No. 821,021. PATENTED MAY 22, 1906.

H. H. CUTLER.

ELECTRICAL STEP-BY-STEP CONTROLLER.

APPLICATION FILED MAY 10, 1902.

2 SHEETS—SHEET 1.

Fig. 1.

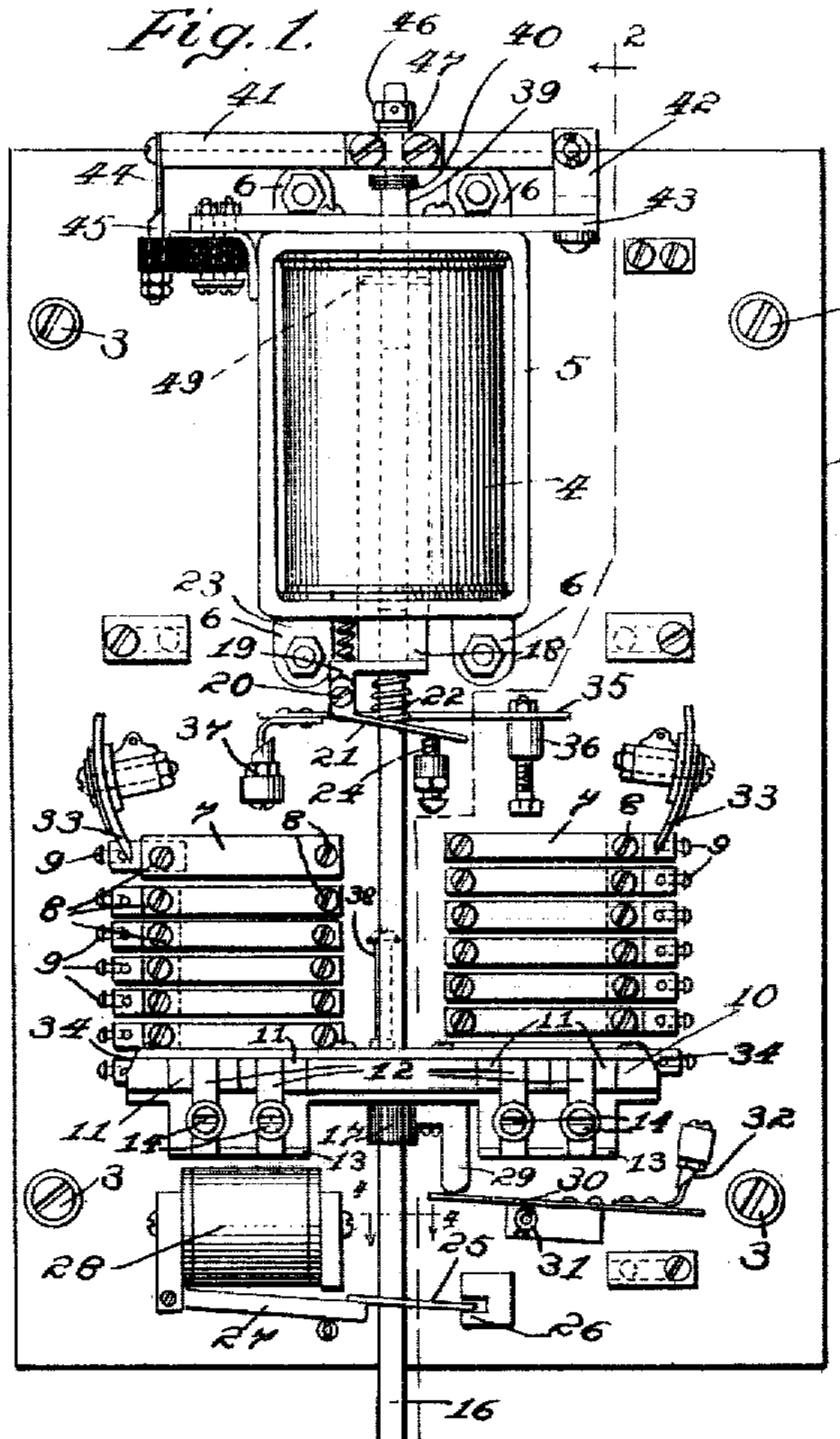


Fig. 2.

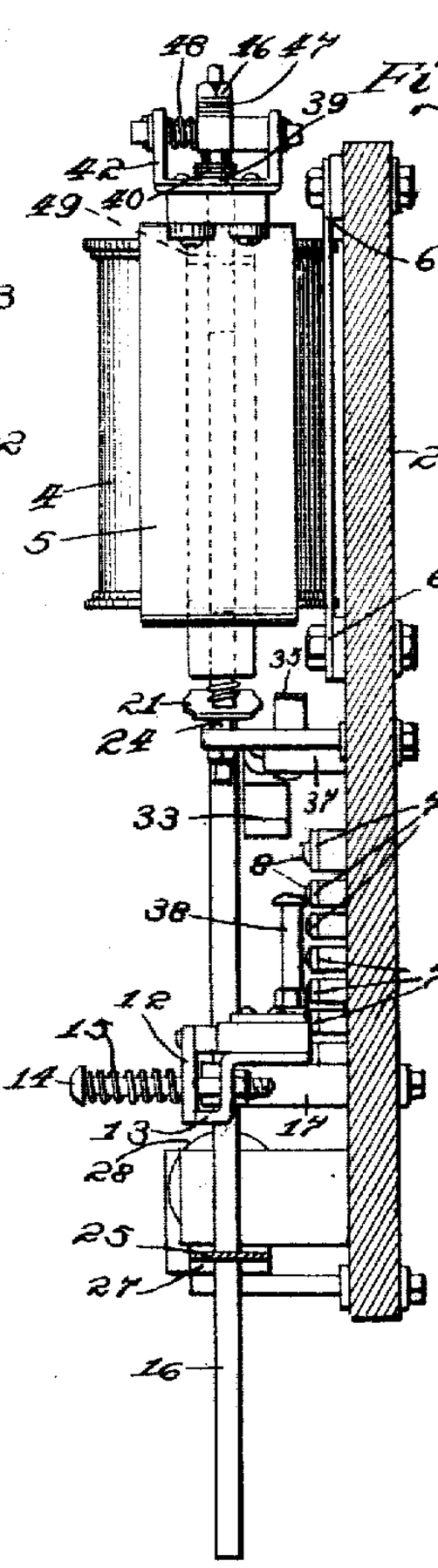


Fig. 3.

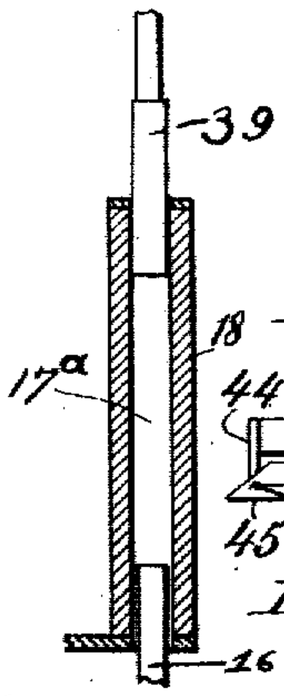


Fig. 4.

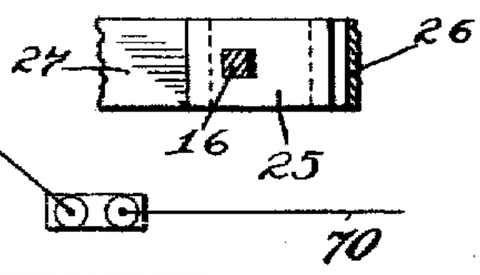
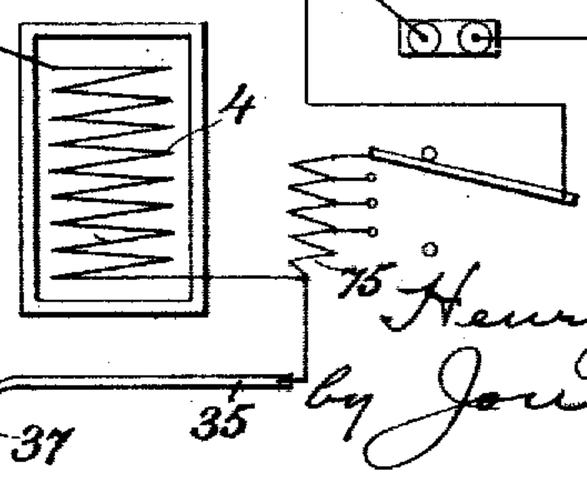


Fig. 6.



Witnesses:

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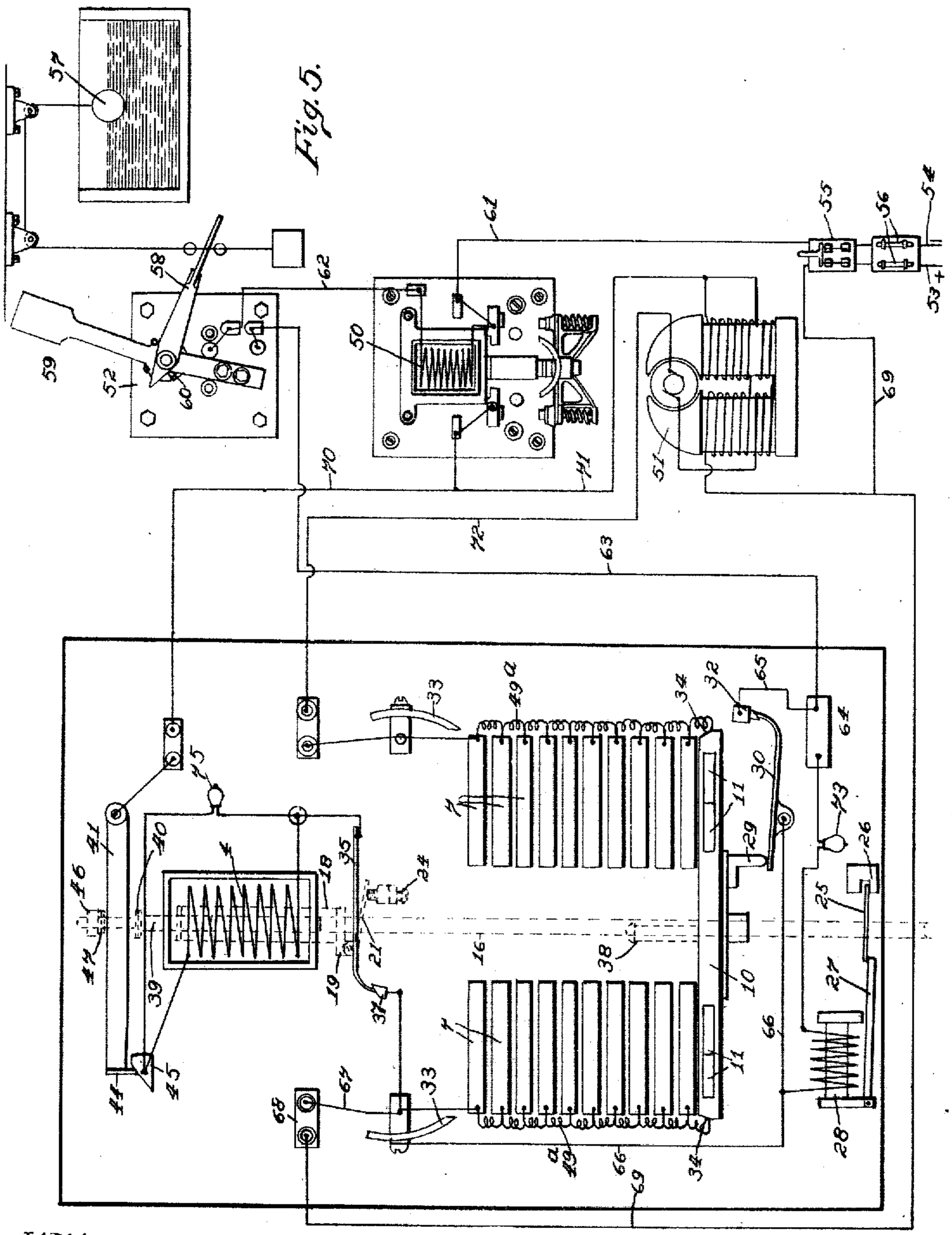
2 SHEETS—SHEET 2.

Fig. 5.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL STEP-BY-STEP CONTROLLER.

No. 821,021. Specification of Letters Patent. Patented May 22, 1906.

Application filed May 10, 1902. Serial No. 106,701.

To all whom it may concern:

Be it known that I, HENRY H. CUTLER, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented a certain new and useful Improvement in Electrical Step-by-Step Controllers, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to improvements in automatic devices of the step-by-step type, and has for its objects to provide a device of the class described that is efficient, positive, and economical in operation, that is capable of ready adjustment as to the extent of movement at each step, and that is simple and inexpensive to manufacture and to install.

My invention is particularly applicable to motor-controllers; but so far as some features are concerned it is in no wise so limited.

It has been proposed heretofore to vary the rate of cutting out or otherwise changing the resistance in a circuit by varying the interval of time between successive actuations of the step-by-step device.

My present invention also contemplates varying the rate of change of the resistance by adjusting the extent of movement of the parts at each energization of the operating-magnet, whereby the net result is to cut out or change the resistance slowly or quickly, according to said adjustment.

The invention is more fully described in connection with the drawings, in which the same reference characters designate like parts throughout the several views, and in which—

Figure 1 is a vertical elevation of the base upon which the step-by-step device is mounted. Fig. 2 is a sectional view of the same upon the line 2 2, Fig. 1. Fig. 3 is a longitudinal view through the core of the solenoid. Fig. 4 is a cross-sectional view upon the line 4 4 of Fig. 1. Fig. 5 is a diagrammatic view of the circuits embodied in the apparatus. Fig. 6 is a diagrammatic view of the modification, showing means for varying the resistance in a shunt path around the operating-magnet.

Referring to Figs. 1 and 4, 2 indicates an insulating-base, of slate, marble, or other suitable material, adapted to be secured to a wall or other vertical support by means of screws 3 passing through the same and into the wall or support. Upon the face of this base-plate 2 the resistance-controlling solenoid 4 is mounted. This solenoid is provided with a frame 5, having the lugs or feet 6 bolted to the base 2 to support the solenoid in position upon the same. Suitable rheostat-contacts 7 are also secured upon the base by means of screws 8 or in any other desired manner, the sections of the resistance being included between the binding-posts 9 thereof. A traveling cross-head 10 carries suitable carbon-brushes 11, one at each end, held in position by means of plates 12, bearing at one end upon the brushes and at the other end upon a raised flange 13, formed upon the lower side of the cross-head 10, these plates being held in place by means of bolts 14 passing through the same and through the vertical portion of the flange 13 and each carrying a coiled spring 15 between its head and the face of the bar 12. By this means a yielding pressure is exerted upon the ends of the brushes 11, so that a good electrical contact will always be maintained between them and the contact-segments 7. This cross-head is rigidly bolted or otherwise fixedly secured to a vertically-reciprocating square rod 16, preferably of brass, passing through a guide 17, carried by the base 2 and which carries the weight of the cross-head and rod under normal conditions. The upper end of the rod 16 enters and loosely fits a central bore 17ª in the core 18 of the solenoid 4, which core reciprocates, as usual, in a brass tube upon which the magnet of the solenoid is wound. The core 18 is provided with an extension 19, upon which is hinged at 20 a thin hardened-steel clutch strip or member 21. A coiled spring 22 surrounds the rod 16 and is located between the lower end of the core and the top of the clutch member 21, and a similar spring 23 is placed between the upper edge of the extension 20 of the core and the lower face of the frame 5 of the solenoid. The opposite end of the clutch member 21 rests upon an adjusting-screw 24, suitably mounted in a post upon the base 2. Beneath the cross-head a similar clutching member 25 is carried loosely at one end in a slot formed in a stop-bolt 26, mounted upon the base 2, and at its opposite end upon the armature 27 of a magnet 28, secured to the base 2. A projecting member 29, carried upon the lower side of the cross-head 10, normally engages a switch member 30, pivoted at 31 upon the base and adapted normally to contact at its opposite end with the

beveled face of a stationary contact 32, suitably mounted upon the base 2. Contacts 33 are provided upon the outside of the rows of contact-strips 7 at their upper ends to engage with the beveled edges 34 of the cross-head 10 in its raised position to assist in carrying the current when the resistance is cut out. A switch 35 is secured at one end upon a support 36, carried by the base, and at its opposite end carries a contact adapted to coöperate with the beveled face of a contact 37, also carried by the base. As shown in Fig. 2, the switch is in the rear of the reciprocating rod 16 and is adapted to be lifted by a screw-bolt 38, carried upon the upper face of the cross-head 10 when the cross-head is in its uppermost position.

A square rod 39 is rigidly secured in the bore in the upper end of the core 18 of the solenoid 4 and passes through a similarly-shaped aperture in the upper part of the frame 5 of the solenoid. The upper part of this rod is turned off round, thereby forming a shoulder on the square portion, upon which shoulder brass washers 40 of any desired number are carried. This portion of the rod passes through a suitable aperture in a switch member 41, pivoted at one end in a yoke 42, carried by a plate 43, mounted upon the upper end of the frame 5 of the solenoid. The opposite end of the switch 41 carries a contact 44, adapted to engage the beveled face of a contact 45, suitably supported by and insulated from the projecting end of the plate or bar 43. Upon the upper end of the rod 39 a nut 46 is placed, between which and the upper edge of the switch 41 a number of brass washers 47 are located. This switch carries the weight of the solenoid-core through the medium of the rod 39 when the device is not in operation. A coiled spring 48 is mounted upon the pivot-bolt of the switch 41 and presses against one side of the said switch, whereby the friction causes the switch to remain either in its upper or lower position until positively moved by means of the core. A brass washer 49 is carried upon the upper end of the core 18.

Under normal conditions the parts are in the position shown in Fig. 1. When the magnet 28 and the solenoid 4 are energized, the core 18 is lifted, which causes the clutch member 21 to engage and lift the square rod 16, together with the cross-head 10. As soon as the upper washer 40 strikes the switch 41 it is opened, thereby opening the circuit of the solenoid 4, which allows its core to drop. The cross-head is prevented from dropping at this time by the clutch member 25, which maintains it in the position to which it was raised by the solenoid. The switch 41 remains open until the washers 47, carried beneath the nut 46 upon the rod 27, strike its upper edge, when the core drops. As soon as the cross-head 10 moves out of its normal position the projection 29 carried thereby is moved away from the end of the switch 30, which is opened by gravity. The closing of the switch 41 upon its contact 45 again energizes the solenoid 4 and causes a repetition of the above-described operation. The cross-head is thus lifted step by step until the screw carried thereby engages the switch 35 and opens the same. This is arranged to open the circuit of the solenoid 4, so that it cannot be again energized until the cross-head is dropped. Of course when magnet 28 is de-energized the clutch member 25 releases the rod 16 and the cross-head will fall to normal position. The square rod 16 provides more clutching-surface than would a round rod, while brass is a better material for the rod than iron or similar material.

In Fig. 5 the circuits and other apparatus involved in the system are shown. A solenoid-switch 50 is employed to control the circuit of the motor 51 and other apparatus, and a switch 52, automatically controlled through the medium of a float, is used to control the operation of the switch 50. The plus and minus sides of the power-circuit are indicated, respectively, by the numerals 53 and 54. When the switch 55 is closed, the apparatus is in condition for automatic operation from the float 57. With the parts in the position shown in the figures the motor is not operating and all parts are in normal position. When the liquid in the tank falls sufficiently, the lever 58 of the automatic switch 52 is raised and lifts the weighted arm 59 beyond the vertical, when it falls toward the left, striking the switch-arm 60 and carrying it into contact with the terminals of the switch. The circuit of the main switch 5 is thus closed from the negative side 54 of the power-circuit over conductor 61 through the winding of the solenoid 50, conductor 62, through the contacts of switch 52 over conductor 63 to binding-post 64, thence over conductor 65 to contact 32 of the switch 30, thence through the arm of the switch 30 and conductor 66 to the left-hand contact 33 of the rheostat-conductor 67 to binding-post 68, and thence over wire 69 to the positive side 53 of the power-circuit. The switch 50 is thus energized and closes a circuit through its bridging contact from the conductor 61 over conductor 70 through switch 41, the winding of the solenoid 4, switch 35 to terminal 33, and thence over wires 67 and 69 to the opposite side of the power-circuit. At the same time a circuit is closed from the switch 50 over conductor 71, through the series coil and the armature of the motor 51, thence over conductor 72 and through the right-hand section of the armature resistance 49^a, thence across to the opposite section through the cross-head 10 and through the latter section of the resistance and over conductors 67 and 69 to the opposite side of the power-circuit. Another path

for current is provided from the conductor 71 through the shunt-coils of the motor to the conductor 69 and thence to the opposite side of the power-circuit. The coil of the solenoid 4 is now energized and lifts its core which carries the clutch member 21 with it and serves to lift the rod 16 and cross-head 10. As soon as the cross-head 10 is lifted its projection 29 is moved out of the path of the switch-arm 30, the opposite end of which drops and opens the circuit through its contact 32. The path through the switch 30, which forms the shunt of the magnet 28, being opened the current is forced to flow through the magnet 28 and lamp 73. The magnet 28 is thus energized and lifts one end of the clutch member 26, the adjustment being such that the rod 16 can be freely lifted through the same, but is prevented from dropping by means of the friction member 25 when its end is lifted by the armature 27. The inclusion of the magnet 28 and the lamp 73 in the circuit of the switch 50 serves to cut down the consumption of the current therein, whereby but little is used during the further operation of the same. As soon as the core 18 of the solenoid 4 is lifted the washers 40, carried upon the rod 39, engage the switch 41 and open the same at the contacts 44 and 45. This serves to deënergize the solenoid 4, permitting its core to drop, while the rod 16 and cross-head 10 remain in the position to which they have been lifted, owing to the clutching member 25. The switch 41, as above explained, remains in this lifted position until the stop carried upon the upper end of the rod 39 strikes it and causes it to again close, when the operation of energizing the magnet 4 and lifting the cross-head is repeated. This operation is repeated successively until the cross-head is lifted to the upper contact 7 of the series, and thus entirely cuts the resistance 49 out of the armature-circuit of the motor. When in this position, the stop 38 carried thereby engages the switch 35 and positively opens the circuit of the solenoid 4, which prevents its successive actuation. The magnet 28, however, remains energized, so that the clutch member 25 maintains the cross-head 10 in its raised position. The contacts 33 engage the beveled ends of the cross-head 10 and assist in carrying the operating-current.

The extent to which the cross-head 10 is moved at each actuation of the magnet or solenoid 4, and therefore the time required for cutting out the resistance 49, may be varied by adjusting the stop 24 and also by varying the number of washers 40 and 47 carried upon the rod 39, secured to the upper end of the core 18 of the solenoid 4.

A shunt-circuit path is provided around the magnet of the solenoid 4 to provide a path for the surge of current or "kick" when the circuit thereof is broken. This surge being in the same direction as the energizing-current it maintains the magnet energized longer than if this parallel path were omitted. By this means the time of deënergization is increased, whereby the rapidity of vibration of the core of the solenoid is decreased. By varying the amount of the resistance in this shunt-path the time of deënergizing the solenoid may be varied, since the lower the resistance the greater and longer the flow of the extra current and the longer the time required for deënergizing the magnet. The presence of this parallel path also prevents the rapid building up of the magnetism in the solenoid, for the reason that the current of self-induction is opposed to that of energizing-current. By this arrangement a further means of adjusting the rate of vibration of the solenoid is obtained. The lamps 75, which are usually for this purpose, correspond to the voltage of the power-circuit—that is, if one hundred and ten volts are used on the power-circuits one-hundred-and-ten-volt lamps should be used. If two hundred and twenty volts are used, a two-hundred-and-twenty-volt lamp should also be employed, and so on. The presence of the lamp or resistance 75 and the parallel path also prevents sparking between the contacts 44 and 45.

The parts remain in the described condition and position until the float reaches its opposite limit, when the lever 58 throws the weighted arm 59 to the opposite side of its pivot, which suddenly opens the switch-arm 60, thus breaking the circuit of the main solenoid 50 and the magnet 28. These parts being deënergized the motor-circuit is opened as well as the operating-solenoid circuit, and the clutch 25 is released, thus permitting the cross-head to fall and return all parts to the position shown in the figures.

I do not wish to be limited to the precise details shown, which have been worked out for commercial purposes, as it is obvious that various changes may be made therein and not depart from the scope or principle of the invention. For example, the switch 35 may be dispensed with and the upper end of the rod 16 depended upon to stop the vibration of the solenoid by being lifted into the path of the rod 39, secured in the core, and thus mechanically prevent the actuation of the switch 41. Other changes, it is apparent, may also be made without materially altering the construction or operation.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an electric controller for motors, a variable resistance adapted to be included in a motor-circuit, a magnetically-controlled means adapted to be successively operated to vary the amount of said resistance in the circuit, and means whereby the amount of movement of the resistance-varying device at

each successive operation is changed for governing the time required for the total variation, substantially as described.

2. In an electric controller for starting motors, a resistance, magnetically-operated means for cutting out said resistance by successive movements in one direction, and means for varying the extent of each movement, substantially as described.

3. An electric controller employed in starting a motor, comprising a single solenoid and its core, means whereby the successive movements of the core in one direction will cut out the resistance in the armature-circuit of an electric motor, and means for varying the amount of each said movement, whereby the time period required for cutting out the whole resistance may be changed, substantially as described.

4. An electric controller employed in starting a motor, comprising a single solenoid and its core, means whereby the successive movements of the core in one direction will cut out the resistance in the armature-circuit of an electric motor, and means for varying the extent of the movement of the core, substantially as described.

5. In an electric controller, the combination with a variable resistance adapted to be included in an electric circuit, of a resistance-varying element therefor, means for operating said element step by step, and further means for adjusting the amount of movement imparted to said element at each step, substantially as described.

6. In an electric controller, the combination with a variable resistance adapted to be included in an electric circuit, of a resistance-varying element therefor, a solenoid and its reciprocating core for operating said element step by step, and means for adjusting the movement of said element at each step, substantially as described.

7. In an electric controller, the combination with a variable resistance adapted to be included in an electric circuit, of a resistance-varying element therefor, a solenoid and its reciprocating core for operating said element step by step in one direction, independent means for permitting the return of said element, and means for adjusting the extent of movement of said element at each step, substantially as described.

8. The combination with a rheostat having a series of contact-segments, of a brush adapted to be moved over said segments, a rod to move the same, and a ring-clutch mechanism magnetically controlled to move said rod and brush step by step from one end of said series to the other, substantially as described.

9. The combination with a rheostat having a series of contact-segments, of a brush adapted to be moved over said segments, a rod carrying the brush, a ring-clutch magnetically controlled to lift said rod step by step to move the brush from one end to the other of the series of segments, and a second ring-clutch also magnetically controlled to maintain the brush and rod as long as desired in the position to which it is lifted, substantially as described.

10. The combination with a rheostat having two series of contact-segments, of a cross-head carrying brushes adapted to travel over said segments, a rod to which said cross-head is secured, a solenoid having a core, a ring-clutch actuated by said core to lift the said rod and cross-head to cause the brushes to travel over the contact-segments, and a similar ring-clutch for said rod and a magnet to control the same to maintain the cross-head as long as desired in any position to which it is lifted, substantially as described.

11. The combination with a series of contact-segments, a brush adapted to travel over the same, a rod carrying the brush, a solenoid having a core, a ring-clutch secured to the lower end of the core, and adapted to lift the rod, a pivoted switch mounted above the solenoid, a rod carried by the said core and extending through the switch, and adapted in its upper movement to open the switch and in its downward movement to close the same, whereby when the circuit of the solenoid is closed at the main switch it is automatically and successively energized to lift the rod and brush, substantially as described.

12. In a system of motor control the combination with a main switch, of a rheostat and its operating-solenoid, the circuit of said solenoid being controlled by said switch, an auxiliary magnet to maintain the movable element of the rheostat in operated position, said magnet being normally shunted by said movable element but adapted to be connected in series with the main-switch magnet at other times, whereby the main switch receives a strong current at first but a weaker current thereafter owing to the presence in its circuit of the said auxiliary magnet, substantially as described.

13. In a controller, the combination with a resistance, of magnetically-operated means for cutting out said resistance step by step, and means for varying the time required for deënergizing the magnet to vary the rapidity of operation of the step-by-step device, substantially as described.

14. In a controller, the combination with a resistance, of magnetically-operated means for cutting out said resistance step by step, and means for varying the time for cutting out the said resistance by adjusting the time required for energizing and deënergizing the magnet and the extent of movement of said means at each step, substantially as described.

15. The combination with a motor, of a starting-rheostat therefor actuated step by step to cut out the resistance of said rheostat

in the motor-circuit and electrical means for varying the time of movement of said step-by-step device at each step.

16. The combination with a motor, of a starting-rheotsat therefor having its resistance included in the armature-circuit of said motor at the time of starting the same, said rheostat being actuated step by step, and means for adjusting the time of movement imparted to said step-by-step device at each step.

17. The combination with an electric motor, of a controller therefor, consisting of a rheostat, the resistance of which is included in the armature-circuit of the motor at starting, a solenoid and its reciprocating core for operating the movable element of said rheostat step by step in one direction, independent means for permitting the return of said element to normal position, and further means for adjusting the extent of movement taken by said element at each step, substantially as described.

18. The combination with a rheostat, of a solenoid and its core adapted to operate said rheostat, a switch controlling the energization of said solenoid adapted to be operated by the core of said solenoid, and a resistance in addition to that of the rheostat connected in parallel to the solenoid to govern the variation of the resistance of the rheostat and to prevent sparking at the contacts of the switch, substantially as described.

In witness whereof I have hereunto subscribed my name in the presence of two witnesses.

HENRY H. CUTLER.

Witnesses:
F. L. PIERCE,
T. R. BACON.