April 29, 1930. A. F. POOLE 1,756,472

ELECTRIC CLOCK

Filed Jan. 10, 1924 5 Sheets-Sheet 1

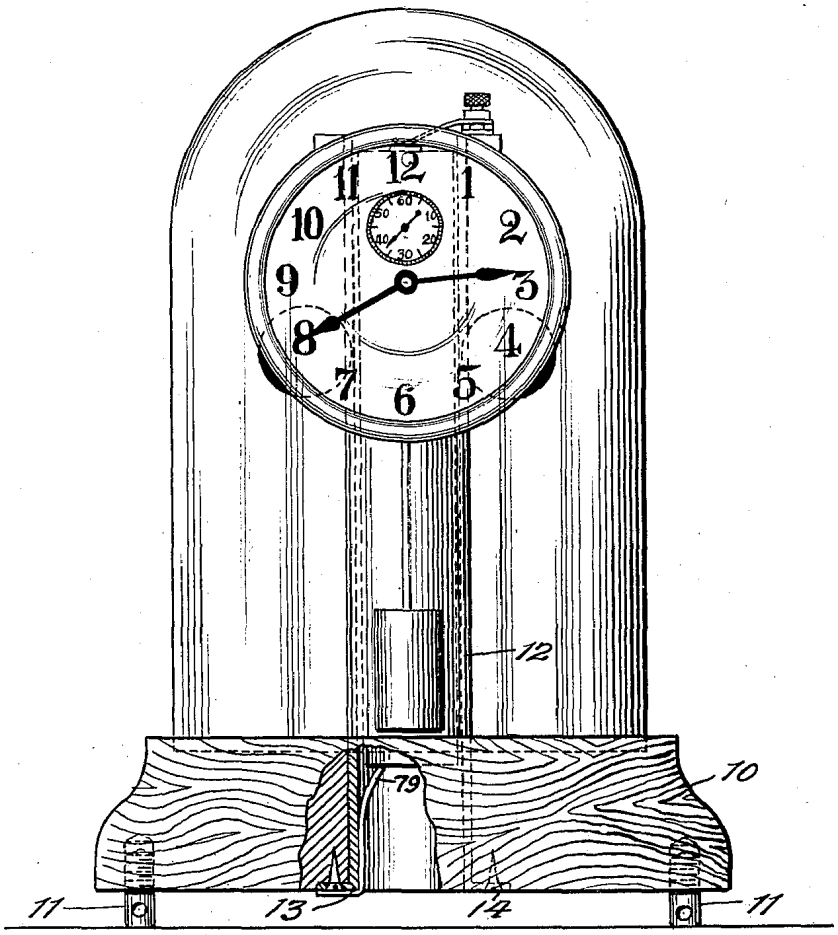

Fig. 1.

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Fig. 2.

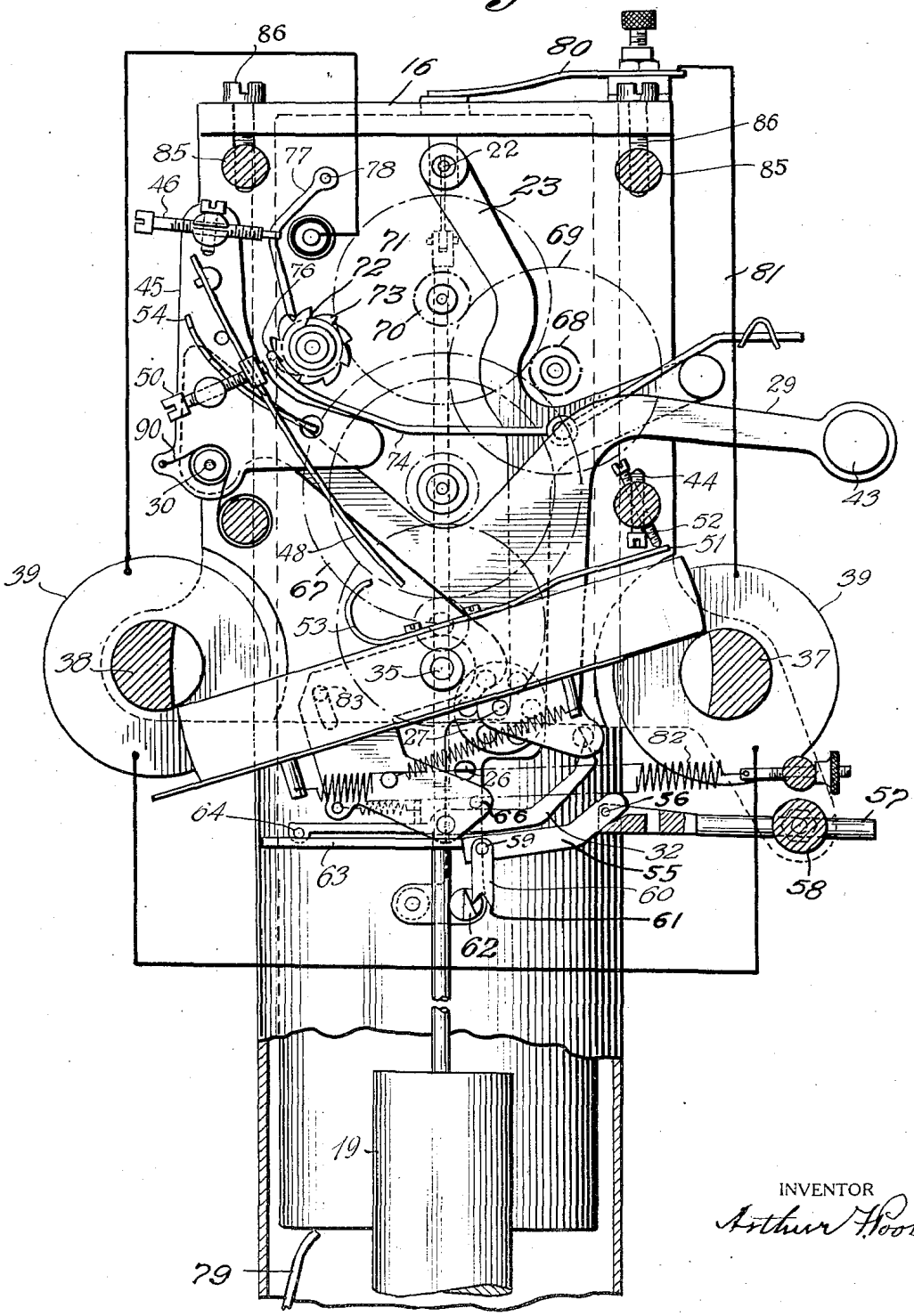

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Fig. 3.

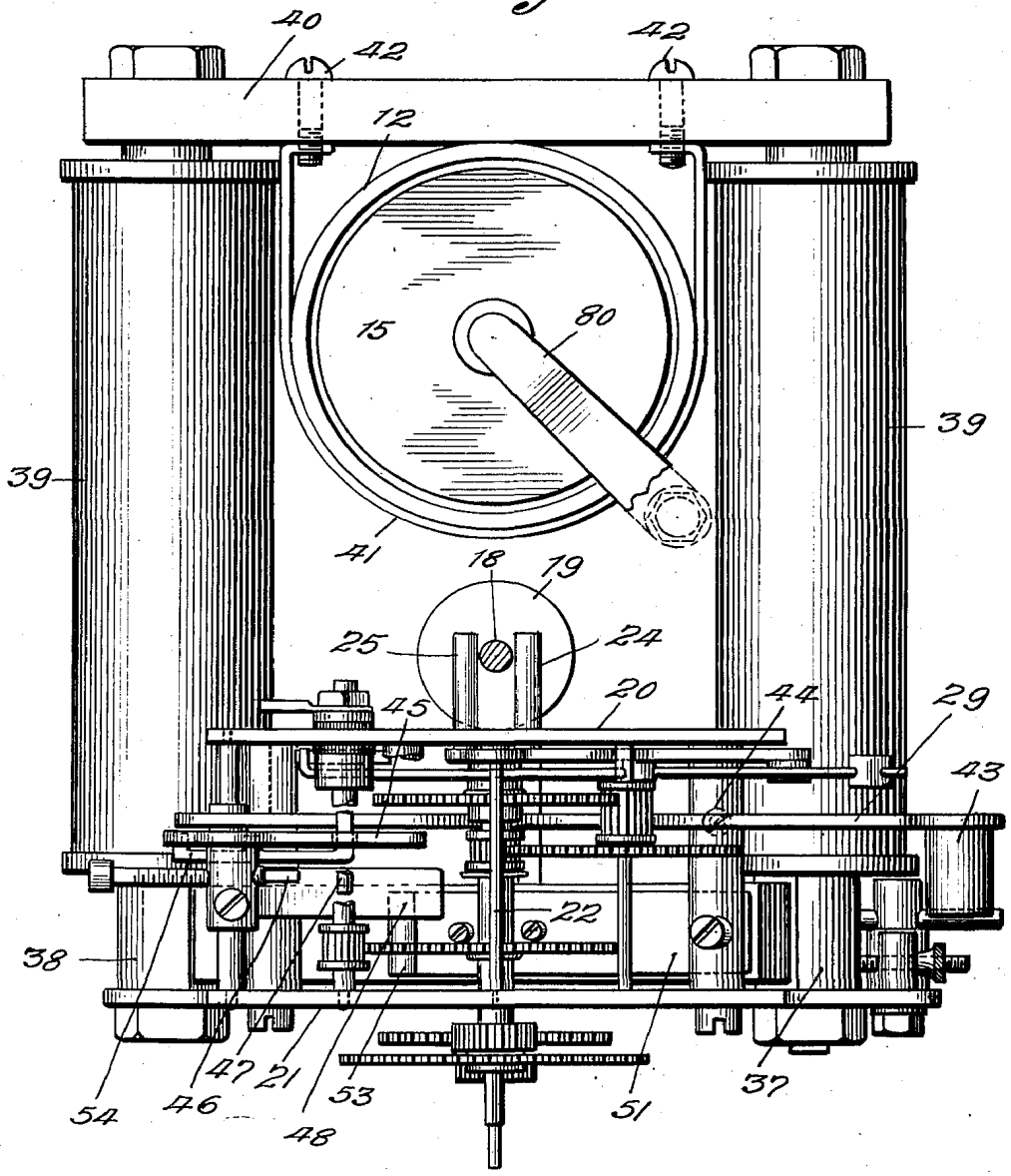

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Fig. 4.

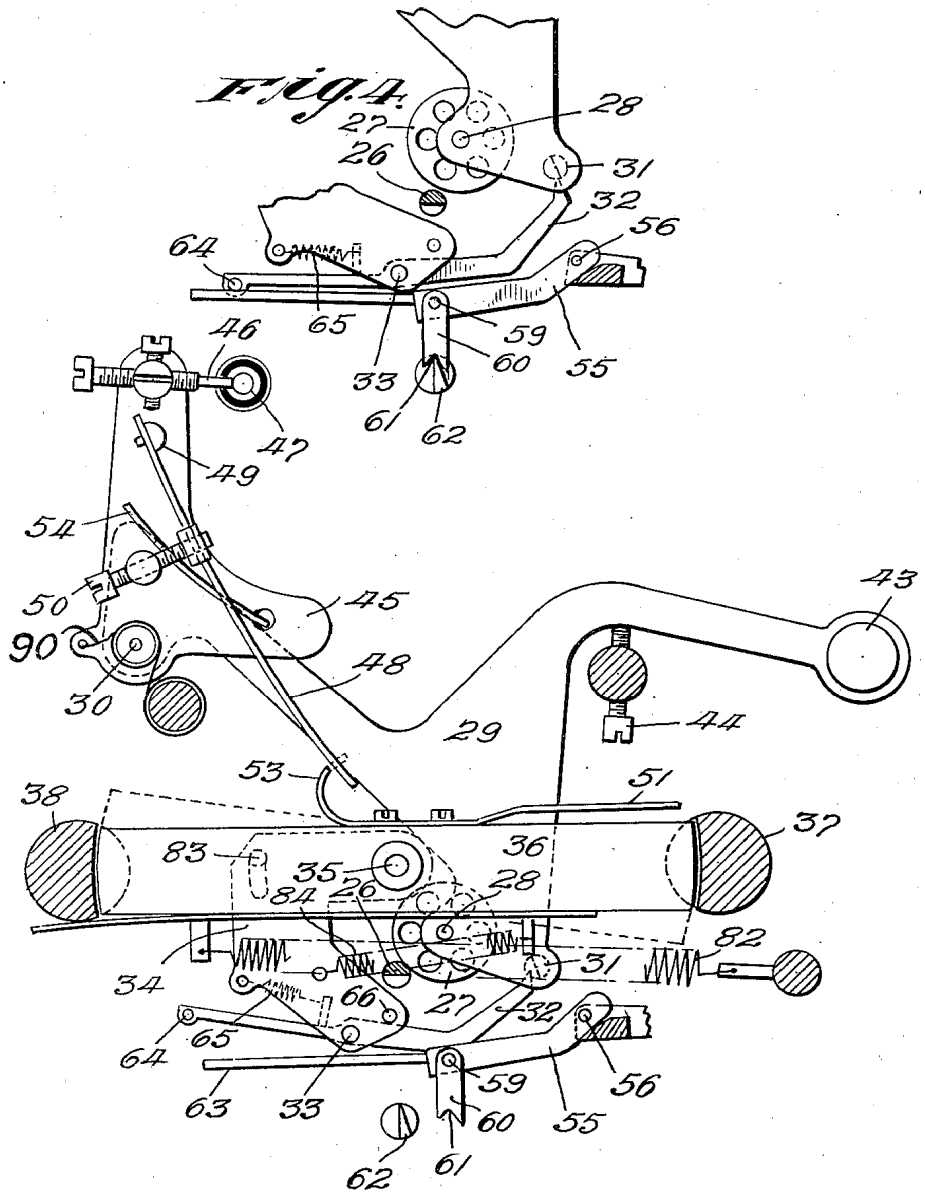

Fig. 5.

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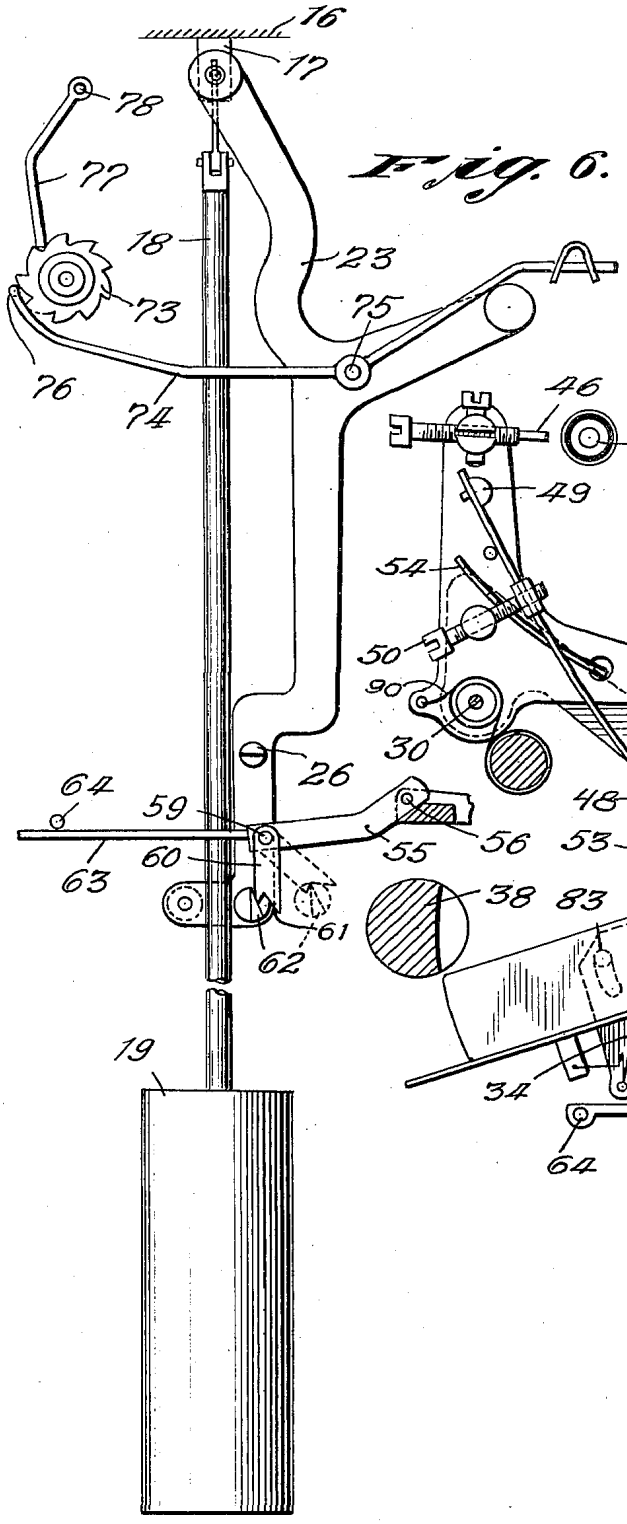

Fig. 6.

Fig. 7.

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UNITED STATES PATENT OFFICE

ARTHUR F. POOLE, OF PELHAM MANOR, NEW YORK, ASSIGNOR TO POOLE MANUFACTURING COMPANY, INC., OF WESTPORT, CONNECTICUT, A CORPORATION OF NEW YORK

ELECTRIC CLOCK

Application filed January 10, 1924. Serial No. 685,387.

My invention is an electric clock and has for its object the provision of a novel pendulum actuating mechanism which will insure a constant average arc of the pendulum, thereby rendering the clock an accurate timepiece. Another object of my invention is the provision of certain improvements in the details of the mechanism which will hereinafter be pointed out.

My invention may be best understood by reference to the accompanying drawings of which Figure 1 is a front elevation of the clock embodying my herein described invention. Figure 2 is an elevation, on an enlarged scale, of the clock movement with the front frame plate section cut away. Figure 3 is a top view with the top frame plate removed. Figures 4, 5, 6 and 7 are details of the mechanism peculiar to my invention.

The general plan of my clock may be described as including a pendulum which is adapted to receive impulses at suitable times from a falling weight. This weight is normally retained in a position out of contact with the pendulum by a detent and when the arc of the pendulum has decreased to a certain point it is then determined that the weight shall fall on the pendulum giving it an additional impulse.

The pendulum has connected to it a pawl and ratchet mechanism whereby said pendulum actuates the hands of the clock thereby keeping count of the number of vibrations in the pendulum.

In the particular embodiment of my invention herein described I have shown an electromagnet mechanism adapted to restore to normal position the weight which actuates the pendulum. However, this electromagnetic mechanism is not essential to my invention but is shown as being the preferred form.

Referring now to the figures, the clock is mounted on a suitable base 10, which is supported by three levelling screws 11. Mounted in the base 10, is a piece of tubing 12, having a flange 13 at its lower end and held in the base 10 by suitable screws 14. The tube 12 serves the double purpose of providing the support for the clock movement as a whole and as a case for the battery 15.

On the top of the tube 12, and fastened rigidly to it by any suitable means, is a supporting plate 16 which extends horizontally forward and in which is mounted a stud 17, which serves as a support for the pendulum 18, the bob 19, of which is threaded on the rod 18, in the usual manner so that this bob may be raised or lowered to regulate the clock.

The works of the clock are supported between two plates 20 and 21 which, as usual in this class of mechanism, are shown connected by posts 85, two of which are shown in Fig. 2 fastened by screws 86 to the top plate 16. In Fig. 3 the two uppermost posts 85 are omitted to avoid hiding the movable parts. These works are shown best in elevation in Figure 2.

Mounted between the plates 20 and 21, on a shaft 22, is a crutch 23, (Fig. 6) having two pins 24 and 25, adapted to embrace the pendulum rod 18. The crutch 23 is pivoted so as to be approximately concentric with the arc of the pendulum.

Projecting from the front of the crutch is an impulse pin 26 which is in the path of the impulse wheel 27, Figs. 4 and 5, pivotally mounted at 28 in the impulse arm 29, pivoted in the frame work on a shaft 30.

A stud 31, is mounted on the impulse arm 29 and is adapted to contact with a detent 32, pivotally mounted at 33 on a plate 34, pivotally mounted on a shaft 35 which is supported between the plates 20 and 21.

The shaft 35 also provides a support for an armature 36 which swings between the pole pieces 37 and 38 of the electromagnet 39. The electromagnet 39 has its forward end supported in the plate 21 and its yoke 40 is held to the tube 12 by a strap 41 attached to the yoke 40 by the screws 42. The piece 34 is influenced by a tension spring 84 connecting it with the armature 36 and tending to turn said piece 34 counter-clockwise in Fig. 7. A pin 83 projecting from said armature into a slot in the piece 34, limits the relative motion of said piece and armature. The piece 34 is in effect an arm of the swinging armature but mounted to yield in one direction for cushioning purposes. A tension spring 82 normally holds the armature 36 in the posi-

tion shown in Fig. 7 and returns it to that position.

The impulse arm 29 carries an impulse weight 43 (Figs. 3 and 5) and its downward motion is limited by a banking screw 44 mounted in the frame work. Rotatably mounted on the shaft 30, which serves to support the impulse arm 29, is a contact piece 45 carrying a contact screw 46 adapted to contact with a stud 47 insulated from the frame work and connected to the electromagnet 39 in a manner hereinafter described.

The contact piece 45 carries a spring arm 48 mounted on a stud 49 and provided with an adjusting screw 50 by means of which the position of the spring 48 in reference to the contact piece 45 may be adjusted. Mounted on the armature 36 is a spring 51 which is adapted to contact with a stop screw 52, thereby determining the normal position of the armature 36 (Figure 7).

The spring 51 is bent into a contact piece 53 which is adapted to actuate the spring arm 48 in a manner hereinafter to be described. The leaf spring 54 is mounted on the contact piece 45 and extends through said piece and contacts with the impulse arm 29 thereby determining the position of the contact piece 45 in reference to said impulse arm.

The parts just above described stand normally in the positions shown in Figs. 2 and 7. The armature 36 stands with its cushioning spring 51 in contact with the screw 52; the pawl 32 acting on stud 31, holds the weighted impulse member 29 in its upper position where the wheel 27 is out of range of the oscillations of the stud 26 on the crutch 23; and the cushioning spring arm 54, resting on the piece 29, holds the contact piece 45 with its contact 46 out of contact with the conductor 47. These parts stand as shown and described until the oscillations of the pendulum have died down to a certain minimum amplitude, whereupon, by means to be presently described, the pawl 32 is tripped, this being done in the early part of a swing of the pendulum leftward. The impulse member 29 being released, drops by its weight, and the wheel 27 pressing on the stud 26 gives the required impulse to the pendulum. The impulse member 29 drops until arrested by the screw 44 as shown in Fig. 5, thus conveying a measured amount of energy to the pendulum. The piece 45 follows the impulse member and closes the circuit at 46, 47. The armature 36 is immediately swung from its normal position shown in Fig. 7 to the position shown in full lines in Fig. 5, and it moves on by momentum to the position shown in dotted lines in that figure. This motion is made against the tension of the spring 82 which immediately restores the armature to its normal position. When the armature swings by momentum to the dotted-lined position of Fig. 5, the arm 53 striking the elastic arm 48 swings the contact piece 45 and breaks the circuit thus leaving the armature free to be returned to its normal position by the spring 82.

When said pawl 32 was first tripped, the stud 31 moved leftward out of reach of said pawl. When the armature was swung by the magnet said pawl being in this motion practically mounted on the armature, was swung leftward further than said stud and thereby reached a point to the left of said stud as shown in Fig. 5. When the armature was restored to normal position the piece 34 and pawl 32 swung with it and said pawl striking the stud 31 restored the piece 29 to its normal position. The parts were then back in their normal positions, shown in Figs. 2 and 7 where they remain until the next time the oscillations of the pendulum die down to the same point as before, when all of these operations are repeated.

When the piece 45 is thrown counter-clockwise by the armature to break the circuit, it is prevented from swinging too far by striking a relatively fixed part: e. g., the spring arm 48 may strike the staff of the center wheel 67. Said piece 45 has its center of gravity to the right of its pivot and would return to circuit closing position by rebound and gravity; but a light returning spring 90 may be provided if desired. The forces tending to restore this piece 45 are much weaker than those tending to restore the armature, and said armature moves in returning direction far enough to lift the member 29, before said piece 45 returns to close the circuit a second time.

I shall now describe the means by which the arc of the pendulum is prevented from going below a certain amount.

A lever 55 is pivoted at 56 on a rod 57 Fig. 2 which is mounted in the framework on a pillar 58. The pillar 58 is made adjustable so that the rod 57 may be moved in and out and also rotated around said pillar thereby locating the position of the lever 55. Pivotally hung from a stud 59 on the lever 55 is a pendent 60 having a notch 61 therein which is adapted to be engaged by an angular or knife edge piece 62 on the pin 24.

As long as the arc of the pendulum exceeds a certain amount the angular piece 62 will swing past the pendent 60 which will be swung about its pivot 59, first right and then left and the lever 55 will not be disturbed. However when the arc of the pendulum dies down so that it no longer swings past the pendent 60 (see dotted lines in Figure 6) then on the return swing of the pendulum the angular piece 62 will catch in the notch 61, thus lifting the lever 55 which has a tail 63 thereon adapted to engage a stud 64, mounted in the detent 32 Fig. 4. When the tail 63 engages the stud 64 the detent 32 will be rocked on its pivot 33 against the tension of

the spring 65 which serves to hold the detent 32 in a normal position against a banking stud 66. The detent will then release the impulse arm 29 and said arm will fall, the wheel 27 making contact with the impulse pin 26, thus giving a push to the pendulum which will make the pendulum swing through a larger arc as hereinbefore described.

I will now describe the mechanism by which the vibrations of the pendulum are counted. This is done through the customary train of wheel work which is diagrammatically shown in Figure 2 and consisting of a center wheel 67 gearing into an intermediate pinion 68 on the intermediate wheel 69 which gears to the seconds pinion 70 on the seconds wheel 71 which gears into the ratchet pinion 72 on which is mounted a ratchet wheel 73.

The center wheel 67 revolves once an hour, the wheel 71 once a minute and the wheel 73 has a suitable number of teeth so as to insure the proper rotation of the wheel 71, as the wheel 73 is driven by the pendulum.

Mounted on the crutch 23 is a pawl 74 (see Figure 6) pivoted at 75 and having a bent portion 76 adapted to engage the teeth of the ratchet wheel 73. The retaining clip 77 is pivoted in the framework at 78 and serves to prevent backward movement of the ratchet wheel 73.

The electrical connections of the clock are as follows: One pole of the battery 15 is connected to the frame work by the contact spring 79 Fig. 2. The other pole of the battery 15 makes contact with a clip 80 mounted on the plate 16 and insulated therefrom. The clip 80 is connected to one end of the electromagnet winding by a wire 81 and the other end of the electromagnet winding is connected to the stud 47 which, it will be remembered, is insulated from the framework. Consequently, when the screw 46 comes in contact with the stud 47 the circuit is closed through the magnet and the operations hereinbefore described occur.

Having now described the mechanism of my clock I shall describe its operation. Starting with the parts in the position as shown in Figures 6 and 7 the arc of the pendulum gradually dies down until the piece 62 engages the notch 61. At this time the detent 32 is actuated, allowing the impulse arm 29 to fall. At this instant the parts are in the position shown in Figure 4.

As the pendulum swings to the left it receives an impulse from the arm 29, through the wheel 27 and thus continues until the parts reach the position shown in Figure 5 in which the screw 46 as contacted with the arm 47 closing the circuit. The armature 36 is swung clockwise but does not stop at the full line position shown in Figure 5 but is carried by its momentum into its dotted line position shown in said figure which serves to separate the screw 46 from the stud 47 by reason of contact of the piece 53 with the spring 48. As soon as the contact is broken the armature 36 is free to return to its normal position and the detent 32 has engaged the stud 31 and under the influence of the spring 82, the parts are restored to their normal position.

The duration of the current is very short as will be evident that the arrival of the armature to the position shown in Figure 5 will serve to break the electric circuit. From this it follows that the current consumed is very small and there is practically no spark when the current is broken since the motion of the armature develops a counter electromotive force which makes the current much less than the current which would flow through the circuit were this movable armature not present.

One of the objects sought to be obtained by this clock is the elimination of noise. To this end I have provided the armature with a spring 51 which serves to determine the normal position of said armature, as hereinbefore described. I have also provided the contact arm with a spring 54 and have provided a spring 48 to actuate said piece. To the same end, instead of mounting the piece 34 which serves to support the detent 32 rigid with the armature 36, I have mounted this piece rotatably on the shaft 35 and provided a stud 83 in the armature to determine the normal position of the piece 34 against the tension of the spring 84. This is to reduce the blow of the detent 32 on the stud 31 when these two parts come into engagement upon the resetting of the impulse arm 29.

While I have shown the electromagnetic mechanism to restore the impulse arm 29, it is obvious that an ordinary clock train could be used for the same purpose.

It will be apparent that the average arc of the pendulum will be constant, irrespective of the load put on the pendulum or by the work of actuating the ratchet wheel 73. The impulse given to the pendulum by the impulse arm 29 is constant and the minimum arc of the pendulum is constant, also, since this is determined by the position of the angular piece 62 in relation to the pendent 60. Any additional work put on the pendulum would simply result in a shorter period between impulses. However this would not affect the length of the average arc.

It may be of interest to note that in the construction herein shown I have made the pendulum so that it makes 160 single vibrations per minute and the weight 43 gives the pendulum sufficient impulses to make it vibrate about 60 single vibrations between the times of taking current.

I wish to call attention to the fact that the impulse arm 29 is restored to its normal position on the back stroke of the armature 36, thus rendering the force of the restoring ac-

tion largely independent of the strength of the battery 15, and dependent only on the strength of the spring 82. It is obvious that the spring 82 may be given a suitable tension to restore the parts quickly and positively to their position without undue noise, and that once this tension is determined, it will be maintained irrespective of variations of the strength of the battery 15. I consider this particular arrangement of marked advantage and shall claim the same.

It will be perceived from the drawing that in the oscillations of the pendulum and the crutch, the pendulum pin 26 swings about the shaft 22 as an axis, and that the wheel 27 rocks about the shaft 30 as an axis. The banking screw 52 may be so adjusted that when said wheel 27 is in its normal position it is just out of the path of the pin 26, which swings under and past it, so that said wheel is held out of contact with said pendulum pin in all positions of said pendulum and even if the pendulum were given an oscillation of excessive amplitude. Preferably also the stop 52 is so adjusted as to cause the release of the member 29 just as the pin 26 is passing the wheel 27, so that the latter and said member 29 have only a minute distance to drop, before the wheel rests on the pin. The advantages of this construction are obvious.

The herein described provision of the tube 12 which constitutes a common support for the battery, clock movement, pendulum and electromagnet with an open upper end so that the battery can be inserted without moving the clock or disturbing the mechanism is of marked advantage, and I believe that this structure is new and wish to claim the same.

I also wish to call attention to the particular contact and armature arrangement herein discussed. This consists of having the impulse weight or means connected therewith to close a circuit which is opened by the armature on the positive stroke of the latter. Immediately on its back stroke the armature restores the impulse weight. As a result of this arrangement, the current consumption is very small, since the front stroke of the armature produces a counter electromotive force in the circuit which cuts down the current. It will be noted that the impulse member imparts to the pendulum an exactly uniform amount of energy at each operation, viz, the energy developed by the fall of its weight from the normal position against the stop 52 (Fig. 7) to the lower position against the stop 44 (Fig. 5); and that when the parts reach the position shown in Fig. 5, the stud 26 moves away from the wheel 27 and the impulse mechanism is all restored to normal before said stud gets back to the Fig. 5 position on the return stroke of the pendulum. The pendulum swings free until it reaches a measured minimum of amplitude, whereupon it is given an exactly uniform fresh impulse, thus swinging it to a uniform maximum amplitude. The average amplitude is therefore uniform, and the clock will therefore keep accurate time. At the time when the battery acts, and when the whole restoring mechanism acts, the pendulum is entirely free of the impulse mechanism. The effect on the pendulum is therefore entirely independent of the strength of the battery.

Many changes or variations may be made in the herein described structure without departing from the spirit of my invention since I claim:

1. In a clock the combination of a pendulum, means acting directly on the pendulum adapted to give said pendulum an impulse, a detent to render said impulse means inoperative on said pendulum, arc determining means for said pendulum adapted to move said detent and release said impulse means and means exclusive of said arc determining means and operable to restore said detent.

2. In a clock the combination of a pendulum, means adapted to give an impulse to said pendulum and acting directly thereon, means functionally free from said impulse means to determine the arc of said pendulum, a latch holding said impulse means ineffective and actuated by said arc determining means to render said impulse means effective on said pendulum and means for restoring said impulse means to its initial position and to the control of the latch.

3. In an electric clock the combination of a pendulum, means adapted to give equal impulses to said pendulum and operating directly on the pendulum, means to determine the arc of said pendulum, means actuated by said arc determining means to render said impulse giving means effective on said pendulum and electromagnetic restoring means free of the control of the arc determining means and rendered effective by said impulse means after the delivery of an impulse to said pendulum to restore said impulse giving means.

4. In an electric clock the combination of a pendulum, means adapted to give an impulse to said pendulum, means to determine arc of said pendulum, an electromagnet and an armature pivoted between the poles of said electromagnet, and arranged to restore said impulse giving means to its normal position.

5. In an electric clock the combination of a pendulum, means adapted to give an impulse to said pendulum, means to determine arc of said pendulum, an electromagnet and an armature pivoted between the poles of said electromagnet, and arranged to restore said impulse giving means to its normal position, said armature being arranged to restore and releasably hold said impulse giving means on its back stroke.

6. In an electric clock the combination of a pendulum, a lever to give an impulse to said

pendulum, a detent to hold said lever in a normal position, means controlled by the amplitude of the arc of said pendulum to operate said detent and a power device rendered effective by said lever after its impulse movement for reengaging said detent with said lever and then restoring said lever through said detent.

7. In an electric clock the combination of a pendulum, means to give an impulse to said pendulum, an electromagnet and armature adapted to restore said impulse means on the back stroke thereof, an electric circuit including a contact normally open, means operated by said impulse means to close said contact and means operated by said electromagnet to open said contact on the front stroke thereof, whereby said circuit is opened on the arrival of said armature in a position to restore said impulse means.

8. In a clock the combination of a pendulum, a weight adapted to give an impulse thereto, a detent, normally holding said weight out of contact with said pendulum in all positions of said pendulum, arc determining means for said pendulum operative on said detent, and means rendered effective by said weight at the end of an impulse movement for first moving the detent into reengagement with said weight and then restoring said weight and detent to impulse giving position.

9. In a clock the combination of a pendulum, weight operated means operating directly on the pendulum adapted to give an impulse thereto, a detent, normally holding said weight out of contact with said pendulum in all positions of said pendulum, arc determining means for said pendulum operative on said detent and electromagnetic means including a circuit controlled by said weight and rendered effective automatically at the end of the action of the weight on the pendulum to restore said weight to its normal position after the release of said detent.

10. In a clock the combination of a pendulum, means to determine the arc of the pendulum, a weight operating directly on the pendulum to give impulse to said pendulum and adapted to be released by said arc determining means and means in addition to said arc determining means to determine the amount of said impulse.

11. In an electric clock the combination of an electromagnet normally inactive, a pendulum, an arc determining device, an impulse device for said pendulum and operative thereon directly, means controlled by said arc device to determine the release of said impulse device and means controlled by said impulse device to make said electromagnet active.

12. In an electric clock the combination of an electromagnet, a pendulum, an impulse device acting directly on said pendulum, an arc determining device unaffected when said pendulum swings beyond a predetermined arc but effective when said pendulum dies down to a predetermined arc, means controlled by said arc device to determine the release of said impulse device and means controlled by said impulse device to make said electromagnet active.

13. The combination with a clock train and a pendulum which drives said train, of an impulse member, a detent normally holding said member out of action, means whereby said pendulum on a vibration of minimum amplitude trips said detent, an electric circuit closed by said impulse member and an electro-magnet in said circuit and having an armature, means whereby said armature on its positive stroke breaks said circuit, and means whereby said armature on its return stroke restores said impulse member.

14. The combination with a clock train and a pendulum which drives said train, of an impulse member, an electromagnet having an armature, a pawl connected with said armature and normally holding said impulse member out of action, means whereby said pendulum on a vibration of minimum amplitude trips said pawl, and means whereby said impulse member closes the circuit of said magnet, said pawl on the positive stroke of said armature moving to a position to reengage said impulse member and on the return stroke of said armature restoring said member.

15. In a clock the combination of a pendulum, impulse means operating directly upon said pendulum to maintain its vibrations, electro-magnetic means to restore said impulse means, a detent holding said impulse means in a position inoperative on said pendulum and arc determining means to operate said detent and release said impulse means.

16. In an electric clock, an impulse element biased for movement in one direction, an electromagnetic device having a movable magnetically responsive part biased to retracted position and releasably holding said element against movement in said one direction, an electric circuit including said device and controlled by said element, whereby at the end of movement of said element in said one direction a movement of said part in a manner to re-engage said element will be caused, said part being operable to restore said circuit to initial condition as said part moves in a direction opposite to its bias and after its reengagement with said element, whereby said part may return to initial position and also return said element to initial poised position.

17. In an electric clock, an impulse element biased for movement in one direction, an electromagnetic device having a movable magnetically responsive part biased to a normal position and operable by a variation in

an electric current therethrough to change its position, a latch carried by said part and engageable with said impulse element for releasably holding said impulse element in poised position when said part is in its biased position, an electric circuit including said device, a circuit controller included in and controlling said circuit and held in one position by said element when in poised position to create a circuit condition permitting said part to remain in biased position, and operable into a different position to change the circuit condition and cause a movement of said part in a manner to reengage said latch to said element after said element has completed a selected movement in said one direction, said part being operable upon said controller as it approaches its changed position and after reengagement with said element for restoring said circuit to initial condition and permitting return of said part to biased position and through it the return of said element to said poised position.

18. In an electric clock, an impulse element biased for movement in one direction, an electromagnetic device having an armature biased into a normal position, said armature being releasably latched to said element for holding said element in poised position when said armature is in normal position, a circuit for said device, and a circuit controlling member for said circuit operable when in one position to cause movement of said armature away from normal position, said circuit controlling member being held in inoperative position by said impulse element and operable automatically into a position to cause movement of said armature from normal position when said impulse element is unlatched and approaches its limit of movement in said one direction, said armature when moving away from normal position moving into relatched engagement with said impulse element, said armature being operable upon said member to restore said circuit into original condition after said armature has been relatched to said element, whereby said armature may return to biased position and while so returning return said element to poised position.

19. In an electric clock, an impulse element biased for movement in one direction, an electromagnetic device having an armature biased into a normal position, said armature being releasably latched to said element for holding said element in poised position when said armature is in normal position, a circuit for said device, a circuit controlling member for said circuit operable when in one position to cause movement of said armature away from normal position, said circuit controlling member being held in inoperative position by said impulse element and operable automatically into a position to cause movement of said armature from normal position when said impulse element is unlatched and approaches its limit of movement in said one direction, said armature when moving away from normal position moving into relatched engagement with said impulse element, said armature being operable upon said member to restore said circuit into original condition after said armature has been relatched to said element, whereby said armature may return to biased position and while so returning return said element to poised position, an oscillating member, and means operable automatically when the oscillations of said oscillating member decrease below a selected minimum of amplitude, for causing a release of said impulse element from said armature, and said element when released being operable upon said oscillating member to increase the amplitude of oscillation thereof.

20. In an electric clock, an oscillating member, an impulse element biased for movement in a direction to engage said oscillating member and impart an impulse thereto in a direction to increase its amplitude of oscillation, an armature biased to retracted position and latched to said impulse element for releasably holding the latter in poised inoperative position, an electromagnetic device for attracting said armature into relatched engagement with said element after the latter has been released from said armature and after imparting an impulse to said oscillating member, means including a circuit, a circuit controller, and said electromagnetic device, said controller being normally held inactive by said impulse element until the latter reaches approximately the end of its impulse movement, said armature being operable upon said circuit controller to alter the circuit means and permit return of said armature to release position after it has been attracted into relatched engagement with said element, whereby said impulse element will be restored to poised position automatically.

21. In a clock, the combination of a pendulum, means adapted to give said pendulum an impulse and operable directly thereon, a detent to render said impulse means inoperative on said pendulum, arc determining means for said pendulum adapted to move said detent and release said impulse means, and means rendered operable by the completion of an impulse af said impulse means for restoring said impulse means automatically to poised position and the control of said arc determining means.

22. In a clock, the combination of a pendulum, step by step feeding means actuated by said pendulum, means adapted to give an impulse to said pendulum and operable directly thereon, means to determine the arc of said pendulum, means actuated by said arc determining means to render said impulse means effective on said pendulum, and means controlled by said impulse means and ren-

dered operative automatically after a pendulum actuating movement thereof for placing said impulse means in condition for a further impulse to said pendulum.

23. In a clock, a pendulum, a gear train, time indicating means operated by said train, means operated by said pendulum to feed said gear train step by step, an arc determining device for said pendulum, separate from said feeding means, a pendulum impulse device, a latch holding said impulse device inoperative, means operated by the arc determining device and operable to release said impulse device to render said impulse device effective upon said pendulum when the arc of said pendulum falls below a predetermined arc, said means controlled by said impulse device for restoring said impulse device to the control of said latch.

24. In a clock, an oscillating time element having a regular period of oscillation, impulse means operable directly upon said element to maintain said element in oscillation, time mechanism operated by said element, a latch device normally and releasably holding said impulse means inoperative and ready for an impulse action upon said oscillating element, and means separate from said impulse means and rendered effective by a fall in the arc of oscillation of said element below a selected minimum arc, for operating said latch device to release said impulse means for an impulse operation upon said oscillating element.

25. In an electric clock, an oscillating time element having a regular period of oscillation, impulse means operable directly upon said element to prolong the oscillations of said element, time mechanism operated by said element, a latch device for positively and releasably restraining said impulse means, but operable to release said impulse means, and arc determining means separate from said impulse means for releasing said impulse means from said latch device when the arc of oscillation of said element falls below a selected minimum arc.

26. In a clock, an oscillating time element having a regular period of oscillation, impulse means operable directly upon said element to maintain said element in oscillation, a time train, means operable by said element for propelling said train step by step in accordance with the oscillations of said element, impulse means operable upon said element to prolong its oscillations, a latch device positively and releasably holding said impulse means from action on said element, an arc determining device separate from said propelling means for effecting a release of said impulse means from said latch device when the arc of oscillation of said element falls below a predetermined minimum arc.

27. In a clock, an oscillating time element having a regular period of oscillation, impulse means operable directly upon said element to maintain said element in oscillation, a time train, means operable by said element for propelling said train step by step in accordance with the oscillations of said element, impulse means operable upon said element to prolong its oscillations, a latch device positively and releasably holding said impulse means from action on said element, an arc determining device separate from said propelling means and from said impulse means for effecting a release of said impulse means from said latch device when the arc of oscillation of said element falls below a predetermined minimum arc.

28. In a clock the combination of a pendulum, means adapted to give an impulse to said pendulum directly, means to determine the arc of said pendulum, latch means to hold said impulse means ineffective and actuated by said arc determining means to render said impulse means effective on said pendulum, and means functionally separate from said arc determining means for restoring said impulse means to its initial position and to the control of the third mentioned means.

29. In a clock, an oscillating element having a uniform rate of oscillation, means operable directly on said element to give said element an impulse to prolong its oscillations, a detent to render said impulse means inoperative on said element, arc determining means operable to cause a release of said impulse means from said detent when the arc of oscillation of said element decreases below a selected minimum arc, an electromagnet, an armature therefor operable to restore said impulse means to the control of said detent, a circuit for said electromagnet controlled by said impulse means to cause operation of said armature following an action of said impulse means upon said element, said circuit being rendered effective to cause an operation of said armature throughout a considerable portion of the travel of the armature, whereby chattering of the armature will be avoided.

30. In an electric clock, an oscillating element having a uniform rate of oscillation, means arranged to give said element an impulse to prolong the oscillations of said element, means operable when the arc of oscillation of said element falls below a selected minimum arc for rendering said impulse means effective upon said element, electromagnetic means having an armature connected to said impulse means for restoring the impulse means to normal position, said armature being operable to restore said means on its back stroke, and circuit means controlling said electromagnetic means and rendered effective to cause a restoring action of said armature automatically following an action of said impulse means on said element.

31. In a clock, an oscillating element having a uniform rate of oscillation, means ar-

ranged to give said element an impulse to prolong the oscillations of said element, means for limiting the duration of the impulse and adjustable to vary said duration selectively, and means for controlling the activity of said impulse means in accordance with the magnitude of arc of oscillation of said element.

32. In a clock, an oscillating element having a uniform rate of oscillation, means arranged to give said element an impulse to prolong the oscillations of said element, means for limiting the duration of the impulse and adjustable to vary said duration selectively, means for resetting said impulse means for a new impulse action automatically after delivery of each impulse, and means controlled by said element for rendering said impulse means effective when the arc of oscillation of said element falls below a selected minimum arc.

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