(No Model.) 2 Sheets—Sheet 1.

H. WHITING.

ELECTRICAL DEVICE FOR SYNCHRONIZING CLOCK PENDULUMS.

No. 346,970. Patented Aug. 10, 1886.

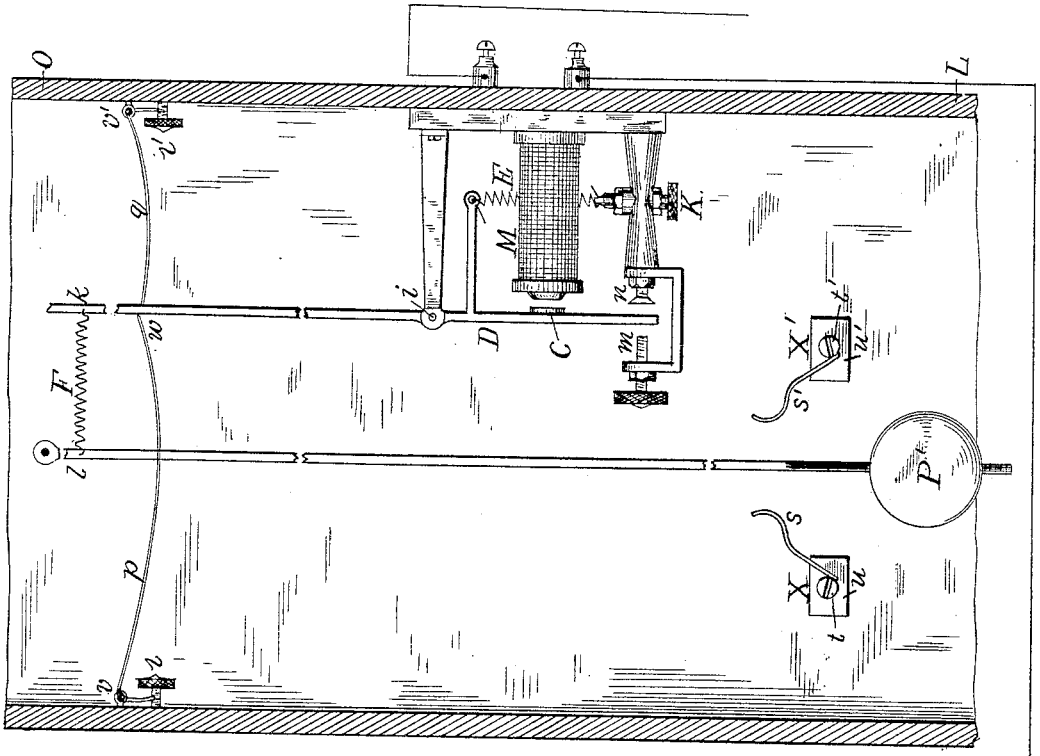

Fig. 1.

Witnesses.
Saml. C. Bennett
Robert F. Babson.

Inventor,
Harold Whiting

(No Model.) 2 Sheets—Sheet 2.

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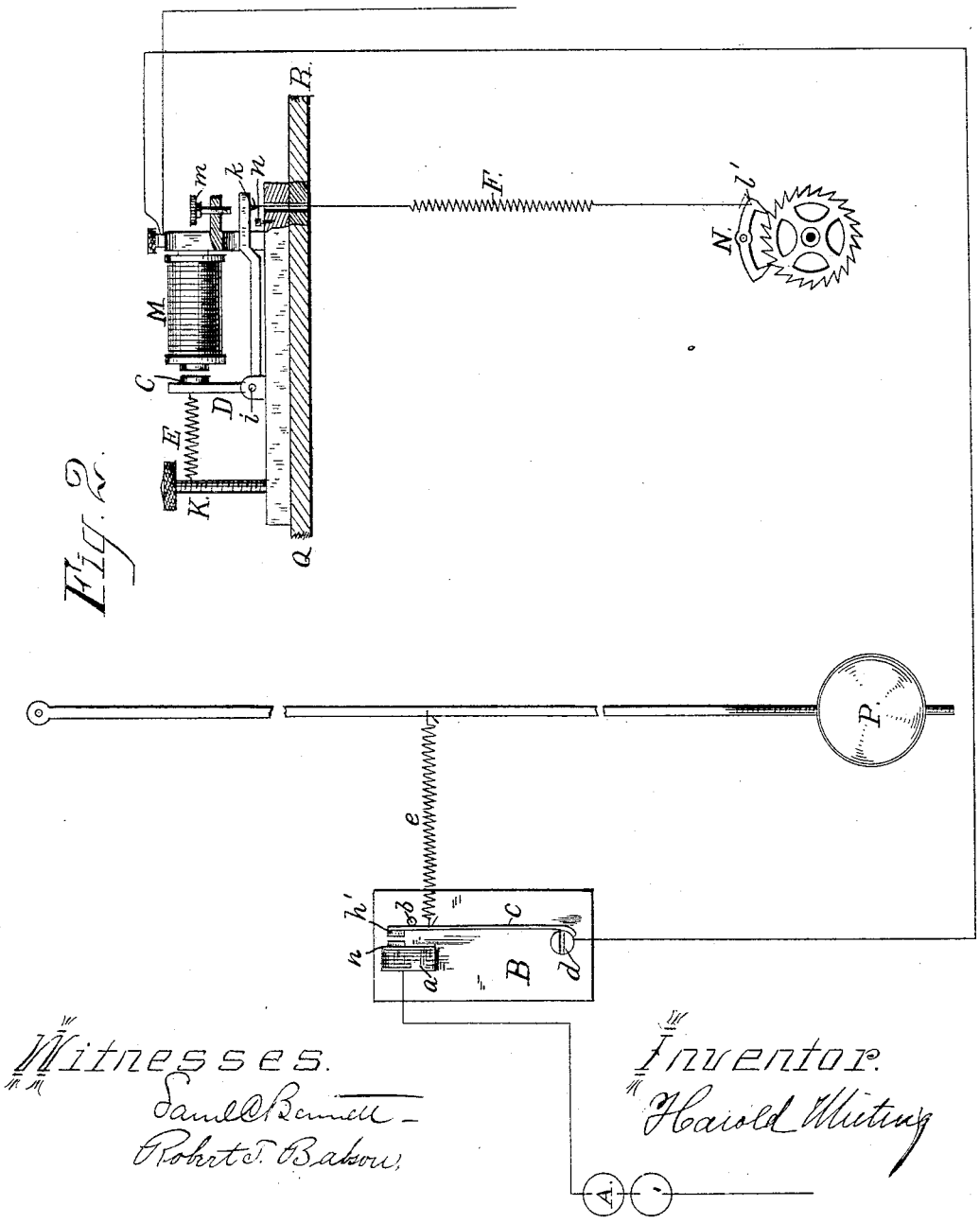

Fig. 2.

Witnesses.
Saml. A. Bennett
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UNITED STATES PATENT OFFICE.

HAROLD WHITING, OF CAMBRIDGE, MASSACHUSETTS.

ELECTRICAL DEVICE FOR SYNCHRONIZING CLOCK-PENDULUMS.

SPECIFICATION forming part of Letters Patent No. 346,970, dated August 10, 1886.

Application filed February 23, 1886. Serial No. 192,906. (No model.)

To all whom it may concern.

Be it known that I, HAROLD WHITING, a citizen of the United States, residing at Cambridge, in the county of Middlesex and Commonwealth of Massachusetts, have invented a new and useful Improvement in Electrical Devices for Synchronizing Clock-Pendulums, of which the following is a specification.

My invention relates particularly to an improved electrical apparatus by which the pendulums of one or more secondary clocks, automatically actuated, may be controlled by and compelled to vibrate synchronously with the vibrations of the pendulum of some standard clock or regulator.

The object of my invention is to combine, in a simple and cheap mechanism, as has never yet been done, even in the most complicated devices, the following advantages: First, complete separation of said mechanism from the clocks to which it may be applied, so that it can be attached or detached without change in the construction of said clocks; second, independence of the strength of the battery employed; third, perfect synchronism of the controlling-pendulum with that controlled, independent of the arc of oscillation; fourth, such adjustability that the relation of the phase of the secondary pendulum to that of the primary may be altered at will; fifth, independence of false time-signals; sixth, power of correcting the largest possible error which can be corrected by such a mechanism, whereby the clock is rendered as independent as possible of a continuous interruption of the time-signals; seventh, the minimum of friction in the parts which may be operated by the clock. I attain this object by the use of a mechanism constructed as illustrated in the accompanying drawings, in which—

Figure 1 represents a general view of my apparatus as attached to a standard and one secondary clock: Fig. 2, the same, but with a different method of attachment to the secondary clock.

Similar letters refer to similar parts throughout the drawings.

In the figures, P represents the pendulum of the standard clock or regulator; P′, the pendulum of the secondary clock, which is to be compelled to vibrate synchronously with P.

h and *h′* are two contact-pieces of platinum, of which *h* is carried on the block *a*, which is mounted on the stand B, and *h′* on one end of the flat steel spring *e*, the other end of which is fastened permanently to the screw *d*. The spring *e* is connected, near the contact-piece *h′*, with the pendulum P by means of the spiral spring *c*. The spring *e* is adapted to always maintain tension on the spring *c* through all points of P's swing, and should have sufficient elasticity not to be permanently strained by following the vibrations of P, and should be of as great stiffness as is consistent with the compensation of its accelerating effect on P by lowering the bob of P, without exceeding the limits of the screw ordinarily provided for that purpose.

The spring *e* is best made from three to four inches in length, and must be of sufficient elasticity, as compared with the spring *c*, to allow a play of *h′* from one-sixteenth to a quarter of an inch when the pendulum P is in vibration, provided no stops checked its play. It must also be of sufficient strength to be able to bring the contact-pieces *h* and *h′* into contact at any desired point of the pendulum P's swing. The length of the time of contact between *h* and *h′* may then be regulated by increasing or diminishing the tension of the spring *e* by turning the screw *d*, to which it is firmly fixed, to the left or right.

In order that the effect of the spring *e* upon the pendulum P may be constant, a stop, *b*, is placed in the stand B, so as to reduce the play of *h′* to as small an arc as consistent with the complete breaking of the electric circuit. I prefer in some cases to make this stop and the platinum contact-piece *h′* adjustable, so that the size of this arc may be slightly increased or diminished, as desired. As the spring *e* returns to the pendulum P in its return swing substantially the same energy as was expended in stretching it, any tendency of my circuit-closing device to stop the pendulum P is practically obviated. Subject to the qualifications set forth, the stand B can be placed in any part of the primary clock convenient for at-

taching spring *e* to the pendulum P, and can obviously be attached or detached at pleasure.

My device for controlling the secondary clock's pendulum P′ may be constructed as follows: The electro-magnet M, which is mounted on a stand which can be fastened inside the clock-case—as, for example, against the side O L, as in Fig. 1—has an armature of soft iron, C, carried on the vibrating lever D, which lever is pivoted at *i*. Two stops, *m* and *n*, each of which is provided with a check-nut, to keep it in place, are situated in any manner convenient for controlling the play of D—as, for example, in Figs. 1 and 2. Two other stops, *p* and *q*, of some elastic material, are fastened to the thumb-screws *r* and *r*′, placed in the sides of the clock, and, passing through two eyes, *v* and *v*′, also placed in the sides of the clock, are attached to D as near its center of percussion, *w*, as possible. Their tension may be increased or diminished by means of the thumb-screws *r* and *r*′. A spring, E, is arranged to draw the lever D away from the electro-magnet M when the armature C is released by the breaking of the electric circuit, and should be strong enough to do so no matter in what part of its swing the pendulum P′ may happen to be. The tension of the spring E may be increased or diminished by means of the thumb-screw *k*, to which it is attached, and which thumb-screw should be provided with a check-nut to keep it in place. A spiral spring, F, connects the lever D with the pendulum P′, and the distance from *k*, where such spring is attached to D, to the pivot *i* must be enough greater than from C to *i* that the maximum play of D at *k* shall be nearly equal to that of P′ at its corresponding point, *l*. The device must also be so arranged that the motion of the points *k* and *l*, at which spring F is attached, shall be as nearly as possible in the same straight line. Instead of attaching the lever D to the pendulum-rod, as in Fig. 1, it may be attached by spring F to one arm of the anchor N of the escapement, as in Fig. 2. When this method of attachment is used, I place my device on top of the clock-case, a section of which is represented by Q R in Fig. 2, using D in the form of a straight or bent lever, (the latter is used in Fig. 2,) as most convenient. The control is constructed in other respects as hereinbefore described, with the exception that the elastic stops *p* and *q* are omitted, and the lever D shortened, so that the maximum play of *k*, when spring F is attached, is nearly equal to and in the same direction as that of *l*′, the corresponding point of the clutch N. Two adjustable buffers are also placed in each secondary clock, so that by advancing them the length of the arc of oscillation of P′ may be limited. Such buffers may be constructed like X and X′ in Fig. 1, in which *s* and *s*′ represent curved springs, made of flat steel, which are firmly fixed to the screws *t* and *t*′. *t* and *t*′ are mounted on the stands *u* and *u*′, which are fastened to the back of the clock-case, and are sufficiently high so that the springs *s* and *s*′ can be made, by turning the screws *t* and *t*′, to engage the pendulum P′, and cut off a portion of its swing.

In practice my device for controlling the pendulum of the secondary clock or clocks can be made out of an ordinary telegraphic sounder by attaching the lever carrying the armature by means of a spring, F, to the pendulum rod or anchor, as hereinbefore described. It will generally be found, however, that when the control is attached as in Fig. 1 the lever will require to be elongated by the addition of a light arm, so that its point *k*, when spring F is attached, may have the necessary play. The same may also be done, if necessary, when the attachment is made as in Fig. 2. The accelerating effect of spring F upon P′ may be compensated by lowering the bob, and spring F should not be so strong that its effect cannot be compensated without lowering the bob beyond the limits allowed by the screw ordinarily provided for that purpose. In compensating for the effect the bob should be lowered sufficiently that the natural vibrations of the pendulum P′ with the spring attached may be nearly synchronous with those of the pendulum of the standard clock or regulator. The spring F must be strong enough, when my device is in operation, to give the pendulum P′, previously at rest, an oscillation of one degree in the course of half an hour. It must also be elastic enough to allow the pendulum P′ to vibrate easily, no matter in what position the lever D, to which its other end is attached, may be, and should be adjusted so as to always maintain a state of tension on the pendulum P′.

Subject to the above qualifications, my device may be placed in or on any part of the case of the secondary clock most convenient for attaching it to the pendulum rod or anchor, as may be desired, and the spring F may be made of sufficient length for such connection.

Instead of a long lever, D, and spring F, I may use any other form of device by which a vibrating arm communicates its vibrations through a spring to the pendulum P′—as, for example, a springy arm, upon which the armature C may be mounted.

The operation of my invention is as follows: One pole of the battery A is connected with either the contact-piece *h* or *h*′, and the other contact-piece is connected with a main line, with which the control for the secondary clock is connected, and which can be returned to the other pole of the battery directly or through the ground. The break-circuit and control can each be fitted with screw-cups or switches, so that this connection can be made or broken at pleasure. As the circuit is closed by the swings of P, the electric current passes through the electro-magnet M, and makes it attract the armature C. When the circuit is broken by the return-swing, C is released, and the spring

E draws the lever D back to its former place. Thus a periodic vibration of the lever D is produced which causes periodic changes in the tension of the spring F, which changes will control the vibrations of the secondary pendulum P', and compel it to vibrate synchronously with P. The relative position in its phase that P' will maintain with P depends largely upon the length of the contact, and whether the control is attached as in Fig. 1 or in Fig. 2. When the contact is made and broken at equal intervals, and the control is attached as in Fig. 2, the pendulum P' will be compelled by the control to vibrate in such a manner that it will be met by the changes in the tension of the spring F at that limit of its swing in which the action of the control will increase rather than diminish the arc of oscillation. When the contact is made or broken but for a moment, the effect of the increase of tension is the same as a blow, and the position in which P' will be met by the change will be its central point, the pendulum vibrating in one direction or the other, according as it is the make or break which is momentary. When the attachment is made as in Fig. 1, the length of the lever D and the use of the elastic stops *p* and *q*, instead of the stops *m* and *n*, combine to produce a secondary effect, through the inertia of the lever and spring, which will carry the point *k* beyond its place of rest, and thus cause it to recoil thereto, producing the effect of a double blow in opposite directions on the pendulum. This secondary effect will maintain the vibrations of P' in such a manner that it will tend to be met by the changes in tension of spring F at the limit of its swing. When I desire to have P' vibrate so as to maintain the same phase as P, I arrange my contact-breaker so that the circuit shall be made and broken at equal intervals, and place my elastic buffers X and X' so as to limit the arc of oscillation of P'. When P and P' are vibrating together, and the contact is made and broken at equal intervals, the change in tension of spring F will occur when P' is at its zero-point. This, ordinarily, will tend to retard P; but as soon as P' falls a little behind the action of the control will increase its arc of oscillation. If, now, I cut off this increase by my elastic buffers, P' will be accelerated and compelled to maintain its vibration, so that it will continue to be met by the changes in tension of spring F at very nearly its central point.

By changing the length of contact between *h* and *h'*, the mode of attaching the control, as in Figs. 1 or 2, by using the break-circuit as a shunt instead of as a key, and by the use of the elastic buffers X and X', as hereinbefore explained, I can maintain the secondary pendulum P' in any phase of its vibration in relation to the phase of the primary pendulum P, I may desire.

The effect of any control applied directly to the pendulum of a secondary clock is to regulate the vibration of said pendulum so that it will always maintain a certain phase in reference to that of the pendulum of the primary clock; hence it is obvious that no greater error than the time of one swing can be corrected. As the spring F is adapted to always maintain a tension on the secondary pendulum, its periodic change will correct this full error, as cannot be done by devices in which the effect of the magnetism is not felt through all portions of the pendulum's swing.

The amount of each of the pulls upon the pendulum P' of the secondary clock is dependent wholly upon the stiffness of the spring F and the amplitude of the vibrations of the lever D. It is therefore a constant quantity, which can be enlarged or diminished by means of the stops *m* and *n* or *p* and *q*. So long therefore as the battery is strong enough to produce a vibration of the lever D, the amount of this pull is independent of the strength of the battery. The pendulum P can also be fitted with my pendulum-control, and when so fitted can be connected with and controlled by any time-circuit in which the current is interrupted at intervals, which may be any even multiple of the time of vibration of P; or my controlling device may be used alone in connection with such a time-circuit, to control the vibrations of the pendulums of one or more ordinary clocks. I prefer, however, to use my pendulum-control in combination with my circuit-breaker and elastic buffers in all cases when it is desired to have the vibrations of the pendulum of the secondary clock take place in the same time and direction as those of the pendulum of the standard clock. Care must be taken, however, when the lever D is pivoted, as in the drawings—between C and *k*—to place the circuit-breaker and control on the opposite sides of their respective pendulums, and on the same sides when C is on the same side of the pivot *i* as *k*, for otherwise P and P' will swing in exactly opposite directions.

Any number of my circuit-breakers can be used on either or both sides of the same pendulum, and either in series or in multiple arc, the only limit being the number the pendulum is able to operate. I prefer to make use of two or more in multiple arc when I desire to make the contact absolutely certain, and in series to obtain a short contact twice in each swing. Thus, for example, when I wish to synchronise a clock beating half-seconds with a standard clock beating seconds I use a circuit-breaker on each side of the pendulum of the standard clock, and arrange them to make and break the circuit with every swing.

Any number of secondary clocks can be controlled by the standard clock by fitting them with a device for controlling their pendulums, as has been described, and connecting such devices in the ordinary fashion with the main circuit.

My pendulum-control can also be used in

certain cases to maintain, as well as control, the vibrations of the pendulum to which it is attached by fixing the escapement, by means of ratchets or otherwise, so that it cannot move backward, in which case the spring or weight for actuating such clock may be dispensed with; but wherever the circuit is liable to interruptions I prefer to actuate the secondary clock by a weight or spring, whereby the clock is rendered independent of such interruption.

I am aware that a vibrating lever and spring has been used as a part of a prior device (patent to Hall, No. 11,723, September 26, 1854) to drive a clock by means of electricity; but the mechanism has been so constructed that the vibrations of the pendulum control the interruptions of the electric current, and not the interruptions of the current the vibrations of the pendulum. The maintenance of the motion has been the sole object, and the mechanism has been arranged so as to eliminate any possible effect of the electricity in accelerating or retarding the pendulum, and hence, without essential modification, such apparatus is incapable of acting as a control.

I do not claim the combination of a vibrating lever and spring, broadly.

What I do claim as new, and desire to secure by Letters Patent of the United States, is—

1. The combination of a battery, electric circuit, a primary clock independently actuated and controlled, means, substantially such as described, for making and breaking said electric circuit by means of the vibrations of the pendulum of said primary clock, one or more secondary clocks independently actuated by a weight, spring, or other device, one or more electro-magnets included in said circuit and placed, respectively, in said secondary clocks, an armature and vibrating armature-lever applied to each of said magnets, a spring connecting each of said levers with the pendulum of the secondary clock in which its magnet is placed, and elastic buffers X and X′, placed in one or more of said secondary clocks, so as to limit the oscillation of its pendulum, all substantially as described.

2. The combination of a battery, an electric circuit, a primary clock independently actuated and controlled, means, substantially such as described, for making and breaking said electric circuit by the vibrations of the pendulum of said primary clock, one or more secondary clocks independently actuated by a weight, spring, or other device, one or more electro-magnets included in said circuit, and placed, respectively, in said secondary clocks, an armature and vibrating armature-lever applied to each magnet, and a spring connecting each magnet with the pendulum of the secondary clock in which its respective magnet is placed, all substantially as described.

3. The combination of a stationary contact-piece, a movable contact-piece, a spring carrying such movable contact-piece, and so adapted that its action will tend to keep such movable contact-piece in contact with the other contact-piece, and a spring connected to said first spring, and so adapted that when attached to the pendulum of a clock the vibrations of said pendulum will open and close said contact, all substantially as described.

4. The combination of the pendulum of a clock, spring *e*, spring *c*, screw *d*, contact-pieces *h* and *h′*, block *a*, stop *b*, and stand B, all substantially as described.

5. The combination of a battery, an electric circuit, means by which the current in such circuit is interrupted or varied at intervals determined by an independent primary clock or regulator, one or more secondary clocks independently actuated by a weight, spring, or other device, one or more electro-magnets included in said circuit and respectively placed in each of said scondary clocks, an armature and vibrating armature-lever applied to each of said magnets, and a spring connecting each of said levers with the pendulum of the clock in which it is placed, all substantially as described.

6. The combination of a battery, an electric circuit, means by which the current in such circuit is interrupted or varied at intervals determined by an independent primary clock or regulator, one or more electro-magnets included in said circuit, an armature and vibrating armature-lever applied to each magnet, and means by which the vibrations of each lever are communicated through a spring to the clock-pendulum or other vibrating body to which its respective magnet is applied, thereby regulating the vibrations of the same, all substantially as described.

7. The combination of an electric circuit, means by which the current in such circuit is established and interrupted or varied at intervals determined by an independent primary clock or regulator, one or more electro-magnets included in said circuit, an armature and vibrating armature-lever applied to each magnet, and means by which the vibrations of each lever are commuicated through a spring to the clock-pendulum or other vibrating body to which its respective magnet is applied, thereby regulating the vibrations of the same, all substantially as described.

8. The combination of a battery, an electric circuit, means by which the current in such circuit is interrupted or varied at intervals determined by a primary clock or regulator, one or more secondary clocks independently actuated by a weight, spring, or other device, one or more electro-magnets included in said circuit and placed, respectively, in said clocks, an armature and vibrating armature-lever applied to each magnet, a spring connecting each lever with the pendulum of the clock in which its respective magnet is placed, and elastic buffers X and X′, placed in one or more of said secondary clocks to limit the arc of oscillation of their respective pendulums, all substantially as described.

9. The combination of a battery, an electric

circuit, means by which the current in such circuit is interrupted or varied at intervals determined by an independent primary clock or regulator, an electro-magnet, M, included in said circuit, an armature, C, and armature-lever D, retracting-spring E, screw K, stops *m* and *n*, and *p* and *q*, and spring F, connecting said lever D with pendulum-rod of an ordinary clock, in which magnet M is placed as a device for controlling the pendulum of said clock, all substantially as described.

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