# PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

## Improvements in Electric Clocks.

I, CHARLES EDMOND PRINCE, British subject, of Stubbings Manor, Burchetts Green, Berkshire, do hereby declare the nature of this invention to be as follows:—

This invention relates to electrically driven clocks and its object is to provide a clock in which the vibrations of the pendulum shall be almost entirely free and such work as the pendulum has to perform is symmetrical and very small.

According to this invention I provide a polarised reversing relay in circuits which are so arranged that they are made by the pendulum and broken by the relay. Preferably the relay consists of a pivoted soft iron bar or armature carrying a winding, and with one of its ends between the poles of a permanent magnet, while its other end carries, preferably at the extremity of a flexible arm so that contact is retained for a longer period during the movement of the armature, a contact adapted to come alternately against two fixed contacts. Each of these fixed contacts is in series with a battery or other source of current, an electro magnetic device such as a solenoid winding, and a light spring contact adjacent to the pendulum. Let us suppose that the contact carried by the relay armature is touching the right hand one of the two fixed contacts. Then when the pendulum during its swing to the right touches the right hand spring contact, it completes the circuit through the winding of the relay armature, and through the right hand solenoid, which therefore attracts a core carried by the pendulum rod, so imparting a sustaining impulse to the pendulum. The current flowing through the winding on the relay armature, however, causes the armature to turn on its pivot until its spring contact breaks the circuit and comes against the left hand fixed contact, thus preparing the other circuit. The pendulum then swings over to the left until the contact carried by it completes the other circuit, whereupon, as before, a momentary current flows through the left hand solenoid, which attracts the core of the pendulum rod, and being now arranged to be in a reversed direction through the armature winding, causes the latter to swing back and so on. The momentary current through the armature winding may be employed to work one or more step by step clock mechanisms by any method well known in the art.

Instead of employing two sources of current to effect the reversal through the armature winding, one source can be employed, and the armature may carry two contacts so connected as to effect the necessary reversal.

Alternatively, the sustaining impulse instead of being imparted to the pendulum on each oscillation may be given by one solenoid at every alternate oscillation, or through the step by step mechanism at any desired intervals.

Since this invention can easily be made to allow considerable latitude in the position of the parts in a vertical direction, a feature of it is that a fine adjustment of the pendulum may be made from the upper end without the necessity of stopping it, by moving a portion of its length through the fixed point of suspension; as, for instance, by hanging the rod from a thin strip of metal passing through a narrow aperture in the frame, and by drawing this strip upwards, or by allowing it to pass downwards, by means of a screw and nut.

It will be seen that with such an arrangement the mechanical work that is to be done by the pendulum is exceedingly light, and is perfectly symmetrical; that the pendulum only makes and never breaks the circuits, so that there is no

tendency to spark and stick; that the impulse given to the pendulum may be symmetrical, and its duration depends only on the time lag of the relay; that the amplitude of the swing of the pendulum may be very small, which tends to accuracy; and that the construction is simple, and depends very little on mechanical perfection.

A feature of this invention is that the clock can easily be set, even at a distance, to the accurate time given by a time-signal, as follows:—

If the clock be fast the circuit of the armature may be broken or the step by step mechanism short-circuited so that the pendulum will vibrate idly without actuating the step by step mechanism until released.

If, on the other hand, the clock be slow, it can be "run up" by connecting together the contact on the pendulum rod and the two spring contacts, when the relay will vibrate rapidly and automatically, and actuate the step by step mechanism until released.

Dated the 1st day of June, 1922.

C. E. PRINCE.

## COMPLETE SPECIFICATION.

# Improvements in Electric Clocks.

I, CHARLES EDMOND PRINCE, British subject, of Stubbings Manor, Burchetts Green, Berkshire, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to electrically driven clocks and the main idea of the invention is the mechanical separation of the pendulum or time-keeping element from the clockwork or indicating mechanism, so that the former vibrates substantially freely, such work as it has to perform being not only very small but also preferably of equal value at each swing of the time keeping element. The time-keeping properties of the oscillating time-keeping element are thus entirely unaffected by lack of accuracy in the construction or adjustment of the indicating or clock mechanism which can therefore be of a comparatively rough and cheap character without detriment to the accuracy of its indications.

The time indicating mechanism may be of any suitable known character the step by step movements of which are either effected or controlled by the operation of an electromagnetic device which is included in a circuit controlled by the swings of the pendulum and is momentarily closed at each swing by the engagement of a light yielding contact, and is automatically opened by an auxiliary device, such as an electromagnetic circuit breaker, prior to the disengagement of the pendulum contact. The circuit arrangements are such that upon each swing of the pendulum a transient current traverses the circuit energising the relay or electromagnet which controls or actuates the indicating mechanism, and also traverses the energising coil or coils of the circuit breaker, which thereupon breaks the circuit and effects other connections such that upon the re-establishment of the current on the next swing of the pendulum this current traverses the energising coil or coils of the circuit breaker in the reverse direction.

The impulse required to maintain the amplitude of the pendulum swings may be derived from the transient currents in the pendulum controlled circuit as by means of a solenoid or electromagnet traversed by such currents exerting a pull on a soft iron bar rigid with the pendulum, or these currents may be utilised alternately to energise and release a gravitational or spring device through which an impulse is periodically applied to the pendulum, or any other suitable means may be adopted for automatically sustaining the pendulum vibrations, and such means may alternatively be operated by currents in a circuit established periodically by a contact or contacts upon or controlled by any suitable moving part of the time indicating mechanism.

In the accompanying drawings Fig. 1 is an elevation, more or less diagrammatical, of an electrically driven clock illustrating one arrangement for carrying the invention into practice; Fig. $1^a$ a detail showing the preferred suspension for the pendulum; Fig. 2 is a diagram of the electric circuits; Fig. 3 a detail illustrating one form of spring contact: and Fig. 4 an alternative arrangement of the automatic circuit breaker.

Referring first to Fig. 2 the pendulum or timing element 1 which is pivoted at 2 carries a pair of light contact springs 3, 4, one or either side of the pendulum, which cooperate with the fixed contacts $3^1$, $4^1$. These fixed contacts $3^1$, $4^1$ are permanently connected by leads 5, 6 with

two fixed contacts 7 and 8 respectively of the movable element 9 of an electromagnetic circuit reverser. The contact 7 is a member of a pair of contacts 7, $7^1$ which cooperate with a spring contact 10 of the movable element, and the contact 8 is one of a pair 8 and $8^1$ which cooperate with another spring contact 11 of the movable element. The contacts $7^1$ $8^1$ are connected by leads $12^1$ and $12^{11}$ respectively and lead 12 with one pole of a contacts 13, the other pole of which is connected by leads $14^1$, 14 with the pendulum through its suspension at 2. The leads $14^1$, 14 include an electromagnetic device indicated by the coil 15 which is adapted to operate or control the time indicating device indicated by 16.

The movable element 9, which comprises an energising coil and a soft iron core, oscillates upon a central pivot under the influence of a permanent magnet $9^1$, according to the direction of the current in the energising coil, so that in one position the fixed contact 7 is electrically connected through the flexed spring contact 10, coil 9 and flexed spring contact 11 with fixed contact $8^1$. Assuming this position of the circuit breaker and the pendulum 1 to be swinging towards the left, then when contacts 3 and $3^1$ engage a circuit is established from battery 13 through leads 12, $12^{11}$, contacts $8^1$, 11, coil 9, contacts 10, 7, lead 5, contacts $3^1$, 3, lead 14, electromagnet 15, lead $14^1$ back to battery 13. The polarity of the movable element 9, when the current flows in this direction through its energising coil is arranged to be such that the movable element is turned about its pivot under the influence of the permanent magnet so as to bring contacts 10 and 11 up against the fixed contacts $7^1$ and 8 respectively. In moving into this new position the circuit is broken and the duration of engagement between contacts 3 and $3^1$ is arranged to be such that the circuit is broken at the contacts 7, 10 before it is broken at the contacts 3, $3^1$ upon the pendulum 1 swinging in the reverse direction. As the pendulum swings from left to right, contact is established between the contacts 4, $4^1$ thereby completing the circuit from battery 13 through leads 12, $12^1$, contacts $7^1$ and 10, coil 9, contacts 11, 8, lead 6, contacts $4^1$, 4, lead 14, electromagnetic coil 15, lead $14^1$ back to battery. As the current thus established again reverses the polarity of the movable element 9, the latter is again turned upon its pivot into the other operative position. These is therefore a transient current through the device 15 upon each swing of the pendulum, and it is to be noted that the circuit traversed by this current is not broken at the pendulum contacts 3, 4 but at the circuit breaker contacts 10 and 11. Each transient current energises the device 15 which is arranged, upon being energised, to operate the clock mechanism 16 or alternatively to permit the operation of this mechanism, which is of any suitable known step by step character. There is shown included in the lead 6 a solenoid 17 which is traversed by the transient current which flows around the circuit when the contacts 4, $4^1$ are in engagement, and rigidly attached to the pendulum 1 is an arm $17^1$ of magnetic material or partly magnetic material suitably arranged with respect to the solenoid 17 so as to come within its influence during part of the swing towards the right and thereby receive an impulse which maintains the amplitude of swing of the pendulum. Any suitable magnetic means may be employed to prevent the action of the coil 17 producing an increasing amplitude of swing, as for example by having only the outer end of the rod $17^1$ of magnetic material or by so grading the cross section or magnetic permeability of the rod that as soon as the pendulum swings outwardly to the required extent the pull exerted by the coil 17 will be reversed. Coil 17 may be arranged to impart the sustaining impulse at the most effective moment, that is when the pendulum has maximum velocity, or it may be arranged to effect the impulse after that position has been passed, in which case a slightly greater energy is required, but this disposition of the coil tends to compensate automatically for decreasing or increasing amplitudes of swing.

The arrangement illustrated diagrammatically in Fig. 2 is shown in somewhat greater detail in Fig. 1, in which corresponding parts are indicated by the same reference numerals. As shown in this fig. the pendulum 1 is suspended by means of a strip 18 of steel or other suitable resilient material rigidly held by a clamp 19 between the jaws of which the strip 18 passes to an adjustment pin 20 to which the end of the strip is secured and which can be raised or lowered in a guide 21 carried by a bracket 22 by means of a nut 23 upon the screw-threaded upper end of the pin 20, the clamp 19 being released to effect such adjustment.

Instead of the pendulum contacts 3, 4 being flexible and the fixed contacts $3^1$, $4^1$ being rigid, the arrangement may be reversed, in which case the yielding fixed

contacts may conveniently be of the form shown in Fig. 3. As therein shown, a metal tube 24 closed at its outer end fits friction-tight upon a split boss 25 of a terminal block 26 suitably connected in the circuit. Inside the tube 24 is a hair-pin shaped wire spring 27 the outer free end of which is exposed by a portion of the tube 24 being cut away as indicated at $24^1$, while the inner fixed end is rigidly connected with the metal tube 24. A certain range of adjustment is possible by rotating the tubes 24 upon their sockets, or alternatively the contacts $3^1$, $4^1$, whether these are rigid or yielding, may be mounted as shown in Fig. 1 on crank arms 28 fulcrummed upon pins 29 suitably connected with the circuit and adjustable by means of handles 30, suitable means such as the pin and slot clamps 31 being provided to secure the contacts after adjustment.

In the arrangement shown in Figs. 1 and 2 the movable element 9 of the circuit breaker is non-polarised and the fixed element $9^1$ is polarised. In the modification shown in Fig. 4 the movable element 9 is polarised as by means of a permanent magnet $9^{11}$, while the fixed element $9^1$ consisting of a horseshoe electromagnet having an energising coil on each limb and a soft iron core is non-polarised and the circuit arrangements are modified so that the polarity of the horseshoe magnet is changed by the current traversing one of the energising coils at one swing of the pendulum and the other energising coil upon the reverse swing.

In the further modification shown in Fig. 5 the movable element 9 is polarised by means of a permanent magnet $9^{11}$ and carries an arm having a flexible contact member 10 which swings between two fixed contacts $10^1$, $10^{11}$ connected respectively with energising coils on the two elements of a soft iron core $9^1$. In either position of rest the flexible contact 10 is fixed to the extent necessary to give appropriate duration to the fleeting impulse current.

The rate of the clock is conveniently adjusted by means of the pendulum adjustment hereinbefore described, and the error may also conveniently be corrected, *e.g.* upon receipt of a correct time signal from any source. Thus, if the clock is too fast the indicating mechanism 16 may be temporarily cut out by a short circuiting lead 32 shown by the dotted and dashed line in Fig. 2, which is connected across the terminals of the recording mechanism as required by means of a switch such as a push switch indicated at 33 in Fig. 1. When this circuit is closed the recording mechanism stops and upon releasing the push button when the time as recorded by the clock coincides with the correct time the recording mechanism resumes functioning. Similarly by connecting the contacts $3^1$, $4^1$ with the pendulum suspension, as indicated by the dot and dashed lines 34, 35 in Fig. 2, which connection may be effected as by means of a push switch 36 indicated in Fig. 1, the automatic circuit breaker 9 will work rapidly and so advance the hands of the time recording mechanism quickly to correct the error of a slow running clock, the push switch being released when the recording mechanism again indicates the true time.

It is to be noted that the duration of the transient current which operates the recording mechanism depends merely upon the time constant of the automatic circuit breaker 9 so long as the duration of contact of the pendulum contacts 3, $3^1$ and 4, $4^1$ is not less than the time lag of the circuit breaker. Consequently the clock will work perfectly with quite a small amplitude of swing and therefore with exceptionally small air resistance and circular error.

Further, the sustaining impulse applied to the pendulum tends to be self-correcting for variations of the E.M.F. of the battery. The contacts of the circuit breaker do not open instantaneously when a current is established through it, since the contacts are flexible, so that should the E.M.F. of the battery decrease and with it the energising current of the contact breaker and of the sustaining solenoid 17, the weaker current will be maintained for a longer period, thereby tending to give a constant sustaining impulse to the pendulum.

Apart from overcoming air resistance the work done by the pendulum is limited to the bending or compression of the light springs 3 and 4 on each excursion of the pendulum, this work being stored in the springs as potential energy which is returned to the pendulum upon its return swing, and even should the work involved in compressing these springs not be perfectly constant, consequent for example upon change in the elasticity of the springs, the period of the pendulum would not be affected by such change. As these pendulum contacts come into place only in the establishment of the circuit and never break the circuit and as, moreover, they are of the nature of rubbing contacts, there is no sparking at these contacts nor any tendency for them to become dirty or stick together. The extremely small loss in friction at these

rubbing contacts is equivalent only to a minute addition to the air resistance of the pendulum, but unlike the air resistance it is independent of such variables as barometric pressure and being constant does not affect the time keeping, but only and to quite an inconsiderable extent the amount of energy required to sustain the pendulum vibrations.

This sustaining impulse need only be very small and as previously indicated it can be made quite constant, even when the clock is run off a comparatively variable source of electric supply, as for example an electric lighting circuit, by utilising the transient currents to energise and release successively a gravity or spring device for applying the sustaining impulse to the pendulum.

It will be readily understood that the invention may be applied either to a self-contained electrically driven clock or one or more clocks may be driven from a distance from a pendulum and circuit breaking apparatus such as hereinbefore described placed in a position in which it is free from disturbance, or by means of a master clock operating according to the present invention. Thus, for example, in place of the clock mechanism 16 there may be substituted a relay controlling a local circuit by means of which a turret or other clock or a number of such clocks of any size can be operated.

One or more subsidiary clocks may be driven from the apparatus described by providing in lead 5 (Fig. 2) a pair of contacts which are normally closed but are opened once a minute for a very short interval of time, such as two or three seconds, by means of a cam on the seconds arbour of the clock mechanism 16, the break thus made in the lead 5 being short circuited by an electromagnetic device whereby the indicating mechanism of the subsidiary clock is actuated each minute at a definite moment determined by the action of the time-keeping element. When it is desired to operate a system of clocks in this manner the electromagnetic device brought into operation once a minute would be of the character of a slow releasing relay for switching in a power circuit for operating the clocks. A similar arrangement could be used for applying the sustaining impulse to the pendulum at any required less frequent interval of time instead of at every second swing of the pendulum.

It will be obvious that the apparatus herein described may be modified in many respects without departing from the invention. For example, the contact breaker may be in the form of a pivoted soft iron bar or armature having one of its ends between the poles of a permanent magnet and its other end has a resilient contact member adapted to engage alternately two fixed contacts disposed on either side thereof, each of these fixed contacts being connected in series with a battery or other source of current, a solenoid or equivalent device for imparting a sustaining impulse to the pendulum and one of a pair of light spring contacts which are engaged by the pendulum on successive swings so as to close the respective battery circuits. In this case a sustaining impulse is imparted to the pendulum at each swing thereof.

In the modified arrangement illustrated in Fig. 6 the circuit 5 operating the sustaining solenoid 17 and the clock mechanism 16 is controlled by contacts 40, 41, one of which is fixed and the other is movable, while subject to a centreing or positioning device such as, for example, a spring 42, which bears upon an arm 43 of the pivoted contact 41. This arm 43 is in the path of a pin 44 carried by the pendulum 1, and the arrangement is such that upon the pendulum swinging in one direction, *e.g.* from left to right, the arm 43 is displaced against the return action of spring 42 so as to bring contacts 41, 40 into electrical engagement, the centreing device restoring the arm 43 to its normal position ready for engagement with pin 44 upon the next succeeding swing of the pendulum in the same direction. The transient current thereby established in circuit 5 serves to operate the time indicating mechanism indicated at 16 by any usual electromagnetic device and also to energise the sustaining solenoid 17.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An electrically driven clock, wherein by the mechanical separation of the pendulum or other time-keeping element from the time-indicating mechanism the oscillations of the former are substantially free.

2. An electrically driven clock according to Claim 1, comprising a time-keeping element and an electromagnetic device operating or controlling a time-indicating mechanism wherein the electric circuit operating the electromagnetic device is established by contacts brought into action by the oscillating movement of the time-keeping element and is automatically broken by an auxiliary device.

3. An electrically driven clock according to the last preceding claim, wherein

the auxiliary circuit breaking device comprises a polarised element and a non-polarised element the latter of which is energised by the current established in the circuit controlled by the time-keeping element.

4. An electrically driven clock according to Claim 3, wherein a movable element of the circuit breaking device changes its position upon the latter being energised so as first to break the energising circuit and then establish connections whereby upon the next oscillation of the time-element the current thereby established to energise the circuit breaker reverses the polarity of the non-polarised element thereof.

5. An electrically driven clock according to the preceding claims, wherein means are provided for rendering the time-indicating mechanism inoperative while the time-keeping element continues to function.

6. An electrically driven clock according to the preceding claims, wherein means are provided for electrically operating the time-indicating mechanism independently of the time-keeping element.

7. An electrically driven clock according to the preceding claims, wherein one or more time-indicating mechanisms are operated by the current in a local circuit controlled by the time-keeping element.

8. An electrically driven clock according to the preceding claims, wherein periodic sustaining impulses are imparted to the time-keeping element by means of currents in the circuit established by the time-keeping element

9. An electrically driven clock according to the last preceding claim, wherein the frequency of the sustaining impulses is controlled by the time-indicating mechanism.

10. An electrically driven clock according to Claims 1 to 8, wherein a second time-indicating mechanism is controlled or actuated by an electromagnetic device brought into action periodically by an energising circuit the current in which is controlled by the first time-recording mechanism.

11. An electrically driven clock according to the preceding claims, wherein the time-keeping element is a pendulum suspended by a spring strip secured in a fixed clamp and the rate of the pendulum is adjustable by unclamping the spring suspension, raising or lowering the pendulum with respect to the fixed clamp and re-clamping the suspension in the new position, substantially as herein described.

12. An electrically driven clock according to the preceding claims, wherein the time-keeping element is a pendulum provided with two contacts cooperating respectively with two fixed contacts one on either side of the pendulum, one of each cooperating pair of contacts being of the character of a light spring.

13. An electrically driven clock according to the last preceding claim, wherein one of each cooperating pair of contacts is adjustable in position so as to vary the moment of contact with its cooperating element.

14. An electrically driven clock according to the Claims 12 and 13, wherein the fixed contact elements are carried on crank levers adjustable in position by rotation about their fulcrums and provided with clamping means, substantially as described.

15. An electrically driven clock according to the last preceding claim, wherein the fixed contact elements are rotatably mounted upon their respective crank levers, substantially as described.

16. An electrically driven clock according to the preceding claims, wherein the automatic circuit breaker controlling the duration of the current in the circuit established by the time-keeping element comprises a pivoted magnetic element, which may be polarised or non-polarised, carrying one or more spring contacts each cooperating with a pair of normally fixed contacts adjustable in position, substantially as described.

17. An electrically driven clock according to the last preceding claim, wherein the fixed contacts are also spring contacts constructed substantially as illustrated in Fig. 3 of the accompanying drawings.

18. An electrically driven clock constructed and operating substantially as herein described with reference to the accompanying drawings.

Dated this 29th day of March, 1923.

ABEL & IMRAY,
Agents for the Applicant,
30, Southampton Buildings, London,
W.C. 2.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1923

[This Drawing is a reproduction of the Original on a reduced scale]

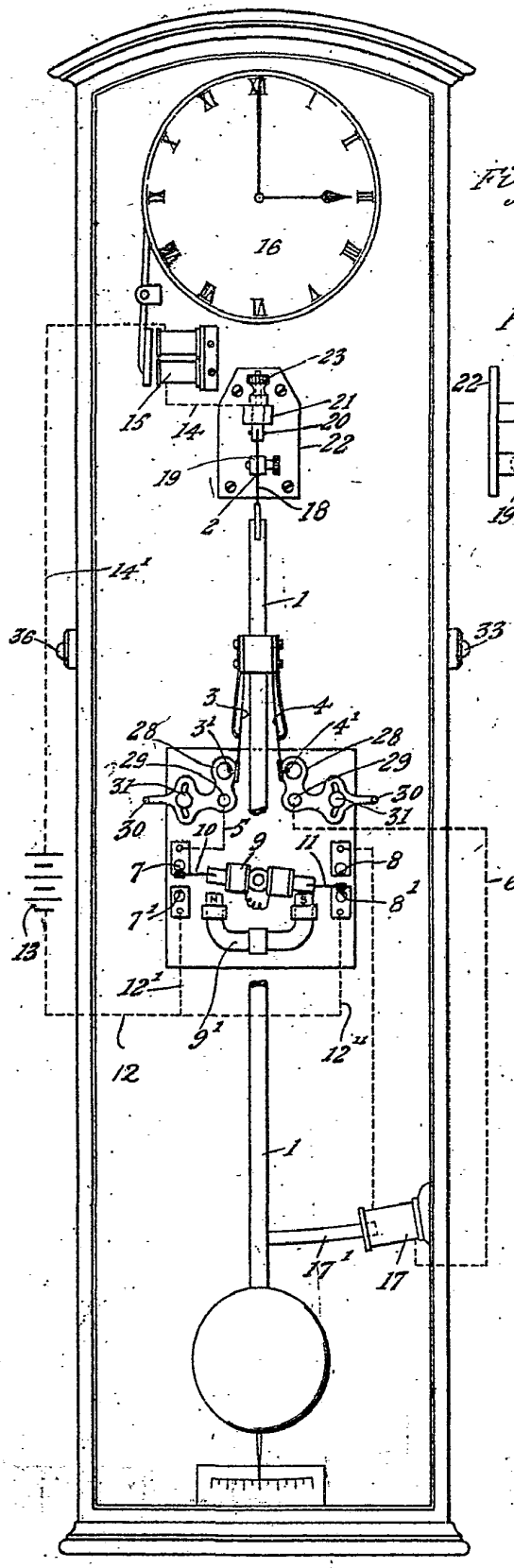


Fig. 1.

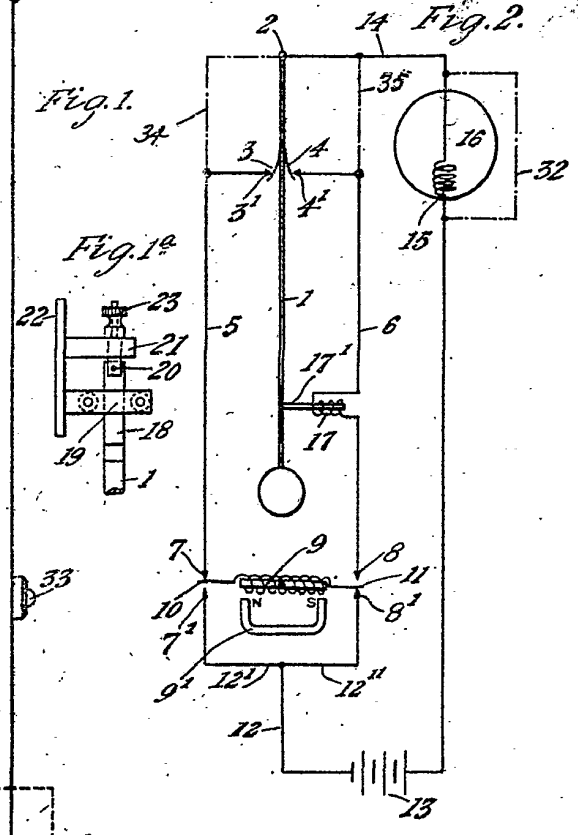


Fig. 2.



Fig. 1a.

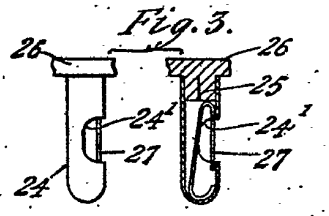


Fig. 3.

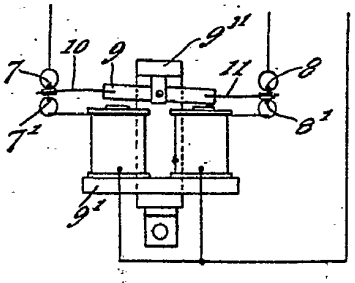


Fig. 4.

Fig. 2.

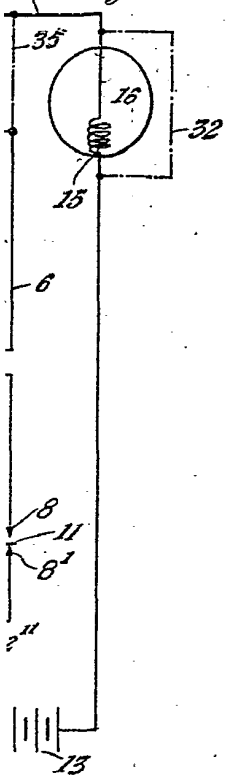



Fig. 5.

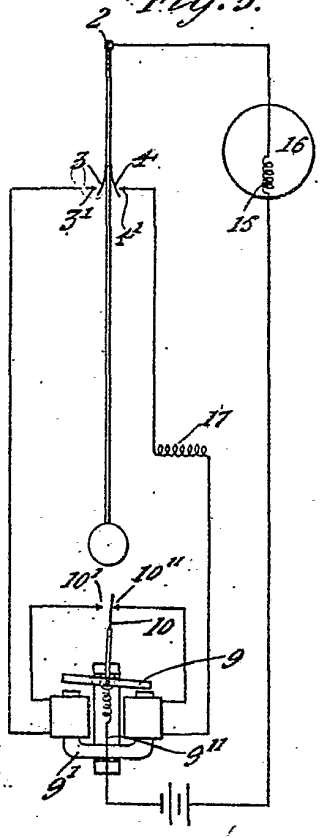
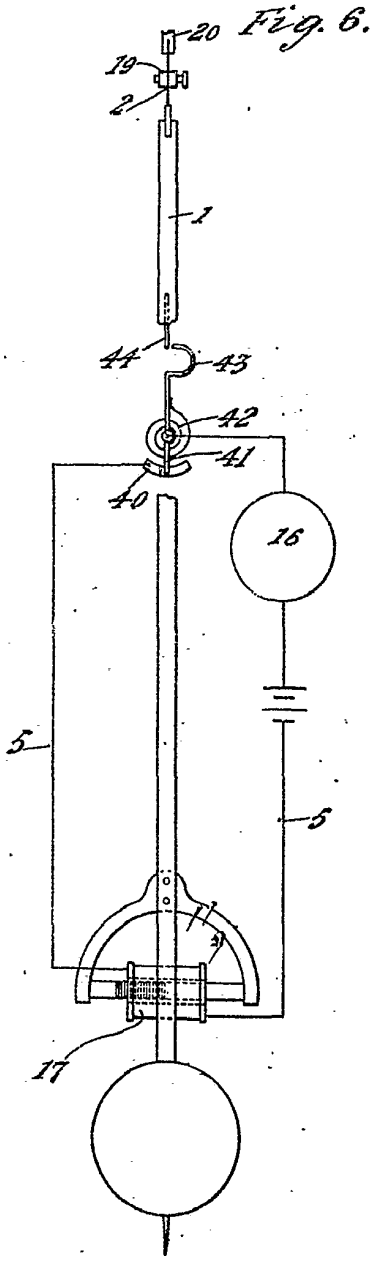
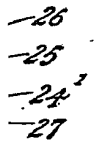



Fig. 6.



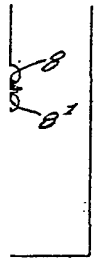




Fig. 4.

Malby & Sons, Photo-Litho

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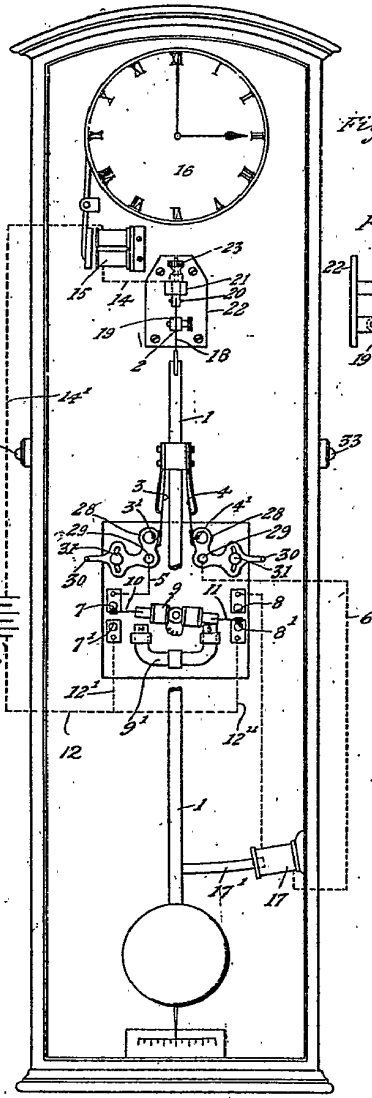

Fig. 1.

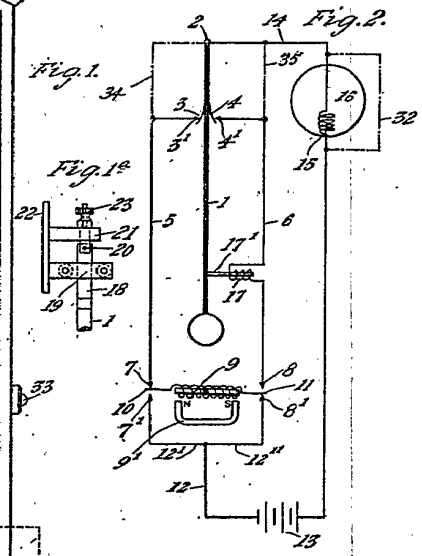

Fig. 2.



Fig. 1a.

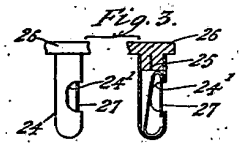

Fig. 3.

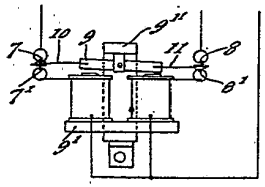

Fig. 4.

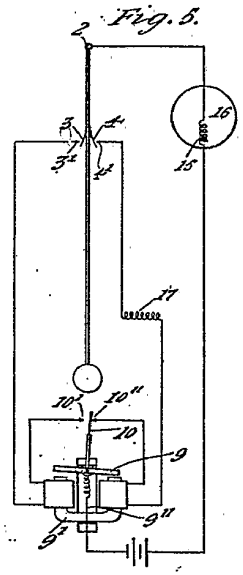

Fig. 5.

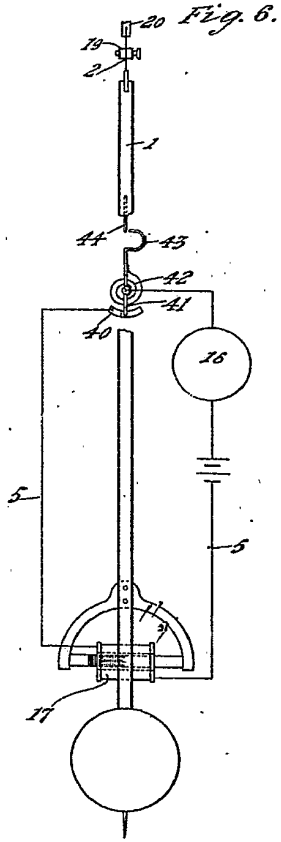

Fig. 6.

Malby & Sons, Photo-Litho