Oct. 13, 1931. C. BATTEGAY 1,826,719

SELF OSCILLATING ELECTRIC CLOCK

Filed June 11, 1928 2 Sheets-Sheet 1

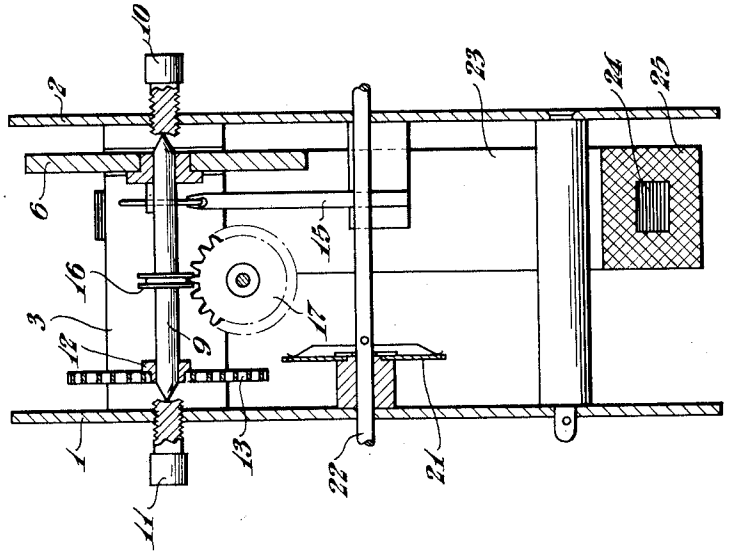


Fig. 2

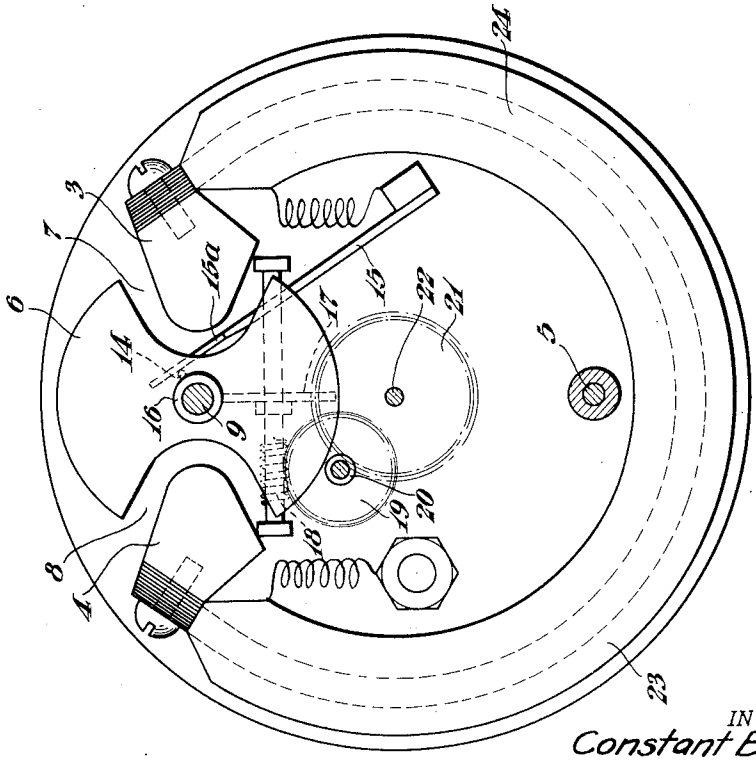


Fig. 1

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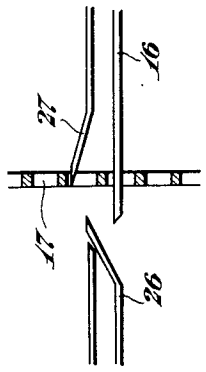


Fig. 4

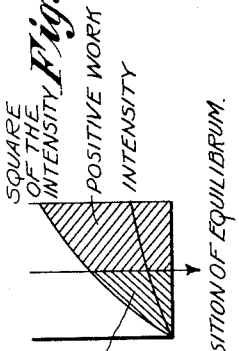


Fig. 7

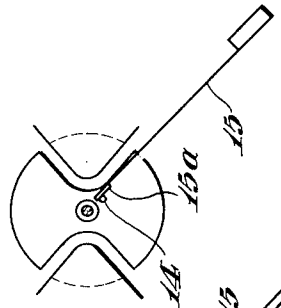


Fig. 6

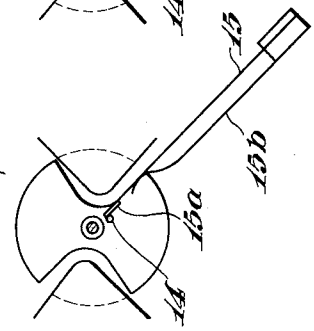


Fig. 5

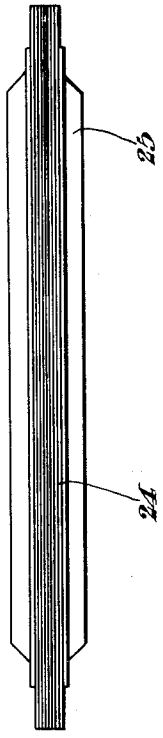


Fig. 3a

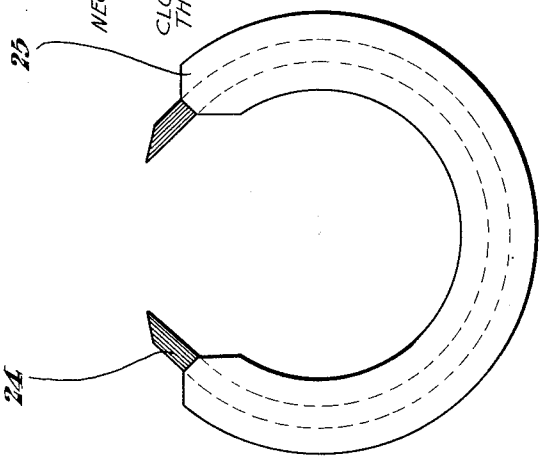


Fig. 3

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SELF-OSCILLATING ELECTRIC CLOCK

Application filed June 11, 1928, Serial No. 284,297, and in Belgium June 21, 1927.

The present invention relates to improvements in clocks with electric self-oscillation of the balance, and chiefly to clocks in which the whole or a part of the balance constitutes the armature of an electromagnet.

It has for its object to provide for a particularly simple and economical construction of said clocks, and to assure the proper electromagnetic efficiency for such apparatus.

The invention chiefly consists in operating the self-oscillating contact in said clocks by the movement of the balance in such manner that the contact will always be closed when in the stopping position.

It further consists in various improvements and methods of manufacture concerning such clocks, as will be hereafter specified.

In the appended drawings:

Figures 1 and 2 represent an electric clock apparatus, according to the invention.

Figures 3 and 3*a* represent an electromagnet in two steps of its construction.

Figure 4 shows a developed arrangement of the device by which the clockwork is actuated by the pendulum.

Figures 5 and 6 show two modified forms of contacts.

Figure 7 is a diagram illustrating graphically the relations of positive work and negative work.

It is a matter of common practice to maintain the self-oscillating movement of a balance by the action of an electromagnet; for example, the clocks having a circular balance, in which the said balance wholly or partially forms the armature of an electromagnet. However, this type of clock offers a low electromagnetic efficiency, and for the self-oscillation contact there is required a first impulse of the balance. Such clocks further show certain defects which I propose to reduce or to entirely obviate.

The characteristic features of the invention are clearly specified in the following description, but it is understood that while the said features may be advantageously employed as a whole, such features may be also partially employed without departing from the principle of the invention:

A—The electromagnet comprises pole-pieces of a considerable developed length which partially surround the rotating armature in such a manner as to afford the maximum increase of the section of the air gap in relation to the section of the iron of the magnetic circuit.

A calculation shows in fact that for the values of the induction employed, the reluctance of the magnetic circuit is largely due to the air gap, but it is necessary, in order to obtain the greatest electromagnetic efficiency, to provide a magnetic circuit of a deformable nature whose permeance can be varied within the maximum limits.

These conditions are obtained in my apparatus, in disposing the movable armature in such a manner, that when in the "off" position it will be relatively removed from the pole-pieces, and that in case of rupture of the current, the permeance will be at its minimum.

B—The pole-pieces are so disposed with relation to the rotating armature, that the efforts which they exercise upon the said armature tend to be mutually annulled in the direction perpendicular to the axis and also in the direction parallel with the axis. The pole-pieces are for instance disposed on either side of the diameter of the armature, and are also symmetrical with relation to the plan of said armature. By this arrangement I am enabled to reduce to a minimum the reactions on the pivots and the wear of these.

C—The soft iron pole-pieces also serve as cross bracing pieces for the apparatus, and may be suitably cut out to give space for the balance and optionally to the spiral spring wheel.

D—The winding of the said electromagnet is given the maximum length in relation to the available space. It is in fact shown by calculation that in order to obtain the greatest possible number of ampere-turns while employing a small amount of electric energy, it is of advantage to increase the length of the winding of the magnetic circuit.

E—The magnetic circuit is laminated either wholly or partially, so as to diminish the losses when making and breaking the circuit.

F—The time-constant of the circuit is the interval required for the current to reach its maximum value after the circuit is closed. The length of this interval is dependent upon the reactance of the circuit, as will be readily understood. The time-constant may be varied as desired by appropriately varying the reactance of the circuit by increasing or diminishing the inductance or capacitance.

The higher the inductive characteristics of the circuit the greater is the interval for the current to reach its maximum value. Accordingly, when the time-constant is of high value, the positive work predominates because the armature is past its mid-position when the pull of the magnet is greatest. The time constant of the circuit, which is herein given a high value, is employed to advantage for the self-oscillating of the balance. To obtain the automatic starting of the apparatus, the contact is symmetrically disposed with reference to the position of the equilibrium of the balance, and consequently the contact will be effected when functioning normally before passing through the position of the equilibrium. It may even be entirely symmetrical with reference to this position, as shown in Figures 1 and 2, without preventing the self-oscillating, which is supposed to be zero in this latter case, since the arc of the negative impulse is equal to the arc of the positive impulse.

It is known that in calculating the time constant of the circuit to have the same magnitude as the time of travel of the balance in the arc of the negative impulse, the negative work, which is in proportion to the square of the current, is very small as compared to the positive work.

This principle is clearly illustrated in Fig. 7, in which the negative work and positive work are represented by areas corresponding to the position of the pendulum with respect to its point of equilibrium and the intensity or value of the current in the circuit of the coil of the electromagnet.

It is well known that the current does not reach its maximum value instantly, the time constant of the circuit being determined by circuit characteristics as stated above. The current increases according to the well-known formula

$$I = \frac{E}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$$

Since the work of an electromagnet varies in accordance with the square of the current and if the average value of the current after passing the equilibrium point is double the average value before reaching that point, the positive work is four times the negative work.

In the present apparatus, the duration of the contact is less than the time-constant of the circuit whereby it is certain that the current value increases throughout the period of contact. This condition is shown by the curve marked "intensity" in Fig. 7.

G—A condenser is connected to the terminals of the self-oscillation contact in order to eliminate or reduce (in the known manner) the sparking at this contact, and also, as a novelty, to increase the efficiency of the actuating electromagnet.

I have discovered that a condenser, thus branched in the circuit will not only eliminate the sparking at the contact, but will also afford a marked increase in the swing of the balance, whereby the consumption of current will be reduced.

The said contact may be further protected by the use of a resistance, without self-induction, which is connected in parallel with the electro-magnet, said resistance may consist for example of a piece of special graphite.

H—The said electromagnet is constructed according to clauses D or E as above specified and represented in Figures 3, and 3*a* and comprises an iron core of relatively small cross-section, but of great length, consisting for example of built-up strips of sheet iron. This core is wound with wire when in a straight position, which is an easy matter, then bent into shape, preferably after a paraffin treatment, in order to close the ends of the pole-pieces. I am thus enabled to construct, in a most economical manner, an electromagnet of a very long shape, while making the best use of the space available in the clock, which has usually a circular shape.

This new form of construction may be employed to advantage in other electromagnetic apparatus, in which case it is to be considered as forming part of the invention.

Figures 1 and 2 represent a clock with electric self-oscillating contact which is constructed according to this invention and which comprises the aforesaid features, but it is obvious that the invention is not limited to the use of the whole of these characteristics, these being used in all desired combinations, whether singly or in conjunction.

The clockwork is mounted between two main plates 1 and 2 which are cross-connected, as specified in clause C by the two pole-pieces 3 and 4 and a third crosspiece 5. The balance 6 of malleable iron is, according to my invention, placed symmetrically in relation to pole-pieces 3 and 4, and has two cut-out portions 7 and 8 which coincide with the respective pole-pieces 3 and 4 in the middle position of the balance.

The balance 6 is mounted on a shaft 9 which can freely rotate between two screws 10 and 11 which are preferably jewelled; said shaft carries the sleeve 12 for the spiral spring wheel and a contact stud 14 which preferably consists of precious metal.

Upon a supporting member, insulated from the said main plate is mounted a spring strip 15 terminated by a wire 15*a* of precious metal.

The shaft of the balance further carries a double ring 16 coacting with the wheel 17 which is the first wheel of the clockwork mechanism which device is shown in Fig. 4 and will be hereafter described.

The said wheel actuates—for instance by worm gearing—the remainder of the clockwork mechanism which is represented in Figgures 1 and 2 by the worm 18 and worm wheel 19, the pinion 20 and the central wheel 21 which is mounted by hard friction on the central shaft 22. The set of gear wheels, which is analogous to that of a watch, is omitted for the sake of clearness of the drawings.

The electromagnet shown at 23 is constructed according to clause H. It consists of a core 24 secured to the pole-pieces 3 and 4 and provided with the suitable winding 25 whereof one end is connected to the contact strip 15 and the other to a source of current whose other pole is grounded upon the metal of the apparatus.

In a modified form of construction, the pole-pieces consist of extending portions of the electromagnet core itself, which are cut out in U shape to provide for the insertion of the balance between the branches of the U.

The double ring 16 for actuating the wheels is shown in the developed position in Figure 4, and it carries two ramps 26—27 which are obtained by first sawing the ring 16 and then bending a portion of each flange of said ring.

In the "off" position, the contact spindle 14 makes contact with wire 15*a*, but the pendulum is always in a slightly unsymmetrical position with reference to the pole-pieces 3 and 4, upon closing the circuit, the balance is attracted by the nearest pole-pieces, and makes first a few slight oscillations until the spindle 14 sufficiently bends the spring 15 and passes to the other side of the middle position. The normal functioning then commences, and the contact is closed in each direction of movement of the balance on the respective sides of the position of equilibrium.

As above stated, by virtue of the time-constant of the circuit, the result will be the predominance of a positive work, this being more strongly marked as the amplitude increases.

During the oscillations of the balance, the ramps 26—27 of the double ring 16 act in turn upon the teeth of the wheel 17 and will cause the latter to rotate.

After each displacement, the escapement wheel is held in position, sometimes by one tooth which is engaged between the two flanges of one end of the ring 16, at other times by the two flanges of the other end of the ring which are engaged between two teeth of wheel 17. It will be observed that this control corresponds to the escapement employed in metronomes, but it operates in the inverse direction.

The flanges of the ring and the said ramps might be formed upon the balance shaft itself, but the device herein represented will offer a particularly simple construction.

The shaft of the wheel 17 further carries a wheel—not shown for the sake of simplicity—having twice the number of teeth in the said escapement wheel and provided with a light cross-piece. This wheel has the advantage of immobilizing the escapement wheel in a position between two successive forward movements. The said cross-piece might also be mounted on the escapement wheel thus as to immobilize directly this latter.

The self-oscillation contact might be further arranged as shown in Figure 5; in which the wire 15*a* is directed in accordance with the shaft of the balance without making contact with same.

In the stopping position, the stud 14 will make contact with one or the other side of the said wire 15*a*, so that the balance will be in the unsymmetrical position with reference to the pole-pieces 3 and 4, and hence the apparatus will be enabled to start.

In normal operation, the contact takes place somewhat before the position of equilibrium, and is broken somewhat before the end of the complete movement of the balance between the pole-pieces.

Experience shows that it is advantageous to effect the rapid damping of the oscillations of the contact strip 15 which will always vibrate after it has been released by the stud 14. This result can be obtained by one of the following methods:

(*a*)—The spring strip 15 is held in a shock-absorbing sheath consisting for example of rubber,

(*b*)—The said strip is provided with a contact plate of light weight but large surface, which effects a rapid damping of the vibrations by air friction,

(*c*)—The said strip is damped by a second spring strip such as 15*b* in contact therewith.

In another method of the invention, the contact shown in Fig. 6 comprises still another contact strip 15 having at its end a wire 15*a*, but this plate is insulated on one side (or stud 14 may be insulated) in such manner that the electric contact will take place only in one direction of movement of the balance. It is therefore of interest that the said contact plate should not be directed towards the axis of the balance, but rather in the unsymmetrical position, as shown in the figure.

The invention is not limited to the methods of application or to the forms of construction herein specified by way of example, but covers all suitable modifications of the apparatus, and chiefly those concerning the forms of construction, the forms in which the several elements have a different construction than what is herein represented while serving like purposes, or in which the aforesaid character-

istic features of the invention are not all employed at the same time.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A system of clockwork mechanism with electric sustained oscillation, comprising in combination a balance adapted to oscillate, a member having two cams and a detent member and controlled by the motion of the balance, and a wheelwork comprising an escapement wheel driven by said cams which coact with the teeth of said escapement wheel, and said detent holding said wheel stationary when said member is in its intermediate position and both of said cams are disengaged therefrom.

2. A system of clockwork mechanism with electric sustained oscillation, comprising in combination a balance adapted to oscillate, a double ring having cams and a crosspiece and being controlled by the motion of the balance, and a wheelwork comprising an escapement wheel that is driven by said double ring, said cams being adapted upon oscillation to drive in a single direction the teeth of said escapement wheel and said crosspiece being adapted to hold said wheel stationary at intervals when said double ring is in its intermediate position.

3. A system of clockwork mechanism with electric sustained oscillation, comprising an electromagnet having a winding, an oscillatable armature constituting a balance and mounted in the field of said electromagnet, and coacting contact members in circuit with said winding and controlled by the motion of the balance and normally closed in the position of equilibrium of said balance and normally closed also in the mid-position of said balance in either direction of its oscillation.

4. A system of a clockwork mechanism with electric sustained oscillation comprising in combination an electromagnet having a winding, an oscillatable armature constituting a balance and mounted to oscillate in the field of said electromagnet and coacting contact members in circuit with said winding and controlled by the motion of the balance and normally engaged in the position of equilibrium of said balance, said contact members comprising a contact stud movable with the balance and a flexible strip adapted to engage said stud in each direction of its oscillation.

5. A system of clockwork mechanism with electric sustained oscillation comprising an electromagnet having a winding, an oscillatable armature for said electromagnet constituting a balance for said mechanism, a rotatable shaft for supporting said balance in the field of said electromagnet, and coacting contact members in circuit with said winding and controlled by the motion of the balance and normally engaged in the position of equilibrium of said balance, said contact members comprising a contact stud mounted on the balance eccentric of its axis and extending parallel thereto and a flexible strip adapted to engage the said stud at each oscillation.

6. A system of clockwork mechanism with electric sustained oscillation comprising an electromagnet having a winding, a balance armature having a rotatable supporting shaft for adapting said armature to oscillate in the field of said electromagnet, and two coacting contact members controlled by the motion of the armature and normally closed in the position of equilibrium of said armature, said contact members comprising a contact stud carried by the armature and a flexible strip adapted to make contact with the said stud at each oscillation, said flexible strip being substantially tangent to the circle described by the contact stud.

7. A system of clockwork mechanism with electric sustained oscillation, comprising in combination, an electromagnet having a winding, a symmetrical oscillatable armature constituting a balance and rotatably supported for oscillation in the field of said electromagnet, two coacting contact members in circuit with said winding and controlled by the motion of the balance and normally closed closed in the position of equilibrium of said balance and when passing through one position of the latter in each direction of its oscillation, the time-constant of the circuit comprising the winding of said electromagnet being of relatively high value, whereby the current therethrough is a maximum at an interval after the circuit is closed in said position.

8. A system of clockwork mechanism with electric sustained oscillation, comprising in combination, an electromagnet having a winding, a symmetrical oscillatable armature constituting a balance and rotatably supported for oscillation in the field of said electromagnet, two coacting contact members in circuit with said winding and controlled by the motion of the balance and normally closed in the position of equilibrium of said balance and when passing through the mid-position of the latter in each direction of its oscillation, the time-constant of the circuit comprising said winding being so arranged that current through said circuit reaches its maximum after the balance passes its mid-position.

CONSTANT BATTEGAY.