TRAINING UNIT
NUMBER 7

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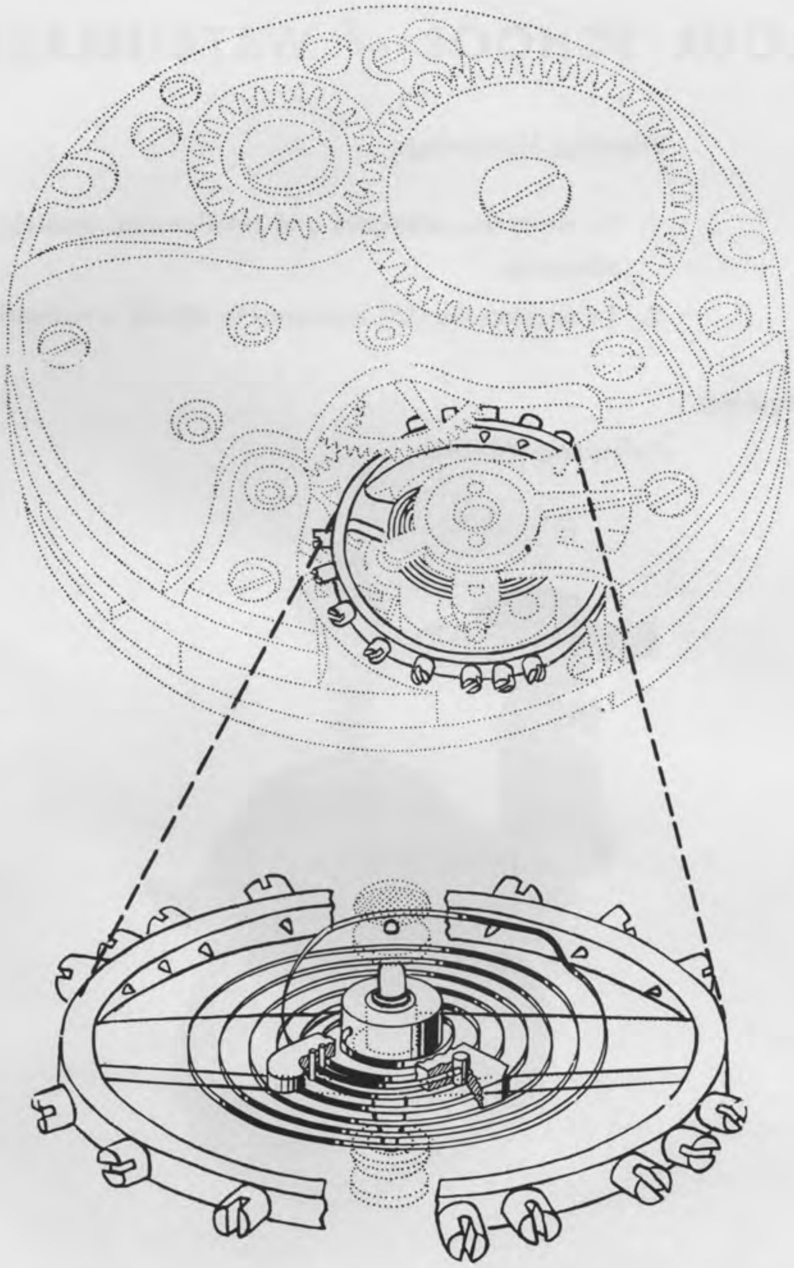
HAIRSPRING VIBRATING

THE ART *of* VIBRATING HAIRSPRINGS

Vibrating is the process of establishing the elastic reaction of a hairspring to the weight of a balance wheel so that the wheel will perform the required number of vibrations per hour. Vibrating is an art by itself; so much so, that in most of the large cities, a large amount of this work is done today by hairspring vibrating specialists.

However, an expert watch repairer should still be able to accomplish this very necessary procedure when the emergency arises. Very often, delays of three months and more in this service are required before the customer's watch can be returned to him. Therefore, the watch repairer who can perform this delicate operation is in an advantageous position.

Moreover, a thorough knowledge and skill in vibrating have a real value in making routine adjustments or repairs on the hairspring when performing a complete watch overhaul. Unless the watch repairer is thoroughly trained in the manipulative skill requisite to the fitting of a hairspring to a balance assembly, he cannot honestly turn out a finished or satisfactory repair job in every case.



BULOVA SCHOOL *of* WATCHMAKING

Subject: Vibrating Hairsprings.

Objectives:

1. To learn the principles and relationships underlying hairspring vibrating.
2. To develop the skill necessary to vibrate a hairspring accurately.

New Tools Required:

Hairspring Vibrator.

Before entering into a detailed discussion on hairspring vibrating, some of the terms relative to the subject should be set forth and defined.

VIBRATION— A vibration is a single swing from one extreme limit to the other of an oscillating body. With regard to the balance wheel and hairspring, one vibration is the motion of the balance wheel from its position at which the hairspring is unstressed to its maximum limit and back again to the unstressed position of the hairspring. Or, stated in another way, the balance and hairspring make one vibration when the balance moves from an extreme position at the end of its swing back to the opposite extreme position at the other end of its swing.

OSCILLATION— An oscillation consists of two vibrations.

If an elastic rod is fixed at one end and deflected at the other, it will, upon being released, vibrate back and forth until the energy stored in the rod by the deflection is used up. (Fig. 1.) The outstanding feature about a vibrating rod is in the constancy of its rate of vibration. Because of the fact that it will continue to vibrate at the same rate until it comes to rest, we have a basis for a time keeping element in a watch or clock. It was this property of elasticity that led to the development of the hairspring. An early step in this development was the employment of a pig's bristle together with a balance wheel as the time keeping element of the watch. (Fig. 2.)

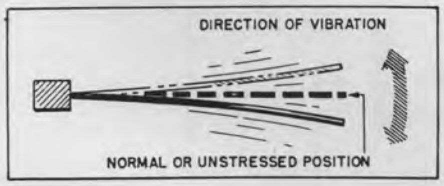


Fig. 1

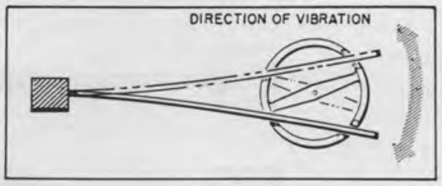


Fig. 2

The pig's bristle was eventually replaced by a steel rod which, because of its delicate nature, was called a hairspring.

Soon it was conceived that if this steel rod were formed into a spiral, and its outer end attached to the pillar plate of a watch and its inner end attached to the balance wheel and then vibrated, it would vibrate a number of times per second, depending upon the length and strength of the spring and the weight of the balance wheel. (Fig. 3.)

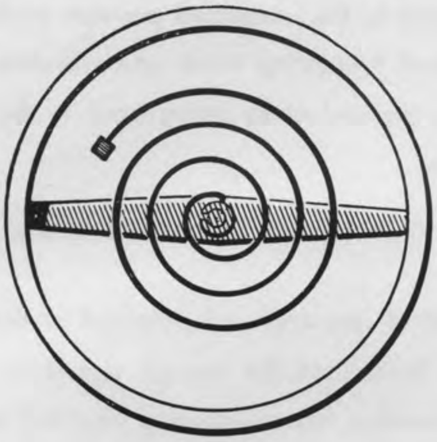


Fig. 3

To understand better the principle involved, let us consider the three simple vibrating rods shown in Fig. 4. Each rod is of the same thickness and width, but differ from each other only in length. Their rates of vibration will differ. Because of a certain law of elasticity, the longer rod will vibrate a fewer number of times in a given time than either of the shorter rods.

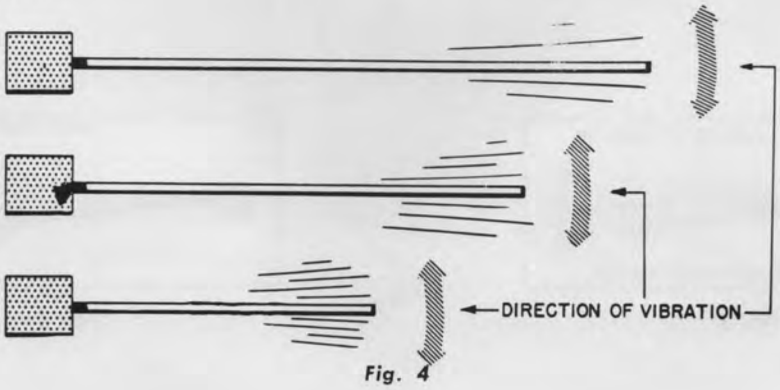


Fig. 4

The rate of vibration of a rod will also depend upon its thickness. If the three vibrating rods in Fig. 5 were of the same length but differed in thickness, we would find that the thinner the rod, the lower its rate of vibration; conversely, the thicker the rod, the faster it would vibrate.

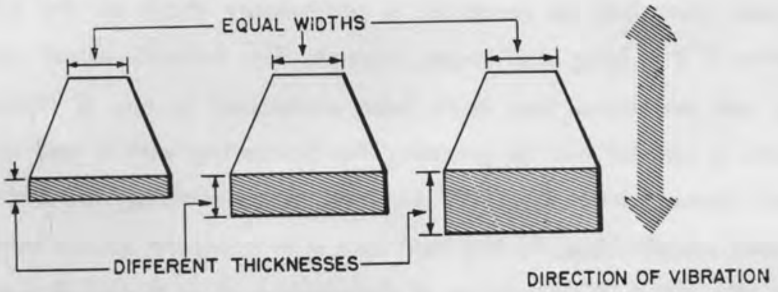


Fig. 5

The elastic principles involved in a simple vibrating rod apply also to a vibrating hairspring. When vibrating a hairspring, it is the length, width and thickness together which influence the selection of the proper spring for a given balance wheel. In the trade, the thickness dimension is referred to as the "strength" of the spring. (Fig. 6.) When springs are received from the manufacturer or materials dealer, the strength is usually indicated by a number. These numbers range from 18 to 96 in the Swiss system. The lower the number, the thicker and stronger the spring.

Because all stock hairsprings of a given number are not of exactly the same strength, the repairman is faced with the task of selecting the proper spring for a given watch. The means for doing this is called "hairspring vibrating." Vibrating is the process of selecting a hairspring with the proper length and strength so as to cause a given balance wheel to vibrate a certain number of times per hour.

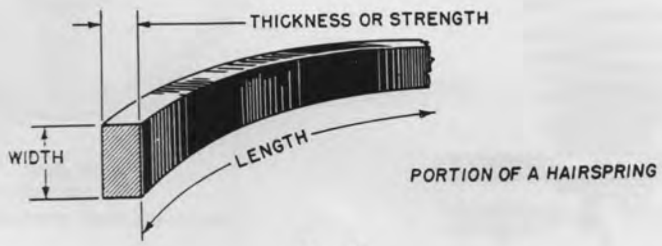


Fig. 6

PRELIMINARY CHECK

Assume that a spring is to be selected for an average watch whose balance vibrates 18,000 times per hour or 5 times per second. Before proceeding with the actual vibrating process, time and labor can be saved by a preliminary check on the spring that will help to determine if it is long and strong enough. The balance wheel assemblies used in this training unit are those that have been developed in No. 6 Training Unit. The preliminary check is carried out by grasping the hairspring with a pair of fine pointed tweezers a short distance from the outer end and then permitting the balance assembly to hang by its own weight. (Fig. 7.) The next step is to count the spaces between the coils downward from the point of suspension. If the count is 8 or 9 and if there are no less than 12 and no greater than 14 whole coils between the tweezer and the pinning-in place at the collet, the spring is suitable for the particular balance wheel. It will be necessary to try several places along the spring before one will be found that will fall within the above limits. When that place is located, it will be found that the diameter of the spring will be approximately equal to the radius of the balance wheel. (Fig. 8.)

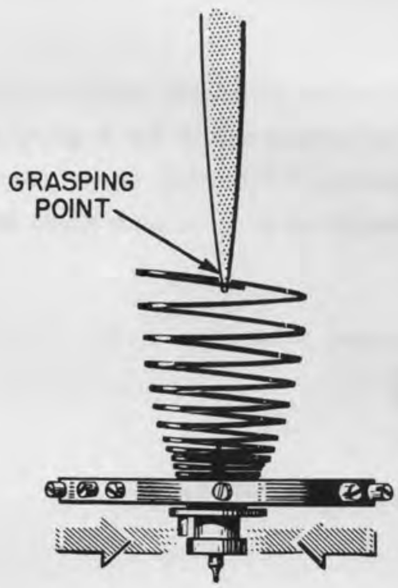


Fig. 7

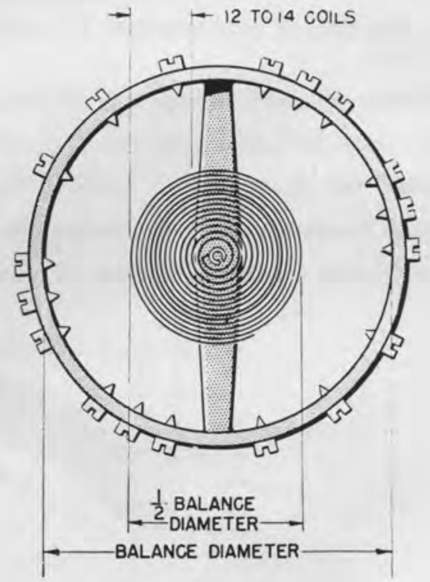


Fig. 8

METHODS OF VIBRATING

1. Oscillation Counting.
2. Master Balance.

Oscillation Counting

It was stated before that the balance wheel of an average watch vibrates 18,000 times per hour. This is 300 times per minute. Because of the physical difficulty encountered when attempting to count 300 vibrations in a given minute, a simpler way is to count every other vibration. When doing it this way, the eye is kept attentive to one of the two ends of the balance arm. A mental note is taken as to where one end of the balance arm is when it is at an extreme end of a swing. Each time that that particular end reaches the extreme end of its swing, the balance has made one complete oscillation or two vibrations. If, for example, it is observed that the count is 150 per minute, then the hairspring has the correct length and strength.

The procedure for finding the vibrating point of a hairspring, which point is finally located between the regulator pins on the balance bridge of the watch, is as follows. Pick up the hairspring with the tweezers at the point found in the preliminary check. Lower the entire assembly until the lower balance pivot just touches the crystal of a watch possessing a second hand. (Fig. 9.) The next step is to start the balance wheel vibrating. This may be done by turning the wheel between the thumb and forefinger against the tension of the hairspring and then suddenly releasing it. With the balance wheel vibrating in the near vicinity of the watch's second hand, it is easy to count the vibrations and keep track of the passing of a given number of seconds. Observe one end of the balance arm and note the point where it reaches an extreme in its angular travel. This extreme will be the reference used in counting every other vibration. When the second hand reaches any convenient starting point, simply start counting every other vibration of the balance wheel, beginning with zero.

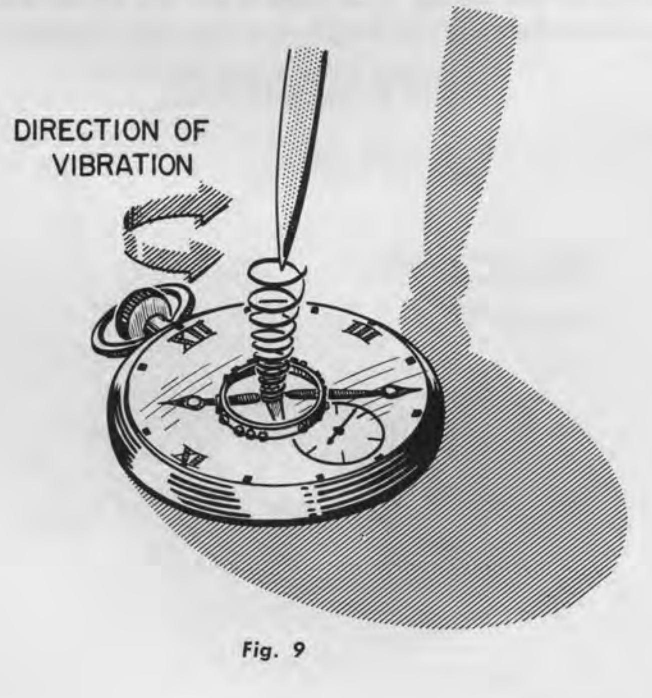


Fig. 9

For a vibrating hairspring whose count is to be 18,000 vibrations or 9,000 oscillations per hour, the coincidence of count with the second hand will be as follows. (Every other vibration is considered to be a count of one.)

2.5 counts	1 second	25 counts	10 seconds
5 counts	2 seconds	75 counts	30 seconds
10 counts	4 seconds	150 counts	60 seconds

Because of the above relationship, it will be possible to determine if a given balance wheel and hairspring are vibrating 18,000 times per hour by simply observing if a count of 25 coincides with a 10 second interval. However, this short method should not serve in finally deciding the exact location of the vibrating point. For more accurate results, several checks over a full minute should be conducted when the probable vibrating point is found by the short 10 seconds count.

If the count is greater than 150 for a minute or greater than 25 for 10 seconds, it is because the length of the hairspring is too short.

If the count is less than 150 for a minute or less than 25 for 10 seconds, it is because the hairspring is too long.

The correct vibrating point and thus the correct length of hairspring is found when the balance wheel oscillates for a count of 150 per minute.

This point on the hairspring which is held between the tweezers is finally located between the regulator pins of the watch. In short, the active length of a hairspring terminates at the regulator pins which is the point of vibration. The actual length of a hairspring ends at the stud. There must be enough spring extending beyond the vibrating point for studding purposes. (Fig. 10.) Therefore the outer coil must be broken off at a point which is equal to the distance from the regulator pins to the stud plus enough to go through the stud. This distance is estimated by actual observation of the balance bridge. Be sure that the regulator is centered. Another and more accurate way of determining where to cut the spring is to take a portion of another spring which has been cut exactly to equal the required length and use it as a gauge.

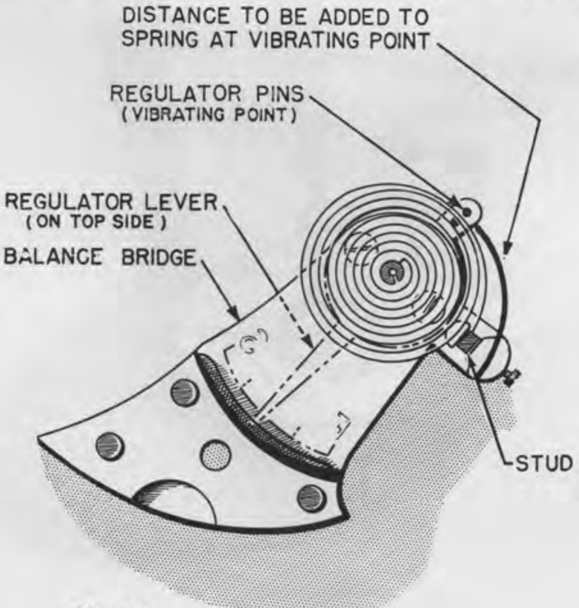


Fig. 10

MASTER BALANCE

In this method, the rate of oscillation of the test balance wheel and hairspring is compared with that of a master balance or vibrator. This vibrator is a tool containing a balance wheel and hairspring which have been very accurately adjusted to vibrate 18,000 times per hour.

The master balance is enclosed in a glass covered case for protection. (Fig. 11.) The vibrator is equipped with tweezers whose jaws are opened by pressing a plunger on its top. When the test hairspring is properly placed between the tweezer jaws, it will be securely held when the pressure on the plunger is released. The tweezers are supported vertically by an arm connected to the main body of the vibrator. The tweezer arm can be raised or lowered.

The process of comparing the rate of vibration of a test balance wheel assembly with that of the master is begun by carefully inserting the test spring in the vibrator tweezers. The next requirement is to lower the tweezer until the lower pivot of the balance wheel is brought into contact with the glass cover above the master. This contact will steady the test balance when it is vibrating and make it easier to observe.

Fig. 11

The vibrator is so constructed that its tweezer arm can be swung and also moved in or out, which feature permits the test balance to be placed directly over the master balance. After the test balance is brought into the correct position, its arms must be brought into alignment with those of the master balance. This is done by turning the vibrator tweezer in its friction support. There is a lever at the bottom part of the vibrator which, when it is depressed and released, gives the starting impulse to both the master and test balance wheels at the same time. If the arms of each balance keep in exact synchronism with each other, it indicates that the test hairspring is held at the exact point of vibration.

The chances are that the correct vibrating point will not be found at the first attempt. Until the correct point is found, the observer must be alert to detect which of the two balance wheels steps out of alignment first. The wheel which moves out first is the faster of the two.

If the test balance steps out of synchronism first, then it is apparent that the active length of its spring is too short. The master balance is then stopped by depressing a small button at the side of the glass top case. The holding point of the vibrator tweezer is then reset so as to increase the active length of the test hairspring and the whole procedure explained above is then duplicated. This correction will bring the two balance wheels more nearly in step. Continue to make corrections until the two remain perfectly synchronized.

Suppose the master balance steps out ahead of the test balance. We know then that the test balance is swinging slower than the master. In this case the active length of the spring must be shortened until the point of vibration is found that allows the balance wheel to keep in exact synchronism with the master.

Then, and then only, will it be certain that the correct point of vibration has been found and that the test balance and hairspring will serve accurately as the time keeping element in the watch.

The final step consists in cutting off the spring at the correct distance from the vibrating point. This procedure has been described above under "Oscillation Counting."

The hairspring is now ready to be studded and overcoiled preparatory to installation in the watch.