G. H. WHITTINGHAM.

APPARATUS FOR CONTROLLING ELECTRIC MOTORS.

APPLICATION FILED MAY 31, 1910.

982,913. Patented Jan. 31, 1911.

3 SHEETS—SHEET 1.

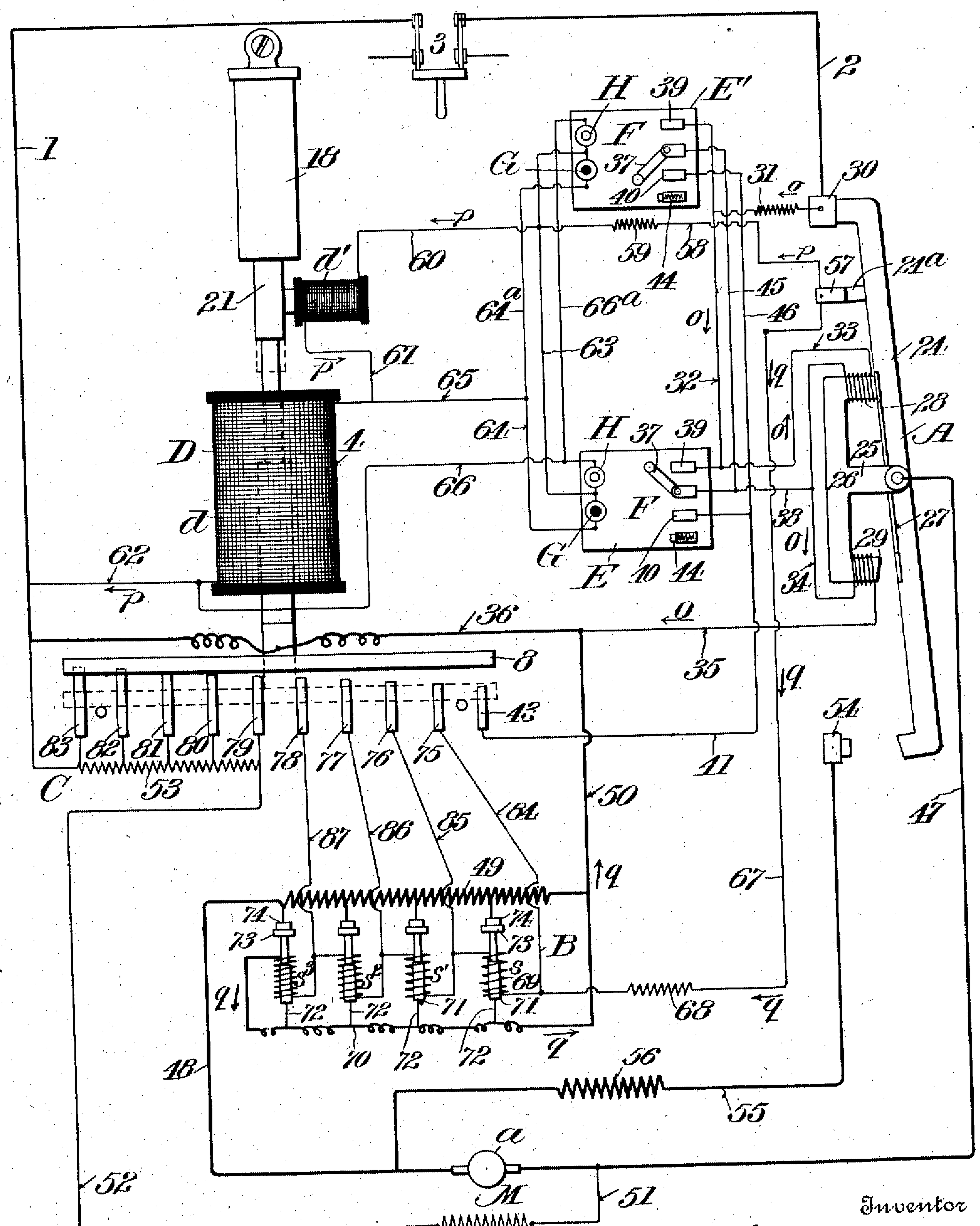

Fig. 1.

Witnesses

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3 SHEETS—SHEET 2.

Fig. 2.

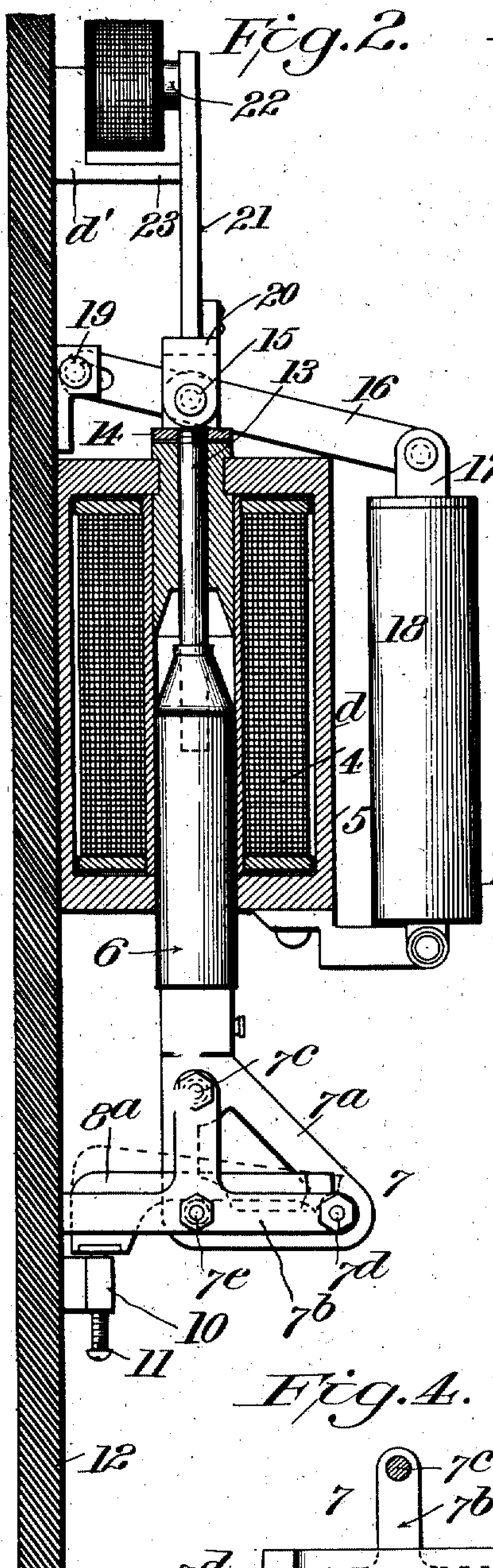


Fig. 5.

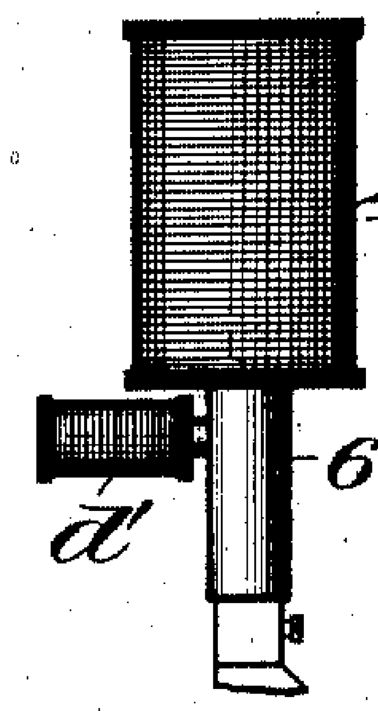


Fig. 3.

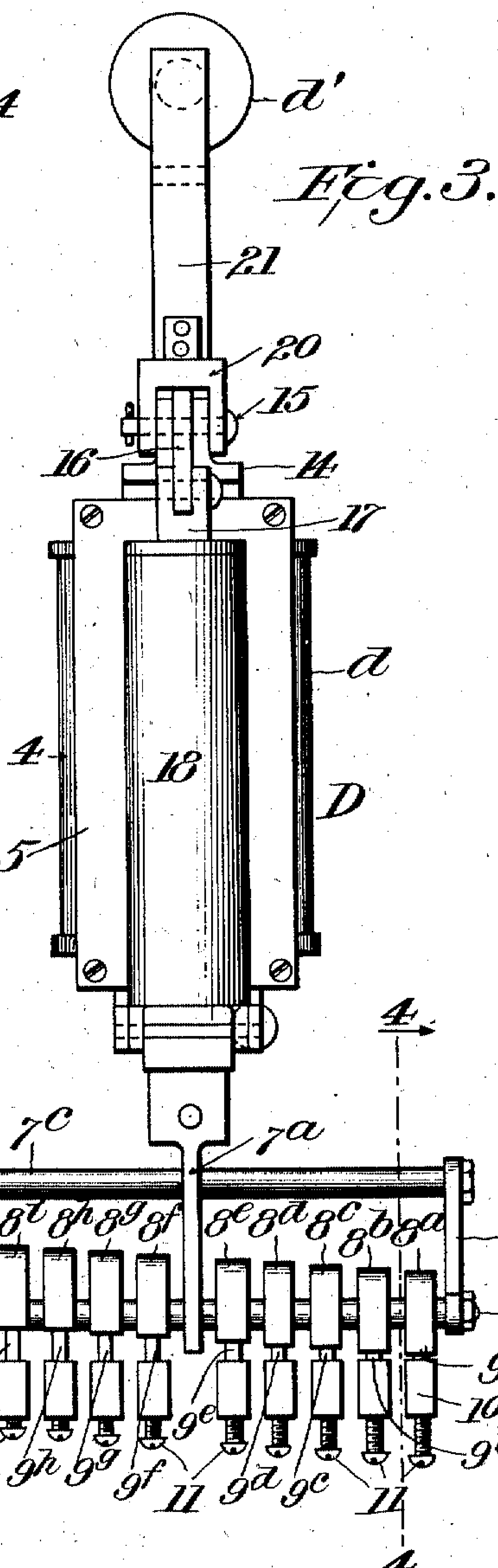
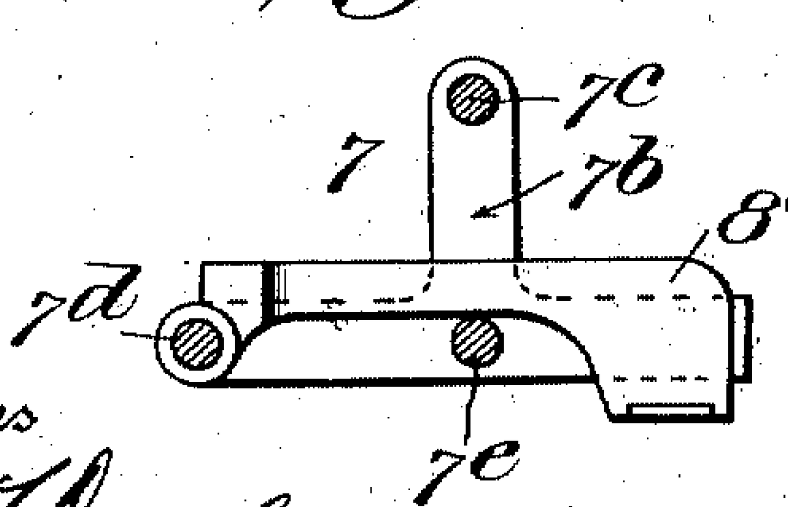


Fig. 4.



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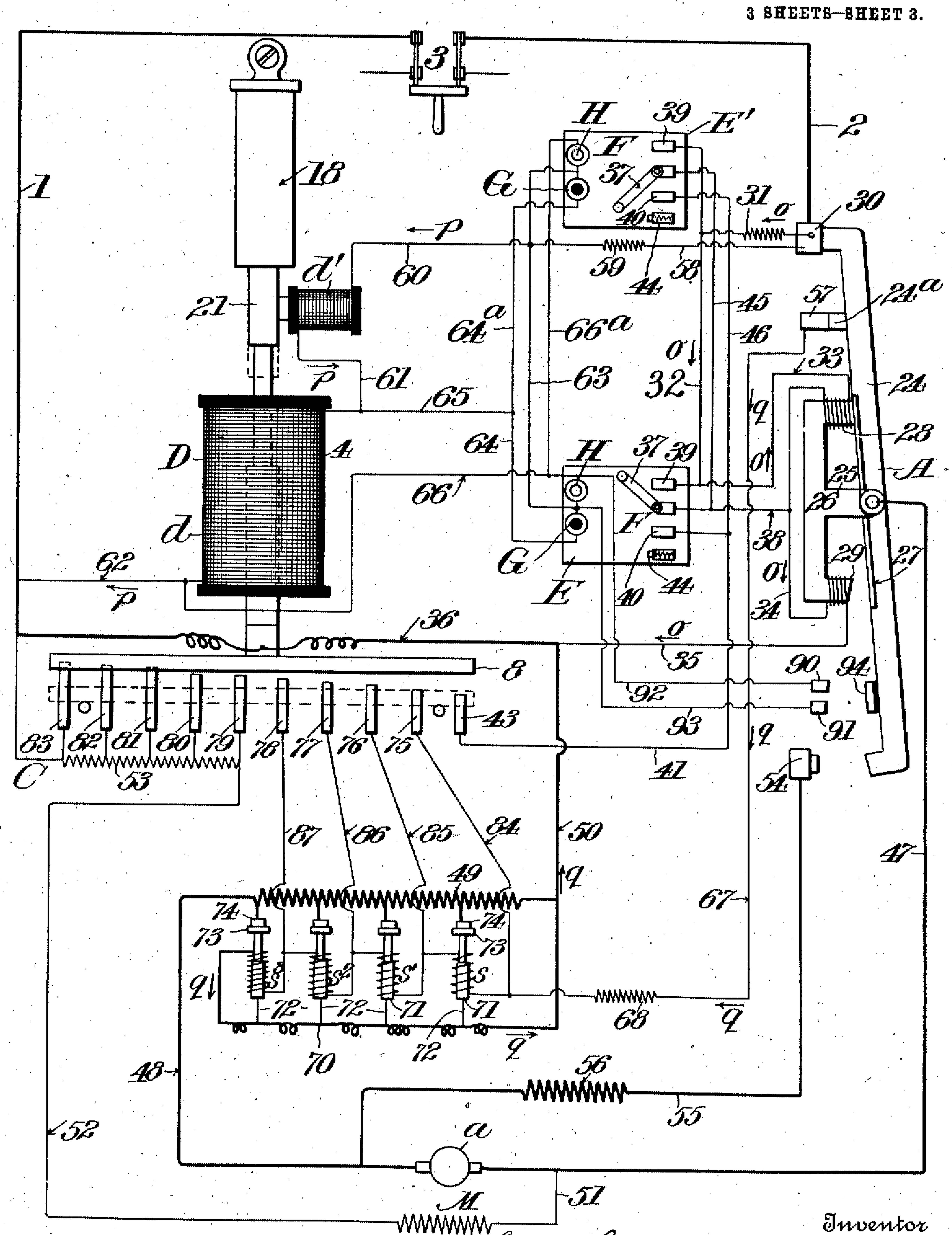

Fig. 6.

Witnesses

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR CONTROLLING ELECTRIC MOTORS.

982,913. Specification of Letters Patent. **Patented Jan. 31, 1911.**

Application filed May 31, 1910. Serial No. 564,164.

To all whom it may concern:

Be it known that I, GEORGE H. WHITTINGHAM, a citizen of the United States, residing at Pikesville, in the county of Baltimore and State of Maryland, have invented certain new and useful Improvements in Apparatus for Controlling Electric Motors, of which the following is a specification.

This invention comprises improvements in controlling devices for electric motors which must be operated at different speeds and controlled from one or a number of points.

In operating certain classes of machinery, such as large printing presses, it is desirable to provide for a wide range of speeds between the maximum and minimum, and also to provide means whereby the speed may be varied, or the motor stopped and started, from different points around the press, and also to provide means whereby if the motor is stopped by a switch located at one point, it cannot be started by a switch located at any other point, until the person operating the first mentioned switch is willing that the motor should start. The apparatus of my invention is designed to fulfil these requirements.

In the accompanying drawing, which illustrates my invention, Figure 1 is a diagrammatic illustration of the elements of the apparatus, and their electrical connections; Fig. 2 is a side view of the current controlled speed regulating devices, the solenoid being shown in central section; Fig. 3 is a front view of the devices shown in Fig. 2; Fig. 4 is a section on the line 4—4 of Fig. 3; Fig. 5 is a side view, on a small scale, of a modification showing the brake magnet applied to the solenoid core. Fig. 6 is a diagrammatic view, the same as Fig. 1, except as to the brake magnet and solenoid circuit connections.

Referring to Fig. 1 of the drawing, 1 and 2 indicate the supply wires or leads connected to the terminals of the supply circuit switch 3; A indicates a switch for making and breaking connection between the supply wire 2 and the circuits of the motor M; B indicates a rheostat or regulating resistance in the armature circuit; C indicates a resistance in the shunt field circuit; D indicates an adjustable speed regulating device and E, E′ indicate panels having manually controlled switches thereon for effecting the desired changes in speed of the motor and for stopping and starting the same.

The details of construction of the speed regulating apparatus D are shown in Figs. 2, 3 and 4, wherein d indicates a solenoid having a high resistance winding 4, contained within a suitable iron-clad casing 5 and adapted to actuate a core 6 from which is suspended a frame 7 having a series of hinged contact fingers, 8^a, 8^b, 8^c, etc., adapted to engage contact points 9^a, 9^b, 9^c, etc., respectively, which are held in suitable metal blocks 10 and adjusted to successively greater heights by adjusting screws 11. The frame 7 comprises a triangular plate 7^a, which is secured to the core 6, and two T-shaped end plates 7^b, the several plates being connected by rods 7^c, 7^d and 7^e. The contact fingers 8, as shown best in Fig. 4, are pivotally connected to the rod 7^d and are adapted to rest upon the rod 7^e when the frame is in its uppermost position. As the frame descends it will be seen that the fingers will engage the contacts in succession, from left to right in Fig. 3, and finally, when the frame is in its lowermost position, shown in Fig. 3, all of the fingers will engage contacts and rest thereon instead of upon the bar 7^e. On the other hand, as the solenoid core and frame 7 move upward, the bar 7^e will raise the fingers, in succession, from right to left in Fig. 3, out of engagement with the stationary contacts. If the core and frame be stopped at any position between the lowest and highest positions of the core, certain of the fingers will engage the stationary contacts while other fingers, at the right in Fig. 3, will be held out of engagement therewith. In the drawing ten fingers and stationary contacts are shown, for the purpose of illustration, but these may be multiplied to any desired extent according to the graduations in speed required. The horizontal part of the plates 7^b abut against the slate switch board 12, so as to prevent the frame from turning and to maintain the fingers in alinement with the stationary contacts. A rod 13 of non-magnetic material connects the upper end of the core 6 with a yoke 14 in which is pivoted, upon a pin 15, a lever 16 connected at one end with a plunger 17 of a dash pot 18 and at the other end to a stationary pivot pin 19. Another yoke 20 upon the pin 15, carries a flat iron rod or bar 21, which rests against the pole pieces 22 and 23 of a brake magnet *d'*.

In the diagram Fig. 1, the contact fingers 8^a, 8^b, etc., are represented by a short circuiting bar 8 and the stationary contacts are represented by metal strips of successively greater lengths with which the short circuiting bar is adapted to engage by sliding contact, while the dash pot is shown above the solenoid and the brake magnet engages the iron bar 21, which is here also represented as the dash pot plunger.

In Fig. 1 of the drawing the apparatus is shown with the circuit connections completed for the operation of the motor, the short circuiting bar 8 being shown, in full lines, in position to cut out all of the armature resistance and include only a portion of the field resistance, the dotted lines indicating the normal position of the bar. The switch A, for completing and interrupting the circuit through the motor, comprises an armature 24 pivoted at its central portion to the central pole piece 25 of an E-shaped magnet 26 and having an armature 27 adapted to engage, alternately, the end pole pieces 28 and 29 of the electromagnet. The end pole pieces 28 and 29 are surrounded by windings, as shown, which are permanently energized, when the switch 3 is closed, through a circuit indicated by the arrow *o*, and which may be traced as follows: from the supply wire 2 to a stationary switch terminal 30, thence through a resistance 31, and wires 32 and 33, to the coil surrounding the pole piece 28, thence through wire 34 to the coil surrounding the pole piece 29, thence through wire 35 to wire 36 and thence to the opposite supply wire 1. Upon each of the panels E and E' is arranged a switch F for short circuiting either one of the coils upon the pole piece 28 and 29, and when the coil of one pole piece is short circuited the other pole piece will attract the armature 27, so that the switch arm 24 may be moved to open or closed position by turning the switch F. Thus, the lever 37 on the panel E is connected by conductor 38 to the wire 34 extending between the coils on the pole pieces 28 and 29 and this lever when swung in one direction is adapted to engage a contact 39 connected to the conductors 32 and 33, and it will be obvious that when the arm 37 is in engagement with the contact 39 the coil on the pole piece 28 will be shunted, the current passing through the contact 39 and arm 37 and wire 38 to the conductor 34 instead of passing through the conductor 33 to said coil, and the pole piece 29 will then attract the armature 27 and rock the switch to move the arm 24 out of engagement with the supply terminal 30. So long as the switch arm 37 on one panel is in engagement with the contact 39, the coil surrounding the pole piece 28 will remain dead and the switch A cannot be closed by the operation of the switch F on any other panel. To rock the switch A in the opposite direction, to close the connection to the supply circuit, the arm 37 is moved into engagement with the contact 40, which results in short circuiting the coil surrounding the pole piece 29, leaving the coil of the pole piece 28 active, and the latter pole piece attracts and holds the armature on the switch arm 24. The short circuit for the coils surrounding the pole piece 29 extends from the conductor 34 through the arm 37 and contact 40 to conductor 41 and thence to a contact 43 which is normally engaged by the short circuiting bar 8, thence through said bar, and conductor 36, which is grounded upon the bar, to the conductor 35. This short circuit, for starting the motor, can only be closed when the contact bar 8 is in its lowermost position, engaging the contact 43, in which position, as will be hereinafter explained, the full resistance is in the armature circuit.

When the switch arm 37 is moved into engagement with the contact 39, to stop the motor, the arm will remain in frictional engagement with said contact until manually removed, and, therefore, the person who stops the motor at one panel may, by leaving said arm and contact in engagement with one another, prevent the starting of the motor from another panel, until he moves the arm 37 out of engagement with the contact 39. In starting the motor, however, only a momentary engagement of the arm 37 with the contact 40 is required (assuming the bar 8 to be in its lowermost position), and it is necessary to avoid a permanent or continued short circuit of the coil surrounding the pole piece 29, so that the motor may, when running, be stopped at any time from any panel. Therefore, a spring plunger 44 is provided, which automatically moves the arm 37 away from the contact 40 as soon as the pressure of the hand is relieved from said arm, and thus, after the coil surrounding the pole piece 29 has been temporarily short circuited, this short circuit will be interrupted automatically by the spring pressed plunger 44 which moves the arm 37 away from the contact 40. It will be understood that although the pole piece 29 thus becomes energized after the interruption of the shunt around its coils, it will not operate the switch arm 24 because the armature 27 is then in engagement with the other active pole piece 28 of the electromagnet.

The contacts 39 on the several panels are connected together by the conductor 32; the switch arms 37 are connected together by conductor 45 and the contacts 40 are connected together by conductor 46 so that each switch F, on each panel, operates to open and close the same shunt circuit connections to stop and start the motor.

The armature circuit extends from the switch arm 24 through wire 47, armature *a*, thence through wire 48 to the resistance 49, thence through wire 50 to the wire 36 and thence to the supply wire 1. The shunt field *f* of the motor is connected at one end to wire 47 by wire 51 and at the other end by wire 52 to the resistance coils 53 and thence to the wire 1. A dynamic brake circuit for the motor extends from a stationary contact 54 through a conductor 55, in which is interposed a brake resistance 56, to the conductor 48, and when the switch arm 24 moves out of engagement with the supply terminal 30, it engages the stationary contact 54 and thereby closes the dynamic brake circuit which operates to stop the motor, in a well known manner.

When the switch arm 24 is moved to connect the motor with the supply circuit it also closes two other circuits through a contact 24^a on said arm and a stationary contact 57. One of these circuits, indicated by the arrows *p*, extends through the brake magnet *d′* and the controlling solenoid *d*, in series, while the other circuit indicated by the arrows *q*, extends through the coils of a series of relays s, s', s^2, and s^3, which operate to control the resistance in the armature circuit.

The circuit *p* may be traced as follows: from the contact 57, through wire 58, high resistance coil 59, wire 60, coils of magnet *d′*, wire 61, coils of solenoid *d* and wire 62 to the supply wire 1. When the switch 24 is closed, therefore, the brake magnet and solenoid are connected in series, across the line, with an interposed resistance 59, and normally the solenoid tends to lift its core, but movement of the core is prevented by the brake magnet *d′* which engages the iron bar 21, or which may engage the core of the solenoid as shown in Fig. 5. The closing of the supply switch 24, therefore, by the operation of the switch F, does not cause the upward movement of the solenoid core and contact bar 8, for the reason that the brake magnet is energized simultaneously with the closing of the circuit. To permit the solenoid to move the bar 8 upward, the brake magnet is short circuited by a push button switch G, one terminal of said push button switch being connected by a wire 63, to the wire 60. leading to one end of the brake magnet coil, and the other terminal of said push button switch being connected by a wire 64 and wire 65 to the wire 61 which extends between the brake magnet and the solenoid. By closing the push button switch G, it will be evident that the brake magnet will be short circuited through the conductors 63, 64 and 65 and said switch, and as long as the push button switch is closed the solenoid core will move upward, retarded by the dash pot, until the core reaches the upper limit of its movement. When the push button is released, the brake magnet immediately becomes energized and holds the core and contact bar in the position to which it was carried while the brake magnet was deënergized. To permit the solenoid core and the contact bar 8 to descend, provision is made for short circuiting both the brake magnet and the solenoid through a push button H, one of which is provided on each panel. As shown the push button H on the panel E has one terminal connected to the wire 63 and the other terminal connected to a wire 66 which leads to the wire 62 and thence to the supply wire 1. Upon closing the push button H on the panel E, the current will flow from conductor 63, the push button H and wire 66 to the wire 62, instead of flowing through the brake magnet and solenoid, and, hence, the magnet and solenoid will be deënergized and the solenoid core and contact bar will fall by gravity, retarded by the dash pot. When the push button H is released the solenoid and brake magnet will become instantly energized and the magnet will hold the core and contact bar in the positions to which they were carried while the button was depressed. The corresponding terminals of the push buttons G and H on the several panels are connected together so as to operate in the same way. Thus the wire 63, as shown in the drawing, connects the adjacent terminals of the push buttons G and H on the panels E and E′ and the outer terminals of the push buttons G on the different panels are connected by the conductors 64 and 64^a while the outer terminals of the buttons H are connected by a conductor 66^a.

The circuit *q* through the relays of the rheostat B is traced as follows: from the contact 57 through conductor 67 to a resistance 68, thence through the coils 69 of the relays s'—s^3, inclusive, in series, thence through wire 70 to the wire 50, thence through wire 36 to the supply wire 1. The cores 71 of the relays are normally in their lowermost positions, and are connected, as shown at 72, to the conductor 70, and they are provided at their upper ends with contacts 73, adapted to engage stationary contacts 74, when the cores are moved into their uppermost positions, shown in Fig. 1. These contacts 74 are connected to successive points in the armature resistance 49. Stationary contacts 75, 76, 77, 78 on the controller are connected by wires 84, 85, 86 and 87, respectively, to the circuit *q*, the wire 84 being connected between the high resistance 68 and the windings of the relay *s*, and the wires 85, 86 and 87 being connected to said circuit at points between the successive relays, the arrangement being such that when the bar 8 is in its lowermost position, shown in dotted lines, the current in the circuit *q*, instead of flowing through the coils of the relays, will flow from the wire 67 and conductor 84 to the contact 75, thence to the bar 8 and to the conductor 36, grounded thereon, and thence to the supply wire 1. All of the relays will thus be shunted and the contacts 73, being out of engagement with the contacts 74, the armature resistance 49 will all be included in series with the armature. If the bar 8 is moved upward off of the contact 75 but left in engagement with the contact 76, the current in the circuit *q* will flow through the resistance 68, the coils of the relay *s*, conductor 85 and contact 76, to the bar 8 and thence through conductor 36 to the wire 1. The relay *s* will then lift its core and close the connection between its contact 73 and the co-acting contact 74 of the armature resistance, and the right hand section of the armature resistance will be short circuited, the armature current flowing from the resistance 49 through the core of the relay *s* and the connection 72 to the conductor 70 and thence to the conductors 50, 36 and 1. A further upward movement of the bar 8 will break the connection with the contact 76, and this will open the shunt around the next relay s' and cause said relay to lift its core and cut out another section of starting resistance. The current in the relay circuit *q* will then flow, from the wire 67, through the resistance coil 68 and through the coils of the relays *s* and s', in series, and thence through the wire 86, and contact 77, to the bar 8 and thence to conductors 36 and 1. Similarly when the bar 8 moves upward off of the contact 77 the shunt around the relay s^2 will be broken, and said relay will lift its core and cut out another section of starting resistance, and the current in the relay circuit will then flow through the resistance 68 and through the coils of the relays *s*, s' and s^2, in series, to the wire 87 and contact 78, and thence out through the bar 8 and conductor 36 to the supply wire 1. A further upward movement of the bar 8 will break the connection between said bar and the contact 78 and thereby include the coils of the relay s^3 in series with the coils of the other relays and the upward movement of the core of the relay s^3 will cut out the final section of the armature resistance. Still further upward movement of the bar 8 will open the shunt circuits around the field resistance 53, as the bar leaves the successive contacts 79—83, inclusive. The downward movement of the bar 8 will first short circuit the sections of the field resistance, in succession and then bridge the shunts around the relays in succession, and thus cause the gradual introduction of the field and armature resistance.

When the bar 8 is in its lowermost position and the relays are all shunted, the resistance 68 prevents a short circuit. As the bar 8 moves upward the quantity of current flowing in the relay circuit *q* is reduced by the resistance of the relay coils as each successive relay is added, in series, to the circuit. Therefore, to compensate for this reduction in the quantity of current flowing and to give each relay the same strength, the relays in succession are wound with wires of greater lengths and smaller diameters, the arrangement being such that each will receive and operate with the same number of watts. An important feature of this arrangement for including and excluding the armature resistance is the absence of sparking between the contact making bar 8, and the several contacts which it engages. It will be noted that this bar merely opens and closes the shunt circuits around the relays, to introduce and cut out the armature resistance, and the differences of potential at the terminals of the relay coils are not sufficient to cause arcs to form between the stationary contacts 75—78 and the bar 8. It is immaterial, therefore, whether the bar, after leaving a contact remains close to it or is moved some distance from it, as no injurious effect can result. Hence it is not necessary to stop the bar at any definite point with respect to the contact which it engages and if the push button H is released immediately after the bar 8 passes from the end of a contact, the brake magnet will hold the bar in that position without any danger of an arc being formed between the bar and the contact, no matter how closely together they may remain. By this arrangement a large number of contacts may be employed, say twenty or thirty, if desired, and they may be set so that in engaging and disengaging the entire series of contacts the movement of the bar need not be more than say five-eighths of an inch. This is important also because the controlling solenoid may be made comparatively small and will operate with a smaller consumption of current than if the solenoid were required to move its core through a long distance.

It will be seen, by comparing Fig. 1 with Figs. 2, 3 and 4 of the drawing, that the fingers 8^a, 8^b, 8^c, etc., coöperating with the contacts 9^a, 9^b, 9^c, etc., will serve the function of the short circuiting bar 8 but avoid the sliding contact which is not so desirable as the butt contacts made by the fingers.

In operation, the switch arms 37 of the switches F being all in their neutral positions, the motor may be started, stopped, or controlled in its speed from any of the switch panels E, E′, etc., of which there may be any desired number, having the corresponding switch terminals thereon connected together. Normally the fingers 8^a, 8^b, 8^c, etc., rest upon all of the stationary contacts 9^a, 9^b, 9^c, etc., this position being indicated in the diagram by the dotted position of the bar 8 which engages the contact 43 and the contacts 75 to 83, inclusive. The main switch arm 24 is normally out of engagement with the supply contact 30 and in engagement with the contact 54 of the dynamic brake circuit. To start the motor, the switch 3 being closed, an operator at one of the panels E moves the switch arm 37 of the switch F into engagement with the contact 40 and thus short circuits the coil on the pole piece 29 of the electromagnet switch A and the opposite pole 28 attracts the armature on the switch arm 24 and thereby closes the circuit through the motor and through the entire armature resistance, the field resistance being bridged by the bar 8. When the operator releases the hand pressure from the arm 37 the spring plunger 44 immediately moves said arm out of engagement with the contact 40 so that the coil surrounding the pole piece 29 will become again energized and able to attract the armature on the switch arm 24 if some one should swing the arm 37 of the switch F into engagement with the contact 39 to short circuit the coil on the pole piece 28 to stop the motor. If the arm 37 is moved into engagement with the arm 39, to stop the motor, it remains frictionally in engagement with said contact until purposely removed so that no one at another panel may start the motor. This protects the operator who stops the motor, and who may desire to work upon the printing press or other machine, from injury which might be caused if the motor could be again started from another panel. When the operator who stops the motor is willing that it shall again be set in operation, he removes the arm 37 from the contact 39 and the motor may then be started from any panel.

When the motor is started by the operation of the switch F the controller remains with the short circuiting bar 8, (or fingers 8^a, 8^b, 8^c, etc.) in its lowermost position, with all the armature resistance in circuit and all of the field resistance out of circuit, unless the push button G, on one of the panels, is depressed to short circuit the brake magnet. If it is desired to increase the speed of the motor, a button G is depressed, deënergizing the brake magnet, and the solenoid is then free to move the short circuiting bar 8 upward. When the bar 8 reaches the proper point to give the desired speed, the push button G is released and the brake magnet immediately stops further upward movement, the magnet being powerful enough to overcome the attractive power of the solenoid upon its core. If it is desired to decrease the speed, the push button H on one of the panels, is depressed, thus short circuiting both the controlling solenoid and the brake magnet, and the core and short circuiting bar descend by gravity until the button H is released, when the solenoid and the brake magnet will be immediately energized and the magnet will prevent the solenoid from lifting its core and will hold the bar stationary in the new position.

As the switch F may be moved to stop the motor while the contact bar 8 is in an upper position, with all of the armature resistance removed from circuit, and then immediately moved into position to start the motor, provision is made for preventing the starting until the bar 8 reaches its lowermost position, to include the starting resistance in series with the motor. To accomplish this result the circuit for shunting the coil around the magnet pole 29 includes the contact 43 and this shunt circuit can only be completed when the bar 8 is in its lower position in engagement with said contact. Therefore, if the motor is stopped by the switch F when the bar 8 is out of engagement with the contact 43 and then the switch F is closed on the contact 40, before the bar 8 has time to descend the motor will not start until the bar 8 descends and engages the contact 43, to complete the shunt around the coil on the pole piece 29 of the main switch magnet.

In Fig. 6, the arrangement is the same as in Fig. 1, except that the circuit *p*, instead of being connected to the contact 57, is connected directly to the supply terminal 30, and remains permanently energized whether the supply circuit switch A be opened or closed, and provision is made for automatically short-circuiting the brake-magnet and operating solenoid *d* when the supply circuit switch A is opened. As shown, two stationary contacts 90 and 91 are connected by wires 92 and 93 in parallel with the push-buttons H, and a metal bridge piece 94, secured to the arm 24 of the supply switch, but insulated therefrom, is adapted to bridge the stationary contacts 90 and 91 when the switch A is moved into position to stop the motor, and to break the connection between said stationary contacts when the switch A is moved to start the motor. The effect of bridging the contacts 90 and 91 is the same as closing one of the push buttons H,—that is, it causes the magnet *d* and solenoid, *d′*, to become shunted and deënergized, so that when the switch A is moved to the stop position by the operation of the hand switch F, the contact bar 8 may descend, but when the switch A moves to the closed or starting position, the shunt around the brake magnet and solenoid is broken and said magnet and solenoid immediately become energized. The dead resistance 59 prevents a short circuit when the brake magnet and solenoid are shunted at the contacts 90 and 91, just as it does when these devices are shunted at the push-buttons H.

What I claim is:—

1. In a controlling mechanism for electric motors a main switch for stopping and starting the motor, a resistance regulating means comprising a contact member and an electromagnetic controlling device normally energized while the motor is in operation and constantly tending to move said member to vary the resistance in circuit with the motor, a brake magnet normally preventing such movement, while the motor is in operation, and a manually controlled switch and connections for rendering said brake magnet ineffective to prevent such movement.

2. In a controlling mechanism for electric motors, a main switch for stopping and starting the motor, a resistance regulating means comprising a contact member and an electromagnetic controlling device normally energized while the motor is in operation and constantly tending to move said member to vary the resistance in circuit with the motor, a brake magnet normally preventing such movement while the motor is in operation, a manually controlled switch and connections for rendering said brake magnet ineffective to prevent such movement, and another manually controlled switch and suitable connections for both deënergizing said controlling device and rendering the brake magnet ineffective to hold the contact member.

3. In a controlling mechanism for electric motors, a main switch for stopping and starting the motor, and resistance regulating means comprising a contact member, an electromagnetic moving device normally energized while the motor is in operation and tending to move said member to cut out resistance, an electromagnetic brake device normally energized while the motor is in operation and normally preventing such movement of said member, and a switch and connections for deënergizing the brake device without deënergizing said moving device.

4. In a controlling mechanism for electric motors, a main switch for stopping and starting the motor, and resistance regulating means comprising a contact member, a solenoid normally energized while the motor is in operation and tending to move said member to cut out resistance, a brake magnet normally energized while the motor is in operation and normally preventing such movement of the solenoid core, and a switch and connections for deënergizing the brake magnet without deënergizing the solenoid.

5. In a controlling mechanism for electric motors, a main switch for starting and stopping the motor, and resistance regulating means comprising a contact member, an electromagnetic moving device normally energized while the motor is in operation and tending to move said member to cut out resistance, an electromagnetic brake device, normally energized while the motor is in operation and normally preventing such movement of said member, a switch and connections for deënergizing the brake device without deënergizing said moving device and another switch and connections for deënergizing both of said devices.

6. In a controlling mechanism for electric motors, a main switch for starting and stopping the motor, and resistance regulating means comprising a contact member, an electromagnetic moving device and an electromagnetic brake device having their coils connected in series across the line, said devices being normally energized, said moving device tending to normally move said member away from said contacts and said brake device normally preventing such movement, a manually controlled switch for shunting the coils of said brake device without shunting the coils of said moving device, a manually controlled switch for shunting the coils of both of said devices and a switch controlled by the main switch for shunting both of said devices when the main switch is opened to stop the motor.

7. In a controlling mechanism for electric motors, a main switch for starting and stopping the motor, and resistance regulating means comprising a contact member, a solenoid normally energized while the motor is in operation and tending to move said member to cut out resistance, a brake magnet normally energized while the motor is in operation and normally preventing such movement of the solenoid core, a switch and connections for deënergizing the brake magnet without deënergizing the solenoid, and another switch and connections for deënergizing both the solenoid and the brake magnet.

8. In a controlling mechanism for electric motors, a main switch for starting and stopping the motor, and resistance regulating means comprising a contact member, a solenoid, normally energized while the motor is in operation and tending to move said member to cut out resistance, a brake magnet normally energized while the motor is in operation and normally preventing such movement of the solenoid core, a normally open circuit in shunt to the brake magnet alone, a normally open circuit in shunt to both the brake magnet and the solenoid, and manually controlled switches for closing said shunt circuits.

9. In a controlling mechanism for electric motors, an armature resistance, relay-switches for cutting in and out said resistance and means for controlling the operation of said relays comprising a series of con-

tacts connected to the relay circuit, a movable contact member adapted to engage said contacts successively, electromagnetic means for moving said member relatively to said contacts, a brake magnet normally preventing the movement of said member, a switch and connections for rendering said brake magnet ineffective to prevent such movement, and a separate switch and connections for deënergizing said electromagnetic means and rendering said brake magnet ineffective to prevent the movement of said member.

10. In a controlling mechanism for electric motors, an armature resistance, relay-switches for cutting in and out said resistance and means for controlling the operation of said relays comprising a series of contacts connected to the relay circuit, a movable contact member adapted to engage said contacts successively, a solenoid for moving said member out of engagement with said contacts, a brake magnet arranged to prevent the operation of the solenoid, said solenoid and magnet being normally energized while the motor is in operation, a switch and connections for deënergizing both the solenoid and the brake magnet and another switch and suitable connections for deënergizing the brake magnet without deënergizing the solenoid.

11. In a controlling mechanism for electric motors, a resistance in the armature circuit, a series of relay switches for cutting in and out the armature resistance, circuits for shunting the coils of said relays, contacts connected to said shunt circuits, a contact member adapted to normally bridge said contacts and close said shunt circuits, a solenoid adapted to move said member away from said contacts, a brake magnet arranged to prevent such movement, and means for rendering said brake magnet ineffective to prevent such movement.

12. In a controlling mechanism for electric motors, a resistance in the armature circuit, a series of relay switches for cutting in and out the armature resistance, the coils of said relays being connected in series with one another, circuits for shunting the coils of said relays, contacts connected to said shunt circuits, a contact member adapted to normally bridge said contacts and close said shunt circuits, an electromagnetic moving device adapted to move said member away f om said contacts, an electromagnetic brake device arranged to prevent such movement, and means for rendering said brake device ineffective to prevent such movement.

13. In a controlling mechanism for electric motors, a resistance in the armature circuit, a series of relay switches for cutting in and out the armature resistance, the coils of said relays being connected in series with one another, circuits for shunting the coils of said relays, contacts connected to said shunt circuits, a contact member adapted to normally bridge said contacts and close said shunt circuits, a solenoid adapted to move said member away from said contacts, a brake magnet arranged to prevent such movement, and means for rendering said brake magnet ineffective to prevent such movement.

14. In a controlling mechanism for electric motors, the combination with a motor, of armature and field resistances therefor, a relay-circuit, a series of relay switches therein for cutting in and out the armature resistance, a series of contacts connected to said relay circuit, a series of contacts connected to the field resistances, a contact member adapted to normally bridge said contacts, an electromagnetic device normally tending to move said member away from said contacts while the supply circuit is closed through the armature, a brake magnet normally preventing such movement while the supply circuit is closed, a manually controlled switch and connections for deënergizing the brake magnet without deënergizing said device and another manually controlled switch and connections for deënergizing both the brake magnet and said device.

15. In a controlling mechanism for electric motors, a resistance in the armature circuit, a series of contacts and a member movable into and out of engagement with said contacts to vary the resistance in the armature circuit; in combination with a supply circuit switch, an electromagnet having two normally energized coils, for operating said switch, and a circuit for shunting one of the coils of said magnet, said circuit including a manually controlled switch adapted to open automatically when moved to closed position and a contact adapted to be engaged by said contact member when the latter is in its normal position.

16. In a controlling mechanism for electric motors, a resistance in the armature circuit, a series of relay switches for cutting in and out the armature resistance, circuits for shunting the coils of said relays, contacts connected to said shunt circuits, a contact member adapted to normally bridge said contacts and close said circuits, an electromagnetic device normally energized while the motor is in operation and tending to move said member to open said shunt circuits, said device having connected therewith a magnetizable rod or bar, a brake magnet, normally energized while the motor is in operation and co-acting with said bar to prevent movement of said member, means for deënergizing said brake magnet without deënergizing said device and means for deënergizing both said brake magnet and said device.

17. In a controlling mechanism for electric motors, a resistance in the armature cir-

cuit, a normally open relay circuit comprising a high resistance and a plurality of relay coils in series, relay switches movable by said coils to vary the armature resistance, circuits for shunting the coils of said relays without shunting said high resistance, contacts connected to said shunt circuits, a contact member adapted to normally bridge said contacts and close said shunt circuits, an electromagnetic moving device adapted to move said member away from said contacts, an electromagnetic brake device arranged to normally prevent such movement, means for rendering said brake device ineffective to prevent such movement, and a main switch for opening and closing the armature circuit and said relay circuit.

In testimony whereof I affix my signature, in presence of two witnesses.

GEORGE H. WHITTINGHAM.

Witnesses:
FELIX R. SULLIVAN,
C. W. R. MOORE.