No. 840,557. PATENTED JAN. 8, 1907.

H. G. CRAWFORD.

AUTOMATIC CIRCUIT CONTROLLING MECHANISM.

APPLICATION FILED MAR. 22, 1905.

4 SHEETS—SHEET 1.

Fig. 1.

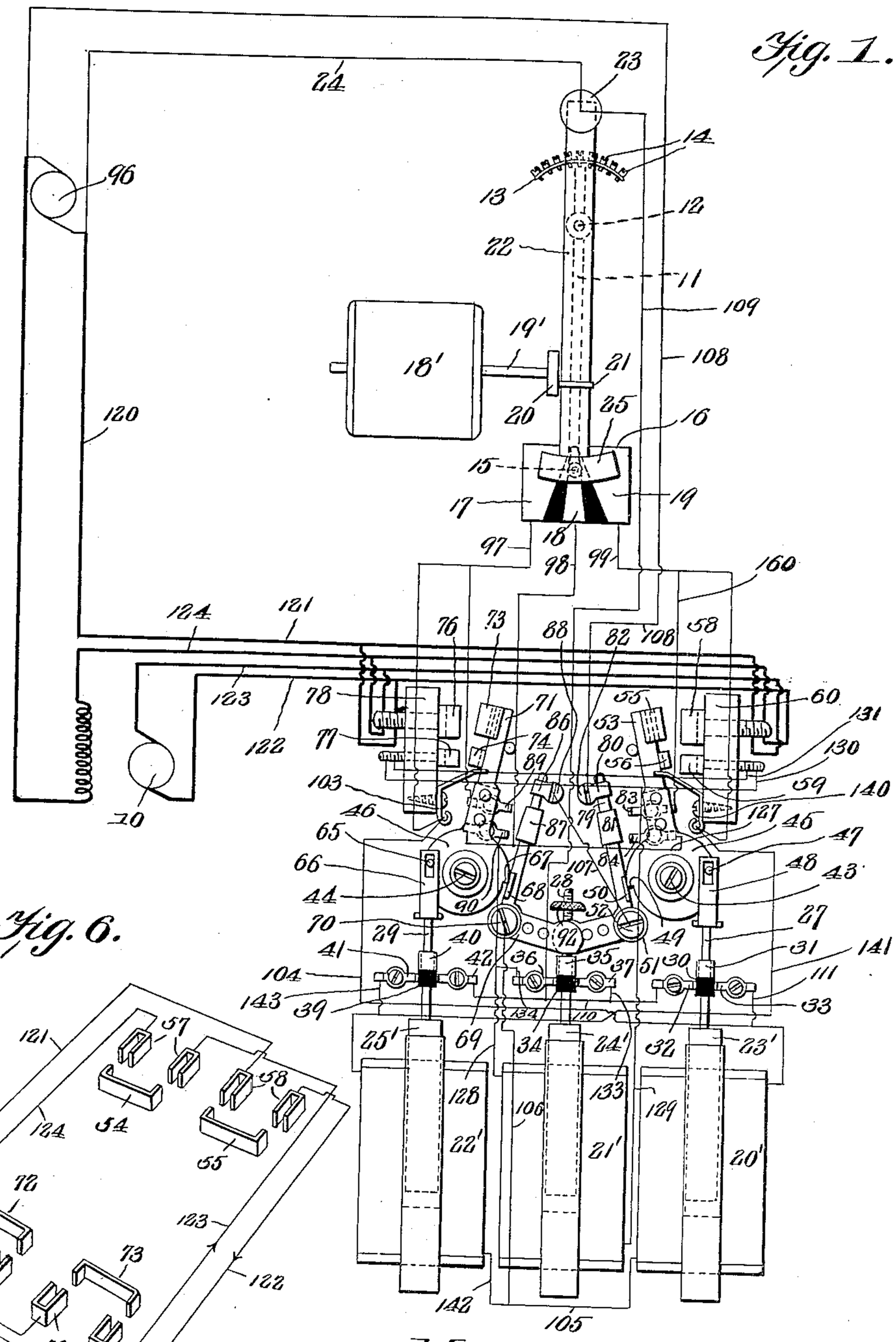


Fig. 6.

Witnesses

E. F. Stewart

Jno. C. Porter

Herbert G. Crawford,

Inventor.

by Church & Co.

Attorneys

No. 840,557. PATENTED JAN. 8, 1907.

H. G. CRAWFORD.

AUTOMATIC CIRCUIT CONTROLLING MECHANISM.

APPLICATION FILED MAR. 22, 1905.

4 SHEETS—SHEET 2.

Fig. 3.

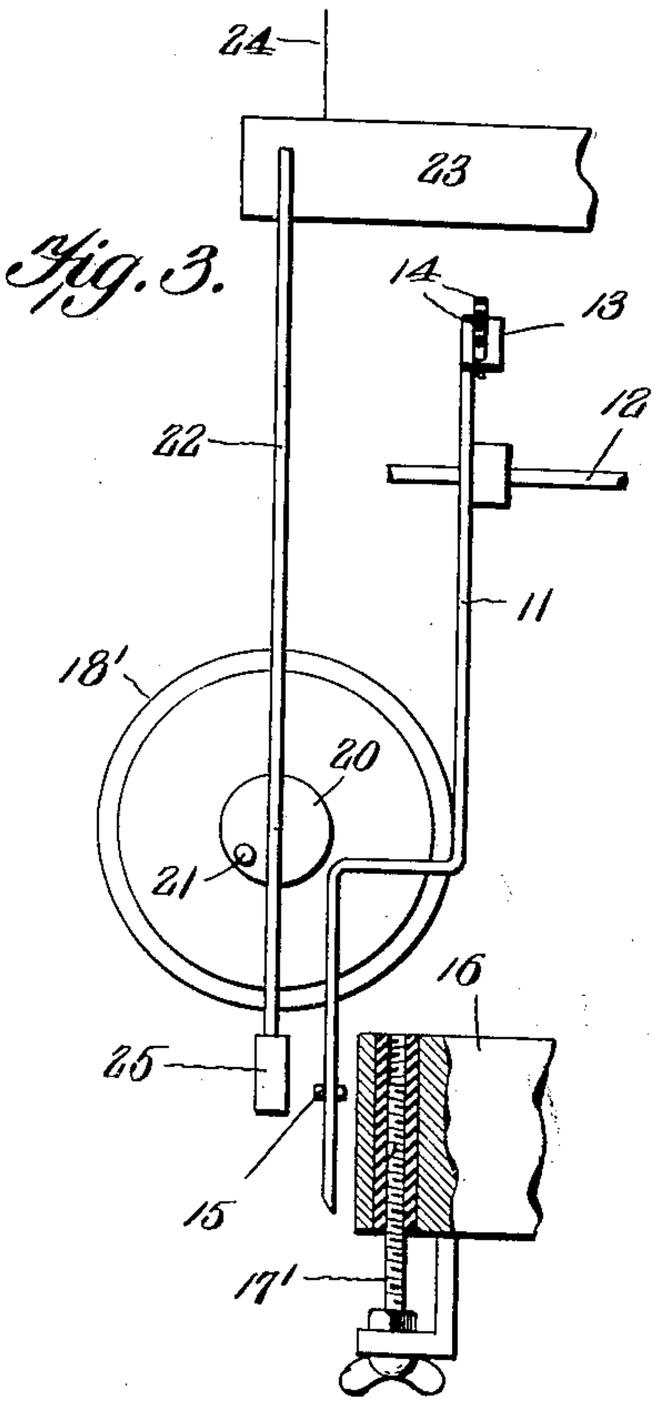


Fig. 2.

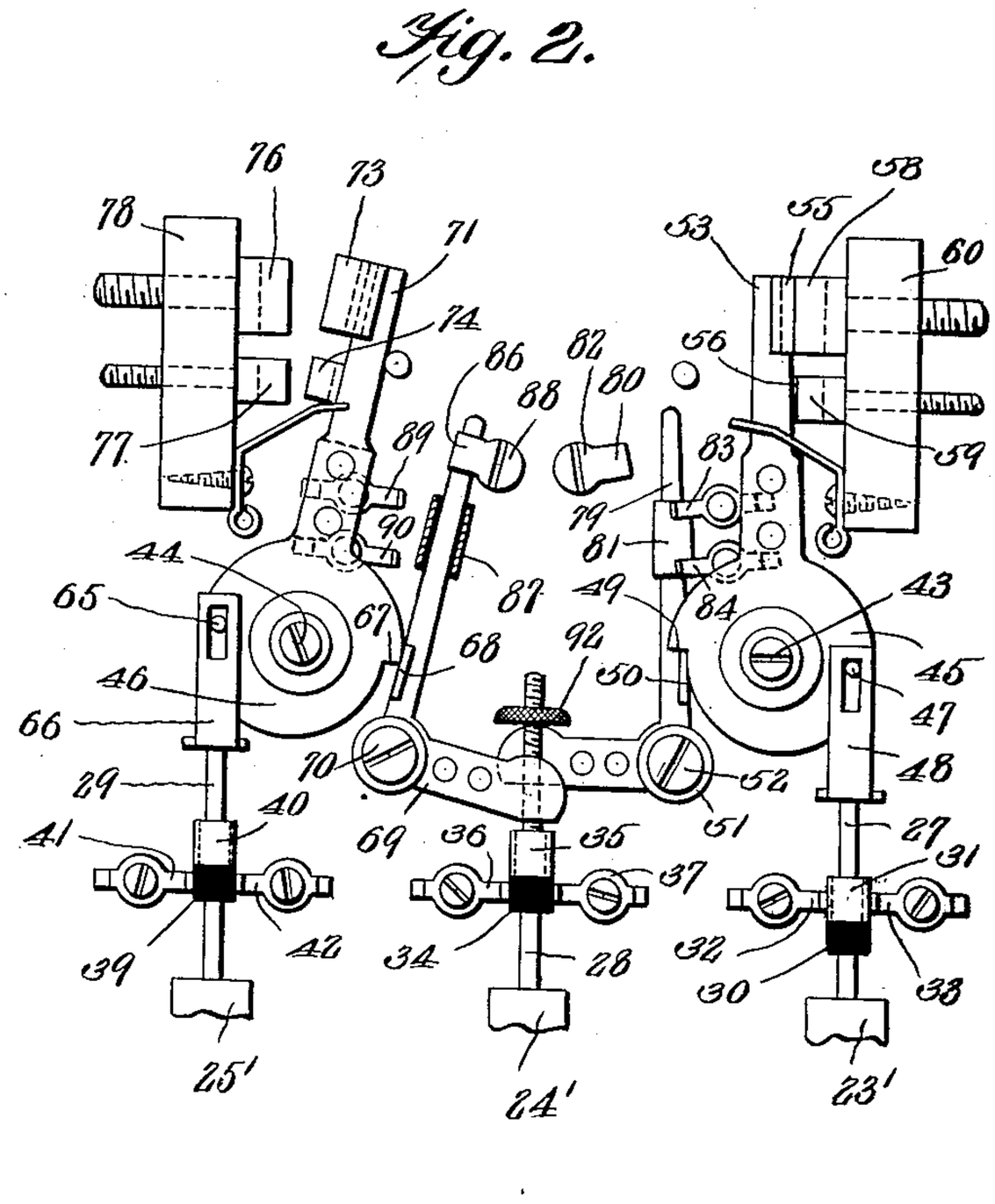


Fig. 5.

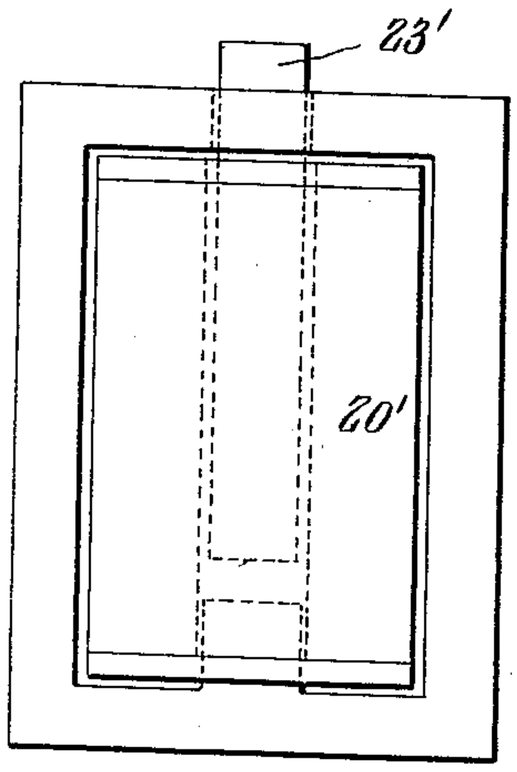


Fig. 7.

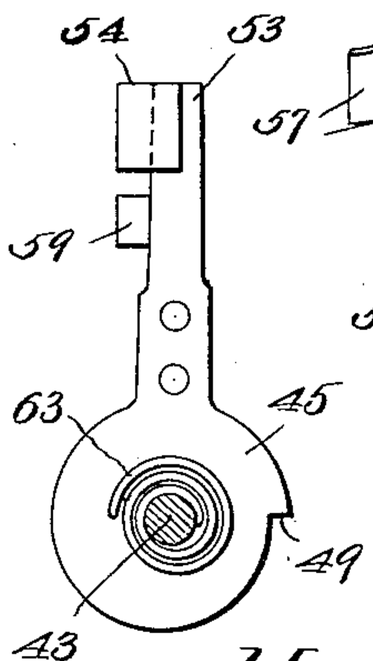
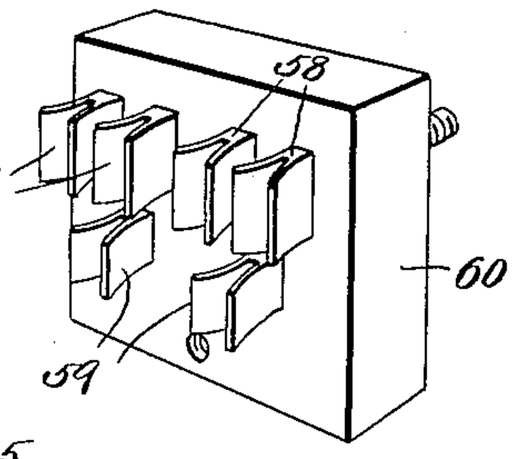


Fig. 4.



Witnesses
E. F. Stewart
Jno. E. Parker

Herbert G. Crawford,
Inventor.
by Cachow & Co.
Attorneys

No. 840,557. PATENTED JAN. 8, 1907.

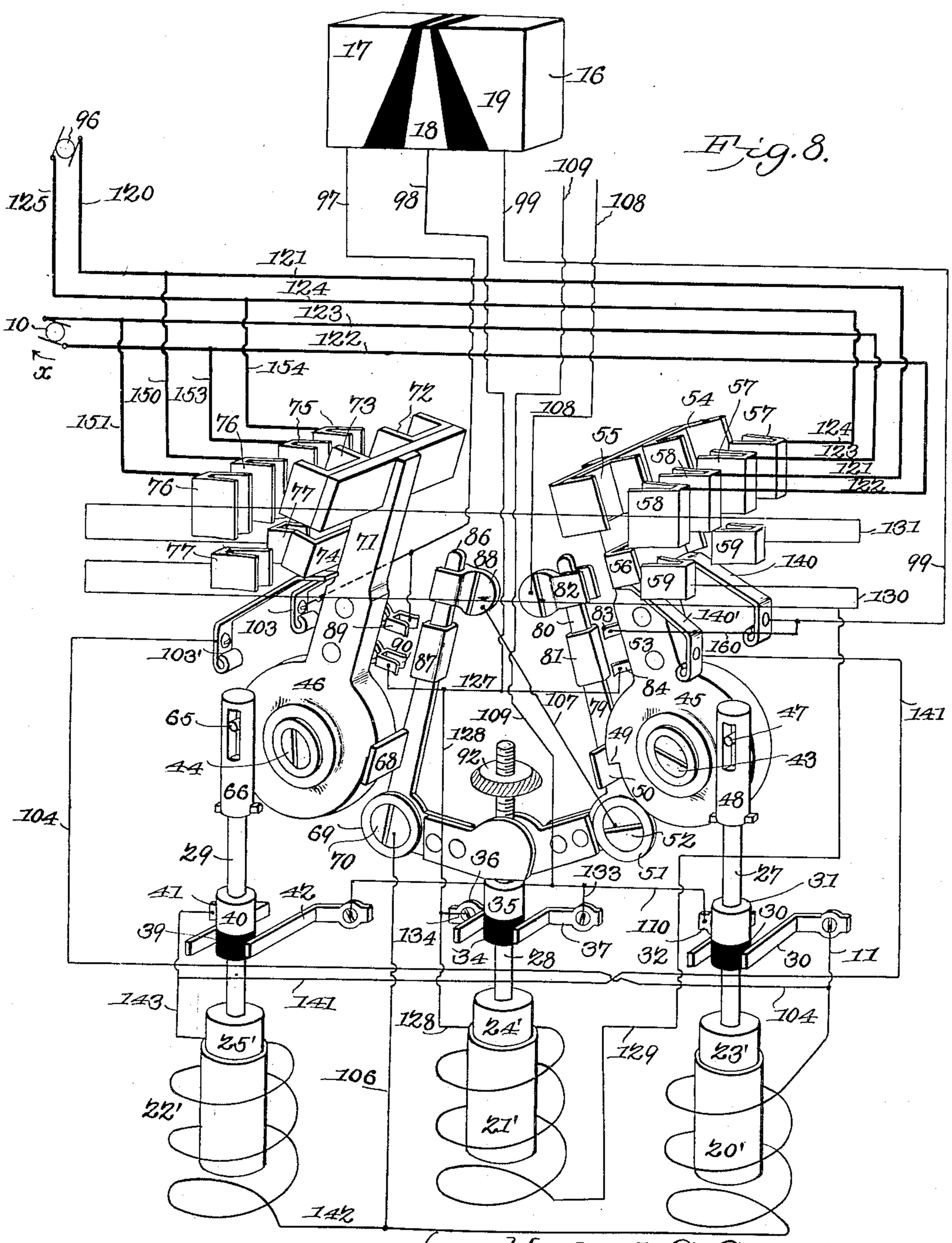
H. G. CRAWFORD.

AUTOMATIC CIRCUIT CONTROLLING MECHANISM.

APPLICATION FILED MAR. 22, 1905.

4 SHEETS—SHEET 3.

Fig. 8.



Witnesses

E. C. Stewart

Jno E Parker

Herbert G. Crawford,

Inventor.

by Cushman & Co

Attorneys

No. 840,557. PATENTED JAN. 8, 1907.

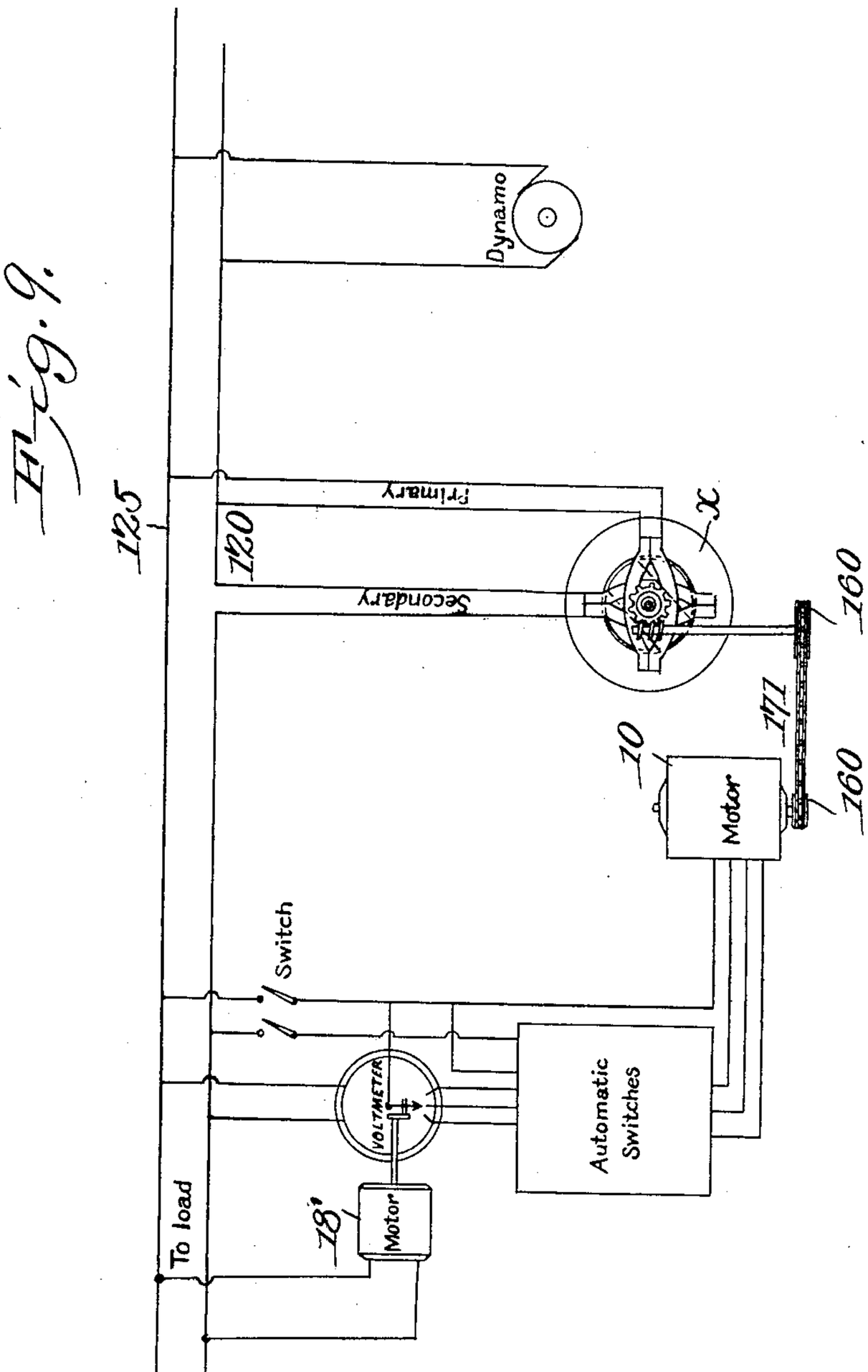
H. G. CRAWFORD.

AUTOMATIC CIRCUIT CONTROLLING MECHANISM.

APPLICATION FILED MAR. 22, 1905.

4 SHEETS—SHEET 4.

Fig. 9.



Witnesses
E. F. Holcomb
Jno. E. Parker

Herbert G. Crawford,
Inventor.
by Crawford & Co
Attorneys

UNITED STATES PATENT OFFICE.

HERBERT G. CRAWFORD, OF ELMONT, VIRGINIA.

AUTOMATIC CIRCUIT-CONTROLLING MECHANISM.

No. 840,557. Specification of Letters Patent. Patented Jan. 8, 1907.

Application filed March 22, 1905. Serial No. 251,509.

To all whom it may concern:

Be it known that I, HERBERT G. CRAWFORD, a citizen of the United States, residing at Elmont, in the county of Hanover and State of Virginia, have invented a new and useful Automatic Circuit-Controlling Mechanism, of which the following is a specification.

This invention relates to electric regulators.

The principal object of the invention is to provide a regulating means of such nature that the variation of a delicately-balanced needle or other member from a given point in either direction will cause either the making or breaking of circuits through which either directly or indirectly the needle or its carrier will be made to reassume such initial position.

A further object of the invention is to provide a novel form of voltage-regulator wherein the system is to be regulated by a potential-regulator of well-known construction—such, for instance, as that shown in the Steinmetz patent, No. 548,400, dated October 22, 1895.

A still further object of the invention is to provide a device of this character in which full movement of the magnet-cores is insured even where the initial circuit-closing is but momentary, and, further, to provide mechanism of such construction that the switch members on breaking the circuit may be moved very quickly.

With these and other objects in view, as will more fully hereinafter appear, the invention consists in certain novel features of construction and arrangement of parts hereinafter fully described, illustrated in the accompanying drawings, and particularly pointed out in the appended claims, it being understood that various changes in the form, proportions, size, and minor details of the structure may be made without departing from the spirit or sacrificing any of the advantages of the invention.

In the accompanying drawings, Figure 1 is an elevation of an electric regulator constructed in accordance with the invention, the wiring connections being shown in diagrammatic form. Fig. 2 is a similar view of a portion of the mechanism with one of the switches in circuit-closing position. Fig. 3 is a side elevation of the needle, the initial contacts, and the needle-depressing mechanism drawn to an enlarged scale. Fig. 4 is a detail perspective view of one of the base-plates employed for carrying the switch members. Fig. 5 is a side view of one of the electromagnets. Fig. 6 is a detail perspective view showing principally the location and connections of the line-wires leading between the source of energy and the motor or similar member. Fig. 7 is a detail view of one of the circuit-closing arms, showing the spring for restoring it to normal position. Fig. 8 is a general diagram of the principal wiring connections, showing more especially the local circuits under the control of the automatic switches. Fig. 9 is a general diagram of the system, showing the source of energy, the regulator, and the mechanism for operating said regulator.

Similar numerals of reference are employed to indicate corresponding parts throughout the several figures of the drawings.

The present invention aims to provide a mechanism for automatically controlling circuits, and in the present instance the drawings illustrate a voltage-regulator operated by a motor 10, the circuit of which is controlled by the movement of a delicately-balanced needle 11. The needle is operated in any manner, and it may form the movable member of a galvanometer or other instrument controlled by the varying strength or amperage of an electric current. Whatever its nature, the position of the needle at a neutral or other predetermined point results in the breaking of the motor-circuit. If the needle moves in one direction, a circuit will be established through the motor to revolve the same in one direction, and if the needle moves in the opposite direction a circuit will be closed to rotate said motor in the opposite direction, and the motor may be connected in any suitable manner to any mechanism that will either directly or indirectly tend to restore the needle to its initial position or the needle-support to a predetermined position.

The needle 11 is shown in the present instance as mounted on an arbor 12, having an arc 13, provided with threaded openings for the reception of poising-screws 14. Near the lower end of this needle is a contact-point 15, that preferably is formed of platinum, and as the needle moves it swings over a block 16, having a number of contacts 17, 18, and 19, three being shown in the present instance, although the number may be increased or diminished in accordance with the use to which the device is to be put. These con-

tacts are preferably tapered, and the block 16 is provided with an adjusting-screw 17′, by which the positions of the contact may be adjusted with relation to the swinging contact-point, and thus vary the sensitiveness of the device, so that a greater or less range of movement of the needle will be necessary to bring it opposite the outside contacts.

On the base-plate is mounted a suitable motor element 18′, which may tak the form of an electric motor, and this motor element drives a shaft 19′, on which is secured a crank-disk 20, carrying a crank-pin 21. As the crank-pin revolves it engages a strip 22, formed, preferably, of spring metal and having its upper edge embedded in a metallic block 23, to which a line-wire 24 is connected. The lower end of the spring-strip carries an arc-head 25, which is pressed into contact with the needle or the contact 15 each time the crank-pin is revolved. No matter what the position of the needle may be, the head 25 will engage it at each revolution of the crank-pin, and this may occur every few seconds. At times the contact 15 may be forced into engagement with contact 18, which will break the motor-circuit if the latter be energized, or if it be forced into engagement with contact 17 a current in one direction will be sent through the motor and if forced into engagement with the contact 19 a current in the opposite direction will be sent through the motor.

At a suitable point on the base is arranged a series of electromagnets 20′, 21′, and 22′, each of which have closed magnetic circuits and are provided with movable core members 23′, 24′, and 25′, respectively, there being a separate electromagnet for each of the needle-engaged contacts, and in this connection it is to be observed that contact 17 controls the circuit of electromagnet 20′, contact 18 that of electromagnet 21′, and contact 19 the circuit of electromagnet 22′. The cores 23′, 24′, and 25 carry pins 27, 28, and 29, respectively. On the pin 27 is an insulating-block 30 and a conducting-sleeve 31, the insulating-block normally engaging two contacts 32 and 33, carried by the base-plate; but when the electromagnet is energized and the core is pulled down the sleeve 31 will be brought into engagement with the contacts 32 and 33, and a circuit will be closed for a purpose hereinafter described. The pin 28 carries an insulating-block 34 and a conducting-sleeve 35, which under similar conditions is brought into engagement with contacts 36 and 37 to close a circuit between them. The pin 29 carries a block 39, of insulating material, and a conducting-sleeve 40, which may be lowered to engage two contacts 41 and 42, carried by the base-plate.

At a point above the electromagnets 20′ and 22′ are screws or pins 43 44, on which are mounted rocking disks 45 and 46, respectively. The disk 45 carries a pin 47, arranged in a vertical slot formed in a strip or block 48, that is carried by the pin 27, and said disk has a shoulder 49, with which may engage a locking-plate 50, carried by a bell-crank lever 51, that is pivoted on a pin 52 on the base-plate. From disk 45 projects an arm 53, which carries three switch members 54, 55, and 56, all insulated from each other and arranged to engage, respectively, the pairs of contacts 57, 58, and 59, that are carried by a block 60, formed of insulating material, the several contact members being provided with binding-screws of the usual type for connection to the line-wires, and these switch members control the circuit between the source of energy and the motor. A coiled spring 63 is arranged around the pivot-screw 43 and has one end connected to the disk and the other end to the base. The springs serve to move the switch to open position when the shoulder 49 is disengaged from the locking-tongue 50.

The disk 46 is provided with a projecting pin 65, which enters a vertically-disposed slot in a strip or plate 66, carried by the upper end of the pin or rod 29, and on said disk is a shoulder 67, with which may engage a locking-tongue 68, carried by a bell-crank lever 69, that is fulcrumed on a stud 70, carried by the frame. From the disk 67 projects an arm 71, carrying three switch members 72, 73, and 74, that are adapted, respectively, to engage with pairs of contacts 75, 76, and 77, carried by a block 78, that is formed of insulating material, and said switch members 75, 76, and 77 are provided with the usual binding-screws for connection to the line-wires. The disk 46 is also restored to its initial position by a spring similar to that employed on the disk 45.

The bell-crank lever 51 is provided with an approximately vertical arm 79, that carries two contacts 80 and 81, the contact 80 being electrically connected to the bell-crank lever, while the contact 81 is insulated therefrom. When in the position shown in Fig. 1, contact 80 engages a contact 82, carried by the base, and when in the position shown in Fig. 2 the contact-plate 81 engages a pair of contacts 83 and 84 and closes a circuit.

The bell-crank lever 69 is provided with two contacts 86 and 87, the contact 86 being electrically connected to the bell-crank lever, while the contact 87 is insulated therefrom. When in the position shown in Figs. 1 and 2, contact 86 engages a stationary contact 88, carried by the base-plate, and when moved the contact 87 will engage a pair of contacts 89 and 90 to close a circuit between them.

The upper end of the pin 28 is threaded for the reception of a milled nut 92, and that portion of the pin between the conducting-sleeve 35 and the nut receives the ends of the approximately horizontal arms of the bell-

crank levers 51 and 69, the end portions of said levers being rounded at the point where they engage with the nut.

For operating the device a source of energy, such as a dynamo 96, is employed, and from one pole leads wire 24 to the block 23, and when spring-strip 22 and needle 11 are depressed a current will flow through contacts 17, 18, or 19 and wires 97, 98, and 99, depending on the position of the needle at the time the contact is made.

Tracing the circuit from contact 17, it will be followed through wire 97 to contact-strip 103′, switch 74, contact 103′, wire 104, to the winding of electromagnet 20′, thence by wire 105, wire 106, bell-crank lever 69, contact 86, contact 88, wire 107, screw 52, bell-crank lever 51, contact 80, contact 82, wire 108, and return to the dynamo or other source of energy. This energizes momentarily the electromagnet 20′, and its core 23′ is pulled down, so that the conducting-sleeve 31 is placed between and connects electrically contacts 32 and 33, whereupon a circuit is established from block 23, wire 109, wire 110, contact 32, sleeve 31, contact 33, wire 111, wire 104, electromagnet 20′, wire 105, and return as before through wire 108 to the dynamo. This is for the purpose of creating a continuous circuit through the coil in order to insure positive operation of the core, inasmuch as the closing of the circuit through the needle and contact 17 is but momentary. The downward movement of the core acts upon slotted plate 48 on pin 47 and partly revolves disk 45, moving the arm 53 until its several contacts 54, 55, and 56 are engaged, respectively, with the pairs of contacts 57, 58, and 59. This closes a circuit through the motor 10, as hereinafter described. As soon as the disk 45 has been rotated to a sufficient extent the bell-crank lever 51 will move to the position shown in Fig. 2 and tongue 50 will interlock under the shoulder 49 of the disk, holding the latter, with its switch-arm, in circuit-closing position. At the instant this occurs contact 80 leaves contact 82, and the circuit through the coil 20 will be broken, so that the core is free to return without in any manner affecting the position of the disk 45, the slot in strip 48 being made for this purpose. The moving of the core upward causes the conducting-sleeve 31 to disengage from contacts 32 and 33, the insulating-block 30 being placed between said contacts.

When the bell-crank lever moves to the position shown in Fig. 2, contact 81 engages the two contacts 83 and 84 and closes a circuit the purpose of which will be hereinafter described.

When the contacts have been closed in the manner described, a circuit may be traced from the dynamo or other source of energy through wire 120, wire 121, (referring now more particularly to Fig. 6,) one of the contacts 58, contact 55, second contact 58, wire 122, to motor 10, and back through wire 123 to one of the contacts 57, contact 54, second contact 57, wire 124, and wire 125 to the dynamo, the circuit through the field being omitted in this figure to avoid confusion. This we will assume revolves the motor in the direction of the arrow *x*. The motor continues to revolve and to effect change in the voltage or amperage, and the needle once more moves toward its neutral or predetermined position. If the needle be above the contact 18 when spring 22 is again depressed, a circuit may be traced through wire 98, wire 127, wire 128, to electromagnet 21′, thence through wire 129, wire 130, one of the contacts 59, contact 56, the second contact 59, wire 131, and wire 108, previously described, to the source of energy. This energizes the electromagnet 21′, and its core is pulled down, the first effect of the movement being to bring the conducting-sleeve 35 between the two contacts 36 and 37, whereupon the circuit may be traced from block 23, wire 109, wire 110, wire 133, contact 37, sleeve 35, contact 36, wire 134, wire 128, the electromagnet 21′, wire 129, wire 130, contacts 59 and 56, wire 131, and wire 108, to the source of energy. This maintains the circuit through the electromagnet 21′, and as the core is pulled down farther the nut 92 will engage the approximately horizontal arm of bell-crank lever 51 and will pull the same down until the tongue 50 is disengaged from the shoulder 49 of the disk, whereupon the disk is free to move to its initial position under the influence of its returning spring, and the arm 53 will be moved in such manner as to instantly break the motor-circuit. At the same time contact 80 will move against the contact 82. Movement of the bell-crank lever 51 disengages contact 56 from the contacts 59 and instantly breaks the circuit through the electromagnet 21′, so that the core of the latter is then free to move to its normal position under the influence of its spring, and the parts will again be in the position shown in Fig. 1—that is to say, with no current passing to the motor.

Should the needle be in a position over the contact 19 when the strip 22 is depressed, the circuit will be closed through wire 99, contact 140, switch 56, contact 140′, wire 141, to electromagnet 22′, and from thence through wire 142, wire 106, screw 70, bell-crank lever 69, contact 86, contact 88, wire 107, screw 52, bell-crank lever 51, contact 80, contact 82, and wire 108 to return to the source of energy. This energizes the electromagnet 22′, and the core is pulled down until sleeve 40 enters between contacts 41 and 42, whereupon a circuit may be traced from wire 109, wire 110, contact 42, sleeve 40, contact 41, wire 143, the winding of the electromagnet

22′, wire 142, wire 106, screw 70, bell-crank lever 69, contact 86, contact 88, wire 107, screw 52, bell-crank lever 51, contact 80, contact 82, and wire 108 to return to the dynamo. On the energizing of the electromagnet 22′ slotted plate 66 is pulled downward and acts through the pin 65 to move the disk 46 until arm 71 is moved to the left, bringing the contacts 72, 73, and 74 into engagement, respectively, with the pairs of contacts 75, 76, and 77. This closes a circuit which may be traced from the dynamo through wire 120, wire 150, one of the contacts 76, contact 73, the second contact 76, wire 151, to wire 123, to motor, and return by wire 122 to wire 153, one of the contacts 75, contact 72, second contact 75, wire 154, and wires 124 and 125 to the dynamo, the course of the current being opposite that in which it previously traveled and revolving the motor in a direction opposite to the direction indicated by arrow *x*.

The motor 10 is operated for the purpose of producing an effect the opposite of that produced by the previous rotative movement and results in again restoring the needle to its neutral or initial position, and if again depressed the needle will strike the contact 18, and the circuit through the electromagnet 21′ will be established in the manner previously described in order to release disk 46 and break the motor-circuit.

To prevent the possibility of both switch members being closed at the same time, the circuits are so arranged that should one switch be closed and then contact be made that would otherwise close a circuit through the electromagnet operating the other switch a circuit will be closed through magnet-coil 21′, opening the first switch, and then at the next depression of the spring-strip 22 the circuit will be closed through the electromagnet operating the second switch in the ordinary manner. For example, if the switch operated by the electromagnet 20′ is closed by a previous depression of the block 15 into engagement with contact 17 and the needle should be moved in such manner that on the next depression contact would be made with block 19 a circuit will be closed through the spring-strip, the contact 15, contact 19, wire 99, wire 160, contact 83, contact 81, contact 84, wire 127, wire 128, electromagnet 21′, wire 129, wire 130, contacts 59 and 56, wire 131, and wire 108, to return to the dynamo. The magnet-core 24′ is then pulled down and the switch is moved to open position, the circuit through the coil 21 being opened as soon as switch member 56 leaves switch members 59. On the next depression of the needle, if the latter is still over contact 19, the circuit will be closed through electromagnet 22′ in the manner previously described.

Where the apparatus is employed for voltage regulation, the connections are made in the manner shown in Fig. 9. The potential-regulator *x* has one winding connected in series with one of the mains 120, while the second winding is connected in shunt to the mains 120 and 125. In order to operate the regulator, it is connected by suitable gearing, including sprocket-wheels 160 and a link belt 171, to the motor 10, the motor connections being controlled by the switching mechanisms previously described, so that by turning said motor in one direction or the other the regulator may be actuated for the purpose of regulating the voltage of the lines. The main circuit-closing device in this case takes the form of a voltmeter, the movable needle or pointer of which is depressed at regular intervals for the purpose of closing one or other of the switch-circuits.

As before stated, it is obvious that the mechanism may be used for a variety of purposes and that the number of switches and contacts may be increased or diminished and that by proper adjustment of the screw 17′ the instrument may be made more or less sensitive for the purpose of closing or opening circuits of a greater or less range of movement of the needle.

Having thus described the invention, what is claimed is—

1. In apparatus of the class described, a delicately-balanced needle responsive to varying conditions, a plurality of contacts over which the needle swings, a needle-depressing member forming part of a normally open circuit of which the contacts form terminals, and means for forcing said member in the direction of the needle at predetermined intervals, and thereby engaging the needle with the contacts to close the circuit through said member.

2. In apparatus of the class described, the combination with a delicately-balanced needle responsive to varying conditions, of a plurality of contacts over which the needle swings, a spring-strip having an enlarged head for contact with the needle, said spring-strip being formed of conducting material and constituting a part of a circuit of which the contacts form terminals, a revoluble shaft, and a crank-pin supported by the shaft and arranged to engage said strip.

3. In apparatus of the class described, the combination with a needle responsive to varying conditions, of a contact carried by said needle, a plurality of contacts over which the needle swings, a spring-strip held in a fixed support at one end and provided at its free end with an enlarged head for engaging the needle-carried contact, said spring-strip being formed of conducting material and constituting a part of a circuit of which the contacts form terminals, a revoluble shaft, a crank-disk on the shaft, and a crank-pin projecting from the disk and arranged to engage said strip.

4. In apparatus of the class described, the

combination with a delicately-balanced needle responsive to varying conditions, of a plurality of contacts arranged on convergent lines and over which the needle swings, and means for adjusting said contacts to alter the sensitiveness of the device by increasing or decreasing the distance between the contacts at the point of movement of said needle.

5. The combination with a delicately-balanced needle responsive to varying conditions, of a plurality of contacts arranged on convergent lines, and over which the needle swings, a block carrying said contacts, means for adjusting the block to vary the sensitiveness of the device, a spring-strip having a fixed support at one end and provided at its opposite end with an enlarged head arranged to engage the needle, and means for depressing the strip at regular intervals.

6. In apparatus of the class described, the combination with a shaft or arbor, of a needle mounted thereon and provided with a threaded arc having poising-screws, a contact carried by the needle, a plurality of contacts over which the needle-carried contact swings, and means for causing engagement of a needle-carried contact with one of the other contacts at regular predetermined intervals.

7. In apparatus of the class described, a circuit-closing member responsive to varying conditions, a plurality of contacts with which said member may engage to close different circuits, a mechanically-actuated means for forcing said member into engagement with the contacts, electromagnets arranged in said circuits, switches under the control of said electromagnets, a source of energy, a translating device, and circuits extending between the source of energy and the translating device and including said switches.

8. The combination with a source of energy, of a translating device, circuits connecting the two, a pair of switches included in said circuits, pivotally-mounted arms forming the movable members of the switches disks carrying said arms, electromagnets having movable cores connected to said disks, catches for engaging the disks and holding the switches in closed position, and a third electromagnet having a movable core connected to said catches.

9. In apparatus of the class described, the combination with a source of energy, of a translating device, circuits connecting the two, switches included in said circuits, pivoted disks having extended arms forming the movable members of said switches, electromagnets having movable cores, pin-and-slot connections between the movable cores and disks, catches for engaging the disks to retain the switch members in closed position, a third electromagnet, and means connecting the core of the third electromagnet to said catches.

10. In apparatus of the class described, the combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches arranged in said circuits, electromagnets connected to the switches, contacts arranged in circuits each including an electromagnet, a third electromagnet operating to release and permit opening movement of the switch, a contact connected to the third electromagnet, a movable member responsive to varying conditions and arranged to swing over said contacts, and means for forcing said movable member in the direction of the contacts at regular intervals.

11. The combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches arranged in said circuits, electromagnets having movable cores connected to the switches, catches for holding said switches in closed position, a third electromagnet, means connecting the core of the third electromagnet to the catches, a plurality of contacts arranged independently in circuits with said electromagnets, a delicately-balanced needle responsive to varying conditions and arranged to swing over such contacts, and means for forcing the needle at predetermined intervals in the direction of said contacts.

12. In apparatus of the class described, the combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches arranged in said circuits and each including a pivoted disk having a locking-shoulder and provided with an extended arm for the support of the switch members, a pin projecting from the disk, an electromagnet adjacent to each disk and provided with a movable core, a plate connected to the core and having a slot for the reception of the pin, means for momentarily closing a circuit through either electromagnet, and means controlled by the movable core for holding the circuit closed until the core completes its movement.

13. In apparatus of the class described, the combination with a source of energy, of a translating device, circuits connecting the two, normally opened switch members included in said circuits and each including a pivotally-mounted disk having a locking-shoulder and a projecting supporting-arm for the switch members, a pin projecting from the disk, an electromagnet having a movable core, a slotted plate or bar carried by the core and arranged for the reception of the pin, a catch for engaging the locking-shoulder and holding the switch in closed position, a catch-operating electromagnet, and means for automatically closing the circuit through any one of the electromagnets.

14. The combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches in said circuits and each including a disk having

a locking-shoulder and a projecting supporting-arm for the switch members, a pin projecting from each disk, an electromagnet adjacent to each disk and having a movable core, a slotted plate carried by the core and arranged for the reception of the pin, a circuit-closing device carried by the core and serving to maintain a circuit closed through the electromagnet until the completion of movement of the core, a third electromagnet arranged between the others, a pair of bell-crank levers having catches for engaging the shoulders of the disks, and a movable core under the control of the third electromagnet and arranged to engage said bell-crank levers and permit opening movement of the switches.

15. The combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches in said circuits, an independent electromagnet for operating each switch, and having a loose connection therewith, catches for holding the switches in closed positions after the electromagnets have been deënergized, a third electromagnet having a movable core, bell-crank levers carrying the catches and provided with arms engageable by said movable core, and means for closing a circuit through any one of said electromagnets.

16. The combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches arranged in said circuits, independent electromagnets for operating the switches, each of said magnets having a movable core, a circuit-closing device carried by each core and arranged to maintain closed a momentarily-energized circuit until the core has completed its movement, catches for holding the switches in closed position, pawl-carried levers carrying said catches, a third electromagnet having a movable core, a threaded pin projecting from the core of the third member, an adjustable nut carried by the pin and arranged to engage the arms of the bell-crank levers to effect movement of the catches to release position, means for holding closed a momentarily-energized circuit through said electromagnet, and contacts connected in circuits with the several electromagnets, a delicately-balanced needle responsive to varying conditions and arranged to swing over said contacts, and means for forcing the needle against said contacts at predetermined intervals.

17. The combination with a source of energy, of a translating device, circuits connecting the two, normally opened switches arranged in said circuits, electromagnets for operating said switches, each magnet having a movable core, a pair of contacts adjacent to each core, means carried by the core for closing a circuit between the contacts and thus maintaining closed a momentarily-energized circuit until the core has completed its movement, bell-crank levers having catches for maintaining the switches in closed position, auxiliary circuit-controlling contacts carried by the bell-crank levers and adapted to open the circuits of the electromagnet when the switches have been closed, a third electromagnet having a movable core for engaging said bell-crank lever, contacts to which the electromagnets are electrically connected, and a movable member for engaging said contacts to close a circuit through any one of the electromagnets.

18. In apparatus of the class set forth, a switch, an electromagnet having a movable core connected to said switch, a movable contact member carried by the core, stationary contacts with which the movable contact engages to complete and hold close the energizing-circuit of the electromagnet until the core has completed its movement, and means for momentarily energizing the electromagnet.

In testimony that I claim the foregoing as my own I have hereto affixed my signature in the presence of two witnesses.

HERBERT G. CRAWFORD.

Witnesses:
CLAIR E. CRAWFORD,
E. J. DORAN.