Dec. 19, 1939. E. R. MORTON 2,183,655

MEANS FOR ADJUSTING VIBRATING SYSTEMS

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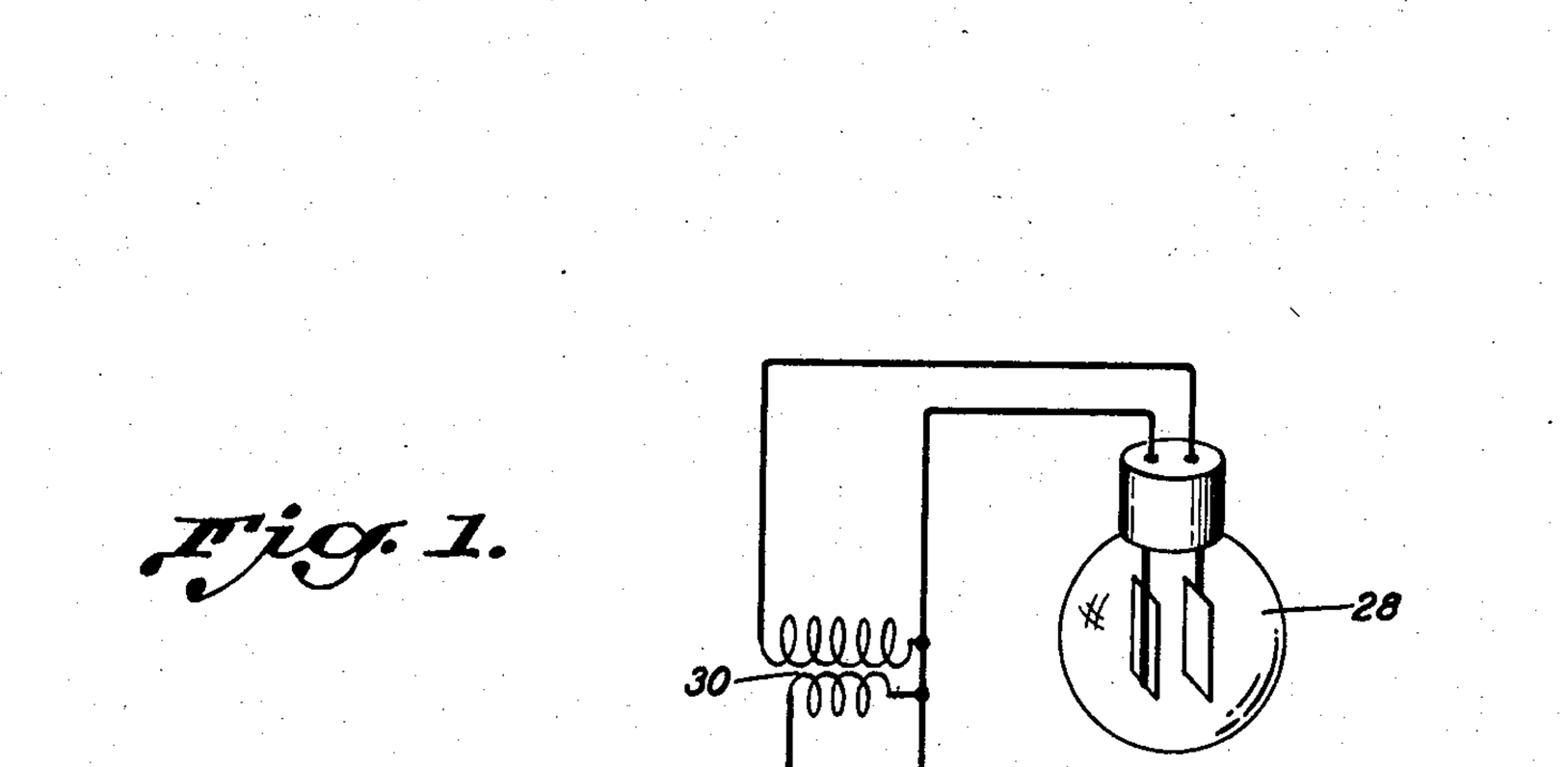
Fig. 1.



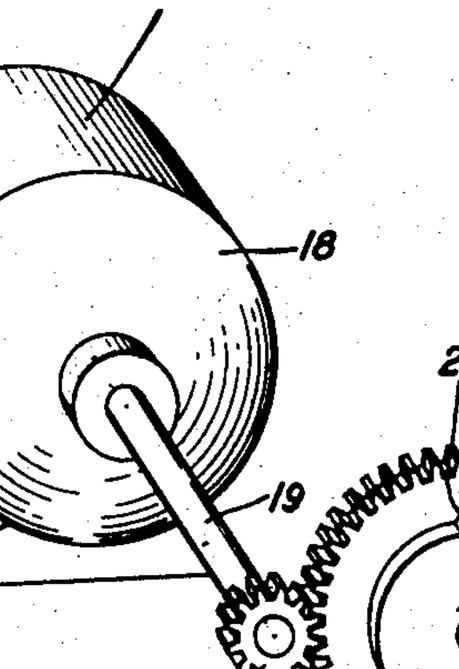


Fig. 2

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MEANS FOR ADJUSTING VIBRATING SYSTEMS

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5 Claims. (Cl. 73—51)

This invention relates to apparatus for the optical calibration of oscillating members and more particularly relates to a device for the adjustment of rate of oscillation of the balance wheel of a timepiece before its assembly in the timepiece.

A very important feature in the manufacture of timepieces is their accurate adjustment. In the case of high grade watches, it is not unusual to prolong the comparison of the manufactured timepiece with a standard timepiece over a period of days or perhaps weeks. In the case of more inexpensive watches, the time taken for correct adjustment materially increases the cost of manufacture and thus the manufacturer is faced with the problem of either spending too much time adjusting the watch in view of the selling price, or turning out watches which are not properly adjusted.

An object of the present invention, therefore, is an adjusting apparatus which will permit the rapid adjustment of the rate of oscillation of a vibrating system such as the balance wheel of a watch before installation.

A further object of the invention is an apparatus for observing substantially instantaneously the deviation of the resonance of a vibrating system from the desired resonance.

In accordance with the present invention these and other objects are attained by employing a device comprising driving means for oscillating the vibrating system to be regulated at the desired frequency, and then viewing the vibrating system in stroboscopic flashes of a lamp periodically actuated by the driving means. The vibrating system although driven in synchronism with the lamp flashes will ordinarily appear, when viewed in those flashes, to be out of phase with the driving means. A suitable adjustment of the vibrating system is then made until the vibrating system is brought into phase with the driving means.

In applying this invention to timepiece regulation, the balance wheel of the timepiece is oscillated at the desired predetermined frequency and viewed in the lamp flashes. Any apparent difference in phase is corrected by changing the effective length of the hair spring associated with the balance wheel. When there appears to be no difference in phase when viewed in the lamp flashes the hair spring of the timepiece is correctly adjusted.

In the preferred form of the invention the testing and regulating device comprises a synchronous motor which by means of a rack and pinion drives a loose coupling with an oscillatory movement having a frequency equal to the desired frequency of the balance wheel. At the same time the motor periodically closes contacts to cause a neon lamp to flash at the moment of maximum velocity during each half cycle of the oscillatory movement. For the adjustment of the oscillating member of a timepiece the shaft of the balance wheel with its attached hair spring is placed in the loose coupling in such a manner that the balance wheel is forced to oscillate at the frequency of oscillation of the loose coupling. If the natural period of oscillation of the balance wheel is different from the impressed frequency of oscillation there will be a difference in phase between the loose coupling and the balance wheel and by observing the balance wheel during successive light flashes its phase difference will be indicated by the failure of the image of the balance wheel to appear stationary. When the effective length of the hair spring is adjusted to cause the image of the balance wheel to appear stationary the phase difference is substantially zero and the natural period of oscillation of the balance wheel is equal to that of the driving force. This, therefore, indicates that the hair spring and balance wheel are correctly adjusted and are ready for installation as a part of a watch movement.

This invention will be more clearly understood from the following detailed description and attached drawing in which:

Fig. 1 is a schematic view of the essentials of the apparatus of this invention for regulating the oscillation of a balance wheel; and Fig. 2 shows a stroboscopic means for viewing the vibrating member.

As shown in the drawing, a balance wheel 5 and its associated hair spring 6 are mounted on the balance wheel shaft 7. One conical end of shaft 7 is located in a suitable bearing in plate 8 and the other conical end of the shaft rests in a suitable bearing held by sleeve 9 which is attached to a separate shaft 15. Sleeve 9 with its bearing constitutes a loose coupling between the driving shaft 15 and the balance wheel shaft 7.

The outer end of the hair spring 6 is clamped at the point 10 by a suitable clamping member which may comprise a wedge block 12 and a flat block 13 inserted in a slot in a plate 14 so that the effective length of the spring 6 can be readily adjusted.

The loose coupling member 9 is mounted on shaft 15 and is oscillated by gear 16 and rack 17. The rack 17 is driven by a suitable means

such as a constant speed motor 18 which acts through its shaft 19, gears 20, 21 to rotate cam 22 at a desired constant speed. Cam 22 engages rack arm 24 by means of its crank pin 23 so that the rotation of cam 22 imparts a reciprocating movement to rack 17. It is to be assumed that the rotational frequency of cam 22 is made equal to the desired natural frequency of oscillation of the balance wheel 5 and its hair spring 6.

Cam 22 also carries two diametrically opposite projections 25 and 26 on its circumference which serve to close electrical contacts 29 and complete a circuit through battery 27 twice per cycle of oscillation of rack 17. Each time the circuit through battery 27 is closed a step-up transformer 30 serves to supply a brief current impulse to the neon lamp 28 to cause it to flash momentarily and illuminate balance wheel 5 as more clearly shown on Fig. 2. The closure of contacts 29 is preferably timed to occur at the middle of each swing of rack 17, that is, at the moment of its maximum velocity and a telescope or lens system 31 is preferably provided as shown to facilitate observing the position of the balance wheel.

On starting the motor 18 the balance wheel assembly due to loose coupling 9 will be driven at the desired frequency of oscillation even though its natural frequency of oscillation differs from that of the driving force. The balance wheel will be illuminated once each half cycle at the moment when the driving rack 17 is at its maximum velocity. If the natural frequency of oscillation of the balance wheel assembly differs from the frequency of the driving force the balance wheel will not oscillate in phase with the driving force and hence the balance wheel as viewed through the telescope 31 by the lamp flashes will not appear stationary and the image of a selected spoke of the wheel for one half cycle will not be superposed on the image of the spoke for its second half cycle of oscillation. That is, if the natural frequency of the balance wheel differs from the frequency of the drive, the spoke will appear alternately at two positions. If the length of the hair spring is now changed the amplitude of the oscillation will be reduced if the adjustment is in the wrong direction; but if in the proper direction the angle between the two alternate positions of the spoke will be reduced until the two images are superposed when the correct length of the hair spring is reached. Therefore to obtain the correct adjustment hair spring 6 should be pulled through the clamp until the balance wheel appears to be stationary and the two images superposed when viewed in the lamp flashes. When this result is obtained this indicates that the balance wheel is now oscillating in phase with the driving force and that the hair spring is, therefore, correctly adjusted to the proper length to have the desired natural period of oscillation. The spring 6 may then be suitably marked to indicate the clamping point 10 and the balance wheel assembly can then be installed in a timepiece where it will oscillate at the desired rate.

An alternative method of describing this testing operation is to consider the electrical equivalent of the mechanical assembly just described. The hair spring, balance wheel and pivot friction at the point 9 may be considered as a closed oscillating system which is coupled to a constant amplitude driving force through the friction of the pivot 9. When the balance wheel system is greatly out of resonance there will be a negligible current or velocity in the tuned circuit representing the balance wheel assembly. As resonance is reached, the amplitude will increase, approaching a maximum and the velocity will, exactly at resonance, go into phase with the driving force. As previously stated, the phase angle of the stroboscopic lamp 28 is adjusted to the positions of maximum velocity of the driving force by the proper relation between projections 25, 26 and electrical contacts 29. When the balance wheel assembly is in resonance with the frequency of the driving force the flashing lamp will illuminate the wheel at its points of maximum velocity, that is, in the middle of its swing, and the images of the selected spoke of the wheel will be superposed as the wheel reverses its direction.

Since the above method of adjustment depends upon observing the change of phase angle at the position of maximum rate of change the method is very rapid in operation since the only time required is that for a steady rate to be reached.

While the rack and pinion arrangement for oscillating the loose coupling is preferred, it is obvious that various other suitable mechanical devices may be substituted therefor without departing from the scope of the invention.

What is claimed is:

1. Apparatus for adjusting a vibrating system to a desired frequency, comprising means independent of the vibrating system to be adjusted for driving said vibrating system at a constant predetermined frequency, a loose coupling between said vibrating system and said driving means, stroboscopic means for observing the phase angle between said driving means and vibrating system, and means engaging said vibrating system for adjusting said phase angle to a predetermined value.

2. In a device for adjusting the rate of oscillation of a balance wheel of a timepiece, a synchronous motor, a loose coupling oscillated by said motor, a lamp periodically illuminated by said motor, a balance wheel assembly to be adjusted, means comprising said loose coupling for oscillating the balance wheel assembly, means including said lamp for viewing the phase angle between said oscillating coupling and balance wheel, and means comprising means for adjusting the length of the hairspring of said balance wheel assembly for causing the phases of said elements to correspond.

3. Apparatus for adjusting a vibrating system including means independent of the vibrating system to be adjusted for driving said vibrating system at a desired predetermined frequency, a loose coupling between said vibrating system and said driving means, means for observing the phase relation between said driving means and said vibrating system and means engaging said vibrating system for adjusting said phase angle to a predetermined value.

4. In a device for regulating the rate of oscillation of a vibrating member, driving means independent of the vibrating member and including a loose coupling for oscillating said vibrating member at a predetermined desired rate, stroboscopic means actuated by said driving means for illuminating said vibrating member, and means for adjusting the natural frequency of said member to a value such that its phase corresponds with that of the driving means when viewed by said stroboscopic means.

5. In a device for regulating the rate of oscillation of a vibrating member, driving means independent of the vibrating member and includ-

ing a loose coupling for oscillating said member at a constant predetermined frequency, stroboscopic means actuated by said driving means for illuminating said vibrating member at the same point during each oscillation in opposite direction and at the moment of maximum velocity of said member thereby producing a pair of images which indicate the phase variance between said member and the driving means, and means for adjusting the phase of said member to bring the images into coincidence thereby indicating that the vibrating member and the driving means are in phase.

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