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COMPLETE SPECIFICATION.

Improvements in Electric Clocks.

We, GEORGE STEELE TIFFANY, of 30 Rose Street, in the City of New York, in the State of New York, United States of America, Electrician, and JAMES VAN INWAGEN, of 1202 Chamber of Commerce Building, in the City of Chicago, in the State of Illinois, United States of America, Manufacturer, 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;

The object of this invention is to provide an electric clock which will keep time continuously for a long period—say a year more or less—without requiring attention except in case of accident and with a very small current consumption. To this end the clock is made very simple and comprises the adaptation of a torsional pendulum to the control of an electro-magnetic driving mechanism in such a manner as to leave the pendulum separate from the driving mechanism, whereby it is relieved of the work of mechanically actuating the parts of said mechanism and is free to rotate independently of the movement of the armature constituting a part of said mechanism. By this means the benefit of the long-period beats incident to the torsional pendulum is obtained without encumbering said pendulum with mechanism which will impair its regular and efficient action. The current consumption being used for an instant only near the middle of each beat to impulse the pendulum. The variations in frictional resistance of the driving mechanism due to changes of weather and changes in conditions of lubrication cannot be imparted to the pendulum and create irregularity thereof.

The invention also relates to the structure of the torsional pendulum which may constitute a part of the clock, this pendulum being accurately adjustable to regulate the length of the beat and self-compensating to enable it to adapt itself to the variations in temperature. This pendulum comprises a torsional pendulum rod having a lateral extension provided with a stop which is preferably adjustable, a weight of solid metal on said extension and automatic means for holding said weight in contact with said stop, the weight and extension having different expansibilities under varying temperature which adapt them to act automatically by expansion and contraction to shorten the radial distance between the weight and the axis of the rod as the extension expands and to increase said radial distance as the extension contracts.

Figure 1 of the accompanying drawings represents a rear elevation of this clock, a few pieces being broken out to secure a better illustration.

Fig. 2 represents a side elevation thereof looking from the right of Figure 1, some parts being broken out.

Fig. 3 represents on an enlarged scale a plan view of the armature with its contact studs and the pendulum rod with its contact arm.

The same reference numbers are used in all figures to designate the same parts.

The mechanism of this clock may be supported in a clock frame of any suitable construction. In the form in which the invention is embodied in

the accompanying drawings the frame comprises a back-plate 10 having on its front face posts as 11 and 12 near its periphery, and on its rear face at its top an elongated pendulum post 13 insulated from the back-plate, a shorter post 14 disposed near the pendulum post and also insulated from the back-plate and a post 15 disposed below and on the other side of a vertical diametrical line passing through the pendulum post.

A clock dial 20 is secured to the posts as 11 and 12 in front of the back-plate 10. This dial may be of any suitable construction.

A bracket 30 composed of non-magnetic material is secured by means of screws 31 and 32 or otherwise to the lower portion of the back-plate 10 on the rear face thereof. The bracket 30 extends upward and is recessed above its place of attachment, forming a space 33 between it and the back-plate, and it has a laterally projecting ear 34 opposite the center of the back-plate 10 and two laterally projecting ears 35 and 36 below the ear 34 and on a horizontal line with each other.

A central arbor 50 is supported in a bearing of the back-plate 10 and at its inner extremity in a bearing of the ear 34 of the bracket 30. This arbor is provided with a fixed collar 51 near its inner end and with a pinion 52 between the back-plate and the dial. A minute hand 60 is secured to the outer end of the arbor in front of the dial 20.

An hour hand sleeve 70 surrounds the arbor 50 in the usual manner and extends through the dial 20, being provided at its outer end in front of said dial with an hour hand 80 and at its inner end between the dial and back-plate 10 with a gear-wheel 71.

An auxiliary arbor 90 supported in suitable bearings is disposed between the back-plate and the dial to one side of the central arbor 50. The auxiliary arbor is provided with a gear-wheel 91 which meshes with the pinion 52 of the central arbor and is also provided with a pinion 92 which meshes with the gear-wheel 71 of the sleeve 70 carrying the hour hand. The motion of the arbor of the minute hand is communicated to the sleeve of the hour hand by this or any suitable means.

A ratchet-wheel 100 is disposed on the central arbor 50 and extends into the recess 33 of the bracket 30, and is held against the collar 51 by a spring clamp 101.

An electro-magnet of any suitable construction is secured to the back-plate at one side of the center thereof. In the form herein shown this magnet comprises cores 110 and 120 and spools or helices 130 and 140 are disposed thereon. The cores are supported at one end in the bracket 30, and are secured thereto by set screws 112 and 122 and are connected at their other end by a yoke 40. The ends 111 and 121 which extend through the bracket 30 constitute the poles of the magnet. These cores are preferably composed of mild steel so as to hold residual magnetism after the current is cut off.

An armature 150 is hinged to the ears 35 and 36 of the bracket 30 below the electro-magnet and extends upward past the projecting pole ends of said magnet with which it is adapted to form contact when the cores are magnetized. The armature is provided with means for drawing it away from the magnet. The means shown consists of a spring 160 connected at one end to an arm 41 depending from the bracket 40 and at the other end to the armature 150 below the pivot thereof, and this spring tends to swing the armature away from the magnet. A pawl 170 is pivoted on an arm 158 at the upper end of said armature and engages teeth of the ratchet-wheel 100. An adjusting screw 16 engages post 15 and serves as a stop against which the pawl abuts on completing its stroke whereby the action of the spring 160 is controlled. A spring check pawl 180 engages the ratchet-wheel 100 and serves to hold it in position during the retraction of the pawl 170.

The armature 150 is provided at or near its upper end with two electric contacts or contact studs 151 and 152 disposed apart from each other on

opposite sides of a vertical line passing through the center arbor. These studs are insulated from the armature and may be secured to the armature by means of a short cross-bar 153 composed of insulating material and disposed at the upper end thereof.

The armature also carries a third contact 157, preferably attached to a plate 156 disposed on a stud 154 secured to and insulated from the armature 150. A spring 155 is also disposed on the stud 154 and in electrical connection with said armature but insulated at its point of attachment from the plate 156. This spring rests normally against the contact 157 and serves to close the circuit through the plate 156. This spring extends beyond said plate and is adapted to engage at its outer end a contact 190 which is preferably adjustable on the insulated post 14. When the armature 150 is swung towards the magnet, the free end of the spring 155 engages the contact 190 of the energizing circuit and is thereby separated from the contact 157 of the plate 156 of the releasing circuit. The spring thus acts in connection with these parts as an automatic switch to shift the current from one circuit to the other and the contact 190 thus serves as a circuit breaker for the releasing circuit.

A suitable electric source is disposed on or connected with the clock, as for instance a battery 200. A conductor 201 connects the positive pole thereof with the contact 151 on the armature, a conductor 202 connects the pendulum post 13 with the helix 130 of the electro-magnet, a conductor 203 connects the helix 130 with the helix 140, a conductor 204 connects the helix 140 with the heel 40 and conductor 205 connects the armature with the spring 155, a conductor 206 connects the contact 152 with the negative pole of the battery, a conductor 207 connects the plate 156 with the conductor 206 and a conductor 208 provided with a resistance 209 connects the contact 190 with the positive conductor 201.

A shunt circuit 210 is connected with the coils of the electro-magnet and provided with a resistance coil 211 which imparts to the shunt circuit a considerably higher resistance than that of the magnet.

A compensating pendulum is preferably employed in connection with this clock. The pendulum shown comprises a torsional pendulum support or rod 220 suspended from the pendulum post 13 and a pendulum bob 230, whose arc of oscillation is horizontal, secured to the lower end of said rod. The pendulum rod is composed of a flat elastic metallic strip or wire or strands of wire or other material adapted to receive and resist a torsional force. This pendulum rod has means for completing an electric circuit through its main body or otherwise, and is provided with a contact arm 221 secured at one end to said rod and projecting at the other end between the contact studs 151 and 152 of the armature. As the pendulum rod oscillates the arm 221 touches one or the other of said contacts, preferably by means of an upright stud 222 secured to the free end thereof.

The pendulum bob 230 suspended from the pendulum rod comprises a horizontal coupling-bar 231 which constitutes lateral extensions in two directions of the pendulum rod; stops 235 and 236 on said bar, weights 232 and 233 on said bar between said stops and a spring clip 234 suspended from the pendulum rod and operative to hold the weights against the stops and permit them to expand towards each other. The weights are preferably spherical in form and provided with diametrical holes into which the opposite ends of the bar enter. These weights are preferably adjustable on the coupling-bar to regulate the torsional swing of the pendulum and to compensate for variations in the elasticity of the torsional support from changes of temperature. Any suitable means of adjustment may be employed. The means shown consist of screws 235 and 236 which engage screw-threaded holes in the end of the bar and serve as stops for the weights. These screws render the coupling-bar extensible. The spring clip 234 is preferably in the form of an expansible fork. The coupling-bar extends through holes in the legs

of the fork and the latter bear against the weights and hold them apart from each other in contact with the stops 235 and 236. The pendulum is regulated to increase the speed of its beats by adjusting the weights nearer together and to decrease the frequency of its oscillations by moving them further apart. This adjustment is readily effected by means of said adjusting screws or stops.

To avoid variations due to changes in temperature and to secure uniform action of the pendulum, the parts of the bob are so constructed as to compensate for such differences. The coupling-bar 231 is composed of a material which expands less for a given increase in temperature than the material of which the weights are composed. For instance the coupling-bar may be composed of steel which has a comparatively low expansibility and the weights of an alloy of lead which has a comparatively high coefficient of expansion. An increase of temperature will cause an expansion of the coupling-bar and weights and the expansion of the coupling-bar will tend to move the weights apart, and the greater expansion of the weights, operating against the stops will tend to bring the weights nearer together. The relative dimensions and expansions of these elements respectively are such that as the coupling-bar expands outwardly, the weights expand inwardly the required extent to maintain the normal relation between the weights and bar; and as the parts contract on a lowering of temperature, and the weights shrink in greater ratio than the coupling-bar, the spring clip holds the weights against the stops and the weights are thereby separated from each other or moved further from the center of oscillation. The parts of the pendulum may be so proportioned as to compensate for variations in the length or stiffness of the torsional wire due to variations in temperature.

The operation of the clock will now be described. Assuming the armature 150 to be away from the electro-magnet 130—140 and the pendulum contact 221 touching the armature contact 151, the current takes the following course constituting the energizing circuit: from the positive pole of the battery 200 to the contact 151 on the armature 150, thence through the contact arm 221, thence through the torsional pendulum rod 220, thence through the pendulum post 13, thence through the conductor 202, thence through the coil 130, thence through the conductor 203, thence through the coil 140, thence through the conductor 204, thence through the yoke 40, thence through the magnet cores 110 and 120, thence through the bracket 30, thence through the pivot of the armature, thence through the armature 150, thence through the contact spring 155, thence through the contact-plate 156, thence through the conductor 206 to the negative pole of the battery. A small portion of the current will leak through the spark coil 211 which is in a shunt around the magnet.

The electro-magnet being thus energized by the passage of the current through the coils 130—140, attracts the armature 150 and the latter swings into contact with the poles 111 and 121 dragging its pawl 170 over the teeth of the ratchet-wheel 100 and assuming the position shown in Figure 1. In this movement of the armature the spring 155 engages the contact 190 and is thereby bent away from the contact 157, whereby the circuit is broken. The armature will, however, remain in contact with the magnet until the current is reversed, owing to the residual magnetism of the steel cores.

This swinging of the armature towards the magnet imparts a torsional movement to the pendulum in the direction of the arrow-head 1 construed as in perspective through the arm 221 attached to the pendulum rod 220. This movement is not, however, imparted to the pendulum instantaneously. The pendulum being separate from the driving mechanism and independent of the movement of the armature, except to receive its impulses therefrom, the momentum imparted to it on the previous outward movement of the armature will cause it to continue its rotation in the direction of the arrow-head 2 against the flexibility of its contact arm and the torsion of its rod for a substantial

period in the same direction after the swinging of the armature. After the resistance of the rod and contact overcomes the momentum of the bob, the rotation of the pendulum is reversed and the arm 221 is caused to swing away from the armature contact 151 over against the armature contact 152 and the circuit is then closed through the latter. The current then passes through the following course constituting the releasing circuit, to wit; from the positive pole of the battery 200 through the conductor 201 through the conductor 208 including the resistance 209 to the contact 190 in the stud 14, thence through the spring 155 to the armature 150, thence through the bracket 30, thence through the cores 110 and 111 of the magnet, thence through the conductor 202, thence through the pendulum post 13, thence through the pendulum rod 220, thence through the arm 221 thereon, thence through the stud 152, thence through the conductor 206 to the negative pole of the battery. The course of the current through the magnet is thus reversed and the polarity of the magnet thereby changed, whereby its residual magnetism is weakened or neutralized. The spring 160 then withdraws the armature 150 from the magnet and causes the pawl 170 to impart a stop movement to the ratchet-wheel 100 and then come to a stop against the stud 16. The movement of the ratchet-wheel turns the hands of the clock the required distance for a single impulse. The outward spring of the armature separates the spring 155 from the contact 190, breaking the releasing circuit and permitting said spring to rest against the contact 157 on the plate 156 of the energizing circuit, preparatory to the reformation of said energizing circuit by the subsequent swing of the pendulum. This swinging of the armature towards the left imparts through the arm 221 on the pendulum rod 220 a rotary impulse to the pendulum in the direction of the arrow-head 2 and after the torsional action of the pendulum has overcome the momentum of the previous impulse, the arm 221 swings away from the stud 152 into contact with the stud 151, whereby the circuit is again restored in the direction before described and another impulse imparted to the pendulum in the direction of the arrow-head 1.

This arrangement of contacts thus operates as a pole changer with means for opening the battery circuit after each reversal of the current and movement of the armature.

The object of the resistance 209 is to weaken the current for releasing the armature, as a much weaker current is sufficient to neutralize the residual charge than that necessary for energizing the magnet for throwing up the armature.

The resistance 211, which is in parallel with the magnet coils, affords a path for the discharge current of the magnet when the circuit of the battery and the magnet is opened thus avoiding sparking at the contact.

It will be seen from the foregoing that for every swing of the pendulum there is a movement of the armature and this movement of the armature will always give the pendulum an impulse tending to keep it in motion; and every alternate motion of the pendulum will propel the wheel of the clock the distance of one tooth. Consequently in order that the clock may keep accurate time it is merely necessary to adjust the beat of the pendulum to the number of teeth in said wheel. It will also be observed that the pendulum has no mechanical work to perform in controlling the clock and consequently the frictional error is reduced to a minimum, being reduced practically to the resistance of the air.

I find that a pendulum having beats of five seconds each and a wheel having 360 teeth, moving one tooth every ten seconds, will give good results in a small clock.

The mechanism may be varied in construction and arrangement without departing from the scope of this invention.

The battery circuit being opened immediately after each effective action of the magnet, and the torsional pendulum being permitted to oscillate in both

directions of rotation after the circuit is reversed, whereby the intervals between the closings of the circuit are prolonged, it follows that the current consumption is very small. As a matter of fact, it is scarcely measurable. As the pendulum is separate from the driving mechanism proper and acts merely as a contact device to control said mechanism, it is not retarded or made irregular in its action by the varying friction and irregularities of the mechanical devices constituting a part of said mechanism.

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

1. The combination of a clock train, a torsional pendulum, and an electro-magnetic clock train driving mechanism independent of said pendulum and comprising an armature separate from said pendulum, said pendulum being provided with an electric contact for controlling said electro-magnetic driving mechanism and being free to rotate independently of the movement of said armature.

2. The combination of a clock train, a clock train driving mechanism therefor comprising an armature, an electro-magnet for actuating said mechanism, alternate reversing electric circuits for energizing said magnet, and a regulating torsional pendulum independent of said driving mechanism and provided with an electric contact for controlling said circuits, said pendulum being free to rotate independently of the movement of said armature.

3. The combination of a clock train, an electro-magnet, an armature movable into contact with said magnet, mechanism operated by said armature for driving said clock train, alternate reversing electric circuits, mechanical means for swinging said armature out of contact with said magnet, a torsional pendulum provided with an electric contact, two contacts mounted on said armature and adapted to be engaged by said pendulum for closing the respective circuits, a third contact also mounted on said armature and composed of separable parts respectively connectible with said circuits, and a device adapted to separate said parts to open one of said circuits immediately after the closing thereof and to form a connection with the other circuit preparatory to its being closed by the return of the pendulum.

4. The combination of a clock train, a driving mechanism therefor, an electro-magnet for actuating said mechanism, alternate reversing electric circuits for energizing said magnet, pole-changing contacts separate from the pendulum, and connecting with said circuits, respectively, and a regulating torsional pendulum provided with an electric contact adapted to operate in connection with said pole-changing contacts to open, close and reverse said circuits.

5. The combination of a clock train, a torsional pendulum, mechanism for actuating said train and imparting impulses to said pendulum, an electro-magnet for operating said mechanism, electric circuits controlled by said pendulum for energizing said magnet, and a shunt circuit connected with the magnet coils and including a resistance.

6. The combination of a central arbor carrying a minute hand, a sleeve on said arbor carrying an hour hand, a train between said arbor and sleeve, a large rachet-wheel on said central arbor, a torsional pendulum, a contact arm connected with said pendulum, an armature provided with two contacts between which said arm projects, means for moving said armature in one direction, an electro-magnet for moving it in the opposite direction, a pawl connected with said armature for actuating said large rachet-wheel, and electric connections adapted to close the circuit through the electro-magnet by way of either of said armature contacts.

7. In an electric clock, the combination of an electro-magnet, an armature provided with a conductive plate, and with a conductive spring disposed

adjacent to said plate and normally in contact therewith, a fixed contact with which said contact spring engages on the movement of the armature in one direction, and electric connections forming alternate circuits passing through said spring and plate respectively.

8. In an electric clock, the combination of a clock train, a torsional pendulum, electro-magnetic means for propelling the clock train and maintaining motions of said pendulum, the circuits of said electro-magnetic means being adapted to be alternately closed by the movement of said pendulum and opened independently of said pendulum.

9. The combination of a clock train, a driving mechanism therefor, an electro-magnet for actuating said mechanism, electric means for energizing said magnet, and a pendulum controlling said electric means and comprising a pendent torsional rod provided with a contact arm, and means mounted on said driving mechanism and engaging said contact arm for actuating said pendulum.

10. In an electric clock, a compensating pendulum comprising a pendent torsional rod having a lateral extension provided with a stop, a weight of solid metal on said extension, the weight and extension having different expansibilities adapting them to act automatically by expansion and contraction to vary the radial distance between the weight and the axis of the rod to compensate for the contraction and expansion of the extension, and automatic means for holding said weight in contact with said stop.

11. In an electric clock, a compensating pendulum comprising a pendent torsional rod, a coupling-bar connected with said rod and provided with adjustable stops, weights on said coupling-bar between said stops, and resilient means operative to hold said weights in contact with said stops and permit them to expand toward each other, the weights and bar being of different solid metals and the metal of the weights being more sensitive to the changes of temperature than the metal of the bar, and adapted by expansion and contraction to compensate for the expansion and contraction of the coupling-bar.

12. In an electric clock, a compensating pendulum comprising a pendent torsional rod, a spring clip attached thereto, a coupling-bar supported by said spring clip and provided with stops, and weights on said coupling-bar between said clip and stops, the weights and bar being of different metals, the metal of the weights being more sensitive to changes of temperature than the metal of the bar, whereby the pendulum is self-compensating.

Dated this 18th day of January 1904.

ALLISON BROS.
Agents for the Applicants.

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A.D. 1904. JAN. 18. N° 1258.
TIFFANY & *another's* COMPLETE SPECIFICATION.

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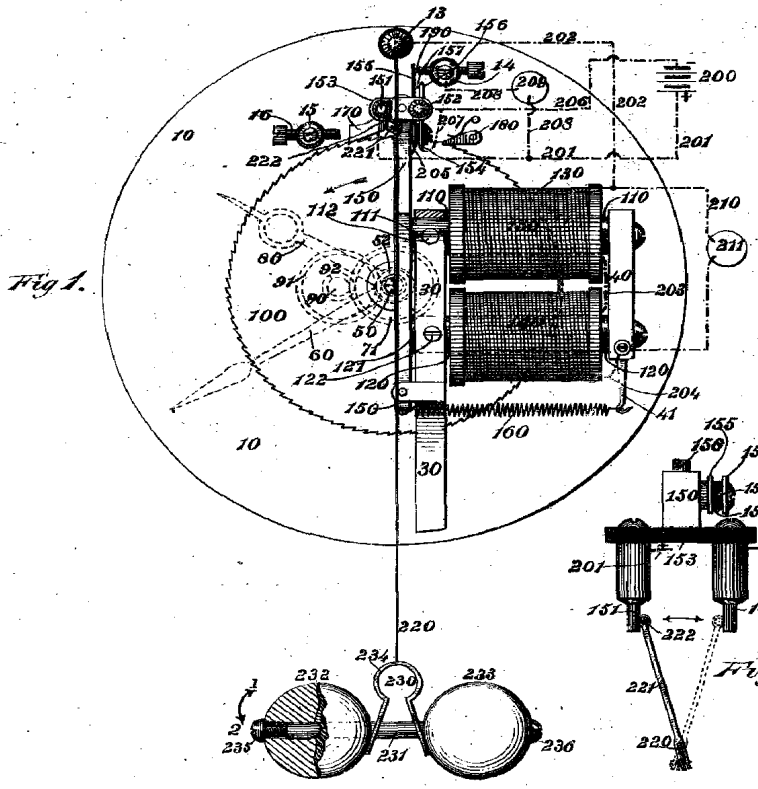

Fig 1.

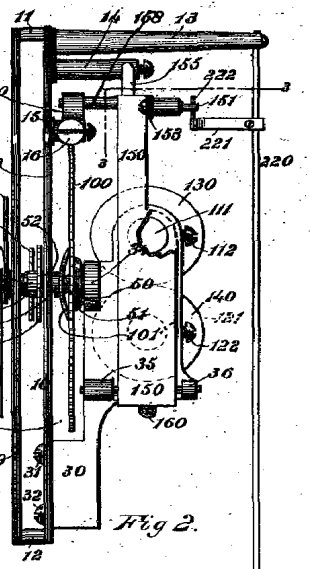

Fig 2.

Fig 3.

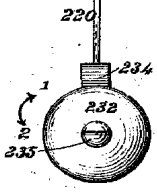

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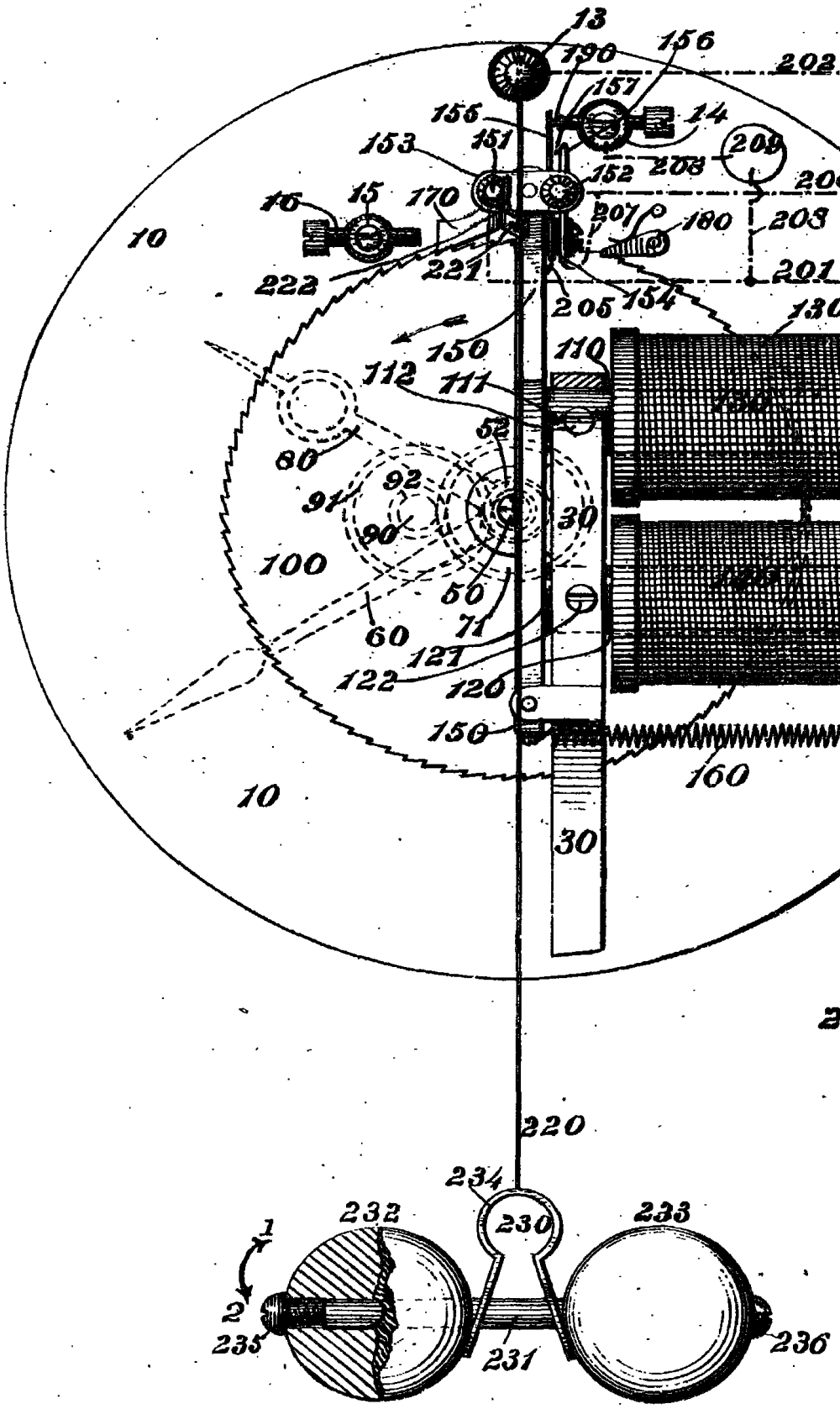
Fig 1.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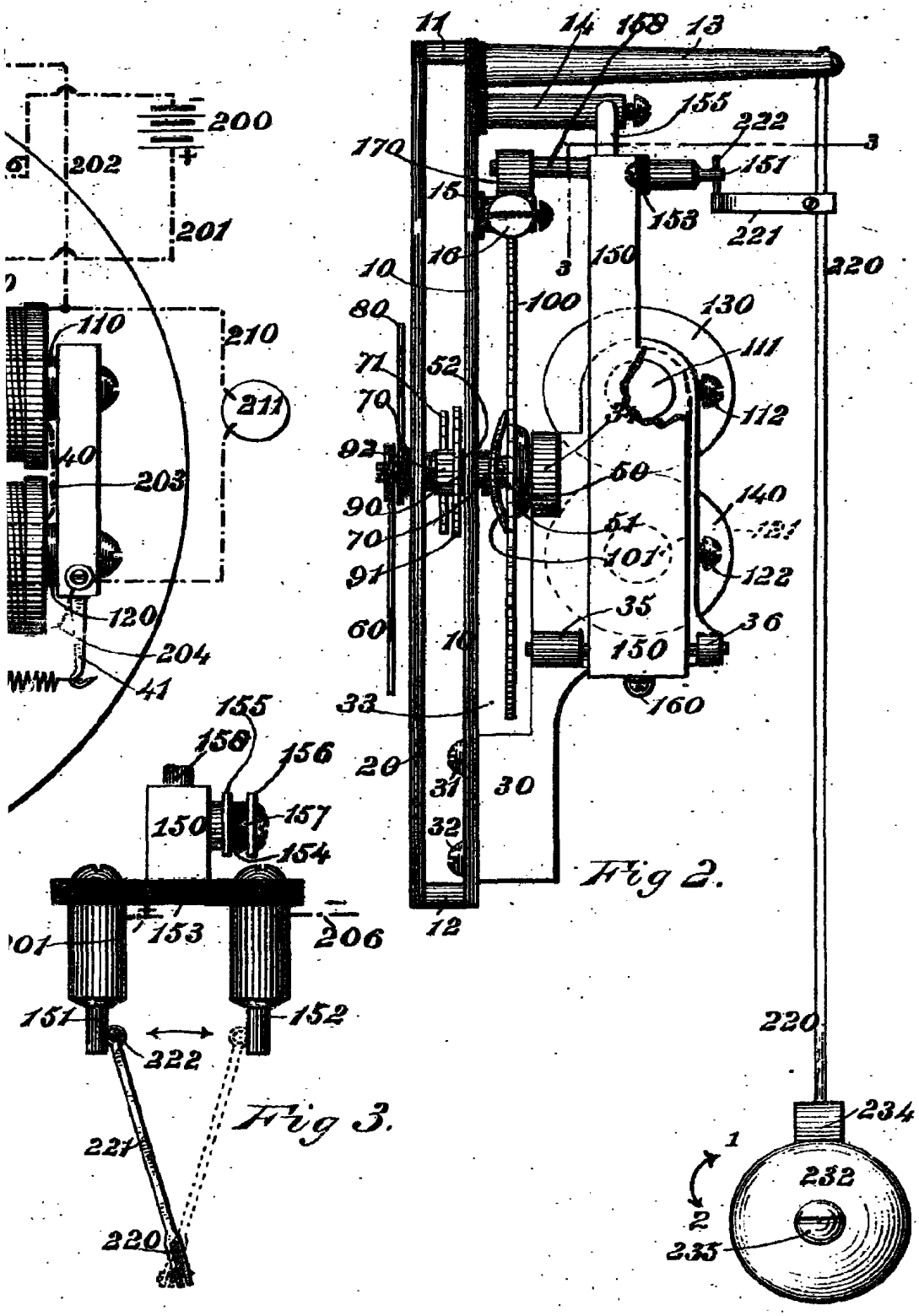

Fig 2.

Fig 3.

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