Dec. 25, 1951 G. G. ENSIGN ET AL 2,579,914

CHRONOMETRIC CIRCUIT CONTROLLER

Filed Dec. 9, 1949 2 SHEETS—SHEET 1

Fig.1

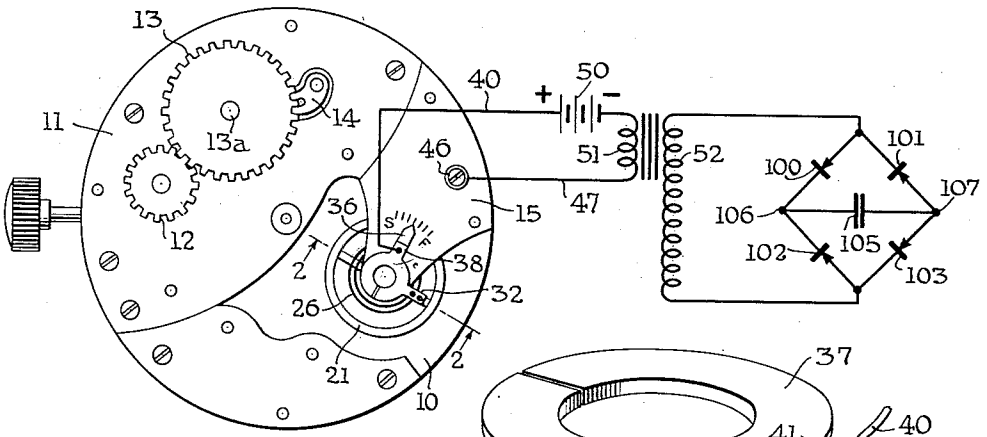


Fig.3

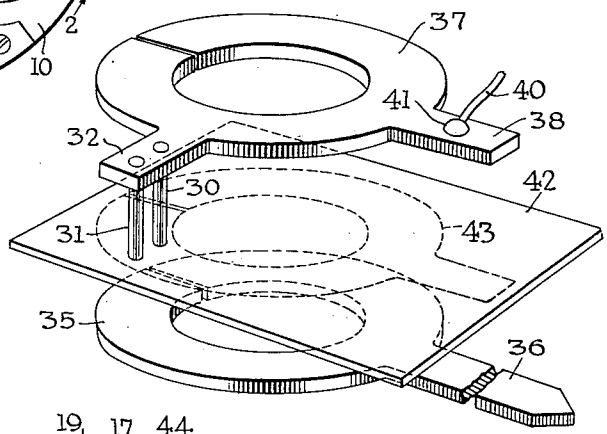
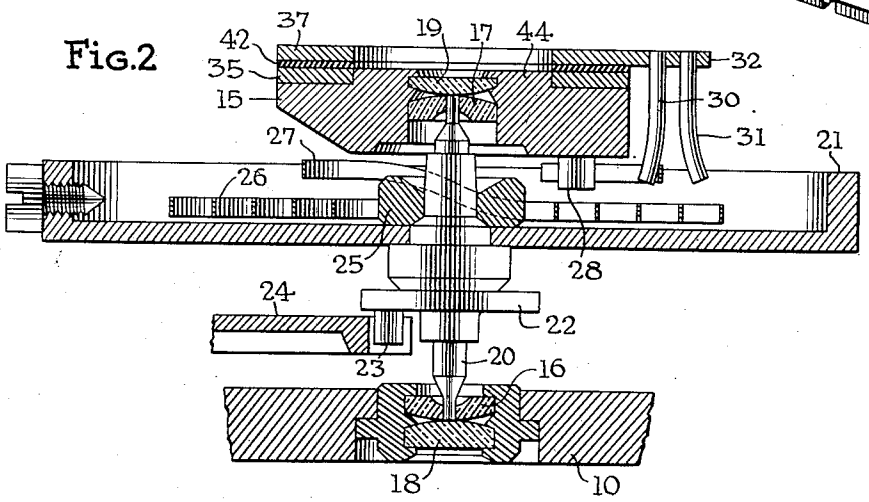


Fig.2



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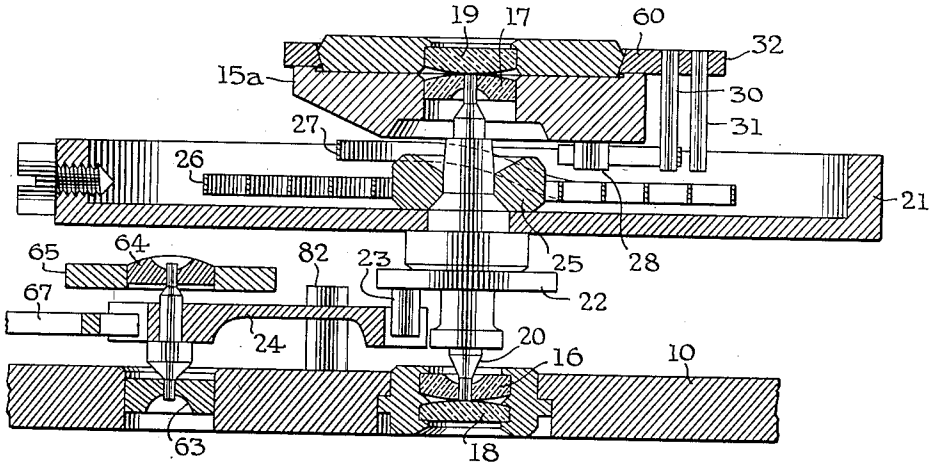
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CHRONOMETRIC CIRCUIT CONTROLLER

Filed Dec. 9, 1949

2 SHEETS—SHEET 2

Fig. 4



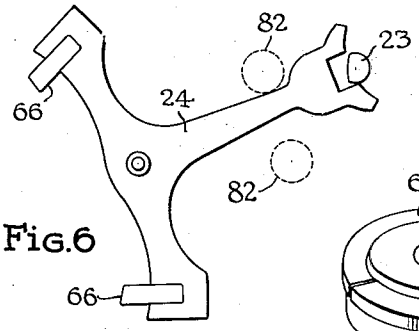


Fig. 6

Fig. 5

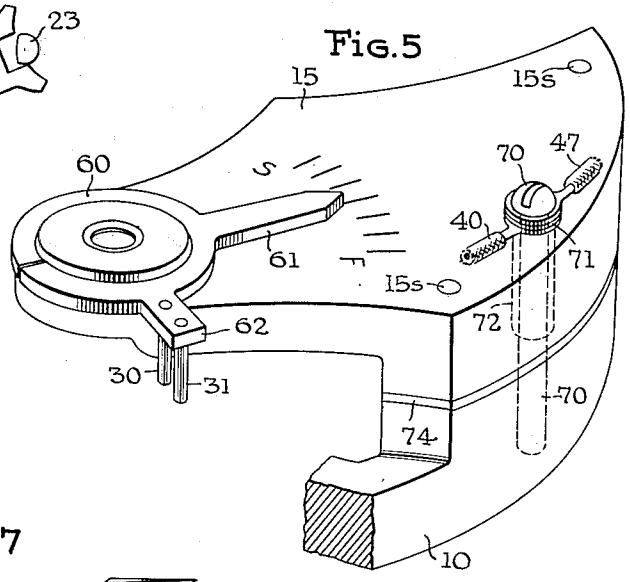
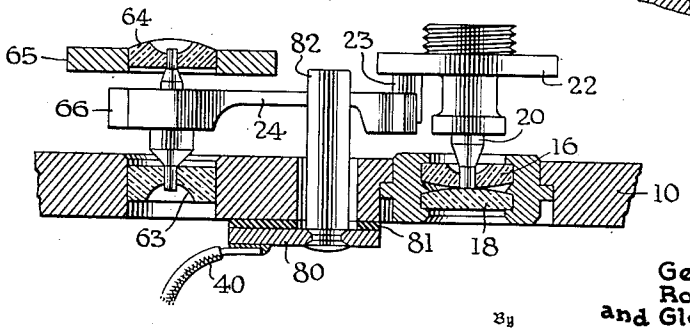


Fig. 7



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CHRONOMETRIC CIRCUIT CONTROLLER

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10 Claims. (Cl. 58—33)

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This invention relates to a chronometric circuit controller in which a horological movement, driven from a source of power such as a mainspring and including a gear train whose movement is controlled by a balance-and-escape system, is employed for accomplishing the closing and opening of an electrical circuit successively at predetermined time intervals.

A feature of the invention is the provision of a small, light, and compact chronometric circuit controller, of small weight and capable of cheap construction by the employment of normal parts of a standard watch movement, with the addition or modification of minor parts for the circuit-breaking and connection elements.

Another feature of the invention is the provision of a chronometric circuit controller employing a standard watch movement modified by the separation electrically from the main frame structures, of parts of the balance-and-escape system whereby the already-occurring mechanical contacts in said systems, as an incident of the operation thereof, are employed for making and breaking an electrical circuit.

A further feature of the invention is the provision of a chronometric circuit controller employing a normal watch movement modified by the employment of an insulated part for the regulator lever and carrying at least one regulator pin, whereby an electrical circuit is made and broken by the expanding and contracting motion of the hair-spring during oscillation, wherewith the hairspring makes contact with said regulator pin.

Another feature of the invention is a modified form of construction wherein a chronometric circuit controller comprises a normal watch movement having jewel bearings for the balance assembly, this assembly being electrically isolated from the main frame, and employing a conductive roller pin for engaging the conductive pallet or escapement piece, and with preference of employment of a conductive support bearing for the arbor of said pallet or escapement piece, whereby to complete a short path to the main frame of the movement.

A further feature is the provision of a chronometric circuit controller in a form in which a normal watch movement is modified to have the balance support, such as the balance cock, insulated from the main frame or pillar plate and in which the bearing for the balance staff, provided in the balance cock, is of conductive material to provide a part of an electrical circuit by which a conductive roller pin makes intermittent contact with the pallet or escape piece during the

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course of oscillation: and preferably with a conductive support bearing for the pallet or escape piece arbor to provide a short path to the main frame.

With these and other features as objects in view, illustrative forms of practice of the invention are shown on the accompanying drawings, in which:

Figure 1 is a rear view of a normal watch movement, modified in accordance with one form of practice of this invention, and having a conventionalized external electrical circuit connected therewith.

Figure 2 is an upright sectional view substantially on the plane 2—2 represented on Figure 1, showing parts of the circuit controller on a larger scale.

Figure 3 is an exploded perspective view, showing the parts of the regulator assembly as modified for this first form of the invention.

Figure 4 is a view corresponding to Figure 2, but showing a modified form of construction of the parts.

Figure 5 is a fragmentary perspective view, substantially on the scale of Figure 4, showing a method of insulating the balance cock and of connecting wires to establish external conductors.

Figure 6 is an elevation of a pallet for use in the structures, and indicating a position of the roller pin.

Figure 7 shows a further modification, shown as applied to parts of the structure in Figure 4.

In these several forms of construction, a standard watch movement has been illustrated as being modified for the purpose of forming the chronometric circuit controller.

In Figure 1 the watch movement is shown in rear elevation, and it will be understood that this movement includes the various parts such as mainspring, gear train, and the like, present in the normal watch movement. In this rear elevation, the main front or pillar plate 10 is connected to the other parts, such as a bridge 11 on which are mounted the wheels 12, 13 of the winding train leading to the mainspring arbor 13*a*, and the retaining pawl 14 of this winding train, which holds the mainspring in wound condition. Likewise, the pillar plate 10 supports the balance cock 15.

As shown in Figure 2, the pillar plate 10 and the balance cock 15 receive the hole-stones 16, 17, and the end-stones 18, 19 which are of sapphire and of normal form and supported in a normal fashion. The balance staff 20 oscillates in these bearings. The balance staff supports the balance

wheel 21 and the roller 22 having the illustrated roller pin 23 for engaging in the fork of the pallet or escape piece 24. The staff 20 also supports the collet 25 to which is attached the inner end of the hairspring 26. This hairspring includes an over-coil 27 at its outer end, which is raised above the general plane of the spirally coiled part of the hairspring 26, and is passed into the hairspring stud 28 and pinned thereto in the usual fashion (not shown), with this hairspring stud 28 fastened to the balance cock 15 as usual. These parts are normal and the standard watch movement can be employed therefor.

Likewise, the over-coil portion 27 of the hairspring alternately engages the inner regulator pin 30 and the outer regulator pin 31 during its oscillation, these pins being carried by the usual radial projection or ear 32 of the regulator lever.

One modification for forming the device as a chronometric circuit controller is to form this regulator lever in two parts, as shown in Figure 3. The lower part 35 has an index arm 36 of the usual length, but does not have an ear or radial projection for supporting regulator pins: it can be made from a normal regulator lever by removing this ear therefrom. The upper part 37 of the regulator lever has a shortened index arm 38, and is provided with the usual ear 32 for the regulator pins 30, 31 which can be formed as usual with a friction fit in the ear 32. An electrical conductor leading to the exterior of the movement includes a wire pig-tail 40 which is attached by a screw or by soldering 41 to the clipped index arm 38. During the preparation and assembly of the parts of the regulator lever, the lower surface of the upper part 37 and the upper surface of the lower part 35 are coated with an adhesive insulating cement, such as a phenol-aldehyde semi-cured resin: they are then pressed together with a thin insulating sheet 42, such as cellophane, between them, and the unit is heated in an oven to about 150° C. for an hour to cure the cement to insoluble and firmly adherent condition. The sheet 42 can then be trimmed as indicated by the dotted lines 43. The assembly can then be frictionally mounted upon the balance cock dome in the usual fashion, wherewith the insulating layer 42 holds the regulator part 37 spaced and elevated out of electrical contact with the balance cock dome 44.

The balance cock 15 is normally secured to the pillar plate by a screw 46, and a further conductor 47 may be connected beneath this screw to establish electrical connection to the balance cock, as the frame and balance cock are electrically connected and at the same potential.

The external circuit, for illustrative employment of the chronometric circuit controller as a part of a system in which a battery current is made and broken periodically through a transformer, is shown by Figure 1 to have an extension of the conductor 40 to the positive pole of a battery 50, then through the primary winding 51 of the transformer, and back by the conductor 47 to the balance cock. That is, it is preferred that the positive pole of the battery be connected to the regulator pins 30, 31. The secondary coil 52 of the transformer may have a greater number of turns than the primary, and in practice it has been found that by use of a battery 50 having a potential of 1½ volts, a potential as high as 1500 or 2000 volts may be developed at the terminals of the secondary winding 52.

In some cases it has been found advantageous to employ beryllium-copper hairsprings 26, 27 and any sparking effects can be reduced by the presence of a rhodium plating upon the hairspring. The regulator pins 30, 31 can be made of palladium or of platinum-iridium, with a like advantage of avoiding electrical troubles.

The operation of the device is as follows:

The watch movement operates in normal fashion. That is, the power from the mainspring is delivered through the normal train to the escape wheel, and this escape wheel is being detained by the pallet pins in the usual fashion. As the balance wheel 21 oscillates at a rate determined by the mass of the balance system and the elasticity effect in the hairspring 26, the roller pin 23 of the balance system enters the fork of the pallet, in usual fashion, and causes an oscillation of this pallet. As usual, a clockwise movement of the balance will cause movement of the pallet in one direction, with a corresponding movement of the escape wheel: while the counterclockwise return stroke of the escape system effects the further release of the escape wheel by the one unit of movement, through the action of the pallet. On each occasion that the pallet moves to unlock and thereby permit movement of the escape wheel, the escape wheel also acts through the pallet to give impulse to the balance system to maintain the motion thereof. All this is old and well-known, and is described herein as indicating that the balance system is kept in maintained oscillation at a predetermined rate. At each oscillation, the hairspring 26 tends to increase in the relative radius of each of its turns during motion in one direction, and to decrease in such radius during motion in the opposite direction, with respect to the position occupied by the hairspring spiral when the system is at rest. As the hairspring expands (Figure 2) the over-coil portion 27 of the hairspring likewise increases in relative radius, so that this part of the hairspring encounters the outermost regulator pin 31. During the free movement of the over-coil portion 27 between the regulator pins, a tentative circuit has been established from the battery 50 extending on the one hand by conductor 40, with its pig-tail, the regulator arm 38 which is insulated from the rest of the watch movement, and the regulator pins 30, 31. On the other hand, the battery 50 is connected through the primary winding 51 of the transformer and the conductor 47 to the balance cock 15, the hairspring stud 28, the over-coil portion 27 of the hairspring, but gaps exist between this over-coil portion 27 and the regulator pins 30, 31 so that no current flows. However, when the over-coil portion 27 encounters the regulator pin 31, the circuit is closed and current flows through the primary winding 51 of the transformer, so that the field strength thereof is built up. As this magnetic field strength varies, correspondingly a current flow begins in the secondary winding 52 with a voltage across the terminals of the secondary winding 52 which is roughly proportional to the turns-ratio in the transformer multiplied by the voltage of the battery 50.

It will be noted that this encounter of the over-coil 27 with the regulator pin 31 is a normal procedure in the operation of the watch movement. It occurs near the end of the particular stroke of oscillation of the balance system and lasts for a time dependent upon the relative position or adjustment of the regulator pin 31. Thus, to shorten the duration of this contact, the regulator pin can be bent outwardly at an angle, at its lower end, as shown in Figure 2: and a further control can be exercised by changing the

position of the regulator, wherewith the duration of the contact can be increased or reduced without a major change of the rate of oscillation.

When the hairspring 26 has brought the balance system to a standstill at the end of such stroke, the energy stored in the hairspring causes the balance to accelerate in the return stroke, wherewith the over-coil portion 27 soon moves away from the regulator pin 31, therewith opening the circuit again. Since the energization in the transformer core is no longer being maintained, its magnetic field drops, and therewith a new current effect is established in the secondary winding 52, in the opposite direction.

The balance system accelerates until it reaches neutral axis, and therewith the hairspring 26 attains its spiral position of rest: but the momentum of the balance wheel 21 now causes the system to continue in its movement past the neutral axis, therewith again storing energy in the hairspring 26, but causing a decrease in the relative radius of the turns of this hairspring. As the balance system slows down, near the end of this return stroke, the over-coil portion 27 now encounters the other regulator pin 30, and again makes the circuit as before. When this return stroke is completed, and the balance system again begins to move in the forward stroke, the circuit is again interrupted between the over-coil portion 27 and the regulator pin 30. It will be noted that the time duration of closure of circuit between the over-coil portion 27 and the regulator pin 30 can here also be adjusted by bending the regulator pin 30, as indicated in Figure 2. It will be understood that Figure 2, for clearness, has shown the relative spacing of the regulator pins 30, 31, and the relative thickness of the over-coil portion 27 of the hairspring as greatly exaggerated.

Thus, in this illustrative form where both regulator pins 30, 31 are electrically connected to the ear 32 and conductor 40, the circuit for energizing the core of the transformer 51, 52 is energized twice during each oscillation of the balance system, once during the forward stroke and once during the return stroke.

While the normal hairspring length and section can be employed, this is not compulsory: and it is feasible to use shorter hairsprings, or hairsprings of a different section, e. g. not normal for the specific watch movement size; so that, for example, the balance system will have a 10-beat movement instead of a 5-beat movement per second.

In Figure 4, the pillar plate 10 and the balance cock 15*a* support parts as described for Figure 2 except that the regulator lever 60 is of usual construction, as indicated in Figure 5, with the index arm 61 and the ear 62 for supporting the regulator pins 30, 31. The pallet or escape piece 24, with its fork, is shown in Figures 4 and 6 as supported by bearings 63, 64 carried respectively by the pillar plate 10 and by the pallet bridge 65 supported as usual from the pillar plate 10. The pallet carries the sapphire pallet stones 66 for engaging the escape wheel 67. As the sapphire is non-conductive, there is no transmission of electric current directly between the pallet and the escape wheel, and hence no spurious current changes at unlocking, drop, etc.

In this form, the balance cock 15 is insulated from the pillar plate 10. The steady pins 15*s* are of insulating material, e. g. of nylon. As shown in Figure 5, the balance cock 15 is secured to the pillar plate by a screw 70 which is illustrated as

having its head extending above the balance cock, and electrically engaged with the conductor 47. Beneath this conductor, as it surrounds the screw 70, is a disk 71 of insulating material, such as a plastic: cellophane has been found satisfactory for most employments. Beneath this disk 71 is an eye formed at the end of another conductor 46, this conductor thus being in electrical contact with the balance cock 15. An insulating sleeve 72 shown in dotted lines in Figure 5, insulates the screw 70 from the balance cock 15 along the length of the screw. The threaded lower end of the screw engages in and forms both mechanical and electrical connection to the pillar plate 10. A layer of insulating material 74, such as cellophane, is interposed between the balance cock 15 and the pillar plate 10. Thus, the balance cock and its structures, including the regulator pins 30, 31 is insulated from the pillar plate 10. When the watch parts used are of limited size and tolerance, the balance cock can be dressed off by an amount corresponding to the thickness of the insulating layer 74.

The operation of this system comprises the normal operation of the watch movement as described above. When the over-coil portion 27 of the hairspring is free of the regulator pins 30, 31, the current passage can be from the battery 50 by the conductor 49 to the balance cock 15, stud 28, the hairspring 27, 26, collet 25, the staff 20, and roller 22 to the metal roller pin 23: but this circuit is only completed at the roller pin 23, when this roller pin is in contact with one or another part of the pallet 24. Thus, as the balance system approaches neutral axis in its forward movement, the metal roller pin 23 enters the roller notch on the pallet 24 and makes contact with the far side of this notch, therewith producing mechanical movement of the pallet to unlock the escape wheel and at the same time completing the electrical circuit, so that the current can continue its flow through the pallet, the pallet staff, the metal bearings 63, 64, of the pallet arbor, the pallet bridge 65 and the pillar plate 10, screw 70, and conductor 47 back through the primary winding 51 of the transformer to the battery 50, using the same external circuit as shown in Figure 1. Thus, the core of the transformer is magnetically energized. The unlocking of the escape wheel is, however, promptly followed by the movement of this wheel and its action upon the pallet to deliver impulse to the roller pin and thus to the balance system. Therewith, the pallet is accelerated and moves faster than the roller pin, so that this circuit is opened again momentarily. When the pallet again strikes the roller pin, to deliver impulse, the circuit is again closed. Finally, since the pallet and the roller are moving about different axes, they again separate in the usual movement of the watch structures, and the circuit is opened again. During the return stroke of oscillation of the balance system, likewise, two circuit closures occur, the first taking place when the roller pin encounters the pallet and causes unlocking of the escape wheel, and the second closure taking place when the pallet has accelerated and delivers the impulse to the balance system.

By the use of conductive bearings, such as metal bearing pieces 63, 64, for the pallet arbor, the current path is direct to the pillar plate 10 and the pallet bridge 65, without requiring transfer into the gear system: and by having the pallet stones 66 of sapphire, actual insulation is provided, so that the opening and closing of the

electrical circuit is not a function of the unlocking or impulsing between the escape wheel and the pallet.

The structure shown in Figures 4, 5 and 6, and employing sapphire bearings for the balance staff 20, is of use and value where a relatively high resistance in the primary circuit is permissible or desirable. In this arrangement, the current flows through the entire length of the hairspring between the stud 28 or the regulator pins 30, 31 and the collet 25.

Where the employment of such a high resistance is not desirable or permissible, a modified form of construction can be used, which is essentially identical in general appearance with that shown in Figures 4, 5 and 6, but in which the bearing stones 17, 19 are of conductive material, such as metal. The operation, in this case, involves the normal movement of a watch structure as described above, but in this case the current flows from the balance cock 15 through the conductive bearing pieces 17, 19 directly to the staff 20.

When a pulse of extremely short duration is required, this can be attained with the same general structure, but with the banking pins insulated relative to the frame: that is, as in Figure 7, the sub-plate 80 is separated from the main frame by bonding insulation 81 and supports the metal banking pins 82, the circuit then leading from the sub-plate 80 by conductor 10. In this case, the contact of the conductive roller pin 23 with the pallet 24 closes the circuit through the pallet and the banking pin 82 then in contact with the pallet, and thence by conductor 10 as before. The mechanical action of the roller pin upon the pallet, however, immediately separates the pallet from the banking pin, and the circuit is thus quickly and immediately broken again. As the pallet moves, it over-speeds the roller pin, and comes to rest against the other banking pin without re-making the circuit. When both banking pins are conductive, such rapidly succeeding make-brake actions occur in both strokes.

The higher resistance path, through the hairspring 26, 27 exists as before, but is in parallel to the main low resistance path through the bearings 17, 19, and is not dominant in the action.

The operation of the devices, as described above, produces single beats or double beats per stroke of the balance system, and these beats appear as electrical impulses of predeterminable length and frequency. Another feasibility of employment of the system is that of providing a mechanical interrupter of small size and weight but capable of delivery of calibrated quantities and voltages of current. Such an employment is indicated in Figure 1, in which the secondary or output winding 52 is connected to the four rectifiers 100, 101, 102, 103 arranged in bridge for double-wave rectification of the alternating impulses from the winding 52, and so directing these impulses that they build up a unidirectional potential difference upon the condenser 105 connected between the mid-points of the pairs of rectifiers 100—102 and 101—103. These mid-points 106, 107, thus constitute terminals from which a steady high potential direct current may be drawn. Such a current can thus be easily and simply produced for use in an electrometer or like electrical potential device.

In practice, the device will handle relatively high current density at the contacts. In one example of practice with the structure shown in Figures 1, 2 and 3, the current density during electrical flow, in the fraction of the hairspring between the stud 28 and the regulator pin 30 or 31, was above one million amperes per square inch.

It is obvious that the invention is not limited to the forms of construction shown, but that it may be employed in many ways within the scope of the appended claims.

We claim:

1. A chronometric circuit controller including a chronometric movement having a frame and thereon a balance assembly of staff, wheel, and hairspring and a pallet, the combination therewith of a regulator lever electrically insulated from the frame and carrying a conductive regulator pin for engagement by the hairspring during balance oscillation, and conductors electrically connected to the hairspring and to said regulator lever.

2. A chronometric circuit controller as in claim 1, in which the said regulator lever is part of an assembly comprising a bearing portion, an eared portion, and an insulation layer mechanically connecting said portions and insulating them from one another, the ear of said latter portion supporting the regulator pin.

3. A chronometric circuit controller as in claim 1, in which the said regulator lever is movable for varying the position of the regulator pin relative to the hairspring, whereby to change the duration of contact of the hairspring and regulator pin.

4. A chronometric circuit controller including a chronometric movement having a main frame piece and a balance cock piece, electrically insulating material separating said pieces, a balance wheel and staff mounted in said pieces for oscillation, a hairspring connected to the balance wheel and staff at one end and to the balance cock at the other end, a pallet pivoted on said main frame, a roller on said staff and having a conductive roller pin cooperative with said pallet, and conductor means leading from the balance cock and the pallet.

5. A chronometric circuit controller as in claim 4, in which the main frame piece has an electrically conductive bearing for the pallet, forming part of the conductor means from the pallet.

6. A chronometric circuit controller as in claim 5, in which the pallet has insulating pallet stones.

7. A chronometric circuit controller, including a chronometric movement having a frame and thereon a balance assembly of staff, wheel, and hairspring and a pallet, said balance staff being electrically connected to the frame, the combination therewith of an electrically conductive banking pin electrically insulated from the frame, said pallet being of electrically conductive material and electrically insulated from the frame, and a roller of electrically conductive material carried by said balance staff and having thereon a conductive part cooperative with the pallet during the oscillation of the balance assembly, and conductors leading from the frame and from the said pin.

8. A chronometric circuit controller, including a chronometric movement having a frame and a balanced assembly including a balance staff, said balance staff being electrically connected to the frame, a conductive element carried in oscillation by said staff, a contact member mounted on the frame and presenting a part in the path of oscillation movement of the said conductive element to be contacted electrically and moved mechanically thereby, a conductive element insu-

latedly mounted on the frame and positioned in the path of movement of said contact member, and electrical conductors leading from said conductive elements whereby the circuit through said conductors is closed only during the period when said contact member is simultaneously engaged with both said conductive elements.

9. A chronometric circuit controller including a chronometric movement having a frame and a balance assembly including a balance staff, a contacting element carried in oscillation by said staff, a conductive contact member mounted on the frame and presenting a part in the path of oscillation movement of the said contacting element and moved mechanically thereby, a conductive element insulatedly mounted on the frame and positioned in the path of movement of said conductive member, and electrical conductors leading from the said conductive element and conductive contact member whereby the circuit through said conductors is closed only during the period when said conductive contact member is simultaneously engaged with both said contacting element and said conductive element.

10. A chronometric circuit controller including a chronometric movement having a frame and a balance assembly including a balance staff, said balance staff being electrically connected to the frame, a conductive element carried in oscillation

by said staff, a contact member mounted on the frame and insulated from the frame and presenting a part in the path of oscillation movement of said conductive element to be contacted electrically and move mechanically thereby, a second conductive element insulatedly mounted on the frame and positioned in the path of movement of said contact member, and electrical conductors leading from said conductive elements whereby the circuit through said conductors is closed only during the period when said contact member is simultaneously engaged with both said conductive elements.

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