No. 704,665. Patented July 15, 1902.

W. J. RICHARDS.

CONTROLLING APPARATUS FOR ELECTRIC MOTORS.

(Application filed Nov. 16, 1901.)

(No Model.) 3 Sheets—Sheet I.

Fig. 1.

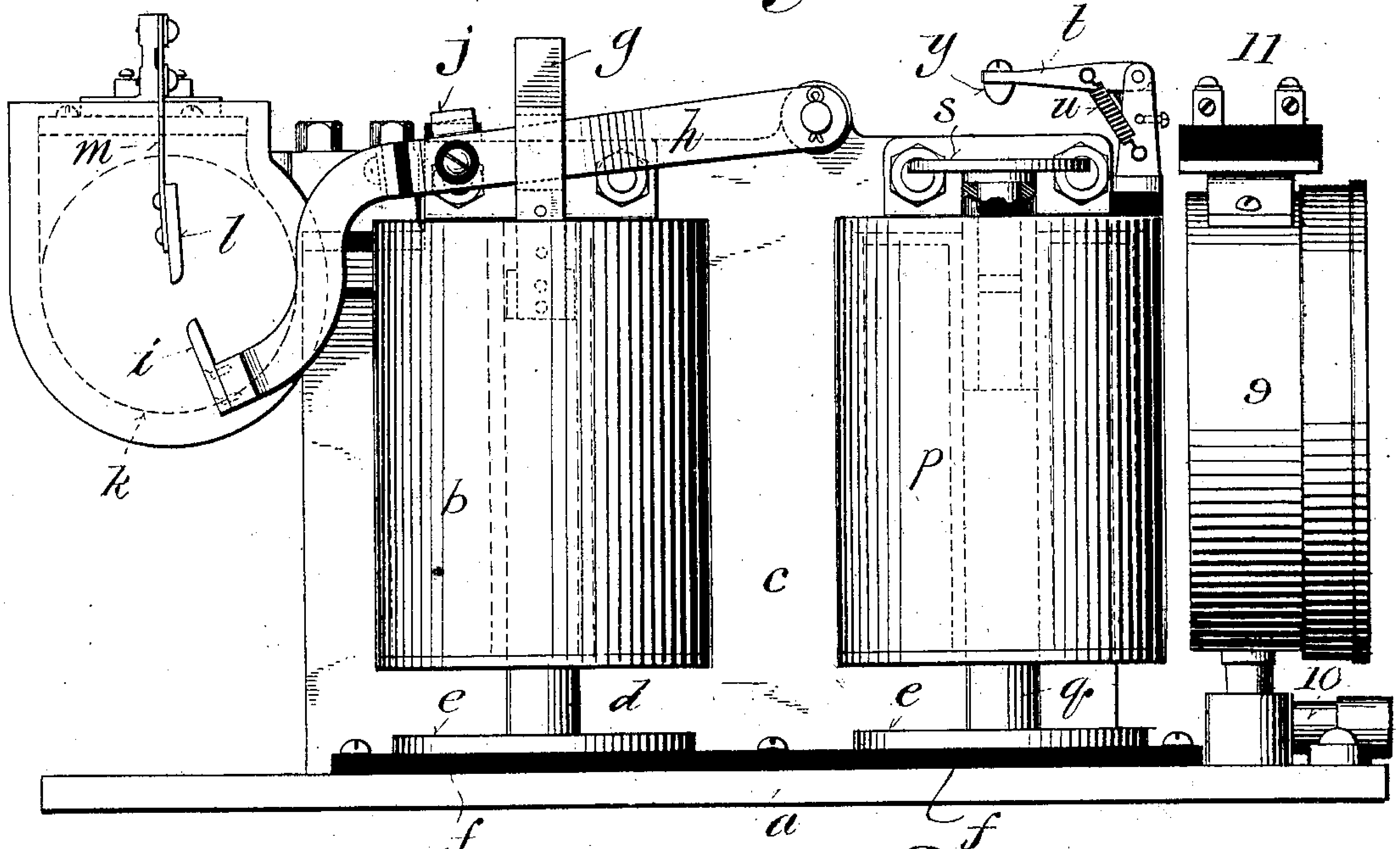
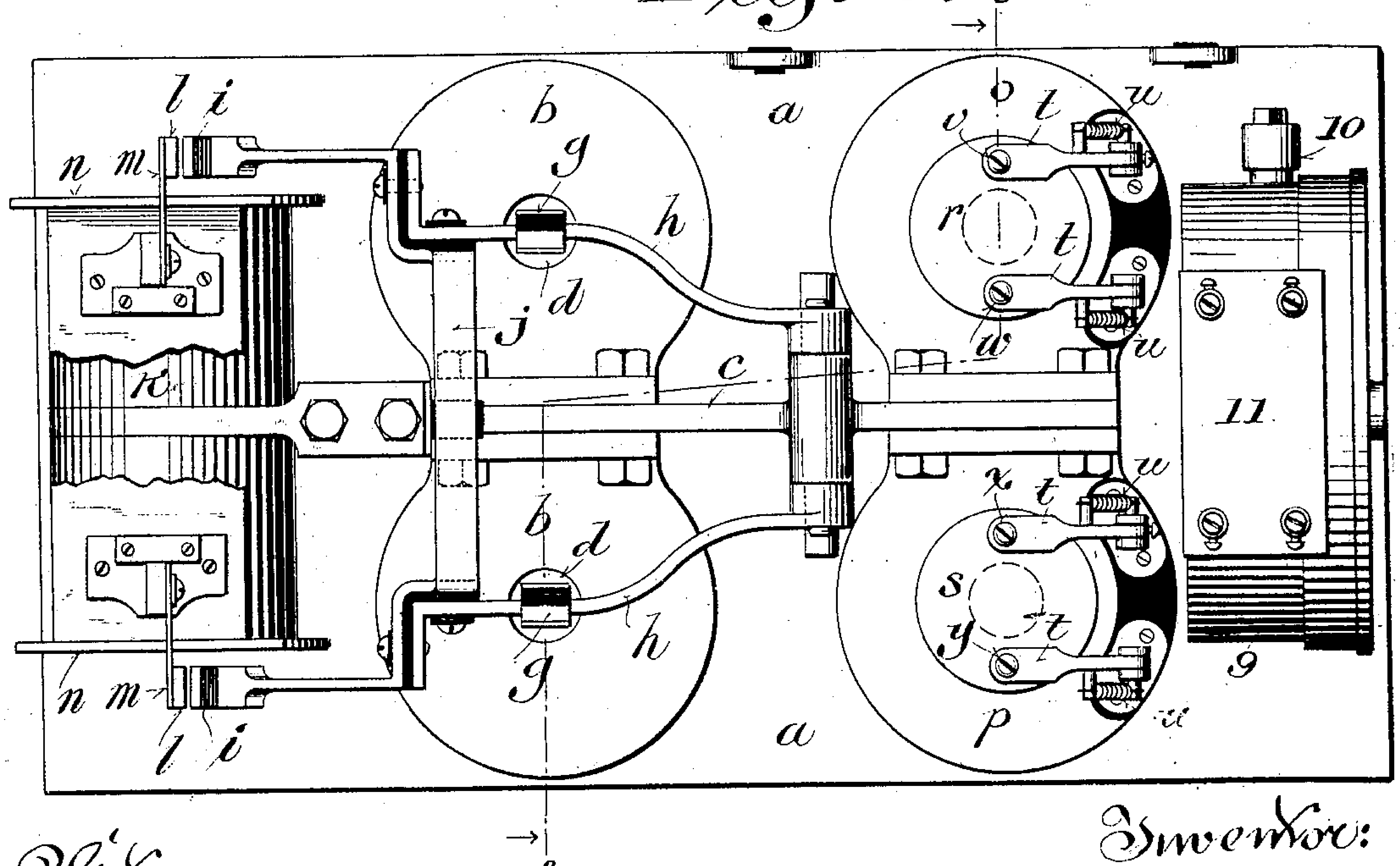


Fig. 2.



Witnesses:
Geo. W. Young,
Chas. L. Goss.

Inventor:
Walter J. Richards,
By Wheeler Flanders Quick Bottum & Viles,
Attorneys.

No. 704,665. Patented July 15, 1902.

W. J. RICHARDS.

CONTROLLING APPARATUS FOR ELECTRIC MOTORS.

(Application filed Nov. 16, 1901.)

(No Model.) 3 Sheets—Sheet 2.

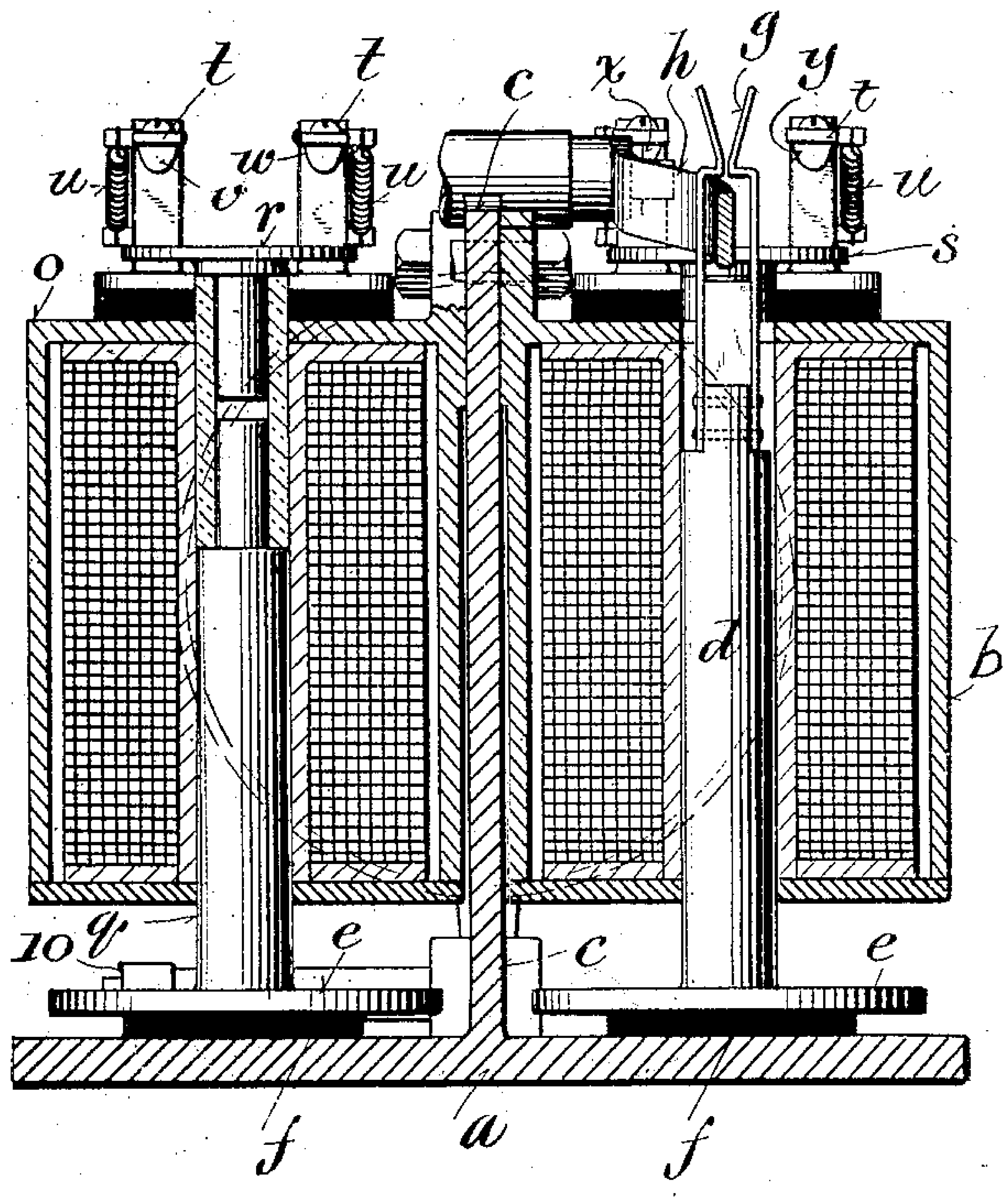
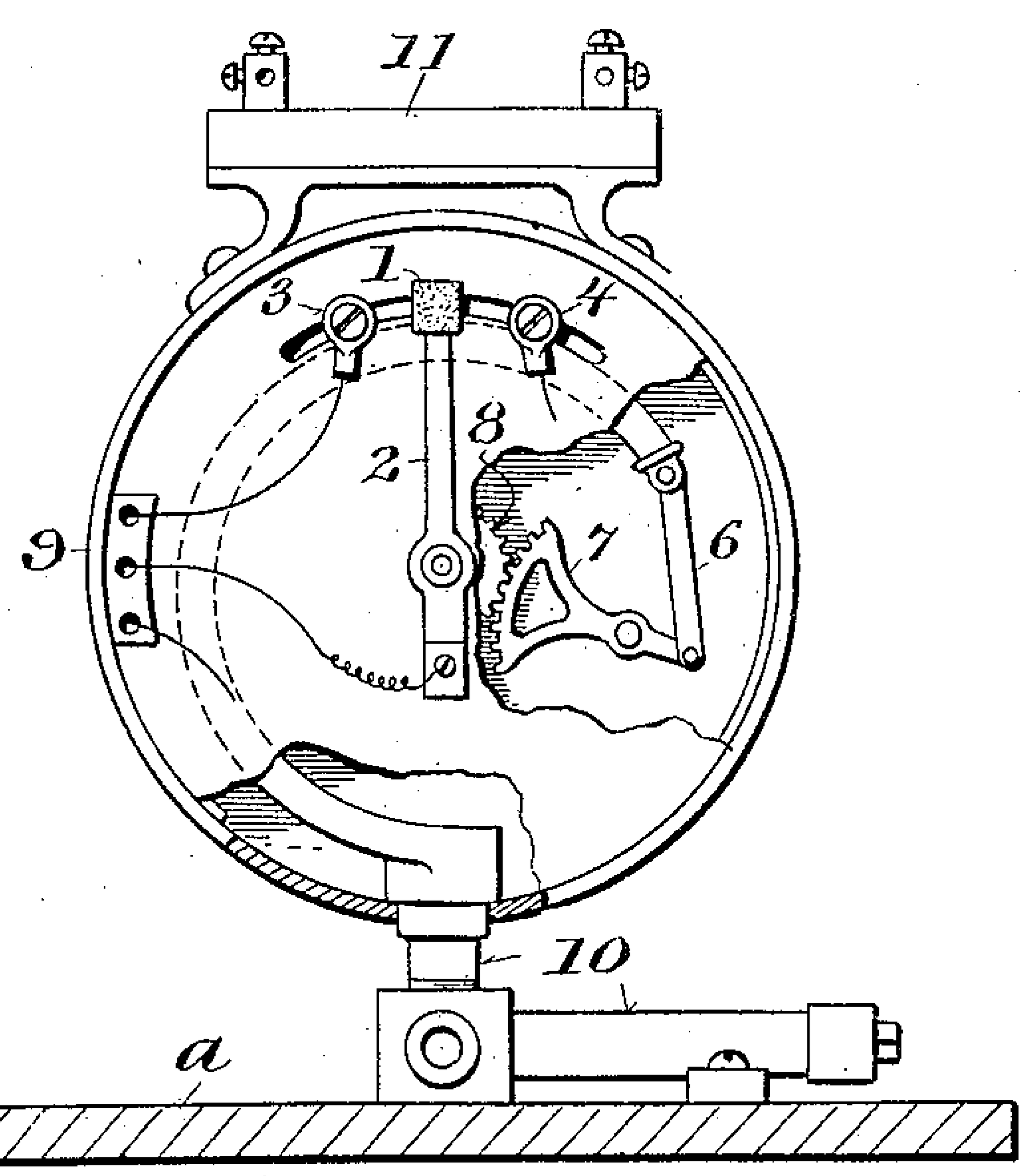


Fig. 3.

Fig. 4.



Witnesses:
Geo W. Young.
Chas. L. Goss.

Inventor:
Walter J. Richards.
By Wheeler Sanders Smith, Bottum & Vilas,
Attorneys.

No. 704,665. Patented July 15, 1902.

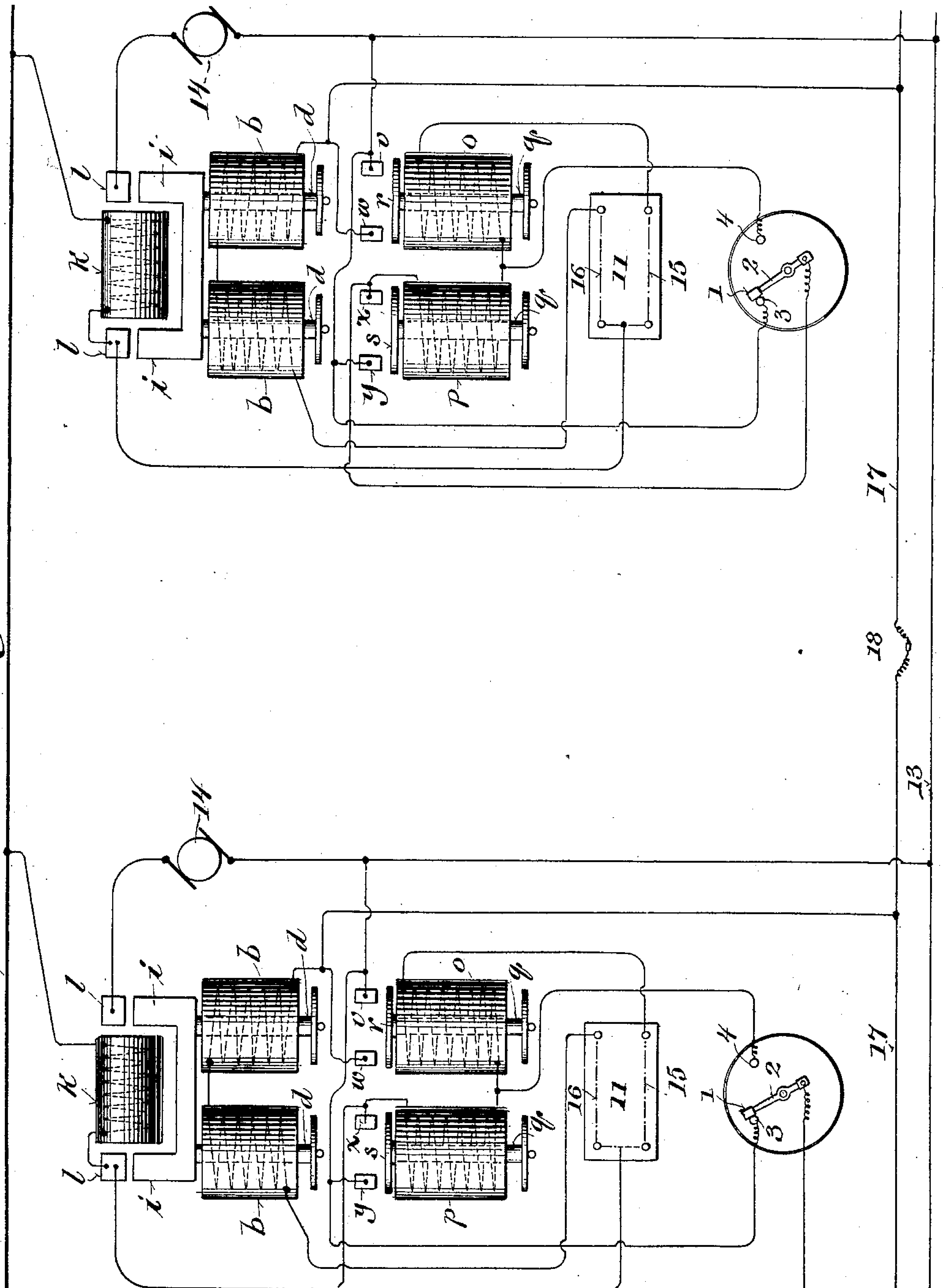
W. J. RICHARDS.

CONTROLLING APPARATUS FOR ELECTRIC MOTORS.

(Application filed Nov. 16, 1901.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 5.



Witnesses:
Geo. W. Young,
Chas. L. Goss

Inventor:
Walter J. Richards,
By Winkler Flanders Smith Bottum & Vilas
Attorneys.

UNITED STATES PATENT OFFICE.

WALTER J. RICHARDS, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO NIELS A. CHRISTENSEN, OF MILWAUKEE, WISCONSIN.

CONTROLLING APPARATUS FOR ELECTRIC MOTORS.

SPECIFICATION forming part of Letters Patent No. 704,665, dated July 15, 1902.

Application filed November 16, 1901. Serial No. 82,518. (No model.)

To all whom it may concern:

Be it known that I, WALTER J. RICHARDS, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Controlling Apparatus for Electric Motors, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

The main objects of this invention are to maintain a given range of air-pressure for air-brake service on electrically-propelled trains or cars and for other purposes, to automatically and simultaneously start and stop at predetermined minimum and maximum pressures a number of compressor-motors in a multiple-unit system; to open and close the several motor-circuits in such a system by separate switches, all governed and made to operate in unison by controllers in circuits independent of the motor-circuits; to prevent in the equalizing-conductor connecting the several controllers in a multiple-unit system sufficient current to operate the controlling devices of the propelling-motors in a railway-train or of other motors the operation of which is governed by one or more conductors carried in the same cable with said equalizing-conductor in case of accidental crosses or grounds whether the compressor-motors are in operation or at rest; to make all parts of the apparatus easily accessible for inspection and repair, and generally to improve the construction and operation of devices of this class.

The invention consists in certain novel features of construction and arrangement of parts and in the combinations of parts hereinafter particularly described, and pointed out in the claims.

In the accompanying drawings like characters designate the same parts in the several figures.

Figure 1 is a side elevation, Fig. 2 a plan view, and Fig. 3 a vertical cross-section on the line 3 3, Fig. 2, of controlling apparatus embodying my invention. Fig. 4 is a face view of the primary switch forming a part of the controlling apparatus as viewed from the right with reference to Figs. 1 and 2, the dial or face being broken away to disclose the internal mechanism; and Fig. 5 is a diagram showing two sets of the controlling apparatus as arranged and connected for use in a multiple-unit system.

Each controller comprises a main switch which governs the motor-circuit, one or more magnets for operating said switch, a relay-switch which controls the circuit of the main magnet or magnets, a magnet for operating said relay-switch, a primary switch which is operated by fluid-pressure and which controls the circuit of the relay-magnet, an auxiliary switch for short-circuiting one of the contacts of the primary switch and for opening the circuit of the relay-magnet, and a magnet whose circuit is controlled by the primary switch for operating said auxiliary switch.

All of the parts above mentioned are assembled and mounted on the same base *a* and are inclosed and protected in practice by a removable case or cover, which is not shown.

b b are the main magnets, bolted to opposite sides of a vertical rib *c*, extending lengthwise of the base. Each of these magnets, which are of the solenoid type, has a plunger *d*, movable axially therein and provided at its lower end with a plate or enlargement *e*, which rests normally when the magnet is not enegized on a non-magnetic stop or support *f*, attached to the base *a*. At their upper ends these plungers are provided with spring hooks or catches *g g*, adapted to engage loosely with arms *h h* of a forked lever, which is fulcrumed at one end to the rib *c* and carries at its opposite end the movable contact-pieces *i i* of the main switch. These contact-pieces are connected by a cross-bar *j* and insulated from the lever-arms *h h*.

k is a blow-out magnet arranged crosswise of the base *a* and bolted to the rib *c*. Upon this magnet are mounted the relatively fixed or stationary contact-pieces *l l* of the main switch. These contact-pieces are yieldingly supported adjacent to the poles of the blow-out magnet in the paths of the movable contact-pieces *i i* by the lower ends of springs *m m*, which are attached at their upper ends to insulated brackets on the blow-out magnet. To protect the blow-out magnet from injury by arcs when the contact-pieces of the

main switch are separated, plates or shields *n n*, of insulating and fireproof material, are interposed between said contact-pieces and the poles of said magnet.

o and *p* are the relay and auxiliary magnets, which are like or similar to the main magnets *b b* and are bolted in an upright position to opposite sides of the rib *c* on the base. Each of these magnets has a core or plunger *q* movable axially therein and provided at its lower end with a plate or enlargement *e*, resting when the magnet is not energized on a non-magnetic stop or support *f*. At their upper ends these plungers are provided above said magnets with metallic disks or contact-plates *r* and *s*, which are insulated from the plungers, as shown in Fig. 3. Upon the upper end of each of the magnets *o* and *p* are mounted two posts, to which are pivoted arms *t t*, extending normally over the contact-plates *r* and *s*. These arms are yieldingly held toward said contact-plates by springs *u u* and are prevented from passing below an approximately horizontal position by shoulders or stops on the posts to which they are pivoted. The arms over the contact-plates *r* are provided with contact-pieces *v* and *w*, and the arms over the contact-plate *s* are provided with contact-pieces *x* and *y*. The contact-plate *r* and contact-pieces *v* and *w* constitute the relay-switch, and the contact-plate *s* and the contact-pieces *x* and *y* constitute the auxiliary switch.

For the primary switch a device resembling a pressure-gage is preferably employed. It consists, as shown in Fig. 4, of a movable contact-piece 1, carried by the gage-hand 2, minimum and maximum pressure contact-pieces 3 and 4, adjustable toward and from each other on opposite sides of the contact-piece 1 in a curved slot in an insulating-dial or face-plate of the gage, and a Bourdon or curved spring-tube 5, connected at one end by a link 6, segment-gear 7, and pinion 8 with the gage-hand and rigidly attached to the gage-case 9 at its other end in communication with a manifold connection 10, by means of which the fluid-supply pipe may be connected with the controller either at one end or on one side. Upon the gage-case 9 is mounted a double-pole fuse-block 11. The magnets *b*, *b*, *o*, and *p* are preferably provided with iron casings and with the blow-out magnet *k* are so fastened to the rib *c* that they can be easily detached and removed, and all of the contact-pieces of the several switches are accessible and can be easily detached and removed for inspection, repairs, or renewal.

For multiple-unit or individual service the electrical connections of the controllers may be arranged as shown in Fig. 5, which represents the controlling apparatus of two cars as arranged and connected for air-brake service. 12 and 13 represent the trolley or supply and the ground or return or main conductors through which current is supplied to the apparatus, and 14 designates compressor-motors, by means of which compressed air is supplied for the operation of the brakes and of the primary switches of the controllers.

One terminal of the blow-out magnet *k* is connected with the supply or main conductor 12. In this connection there is usually placed a cut-out switch, which is not shown. One of the contact-pieces *l* of the main switch is connected with the other terminal of magnet *k* and through fuses 15 and 16 with one terminal of magnet *o* and one terminal of one of the magnets *b*. The other contact-piece *l* of the main switch is connected with one terminal of the motor, the remaining terminal of the motor being connected with the return or main conductor 13. One terminal of the other magnet *b* is connected with the contact-piece *w* of the relay-switch. The remaining terminals of the two magnets *b* are connected with each other. The other terminal *v* of the relay-switch is connected with the return or main conductor 13. The gage-hand 2 or the movable contact-piece 1 of the primary switch is connected with one contact-piece *x* of the auxiliary switch and with one terminal of magnet *p*. The remaining terminals of magnets *o* and *p* are connected with each other and with the maximum-pressure contact-piece 4. The remaining contact-piece *y* of the auxiliary switch is connected with the minimum-pressure contact-piece 3 of the primary switch and with the return or main conductor 13.

The operation of a single controller in governing an individual compressor-motor may be described as follows: Assuming that the switch is open between the controller and the supply-conductor 12 and that the air-pressure is at zero or below the minimum limit for which the controller is adjusted, the contact-piece 1 of the primary switch will rest against the minimum-pressure contact-piece 3, and the contact-pieces *i* and *l* of the main switch will be separated. If now the circuit is closed between the controller and the conductor 12, current being supplied to the controller will pass through the blow-out magnet *k*, one of the contact-pieces *l*, fuse 15, magnet *o*, magnet *p*, contact-pieces 1 and 3 of the primary switch, and thence to the ground or return conductor 13. Magnets *o* and *p* will thus be energized and close the relay and auxiliary switches. The engagement of the contact-plate *s* with the contact-pieces *x* and *y* of the auxiliary switch establishes a low-resistance shunt for the contact-pieces 1 and 3 of the primary switch, passing from magnet *p* through the contact-piece *x*, contact-plate *s*, and contact-piece *y* to the ground or return conductor 13. The engagement of the contact-plate *r* with the contact-pieces *v* and *w* of the relay-switch establishes a circuit from the main conductor 12 through magnet *k*, contact-piece *l*, fuse 16, magnets *b*, contact-piece *w*, contact-plate *r*, and contact-piece *v* to the ground or return conductor 13. The

main magnets *b* are thus energized, closing the main switch, the engagement of whose contact-pieces *i* with the contact-pieces *l* closes the motor-circuit from the main conductor 12 through magnet *k*, contacts *l*, *i*, *i*, and *l* of the main switch and motor 14 to the return-conductor 13. The compressor-motor, being thus set in operation, supplies compressed air to the reservoir with which it is connected, and when the pressure reaches a certain point, according to the adjustment of the primary switch of the controller, the contact-piece 1 will leave the minimum-pressure contact-piece 3; but no arc will be formed by the separation of said contact-pieces on account of the above-mentioned shunt around them through the contact-pieces *x* and *y* and the contact-plate *s* of the auxiliary switch. As the pressure increases the gage-hand will be gradually turned to the right, and when the pressure reaches a certain maximum degree, for which the primary switch is adjusted, the contact-piece 1 will engage with the contact-piece 4. This will short-circuit the magnet *p*, the current now passing from the main conductor 12 through magnet *k*, fuse 15, magnet *o*, contact-piece 4, gage-hand 2, contact-piece *x*, contact-plate *s*, and contact-piece *y* of the auxiliary switch, and thence to the return conductor 13. Magnet *p* being thus deënergized allows the contact-plate *s* to drop and open the circuit including magnet *o* at *x* and *y*. Magnet *o* being thus deënergized allows the contact-plate *r* to drop and open the circuit of the main magnets *b* at *v* and *w*. As a result of this the main magnets are deenergized, allowing the contact-pieces *i i* of the main switch to drop and open the motor-circuit at *l l*. The two breaks thus made in the motor-circuit being in the field of the blow-out magnet *k*, the arcs produced by the separation of the contact-pieces *i* and *l* are instantly extinguished, thus avoiding injury to the apparatus. As the compressed air is exhausted the gage-hand recedes to the left until it strikes the minimum-pressure contact-piece 3, whereupon the above-mentioned operations will be repeated, as explained.

For multiple-unit service on a train of cars all or certain cars of which are equipped with compressor-motors and controllers as hereinbefore described in order that all of the compressor-motors may be started and stopped simultaneously at certain minimum and maximum pressures, that each controller may close and open the circuit of the compressor-motor associated therewith independently of the other motor-circuits in the system, and that the flow between controllers on the different cars of sufficient current to operate the controlling devices of the propelling-motors of the train may be prevented, an equalizing or balancing wire or conductor 17 is employed to connect the main magnets *b b* on the several cars of the train on the ground or return side. This wire or conductor is for convenience made in sections, each car being provided with a section extending the entire length thereof, and the several sections being connected between the cars by suitable couplings 18. It is necessary when the compressor-motors are operating that this equalizing-conductor be a part of or connected with the ground or return conductor and when the compressor-motors are not operating that a high resistance be placed in series between it and the trolley or supply conductor, for the reason that other wires or conductors for controlling the operation of the propelling or other motors are run in the same cable with or adjacent to said equalizing-conductor, and in case of accidental crosses or grounds sufficient current might otherwise be supplied to such other conductors from said equalizing-conductor to start the propelling-motors, and thereby lead to serious accidents.

A number of controllers connected in a multiple-unit system will operate as follows: Assuming that the circuits are open between the controllers and the source of current and that the air-pressure in the reservoirs, which are connected with each other for multiple-unit service, is at zero or below the minimum limit for which each of the several controllers is adjusted, all the gage-hands 2 will rest against the associated minimum-pressure contact-pieces 3 and all the other circuits and switches of the several controllers will be open. Upon closing the connections between the controllers and the trolley or supply-conductor 12 current will pass through each of the controllers, with the same results as hereinbefore explained in connection with a single controller. Both or all of the compressor-motors in the system will be started and the gage-hands 2 will leave the contact-pieces 3 of the primary switches without producing arcs. No current will flow under these conditions from one controller to another through the equalizing-wire 17, because the points in the controller-circuits with which it is connected are of the same potential, being connected with the ground or return conductor 13 through the contact pieces and plates *w r v* of the relay-switches. If by chance the gage-hands should engage simultaneously with the maximum-pressure contact-pieces 4 or in receding should simultaneously strike the minimum-pressure contact-pieces 3, the controllers would obviously all operate in unison to open and close the associated motor-circuits and there would be no flow of current through the equalizing-wire. If, however, the gage-hands do not simultaneously engage with the maximum or minimum pressure contact-pieces, and they are rarely, if ever, adjusted to do this, each of the controllers will operate in starting from zero pressure, as above explained; but if one gage-hand—for example, that of the controller at the right in Fig. 5—touches the associated maximum-pressure contact-piece 4 first the associated relay and auxiliary switches will be opened without opening the associated

main switch, since the main magnets *b b* will still have a ground or return connection with the main conductor 13 through the equalizing-wire 17 and the relay-switch contact-pieces *w r v* of the other controller in which the gage-hand has not yet reached the contact-piece 4. Both compressor-motors will thus continue to operate until the gage-hand of the controller at the left engages the associated maximum-pressure contact-piece 4, whereupon the connection between the main magnets *b b* of both controllers and the ground or return-conductor 13 will be broken by the opening of the relay-switch of the controller at the left. As a result the main switches of both controllers will be opened and the associated motors will be simultaneously stopped. As the air-pressure is reduced both the gage-hands recede, and if the gage-hand at the left first touches its minimum-pressure contact-piece 3 the switches associated therewith will be closed, as hereinbefore explained, and the closing of the relay-switch at the left will establish a ground or return connection with the main conductor 13 for the main magnets *b b* of the controller at the right through the equalizing-conductor 17 and the relay-switch contact-pieces *w r v* at the left. Thus both the main switches will be closed and both the compressor-motors will be started simultaneously. In the last-mentioned operation the relay and auxiliary magnets *o* and *p* at the right will not be energized, and hence the associated relay and auxiliary switches will not be closed, because the gage-hand 2 of the associated primary switch did not reach its minimum-pressure contact-piece 3 before the motors were started to increase the air-pressure by which both gage-hands are gradually turned back toward the maximum-pressure contact-pieces 4. It is thus apparent that the gage-hand at the left can alone stop the motors, since the relay and auxiliary switches at the right are open, and under these conditions the engagement of the associated gage-hand with its maximum-pressure contact-piece can have no effect. Upon engagement of the gage-hand at the left with the associated maximum-pressure contact-piece 4 the associated relay and auxiliary switches are opened, thereby breaking the circuits of the main magnets and opening the main switches of both controllers and stopping both motors. Thus it will be seen that the controller whose gage-hand first touches its minimum-pressure contact-piece will after the air-pressure has once been raised to the maximum limit govern the operation of both or all the compressor-motors on the train and that whatever the relative positions of the several gage-hands may be all of the compressor-motors will be started and stopped simultaneously.

It will be observed that the coils of the main magnets *b b* are arranged in parallel between the trolley or supply-conductor 12 and the equalizing-wire 17. This necessitates designing these magnets so that they will afford enough resistance to prevent the flow of sufficient current in the equalizer in case of accidental grounds or crosses to operate the controlling devices of the propelling-motors. Thus increasing the number of the units in the system necessitates increasing the resistance of the main magnets.

The main, relay, and auxiliary switches are all closed and held closed by the force of the magnets *b b*, *o*, and *p* and are opened by gravity when said magnets are deënergized.

The lever-arms *h* have a certain amount of vertical play between the upper ends of the plungers *d* and the catches *g*, so that said plungers may acquire momentum before taking up their load both in closing and opening the main switch, which is thus operated with greater certainty and with the expenditure of less energy than would otherwise be required.

It will be seen that in the operation of the controller current passes in series through the magnets *o* and *p* except momentarily when the contact-piece 1 first touches the maximum-pressure contact-piece 4 of the primary switch. In this way the current is cut down and overheating of said magnets is avoided. The auxiliary switch *s x y* and the minimum-pressure contact of the primary switch are in branches or shunts which are in parallel with each other and in series with the magnets *o* and *p*, and both these branches or shunts must be opened to break the circuit of magnet *o*, and thus open the relay-switch *r v w*. One branch or shunt is first broken by the separation of the contact-pieces 1 and 3 of the primary switch due to increase of fluid-pressure. The other branch or shunt is afterward broken by the opening of the auxiliary switch when the gage-hand 2 touches the maximum-pressure contact-piece 4, and thereby short-circuits and deënergizes magnet *p*, as already explained.

The magnets *o* and *p* being in series the magnet *o* prevents a short circuit between the main conductors 12 and 13 when the magnet *p* is short-circuited through the maximum-pressure contact of the primary switch.

It will be apparent to those skilled in the art to which this invention relates that the controller connections with the main conductors 12 and 13 may be reversed without change in results or in the mode of operation of the apparatus, provided the equalizer connections are shifted from one to the other side of the main magnets *b*, and that various modifications in the construction and arrangement of parts may be made without departing from the principle and intended scope of my invention.

I claim—

1. In controlling apparatus for electric motors the combination of a main switch for governing a motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating said relay-switch, an auxiliary switch

for breaking the circuit of the relay-magnet, means for operating the auxiliary switch, and a primary switch controlling the operation of said auxiliary switch, substantially as described.

2. In controlling apparatus for electric motors, the combination of a main switch for governing a motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating said relay-switch, an auxiliary switch for breaking the circuit of the relay-magnet, a magnet for operating said auxiliary switch, and a primary switch controlling the circuit of the auxiliary magnet, substantially as described.

3. In controlling apparatus for electric motors the combination of a main switch for governing a motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating said relay-switch, a primary switch for closing the circuit of the relay-magnet, an auxiliary switch arranged to short-circuit one of the contacts of the primary switch and to open the circuit of the relay-magnet, and a magnet whose circuit is controlled by the primary switch for operating the auxiliary switch, substantially as described.

4. In controlling apparatus for electric motors the combination of a main switch for governing a motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating said relay-switch, an auxiliary switch for opening the circuit of the relay-magnet, a magnet in series with the relay-magnet for operating said auxiliary switch, and a primary switch having one contact-piece connected with the circuit between the auxiliary and relay magnets and another contact-piece connected with the other terminal of the auxiliary magnet for short-circuiting the auxiliary magnet, substantially as described.

5. In controlling apparatus for electric motors the combination of a main switch governing a motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating the relay-switch, a primary switch having minimum and maximum pressure contact-pieces, an auxiliary switch in a shunt or branch circuit in parallel with the minimum-pressure contact of the primary switch and in series with the relay-magnet, and a magnet controlled by the primary switch for operating the auxiliary switch, substantially as described.

6. In controlling apparatus for electric motors the combination of a main switch governing the motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating said relay-switch, a primary switch having minimum and maximum pressure contact-pieces, an auxiliary switch in a short circuit around the minimum-pressure contact-piece, and a magnet for operating said auxiliary switch in series with the relay-magnet, substantially as described.

7. In controlling apparatus for electric motors the combination of a main switch governing the motor-circuit, a magnet for operating said switch, a relay-switch controlling the circuit of the main magnet, a magnet for operating said relay-switch, an auxiliary switch, a magnet for operating said switch, and a primary switch provided with minimum and maximum pressure contact-pieces, one contact-piece of the auxiliary switch being connected with one of the main conductors and with the minimum-pressure contact-piece of the primary switch, another contact-piece of said auxiliary switch being connected with one terminal of the auxiliary magnet and with a third contact-piece of the primary switch, one terminal of the relay-magnet being connected with the other main conductor and the remaining terminals of the auxiliary and relay magnets being connected with each other and with the maximum-pressure contact-piece of the primary switch, substantially as described.

8. In controlling apparatus for electric motors arranged in a multiple-unit system the combination of main switches governing the several motor-circuits, magnets for operating said switches, relay-switches for controlling the circuits of the main magnets, magnets for operating said relay-switches, primary switches controlling the circuits of the relay-magnets, auxiliary switches for opening the circuits of the relay-magnets, magnets whose circuits are controlled by the primary switches for operating the auxiliary switches, and an equalizing-conductor connecting the several controllers of the system between the main magnets and one of the main conductors, substantially as described.

9. In controlling apparatus for electric motors the combination with a suitable support of two insulated contact-pieces yieldingly connected with said support, two electrically-connected contact-pieces carried by a lever which is fulcrumed to said support, a solenoid-magnet having a vertically-movable plunger connected with said lever and arranged to throw its contact-pieces into engagement with said yielding and insulated contact-pieces when said magnet is energized, relay and auxiliary plunger-magnets mounted on said support and having vertically-movable plungers provided with contact-plates, a pair of insulated contact-pieces yieldingly mounted in the path of each contact-plate, and a primary switch controlling said relay and auxiliary magnets, substantially as described.

10. In controlling apparatus for electric motors the combination with a suitable base or support of two insulated contact-pieces yieldingly connected with said support, two electrically-connected contact-pieces mounted on a lever which is fulcrumed to said support, a solenoid-magnet whose plunger is con-

nected with said lever and adapted when the magnet is energized to carry the movable contact-pieces into engagement with the yielding contact-pieces, relay and auxiliary magnets mounted on said base or support and having plungers provided with contact-plates, a pair of insulated contact-pieces yieldingly connected with each of said magnets, and a primary switch also mounted on said base or support and comprising two insulated contact-pieces, a pivoted contact-arm, and a curved tube connected with said contact-arm and having a fluid-pressure connection, substantially as described.

11. In controlling apparatus for electric motors the combination with a suitable base of a blow-out magnet mounted thereon, a pair of insulated contact-pieces yieldingly mounted on said magnet adjacent to its poles, a forked lever fulcrumed to said base and provided with two electrically-connected contact-pieces which are adapted to be engaged with and disengaged from said yielding contact-pieces by the vertical movement of said lever, two solenoid-magnets mounted on said base and having vertically-movable plungers provided with spring-catches for detachable engagement with said lever, relay and auxiliary magnets also mounted on said base and having vertically-movable plungers which are provided with insulated contact-plates, spring-retracted insulated arms pivotally mounted in pairs on said relay and auxiliary magnets, contact-pieces carried by said arms in the paths of said plates, and a primary switch controlling said relay and auxillary magnets, substantially as described.

12. In controlling apparatus for electric motors the combination with a suitable base of a blow-out magnet mounted thereon, a pair of insulated contact-pieces yieldingly mounted upon said magnet adjacent to its poles, a forked lever fulcrumed to said base and provided with two electrically-connected contact-pieces adapted to be engaged with said yielding contact-pieces, two magnets mounted on said base and having plungers provided with spring-catches for detachable engagement with the arms of said lever, relay and auxiliary magnets also mounted on said base and having plungers provided with insulated contact-plates, spring-retracted pivoted arms mounted upon said relay and auxiliary magnets and insulated from each other, contact-pieces carried by said arms in position to be electrically connected by said plates when said magnets are energized, and a primary switch mounted on said base and comprising insulated minimum and maximum pressure contact-pieces, a pivoted contact-arm and a curved spring-tube connected with said arm and provided with a fluid-pressure connection, substantially as described.

In witness whereof I hereto affix my signature in presence of two witnesses.

WALTER J. RICHARDS.

Witnesses:
CHAS. L. GOSS,
ALICE E. GOSS.