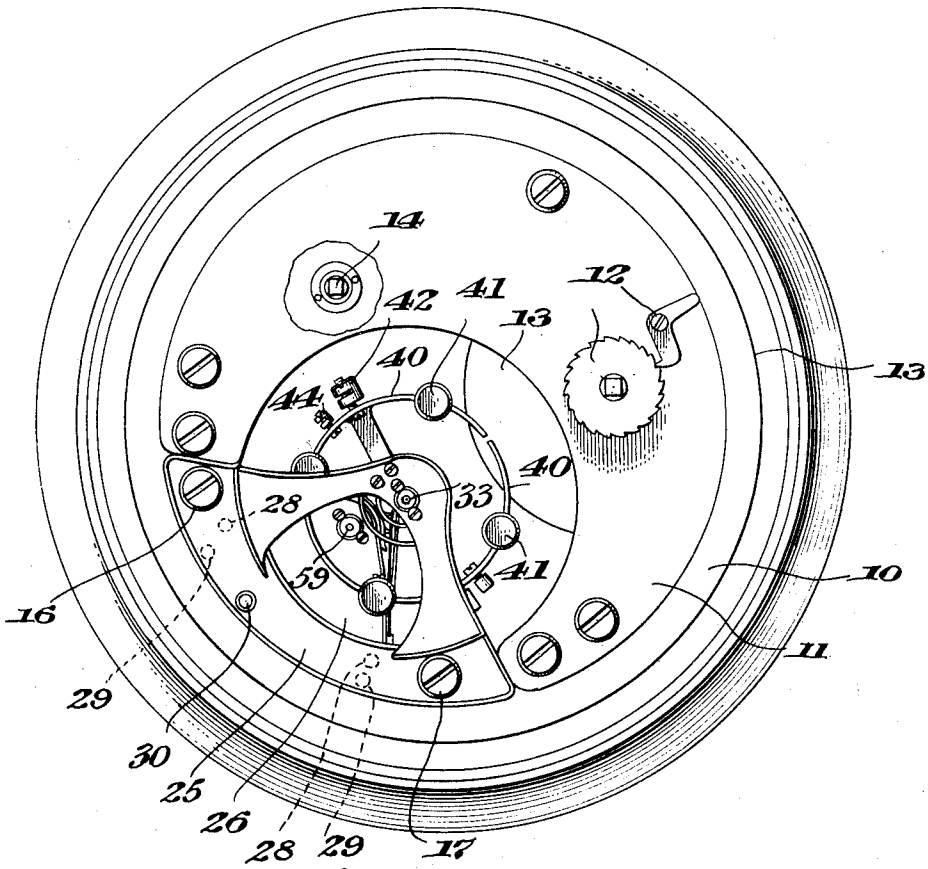
March 21, 1950 G. G. ENSIGN ET AL 2,501,266

MARINE CHRONOMETER DOUBLE TRACK ESCAPE AND PROJECTION SYSTEM

Filed Dec. 10, 1945 3 Sheets-Sheet 1

Fig. 1.



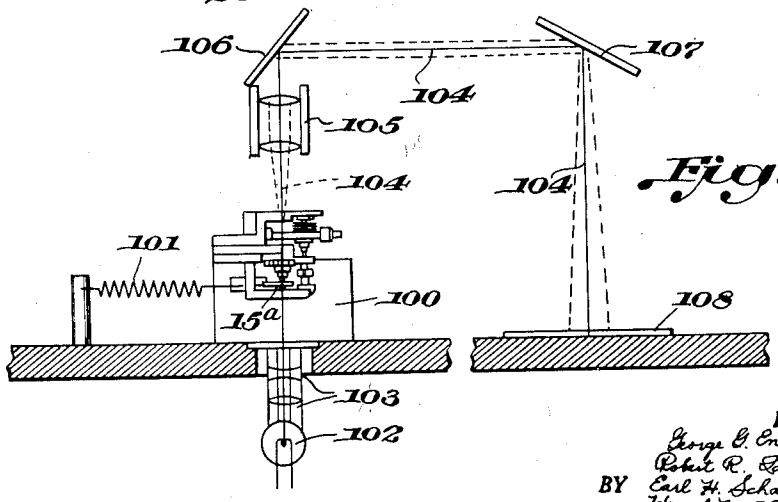


Fig. 8.

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MARINE CHRONOMETER DOUBLE TRACK ESCAPE AND PROJECTION SYSTEM

Filed Dec. 10, 1945 3 Sheets-Sheet 2

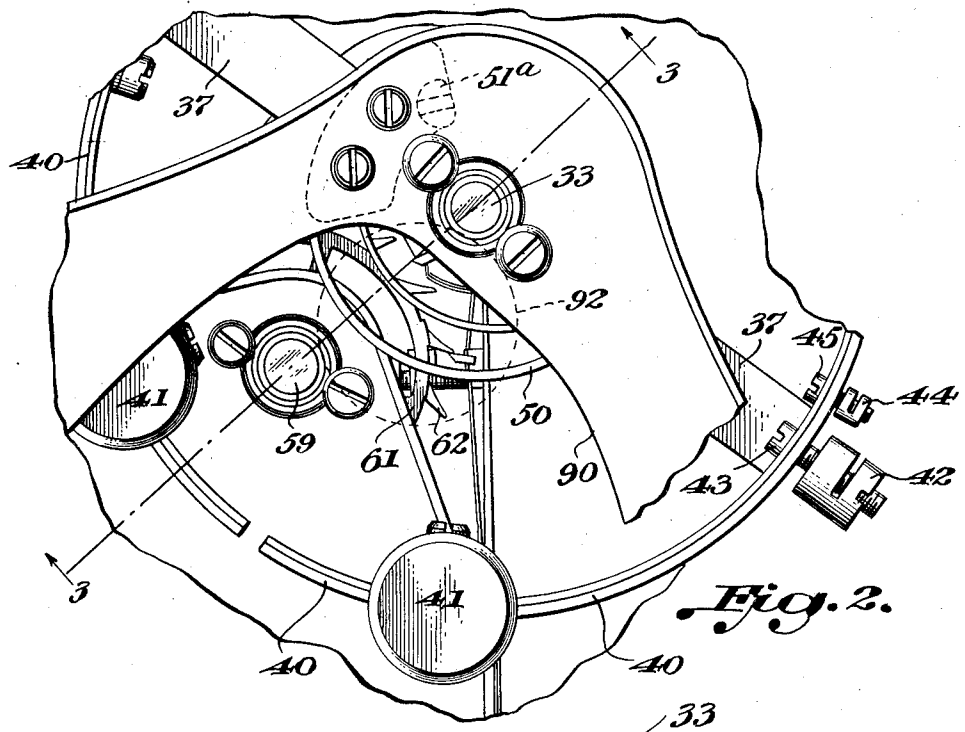


Fig. 2.

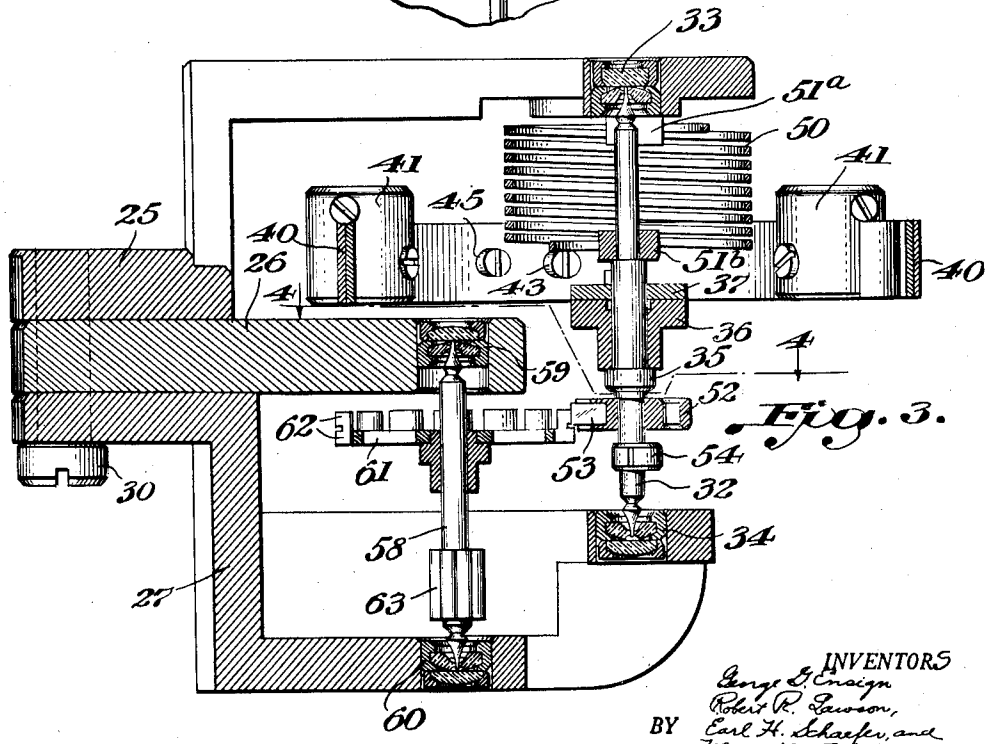


Fig. 3.

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MARINE CHRONOMETER DOUBLE TRACK ESCAPE AND PROJECTION SYSTEM

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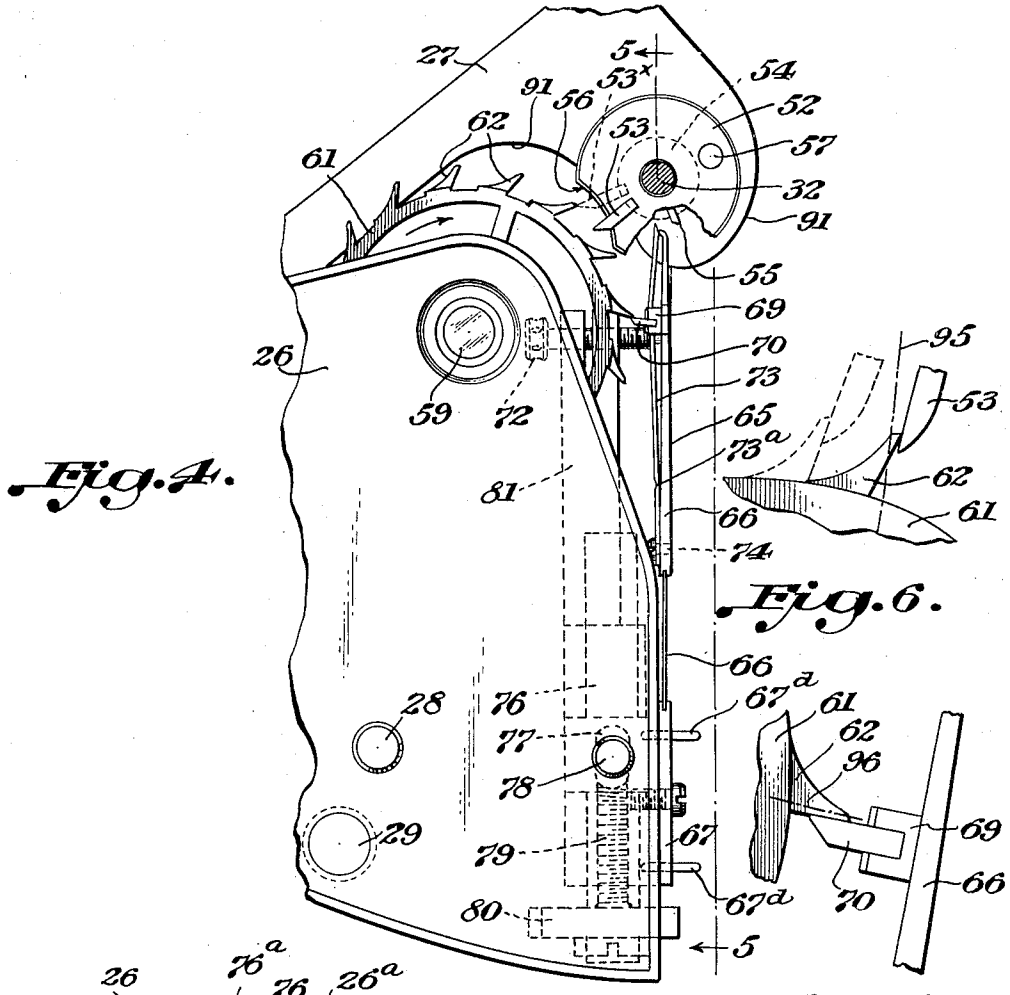


Fig. 4.

Fig. 6.

Fig. 7.

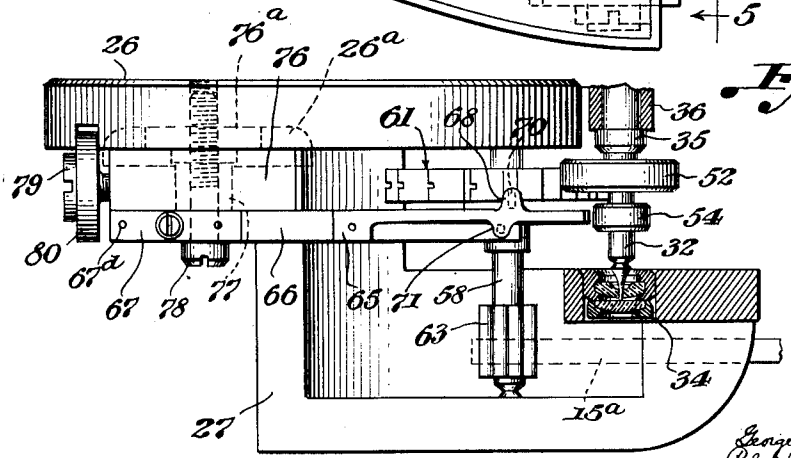


Fig. 5.

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UNITED STATES PATENT OFFICE

2,501,266

MARINE CHRONOMETER DOUBLE TRACK ESCAPE AND PROJECTION SYSTEM

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Application December 10, 1945, Serial No. 633,946

3 Claims. (Cl. 58—118)

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This invention relates to chronometer escapements and comprises structures for assuring accuracy of timekeeping and permitting correct and easy adjustment of these parts preliminary to service therefor.

One of the features of this invention is the provision of an escapement of the so-called chronometer type, in which different parts are employed for delivering the impulse to the balance wheel and for the unlocking or release of the escape wheel, and in which different parts of the escape wheel are utilized for these respective duties so that wear effects resulting from long service will not lead to inaccuracy in the timing.

Other features of the invention reside in the provision of a detent system which is adjustably supported and can be manipulated by adjustment means for assuring close and accurate setting of the detent for engagement by the discharge stone: and in which the shock of an escape tooth upon the locking stone is taken by a couple of forces.

A further feature of the invention is a provision of an escapement system by which the cooperating parts of the escape wheel, impulse roller and detent are so positioned in such relationship to their supports that a beam of light can be passed through the escapement for revealing the relative position of these parts when stationary, and their cooperation while in motion.

With these and other features as objects in view, as will appear in the course of the following description, an illustrative form of the invention is shown in the accompanying drawings in which:

Figure 1 is a general view of the train plate of a chronometer movement, including an escapement unit of an illustrative removable type.

Fig. 2 is a top view of this escapement unit, on a larger scale.

Fig. 3 is a sectional view substantially on line 3—3 of Figure 2.

Figure 4 is a sectional view substantially on line 4—4 of Figure 3, for illustrating the detent action.

Figure 5 is a sectional view substantially on line 5—5 of Figure 4, to show the detent assembly.

Figs. 6 and 7 are fragmentary views on a yet-larger scale, respectively illustrating the effects of wear upon the escapement teeth by the actions of the impulse and locking stones.

Figure 8 is a diagram of a projection system for inspection and adjustment.

In these drawings, Fig. 1 illustrates a chronometer movement having a pillar plate 10 and a train plate 11. The winding stem and ratchet

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12 are connected to the spring barrel 13 which is positioned as usual between the plates 10, 11. This spring barrel can be connected by a chain to a fusee mounted on a shaft 14, whereby to drive a clock train which may be of the usual type and includes a fourth wheel 15a (Fig. 5) supported by a staff in the usual way.

In this illustrated form of the invention, a removable escapement unit is employed, including the top piece or balance cock 25, the middle piece or escape plate 26 and a bottom piece or escape cock 27 (Figs. 1, 2 and 3) which together support the parts for the balance assembly, the escape assembly, the detent assembly, and the other structures which are driven from the fourth wheel 15a of the train and which serve to regulate the movement of the train. This removable escapement unit is secured to the train plate 11 by a screw 16, and is also secured thereto by a screw 17 which may extend into a pillar, as set out in the copending application of Ensign, Lawson, Schaefer and Wochos, Serial No. 594,570, filed May 18, 1945, now Patent 2,419,768, dated April 29, 1947. The train plate 11 has a roughly triangular cut-away portion which is filled by the escape plate 26: and the balance cock 25 is of greater peripheral dimension so that the securing screws 16, 17 pass through it into the train plate 11 to provide a strong and rigid structure.

The illustrated form employing the three pieces, being the balance cock 25, the escape plate 26, and the escape cock 27 in the removable unit, has the escape pieces 26, 27 secured by screws 29, and this sub-assembly connected to the piece 25 by the screw 30. Dowels 28 assure the accuracy of alignment of the pieces.

The balance staff 32 is supported in the jewel bearings 33, 34 respectively mounted in the balance cock 25 and the escape cock 27: each bearing having a hole stone and an end stone. Above the staff collar 35 is a bushing 36 upon which rests the spoke member 37 of the balance wheel BW, this spoke member 37 being tightly fitted to the staff. The balance wheel is formed with a rim provided by the bi-metallic arms 40 upon which are adjustably positioned the weights 41 which contribute a large part of the inertia mass of the balance wheel and provide, by their angular spacing on the thermally responsive arms 40 relative to the spoke member 37, a compensation for temperature variations. The gross adjusting nuts 42 are mounted on the screws 43 secured to the balance rim at the connections to the spoke member 37: each nut 42 has a slit nearly dividing it

with the parts forced out of true axial alignment to provide a lock against accidental movement. The fine adjusting nuts **44** of smaller size are mounted on the screws **45** which are diametrically opposed for poising and are located close to the screws **43**.

The hairspring **50** is of helical shape, with its upper fixed end pinned to the stud **51***a* on the top piece **25**, and the lower vibrating end pinned to the balance spring collet **51***b* which is tightly fitted on the staff **32**.

Below the collar **35**, the staff **32** has the impulse roller **52** mounted thereon and supporting the impulse stone **53**; and also the discharging roller **54** with the discharging stone **55**. The impulse roller **52** has a passing hollow **56** which with the stone **53** is counterbalanced by the hole **57**: and has a tight fit on the staff. The discharge roller **54** has a tight friction fit on the staff, so that its angular position can be shifted but sufficiently tight so that an adjusted position is retained.

The escape staff **58** is carried by the jewel bearings **59**, **60** in the escape plate **26** and the escape cock **27**, and itself supports the escape wheel **61**. This escape wheel (Figs. 3, 4 and 5) has the teeth **62** partly extending from the rim in its plane and partly extending above this plane: this width of each tooth permits engagement of the impulse stone and the locking stone **70** at different levels. The escape staff **58** has the pinion **63** which in the chronometer assembly is in mesh with the fourth wheel **15***a* of the train (Fig. 5).

The detent blade **65** is supported by the detent blade spring **66** connected to the detent foot **67**. An upper projection **68** (Fig. 5) of the blade **65** carries a pipe **69** (Fig. 4) in which is secured the locking stone **70**. The operating end of the stone **70** is thus clear of the pipe **69** and the blade **65**, for visual inspection of its position. A lower projection **71** is spaced along the blade **65** from the stud **69** and rests, during the locking period, against the position adjusting screw **72**, which is also out of alignment with the stone **70**. The passing spring **73**, sometimes called the gold spring, is secured to the detent blade by the screw **74** and extends along the blade between the stud **69** and the screw **72**, and projects beyond the top of the detent horn for engagement by the discharge stone **55**. It is preferred to provide a thinned portion **73***a* on the passing spring to localize most of the bending at a point as far as possible from the active end.

The detent foot **67** is guided by locating dowels **67***d* fixed to the block **76** having a slot **77** through which extends the securing screw **78** that holds the block against the lower face of the escape plate **26**, and maintains the tongue **76***a* of block **76** in guided position in a groove **26***a* in the plate **26**. An adjusting screw **79** has a collar **80** which engages a notch in the escape **26** whereby the screw **79** is held against axial movement but by its threaded engagement with the block **76** it effects longitudinal adjustment of the block **76** with the detent structures. The screw **78** when tightened serves to hold the block **76** securely in adjusted position. The bar **81** is formed as a part of the block **76** and supports the adjusting screw **72**: thus, as the block **76** and detent blade are moved by screw **79**, the screw **72** and the projection **70** are retained in proper correlated position.

The impulse stone **53** engages the upper ends of the teeth **62**, while the locking stone **70** engages the lower ends of these teeth (Fig. 5). Thus, different parts of the escape wheel act for impulse and for locking, so that the wear is distributed over the surfaces.

The wear upon the escape wheel teeth differs accordingly as the contact is made by the impulse stone or the locking stone. The impulse stone swings in an arc while being contacted by the escape teeth: part of this movement is shown in Fig. 6 as the parts pass from the dotted to the full line position, from which it will be seen that the wear is greater at the outer edge of the tooth than at points along its face, whereby the wear leads to a shape as indicated by the dash line **95**. On the other hand, the locking stone **70** is preferably adjusted so that it receives the escape tooth **62** flatwise over a large area at the instant of locking (Fig. 7). During unlocking, when the detent blade **65** is moved outwardly by the discharge stone, the locking stone **70** is drawn along the face of the tooth **62**, so that the wear thereon is essentially uniform as the pressure does not vary greatly. Hence the engaged portion of the surface of tooth **62** during unlocking normally wears along a dot-dash line **96**, which is essentially parallel to the tooth face itself. This difference in wear causes difficulty when both the impulse stone **53** and the locking stone **70** act on the same tooth surface, as the curvature produced by the wear against the stone **53** leads to a shape illustrated by the line **95**, wherewith the escape wheel will creep forward as the locking stone **70** is withdrawn and the discharge action is made irregular. Thus the segregation of functions to the separate parts of the individual teeth **62** assures a longer life, and a more accurate service during the life of the parts. Each tooth part can wear to that shape which each action tends to produce, without complex error arising by the action of the impulse stone in causing wear of the tooth part engaged by the discharging stone, and vice versa. Thus, when the cooperating parts have been "broken in" by initial running, the later wear is very slow and regular.

The balance cock **25** is cut away as indicated by the line **90** in Fig. 2, to provide a hole opposite the impulse stone **53**, the locking stone **70**, the cooperating portions of the periphery of the escape wheel **61**, and adjacent parts of other structures. Similarly, the escape cock **27** is cut away as indicated by the line **91**—**91** (Fig. 4) for likewise exposing the same parts. The spoke arm **37** is of limited size at its center so that the impulse stone **53** projects beyond it, into alignment with these holes, at the moment of impulse reception. The impulse stone **53** and the locking stone **70** are preferably of sapphire, ruby or other colored light-transmitting and wear-resisting materials. Light may be projected as a beam marked by the circle **92** in Fig. 2, through the escapement unit in a direction generally parallel to the axes of the staffs, and then gathered by a focussing system to form an enlarged image upon a pattern sheet; and the image of the stone and detent observed in conjunction with the escape wheel. Thus, the relative positions and operations of the parts of the escapement unit can be studied during the adjustments, and the parts brought to the positions indicated by the pattern sheet.

After assembly of the parts, the operator adjusts the staffs to proper end shake and positions the block **76** so that the discharge stone **55** does not engage the horn of detent blade **65**. It is customary to do this while the illustrated escapement unit is free of the other parts of the chro-

nometer assembly, and to employ a light projection system as set out in Fig. 8, with a fixture 100 in which this unit is mounted in predetermined position. In so mounting it, the parts are brought into engagement with a fourth wheel 15a in the projector which can be driven by appropriate power source such as a coil spring 101. The lamp 102 and condensing lens assembly 103 project a beam of light 104 through the escapement: and the lens system 105 and mirrors 106, 107 cause the enlarged image of the parts within circle 92 of Fig. 2 to appear upon the pattern sheet 108.

The work of assembling the parts brings the escapement into approximate beat. The operations of adjusting to correct operation and rate may be accomplished as follows:

(a) The clearance of the impulse stone is established by releasing the clamping screw 78 and rotating the adjusting screw 79 to move the locking stone 70 and thus to rotate the escape wheel 61 until the two teeth nearest the impulse roller have equal impulse stone clearances. The amount of this movement is small because of the accuracy of manufacture and careful inspection of the parts: and never brings the horn of detent blade 65 into the path of the discharge stone. The clamping screw 78 is tightened to fix the adjustment.

(b) The lock or amount of overlap of the locking stone 70 with the engaged escape tooth 62 is adjusted by the screw 72. Thus, the detent blade 65, 66, 67 is now in position.

(c) The lift of the gold or passing spring 73 is now adjusted by shaping the end of the spring and, with the screw 74 loose, moving the spring 73 endwise towards or from the balance staff until a desired lift and release effect is observed as the rollers are rocked. The screw 74 is tightened to secure the spring 73 in position.

(d) The discharge roller 54 is turned on the staff 32 until the two roller stones are at the correct relative angle. The correct position and unlocking action is present when an escape tooth 62 drops onto the impulse stone when this stone 53 is in a definite position drawn on the projection diagram 108, for example as shown by the full lines 53 in Fig. 6. This diagram is prepared by indicating thereon the end positions of the image of the impulse stone 53 when a standard and properly adjusted balance is oscillating in beat; and the full line position in Fig. 6 is then drawn as that at which the full angle of movement of the impulse stone clearing engagement with an escape wheel tooth 62 is bisected by the line of centers of the escape and balance. The impulse roller 52 in preferred construction is so tightly fitted to the staff that it does not turn thereon; if slippage of the impulse stone occurs while the discharge roller is being turned for adjustment, a beat readjustment is necessary. Some operators prefer to put the escapement in beat before this adjustment (d) is accomplished, to ascertain the prevailing relationships of the staff and its other parts with respect to the rollers.

(e) The detent lift is checked by rotating the balance in a counterclockwise direction in Fig. 4 and observing the action as the discharge stone 55 acts through the detent to disengage the locking stone 70 from the escape wheel tooth. These effects are observed by the projection image and its relation to the standard pattern. If an unsatisfactory action is observed, adjustments (a), (b) and (c) are rechecked and corrections made.

(f) The escapement is put in beat by turning the hairspring collet on the balance staff. When the escapement is in beat, the position of the impulse stone image on the projection diagram should coincide with the position thereon for the balance parts at rest (Fig. 6).

(g) When these static adjustments have been made, power is applied to the escape wheel through a fourth wheel 15a from a temporary drive spring 101 (Fig. 8); and the operation of the system observed by the projected image. Due to the rapidity of movement of parts and the detention of the escape wheel 61 by the locking stone 70 after each balance movement, a stroboscopic effect occurs and the dynamic behavior of the parts can be observed during actuation and slight adjustments made for any error appearing during this test of operation. In practice, a relatively few revolutions of the escape wheel will suffice for this at initial assembly, with due preliminary care in manufacture and inspection of the escape wheel. During this time, also, localized irregularities of other cooperating parts may appear, thus indicating the place and nature of the trouble and permitting further static studies, and studies while slowly moving parts manually: replacements and corrections are then accomplished before assembling into a chronometer.

The balance masses can now be adjusted under varying conditions of temperature, etc., so that the moment of inertia of the balance wheel remains constant under the various conditions of probable service. When this has been accomplished, the unit can be packaged and handled as a replacement for a faulty unit in an existing chronometer, or can itself be introduced into a new chronometer which is being manufactured.

The operation of the escapement may be briefly described as follows:

The main spring performs its usual function of driving the train and operating the hands. The train includes a fourth wheel 15a which is engaged with the pinion 63 on the escape staff 58. With the parts shown in the position of Fig. 4, one tooth 62 of the escape wheel 61 is being detained by the locking stone 70. In this figure the balance has completed its counter-clockwise movement and is now rocking in a clockwise direction. The impulse stone 53 clears the two teeth 62 which are opposite its path. The discharge stone 55 will shortly (after leaving the position of Fig. 4) engage the passing spring 73 and move past this spring, whereupon the spring will return to the position shown in Fig. 4.

When the balance completes its movement in a clockwise direction, it begins to return in the working or counter-clockwise stroke. The impulse stone 53 moves to the position 53x shown in dotted lines in Fig. 4 and attains this dotted position at essentially the same instant when the discharge stone 55 has engaged the passing spring 73 and moved the detent until the locking stone 70 releases the tooth 62 with which it has been engaged. The escape wheel 61 is now free to move: and one of its teeth immediately engages the impulse stone 53 at essentially the position 53x and delivers the maintaining impulse to the balance system. By effecting the adjustments as prescribed above, the impulse angle, or angle of balance movement during the reception of impulse, can be so located as to be bisected by the dead center line, wherewith the retarding and advancing effects thereof neutralize each other.

As the discharge stone 55 releases the passing

spring 73, the detent moves backward and again engages the screw 72 which provides a stop, so that the locking stone 70 is in position to receive the next tooth 62 and thus lock the escape wheel again.

It may be pointed out that the engagement of each tooth 62 with the locking stone 70 produces a couple of forces for the reason that this engagement occurs out of the line of the detent blade 65 and its spring 66, so that there is a bending or rocking of the detent system with the end of screw 72 forming a rest over which there is a slight longitudinal sliding motion of the projection 71 of the detent blade 65. This slight yield cushions the impact of the tooth 62 upon the locking stone 70 and serves to reduce the fatigue wear upon the teeth, and the possibility of fracturing the locking stone 70.

It is obvious that the invention may be employed in other ways within the scope of the pending claims.

We claim:

1. A chronometer escapement comprising plate and cock structures, an escape wheel pivoted on said structures, a balance assembly pivoted on said structures, the balance assembly including an impulse stone actuated from the escape wheel and a discharge stone, and a detent assembly including a detent blade and a locking stone carried by said blade and also including a block guided by the plate for longitudinal adjusting movement with the detent blade thereon, means for clamping said block to the plate in adjusted position, said detent assembly also including a part positioned for engagement and actuation by said discharge stone whereby the detent blade is moved for releasing the locking stone from the detent wheel; said plate and cock structures being constructed and arranged with spaces effective to permit light rays to pass in a direction essentially parallel to the escape wheel axis, said impulse stone and locking stone being attached in positions offset respectively from adjacent opaque parts of the balance and the detent assembly and located opposite said spaces, said escape wheel being constructed and located in said structures so that it projects into the path of said light rays, whereby visual inspection may be made of related static and stroboscopic-dynamic concurrent positions of the escape wheel, impulse stone, and locking stone.

2. A chronometer escapement having a toothed escape wheel, a balance assembly including an impulse stone actuated from the escape wheel and a discharge stone, and a detent assembly including a detent blade, a detent spring supporting the detent blade, a locking stone mounted on the detent blade and effective for detaining the escape wheel and a device on the detent blade actuated by the discharge stone and effective for moving the locking stone toward and from the axis of the escape wheel, characterized in that the impulse stone and locking stone are arranged at different radial planes through the escape wheel whereby the said stones act upon different portions of the teeth of said escape wheel, said teeth having essentially identical sections at the planes of engagement of said stones therewith.

3. A removable escapement structure for a chronometer having a train plate provided with a notch; said structure including a balance cock portion overlying the train plate and secured thereto, a second portion fitted in said notch, and a third and depending portion; said structure including bearings for the balance and escape assemblies, and also including a support for the detent assembly, said second portion and said support having interengaging guide parts for limiting the movement of the support to longitudinal adjustment along said structure toward and from the balance assembly, and means for fixing said support in adjusted position, and balance and escape assemblies in said bearings, said balance assembly including a balance spring having its fixed end connected to said balance cock portion.

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