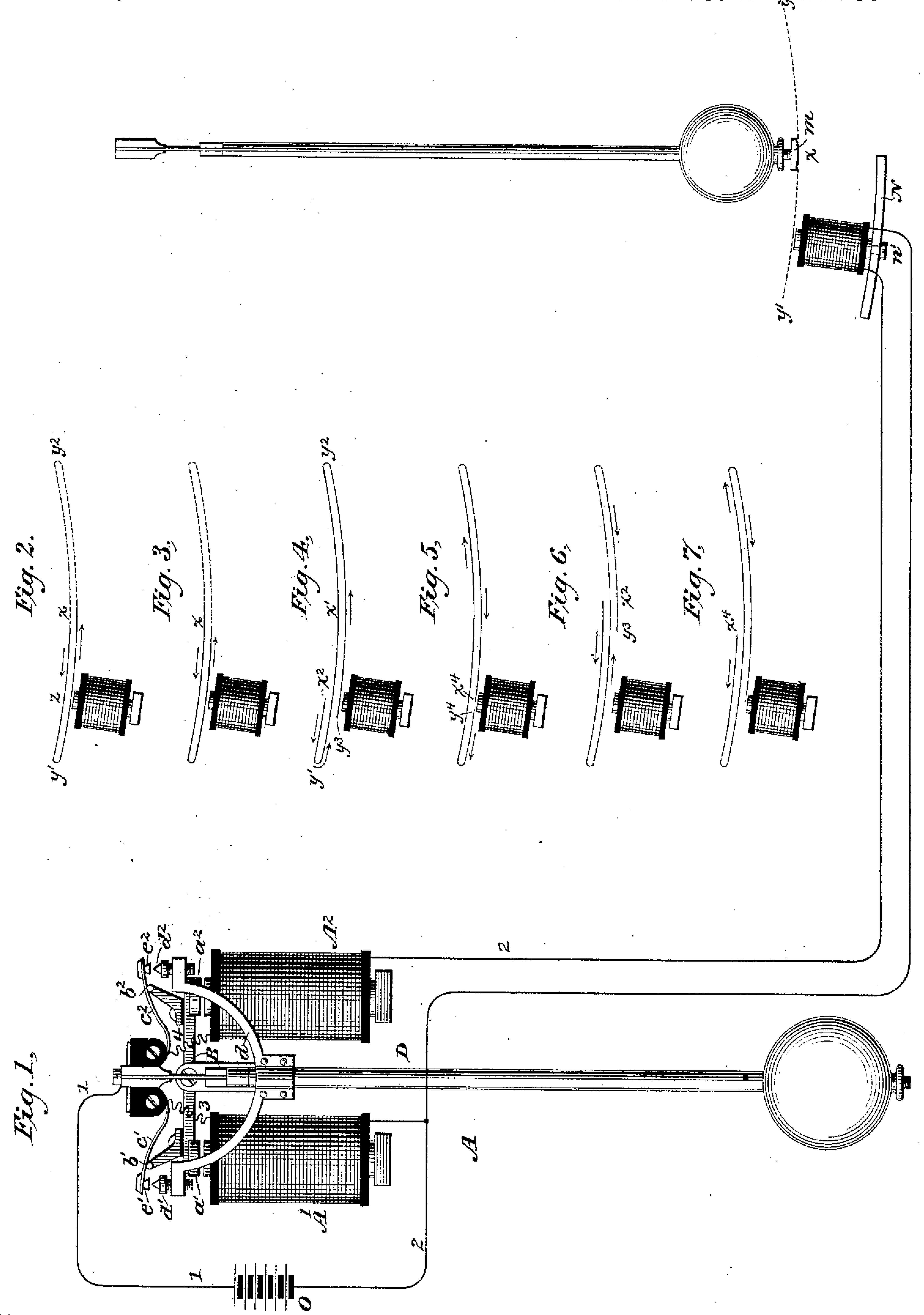
(No Model.)

H. L. BAILEY.

ELECTRIC SYNCHRONIZING DEVICE FOR CLOCK PENDULUMS.

No. 332,987. Patented Dec. 22, 1885.



Witnesses

Geo. W. Breck.

Carrie E. Ashley

Inventor

Henry L. Bailey,

By his Attorneys

Pope & Edgecomb

N. PETERS. Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

HENRY L. BAILEY, OF BROOKLYN, ASSIGNOR TO THE TELEGRAPHIC TIME COMPANY, OF NEW YORK, N. Y.

ELECTRIC SYNCHRONIZING DEVICE FOR CLOCK-PENDULUMS.

SPECIFICATION forming part of Letters Patent No. 332,987, dated December 22, 1885.

Application filed August 10, 1885. Serial No. 173,907. (No model.)

To all whom it may concern:

Be it known that I, HENRY L. BAILEY, a citizen of the United States, residing in Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Electric Synchronizing Devices for Clock-Pendulums, of which the following is a specification.

My invention relates to the class of apparatus employed for the purpose of retarding or accelerating the movements of clock-pendulums, as may be required to maintain their vibration in unison with a standard regulator. Heretofore it has been customary to employ for this purpose a series of electro-magnets, one electro-magnet being placed at each pendulum, and to periodically transmit short impulses through the same. The electro-magnets thus vitalized act upon soft-iron armatures carried by the pendulums, and serve to accelerate or retard them, as may be required. To this end the magnets have been so placed that they act at the limits of vibration of the pendulums, and they are vitalized at the moment the pendulums, when beating in unison, are at those limits. Should any pendulum become too slow, the magnetic attraction is exerted before it reaches the limit and the pendulum is accelerated. Should it become too fast, the attraction is exerted as the pendulum is leaving the magnet, and therefore its movement is retarded. In systems organized upon this principle the period during which the magnet can act is very limited and a considerable time is required to correct a pendulum; moreover, should the error of the pendulum be considerable, the distance through which the magnet is compelled to act becomes so great and the time is so limited that its effects are insufficient to bring the pendulum into unison.

The object of the invention is to provide means for correcting a pendulum, whatever its error may be, and for acting upon the pendulum through a longer period than has been possible heretofore, the correcting influence exerted being for a time in some manner proportional to the error to be corrected.

The invention consists in organizing the apparatus in substantially the following manner: The regulating or controlling clock is provided with means for completing an electric circuit periodically for a determinate time, and then causing it to remain open for an approximately equal time. In the circuit thus controlled there are included one or more electro-magnets, one being applied to each controlled pendulum. These magnets are located at points intermediate between the limits of the vibrations of their respective pendulums. It is designed that the armatures carried upon the several pendulums shall be acted upon continuously during half their beat and then allowed to move freely during the remaining half-beat, or else that they be acted upon during approximately the whole of each alternate beat. Considering that the magnets become vitalized when the pendulum is at its central point and is moving in the direction of the magnet, then an accelerating force will be exerted until the armature is opposite the poles, and from that point a retarding force will be exerted until the pendulum reaches its limit. An accelerating force will then be again exerted until the pendulum is again opposite the poles, and, finally, a second retarding force will be exerted until the pendulum has returned to its central point, where the circuit will be interrupted. It will be readily understood that the first accelerating force will be exactly compensated by the retarding force, and that the first retarding force will be exactly equivalent to the following accelerating force, so that no variation in the beat of the pendulum will be occasioned. Supposing, now, that a controlled pendulum becomes too slow, then the circuit of its magnet will be completed before it has reached its central point, and the first accelerating force is exerted through a greater period of time than when beating in unison. The force exerted while the pendulum is swinging from the poles of the magnet to its limit will be equalized, as before, by the force exerted during its swing from the limit to the poles. When the pendulum passes the poles upon its return-swing, the retarding force is exerted, as before, but the period during which it beats is shortened by as much as the first accelerating force was prolonged. Two factors, therefore, combine in this instance to correct the pendulum—viz., the prolonged accelerating force and the shortened retarding force.

In practice I have found that the controlled pendulum will adjust its swing so that the points at which the circuit is closed and interrupted are approximately constant so long as the position of the magnet and the length of the pendulum are unchanged.

Should the pendulum become too fast, then the duration of the accelerating-force is lessened and that of the retarding force is increased.

Instead of acting upon the pendulum during each alternate half-beat, it may be desirable in some instances to vitalize the electro magnet during each alternate beat. Thus if the pendulum beats half seconds the circuit may be closed during each alternate second. If the pendulum tends to be slow, there will be a proportionate accelerating impulse imparted to each alternate beat, and if it tends to beat fast then a corresponding retarding influence will be exerted each alternate beat.

Various methods of applying this invention will readily suggest themselves, but those which I now consider the most desirable are illustrated in the accompanying drawings, in which Figure 1 is a diagram illustrating the general organization of apparatus and circuits, and Figs. 2, 3, 4, 5, 6, and 7 are theoretical diagrams illustrating the application of the varying forces.

In the drawings, A represents any suitable form of regulating-clock organized to alternately complete and interrupt an electric circuit, and to cause the duration of the completions and interruptions to be approximately equal. In this instance there is shown a clock-movement constructed with two electro-magnets, A' and A^2, included in conductors 1 and 2, leading from a battery, O. A lever, B, carries the respective armatures, a' and a^2, of the magnets. A conductor, 3, leads from the magnet A' to an insulated impulse-spring, c', and a conductor, 4, leads from the magnet A^2 to a similar spring, c^2. Upon the pendulum D there is carried a cross arm, d, which is connected with the battery O by a conductor, 1. Each spring carries a contact, e' and e^2, and these are respectively applied to two similar contacts, d' and d^2, upon the arm d. The movement of the pendulum causes either the contact d' or d^2 to strike its corresponding contact, e' or e^2, and the corresponding electro-magnet thus becomes vitalized. When the magnet A' is vitalized, the armature a' is drawn down and an insulated lifting-pawl, b^2, carried upon the lever, raises the spring c^2. This spring remains under tension until the swing of the pendulum in the opposite direction brings the point d^2 against the point e^2, when the point d' leaves the point e'. The circuit is thus transferred from the magnet A' to the magnet A^2, and the lever is thus tipped in the opposite direction. The spring c^2 acts through the contacts e^2 and d^2 to impel the pendulum back, and meanwhile the spring c' is raised preparatory to imparting its impulse. It will be understood thus that a circuit will be completed through the magnets A' and A^2 alternately, and that if the pendulum D be a second-beating pendulum, then the circuit through each conductor will be complete during one second and interrupted during one second.

It is designed that a synchronizing-magnet of a controlled pendulum shall be included in the conductor 2, for instance, and that it shall thus be vitalized each alternate second. There may be any desired number of these controlled by a single regulator. Considering the controlled pendulum to be organized to beat seconds, then it is designed that the circuit through the conductor 2 shall be completed at the moment the pendulum reaches some particular point in its vibration—say central point, x—and shall remain complete until it returns to that point, having passed beyond the magnet. The magnet may be located at any point between the limits v' v^2 of the swing of the pendulum, preferably, however, about midway between the central point, x, and one limit, y'. Its location may be varied somewhat, and for this purpose it is preferably carried upon a plate, N, along which it is adjustable by means of a set-screw, n', extending through a suitable slot in the plate. The plate is preferably curved to correspond to the arcs described by the pendulum. The pendulum carries an armature, m, which is acted upon by the electro-magnet.

This apparatus may be employed not only for synchronizing pendulums which are actuated by other means, but the pendulums may be both driven and synchronized by this method. It is evident that a pendulum once started will, if it relies upon the impulses to maintain its movement, tend to fall behind a little at each beat; but the accelerating impulse given to it will serve to compensate for this, so that its vibration will be maintained, and these vibrations will necessarily be synchronous with the master-clock.

Referring now to the theoretical diagrams, it will be understood that the circuit becoming closed when the pendulum D is swung in the direction of the arrow y' and is at the point x, for instance, an accelerating force is exerted until the armature is at the point z, opposite the poles of the magnet. Then a retarding force is exerted until the limit y' of the arc of the pendulum is reached. Then an attractive force is exerted until the pendulum again reaches the point z, whereupon a retarding force is again exerted until the point x is reached. It is evident that these forces in effect equalize each other, provided the circuit be completed and interrupted when the pendulum is in the same place, which will be the case when it is in unison with the controlling-pendulum. If, however, the pendulum be slow, the circuit will be completed before it reaches the point x in its swing toward the magnet, and will be broken before it reaches that point upon the return swing. The point at which the pendulum stands when the circuit is interrupted will be on the other side of the point x, but at a distance from it equal approximately to the distance of the point at which the pendulum was when the circuit was closed, as indicated by the full line in Fig. 3. The prolongation of the attractive force and the shortening of the retarding force combine to bring the pendulum into beat.

When the pendulum is fast, the effect is similar, but the reverse, the attractive force being shortened and the retarding force lengthened, as indicated in Fig. 2.

It is not necessary that the duration of the impulses be exactly equal to the intervals between them, for the pendulum will in practice be maintained in synchronism even if these differ considerably, it being essential only that the time during which the impulses last be greater than the time required for the pendulum to swing from the electro-magnet to the nearest limit and back again to the electro-magnet.

The method of synchronizing when applied to pendulums beating in approximately the same time as is occupied by each impulse is somewhat more complex.

In Fig. 4 a diagrammatic representation is made of the relation of the circuit to the beat of the pendulum, tending to beat in a very little less than half the time during which the circuit is closed—that is to say, to pass a given point twice while the circuit is closed, and to do the same while the circuit is open. Thus if the circuit be closed a second and then open a second, and the pendulum be adjusted to beat half-seconds, then if we suppose the circuit closed when the pendulum is at x' and swinging toward the left, it will be open at the second return of the pendulum thereto; but if it is fast, then the circuit will be closed at a point, x^2, and remain closed until the pendulum has reached that point a second time and passed it to y^3—that is a distance dependent mainly upon the degree of its fastness—for it is evident that if the pendulum were adjusted to beat exactly half-seconds the circuit would be opened at precisely the point at which it was closed, but tending to beat faster than half-seconds it will have passed that point. From x^2 to y^2 represents the distance through which it swings, while the circuit is closed after the point x' is passed before the circuit is opened. This line represents the amount of retardation which it is necessary to give the pendulum at each alternate vibration to keep it in unison. Should the pendulum be a slow pendulum, then it will be necessary to accelerate it at each alternate vibration, and the diagram, Fig. 5, illustrates the operation in such a case. The pendulum being slow, the circuit will not remain closed until the pendulum has reached the point y^4, at which the circuit became closed. The section of the line between the points x^4 and y^4 will then represent the accelerating force imparted to the pendulum each time the circuit is closed, which is not counteracted by a corresponding retarding force. A corresponding acceleration will therefore be imparted to the pendulum at each alternate vibration.

It will be noticed that the correction is applied to the pendulum upon the side of the magnet nearest the limit of its vibration toward which the pendulum is swinging when the circuit is first closed. Should the pendulum be started so that the circuit were first closed upon the other side of the magnet, the pendulum will gradually adjust itself until a particular point at which the circuit is closed is reached, and afterward this will remain constant. This will be more evident by considering the diagrams in Figs. 6 and 7. In Fig. 6 the circuit becomes closed when the pendulum is at the center of its beat and is swinging toward the left hand. Considering this to be a fast pendulum, the additional impulse represented by the line $x^2\ y^3$ will be an accelerating impulse. The pendulum is caused thereby to swing still faster, and it will be at a point, x^4, (see Fig. 7,) when the circuit is again closed. Each successive closure of the circuit will therefore find the pendulum at a point nearer the magnet toward which it is swinging. Eventually the point of closure will reach the magnet and pass beyond it. A retarding effect is then exerted upon the pendulum, and ultimately the condition represented in Fig. 5 will be reached.

Precisely the same effect is accomplished in the case of a slow pendulum; for, considering that the points of closing and opening the circuit were upon the right-hand side of the magnet, then the pendulum would be constantly retarded, causing the point of connection to change gradually, until it ultimately adjusts itself to approximately the position shown in Fig. 5.

It may be here observed that the point at which the magnet is applied may be any point between the limits of vibration, excepting that it must not be at the limit, for in that position its effects would be lost.

It is not necessary that the circuit be closed for a time precisely equal to that during which it remains open, but quite a variation may be made in this respect.

I claim as my invention—

1. The hereinbefore-described method of controlling the vibrations of pendulums, which consists in periodically applying thereto correcting-impulses directly proportionate in their effects to the tendency of the pendulums to vary from a fixed standard between the repetitions of the impulses.

2. The hereinbefore-described method of controlling the vibrations of pendulums, which consists in exerting thereupon magnetically accelerating or retarding impulses, as required, proportionate to the error to be corrected between each repetition of such impulses.

3. The hereinbefore-described method of synchronizing clock-pendulums, which consists in alternately accelerating and retarding the same and causing the accelerating or the retarding influence to exceed in value, accordingly as it is desired to hasten or slow the pendulum.

4. The hereinbefore-described method of synchronizing clock-pendulums, which consists in subjecting the same to magnetic influence during its movements in two directions, and in causing the duration of its movements counter to said force to exceed the duration of its movement toward the force, or vice versa, as may be required to correct the error of the pendulum.

5. The hereinbefore-described method of maintaining pendulums in action for time-keeping, which consists in subjecting the pendulum to the influence of electro-magnetic action during its movement toward and away from one of its limits and through the center of magnetic force.

In testimony whereof I have hereunto subscribed my name this 31st day of July, A. D. 1885.

HENRY L. BAILEY.

Witnesses:
DANL. W. EDGECOMB,
CHARLES A. TERRY.