TRAINING UNIT
NUMBER 6

★

HAIRSPRING TRUING

BULOVA SCHOOL of WATCHMAKING

THE ART *of* HAIRSPRING TRUING

Hairspring technique is most important in the study of horology. The high degree of manipulative skill it requires commands the respect and admiration of all experienced horologists.

The general subject of hairsprings is many-sided. Besides attracting the talents of the mathematician, the physicist, and the metallurgist, it affords an exacting field for those who would develop their manual dexterity. The repairman who has knowledge of the physical characteristics of hairsprings and the skill to put such knowledge to work possesses an advantage over a less equipped fellow-worker; his important knowledge and skill wins the appreciation of the customer who observes him make a deft touch on a hairspring that brings his watch back into serviceability.

The tools used are simple ones. The work of manipulating the watch hairsprings is primarily a matter of obtaining an appreciation of the delicacy of the spring, together with a knowledge of the various bending and breaking techniques and how the spring reacts to them. Some hand and finger movements are possessed in part by the learner; the others, acquired by instruction and practice. Mistakes made may be used as stepping stones to success during the learning process. Eventually the spring begins to obey. Error-making gradually is eliminated and correct obedience of the hands to the mind show a progressive change toward success each time the proper manipulative movements are repeated. Finally, after diligent application of correct movements of the hands and fingers, these movements become organized into a pattern, a chain of movements that fit together without delays or confusion and with meaningful relationships to one another and to the job at hand. In short, a skill is born.

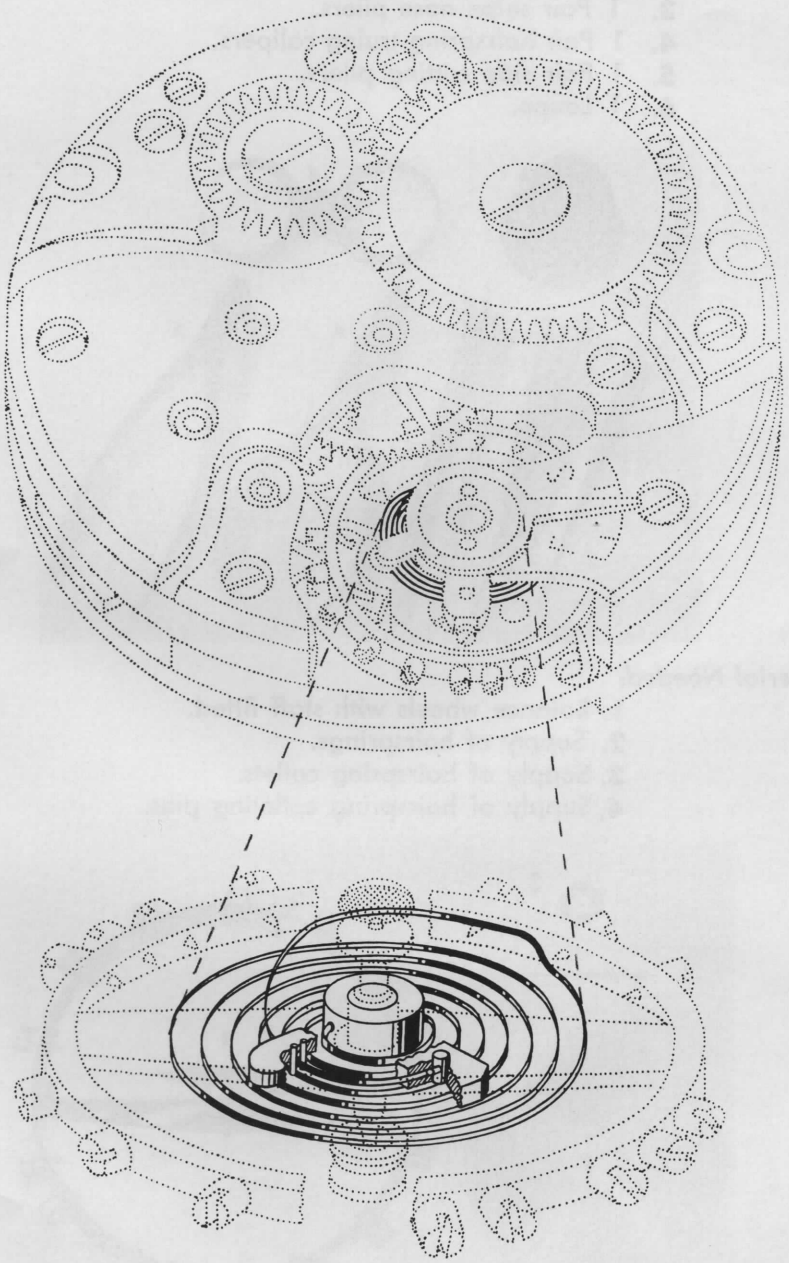
This particular unit is set up to serve as a guide and to lay a broad foundation of the proper manipulative operations required to become proficient in the art of hairspring truing. It can be used to great advantage by the watchmaker who wishes to advance himself, as well as the student who requires a well organized schedule of operations.

In action, the hairspring reveals grace and beauty. It appears to have life. Its expansion and contraction give the semblance of breathing. Its dynamic relationship to the balance wheel, to which it is attached, is so established that it causes the balance to oscillate with a definite period. The spring is like a brain. Through its elastic properties it is the controlling factor in the time keeping function of the watch, being the governor or regulator, over the movement of the balance wheel.

The hairspring of a watch takes the form of a spiral and is rectangular in cross section. It is generally made of steel, but in recent times metallurgical research has brought forth a spring that is practically insensitive to temperature and magnetic changes.

Hairsprings are made by inserting several lengths of ribbon-like wire metal into a hollow, steel, barrel-like forming device. This tool is designed so that several pieces of wire are wound each on top of the other, each taking a flat spiral form. When a sufficient number of turns or coils are wound in a tool, the coils are subjected to a heat treating process which establishes the required degree of elasticity, thus preparing them for the watchmaker whose work begins at this point.

THE HAIRSPRING



BULOVA SCHOOL *of* WATCHMAKING

TRAINING UNIT No. 6

Subject:

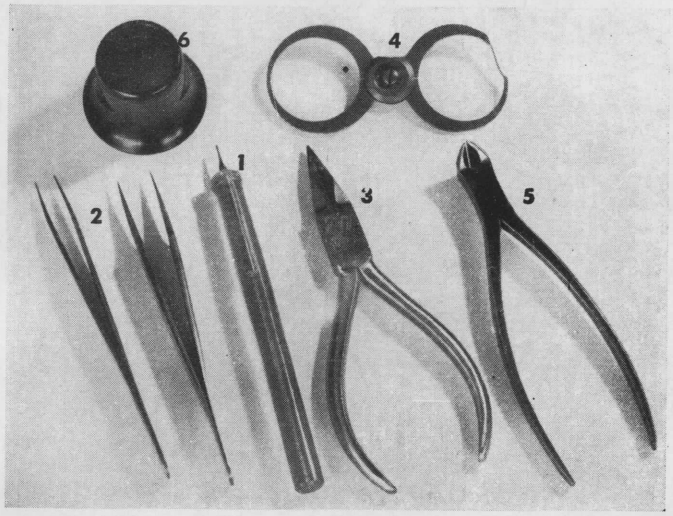
Practical Manipulation of Watch Hairspring.

Objective:

To develop skill in hairspring work.
Practical work 100 hours.
Related theory 20 hours

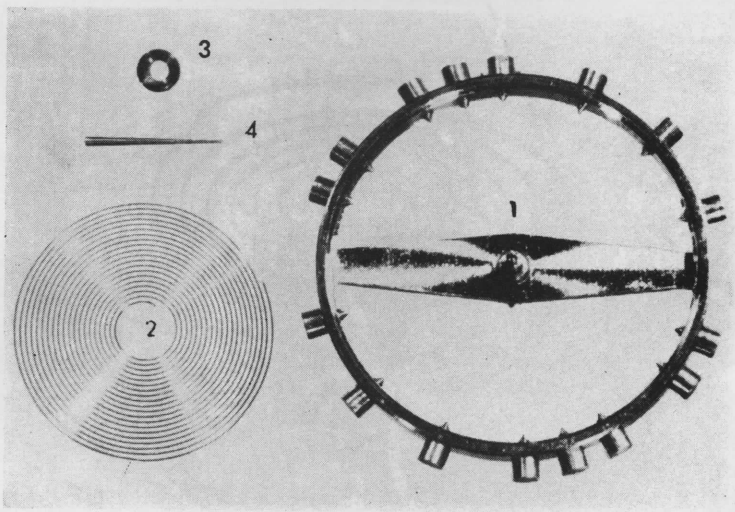
Tools Needed:

1. 1 Colleting arbor.
2. 2 Pair tweezers.
3. 1 Pair snipe nose pliers.
4. 1 Pair hairspring truing calipers.
5. 1 Pair side cutting pliers.
6. 1 Loupe.



Material Needed:

1. Balance wheels with staff fitted.
2. Supply of hairsprings.
3. Supply of hairspring collets.
4. Supply of hairspring colleting pins.



HAIRSPRING TRUING

Practical Manipulation of Watch Hairsprings will be presented in five main sub divisions:

I. Special hand manipulative operations on hairsprings.

II. Colleting.

III. Staking the hairspring and collet to the balance staff.

IV. Truing in the round and flat.

1. SPECIAL HAND MANIPULATIVE OPERATION ON HAIRSPRING

Manipulative Breaking Exercises

Method No. 1, Fig. 2

To break off outer coil, grasp it with a tweezer at the desired point of break. (See point A.) Grasp the coil at point B with another tweezer and bend the coil outward and away from the center of the spring and back again to the original position. Repeat this bending procedure until the break occurs.

Break off one piece from the outer coil of ten hairsprings, each piece to be ten millimeters long.

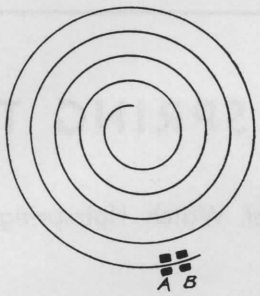


FIG. 2

Method No. 2, Fig. 3

Grasp the coil at the desired point of break. (See point A.) Use another tweezer, placed at B, next to A on the inside of outer coil, break coil away by pulling end with tweezer B as far as necessary for break to occur.

Break off one piece from the outer coil of ten hairsprings, each piece to be ten millimeters long.

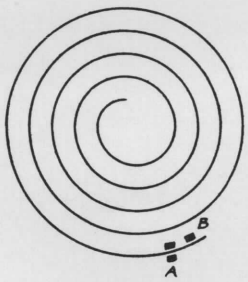


FIG. 3

Manipulative Bending Exercises

Method 1, Fig. 4

First, grasp the outside coil of the spring with a pair of tweezers at point A, 90 degrees from the end. Second, grasp the outside coil at point B with another tweezer and bend the coil inward until it just touches the adjacent coil.

Note: By reversing the direction of the bend, the end of the coil may be bent outward.

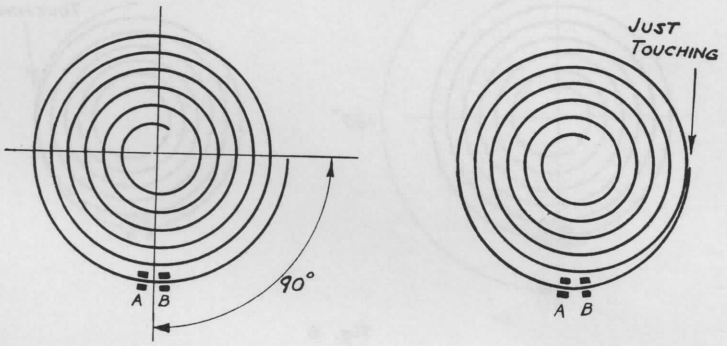


Fig. 4

Method 2, Fig. 5

Grasp the outside coil of the spring with a tweezer at point A, 90 degrees away from the end. Place another tweezer at point B and push an outer coil until it just touches the adjacent coil.

Note: To reverse the direction of the bend, place tweezer at point C, and pull coil outward.

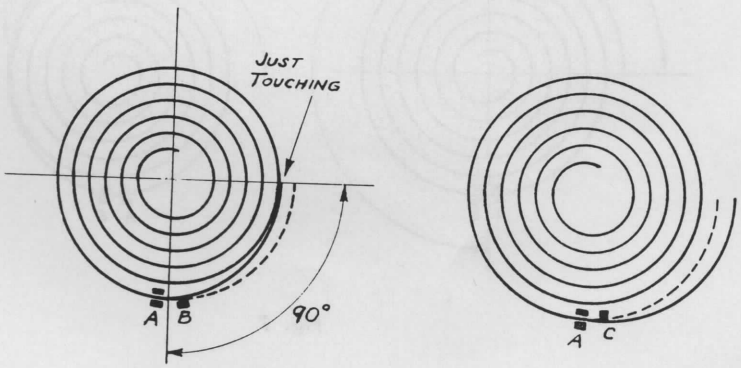


Fig. 5

Fig. 6

In this exercise, follow bending Method 1 with the exception that in this instance the bend is to be made 180 degrees from the outside end of the spring.

Note: Bending method 2 can also be used to accomplish the same result in this and the following exercises.

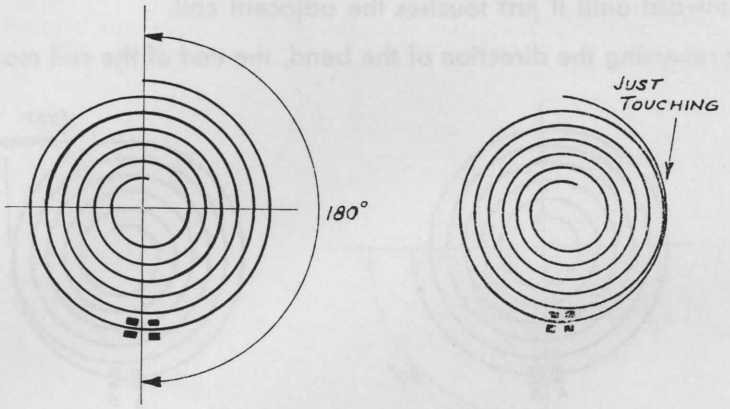


Fig. 6

Fig. 7

Again, this exercise is a duplication of the preceding one with the exception that the bend is made 270 degrees from the outside end of the spring.

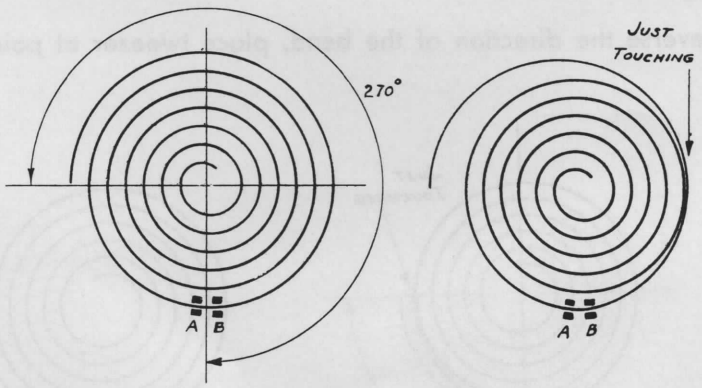


Fig. 7

Fig. 8

Duplicate the procedure already established, but this time the bend is to be made 360 degrees from the outside end of the spring.

After completing the above exercises, bend each coil, regardless of its place of bend, back to its original position.

Having performed this operation, break off the outer coil of each hairspring at the point where the bend was made. Use Method 2 under manipulative breaking exercises.

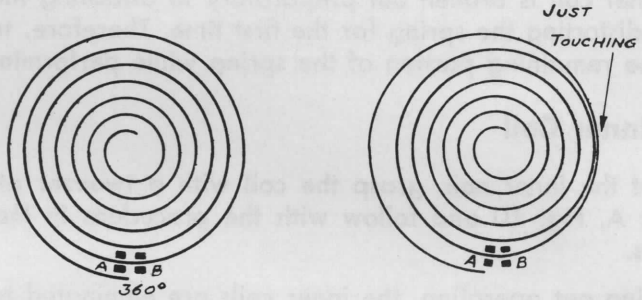


Fig. 8

Fig. 9

To straighten a coil, grasp the coil with a tweezer at desired point (See point A). Use flat pointed tweezer starting close to A and while maintaining gentle pressure between the flat points, pull and pinch coil straight outward toward the end.

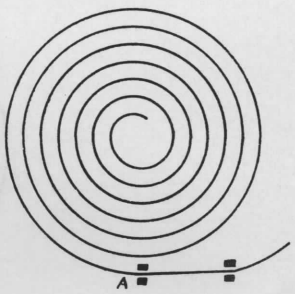


Fig. 9

2. COLLETING

Attaching Hairspring to Collet

Colleting is the procedure of attaching the inside coil of the hairspring to the collet by means of performing the following operations in the order listed:

Breaking out inner coil.
Forming the tongue.
Pinning-in.

When the inner coil is broken out preparatory to attaching the spring to the collet, it will amount to distorting the spring for the first time. Therefore, take utmost care so as not to damage the remaining portion of the spring while performing this operation.

Breaking Out Inner Coil

To break out the inner coil, grasp the coil with a tweezer at the desired point of break. See point A, Fig. 10 and follow with the procedure in Method 2, Fig. 3 in the breaking exercises.

In the breaking out operation, the inner coils are eliminated to an extent necessary to leave room for the collet. There should be enough broken out so that when the collet is placed in the center of the spring the space from the edge of the collet to the first inner coil should be one and one half times as large as the space between any two coils of the spring, Fig. 11.

Due to the fact that these tiny dimensions cannot be measured, the exact space between the edge of the collet and the first coil may be a little more or less than this stated amount.

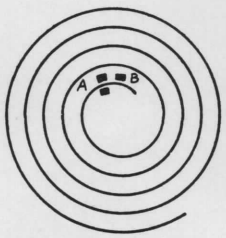


Fig. 10

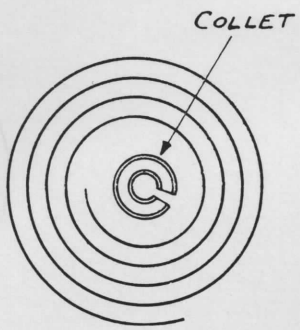


Fig. 11

Forming the Tongue

The tongue consists of a straight portion and an elbow which joins it with the first inner coil. The length of the tongue from point B to point A, part of which is fastened to the collet, should be as long as the collet pin hole plus the distance from the pin hole to the first coil. See Fig. 12.

To accomplish this operation, lay the hairspring flat on the bench. Grasp the inner coil at point A, Fig. 13, with a tweezer. This point will be about 90 degrees away from the inner end of the coil.

Use another pair of tweezers at B, Fig. 14, and bend the coil in the direction of the arrow. The amount of bend can be determined only through experience. Avoid a *sharp* bend at this point.

The curved tongue thus formed must now be straightened. See Fig. 15. The procedure for straightening the coil is shown in Fig. 9.

After completing that operation, the spring is ready to be pinned to the collet. This operation is called "Pinning-in".

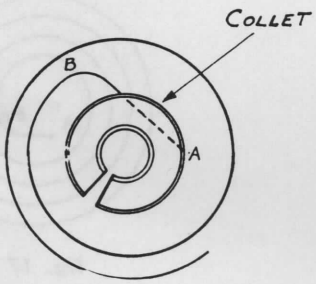


Fig. 12

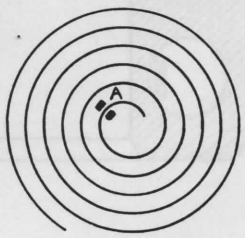


Fig. 13

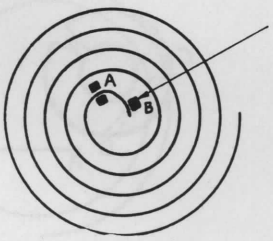


Fig. 14

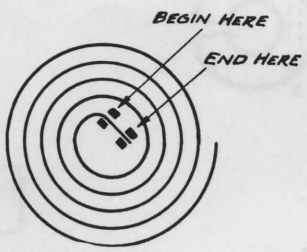


Fig. 15

PINNING-IN

The mechanics of actually pinning-in the spring to the collet will be explained and shown first, followed with a study of the usual errors that are the results of colleting. This is an operation that requires great care and skill. Take extreme precaution not to bend or distort any inside coils.

To Start the Actual Pinning-in Operation

Place the collet on a colleting arbor with top of collet upward and point D, Fig. 16 of pinhole toward you. Hold arbor in left hand.

To insert tongue in collet hole, grasp coil with tweezers at point B, Fig. 17. Bring spring over and down colleting arbor with end of tongue A, Fig. 17 in direct line with point D, Fig. 16 of the pinhole in collet.

While holding tongue A in proper position, turn colleting arbor in a counter-clockwise direction gently enough to bring tongue into pin hole D of collet. Fig. 18. After placing tongue in pin hole, use thumb and first finger to support the spring and prevent it from tipping.

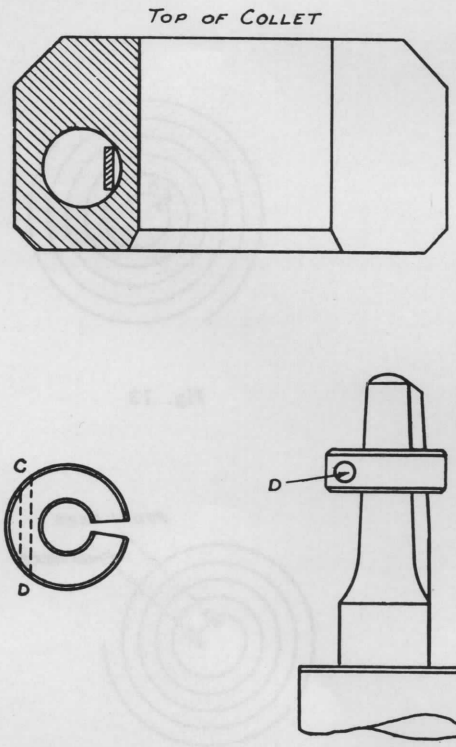


Fig. 16

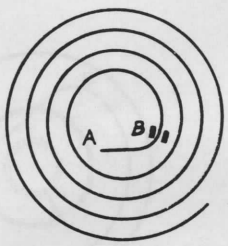


Fig. 17

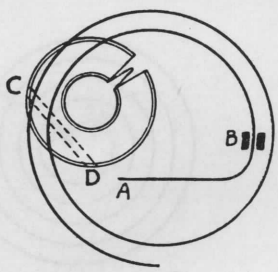


Fig. 18

From the same end D of the pin hole that the tongue entered, insert a tapered brass pin against the side of the tongue by grasping the pin at the thickest part with a tweezer. The pin must extend beyond the collet pin hole above the main body of the spring as shown at E, Fig. 19.

Push the pin just tight enough to hold the spring in place. It will now be necessary to make a preliminary inspection of the spring to determine the position of the inside coil in relation to the collet. Listed below are two of the outstanding errors that may have been established in the pinning in process. Eliminate these errors now, to avoid corrective manipulations in the future.

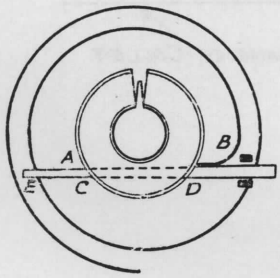


Fig. 19

Preliminary Pinning-in Errors

Fig. 20 shows tongue pinned too far in pin hole.

Fig. 21 shows tongue pinned too far out of pin hole.

If one of the two errors shown above is present, loosen the tapered pin sufficiently so that point B can be pulled or pushed until it is the proper distance from the collet. Inspect position of tongue again. Repeat this procedure until the tongue is pinned-in similar to Fig. 22 which shows tongue pinned in correctly.

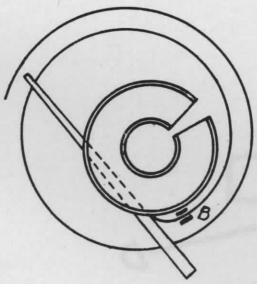


Fig. 20

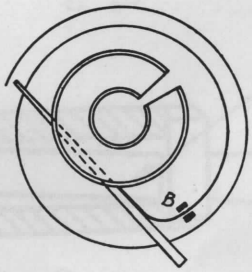


Fig. 21

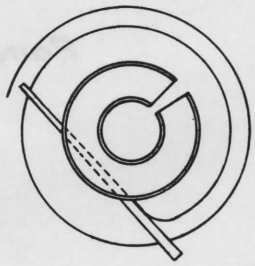


Fig. 22

After this has been accomplished, inspect for errors in the flat. To do this, hold the colleting arbor at such an angle, convenient to the observer, that the plane of the spring is on the line of sight. Use a loupe and observe whether or not the plane of the hairspring is parallel with the plane of the collet as shown in Fig. 23. If the two planes are not parallel, point A of the tongue, Fig. 24 was fixed too low or too high in the collet hole and must be corrected.

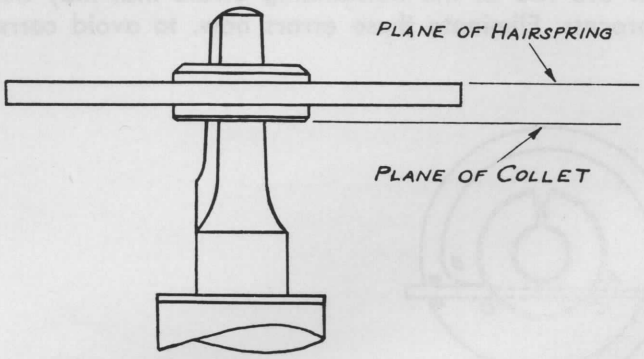


Fig. 23

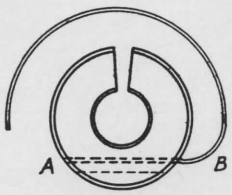


Fig. 24

Preliminary Errors in the Flat

When point A of the tongue becomes fixed too high in collet hole, it will cause all of the coils to be high opposite the pinning point D. See Fig. 25.

When point A of the tongue becomes fixed too low in collet hole, it will cause all of the coils to be low opposite the pinning point D. See Fig. 26.

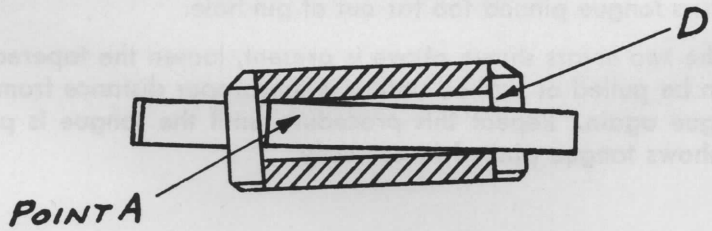


Fig. 25

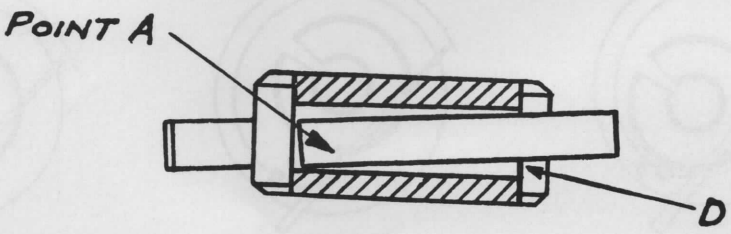


Fig. 26

Correct errors in the flat by holding the arbor in a vertical position and gently raise or lower the inner coil with a tweezer until the spring is reasonably parallel with the collet and perpendicular to the axis of the arbor.

TIGHTENING THE PIN IN THE COLLET

Method No. 1

Grasp the small end of the tapered pin with a pair of snipe nose pliers, and with a pulling and twisting motion, pull the pin tight. See Fig. 27.

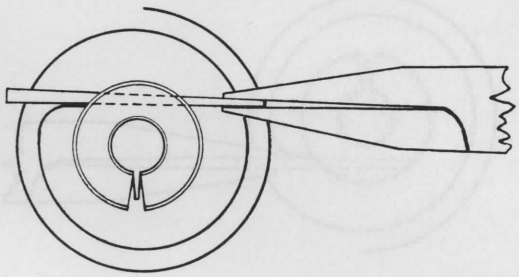


Fig. 27

Break off small end of the brass pin projecting from the hole. To accomplish this, grasp the small end of the pin with the pliers, and maintain a firm pull on the pin. Turn the arbor in a clockwise direction, thereby bending the pin at a sharp 90 degree angle close to the collet. Fig. 28.

Now turn the arbor in the opposite direction and the pin will break off clean. Fig. 29.

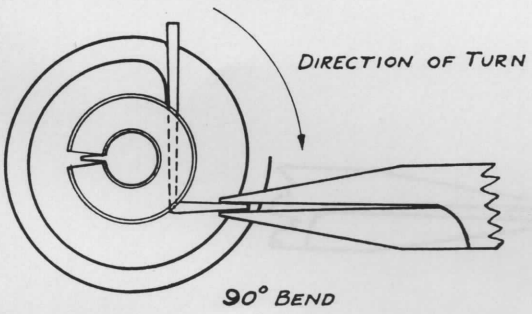


Fig. 28

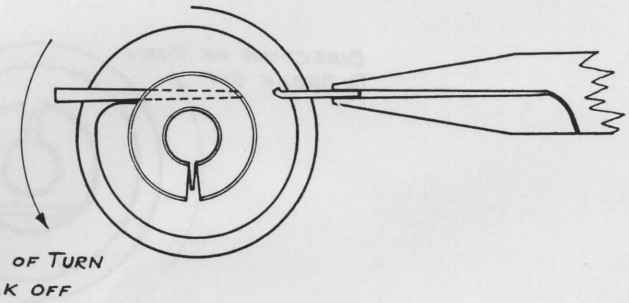


Fig. 29

The large end of the taper pin is broken off in much the same way. Grasp the pin with the snipe nose pliers and push on it while turning the arbor in counter-clockwise direction, thereby putting a sharp 90 degree bend in the pin close to the collet. Be careful while turning the arbor not to loosen the taper pin. See Fig. 30. By turning the arbor in a clock-wise direction the pin will break off close to the collet. Fig. 31.

After pinning-in, examine the position of the collet in relation to the first inner coil. The spring should not touch any part of the collet except at the pinning point.

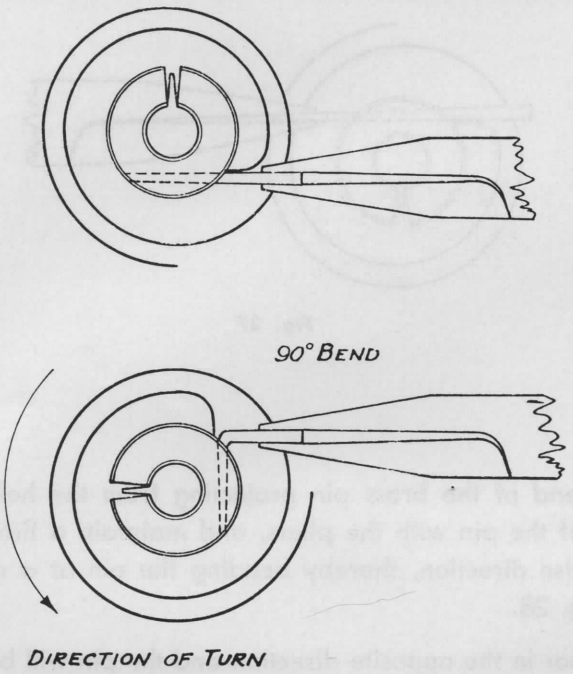


Fig. 30

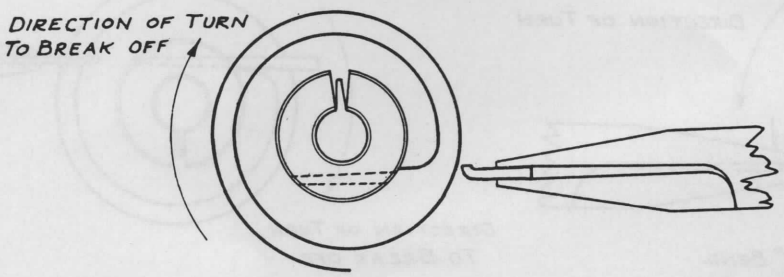


Fig. 31

TIGHTENING THE PIN IN THE COLLET

Method No. 2

Secure the taper pin firmly in place and remove the projecting ends by the following method. By use of the side cutting pliers cut off the large end of the taper pin at a distance from the collet equal to two to two and one half times the diameter of the large end of the pin. Fig. 27A.

Then use the snipe nose pliers to push the taper pin tightly in place by straddling the collet as shown in Fig. 27B. Place one leg of the pliers at A and the other on the large end of the pin at B. When it is pushed in tight, the large end of the taper pin should be flush with the collet.

To remove the small end of the taper pin, use the end cutting pliers. Hold the cutting edges of the pliers close up against the collet and snip the pin off. Fig. 27C.

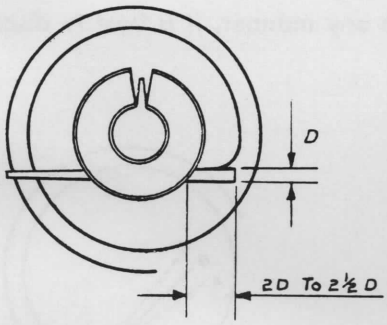


Fig. 27A

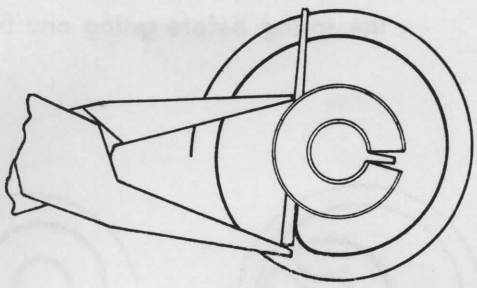


Fig. 27B

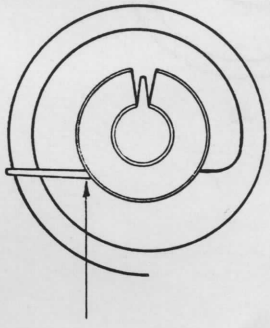


Fig. 27C

Preliminary Errors in the Round

Fig. 32 and Fig. 33 show two basic errors in the round that may have been made by improper forming of the tongue. Because of this, the collet is off center relative to the spring. Fig. 32 shows the result of bending the tongue too much at its elbow. Fig. 33 indicates the case wherein the tongue is not bent enough at the elbow. Fig. 34 shows how these errors compare with each other and with a tongue that is properly formed.

Try to bring the center of the spring to the center of the collet, as closely as possible. The bending is performed on the first one-eighth of the inside coil with a tweezer. Concentrate on centering only.

When preliminary errors in the flat and the round have been corrected, check the collet and spring for the following possible faults before removing from the arbor.

1. Both ends of the pin should be broken off clean at the collet.
2. Taper pin should be tight in collet hole.
3. If any of the inside coils are bent or distorted in any manner, it is best to discard the spring before going any further.

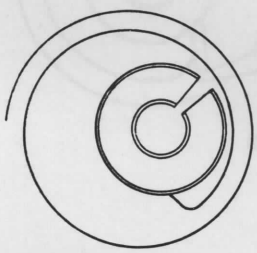
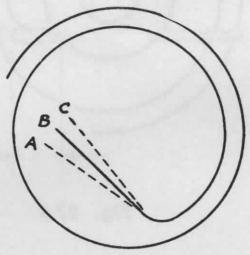


Fig. 32

Fig. 33



A Tongue Not Bent Enough
B Tongue Bent Right
C Tongue Bent Too Much

Fig. 34

III. Staking Hairspring and Collet on the Balance Staff

The hairspring and collet are now ready to be fastened to the balance staff. A staking stand is used to facilitate the operation.

Select a stump with a hole slightly larger than the roller shoulder of the staff, but smaller than the roller table seat. Fig. 35. Place the selected stump in the staking table and insert the balance staff into the stump as shown in Fig. 36.

Now, select a staking punch having a hole slightly larger than the collet shoulder of the balance staff, but smaller than the outside diameter of the collet. Fig. 36.

Lay the hairspring and collet on balance staff with top side of collet upward. Position spiral of spring in a counter-clockwise direction from pinning point. Bring the staking punch down on the collet and gently force the collet onto the collet shoulder until it is firmly seated on the collet seat. Fig. 36. The friction between a properly fitted collet and its collet shoulder is sufficient to hold the spring in place under all conditions.

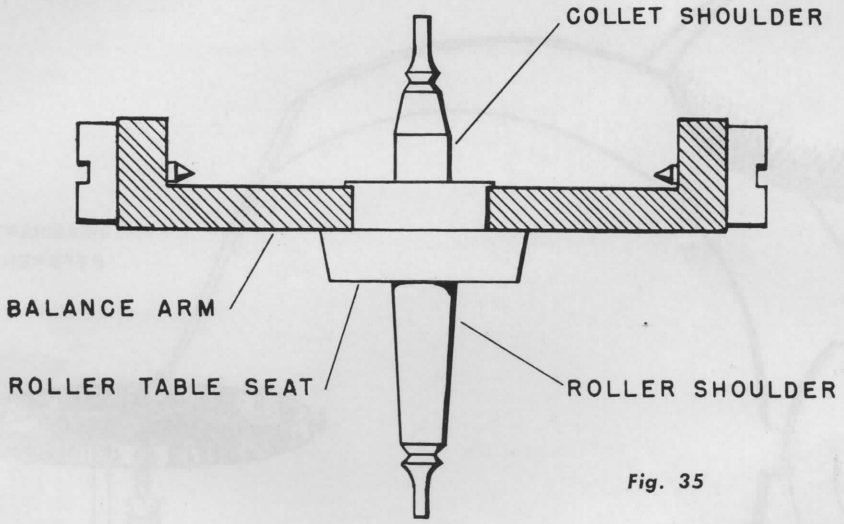


Fig. 35

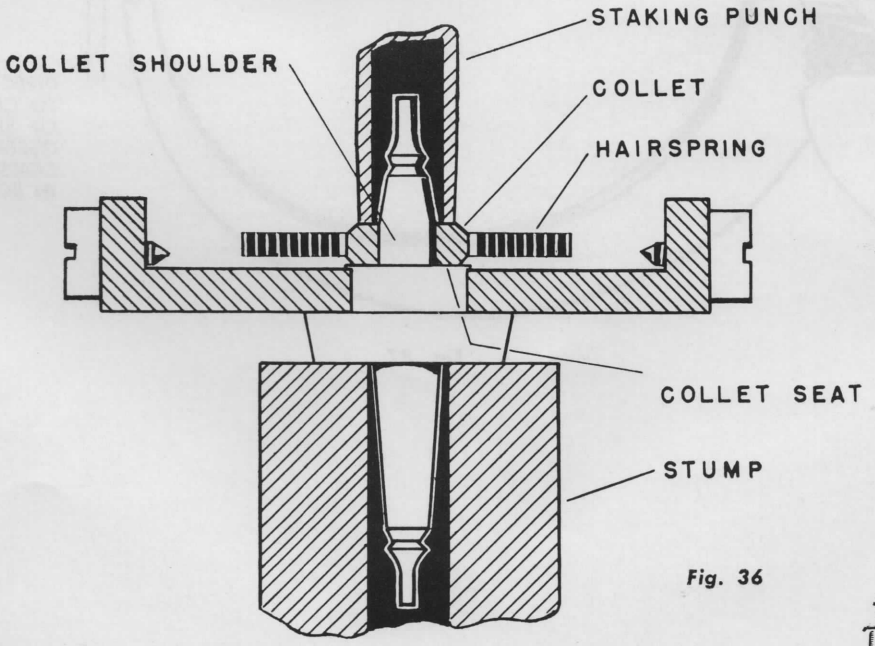


Fig. 36

After staking the springs on the staff, dip the entire assembly in a good cleaning solution, rinse properly, dip in alcohol and dry in box wood sawdust. When this is completed, place each balance wheel separately on the calipers as shown in Fig. 37. Use a camel's hair brush to remove the small particles of sawdust from the hairspring and balance wheel.

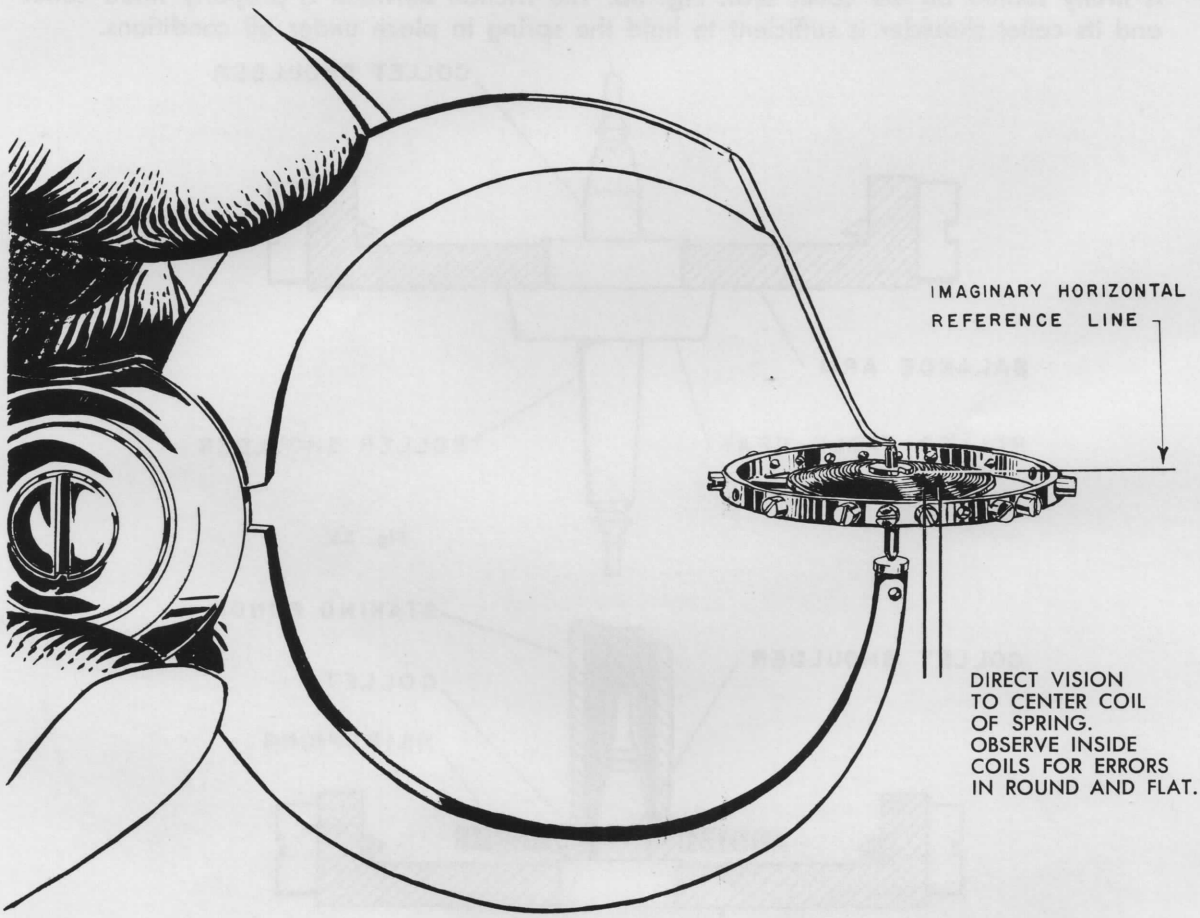


Fig. 37

IV. Truing in the Round and the Flat

Hairspring truing is the procedure of locating the collet so that it will be flat and central with the coils of the spring. It is quite obvious that the operation of attaching the hairspring to the collet requires a considerable amount of skill and it would be assuming too much on the part of the manipulator to perform this operation so that the collet would be perfectly central and flat with the spring. The operating of hairspring truing is necessary to correct the errors caused by the "breaking out", "forming the tongue" and "pinning-in" operations. With this in mind, proceed to locate the errors resulting from colleting.

With the use of calipers, examine the hairspring for the more refined errors and for the final truing in the round and flat.

Fig. 37 and Fig. 38 shows the proper position of a hairspring and balance wheel in the calipers for inspection in the flat and the round.

When making the examination, rotate the balance wheel in the caliper. Rotate the balance wheel slowly enough to observe the inner coil in relation to the collet by applying a light brushing motion to the balance wheel with the side of the forefinger.

While the balance wheel is rotating in the caliper, the spring can be considered true in the round if the first three or four inside coils appear as perfect circles. If the coils seem to jump or describe irregular circles, then there is an error in the round.

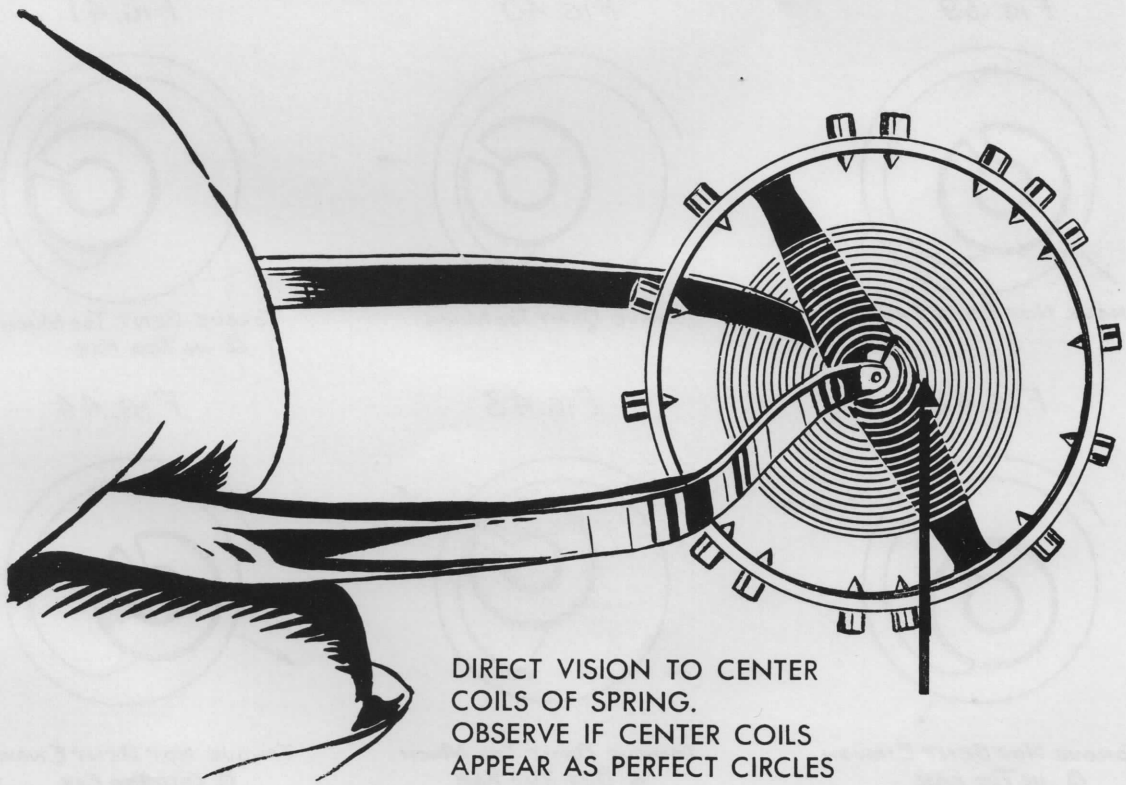


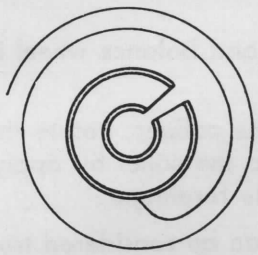
Fig. 38

Errors in the Round

When the collet is placed properly in center of spiral and the spring is correctly pinned to the collet, the spring will look like Fig. 39.

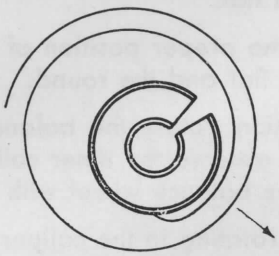
In Figs. 40 to 47 are a combination of eight errors that show the spring is out of true in the round and represents usual errors introduced by colleting. Each diagram has been greatly enlarged and exaggerated to help detect the errors that exist. Each figure describes the position of the collet which is off center in relation to the spring when the tongue is not "formed properly" and "pinned-in" correctly. The direction in which it is off center is indicated by the arrow.

The presence of any of the errors shown below denotes that corrections need to be applied to the spring. Before attempting to correct the errors, first study each spring and compare the errors with those shown in Fig. 40 to Fig. 47.



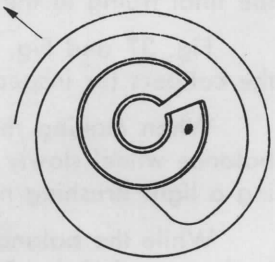
PERFECT

FIG. 39



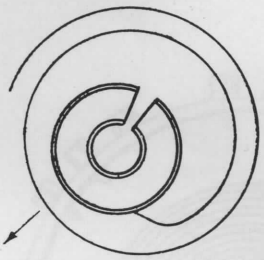
TONGUE IN TOO FAR

FIG. 40



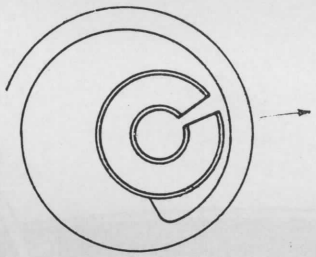
TONGUE OUT TOO FAR

FIG. 41



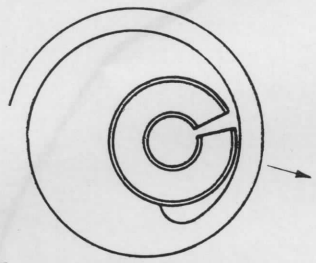
TONGUE NOT BENT ENOUGH

FIG. 42



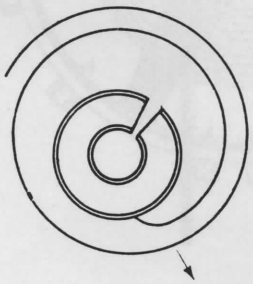
TONGUE BENT TOO MUCH

FIG. 43



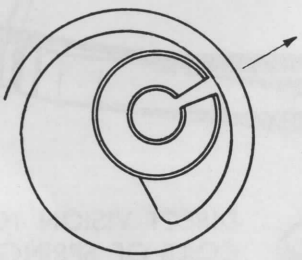
TONGUE BENT TOO MUCH & IN TOO FAR

FIG. 44



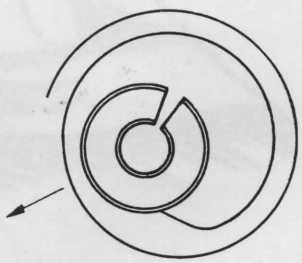
TONGUE NOT BENT ENOUGH & IN TOO FAR

FIG. 45



TONGUE BENT TOO MUCH & OUT TOO FAR

FIG. 46



TONGUE NOT BENT ENOUGH & OUT TOO FAR

FIG. 47

After arriving at a decision concerning the errors of each spring, now turn attention to the corrective bending operations. Methods that are applied individually to correct the errors previously shown will be explained in the following figures. All bends necessary to eliminate the errors can readily be made with the tweezers while the balance wheel is supported in the calipers. Direct all corrective bendings toward locating the center of the collet in the center of the spiral by employing the bend on the first one-eighth coil.

A detailed breakdown of the bending operations used to correct the errors is given as follows:

ERROR shown in Fig. 48-A-B-C

CAUSE: Tongue pinned too far in.

To Correct This:

1. Grasp inside coil with tweezers at point B, Fig. 48A, and bend the coil away from collet as shown by arrow.

2. Then grasp the inside coil at point C, Fig. 48B, and bend the coil toward the collet as shown by the arrow. Fig. 48C shows the net results of the corrective bendings with the collet centered with the spring.

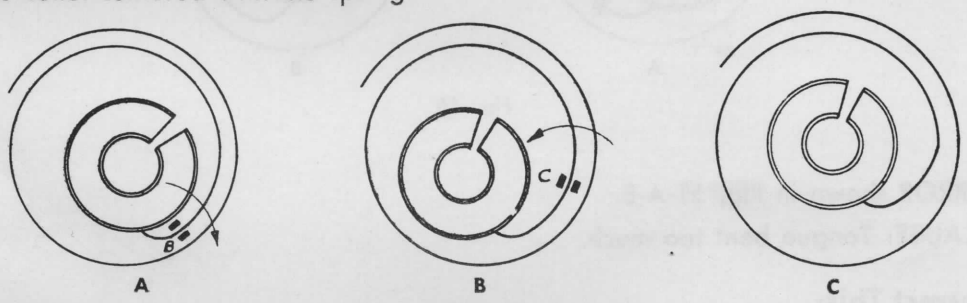


Fig. 48

ERROR shown in Fig. 49-A-B-C

CAUSE: Tongue pinned-to far out.

To Correct This:

1. Place tweezer points in the position shown as A and B, Fig. 49A and gently squeeze point B towards collet as indicated by the arrow.

2. Then grasp inside coil at point C, Fig. 49B, and bend the coil away from collet as shown by the arrow.

Fig. 49C shows the results of the above bendings with the collet centered with the spring.

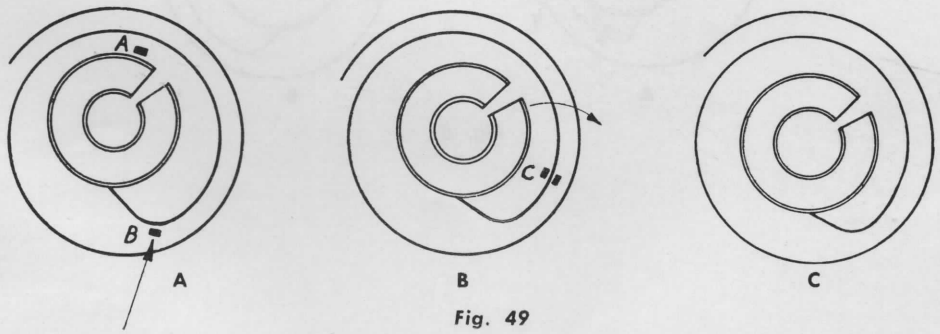


Fig. 49

ERROR shown in Fig. 50-A-B.

CAUSE: Tongue not bent enough.

To Correct This:

1. Grasp inside coil with tweezer at point B, Fig. 50A and bend the coil toward collet as shown by arrow. The collet is now centered with the spring as shown in Fig. 50B.

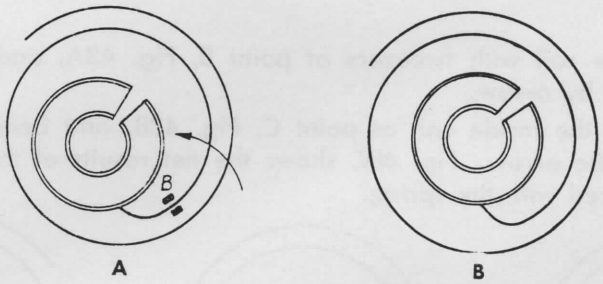


Fig. 50

ERROR shown in Fig. 51-A-B.

CAUSE: Tongue bent too much.

To Correct This:

1. Grasp inside coil with tweezer at point B, Fig. 51A, and bend the coil away from collet as shown by arrow until collet and spring are centered as shown in Fig. 51B.

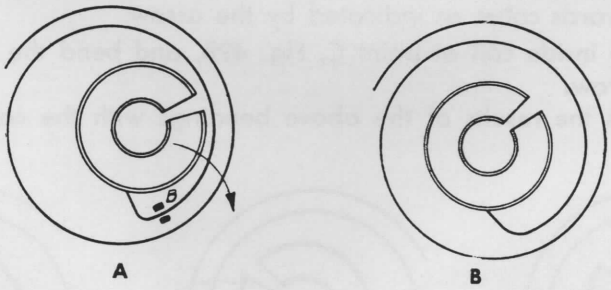


Fig. 51

ERROR shown in Fig. 52-A-B-C.

CAUSE: 1. Tongue bent too much.

2. Pinned in too far.

To Correct This:

1. Grasp inside coil with tweezer at point B, Fig. 52A, and bend the coil away from collet as shown by arrow.

2. Then grasp the inside coil at point C, Fig. 52B, and bend the coil toward the collet as shown by arrow. Fig. 52C shows the collet and spring centered after proper manipulation.

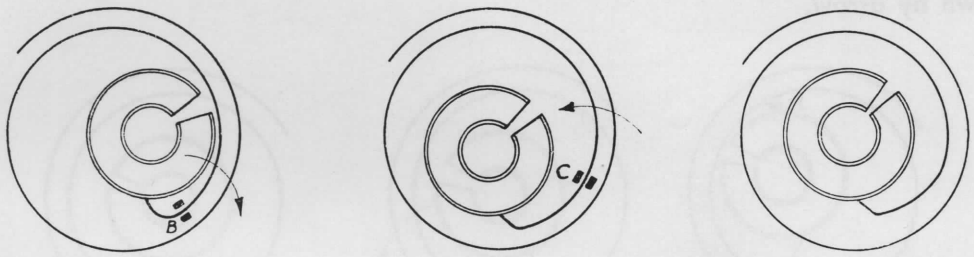


Fig. 52

ERROR shown in Fig. 53-A-B-C-D.

CAUSE: 1. Tongue not bent enough.

2. Pinned in too far.

To Correct This:

1. Grasp inside coil with tweezer at point B, Fig. 53A and bend the coil away from collet as shown by arrow.

2. Then grasp the inside coil at point C, Fig. 53B, and bend the coil toward the collet as shown by arrow.

3. Now grasp the inside coil at point D, Fig. 53C and again bend the coil toward the collet as shown by arrow.

Fig. 53D shows the results after the above bendings have eliminated the errors.

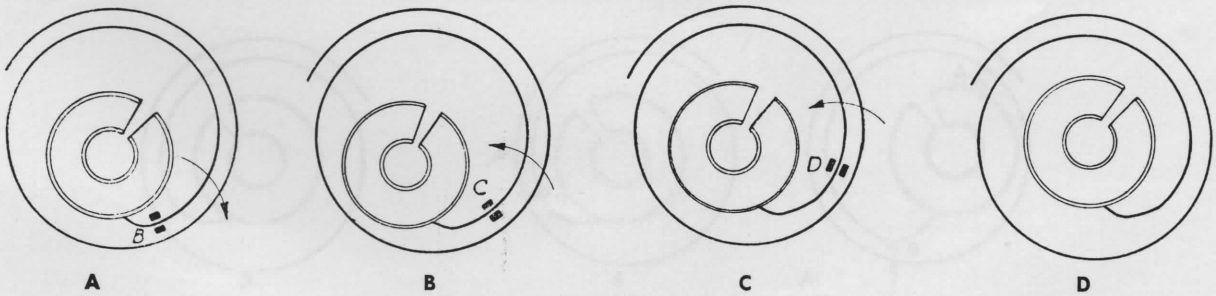


Fig. 53

ERROR shown in Fig. 54-A-B-C.

CAUSE: 1. Tongue bent too much.

2. Tongue out too far.

To Correct This:

1. Place tweezer points in the position shown as A and B, Fig. 54A, and gently squeeze point B toward collet as indicated by arrow.

2. Then grasp inside coil at point C, Fig. 54B, and bend the coil away from collet as shown by arrow.

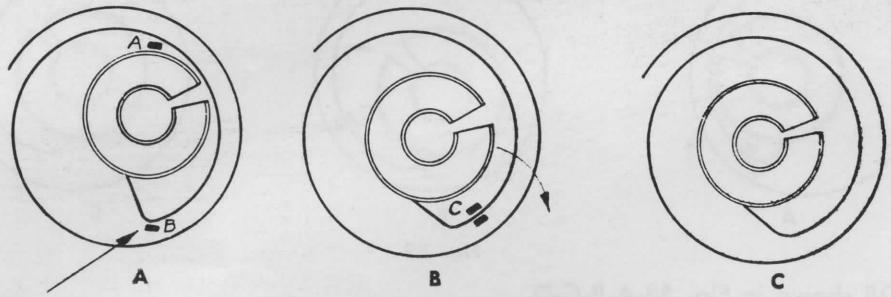


Fig. 54

ERROR shown in Fig. 55-A-B-C.

CAUSE: 1. Tongue not bent enough.

2. Tongue out too far.

To Correct This:

1. Place tweezer points in the position shown as A and B, Fig. 55A, and gently squeeze point B toward collet as indicated by arrow.

2. Then grasp inside coil at point C, Fig. 55B, and bend the coil away from collet as shown by arrow.

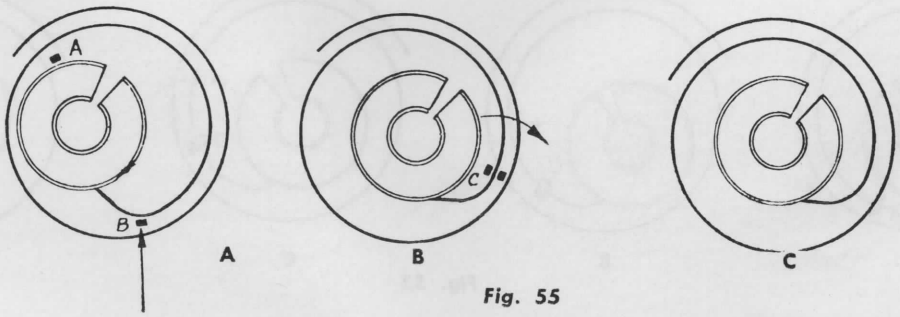
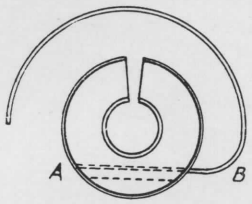


Fig. 55

Errors in the Flat

Here are four conditions that will throw the spring off true in the flat as a result of the spring being bent during the colleting procedure, or fixed in the collet hole other than in a vertical position.

When point A, Fig. 56 of the tongue is bent downward in relation to the spiral portion of the spring, it will cause all of the coils to be high opposite the pinning point.



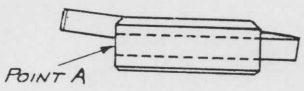


Fig. 56

When point A, Fig. 57 of the tongue is bent upward in relation to the spiral portion of the spring, it will cause all of the coils to be low opposite the pinning point.

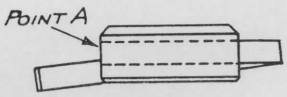


Fig. 57

When the flat face of the tongue is not pinned in a vertical position, but becomes fixed at some angle, as shown in Figs. 58 and 59, the spiral portion of the spring will be high or low, 90 degrees from the pinning point.

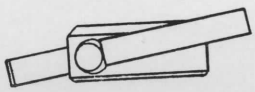


Fig. 58

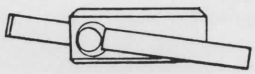


Fig. 59

Since all manipulations during the colleting procedure have been performed on the inside coil, the source of these errors can be corrected by applying a gentle force with a tweezer on the inner coil in the proper direction. To eliminate the error, raise the spring up on the low side or bend it down on the high side, thereby placing the spring level in relation to the collet.

When the spring is true in the flat, check it for trueness in the round. Very often the bending operations used to true the spring in the flat will introduce an error in the round and vice-versa. Therefore, check the spring alternately in the flat and round until it is as true as possible in both the flat and round.