E. R. CARICHOFF.

ELECTROMAGNETIC DEVICE.

APPLICATION FILED JUNE 25, 1909.

1,091,630.

Patented Mar. 31, 1914.

3 SHEETS—SHEET 1.

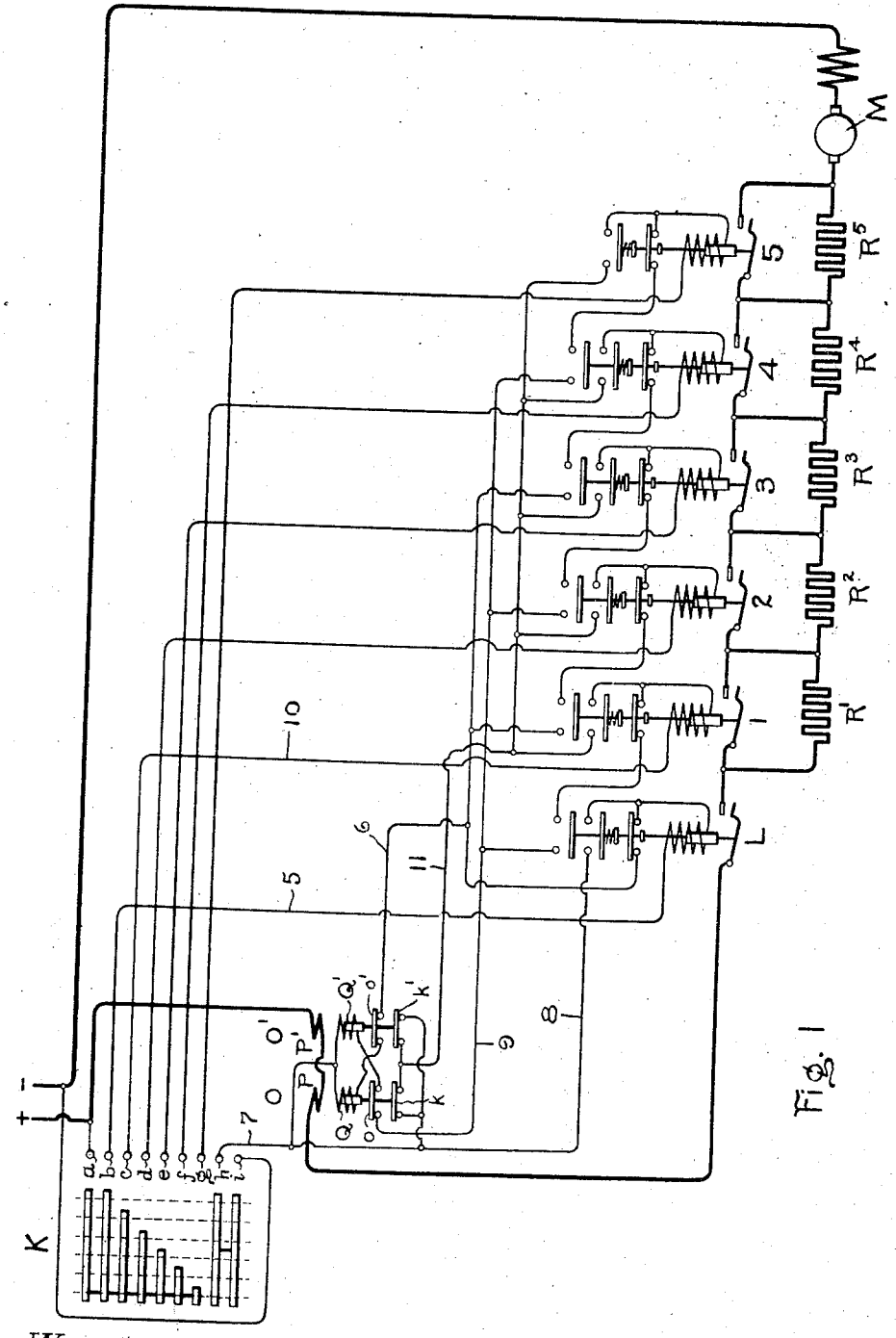


Fig. 1.

WITNESSES:

Lester H. Palmer.

J. Ellis Glen

INVENTOR

EUGENE R. CARICHOFF.

BY Albert G. Davis

ATT'Y.

E. R. CARICHOFF.

ELECTROMAGNETIC DEVICE.

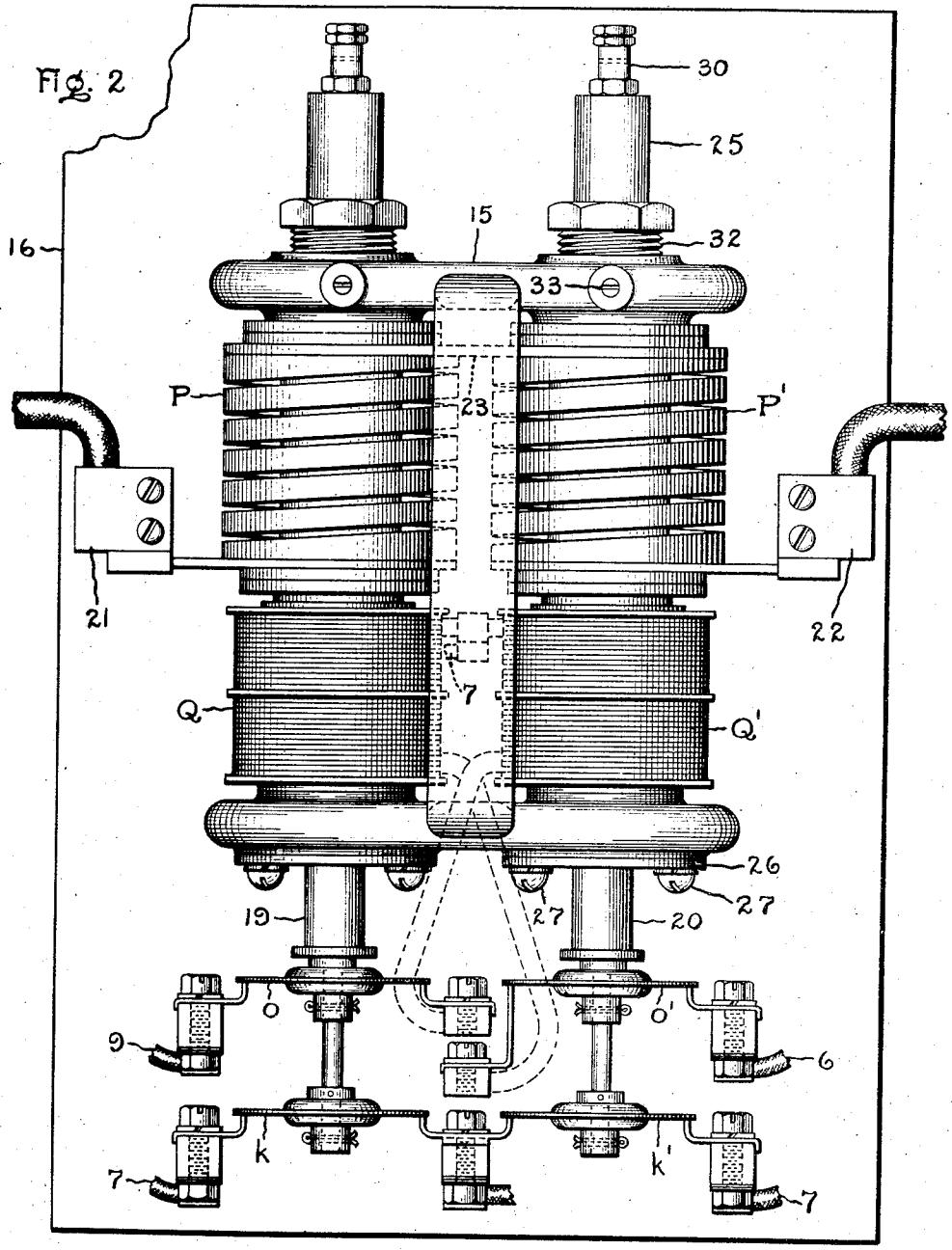
APPLICATION FILED JUNE 25, 1909.

1,091,630.

Patented Mar. 31, 1914.

3 SHEETS—SHEET 2.

Fig. 2



WITNESSES:

Lester H. Eckman.

J. Ellis Glen.

INVENTOR

EUGENE R. CARICHOFF.

BY Albert G. Davis

ATT'Y.

E. R. CARICHOFF.

ELECTROMAGNETIC DEVICE.

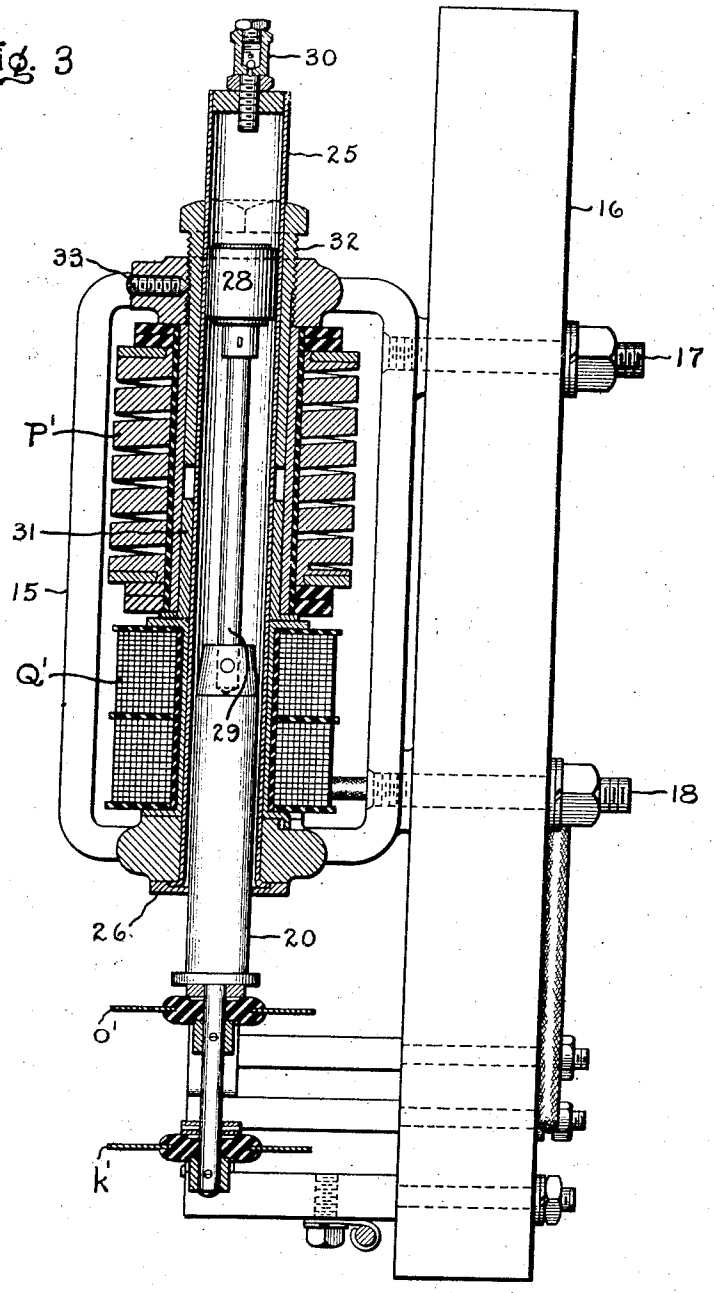
APPLICATION FILED JUNE 25, 1909.

1,091,630.

Patented Mar. 31, 1914.

3 SHEETS—SHEET 3.

Fig. 3



WITNESSES:

Lester H. Brubaker.

J. Ellis Glen

INVENTOR

EUGENE R. CARICHOFF.

BY Allen & Davis

ATT'Y.

UNITED STATES PATENT OFFICE.

EUGENE R. CARICHOFF, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTROMAGNETIC DEVICE.

1,091,630. Specification of Letters Patent. Patented Mar. 31, 1914.

Application filed June 25, 1909. Serial No. 504,321.

To all whom it may concern:

Be it known that I, EUGENE R. CARICHOFF, a citizen of the United States, residing at Schenectady, in the county of Schnectady, State of New York, have invented certain new and useful Improvements in Electromagnetic Devices, of which the following is a specification.

My invention relates to electrically controlled switches or relays.

It is especially useful in connection with systems of motor control in which a plurality of electrically controlled switches are arranged to operate in succession to increase step-by-step the potential applied to the motor. Among such systems of control are those, now well-known, in which a pair of "notching relays" are employed for the purpose of regulating the successive closing of the switches which control the voltage applied to the motor. This system of control is covered by a patent in the name of Archibald S. Cubitt, No. 941,408, dated November 30, 1909, and assigned to the same assignee as this application, and I have, in the present application, illustrated my invention as embodied in a system of this kind.

My present invention comprises certain improvements in the notching relays used in systems of control of the general nature of that set forth in the Cubitt patent above referred to. While my improved relay is not limited to any particular system of control it is particularly well adapted for use in connection with the system which is described and claimed in my patent application Serial No. 715,007, filed August 14, 1912, which is a division of this application. By my present improvements, hereinafter fully described, I am able to provide relays in which the movable magnetic core will be released by the series coil at substantially the same current in the latter, regardless, within certain limits, of the position in which it is when raised. I am also able to provide for easy adjustment of the value of current in the series coil at which the core will drop and at which it will pull up.

Other features of my invention will be understood from the following description taken in connection with the drawings, in which—

Figure 1 illustrates diagrammatically a simple system of motor control having my invention embodied therein; Fig. 2 is a front elevation of the notching relays used in the system of Fig. 1; and Fig. 3 is a side elevation, partly in section, of one of said relays.

In order that the functions and mode of operation of my improved relay may be clearly understood I will first describe a system of motor control in which this relay is employed and will then describe in detail the relay which is the subject matter of my present application.

Referring to Fig. 1, the motor to be controlled is shown at M and the resistance, interposed in the motor circuit at starting and cut out section-by-section in order to increase the voltage applied to the motor, is indicated at R^1, R^2, R^3, R^4 and R^5. The motor is connected to the source through all of the resistance by an electrically controlled switch or contactor L, and contactors 1 to 5 inclusive serve to short-circuit the sections of resistance R^1 to R^5, respectively. The contactors L and 1 to 5 are controlled by a master-switch K, shown in the usual conventional manner, as having fingers *a* to *i* which coöperate with segments on a drum shown in developed form. Notching relays O and O′, shown in the usual conventional manner as having series coils P and P′ located in the motor circuit and shunt coils Q and Q′ located in certain control circuits, control certain actuating circuits for the contactors in the manner set forth in the Cubitt application above referred to, with the exception that certain additional contacts are added to these relays for purposes previously alluded to and hereinafter fully explained. The contactors L and 1 to 5 are provided with certain auxiliary switches or interlocks which make and break certain control circuits for the purpose of insuring the successive operation of the contactors.

These auxiliary switches are shown in the usual conventional manner as being of the disk type which lends itself particularly well to diagrammatic illustration. The order in which these auxiliary switches close will be apparent from the diagram, but it may be stated that when a contactor closes the middle interlock first closes and then the lower one opens and the upper one closes. The manner in which the interlocking switches and the notching relays O and O′ coöperate will be understood from a description of the operation of the system as a whole which will now be set forth.

If the master-switch K is moved to its first "on" position, the actuating coil of the line contactor L is connected to the plus side of the source through controller fingers *a* and *b* and their coöperating segments, through wire 5, lower interlock on contactor L, actuating wire 6, contacts *o′* of relay O′, shunt coil Q of relay O, to the return wire 7 and through fingers *h* and *i* and their coöperating segments to the minus side of the source. The switch L will, therefore, close and will complete the motor circuit through all of the resistance R^1 to R^5, as will be easily traced in the diagram, it being noted that this circuit passes through the series coils P and P′ on the notching relays O and O′. The contactor L in closing closes its middle interlock and opens its lower one, thereby shifting its actuating coil from connection with the actuating wire 6 to connection with the maintaining wire 8 which leads back to the source without going through the contacts of the notching relays. The contactor L in closing also closes its upper interlock, thereby connecting one side of the actuating coil of the resistance controlling contactor 1 to the other actuating wire 9 which leads to the common return wire 7 through the contacts *o* on the relay O and shunt coil Q′ of the relay O′, a circuit which, however, will be temporarily interrupted by the relay O which pulled up, slightly before or simultaneously with the closing of contactor L, as explained in the Cubitt patent above referred to. If the master-switch K is moved to its second position, the actuating coil of the contactor 1 will be connected to the plus side of the source through the wire 10 and this contactor will, therefore, close as soon as the relay O drops. It will be noted that the shunt coils Q and Q′ of the relays O and O′ are energized only momentarily as the circuits through them are interrupted at the lower interlocks on the contactors; the cores of these relays are, therefore, maintained in their raised positions only by the series holding coils P and P′, as explained in the Cubitt patent above referred to. The relays O and O′ may, of course, be provided with dash-pots, or other devices, for the purpose of introducing a time interval between the operation of successive contactors, independently of the current in the motor circuit, and such dash-pots are shown as provided in the relays illustrated in Figs. 2 and 3. Each resistance controlling contactor in closing closes its middle interlock and opens its lower one, thereby shifting its actuating coil from connection to one of the actuating wires 6 or 9 to connection with the maintaining wire 11 which leads to the return wire 7 through the contacts *k* and *k′* on the relays O and O′. These contacts *k* and *k′* are connected in parallel and, therefore, the maintaining circuit for the resistance controlling contactors will be interrupted only when the cores of both of the relays O and O′ are raised. As stated above, during normal operation the series coils P and P′ of the relays O and O′ serve merely to hold the cores of these relays in raised position as long as the current in the motor circuit exceeds a certain value, and said coils will not produce a magnetic field strong enough to actually lift the cores of the relays until the motor current exceeds a considerably higher value. For this reason, the maintaining circuit for the resistance controlling contactors, through the wire 11, will not be interrupted by the alternate lifting of the cores of the relays O and O′ during normal operation in cutting out the resistance, but will be interrupted only when the current in the motor circuit rises to the excessive overload value at which the series coils on the relays actually pull up the cores of the latter. If, however, at any time, either during the starting of the motor or while the control system is in the full speed position, the current in the motor exceeds the excessive value referred to above, the relays O and O′ will pull up and the actuating coils of all the resistance controlling contactors will be deënergized, thereby allowing these contactors to open and causing all of the resistance to be reinserted in the motor circuit. It will, of course, be understood that, if desired, the maintaining wire 8 for the line contactor L might be connected to the return wire 7 through the wire 11 and the contacts *k* and *k′* on the relays O and O′, thereby causing the motor circuit to be interrupted if the current in it rises to the excessive overload value. In fact, any or all of the contactors which control the potential applied to the motor may be controlled through the lower contacts *k* and *k′* on the relays O and O′. In the particular arrangement shown, the resistance controlling contactors can be closed one at a time in response to movements of the master-switch K or, if desired, the master-switch may be thrown to its full

"on" position which will cause the contactors to close automatically in succession under the control of the notching relays O and O′, as explained in the Cubitt application.

The details of construction of the notching relays O and O′ are shown in Figs. 2 and 3. The series coils P and P′ and the shunt coils Q and Q′ are arranged in a single iron frame 15 of the form clearly shown in the drawings, said frame being secured to a back or panel 16 of suitable insulating material, such as slate, by means of bolts 17 and 18. The contacts *o* and *k* and the contacts *o′* and *k′* are shown as of a well-known form comprising disks carried by the movable cores 19 and 20 of the relays, said disks coöperating with fixed contacts secured to the panel 16 in any suitable manner. The points at which the control wires 6, 7 and 9 connect with the fixed contacts of the relays and with the common terminal of the coils Q and Q′, are indicated in Fig. 2 by the reference characters 6, 7 and 9, it being understood that the connections of Fig. 2 correspond exactly with the diagram, Fig. 1. The terminals of the series coils P and P′ are shown at 21 and 22, these coils being connected together at their upper ends by a yoke 23, which is clearly shown in Fig. 2. Referring now particularly to Fig. 3, the core 20 is shown as arranged for movement within a tube 25, of brass or other non-magnetic material, extending through the coils Q′ and P′ and the upper and bottom yokes of the frame 15. The core 20 is guided within this tube by a brass washer 26 secured to the bottom of the frame 15 by screws 27 shown in Fig. 2, and by a piston 28 carried on a rod 29 which is secured to and extends upwardly from the upper end of the core 20. This piston 28 may serve as the movable member of a dash-pot, of which the cylinder member is the shell 25, which may be provided at its top with a valve 30 of any suitable form, which will permit air to escape freely from the space inside of the shell 25 above the piston 28 and will restrict the admission of air to this space, this valve being preferably adjustable for this purpose. This dash-pot action between the piston 28 and the shell 25 is, however, not essential to the successful operation of my relays and is only provided for the purpose of allowing a "time limit" to be given to the operation of the relays and consequently to the successive closing of the contactors controlled by them. The upper end of the core 20 is tapered as shown, and, in its upper position, this tapered end projects into a fixed iron shell 31 mounted within the coil P′, as clearly shown in Fig. 3. Above the fixed shell 31 is an iron shell 32 which is adjustable toward and away from the fixed shell 31. As shown, the shell 32 is threaded and screws into the upper end of the frame 15, being held in any desired position by a set screw 33, this shell 32 being provided at its upper end with a nut-shaped head to facilitate rotation of said shell. By adjustment of the shell 32 the air gap between its lower end and the upper end of the fixed shell 31 can be adjusted and the permeability of the magnetic circuit through the coils P′ and Q′ can be regulated, thereby permitting the relays to be set to hold up and pull up at different values of current in the motor circuit. I have found that by arranging the fixed shell 31 in the relation to the coils and to the movable core 20 shown in Fig. 3, and by making the upper end of the core 20 tapered, the result is attained that the core 20 will be held raised by the same current in the coil P′ at different raised positions of the core 20, over quite a wide range. Or, looking at it in another way, I have found that with the parts constructed and arranged substantially as shown the core 20 will be released by the coil P′ at substantially the same value of current in said coil whether the upper end of said core is a greater or less distance, within certain limits, within the fixed shell 31. This arrangement, therefore, is free from the objection, heretofore often found in relays used for the same purpose, that the movable core will pull up under the influence of the shunt coil and will fall to different points before it will be caught by the magnetizing effect of the series coil, with the result that the core would drop at different current values in the series coil depending upon the position of the core within that coil.

It is not my intention to limit myself to the use of my invention in connection with the particular system of motor control herein illustrated, nor do I wish to convey the impression that the exact construction and arrangement of parts in the relays herein shown are necessary, since it will be understood by those familiar with this art that my invention may be applied to systems of many kinds and that the essential features of my relays may be embodied in many other constructions and types of relay.

I aim to cover all embodiments of my invention which come within the scope thereof as defined by the following claims.

Having now fully described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, a magnetizing coil, a core of magnetic material movable in the field thereof and operatively connected to said movable contact member, a shell of magnetic material located within

said coil adjacent the end thereof at which the movable core in its movement enters said coil, and means for regulating the permeability of the magnetic circuit of which said magnetic shell forms a part.

2. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, a magnetizing coil, a core of magnetic material having a tapered end arranged to move in the field of said coil and operatively connected to said movable contact member, a shell of magnetic material located within said coil adjacent the end thereof into which the tapered end of said core moves, and means for regulating the permeability of the magnetic circuit of which said magnetic shell forms a part.

3. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, a magnetizing coil, a core of magnetic material movable in the field thereof and operatively connected to said movable contact member, a shell of magnetic material located within said coil adjacent the end thereof at which the movable core in its movement enters said coil, and another shell of magnetic material movable to and from said first mentioned shell to vary the permeability of the magnetic circuit through said coil.

4. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, a magnetizing coil, a core of magnetic material having a tapered end arranged to move in the magnetic field produced by said coil and operatively connected to said movable contact member, a shell of magnetic material located within said coil adjacent the end thereof into which the tapered end of said core moves, and another shell of magnetic material movable toward and away from said fixed shell.

5. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, a magnetizing coil, a core of magnetic material having a tapered end arranged for movement within the magnetic field produced by said coil and operatively connected to said movable contact member, a fixed shell of magnetic material located within said coil at the point to which the tapered end of said core moves, and a second shell of magnetic material movable toward and away from said fixed shell whereby the permeability of the magnetic circuit through said coil can be regulated.

6. In a relay, a fixed contact member, a movable contact member coöperating therewith, a magnetizing coil, a frame of magnetic material arranged to furnish a magnetic circuit of low permeability from one end of said coil to the other, a core of magnetic material having a tapered end arranged for movement within said coil and operatively connected to said movable contact member, a shell of magnetic material fixed within said coil at the point to which the tapered end of the core moves, a second shell of magnetic material adjustably supported in said frame for movement within said coil toward and away from said first-mentioned shell whereby the permeability of the magnetic circuit through said coil can be regulated.

7. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, an actuating coil, a holding coil, a core of magnetic material movable in the fields of said coils and operatively connected to said movable contact member, a shell of magnetic material located within one of said coils adjacent the end thereof at which the movable core in its movement enters said coil, and another shell of magnetic material movable to and from said first mentioned shell to vary the permeability of the magnetic circuit through said coils.

8. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, two magnetizing coils, a core of magnetic material having a tapered end arranged for movement within the magnetic field produced by said coils and operatively connected to said movable contact member, a fixed shell of magnetic material located within one of said coils at the point to which the tapered end of the core moves, and a second shell of magnetic material movable toward and away from said fixed shell whereby the permeability of the magnetic circuit through said coils can be regulated.

9. In an electromagnetically operated switch, a fixed contact member, a movable contact member coöperating therewith, two current carrying coils, a core of magnetic material having a tapered end arranged to move in the magnetic field produced by both of said coils and operatively connected to said movable contact member, a shell of magnetic material located within one of said coils at the end into which the tapered end of said core moves, and another shell of magnetic material movable toward and away from said fixed shell.

10. A relay comprising a frame of magnetic material, two coils arranged on the same axis within said frame, a core of magnetic material having a tapered end movable from one coil partially into the other, a shell of magnetic material located within the coil into which the tapered end of the

core moves and at that end of said coil adjacent the other coil, a second shell of magnetic material movable through said frame within one of said coils and toward and away from said first mentioned shell whereby the permeability of the magnetic circuit of said coils can be regulated, a fixed contact member, a movable contact member cooperating therewith, and an operative connection between said core and said movable contact member.

In witness whereof, I have hereunto set my hand this 22nd day of June, 1909.

EUGENE R. CARICHOFF.

Witnesses:
HELEN ORFORD,
BENJAMIN B. HULL.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."