April 14, 1936. C. H. FETTER ET AL 2,037,161

APPARATUS FOR THE OPTICAL CALIBRATION OF TIMEPIECES

Filed June 1, 1933 2 Sheets-Sheet 1

FIG. 1

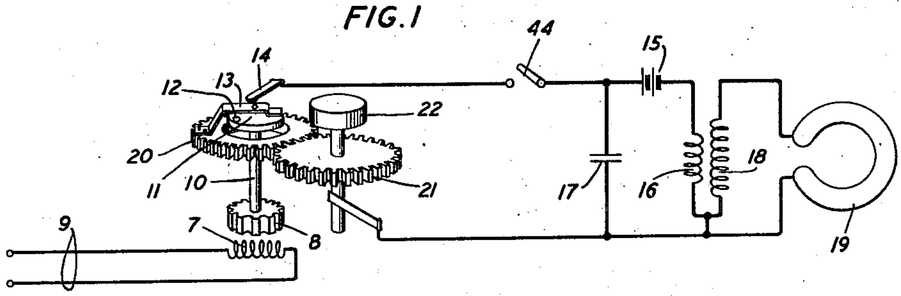

FIG. 2

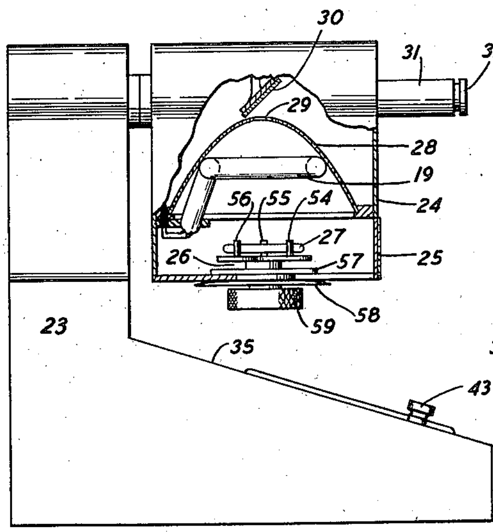

FIG. 3

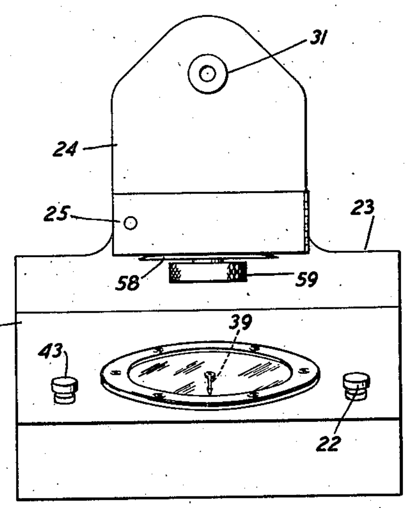

FIG. 4

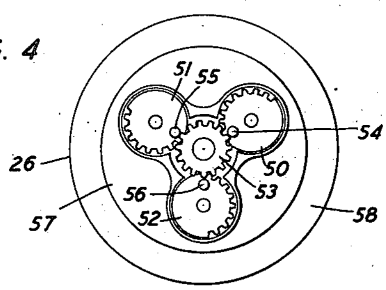

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FIG. 5

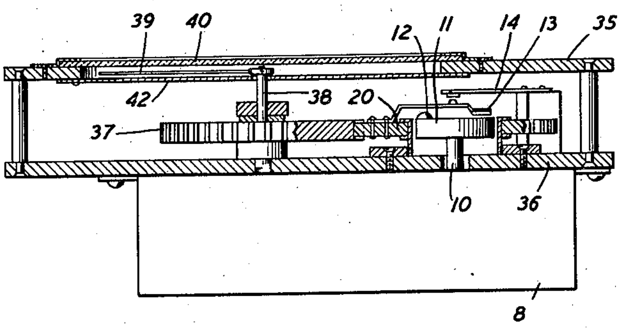
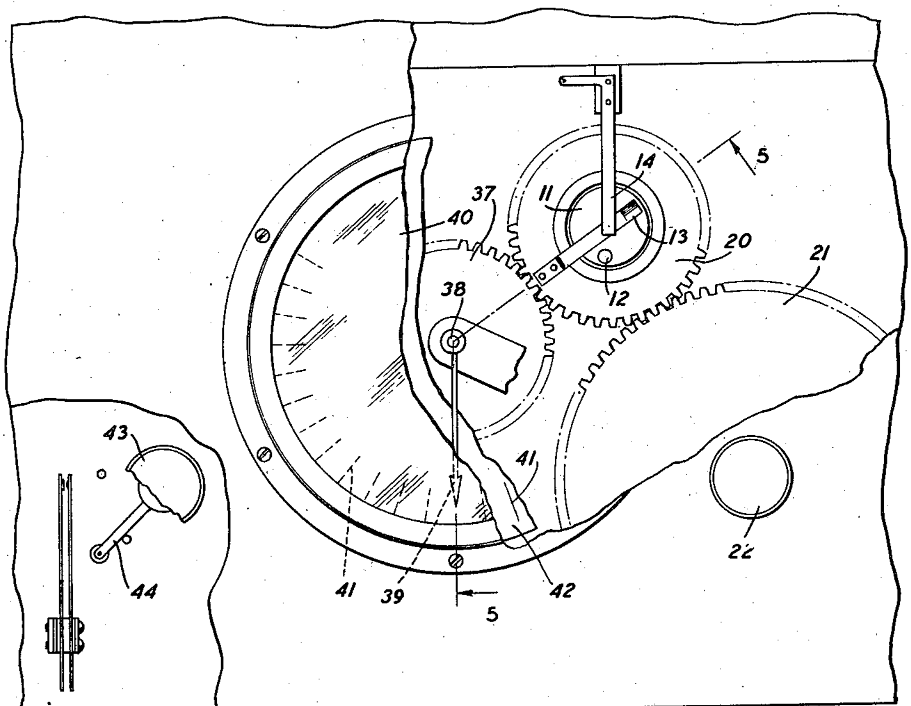


FIG. 6



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UNITED STATES PATENT OFFICE

2,037,161

APPARATUS FOR THE OPTICAL CALIBRATION OF TIMEPIECES

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9 Claims. (Cl. 73—51)

This invention relates to apparatus for the optical calibration of timepieces such as watches or clocks.

An object of the invention is to reduce the time and expense now incurred by manufacturers and repair shops in the speed of adjustment of watches, clocks or other time movements.

In the case of a high grade watch a period of the order of a month has heretofore been required to adjust it to the degree of precision which the mechanism is capable of maintaining in service. The usual procedure has been for the manufacturer or repair shop to maintain a master watch of a high degree of precision which is periodically checked against time signals and then to periodically compare the timepiece to be adjusted with the master watch. In order to observe an appreciable gain or loss in time the observation period usually has extended over several days to several weeks depending upon the precision desired.

The apparatus provided by this invention will enable the watch to be adjusted in a few minutes to an accuracy obtainable only after several days of observation by prior methods. In accordance with the preferred embodiment of this invention a constant speed motor is driven by a source of precision frequency. For example, a current of a constant frequency of 100 cycles per second may serve to drive a small synchronous motor at the exact speed of five revolutions per second. The motor shaft carries a cam which operates a circuit breaker controlling the supply of current to a luminous vapor lamp which periodically illuminates the escapement flywheel of the watch under test. The duration of the flashes from the lamp may be of the order of one-thousandth of a second which is a sufficiently short interval to give a clear image of the position of a spoke of the escapement wheel at the instant of the flash. Since the majority of watches have escapements making 2½ oscillations per second or five half oscillations per second it is evident that by employing five lamp flashes per second the image of the escapement wheel will appear stationary provided the watch is running in synchronism with the 100 cycle source of frequency. In order to maintain the pattern if the watch is gaining or losing, a phase shifter is provided on the circuit breaker which may be manually adjusted by a rotatable dial.

One way in which this apparatus may be used to adjust a watch which is not keeping proper time is for the observer to rotate the phase shifter to a position where the spokes of the escapement wheel appear to be stationary. If the watch is gaining or losing the pattern will soon start moving. After a definite time interval, say one minute, the observer will again adjust the phase shifter to bring the pattern back to a stationary image as originally observed and the amount of the required angular adjustment of the phase shifter to produce the original image is a measure of the rate at which the watch is gaining or losing. The proper adjustment can then be applied to the watch and the process repeated until the desired degree of accuracy has been obtained.

This invention will be better understood by reference to the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 represents the electrical connections to the flashing lamp used in examining the watch movement under test;

Fig. 2 is a side view of one assembly of the apparatus of this invention;

Fig. 3 is a front view of the assembly;

Fig. 4 illustrates a type of clamp which may be used in holding the watch movement during the observation period;

Fig. 5 is a side view of the motor phase shifter and circuit breaker employed in securing the periodic flashing of the source of illumination used in examining the watch movement; and

Fig. 6 is a top view of the apparatus of Fig. 5.

The schematic circuit shown in Fig. 1 comprises a small synchronous motor having a rotor element 8 and a stator winding 7 which by leads 9 may be connected to a suitable source of constant frequency, for example, of a frequency of 100 cycles per second. The frequency source so connected may be any type of precision generator such as a piezoelectric crystal controlled oscillator or a sub-multiple generator energized from such a source, the said source possibly being located at a point remote from the motor 8.

Mounted on the shaft 10 of the motor is a disc 11 which has a projection 12 on its upper face, which projection during each revolution of the motor shaft serves to raise contact spring 13 into electrical connection with spring 14 so as to cause a momentary closure of an electrical circuit including a source of current 15 and the primary winding 16 of a step-up transformer. The said source of current and the primary winding may be shunted if desired by a condenser 17. The secondary winding 18 of the transformer is connected to the terminals of a ring shaped luminous vapor lamp 19 which may be a neon lamp for example or any other type in which a gas is the luminous element as distinguished from a metallic filament. A neon lamp is particularly suitable since it has a substantially zero time lag between lamp current and illumination. The motor 8 is preferably designed so that there will be exactly five flashes per second of the lamp with a degree of accuracy proportional to the accuracy of the frequency source driving the synchronous motor.

As will be explained later it will be frequently desirable to shift the phase of the lamp flashes with respect to the oscillations of the escapement wheel under test. In order to provide for this phase shift, contact spring 13 is mounted on a gear 20 meshing with a gear 21 which may be manually rotated by a knob 22. It will be obvious from the figure that the rotation of knob 22 while the motor is in operation will delay or accelerate the periodic closure of the contacts 13 and 14 and, therefore, produce a phase shift in the energizing current to the lamp by an amount depending upon the movement given knob 22.

One way in which the apparatus of Fig. 1 may be assembled is disclosed in Figs. 2 and 3. The lower part of the cabinet 23 may, as will be explained later, serve as a housing for the motor, the phase shifter, the circuit breaker, the transformer and the battery. The upper part of the cabinet serves as a support for a housing 24 containing the lamp, the watch movement under test and the necessary viewing apparatus. Housing 24 is preferably supported from cabinet 23 in such a manner that the housing may be freely rotated about its axis. The floor of housing 24 contains a slot running from near its center out to the front wall so that by opening a small door 25 in the front of the housing a suitable fixture 26 for supporting the watch movement 27 may be inserted in this slot and moved to a central position beneath the lamp 19. Mounted above the lamp 19 is a parabolic reflector 28 for concentrating the light from the lamp upon the watch movement 27. This reflector has a central aperture 29 to permit light reflected from the watch movement to pass therethrough and be reflected by the plane mirror 30 into the telescope 31, having an adjustable eyepiece 32. An observer therefore, looking into telescope 31 may view the escapement wheel of the watch movement 27 as it is periodically illuminated by flashes of light from lamp 19. It will be apparent that the housing 24 may be rotated through 360° and the escapement wheel will be in the field of view at all positions. Therefore, by turning the stem of the watch movement to various positions in the fixture 26 and then turning the housing 24 to a suitable angle the watch may be observed in any position including its standard test positions which are face up, face down, stem up, stem down, stem right and stem left.

As disclosed in Figs. 5 and 6 the inclined top 35 of the lower portion of the cabinet serves as a support for a plate 36 below which the motor 8 is mounted. The motor shaft 10 passes through an aperture in plate 36 and carries the disc 11 provided with the projection 12 on its upper surface. Plate 36 also serves as a support for the annular gear 20 upon which is mounted the contact spring 13. The other contact spring 14 is supported directly by but electrically insulated from plate 36. Gear 20 as shown in Fig. 6 is driven by gear 21 to which is attached the knob 22 appearing on the upper face 35 of the cabinet. Gear 20 in turn meshes with a gear 37 rotatably mounted on plate 36 and having a vertical shaft 38 attached to a pointer or needle 39, the movement of which due to the rotation of knob 22 may be viewed through the glass window 40 in the platform 35. A scale 41 on the phase shifter dial 42 may be calibrated according to any desired unit and, for example, the divisions on the dial can be calibrated to read in seconds per day gained or lost by the watch under test. Knob 43 on platform 35 may be employed to control a suitable switch 44 for connecting battery 15 to the contact springs 13 and 14.

Any suitable type of clamp may be employed for holding the watch movement during its testing in various positions in the housing 24. Figs. 2 and 4 disclose one type of clamp comprising semi-toothed gears 50 to 52 which by coil springs (not shown) are biased to assume their positions shown in Fig. 4, where the simultaneous movement of all three gears is assured by a common meshing gear 53. The three semi-toothed gears 50 to 52 carry near their outer periphery the vertical pins 54, 55 and 56. It will be apparent from Fig. 4 that when any one of the gears 50 to 52 is moved in a clockwise direction the spacing between the three vertical pins may be increased to a sufficient extent to allow the insertion of a watch movement 27 therebetween, which movement will be clamped between the three pins due to the coil springs which bias the three gears to a position denoting minimum separation of the three vertical pins. The slot in the bottom of housing 24 is bridged by the spaced clamping members 57, 58 and the watch holder may be inserted or withdrawn from the slot after the door 25 is opened, by means of a suitable knob 59.

One method of operating the above apparatus may be described as follows: With the watch placed in the holder 26 as shown in Fig. 2 with battery switch 43 closed and with motor 8 running at a constant speed the observer by means of telescope 31 will find that by rotating the phase shifter knob 22 a position will be found in which the spokes of the escapement wheel of the watch movement 27 will appear stationary. This adjustment is preferably made so that the observed image occurs when the escapement wheel is near the center of its swing where it has the greatest peripheral velocity. If the watch is gaining or losing with respect to the 100 cycle standard frequency source the observed pattern will soon start moving and will appear first on one side of its former position and then on the other, thus giving a pattern wider than the spoke of the escapement wheel first observed. At the end of a definite period of time such as one minute the observer will again adjust the phase shifter to bring the pattern back to a stationary image as originally observed. By noting the amount of angular readjustment of pointer 39 required for the one minute interval it is a simple matter to determine the rate at which the watch is gaining or losing. The divisions of the phase shifter dial 42 can be calibrated to read in seconds per day and the direction of phase adjustment of needle 39 determines whether the watch is gaining or losing. It is thus possible in a period of observation of one minute to check the rate of a watch with as great accuracy as can be obtained in a twenty-four hour elapse of time by the usual method of comparing the watch with a standard clock or with time signals. The watch, of course, may be tested in a similar manner for any one of the standard test positions by the rotation of housing 24 and the adjustment of the watch movement in the holder.

It is, of course, necessary that the interval between the flashes of the neon lamp 19 should correspond to one-half the natural period of oscillation of the escapement under test. The majority of watches have a natural period of 2½ times per second or ⅕ second per half cycle so that it will generally be found satisfactory to have motor 8 rotate at the rate of five revolutions per second to give the same number of flashes of lamp 19 in that period. It will be obvious that in the event that a watch under test operates at a different period it would be necessary to introduce a suitable gear ratio between the motor 8 and breaker 11 to obtain the desired time interval between the lamp flashes.

An alternative method of operation which is useful in the preliminary stages of watch adjustment where the error may be large is to observe the image of a spoke of the escapement wheel and keep the image continually in focus by rotating the phase adjusting knob 22 continuously forward or backward as required and the angular velocity of the required movement of the pointer 39 will be a measure of the rate at which the watch is gaining or losing.

Still another method for determining the rate at which the watch under test is gaining or losing is to adjust the phase of the neon lamp flashes until the image of the flywheel is stationary and then noting the time required for said image to drift out of phase by a predetermined amount such as 180°. Thus the phase shifter knob 22 may be adjusted until the image of the flywheel is stationary, the knob 22 then being moved until the pointer 39 has assumed a position 180° from its first position and measuring the time required for the image of the flywheel to appear stationary at the new position of the phase shifter.

In order to illustrate the great saving in time required for watch adjustment according to the stroboscopic method, above described, consider the case of a watch which is gaining, let us say, two seconds per day. Using the old method the watch would be set to read the same as the standard watch whose rate may be assumed to be precisely correct. It will be five days before the watch under test will gain ten seconds on the standard and a spread of ten seconds between their readings is about the smallest amount which can be estimated with even approximate accuracy. The watch will then be readjusted and the error reduced, let us say, to one second per day. It will now require another period of ten days before the residual error can be determined by comparison with the standard.

Using the stroboscopic method in accordance with this invention the time which must elapse before the watch under test shows a measurable drift ahead or behind is reduced to a matter of minutes rather than days for the reason that the observation is made on the escapement wheel which at the center of its swing has a peripheral velocity of the order of 300 times the average velocity of the end of the second hand. It would, therefore, require only 1/300 of the time to note a given amount of gain or loss in terms of distance along the periphery of the escapement wheel image. However, there is a further reduction in time due to the fact that it is feasible to note a much smaller change in the image width of a spoke or balance weight on the escapement wheel than it is feasible to detect in the positions of the second hands on two watches. The latter observation is difficult for the reason that the observer must quickly transfer his vision from one watch to another and the hands of each watch are moving in steps, whereas in the stroboscopic method he looks at a single stationary image and is able to note any small change in its width and definition. For this reason a further factor of ten may be gained in reducing the necessary interval of observation, thus making the time required $1/300 \times 1/10$ or 1/3000 of that required by the old method, or a reduction from five days to about two minutes.

It will be apparent that the flashing of the lamp 19 may be secured by any suitable means which is capable of operation at a standard rate so as to periodically flash the lamp with the required degree of accuracy. In the arrangement assumed above, where the constant frequency source is of 100 cycles per second, the rotor of motor 18 should have 20 teeth so as to give a motor speed of five revolutions per second. Other changes in the above described apparatus may be obviously made without departing in any wise from the spirit of this invention as defined in the appended claims.

What is claimed is:

1. In a system for determining the accuracy of timepieces, a holder for the timepiece to be regulated, said holder being mounted for angular movement about a fixed axis, a lamp supported by said holder for illuminating said timepiece for a plurality of positions of said holder, a constant speed motor, an electrical circuit for supplying current to said lamp, means controlled by said motor for varying the current supply to said lamp to cause said lamp to emit periodic flashes of light, means supported by said holder and shielded from direct light from said lamp for viewing said timepiece, and means independent of said motor for adjusting the phase of said light flashes with respect to the movement of an element of said timepiece.

2. In a system for determining the accuracy of timepieces, a holder for the timepiece to be regulated, said holder being mounted on a horizontal axis for rotative movement about said axis, a lamp within said holder for illuminating said timepiece, means for causing said lamp to emit periodic flashes of light at a constant rate, means for receiving light reflected by said timepiece and for deflecting said light in a direction substantially parallel to said axis and substantially coinciding therewith and means enabling the eye of an observer to receive said deflected light.

3. In a system for determining errors in a watch movement and the like, a holder for said movement, said holder being mounted for rotation about a fixed axis, said movement being supported a substantial distance away from said axis, the axis of a movable part of said movement being substantially at right angles to said fixed axis and means for receiving light reflected by said movement and for deflecting said light towards the eye of the observer in a direction substantially coinciding with the direction of said fixed axis.

4. In a system for determining errors in a watch movement and the like, a rotatable holder for said movement, a lamp supported by said holder for illuminating said movement, a constant speed motor, an electrical circuit for said lamp, said circuit being normally open, means driven by said motor for periodically closing said

circuit, each closure being of relatively short duration compared to the time between successive closures and means independent of said motor for adjusting the time of said closure relative to a periodic motion of an element of said movement.

5. In a system for determining errors in a watch movement and the like, a rotatable holder for said movement, a lamp mounted on said holder for illuminating said movement at all positions of said holder, means shielded from said lamp for viewing said movement in all positions of said holder, a constant speed motor, a rotatable cam driven by said motor, a source of current, circuit connections between said source and said lamp including a circuit breaker, said circuit breaker being mounted in the path of said cam and means for independently rotating said circuit breaker about an axis parallel to the axis of said cam.

6. In a system for determining errors in a timepiece, a rotatable housing adapted to contain said timepiece, a lamp within said housing for illuminating said timepiece, optical viewing means supported by said housing with its optical axis substantially coinciding with the axis of rotation of said housing, means aligned with said axis of rotation for deflecting light from said timepiece to said optical means, and means for illuminating said timepiece by periodic flashes of light from said lamp.

7. Apparatus for determining errors in a watch movement and the like comprising a stationary support, an apertured member rotatably mounted on said support and rotatable about a substantially horizontal axis, a holder for said movement supported by said member and rotatable therewith, the axis of a movable part of said movement being substantially at right angles to the axis of said member when said movement is in said holder, a lamp for illuminating said movement, means for directing light from said movement into said apertured member and means for flashing said lamp at a standard rate.

8. In a system for determining errors in a timepiece, a rotatable housing adapted to contain said timepiece, a lamp mounted within said housing for illuminating said timepiece, a telescope mounted on said housing with its optical axis coinciding with the axis of rotation of said housing, means aligned with said axis of rotation for deflecting light from said timepiece into said telescope, means for causing said lamp to emit periodic flashes of light at a constant rate and means for adjusting the phase of said light flashes with respect to the movement of an element of said timepiece.

9. In a system for determining errors in a timepiece, a rotatable housing adapted to contain said timepiece, a ring shaped luminous vapor lamp within said housing for illuminating said timepiece, a telescope mounted on said housing with its optical axis coinciding with the axis of rotation of said housing, means for receiving light reflected from said timepiece through the center of said lamp and for directing such reflected light into said telescope, means for causing said lamp to emit periodic flashes of light at a constant rate and means for adjusting the phase of said light flashes with respect to the movement of an element of said timepiece.

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