. A bent wheel could easily interfere with an even flow of power as shown in Fig. 35.



## STOP WORKS

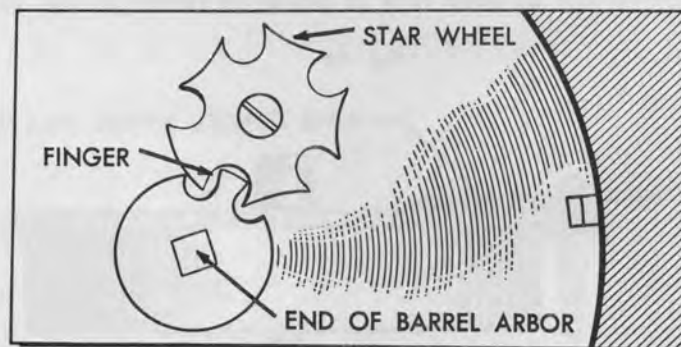
Occasionally, the watch repairman will encounter a barrel equipped with a stop works mechanism. For this reason, the subject will be briefly discussed to complete the full story on mainspring assembly.

Stop works which have been used on the going barrels of better grade Swiss watches for many years have three definite advantages:

1. Utilize the most uniform part of the mainspring by eliminating excess power of mainspring when almost fully wound up and the weakness of the spring when almost run down.
2. The mainspring is prevented from being wound too tight with the result that increased pressure on the barrel teeth is avoided.
3. The coils of the mainspring cannot be squeezed too tightly so that the oil between the coils could be forced out.

The most popular type of stop works known as the Maltese Cross is illustrated in Fig. 36. Here, a finger fitted on the square of the barrel arbor moves a star wheel one notch each time the barrel makes a complete revolution about its arbor. When four turns have been made, the finger jams against the convex curve on the fifth tooth of the star wheel, thus preventing the barrel from any further rotation. This stop action takes place in the winding up process immediately after the arbor has made four turns in the barrel, and again when the power is being released on completion of four revolutions of the barrel. In this way, the most constant power of the mainspring is utilized.

Fig. 36



### HOW TO SET STOP WORKS

1. Determine how many turns the arbor will make in the barrel by winding with a pin vise.
2. If the star wheel has five teeth (usual construction), subtract four from the number of windings.
3. Divide the surplus by three. One-third of the surplus is let down from the fully wound mainspring in the barrel, and the remaining two-thirds will be subtracted from the run down winding of the spring. For example, if the barrel has  $5\frac{1}{2}$  turns, the power would be released  $\frac{1}{2}$  turn before setting stop works. The last weak full turn will then be eliminated.
4. With the spring fully wound up in the pin vise, release  $\frac{1}{3}$  of the surplus and set finger against the stop of the maltese cross.

