

TRAINING UNIT

NUMBER 10

SEE PAGES 297 - 303 INC.



ESCAPEMENT

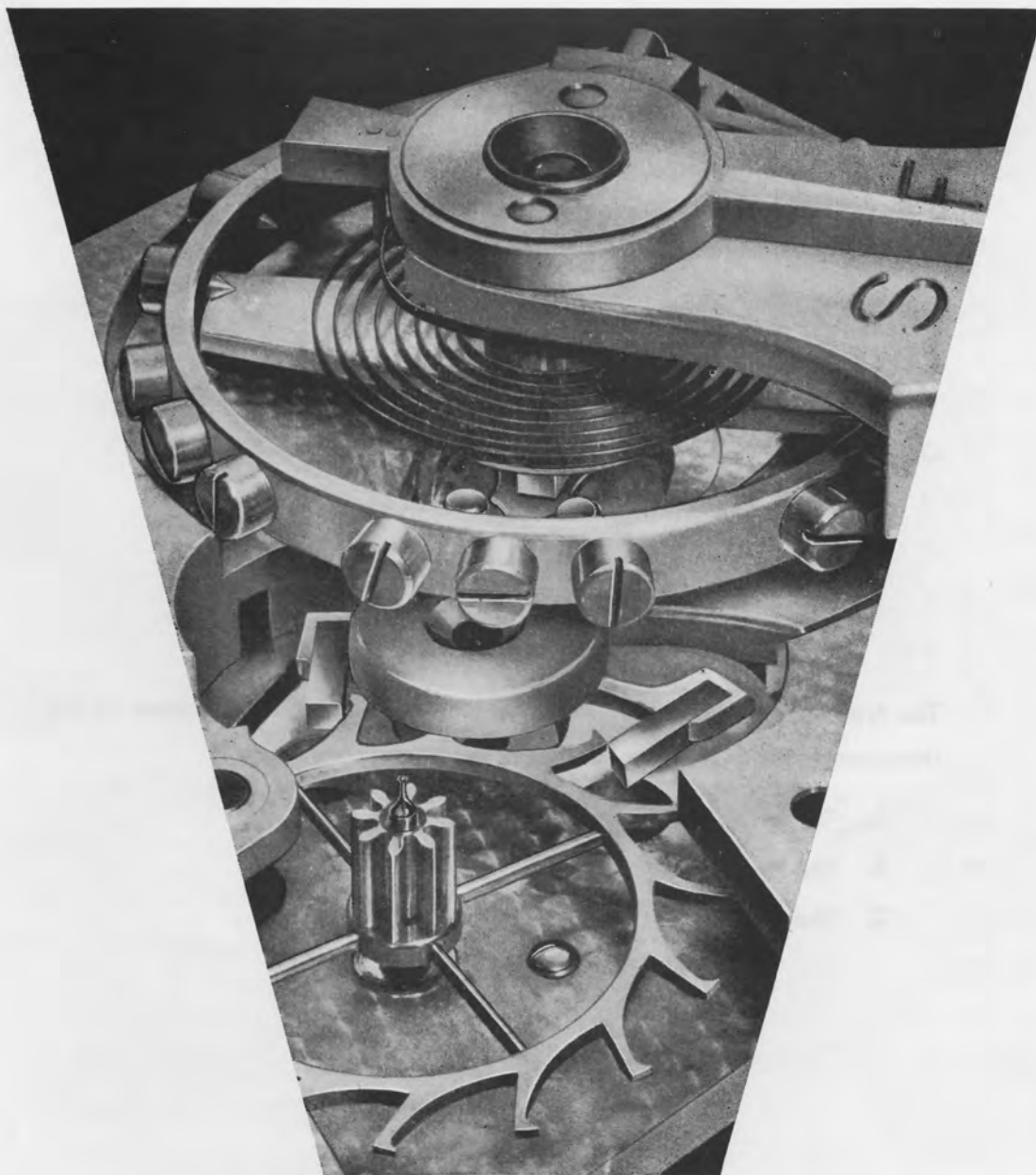


ESCAPEMENT

The escapement is that unit of the watch which serves as the connecting link between the wheel train assembly and the control unit or balance wheel assembly.

Although the balance wheel and hair-spring acting together constitute the time-keeping unit of the watch, the accuracy of this time keeping is also dependent upon the condition of the escapement. For this reason, it is first necessary to have an intimate knowledge of all the actions involved in an escapement before attempting to make adjustments.





BULOVA SCHOOL *of* WATCHMAKING

SUBJECT:

Escapement

OBJECTIVES:

- 1 To understand how the escapement functions.
2. To check a properly matched escapement.

The type of escapement that will be studied in this unit is known as the Detached Lever Escapement. Its three basic components are:

1. The escape wheel.
2. The pallet and fork.
3. The impulse and safety rollers.



DETAILED SEQUENCE OF ESCAPEMENT ACTIONS

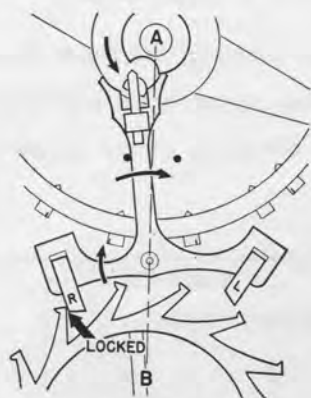


Fig. 2A

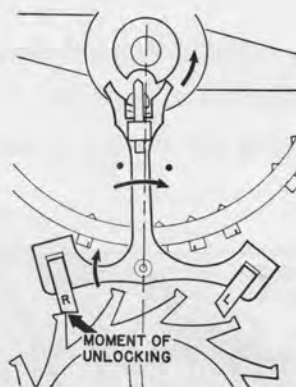


Fig. 2B

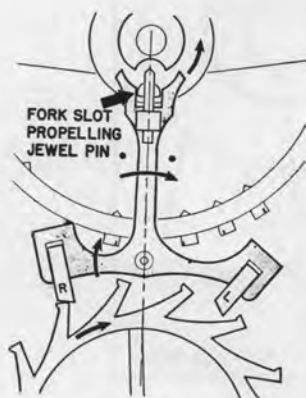


Fig. 2C

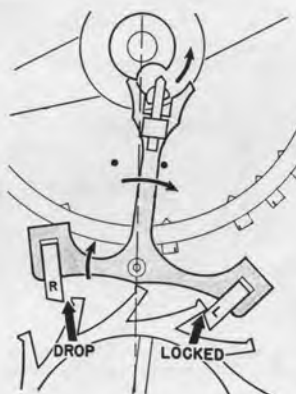


Fig. 2D



Fig. 2E

As the balance wheel swings, the jewel pin is carried back and forth across the center line of the escape wheel, pallet and balance wheel. Line AB in Fig. 2A.

As the jewel pin approaches the center line and when in the position shown in Fig. 2A, it enters and strikes the inside wall of the fork slot.

During the passage of the jewel pin over the center line, the fork is moved in the direction of the arrow (Fig. 2B), causing the R pallet stone to unlock an escape wheel tooth.



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At the instant of unlocking, the escape wheel tooth is released, which creates an impulse on the R pallet stone. This impulse forces the pallet stone out of the path of the tooth. (Fig. 2C.)

The impulse begins at the instant of unlocking. Instead of the jewel pin driving the fork, as was the case in the unlocking period, the fork imparts a propelling force against the jewel pin. This impulse action supplies the energy to maintain the balance wheel in motion.

After the escape wheel tooth slides off the pallet stone, it travels a short distance, known as drop, until another tooth locks on the opposite pallet stone. (Fig. 2D.)

The pallet is caused to move slightly farther than the locking point because of the draw. Draw may be described as a force which tends to hold the pallet against the banking pin. It is the result of the force exerted by the escape wheel tooth on the locking face of the pallet stone. The amount of additional movement of the stone on the tooth is called slide. (Fig. 2E.)

The balance wheel turns until the energy stored in it from the impulse is overcome by the tension in the hairspring, pivot friction and air resistance.

This entire sequence of movements will be repeated when the balance wheel and jewel pin under the influence of the hairspring return to the fork slot.

Each time the jewel pin enters the fork slot, one vibration of the balance wheel has been completed. Two vibrations of the balance constitute one oscillation.

In the Bulova movement, the escape wheel rotates 10 revolutions per minute or 600 revolutions per hour. Since the escape wheel has 15 teeth, it is obvious that 15×600 or 9000 escape wheel teeth will pass a given point in an hour. During a revolution of the escape wheel, each of its teeth delivers two impulses to the pallet. Thus in one hour, 9000 escape wheel teeth will deliver 9000×2 or 18000 impulses to the balance wheel. Since each impulse causes one vibration of the balance wheel and there are 18000 impulses in a one hour period, the balance wheel will vibrate 18000 times an hour, 300 times per minute, or 5 times per second. Because of this, the power of the mainspring is arrested and released every $1/5$ second by the locking and unlocking action of a pallet stone with an escape wheel tooth.



EXAMINATION OF THE FEATURES WHICH ALLOW AN ESCAPEMENT TO FUNCTION

TYPE I: ESCAPEMENTS WITH FIXED BANKING PINS

This method of examination is based upon the assumption that the jewel pin and both pallet stones are correctly located. A well adjusted watch movement, preferably a new one, with fixed banking pins should therefore be used for making this examination.

It is also arranged so as to use the fundamental principles already described, in a manner whereby the condition of the jewel pin shake will provide us with all of the knowledge necessary to make observations relative to the lock, drop, and correct or incorrect position of the pallet stones.

In the detailed examination of an escapement, the hairspring may remain attached to the balance wheel, eliminating the necessity for any disassembly of the movement. This greatly simplifies the work involved in passing judgment on the safe or unsafe condition of any escapement.

Note: In all the sketches shown in this unit, the fork and roller are shown upside down to show the impulse action more clearly.



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Before proceeding with any further discussion of the escapement, it should be mentioned that there are three distinct and different terms used in connection with the jewel pin, namely:

1. Jewel Pin Freedom

Which is the difference between the width of the fork slot and the width of the jewel pin. (Fig. 3.)

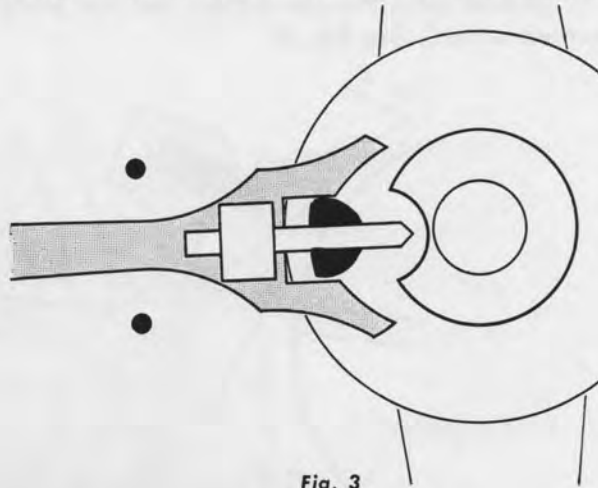


Fig. 3

2. Jewel Pin Shake

Which is the space arrangement between the inside corners of the pallet fork and the front and back of the jewel pin at the instant of "drop." (Fig. 4) Also refer to Fig. 10.

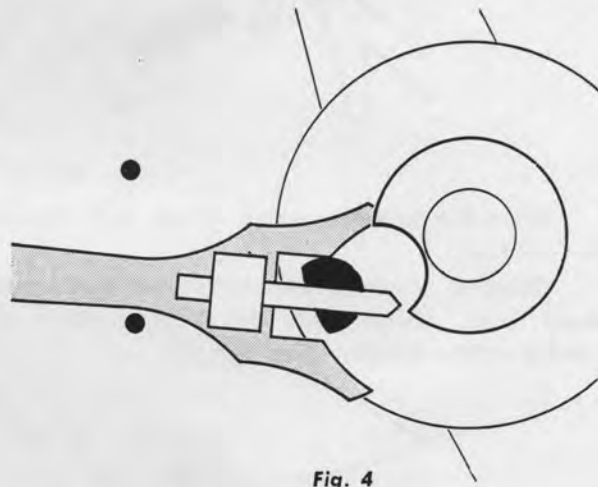


Fig. 4

3. Jewel Pin Clearance

Sometimes called fork horn clearance. This is the clearance for the jewel pin in passing out and past the fork horns. (See Fig. 5.)

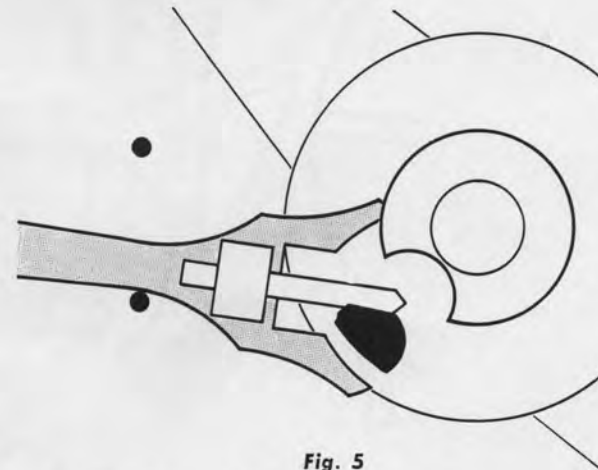


Fig. 5

The three terms relative to the jewel pin must always be used correctly.



EXAMINATION OF A CORRECT ESCAPEMENT

(Based upon the assumption that the jewel pin and both pallet stones are correctly located or set.) See Fig. 6.

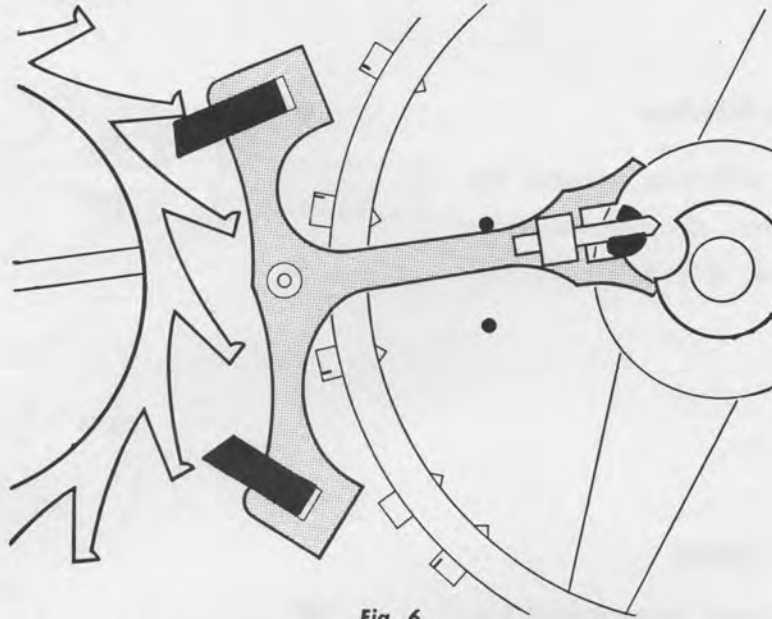


Fig. 6

Move the balance wheel slowly with the first finger, causing the jewel pin to enter the fork slot.

Observe carefully with a double eye loupe that this operation unlocks the escape wheel tooth. (Begin from the R stone side.) At the instant the tooth is unlocked, the impulse action begins. (See Fig. 7.)

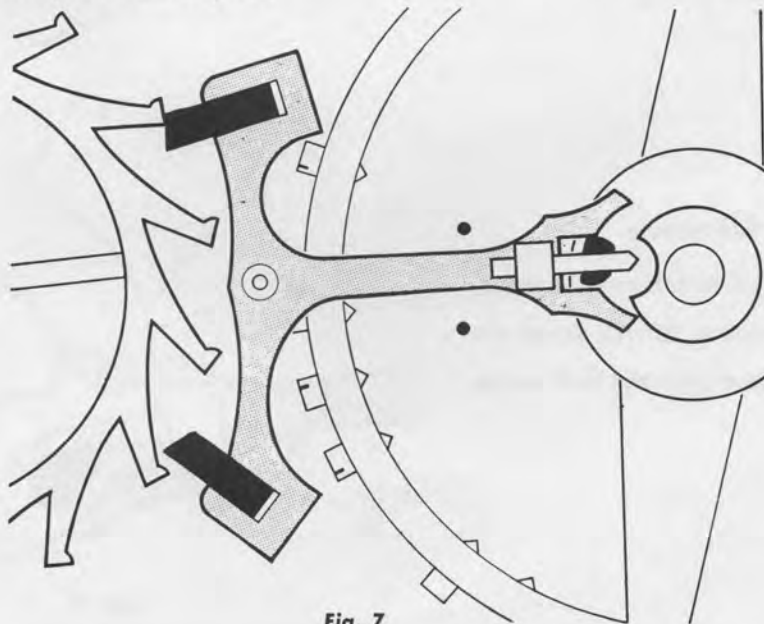


Fig. 7



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The balance wheel should be turned slowly enough so that the travel of the escape wheel tooth across the pallet stone can be clearly observed. (See Fig. 8.)

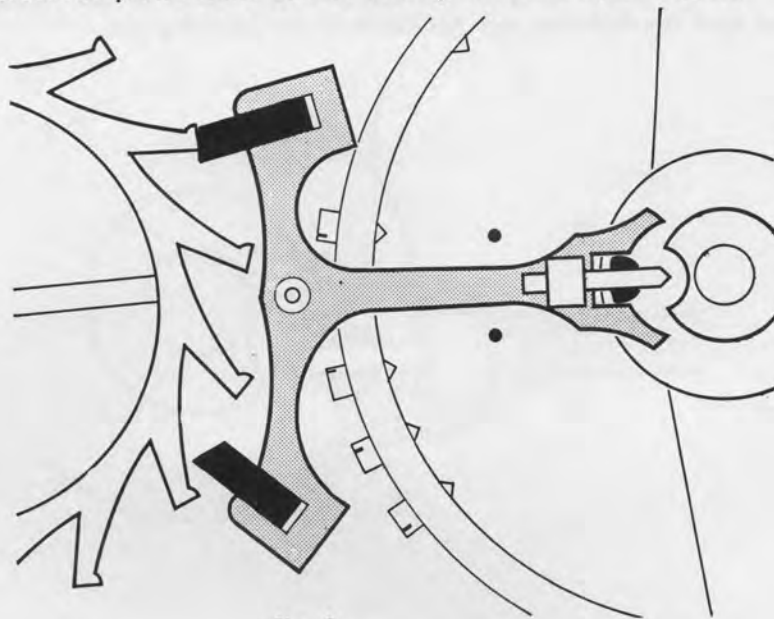


Fig. 8

JEWEL PIN SHAKE

At the exact instant the escape tooth "drops" from the pallet stone, another tooth will "lock" itself on the other pallet stone. The motion of the balance wheel and jewel pin must be stopped at the exact instant of drop and lock, so that the jewel pin shake can be tried or tested. (See Fig. 9.)

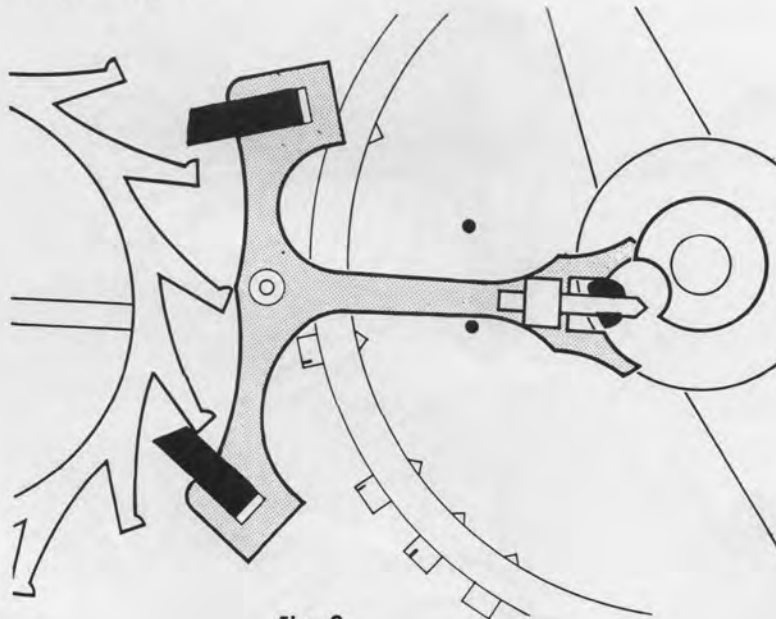


Fig. 9



The jewel pin shake is checked, tested or tried, by moving the fork back and forth. (An escapement trying tool or pivot broach may be used.) This will cause corner A of the fork slot (shown in Fig. 10) to touch the back side of the jewel pin, and corner B to touch the flat face of the jewel pin. During this test for jewel pin shake, it should be carefully noted that the fork has not yet touched the banking pin.

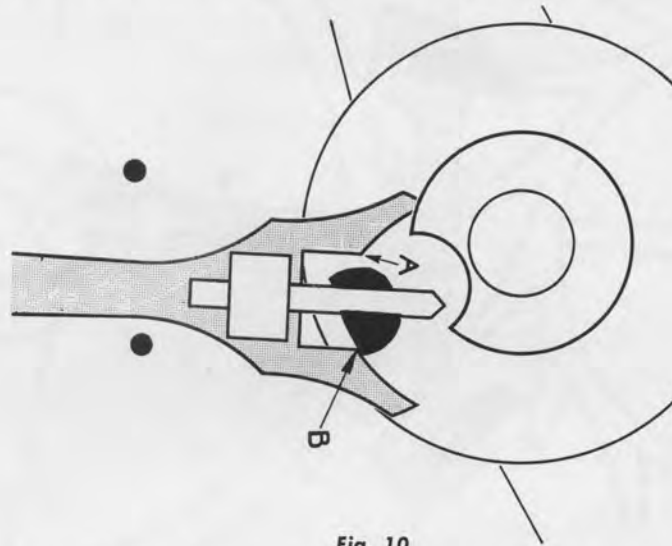


Fig. 10

Now reverse the motion of the balance wheel. The jewel pin will move the fork enough to unlock the escape wheel tooth, the impulse will begin its action. And when the impulse is completed, the drop will occur. Almost simultaneously with and immediately following the drop, the escape wheel will again come to lock. (See Figs. 11a, 11b, 11c)

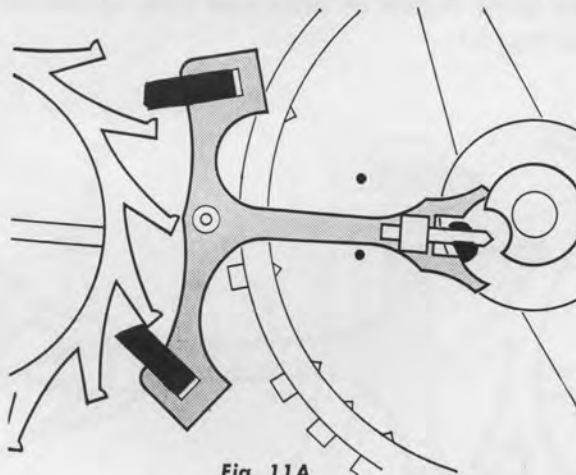


Fig. 11A

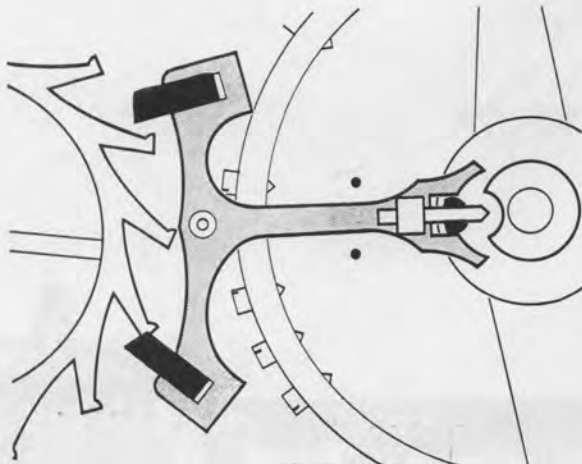


Fig. 11B

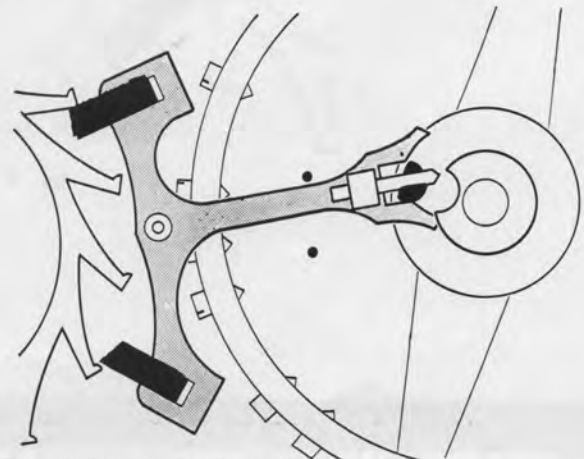


Fig. 11C

At this exact instant or in this exact position, the jewel pin shake is again tested.

Observe that the jewel pin shake is equal on both sides. This indicates that the fork moves as far on one side of the center line as it does on the other side.

JEWEL PIN CLEARANCE

After the jewel pin shake has been tested, we are ready to check the CLEARANCE of the jewel pin in its complete passage out of the fork slot. This is accomplished by turning the balance wheel slowly, causing the jewel pin gradually to pass out of the fork slot and past the fork horn. During this operation it should be noted that the fork is now permitted to come in actual contact with the banking pin.

This jewel pin clearance is tested several times in its (the jewel pin's) movement past the fork horns. In this test, the fork will strike or touch the banking pin at A (Fig. 12) and the fork horn will clear the flat face of the jewel pin at B.

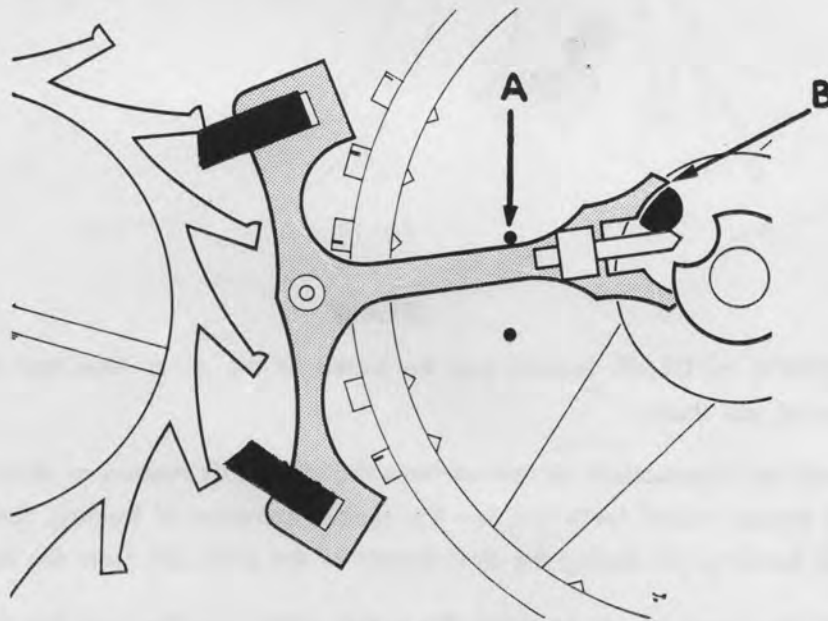


Fig. 12



SLIDE

Slide is the space a pallet stone travels downwards on an escape wheel tooth after the lock occurs.

To observe the pallet stone *sliding* on the escape tooth, move the jewel pin quickly away from the position in which the jewel pin shake is tried and in a direction AWAY from the center line.

REVIEW OF ESCAPEMENT EXAMINATION PROCEDURE

The watchmaker first moves the balance wheel, causing the jewel pin to engage the fork slot. He then continues this motion until:

1. The escape tooth unlocks (R stone).
2. The impulse is completed.
3. The drop occurs.
4. The lock is established.

(see Figs. 6, 7, 8 and 9.)

The passage of the jewel pin into the fork slot, the completion of the impulse, and the final lock must be done slowly and with absolute accuracy. The entire escapement must be brought under observation at the EXACT INSTANT OF THE DROP; the jewel pin must be held in that position without the slightest move back or forth so as to observe and check the condition of:

Lock
Drop
Jewel pin shake

The balance wheel is then turned farther away from the line of centers to check the:

Jewel pin clearance
Guard pin shake
Slide
Draw

Now repeat the procedure, starting with the unlocking of the L stone.

Since the watch used in this examination was known to be in good working order, all clearances and safety actions will be found to be satisfactory.

However this checking procedure should be used on any watch with fixed banking pins whenever any doubt exists as to the proper functioning of its escapement.



**EXAMINATION OF THE FEATURES WHICH ALLOW AN
ESCAPEMENT TO FUNCTION**

TYPE 2: ESCAPEMENTS WITH MOVABLE BANKING PINS

BANKING TO A DROP

Another method of checking the escapement is known as "banking to a drop". This approach to the study of escapement matching is based entirely on the movable banking pins with which some watches were provided before the development of more accurate escapement making machines.

Because millions of these watches are still in use today, an explanation of their adjustment and repair should be in order. For this reason, "banking to a drop" will be briefly discussed.

Here again, the discussion is based upon a correct escapement, and a properly adjusted watch (preferably a new one) with movable banking pins should be used in the procedure to follow.



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In a watch with movable banking pins, "banking to a drop" can be considered the basic reference for investigating the lock, drop, jewel pin shake, and guard pin shake.

After removing the balance wheel, turn the L banking pin so that it will be as close as possible to the line of centers of the escape wheel, pallet arbor and balance wheel. This is possible to do because the banking pins are located off center on the screws which support them. The fork will now rest against the L banking pin, being held there by the power of the mainspring transmitted through the train wheels to the impulse faces of the escape wheel teeth and the pallet stones. (See Fig. 14.)

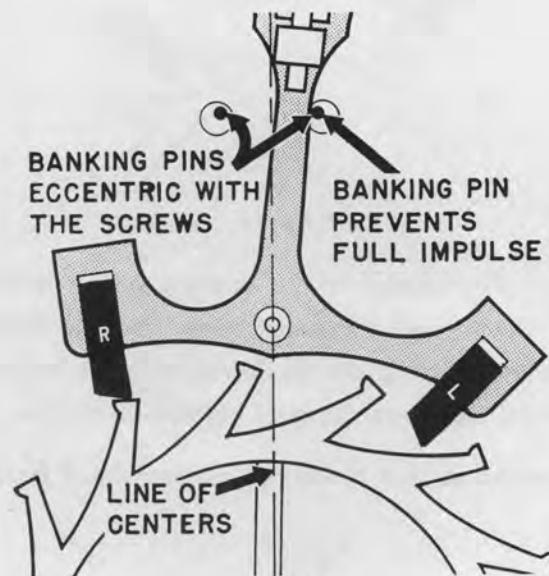


Fig. 14

Hold the watch in the left hand, dial down, and with the screw driver in the right hand, approach the watch from the dial side. Place the screw driver in the screw against which the fork rests, and turn this screw so that the eccentric pin will move away from the line of centers. It is necessary in this operation to look at the escape wheel with a loupe and observe the movement of the impulse face of the escape wheel tooth across the impulse face of the pallet stone. As soon as the impulse face of the escape wheel tooth drops off the R pallet stone, another tooth will lock itself on the L stone. The lock will be about $\frac{1}{4}$ the width of the impulse face of the pallet stone. It is important to remember that at this point we are interested in the amount of lock just after an escape



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wheel tooth has lost contact with a pallet stone. The eccentric banking pin screw should be turned just enough to allow a tooth to escape a pallet stone and no farther. (See Fig. 15.)

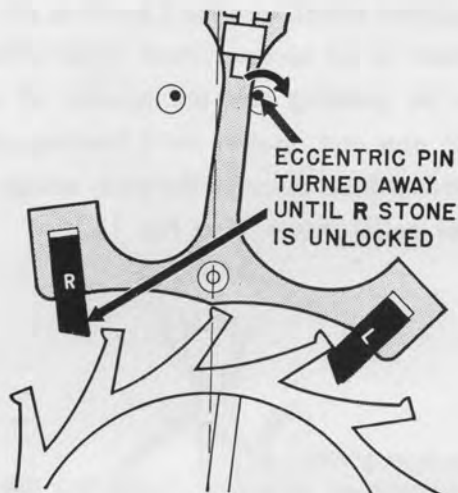


Fig. 15

Also understand that the location of the banking pins is determined by the position of the pallet stones. The farther out the pallet stones are, the farther away from the line of centers must the eccentric banking pin be moved before a tooth will escape. Now turn the R banking pin so that it will be as close as possible to the line of centers.

The fork must be moved so that it will rest against the R banking pin. (See Fig. 16.)

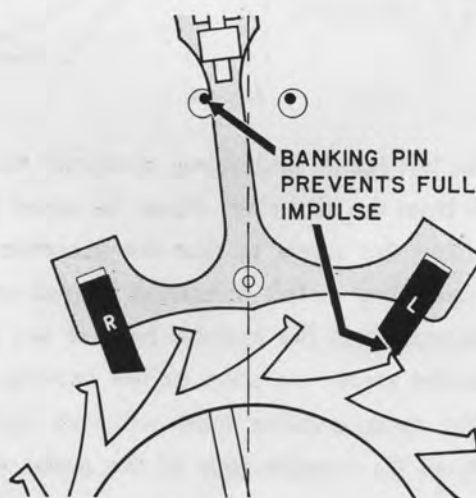


Fig. 16



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The screw for this pin must now be turned just enough so that the escape wheel tooth drops off the L pallet stone. (See Fig. 17.)



Fig. 17

The fork must now be moved back and forth until the escape wheel has made one complete turn.

The pallet may now be considered as banked to the drop. When this is so, the fork should move an equal distance from each side of the line of centers. (Fig. 18.)

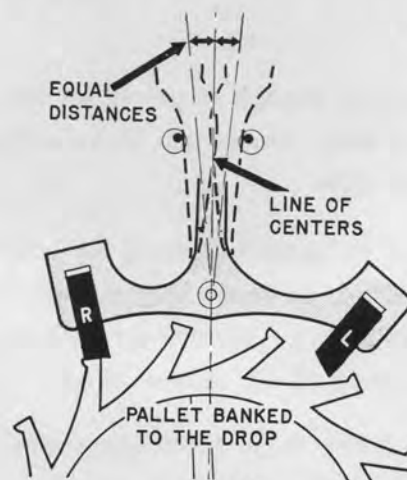


Fig. 18

Replace the balance wheel and hairspring unit in the watch. From here on, the checking of lock, drop, jewel pin shake and guard pin shake proceeds as in the fixed banking pin method.

As the balance is turned away from the line of centers, guard pin shake is tested exactly as in the fixed banking pin procedure. Guard pin shake at this point will be just barely noticeable, not more than $\frac{1}{2}$ degree in a light lock. As the lock is increased, more guard pin shake may be permitted, as much as 1 degree.



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After the lock, drop, jewel pin and guard pin shakes have been found to be satisfactory, slide can now be added. This is accomplished by turning both banking pins away from the line of centers as indicated by the arrows in Fig. 19.

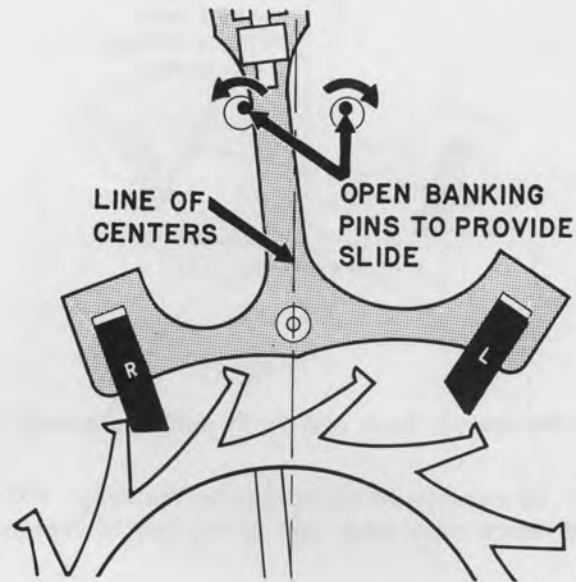


Fig. 19

The pins should be turned just enough to permit an increase of about $\frac{1}{3}$ the lock established when banking to a drop. Guard pin shake will now also be found to have been slightly increased on both sides.

The slide may be observed by carefully turning the balance with the finger. Immediately after the drop, as the balance is turned farther away from the line of centers, the pallet jewel will be seen to move up or slide a short distance on the escape wheel tooth. Slide will be present on each tooth of the escape wheel.

Since the watch used to make these observations was properly adjusted to begin with, it will now be found to function satisfactorily once more.



GLOSSARY OF ESCAPEMENT TERMS

(See Fig. 1 for locations)

R or receiving stone is the pallet stone which first meets or receives the escape tooth in an escapement action.

L or let off stone is the pallet stone which last makes contact with the escape tooth.

Pallet arbor is the staff on which the pallet swings.

Fork is that part located at the tail of the pallet lever, containing the slot into which the roller jewel enters. The fork delivers the impulse to the jewel pin.

Horns are circular projections on each side of the fork slot which provide safety action during unlocking and impulse.

Jewel pin (also called **roller jewel**) usually of ruby or sapphire is suspended perpendicularly from the roller. The jewel pin is the connecting link between the pallet and balance wheel.

Roller table is a flat circular disk from which the roller jewel is suspended.

Double roller is a roller unit consisting of two metal disks: the upper and larger disk supports the roller jewel and is known as the impulse roller; the lower and smaller disk with the crescent notch serves as the safety roller.

Crescent is a notch in the safety roller to allow guard pin to pass freely in either direction when jewel pin is entering the fork.

Guard pin — A small brass pin located below the fork, which serves as a safety device by insuring that the pallet will be in its proper position, ready to receive the jewel pin on its return trip.

Lock is the amount of overlap between the pallet stone and escape wheel tooth.

Locking face is that side of a pallet stone which locks or overlaps the tooth of an escape wheel.



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Toe of tooth — the corner of the escape tooth which locks with the pallet stone.

Heel of tooth — the corner of the escape tooth which is the last part of the tooth to leave the pallet stone in an escapement action.

Let-off corner — extreme tip of the pallet stone where the tooth of escape wheel loses contact with the pallet stone.

Banking pins are the stops on each side of the pallet which control the distance the pallet may swing in either direction.

Impulse begins at the instant of unlocking and is the drive of the escape wheel tooth against the impulse face of the pallet stone, causing the pallet to swing to the opposite side. The pallet imparts this motion through the roller jewel to the balance wheel.

Impulse face — the inclined plane on the end of the pallet stone on which the escape wheel teeth press to produce the lift in an escapement action. Impulse face may also refer to the plane on the end of a club tooth of the escape wheel.

Drop may be defined as the free motion of the escape wheel when one tooth passes the let-off corner of a pallet stone and another tooth locks on the opposite stone.

Banking to a drop — a positioning of the banking pin to a point where the escape wheel teeth will just clear or let off the pallets.

Draw is a force exerted by an escape wheel tooth upon the locking face of a pallet stone, tending to bring the pallet lever against the banking pin.

Slide can be defined as the space or distance a pallet stone travels downward on an escape wheel tooth immediately after the escape tooth comes to a lock with the pallet stone.

