Master WATCHMAKING

SHOP TRAINING
JOB GUIDES

LESSON 18

Truing Hairsprings

—

Sections 376 - 381

CHICAGO SCHOOL OF WATCHMAKING

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SEC. 376—How Hairsprings Are Made

The study of the hairspring is a fascinating subject about which many articles have been written. In our treatment we are restricted to the actual operations required to repair or adjust the hairspring which is furnished with the watch. No attempt is made to delve into the many theoretical discussions and problems.

Although the watchmaker usually buys his own hairsprings and is not concerned with their manufacture, yet almost everyone is curious as to how a hairspring is made. The following description and the method used by early watchmakers is therefore given to satisfy this curiosity.

Tempered steel wire from which hairsprings are made is usually low in carbon. It is first drawn round to a diameter slightly less than the width of the finished flat wire. It is then rolled flat to the required thickness. In drawing and rolling the wire great care must be exercised to avoid breakage or injury to the surface. Frequent annealing is necessary to prevent cracking. The reduction must be done a very little at each drawing and if the rolling is not always begun at the same end the wire will break. For this reason, in drawing and rolling the wire is passed from a spool or arbor through the plate or rolls and wound onto another arbor. It must then be unwound and wound on the original arbor before being again drawn or rolled. To produce a spring of a required strength by bringing the wire to the proper dimensions is a matter of extremely fine measurements. In an 18s hairspring, a difference of one ten thousandth of an inch makes a difference in time of six minutes an hour.

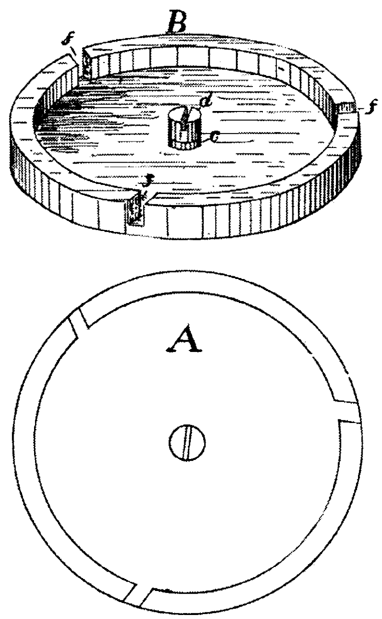

Fig. 18-1

When the hairsprings are to be hardened and tempered they are coiled in a box, usually of copper, as shown in figure 18-1. A, figure 18-1, is a plan and B a perspective view of a hairspring box. It is provided with a hole in the center through which projects the end of an arbor C, which is in turn provided with a screw D. The arbor is slotted for the reception of the ends of the wires and the screw holds them in place. The box shown is for three springs and has three slots each marked F, through which the wire enters. A cap is put down over the wire and the arbor turned until the box is wound full. The spaces between adjacent coils will then be twice the thickness of the wire. Wide coil springs are wound up four in a box; close coil springs, two in a box.

Figure 18-2 will give you an idea of how the springs look when wound in the box. They are then hardened and tempered to a blue. The boxes must be examined after each use and trued out if necessary. Every imperfection in the chamber will be reproduced in the hardened springs.

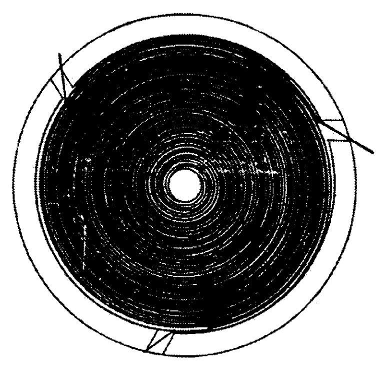

Fig. 18-2

(Insert in Lesson Text 18)

Although hairsprings were originally made of steel, a variety of other metals and alloys are used in present day spring manufacture. Steel hairsprings were subject to temperature changes, magnetism and rust. Early in our present century, Dr. Charles Guillaume, 1920 Nobel Prize winner in physics, invented Invar (from "invariable"), a nickel alloy which was non-magnetic, non-rusting and little affected by temperature changes. Invar was used for mono-metallic balance wheels. Later, in 1913, Dr. Guillaume invented Elinvar, a 36% nickel alloy, harder than Invar, and which came to be widely used for hairsprings. In recent years, manufacturers have produced alloys of higher nickel content, such as the 42% Ni-Span "C."

Beryllium, one of our lightest metals, is also used for hairsprings when alloyed with iron, copper, cobalt, or other metals. The result is harder than Elinvar, but other properties are about the same. Nivarox is one trade name for a beryllium alloy hairspring.

Other metals, such as phosphor bronze, stainless steel, nickel silver, or silver alloys are used for the manufacture of special-purpose hairsprings.

SEC. 377—Purpose of the Hairspring

Dr. Hook, inventor of the hairspring, enunciated the celebrated maxim, "Ut tensio sic vis" — "As is the tension, so is the power." This principle is inherent in the hairspring and constitutes its chief value as a governor for a watch.

When a watch is in beat, the roller jewel when at rest is on a line drawn from the center of the balance staff to the center of the pallet arbor. This is called "the line of centers."

Let us suppose that a balance which is perfectly in beat is started from the line of centers. The first impulse delivered by the escapement moves the balance through a short arc, producing a certain amount of tension in the hairspring. The tension thus set up is sufficient to carry the balance to an equal distance on the opposite side of the line of centers. In passing to this point it receives another impulse which adds to that power and carries the balance still further. This action continues until it reaches the maximum. The reason that the extent of the arcs of vibration does not increase indefinitely although the impulses continue is that the balance meets with constantly increasing resistance from various sources; resistance from the impact of the jewel pin against the fork and the escape wheel tooth against the pallet stone; resistance from the friction of the balance pivots in their jewels; resistance from the roller jewel against the fork; from the pallets and escape teeth, etc. The greatest, however, is the resistance of the atmosphere to the rim of the balance and its screws. When the point is reached where these various frictions overcome the force of the impulse, the balance comes to rest and the power acquired by this tension of the hairspring reverses the motion of the balance and returns it an equal distance in the opposite direction.

As the impulses decrease in force the extent of the vibrations decreases in the same proportion until, when the watch runs down, they cease altogether.

You may have heard people say, "My watch never stops except when I let it run down." The truth of the matter is that the entire mechanism stops at the end of each vibration of the balance—in the average watch 432,000 times every day.

SEC. 378—Experiment in Isochronism

The balance wheel of a watch or the pendulum of a clock oscillates (swings back and forth) in regular periods of time, depending in one case upon the diameter and weight of the balance together with the length and strength of the hairspring, and in the other upon the length of the pendulum.

The term "Isochronism" is of Greek derivation and means equality of time, referring especially to the pendulum and the theory, "The beats of a pendulum are isochronal." It is important that the student understand exactly what this means although we will not make any isochronal adjustments at this time. Suspend from as high an elevation as possible a long piece of light weight cord or linen thread. A ceiling fixture is ideal. On the other end of the cord approximately six inches from the floor tie a small weight, such as a 12 or 16 size watch case. Obtain a watch with a second hand with which to time the vibrations of our improvised pendulum.

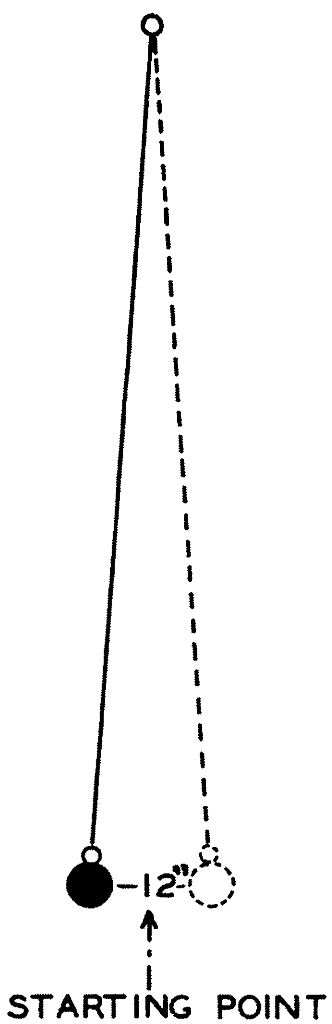

Fig. 18-3

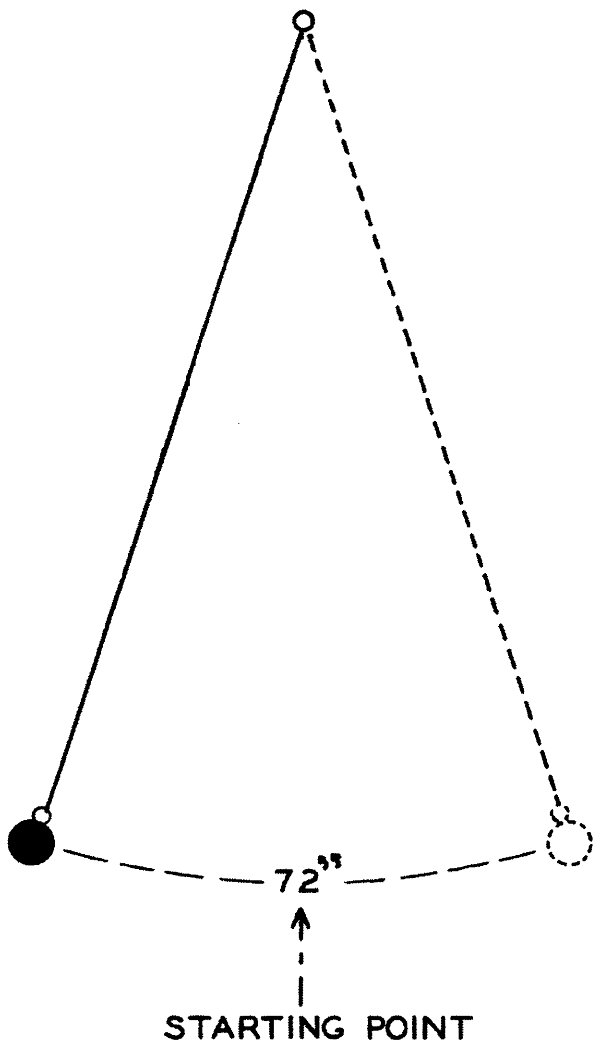

Fig. 18-4

1. With the weight at rest, carefully pull weight back about six inches and then release as shown in figure 18-3.
2. Count the exact number of times the pendulum swings back and forth for 60 seconds. Make a note of the number of vibrations.
3. Repeat steps 1 and 2 but this time pull pendulum back about 36 inches or more, figure 18-4.
4. Compare results. You will find they are the same and from this experiment it is readily seen that the time required for the pendulum to swing through the short arc of twelve inches, figure 18-3, and the long arc of seventy-two inches, figure 18-4, is the same theoretically. However, for all practical work we would have to take into consideration the resistance of the air and in watches, friction of pivots, etc. Isochronal adjustments in a watch are made in order that the watch will have the same, or nearly the same rate whether the balance and hairspring are making a long or a short arc. The longest arc will be found when the mainspring is fully wound and these arcs get shorter as the mainspring unwinds.

SEC. 379—Truing Hairsprings in the Flat

Truing a hairspring in the flat is usually executed with the hairspring and collet on the balance wheel and the balance wheel held in a truing caliper. Release the jaws of the caliper slightly so that the balance will rotate freely. When the coils of the hairspring appear to rotate in the same plane when spinning the balance in the caliper, the hairspring is true in the flat. When truing the hairspring in the flat the bending should be confined

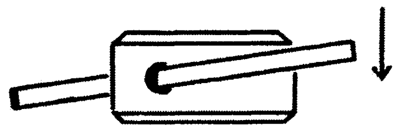

Fig. 18-5

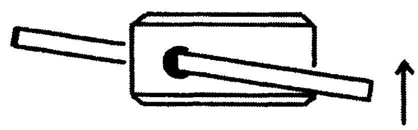

Fig. 18-6

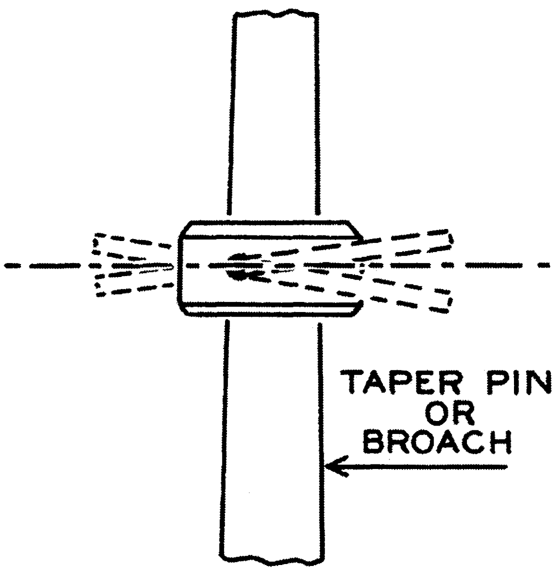

Fig. 18-7

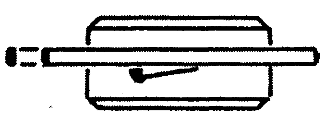

Fig. 18-8

as much as possible to the elbow near the collet. Figure 18-5 illustrates the coils of the hairspring when they are tilted up from the pinning point. Figure 18-6 illustrates the coils of the hairspring when they are tilted down from the pinning point. It is much easier before placing the hairspring on the balance and making the final adjustment to slip the collet over a taper pin or broach as in figure 18-7 and level the hairspring as close to the dotted line as possible, using a pair of fine-pointed hairspring tweezers. When making the final correction with the hairspring on the wheel and the wheel in the caliper, concentrate your observations on the 4 or 5 inner coils. A hairspring should never be trued in the flat by twisting a coil in the manner shown in figure 18-8.

(Note - Insert in lesson text 18 facing Section 379)

Truing Hairsprings in the Flat

As stated in section 379, a hairspring may be examined, errors in flat detected and corrections made on a taper pin before putting on balance wheel. Final examination and minor adjustment are performed on the balance wheel. With hairspring on the balance wheel and in truing calipers, it is not possible to look directly accross the flat of the spring as this view is obstructed by the rim of the balance wheel. The spring should be viewed with the line of vision over the rim of the wheel and in toward the collet. This view will allow you to see half of the spring from the collet to the farthest edge of the spring. Viewing from this angle as you spin the wheel slowly will show up any wobble that would indicate the spring is out of flat. With experience you should be able to pick out the exact point that is low or high. For definitely locating the position, you may use the indicator on the truing calipers much the same as you would for truing wheels.

Correction for an out of flat condition is at the elbow. The method used depends on how much correction is necessary. If spring is quite a bit out of flat you may grasp hairspring at the elbow with fine hairspring tweezers and tilt the body of the spring in desired direction. As an example, in Fig. 18-5 the illustration shows the high side to be to your right. Grasping the hairspring at the elbow and tilting to your right would lower that side of the spring.

Another method, more commonly used, is to press down on the inner coil on the high side of the spring. This pressure should be applied at a point not over a half turn from the inner terminal pinning point. The same correction can be made by lifting on the inner coil. The decision on whether to lift or press downward depends on the location of the error. As an example, Fig. 18-6 shows a spring high on your left. To correct this condition, you should lift the inner coil at the low side. Pressing downward on the left side would not give the desired leverage to make the corrective bend at the elbow. These corrections may be made either on the wheel or on a taper pin. When truing on the wheel, the arms may interfere and thus make it necessary to remove the spring.

Even the most experienced watch repairmen may have to make several attempts before the spring is trued, as there is no way of saying how much pressure to apply in raising or lowering or how much to tilt the tweezers, etc. It will be necessary to rely on your judgement and continued practice will improve your judgement. Keep in mind that this is only one step in truing a hairspring. The spring may also be out of true in the round or you may have moved it out of round when making corrective bends for flat. See section 380 and section 385 in lesson 19.

SEC. 380—Truing Hairsprings in the Round

Truing a hairspring in the round is a difficult operation requiring a great deal of practice. Indeed, it requires an education of the eye to determine the difference between a spring that is perfectly true and one that is nearly so, and still more practice to determine in what direction the greatest difference exists. Truing the spring in the round should be done by bending as near the pinning point as possible never extending beyond the first quarter coil. Experts place the balance and hairspring in a caliper, spin the wheel and observe the action of the first 4 or 5 inner coils of the hairspring. If these coils appear to move smoothly either away from or toward the collet, the hairspring is said to be true in the round. The hairspring should be true in the flat when making this observation.

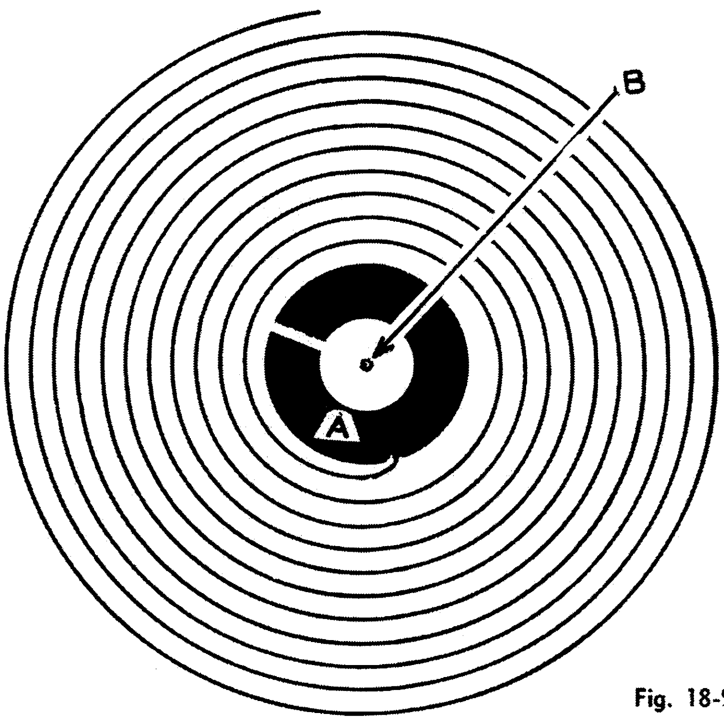

Fig. 18-9

Figure 18-9 illustrates a spiral drawn to represent a hairspring. A represents the collet. When a hairspring is true in the round the center of the spiral and the center of the collet have the common center at B. The slightest variance in centers will cause the hairspring to be out of true.

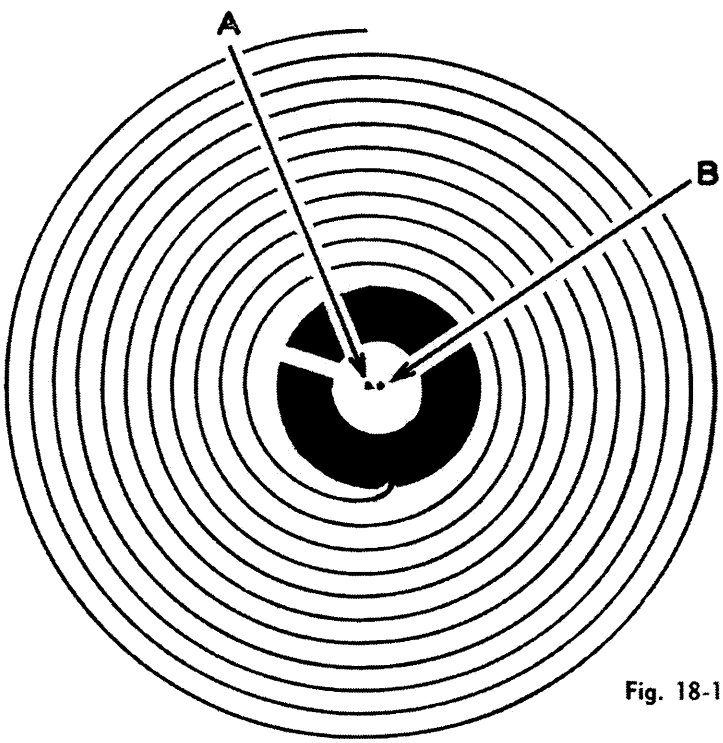

Fig. 18-10

Figure 18-10 illustrates the center of the collet at B and the center of the hairspring at A. These two centers must be made to coincide before the hairspring will be true. When colleting a hairspring the center coils must be broken out enough to allow the center of the collet to be manipulated over the center of the spiral.

(Note - Insert in lesson text 18 facing
Fig. 18-9 and Fig. 18-10)

Truing Hairsprings in the Round

Since the spring is a true spiral, the spacing between coils remains the same throughout the body of the spring. Truing in the round is simply placing the collet in the center of this spiraled hairspring. As already mentioned, corrective bends to move the collet into center may be made at the elbow and in the first quarter of the inner coil only. The only time it should be necessary to make a bend beyond the elbow itself is when it is necessary to alter the elbow by either making it larger or smaller.

The preliminary work of examination and correction is done on a glass work surface, preferably ground glass, Fig. 18-15. The glass surface should be raised above your work bench at least a quarter inch by putting legs under the glass.

Lay the spring on the glass surface and look directly down on it. Keep in mind that the collet is round and the spring is a spiral. The spring, with collet properly centered, shows an ever widening space between the collet and the first coil. This space, starting with the elbow, should increase for a full turn arround the collet and this is what you look for when examining the spring. Keep in mind the space between the collet and the first coil of the spring gradually gets wider. At no two places is this space the same. It should never decrease but always get wider for the full turn. Examine Fig. 19-2 (Lesson 19)(disregard the broken line as it does not apply to this discussion). You will note the above condition.

Moving the collet to the center of the spiral may be done as follows: Grasp spring with tweezers in spot from which correction is needed and with a tapered pin or similar tool, push the collet in direction to center. As an example: Fig. 19-7 shows point at which tweezers grasp the spring and the direction in which the collet must be moved. (The two black dots showing the centers must be brought together) When you have moved the collet to what you believe to be center, examine the spring to see that it is still true in flat. Make necessary corrections. If correction is necessary, the collet may no longer be centered, so examination and possible correction are again necessary. Check and recheck for true in round and flat until both are correct.

Now place hairspring on the balance wheel and examine again for truth in both round and flat. View both from same position. If true, the coils will have a smooth spiraling motion as the wheel is revolved. If not true, the coils will surge toward and away from the center. To determine the exact point of error use indicator on truing calipers as explained in section 380. Minor corrections may be performed on the balance wheel.

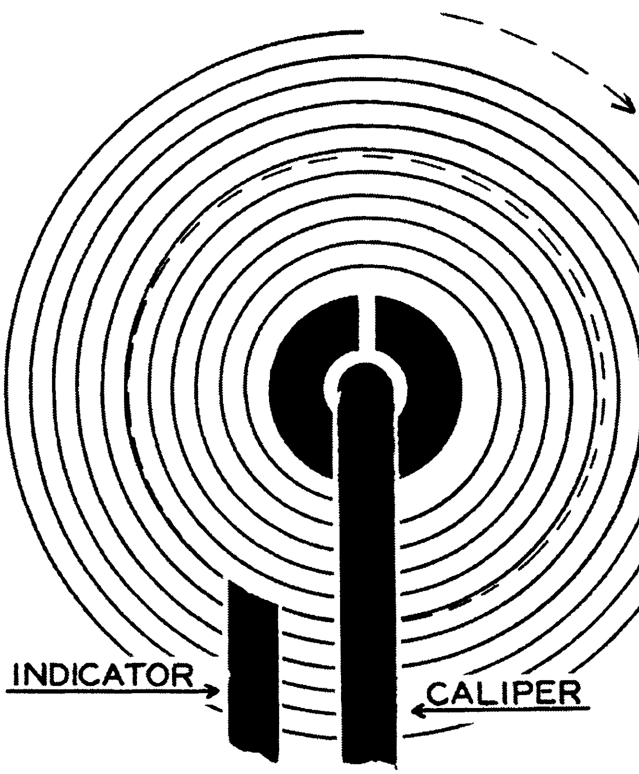

Fig. 18-11

In order to teach the student to make the correct observations, place the balance and hairspring, which is true in the flat, in your truing caliper and set the indicator directly over a coil of the hairspring in the position shown in figure 18-11.

Turn balance ¼ turn and indicator will appear to have moved ¼ of the distance between coils, figure 18-12.

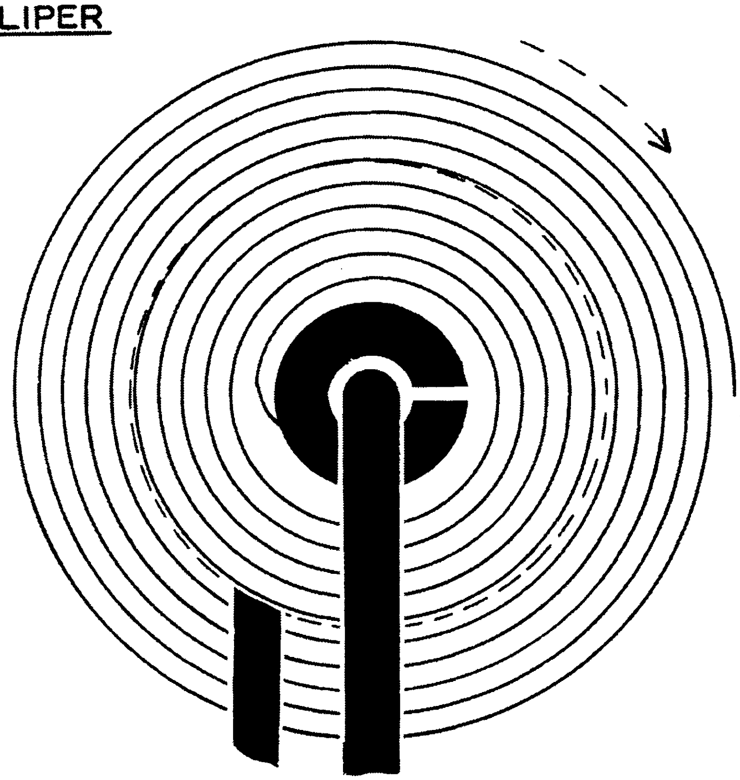

Fig. 18-12

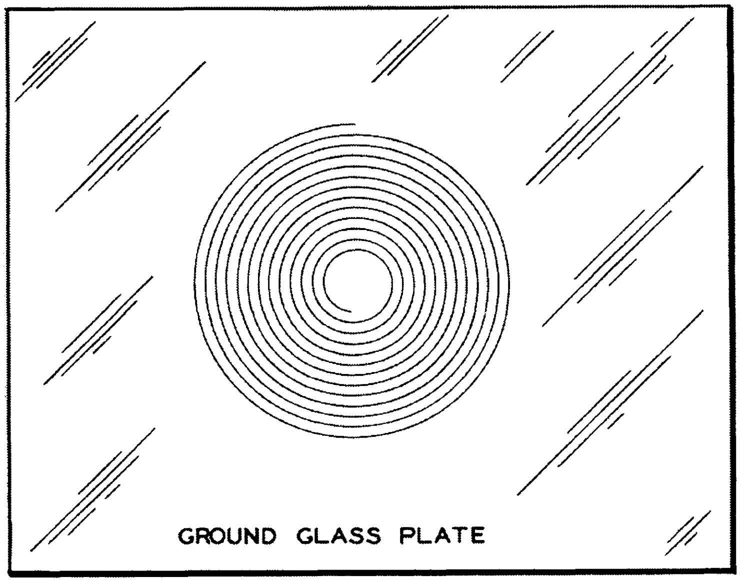

Fig. 18-15

SEC. 381—Locating and Correcting Bends

The student will find it advantageous to make any necessary corrections in the round and flat of the hairspring before placing it on a balance wheel and making the spin test. When working in and around the coils of a hairspring use a piece of glass as the working surface. Ground glass is preferable, figure 18-15. This will drop the shadow of the hairspring coils allowing the workman to see each coil distinctly. Use the best hairspring tweezers available and keep the points protected when not in use. A small pointed steel wire or needle mounted in a small handle can be used to work in between the coils. When making a bend in the coils of a hairspring keep the tweezers vertical, and the pin as close as possible to the tweezer points, figure 18-16.

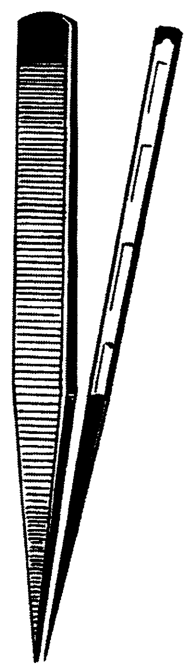

Fig. 18-16

In our work on hairsprings, figure 18-17 will be used to illustrate the following: Fine pointed tweezers, taper pin, and overcoiling tweezers.

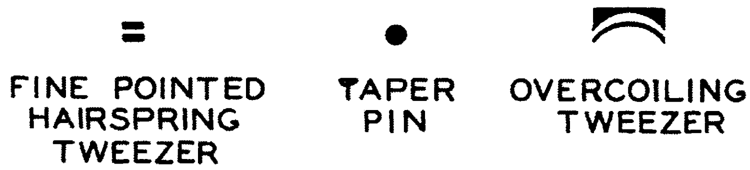

Fig. 18-17

Figure 18-18 illustrates a hairspring which has two bends in it. Bends of this type are traced by following the coil from the **center** until a variation in space between coils is encountered. When the exact point of the bend is located study carefully before attempting to make a correction. In figure 18-18 the first bend has been located and the two dashes represent the points of the hairspring tweezers which have been placed at the bend. The dot represents the pointed steel wire or taper pin. Holding the tweezers and pin close together and vertical, carefully bend hairspring until spiral is perfect again. A slight pressure on the pin will move the center section of the hairspring. The second bend on the outside coil is located by tracing the spiral from the center coil. Place tweezer and taper pin as shown and carefully bend coil in.

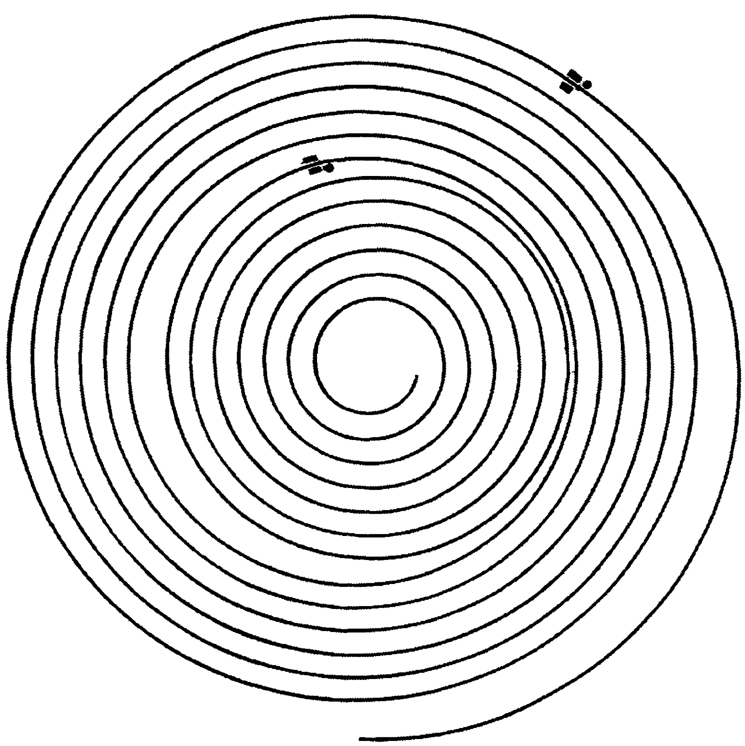

Fig. 18-18

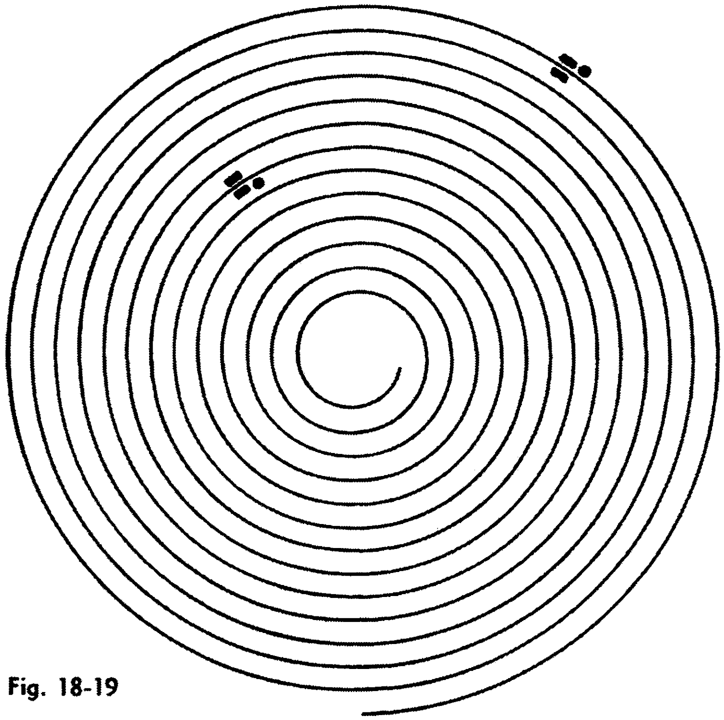

Fig. 18-19

When the coils of the hairspring are spaced as in figure 18-19, the coils of the hairspring are again in a perfect spiral. There are times when, usually due to an accident, several coils of the hairspring may be above or below the plane in which all of the coils should lie. Figure 18-20 illustrates a hairspring in which the collet and a few of the center coils rise above the body of the hairspring. This bend is traced by starting from the pinning point at the collet.

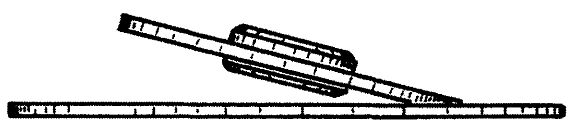

Fig. 18-20

Study the bend carefully because it can be remedied easily if you grasp the coil of the hairspring precisely where the bend is. Figure 18-21 illustrates a cross section of three coils of a hairspring, the center one being the one which is twisted or bent. In this case, lay the hairspring on your ground glass plate and grasp the part of the coil which is correct with a pair of hairspring tweezers, A, figure 18-21. With another pair of tweezers, B, figure 18-21, placed as close as possible to the tweezer A, and on the bent position, bend coil in direction of arrow, and all coils again lie in the same plane.

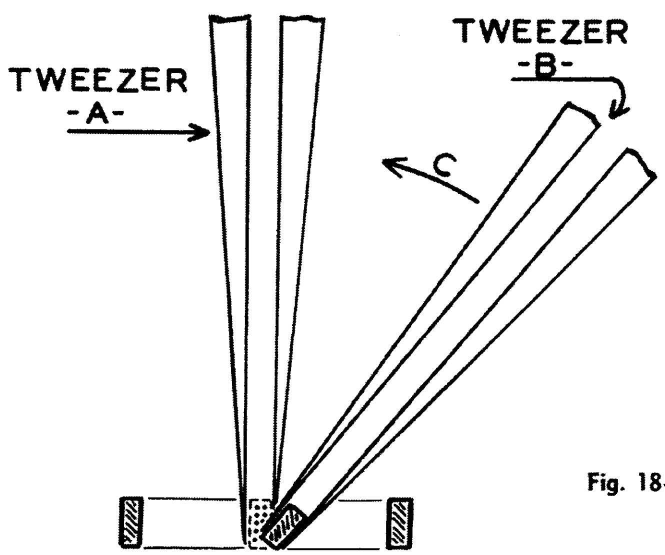

Fig. 18-21