No. 714,411. Patented Nov. 25, 1902.

C. P. STEINMETZ.

CONTROLLING ALTERNATING CURRENT MOTORS.

(Application filed June 7, 1899.)

(No Model.)

2 Sheets—Sheet 1.

FIG. 1.

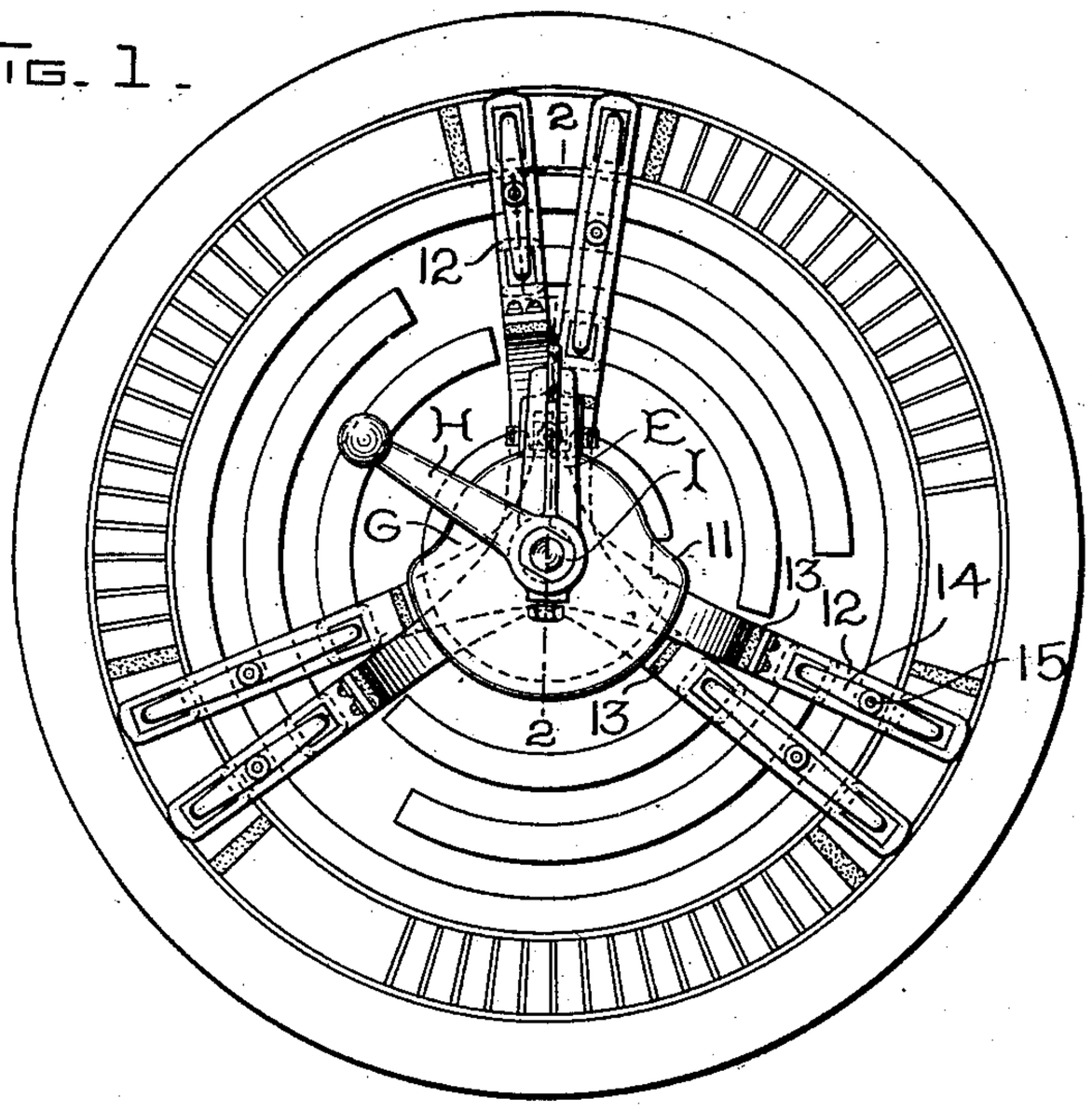
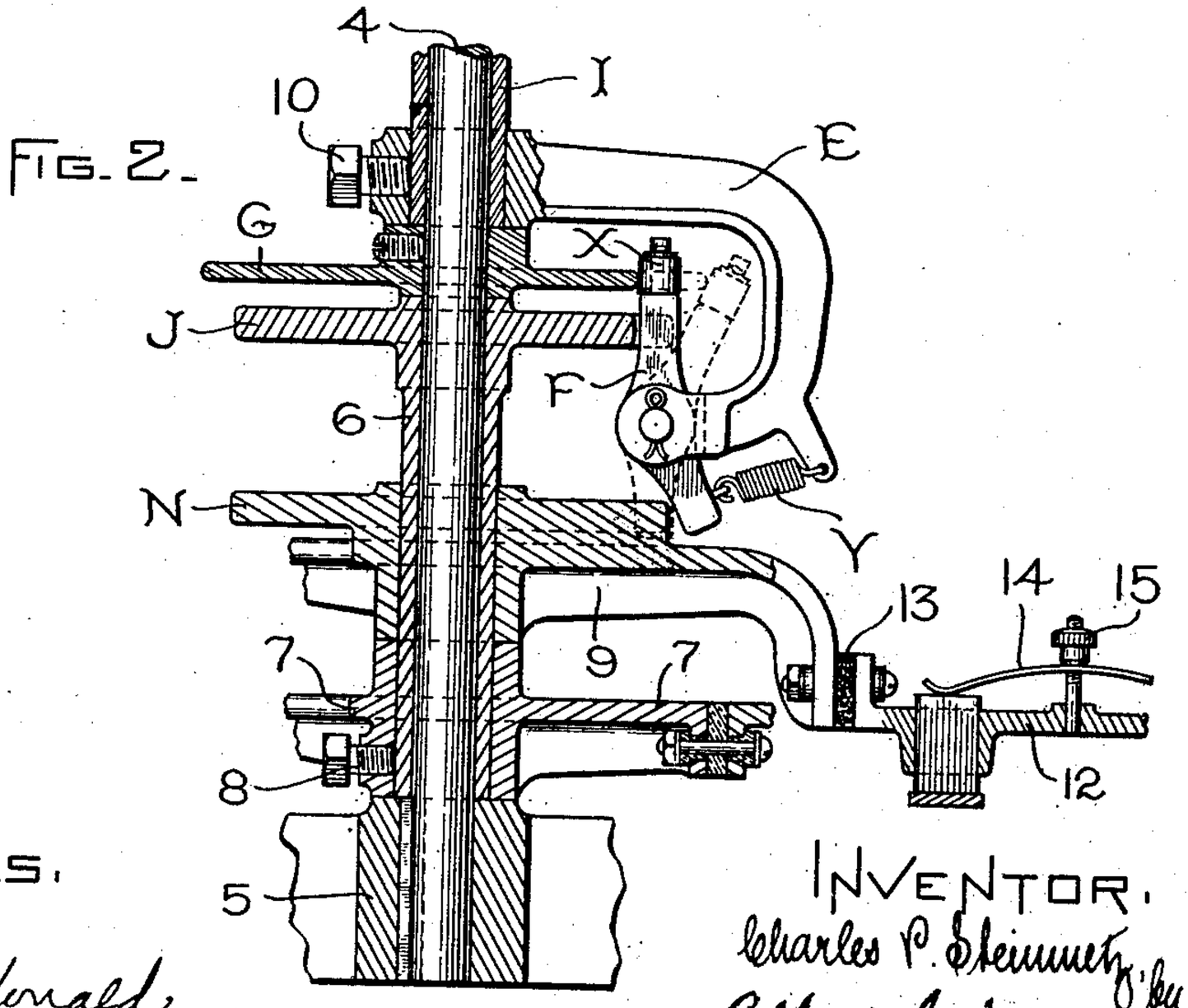


FIG. 2.



WITNESSES.

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No. 714,411. Patented Nov. 25, 1902.

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(No Model.) 2 Sheets—Sheet 2.

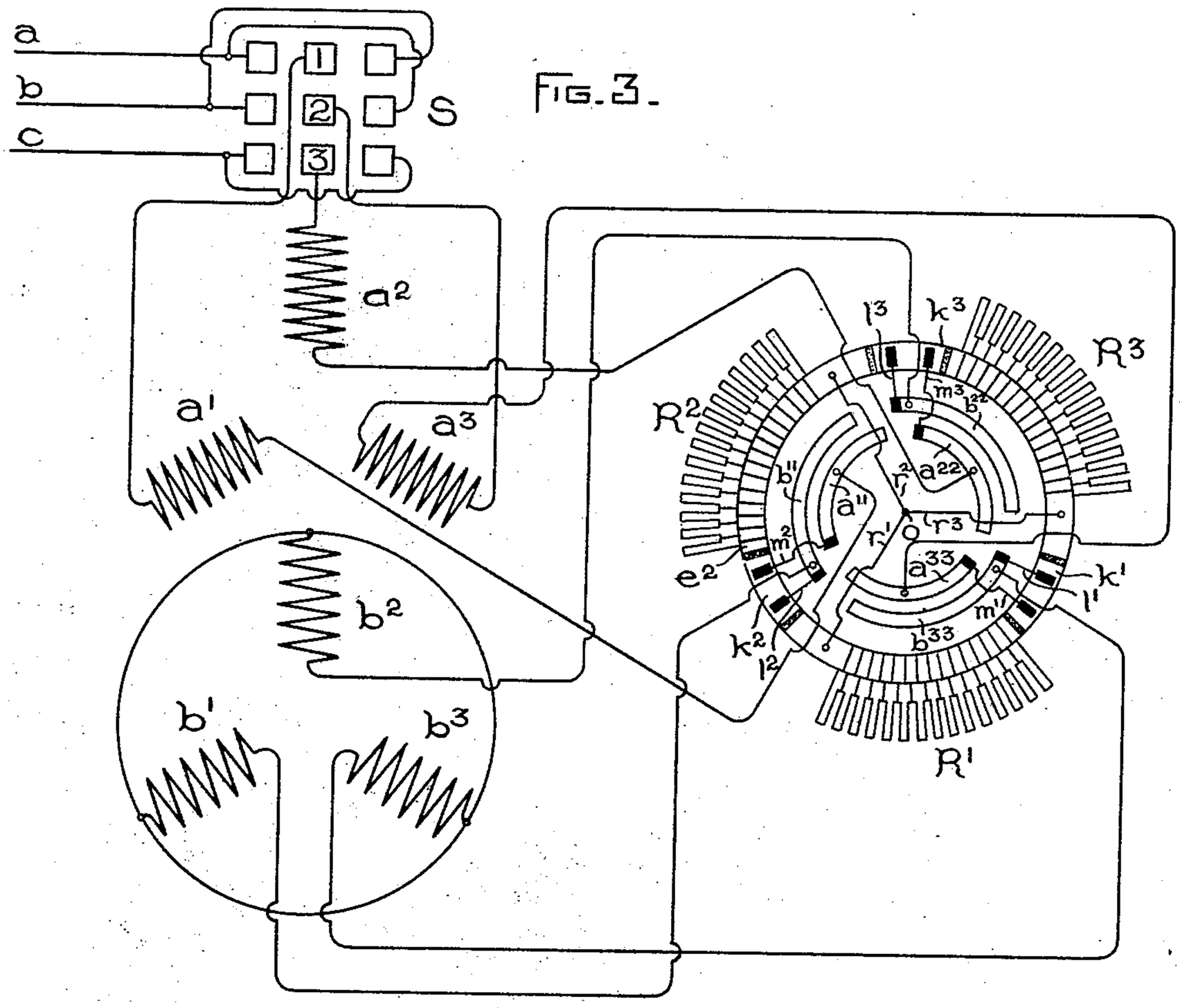

FIG. 3.

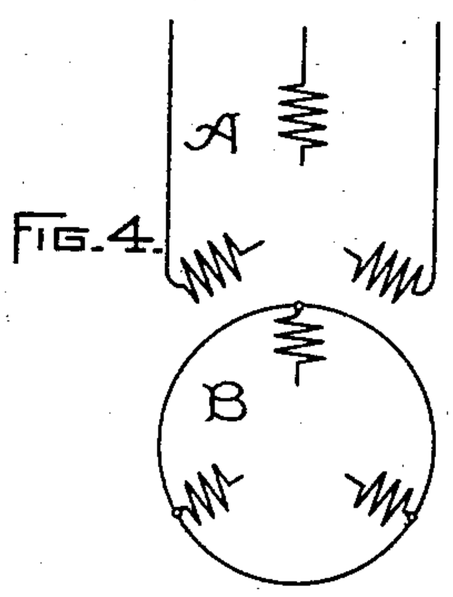

FIG. 4.

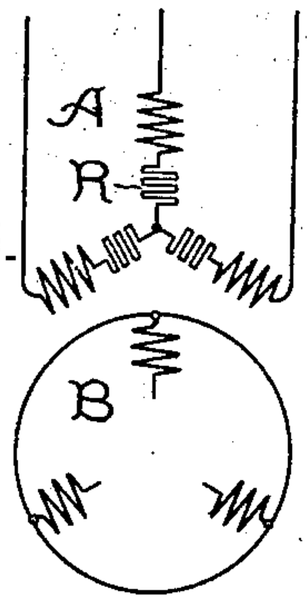

FIG. 5.

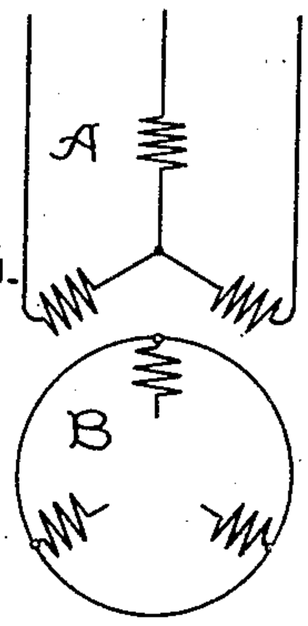

FIG. 6.

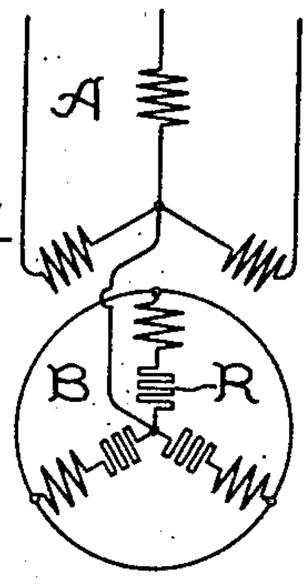

FIG. 7.

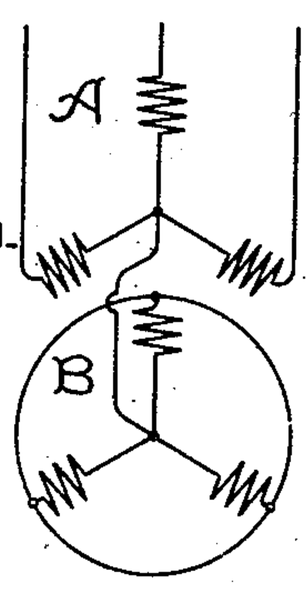

FIG. 8.

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UNITED STATES PATENT OFFICE.

CHARLES P. STEINMETZ, OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

CONTROLLING ALTERNATING-CURRENT MOTORS.

SPECIFICATION forming part of Letters Patent No. 714,411, dated November 25, 1902.

Application filed June 7, 1899. Serial No. 719,696. (No model.)

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Controlling Alternating-Current Motors, of which the following is a specification.

In controlling alternating-current motors considerable difficulty is encountered in the endeavor to extinguish effectually the arcs which result from opening the motor-circuits. Because of the nature of the alternating arc the magnetic blow-out is not always applicable, while the employment of other means—such, for example, as breaking the circuit under oil or other insulating fluid—is attended with many disadvantages. For these reasons I have devised a means for controlling alternating-current motors which does away with the necessity for any special means for extinguishing arcs which may be formed. My invention is more especially valuable where such motors for any reason have a large magnetizing-current.

My invention in its concrete form, as herein illustrated, consists of a switching mechanism with suitable electrical connections for connecting a non-inductive resistance in circuit first with one member of an induction-motor and then in circuit with the other member, the operation being such that on stopping the motor the resistance is first withdrawn from the windings of the secondary member and then placed in circuit with the primary member. With resistance thus placed in circuit with a primary member the magnetizing-current is reduced to a value so small that no difficulty is experienced from arcing when the circuit is opened. It will thus be seen that in accordance with my invention the resistance which is ordinarily used for controlling the speed and torque of an induction-motor possesses in this instance an additional function.

The details of my invention will be better understood by reference to the following description, taken in connection with the accompanying drawings, while its scope will be pointed out in the claims appended hereto.

In the drawings, Figure 1 is a plan view of a switching mechanism made in accordance with my invention. Fig. 2 is a view of the same partly in section. Fig. 3 is a diagram of circuits, while Figs. 4 to 8, inclusive, represent changes in circuit connections effected by the switching mechanism illustrated in Fig. 3.

My invention in its details will be more clearly apprehended by first describing, briefly, its general features, and this can best be done by referring to Figs. 4 to 8, inclusive, which serve to illustrate the same in a general way.

Fig. 4 indicates connections corresponding to the off position of the switch, both primary and secondary windings A and B, respectively, being open-circuited, as indicated. As the controller-handle is turned the first connection made causes a large resistance R to be inserted in series with the windings of the inducing member A, as shown in Fig. 5, while a further movement of the controller-handle causes the resistance to be gradually cut out until, as shown in Fig. 6, the free ends of the primary winding are connected together directly, at which time only the magnetizing-current is flowing through the motor and no torque is exerted by the secondary member. After having been withdrawn from the primary member the whole resistance R is inserted in series with the secondary B of the induction-motor. The motor is thus started in the ordinary manner, and as it gathers speed the resistance is gradually cut out by a further rotation of the controller-handle until the normal running condition is reached, in which the resistance is entirely cut out, as shown in Fig. 8. The function of the starting resistance for induction-motors is so well understood that no explanation of the same is necessary other than to refer to the manner in which the starting resistance is employed in this particular instance.

In starting the motor no useful purpose is served by first inserting the resistance in the primary member and then cutting the same out. It is only when the connections thus described are performed by the controller in the reverse order that the manipulation of the resistance with respect to the primary winding becomes useful.

When running normally, the connections of the motor are as indicated in Fig. 8, and the first step in putting the motor out of circuit consists in inserting resistance in the secondary member, as shown in Fig. 7, and then breaking the circuit of said member, as in Fig. 6. The same resistance is then gradually cut into the primary winding, as shown in Fig. 5, until the magnetizing-current of the motor has been reduced to a minimum, when the primary circuit is opened, thus leaving both members open-circuited, as indicated in Fig. 4. The arrangement of circuits whereby these changes are effected is indicated diagrammatically in Fig. 3, in which a' a^2 a^3 denote the three primary windings of the motor and b' b^2 b^3 the secondary windings. One end of each of the primary windings a' a^2 a^3 is connected, respectively, with one of the terminals 1 2 3 of the reversing-switch S, by means of which the primary winding as a whole is connected to the multiphase supply-mains a b c. When the reversing-switch is thrown in one direction, the terminals 1 2 3 are connected, respectively, to the mains a b c and by virtue of this connection the motor is given a definite direction of rotation, while when the switch is thrown in the opposite direction the terminal 3 is, as before, connected to the main c, while the connections of the terminals 1 2, on the other hand, are reversed, the terminal 2 being connected to the main a and the terminal 1 to the main b, thus causing an opposite direction of rotation of the motor. The opposite ends of the coils a' a^2 a^3 are connected, respectively, with three angularly-displaced fixed contacts a^{11}, a^{22}, and a^{33}, forming part of the switching mechanism.

The secondary windings of the motor are indicated at b' b^2 b^3 and are shown with one end of each winding connected together in any suitable manner and with the free ends connected to fixed contacts b^{11} b^{22} b^{33}, forming part of the switching mechanism and located adjacent to the fixed contacts a^{11}, a^{22}, and a^{33}, to which the free ends of the primary windings are connected. A non-inductive resistance in three sections R' R^2 R^3 is located adjacent to the fixed contacts before mentioned, and each section of the resistance is connected at intervals in its length to suitable contact-blocks or contacts arranged concentrically with respect to the fixed contacts. One end of each section of the resistance is connected to a common point, these connections being indicated in the drawings at r' r^2 r^3, leaving the opposite ends of the resistances normally disconnected. Suitably-insulated contacts k' k^2 k^3 of conductive material are located adjacent to the contacts connected to the respective sections of resistance and with their surfaces flush with the surfaces of the resistance-contacts, so as to allow the switch-arms which coöperate therewith to move from one contact to another. The connections between the various contacts thus referred to are effected by means of two sets of bridging-contacts, the two sets being individually movable with respect to each other and each set formed of three bridging-contacts, each of which operates in conjunction with resistance-contacts and with one of the fixed contacts connected to the motor-windings.

The bridging-contacts l' l^2 l^3 operate in conjunction, respectively, with the fixed contacts k' k^2 k^3 and are carried on the ends of three arms fixed with respect to each other and simultaneously rotatable by means of the controller-handle. One end of each bridging-contact makes connection with one of the fixed contacts k' k^2 k^3 and slides over the surface of one of the corresponding fixed contacts b^{11} b^{22} b^{33}, as indicated. In a similar manner the bridging-contacts m', m^2, and m^3 bear upon one of the contact-blocks k' k^2 k^3 and upon one of the corresponding fixed contacts a^{11}, a^{22}, and a^{33}, connected to the windings of the other member of the motor. The last-described set of bridging-contacts, as in the case of the first set, is carried by projecting arms, also rotated by means of the controller-handle. These two sets of arms are interrelated in a manner hereinafter to be described. The connections made by the bridging-contacts which are carried by these arms will, however, be evident from Fig. 3.

In the position of the parts shown both of the windings of the motor are open-circuited. When the controller-handle is first turned, the set of bridging-contacts m' m^2 m^3 is rotated in the direction of the hands of a watch and moved off of the insulated contacts k' k^2 k^3, upon which they rest when the motor is out of circuit, and then onto the set of contacts connected with the sections of resistance R' R^2 R^3. When the bridging connections are thus shifted, a section of resistance is placed in circuit with each of the primary windings a' a^2 a^3. Thus, for example, the coil a' would be connected through the fixed contact a'' to the free end e^2 of the resistance R^2 and then through the resistance to the neutral point o, to which the corresponding ends of the other sections of resistances are connected. As the controller-handle is moved forward the bridging-contacts m' m^2 m^3 are moved along over the fixed contacts connected to the resistance-sections until finally all the resistance is cut out, this condition being reached when the bridging-contacts rest upon the contacts directly connected with the connections r' r^2 r^3. At this point the arms carrying these bridging-contacts are uncoupled from the controller-handle and the other set of arms, carrying the other set of bridging-contacts, is caused to engage with the handle. The bridging-contacts l' l^2 l^3 thus set into motion by the further movement of the controller-handle are each connected to one of the windings b' b^2 b^3 of the secondary member and operate to insert resistance in the secondary member. Thus, for example, when the bridging-contact l' is moved forward it

passes off of the insulated contact k' and onto the first contact of the resistance R', thus connecting the free end of the winding b^3 of the secondary member of the motor through the resistance R' to the neutral point *o*. In a similar manner the other coils b' b^2 of the secondary member are connected through corresponding resistances R^2 and R^3 to the same common or neutral point *o*. The connections thus made correspond to the starting connections, in which the primary is connected directly across the mains, while the secondary windings are connected together through a large non-inductive resistance. After the motor starts the controller-handle is moved along still farther, thus cutting out the sections of resistance and so increasing the speed of the motor up to the point where all the resistance is cut out and the terminals of the windings of the secondary member are connected directly together through the medium of the bridging-contacts and the connecting wires or circuits r' r^2 r^3. This corresponds to the running connection of the motor. In disconnecting the motor from circuit the operations thus described are gone through with in the reverse order. After the resistance has been cut out of the secondary member the same resistance is then gradually cut into circuit in the primary member, and the circuits of the latter member are then broken, the break taking place as the bridging-contacts m' m^2 m^3 pass off of the contacts connected with the resistance onto the insulated contacts k' k^2 k^3, upon which they rest in the off position of the controller. By thus utilizing the motor-starting resistance the spark which takes place upon opening the primary circuit is very greatly reduced and so much so as to cause but little if any trouble due to arcing.

The switch mechanism which I employ for the purpose of effecting the above-described dissimultaneous movement of the two sets of bridging-contacts is shown in Figs. 1 and 2. At 4 is shown a shaft secured to the top 5 of the resistance-box or other support for the starting resistance. A sleeve 6 surrounds the shaft 4 and rests with its lower end against the top of the support 5. This sleeve is loosely mounted, so as to rotate about the shaft 4, and has secured thereto a three-armed carrier 7, to the arms of which one of the sets of bridging-contacts is secured. This carrier is secured to the sleeve 6 by means of a set-screw 8 or in any other suitable manner and, like the sleeve 6, rests with its lower edge adjacent to or in contact with the support 5. The other carrier 9 for the other set of bridging-contacts is loosely mounted upon a sleeve 6 and rests upon the top of the carrier 7, as shown. The controller-handle is indicated at H and is secured in any suitable manner to a sleeve I, loosely mounted upon the shaft 4. This sleeve carries a hooked arm E, secured thereto by means of the set-screw 10. The hooked arm at its lower end carries a spring-actuated locking-pawl F, which operates in conjunction with a cam G and with two notched plates J and N. The cam G is secured to the shaft 4 by means of a set-screw and in Fig. 1 is shown as consisting of two semicircular portions of different radius merged into each other. The notched disk J is secured to the sleeve 6 and is thus fixed with respect to the carrier 7, while the notched disk N is an integral part of the carrier 9. The locking-pawl F carries an antifriction-roller X, which moves over the working surface of the cam G and is urged against the same by means of the spring Y, connected at one end to a downwardly-projecting arm of the pawl F and at its other end to a finger formed integral with the hooked arm E.

In the position of parts indicated in Fig. 1 the locking-pawl F engages the notch in the disk J, while its antifriction-roller bears upon that portion of the working surface of the cam G nearest to the shaft 4. The forward motion of the controller-handle thus causes the carrier 7 to rotate by reason of the locking connection between the hooked arm E and the disk J, this locking connection, as already described, being formed by means of the pawl F engaging a notch in the disk. After the carrier has moved across all of the resistance-contacts and the outer or last contact of the series the antifriction-rolier X reaches that part of the cam-surface indicated at 11. The upper end of the pawl F is then thrown out, thus causing its lower end to move inwardly and engage the notch in the disk N, attached to the carrier 9. As will readily be understood, a reverse movement of the controller-handle will cause these operations to be performed in the reverse order, so that whereas on its forward motion the first operation of the controller is to insert resistance in the primary member and gradually cut it out on the return motion, on the contrary the last operation is to insert resistance gradually and then break the circuit of the winding of said member.

Each arm of the carriers 7 and 9 carries a bridging-contact, which is of the character indicated in plan in Fig. 1 and more in detail in Fig. 2 in section. Each carrier-arm has an extension 12 secured to the arm, but insulated therefrom by means of suitable insulating material 13. Carbon brushes projecting down from the extension 12 are spring-pressed against the coöperating contacts by means of suitable springs 14, the tension of which may be varied by adjusting-nuts 15.

The apparatus which I have thus shown for carrying out my invention is well adapted to the purpose; but it will readily be understood that many modifications of the same may be effected for securing the same end, and for this reason I do not limit myself to the employment of the above-described apparatus, but include within my invention all devices that may perform the same functions, even though the same be radically different in op-

eration, and although I regard the use of a single resistance both for starting and for limiting the primary current or stopping the motor as a valuable feature of my invention I do not wish to be limited thereto, since it is evident that, if desired, separate resistances may be employed for the purposes mentioned. My invention is therefore not to be understood as restricted to the use of a single resistance.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. The combination with an induction-motor, of means for dissimultaneously varying the resistance of the circuits of the inducing and induced windings respectively.

2. The combination with an induction-motor, of a resistance, and means for inserting the resistance in circuit either with the inducing-winding or with the induced winding of the motor.

3. The combination with an induction-motor, of a resistance, and means for inserting the resistance first in circuit with the windings of one member of the motor, then in circuit with the windings of the other member of the motor.

4. The combination with an induction-motor, of means for inserting resistance in the windings of either member of the motor.

5. The combination with an induction-motor, of means for dissimultaneously inserting resistance in circuit with the inducing and induced windings of the motor.

6. The combination of two independently-movable switch-arms, a controlling-handle and operative connections therewith for causing a positive and successive engagement between the controlling-handle and the switch-arms.

7. The combination of contacts, a plurality of switch-arms each movable over said contacts and means for successively moving said switch-arms.

8. The combination of a plurality of switch-arms, a controlling-handle therefor, and means for automatically disengaging the controlling-handle from one switch-arm and causing it to positively engage the other switch-arm.

In witness whereof I have hereunto set my hand this 5th day of June, 1899.

CHARLES P. STEINMETZ.

Witnesses:
BENJAMIN B. HULL,
MABEL E. JACOBSON.