H. E. WARREN.

ELECTRIC APPARATUS FOR DRIVING CLOCKS OR SIMILAR MECHANISM.

APPLICATION FILED JULY 27, 1910.

1,144,973. Patented June 29, 1915.

2 SHEETS—SHEET 1.

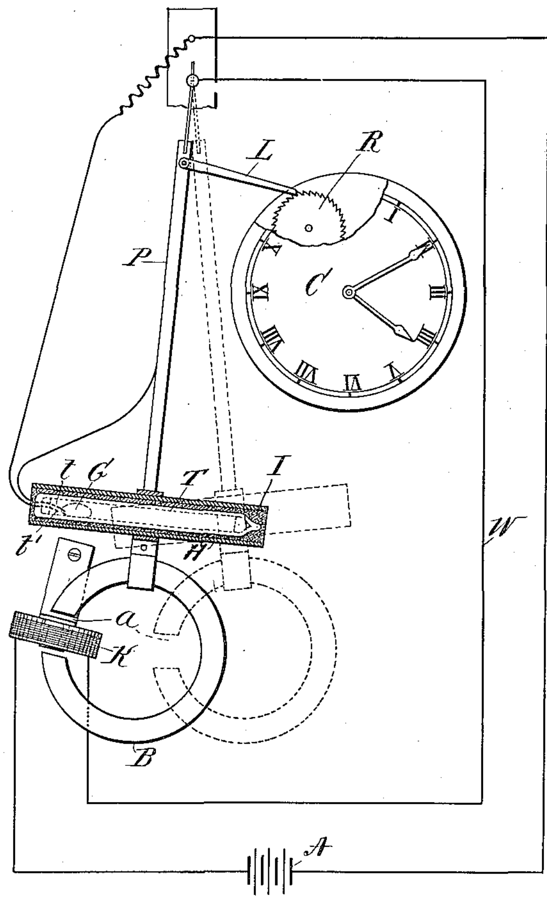

Fig-1-

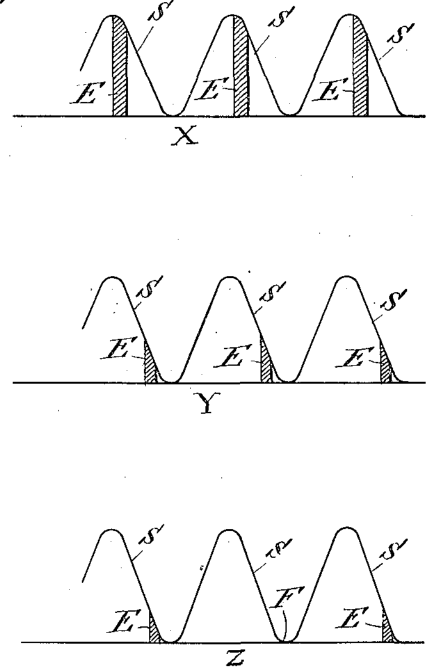

Fig-2-

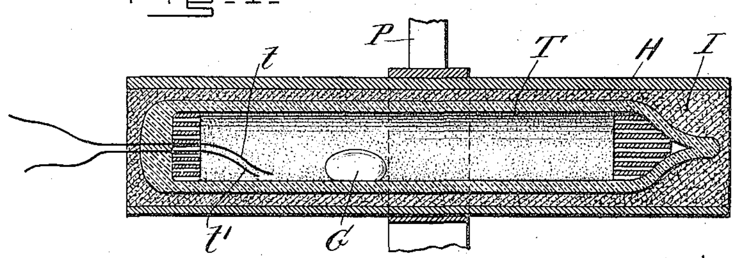

Fig-3-

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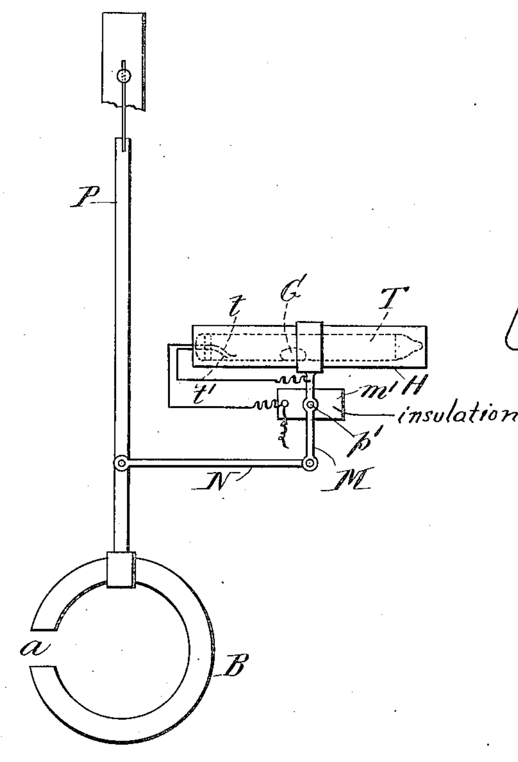

Fig. 4.

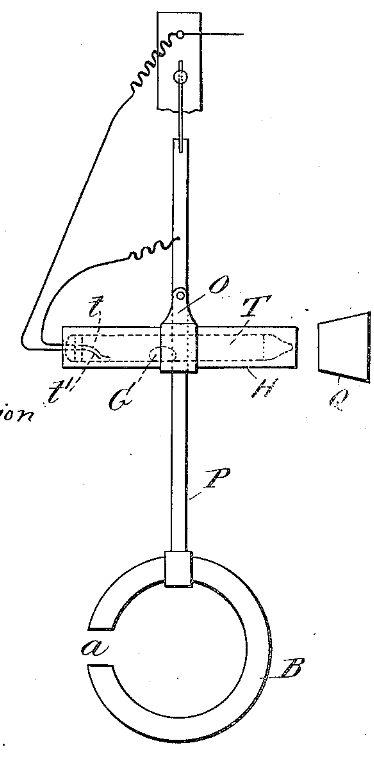

Fig. 5.

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UNITED STATES PATENT OFFICE.

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ELECTRIC APPARATUS FOR DRIVING CLOCKS OR SIMILAR MECHANISM.

1,144,973. Specification of Letters Patent. Patented June 29, 1915.

Application filed July 27, 1910. Serial No. 574,092.

To all whom it may concern:

Be it known that I, HENRY E. WARREN, a citizen of the United States of America, and resident of Ashland, in the county of Middlesex and Commonwealth of Massachusetts, have invented Improvements in Electric Apparatus for Driving Clocks or Similar Mechanism, of which the following is a specification.

This invention relates to mechanism for propelling clocks electrically, and is an improvement upon certain parts of the apparatus shown and described in my Patent No. 1,089,886, dated Mar. 10, 1914.

It appertains chiefly to the construction and arrangement of the parts by which the electric current that gives periodic impulses to the oscillating device in the clock, is opened and closed, and its object is to overcome the liability to interference with the continuously proper operation of such mechanism as that heretofore employed, by reason of the wear, oxidation or fouling of the contacts of the make-and-break devices there used.

The invention consists of a closed vessel which may be a tube of glass or other suitable material, or an elongated troughlike receptacle within a closed vessel having the oxygen or air practically exhausted from the tube or closed vessel. This exhaustion is important, because it is found that commercial mercury, when subjected to long continued agitation in the presence of air, tends to become coated with a film of oxid which interferes seriously with its mobility whether or not electrical current is flowing, and eventually renders it practically useless for this purpose.

Within the elongated receptacle a ball or globule of electric conducting material is placed, and the two terminals of the electric circuit are inserted and sealed into one end thereof in such position that when the said ball or globule moves to that end of the receptacle it will make contact with both terminals, and thus close the electric circuit. I have found a convenient and economical receptacle for the purpose to be a tube of glass, with the electrodes fused into one end, and a globule of mercury within as the circuit closing medium. When a pendulum is used as the oscillating device, this tube is secured to the pendulum rod in a position which is inclined to the horizontal sufficiently to cause the circuit closing globule to assume a position near the electrodes when the pendulum is at rest. When other oscillating devices are employed, as for instance a wheel or disk, the tube containing the mercury globule is secured to the wheel in a position such that the longitudinal axis of the tube will be slightly inclined to the horizontal, when the oscillating wheel is at rest, in equilibrium. Also, when the change of level is as small as that produced by the oscillating device in mechanism of this character, I have found that neither commercial nor chemically pure mercury is sufficiently mobile in traversing the pathway along the lower part of the interior of such a tube, whether of glass or steel, if the interior surface is smooth. This is on account of the adhesion of the mercury to such surfaces, which interferes with the surface tension of the mercury when that is used, and prevents that freedom of movement along the tube which is desirable for such a circuit closer.

When I speak of the "adhesion" of mercury to the surface of the tube, I refer to the temporary adhesion, or molecular attraction of the mercury to a smooth surface, and not to the permanent adhesion of portions of impure mercury, to the inner surface of the containing tube.

When using a globule of mercury, therefore, for the circuit closing medium, I have found that this adhesion to the surface of the containing tube may be counteracted and the desirable mobility preserved in three ways at least; first, by roughening the interior surface of the tube or other receptacle containing the mercury; second, by alloying the mercury with about two one-hundredths (2/100) of one per cent. (1%) of lead; and third, by placing within the tube a small quantity of inert powder such as pulverized glass or fine emery. I prefer the first mentioned way of imparting mobility to the mercury globule. The effect of the roughened surface within the tube is to support the mercury upon a large number of small projections, which do not break through the surface of the globule because of its strong surface tension but reduce the surface contact between the mercury and the interior of the tube to a minimum. In the tube the globule of mercury assumes the form of a flattened ellipsoid which will freely move over the roughened surface; this in the case of the glass tube may be produced by grinding with emery, and with a steel tube, I have found that cutting spiral or longitudinal grooves of twenty or more to the inch upon the inner surface produces the requisite roughness.

When the ends of the glass tube are sealed by fusing, there is a tendency for the roughness immediately about the ends to be obliterated, leaving a smooth surface to which as heretofore stated, the mercury will adhere. To prevent this, guards or buffers are inserted at each end of the tube. These may consist of narrow strips of stout paper or a thin steel ribbon coiled into spirals, which when pushed into the tube are retained in place by their own resiliency, and the convolutions are sufficiently close to prevent the entrance of the mercury between them. This make-and-break device gives excellent results on short pendulums, the rods of which are not more than seven or eight inches long, when the tube is attached to the rod within an inch or two of the center of the bob. On longer pendulums, such as seconds-pendulums, a good position for the tube is near the middle of the length of the rod; exact location is not necessary, as the device will operate with efficiency wherever the tube is located upon the rod, it may even be placed upon an extension of the rod below the bob.

Although the globule of mercury is in many respects preferable as a circuit closer, as heretofore stated, a metal ball may be used with practical results, the ends of the electric terminals being somewhat enlarged to insure greater surface contact.

In the drawings forming a part of this specification,—Figure 1 is an elevation of a pendulum with the improved make-and-break devices attached to its rod with a diagrammatic illustration of the electrical connections, and a simple illustration of the manner in which the clock train is operated by the pendulum; Fig. 2 are diagrammatic illustrations of the variation in the amplitude of oscillation of the pendulum, the duration of the electric impulse upon the pendulum at different stages and the place in each oscillation where the impulse is applied; Fig. 3 is a diametrical longitudinal section of the tube containing the globular or ellipsoidal make-and-break device, here shown as a glass tube with a mercury globule therein, and the whole incased in a protecting metal tube; Fig. 4 is an elevation of a pendulum connected with a make-and-break tube upon an independently supported lever; Fig. 5 is a modification of the manner of supporting the tube upon the pendulum rod, by means of a swinging bracket pivoted thereon and a stationary abutment against which the tube will strike at each swing of the pendulum, and thus change the angle of the tube in relation to the pendulum rod.

Referring to the drawings, and indicating the various parts of the apparatus bv letters, P is the pendulum rod, B its bob, which is shown as a permanent magnet with an air gap *a* between its poles; T the tube containing the make-and-break globule G, H the protecting casing of the tube T which is embedded in plaster of Paris or cement I, within the casing.

K is a wire coil in circuit with a battery A, which circuit through the wires W, W, includes the terminals *t*, *t'* sealed into one end of the tube T, and at which the circuit is opened and closed by the make-and-break globule G. In Fig. 1 is shown a pawl L pivoted to the pendulum rod P near its upper end, which pawl engages the teeth of a ratchet wheel R, in gear with the train of the clock C, which is driven thereby when the pendulum is in oscillation.

In Fig. 4 the casing H with its inclosed tube T, is secured to the upper end of a lever M, which is held on an insulating support *m'* by a pivot *p'*. The lower end of the lever M is connected to the pendulum rod P by a link N pivoted at each end to the respective parts; one of the electrical connections with the electrodes *t*, *t'*, within the tube T being made through the pendulum rod P and the levers N, M, and the other directly with one of the circuit wires W. In Fig. 5 the casing H is secured to a swinging bracket O, pivoted to the pendulum rod P, and when the pendulum swings, the end of the casing H will strike an abutment Q, and thus cause the casing and its inclosed tube T to swing upon its pivot connection with the pendulum rod, thereby imparting a compound motion to the tube T. The action of this movable globule or ellipsoidal mass within a tube much longer than the diameter of the globule, as a means for making and breaking the electric circuit which gives impulse to the oscillating device, is quite different from any means for the purpose heretofore employed, and is substantially as follows: When starting the pendulum from rest and swinging it to the left as in Fig. 1, the tube T will be tilted and the globule of mercury, by its inertia and the force of gravity, will move relatively to the tube along the pathway therein to the right and be separated from the electrodes *t*, *t'*. When the pendulum swings back toward the right the globule will tend to move toward the electrodes, but the lag in its movement will be sufficient to prevent the globule from making contact with the electrodes again until about the time when the pendulum reaches the end of its swing to the right; the momentum of the globule, however, will cause the mercury to completely immerse the electrodes and to remain in contact therewith until the pendulum is well advanced on its next swing to the left, thus keeping the circuit through the coil K closed for a considerable period and during that time attract the magnet bob B, and give it increased swing. The above operation is graphically illustrated at X in Fig. 2, wherein the sine curves S represent the extent of swing of the pendulum, and the shaded spaces E between the two perpendicular lines or ordinates of each curve represent the portion of each oscillation and the time during which electrical energy is being exerted tending to accelerate the movement of the pendulum.

As the pendulum increases in its amplitude of swing, the lag of the mecury globule will increase until a condition exists in which the globule does not return to the electrodes at all on the right hand swing of the pendulum, and does not close the circuit until the pendulum has advanced well toward the left hand extremity of its swing, as is shown for instance in Fig. 1, where only a brief contact is made and there is a correspondingly brief interval during which the magnet tends to increase the swing of the pendulum. If the amplitude of swing increases farther, the lag of the globule becomes greater, and at the same time the duration of its contact with the electrodes becomes less owing to the increased violence with which the globule strikes the end of the tube and rebounds. This condition is illustrated at Y, Fig. 2. Owing to this decreased interval of time during which the circuit remains closed, the rate at which energy is imparted to the pendulum tends to fall off and thus to maintain its amplitude of swing substantially constant. If, however, for any reason the pendulum should be caused to swing through a still wider arc, the lag of the globule will increase to such an extent that it will not make contact with the electrodes at all during one or even more double oscillations of the pendulum. This last named condition is illustrated at F in Z, Fig. 2, and while it continues no additional energy will be imparted to the pendulum, and it will soon assume its normal swing and the conditions, for instance, such as illustrated at Y. Thus with this form of contact-mechanism the use of electric current is automatically adjusted to the requirements of the pendulum. If the latter is swinging through an abnormally small arc the current impulses are of greater magnitude, and the lag angle especially effective in increasing the swing of the pendulum. If the amplitude of swing should become abnormally great, the current impulses decrease in duration and occur at a less effective lag angle. Moreover, increase or decrease in the electro-motive force of the battery supplying current produces only comparatively slight changes in the amplitude of swing of the pendulum for the same reasons as above mentioned. While it is obvious that other conducting liquids than mercury may be used as the contact-maker, the latter or one of its alloys is to be preferred. A desirable construction is to have one electrode project into the end of the tube a little farther than the other, so that when the pendulum is at rest, the longer electrode will not penetrate the surface of the mercury materially, and will hold it out of contact with the shorter electrode and the circuit will not be closed.

I am aware that the use of mercury as means to make periodic electric contacts in connection with a moving pendulum is not new, and that this has been accomplished by the variations in level of a considerable mass of mercury partially filling a closed tube and mounted on a pendulum-rod itself. These prior devices are impracticable and uncommercial for the reason that the oxygen of the air is allowed to remain in contact with the mercury, thus causing deterioration which gradually interferes with its mobility and ability to close the circuit, and also for the reason that none of the liquid circuit closers heretofore used have effected a sufficient lag of the current impulse behind the swing of the pendulum so as to drive it efficiently by direct electro-magnetic impulse, nor have any of these prior devices introduced the feature of a varying lag and varying period of contact tending to greatly reduce the driving impulse in proportion as the swing of the pendulum increases, and in none of them is there produced a variable phase relation between the oscillations or reciprocating movements of the oscillating device and the contact-maker as is done by my improvements, and none of the circuit-breakers heretofore proposed for driving pendulums electrically have been able to produce such a wide clean break and such a low resistance contact as are obtained with my improved means.

The beneficial results of my improvement cannot be obtained by the construction shown in any prior structure which has come to my attention. The isolated globule of conducting liquid upon an antiadherent surface in my apparatus has a movement produced by the swing of the oscillating device, which is suggestive of that of the shuttle in a loom, although usually not so regular; but it has a sensitiveness and activity which cannot be produced in any of the prior structures.

This device may be described as an amplitude regulating circuit-closer for electrically driven pendulums, which gives current impulses that are much more effective for driving a pendulum when it swings through a smaller arc than its predetermined normal, than when it swings through an arc greater than its predetermined normal, and when its swing is greatly in excess of the normal, omits a portion of the impulses, thus increasing the swing when too small and decreasing it when too great.

I claim:

1. An electrically impelled pendulum having an amplitude regulating circuit closer mounted and contained wholly thereon.

2. An electrically impelled oscillating device and a circuit closer contained wholly thereon, which imparts electrical impulses to said device of markedly decreasing effectiveness, with its increase in amplitude of swing.

3. A liquid contact maker for the circuit of an electric clock, which contact is caused to close the circuit momentarily at varying intervals determined by the swing of the pendulum thereby tending to maintain uniformity of its swing.

4. An oscillating device, electrical means to impart energy thereto, a contact-maker in the circuit operated by the oscillating device and adapted to cause current impulses when said device is at different positions between its limits of oscillation, which positions vary with the amplitude of the oscillations of the device and tend to maintain such amplitude constant.

5. An oscillating device, electrical means to impart energy of oscillation thereto, and a contact-maker in the circuit which gives momentary current impulses, the recurrences of which have a variable difference of phase in relation to the oscillations of said device, dependent upon its amplitude of swing, and thereby tends to maintain the uniform constancy of its swing.

6. The combination of an electrically impelled oscillating device, a pathway tilted by said device, an abutment at one end of the pathway, a freely moving mass upon the pathway adapted to strike the abutment and rebound therefrom when the pathway is tilted, and means to momentarily close the electric circuit when the mass strikes the abutment.

7. The combination of an oscillating device, electrical means to give it added impulse when oscillating, an interiorly roughened elongated receptacle adapted to be tilted synchronously with the swing of the oscillating device, a mass of mercury within the receptacle, and electrodes of the impulse giving circuit in the path of movement of the mercury within the receptacle.

8. The combination of an oscillating device, electrical means to give it added impulse when oscillating, an interiorly roughened sealed tube adapted to be tilted by the movement of the oscillating device, an isolated mass of mercury free to move within the tube, which latter has a path of travel greater than that normally given to the mass by the movement of the oscillating device, and electrodes of the impulse giving circuit at one end of the tube.

9. The combination of an oscillating device, a pathway adapted to be tilted by the oscillating device, a globular or ellipsoidal electric conducting mass adapted to move upon the pathway when tilted, means to reduce surface contact between said conducting mass and said pathway, and means at the end of the pathway to close and open an electric circuit respectively when said mass makes contact with and recedes from such means.

10. The combination of an oscillating device, a pathway of rough surface adapted to be tilted by the oscillating device, an electric conducting mass non-adherent to the pathway and free to move thereon when tilted, and means in the path of said mass to close and open an electric circuit respectively when said mass makes contact with and recedes from such means.

11. The combination of an oscillating device, a sealed tube adapted to be tilted by the oscillating device, a mass of mercury contained within the tube, means which minimize the surface of the mercury in contact with the tube, and means to open and close an electric circuit when the mercury moves along the tube.

12. The combination of an oscillating device, a sealed glass vessel adapted to be tilted by the oscillating device, a mass of electric conducting liquid contained within said vessel, means which minimize the surface of the liquid in contact with the vessel, and means to close and open an electric circuit when said liquid moves within said vessel.

13. The combination of an oscillating device, electrical means to give it added impulse when oscillating, a sealed glass tube adapted to be tilted synchronously with the swing of the oscillating device, an isolated mass of mercury within the tube, means to minimize the surface contact between the mercury and the tube, and electrodes of the impulse-giving circuit in the path of movement of the mercury within the receptacle.

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Witnesses:

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