G. H. CONDICT.

REGULATING DYNAMO ELECTRIC MACHINES.

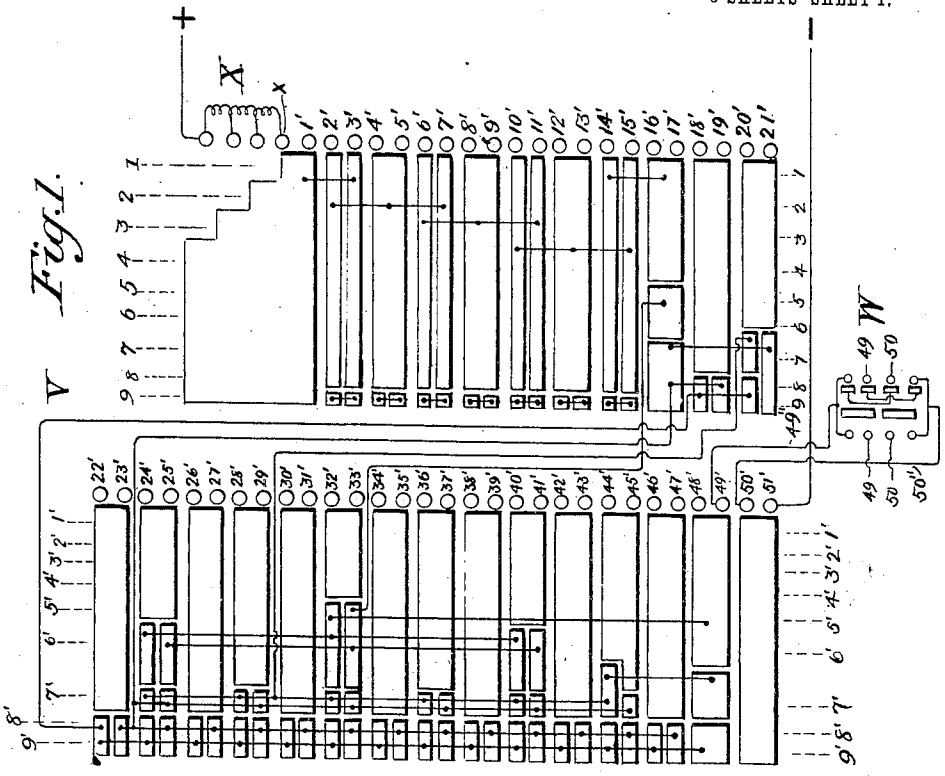
APPLICATION FILED JAN. 10, 1906. RENEWED OCT. 8, 1910.

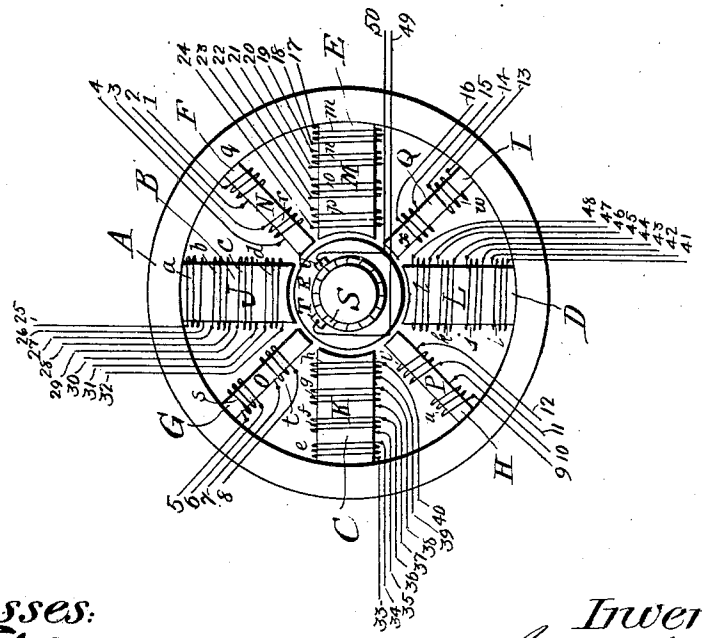
1,029,276.

~~Patented~~ June 11, 1912.

5 SHEETS—SHEET 1.

Fig. 1.





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5 SHEETS—SHEET 2.

Fig. 2.

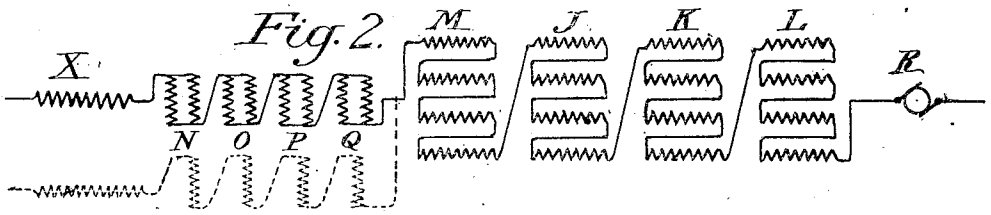


Fig. 3.

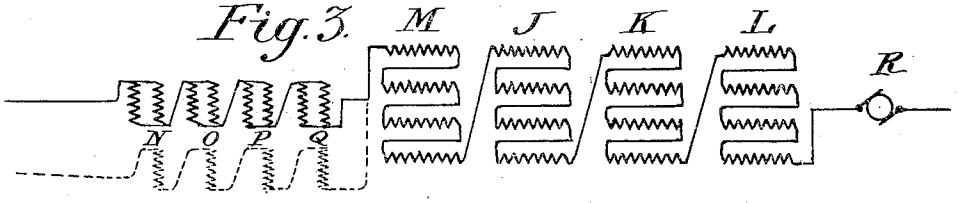


Fig. 4.

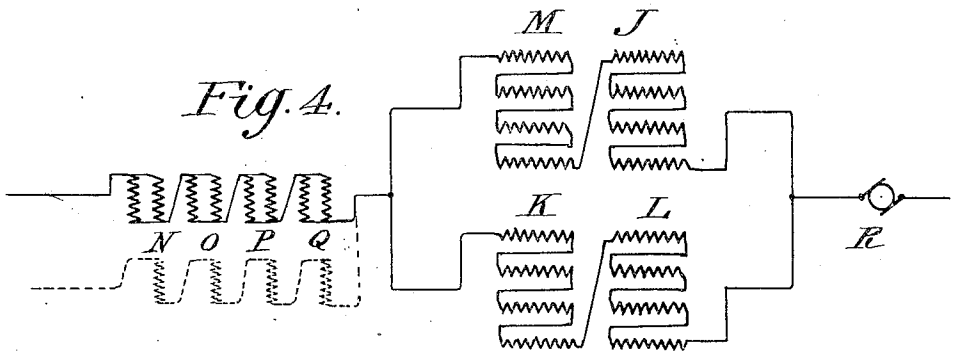
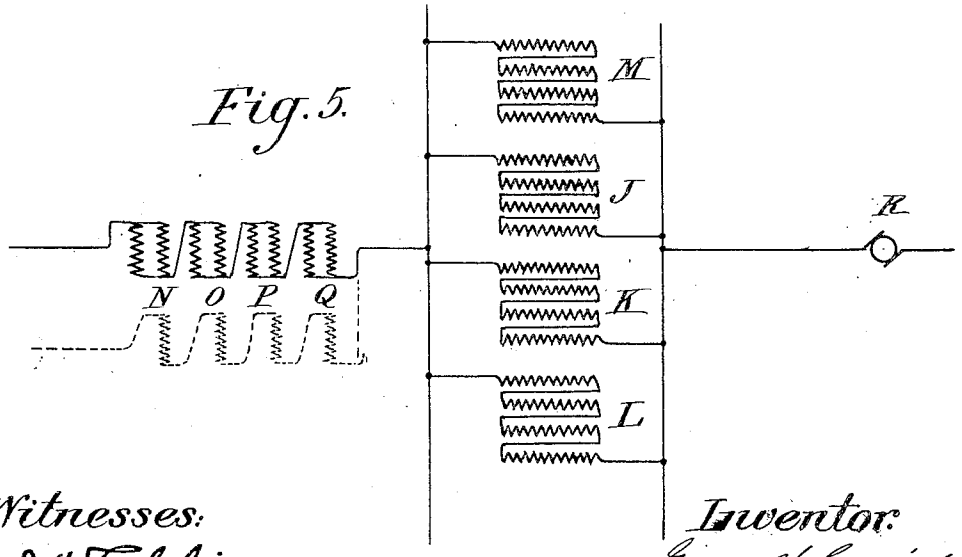


Fig. 5.



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5 SHEETS—SHEET 3.

Fig. 6.

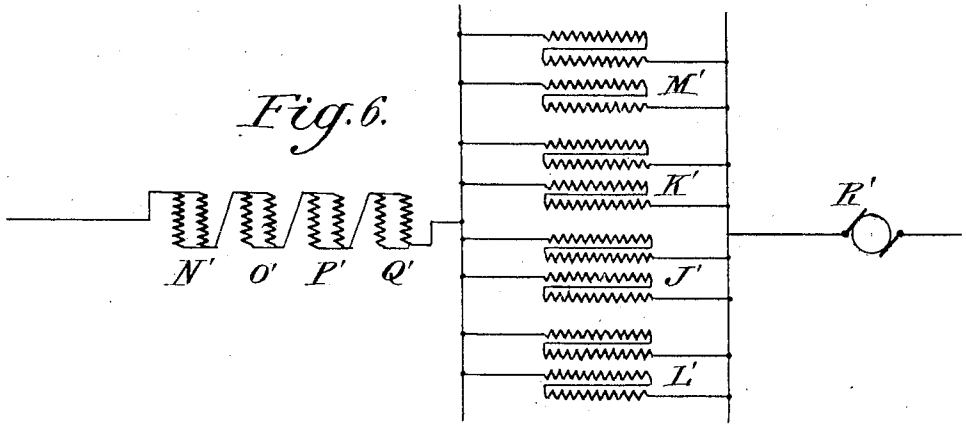


Fig. 7.

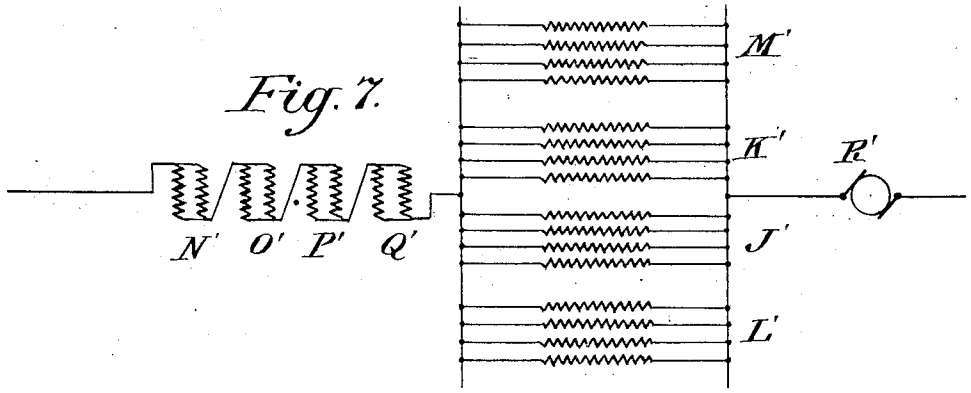
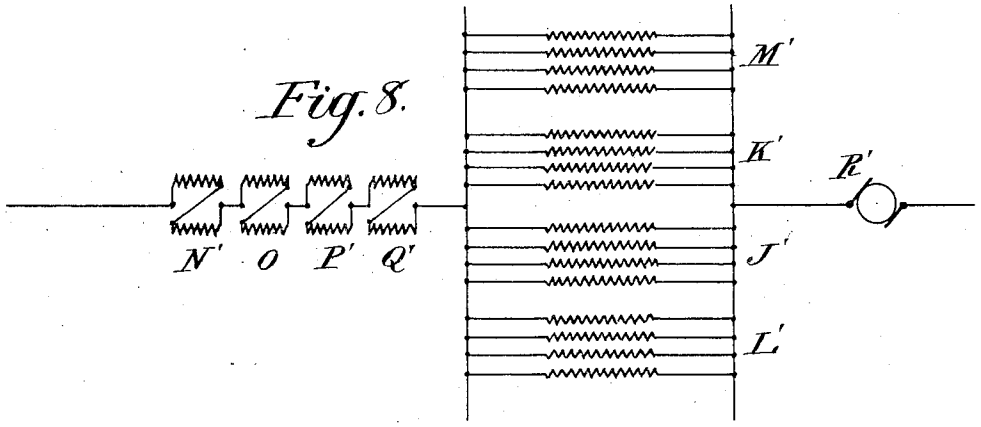


Fig. 8.



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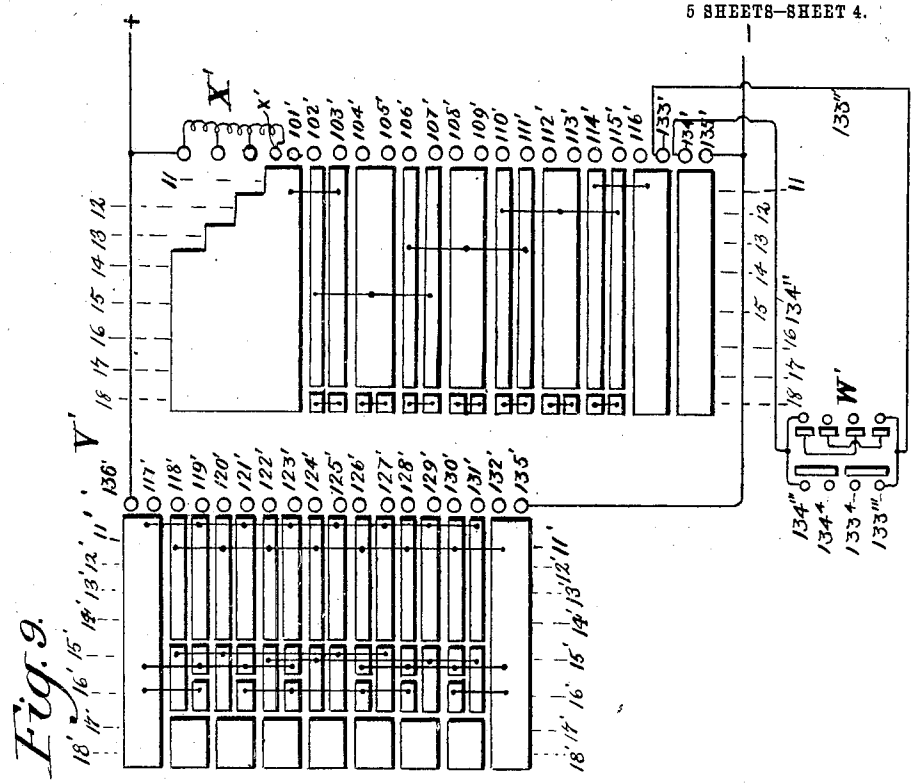
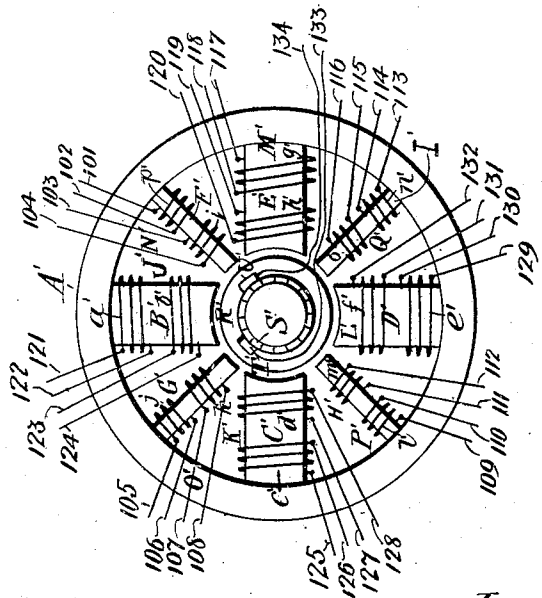


Fig. 9.



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5 SHEETS—SHEET 5.

Fig. 10.

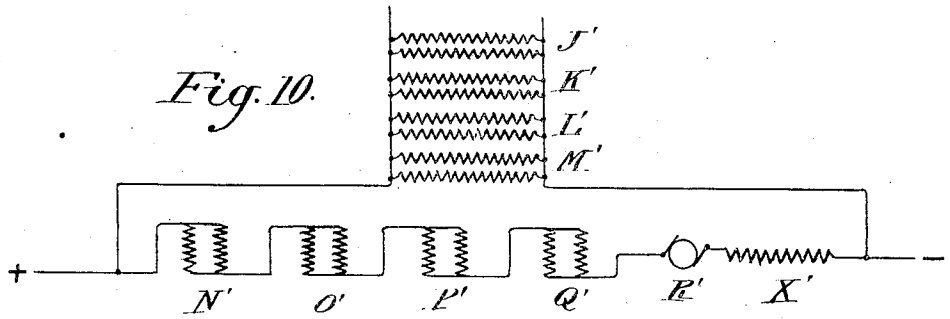


Fig. 11.

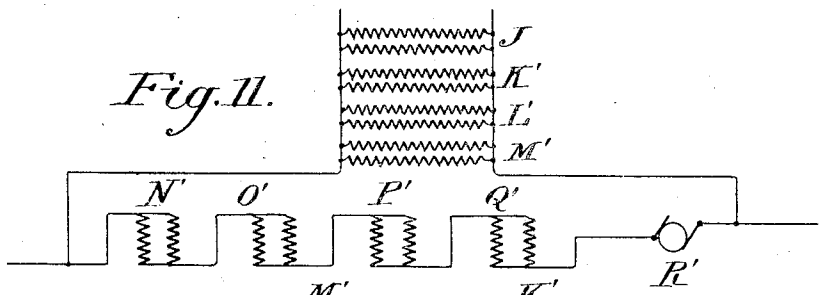


Fig. 12.

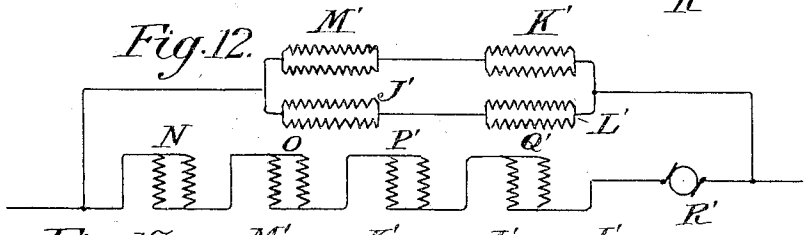


Fig. 13.

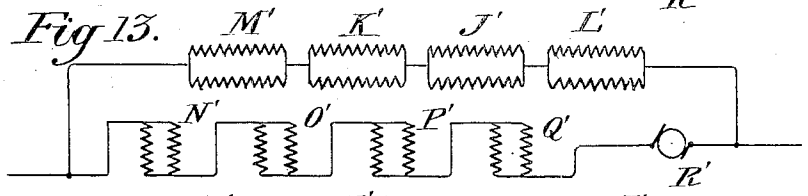


Fig. 14.

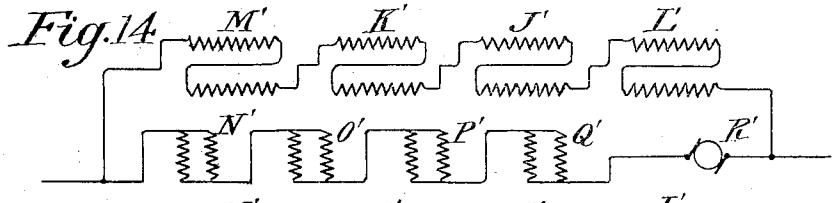
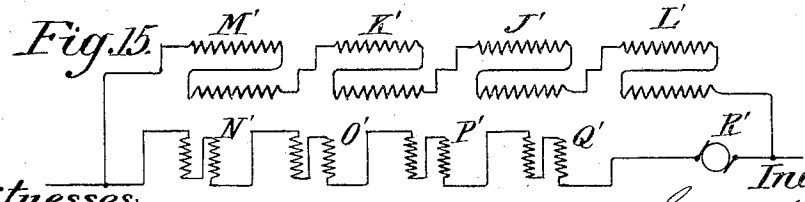


Fig. 15.



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UNITED STATES PATENT OFFICE.

GEORGE HERBERT CONDICT, OF NEW YORK, N. Y.

REGULATING DYNAMO-ELECTRIC MACHINES.

1,029,276. Specification of Letters Patent. Patented June 11, 1912.

Application filed January 10, 1906, Serial No. 295,418. Renewed October 8, 1910. Serial No. 586,069.

To all whom it may concern:

Be it known that I, GEORGE HERBERT CONDICT, a citizen of the United States, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Regulating Dynamo-Electric Machines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to the control of dynamo electric machines.

While the invention may be employed to regulate either generators or motors, it is contemplated that it will be most widely employed to effect the speed control of motors, and especially such motors as are employed in railway service.

It is an object of the invention to effect the desired control in an efficient manner, and to this end there is provided a method of and apparatus for successively connecting certain of the field windings in different relations, the manipulations of the windings referred to being effected without altering the connections of the remaining field windings.

It has heretofore been proposed to effect the control of electric motors by successively connecting their field windings in different relations, but all systems heretofore proposed for this purpose have involved the changing of the relative connections of the windings upon all of the poles. In fact, it is necessary in all prior systems, in order to produce balanced conditions in the armature, that the winding of each pole be simultaneously and correspondingly changed in its connections whenever it is desired to bring about a change in the relative connections of the field coils. In some types of machines, however, it is desirable to effect changes in the relative connections of certain of the coils, whereby the desired regulation is effected, either by changing the relations of the coils of the poles to each other as wholes or the winding of a pole may be divided into sections and the relative connections of the sections varied, or both, while throughout the ordinary regulation of the machine certain other of the field windings remain unchanged.

A notable instance of a type of machine to which the present invention is applicable, is that of a generator or motor which is supplied with main field poles designed to furnish the main excitation and also with auxiliary or compensating poles which supply the commutating field for the armature coils. Machines of this type are especially adapted for use as variable voltage dynamos or variable speed motors, and while the strength of the main poles may be altered to change the voltage or speed as the case may be, the relative connections of the winding upon the auxiliary poles should remain unchanged throughout the ordinary range of regulation. The number of the ampere turns of the windings upon the auxiliary or commutating poles then varies with the current of the circuit to which the windings are connected, and in order that the commutating fields may be of proper values to effect perfect commutation at all loads, the commutating pole windings will ordinarily be connected to the armature circuit so that the commutating fields will vary with the load.

While, as has been stated, the connections of the windings upon the auxiliary poles should not be changed, and the current in those windings should vary with the load throughout the ordinary regulations of the machine, it may be desirable, under some conditions, to vary the commutating fields independently of the load, and it is therefore, a further object of the invention to provide a method of and apparatus for accomplishing that result. This may be done by changing the relative connections of the auxiliary pole windings.

In the accompanying drawings; Figure 1 is a diagram showing the windings of a motor sufficient for an understanding of the present invention, together with a controller for effecting the desired connections. The controller is of the usual cylindrical type, the cylinder contacts being shown as developed upon a plane surface as is customary in illustrating such structures. The stationary contacts are represented as circles according to the usual mode of representation. Figs. 2 to 8 inclusive are simplified diagrams showing the connections of the various parts of the motor at different steps

of the controller. Fig. 9 is a view similar to Fig. 1 of a modified form of motor and controller therefor, and Figs. 10 to 15 inclusive are simplified diagrams showing the connections of the motor of Fig. 9 in the different positions of its controller.

Referring to the drawings and first to Fig. 1, the motor comprises a frame A upon which are mounted the main poles B, C, D and E and the auxiliary or compensating poles F, G, H and I, the last set of poles being designed to furnish the commutating fields for the armature coils and located in the spaces between the main poles. Upon the main poles of the motor are mounted the windings J, K, L and M composed respectively of the sections *a*, *b*, *c*, *d*, and *e*, *f*, *g*, *h*, and *i*, *j*, *k*, *l*, and *m*, *n*, *o*, *p*. Upon the commutating poles are windings N, O, P and Q, composed respectively of the sections *q*, *r*, and *s*, *t* and *u*, *v* and *w*, *x*. Within the poles rotates the armature R having the commutator S and a suitable number of brushes T, U, which bear upon commutator segments connected to coils lying under the commutating poles. The controller V comprises movable and stationary contacts as hereinbefore referred to, and in order to prevent excessive length of the controller, the stationary contacts are divided into two rows instead of being in one row, although the latter construction might be adopted where the practical objections to the length are not present or it causes no serious inconvenience. The various contacts will be referred to in connection with the detailed description to follow. A reversing switch W for interchanging the armature conductors is provided. This switch is of usual construction and requires no special description. It is represented as having its movable contacts in development as in the case of the controller V and, also in correspondence with the illustration of the controller, the stationary contacts are shown as circles. The usual starting resistance X may be provided. Suitable conductors connect the terminals of the various field sections with the stationary contacts of the controller. In order to avoid confusion, however, the conductors are partly broken away, each of the said conductors being numbered and connected to the fixed controller contact designated by the conductor number primed.

The apparatus being in the position as shown in Fig. 1, if the movable contacts be turned toward the right until they come into engagement with the stationary contacts and the rows of the latter lie along the lines 1—1 and 1′—1′ respectively, the circuit may then be traced as follows: From the plus side of the source of supply to the resistance X, stationary contact *x*, to the stationary contacts 1′ and 3′ through conductors 1 and 3, sections *q* and *r* of the winding N upon the commutating pole F and through the conductors 2 and 4 to the stationary contacts 2′ and 4′, which are connected together. It will be observed that the two sections *q*, *r*, are connected in parallel. To the stationary contacts 2′ and 4′ are connected the stationary contacts 5′ and 7′ and therefore the circuit is continued through conductors 5 and 7, sections *s* and *t* of the winding O upon the commutating pole G and the conductors 6 and 8 to the stationary contacts 6′ and 8′, which are connected together, and to the stationary contacts 9′ and 11′. From the contacts 9′ and 11′, the circuit may be traced through the conductors 9 and 11, sections *u* and *v* of the winding P upon the commutation pole H and the conductors 10 and 12 to the stationary contacts 10′ and 12′. The contacts 10′ and 12′ are connected together and to the stationary contacts 13 and 15. From the contacts 13′ and 15′, the circuit proceeds through the conductors 13 and 15, the sections *w* and *x* of the winding Q upon the commutation pole I and the conductors 14 and 16 to the stationary contacts 14′ and 16′ which are connected together and to the stationary contact 17′. It will be observed that the sections of each of the commutation pole windings are connected in parallel with each other and the windings of the poles as wholes are connected in series. From the stationary contact 17′, the circuit proceeds through conductor 17, section *m* of the winding M upon the main pole E, conductor 18, stationary contact 18′, stationary contact 19′, conductor 19, section *n* of the winding M, conductor 20, stationary contact 20′, stationary contact 21′, conductor 21, section *o* of the winding M, conductor 22, stationary contact 22′, stationary contact 23′, conductor 23, section *p* of the winding M, conductor 24, stationary contact 24′, stationary contact 25′, conductor 25, section *a* of the winding J upon the main pole B, conductor 26, stationary contact 26′, stationary contact 27′, conductor 27, section *b* of winding J, conductor 28, stationary contact 28′, stationary contact 29′, conductor 29, section *c* of the winding J, conductor 30, stationary contact 30′, stationary contact 31′, conductor 31, section *d* of the winding J, conductor 32, stationary contact 32′, stationary contact 33′, conductor 33, section *e* of the winding K upon the main pole C, conductor 34, stationary contact 34′, stationary contact 35′, conductor 35, section *f* of winding K, conductor 36, stationary contact 36′, stationary contact 37′, conductor 37, section *g* of winding K, conductor 38, stationary contact 38′, stationary contact 39′, conductor 39, section *h* of winding K, conductor 40, stationary contact 40′, stationary contact 41′, conductor 41, section *i* of the winding L upon the main pole D, conductor 42, stationary contact 42′, stationary contact 43′, conductor

43, section *j* of the winding L, conductor 44, stationary contact 44′, stationary contact 45′, conductor 45, section *k* of the winding L, conductor 46, stationary contact 46′, stationary contact 47′, conductor 47, section *l* of the winding L, conductor 48, stationary contact 48′, stationary contact 49′, conductor 49″ to the two top stationary contacts of the reversing switch W, assuming the reversing switch to be thrown to the left, from the left hand upper stationary contact circuit will be made through the conductor 49 to the brush T and through the winding of the armature R to the brush U, thence through the conductor 50, to the lower middle left hand stationary contact of the reversing switch to the conductor 50″, stationary contact 50′, and the stationary contact 51′ to the minus side of the source of supply. The connections of the various windings are now as shown in Fig. 2. It will now be observed that the sections of the windings upon each main pole are connected in series, that these poles as wholes are connected in series, and that the two sets of field windings (main pole and commutating pole) are connected in series with each other and with the starting resistance and armature. The windings are those of a series motor, in which the field windings are of negligible resistance so that they cause small ohmic drop in the armature circuit. In this position of the controller, it will be seen that the entire armature current traverses each section of the main field windings and therefore the field is at its greatest strength which is a desirable condition at starting. It will be also observed that the windings of the commutating poles are connected in series with the armature, so that the strength of the commutating field is proportionate to the armature current which is desirable for producing perfect commutation at all loads.

If now the cylinder be turned to the right, passing the second and third positions of the controller indicated respectively by the dotted lines 2—2 and 3—3 for one row of stationary contacts and the dotted lines 2′—2′ and 3′—3′ for the other set of contacts, the only changes occurring will consist in the successive cutting out of sections of the resistance X as the controller passes the steps referred to, and when the fourth position is reached as indicated by the dotted lines 4—4 and 4′—4′, the resistance will be entirely cut out. The connections will then be as indicated in Fig. 3, and it will be observed that the relative connections of the various windings have not been altered from those shown in Fig. 2 and the only change which has been brought about is the cutting out of the starting resistance X.

In the next position of the controller indicated by dotted lines 5—5 and 5′—5′, the stationary contacts 16′, 17′ and 33′ are connected together, the contacts 48′, 32′ and 49′ are connected together, otherwise the connections remain as in the fourth position. The connecting together of the contacts as noted results in the connecting together of their respective conductors and consequently the various windings are connected as shown in Fig. 4. An inspection of this last figure will show that the relative connections of the sections forming the winding of a pole have not been changed, but that the pole windings as entireties have been connected two in series and the pairs in parallel. Otherwise the connections are as shown in Fig. 3. The current in the field coils is limited by the counterelectro-motive force of the armature and in the arrangement shown in Fig. 4, the main field coils will each receive one-half of the armature current instead of the whole armature current, as was the case when they were connected in series. The obvious result therefore is that the magneto-motive force of the main poles and consequently their magnetic field is weakened and an increased speed of the armature takes place. The windings of the commutating poles, however, take the full armature current as previously and therefore their field remains the same, except as it may be changed by increase or decrease of load.

In position 6 of the controller as indicated by dotted lines 6—6 and 6′—6′, the stationary contacts 16′, 17′, 25′, 33′, and 41′ are connected together, and the stationary contacts 24′, 32′, 40′, 48′ and 49′ together, otherwise the connections remain as before. This change of connections results in the connecting of each of the main pole windings as a whole singly in parallel with the others, the relative sections of the winding of a pole remaining unchanged. The various windings will then be connected as shown in Fig. 5, which differs from Fig. 4 only in that the main pole windings have been connected singly in parallel instead of connecting two in series and the pairs in parallel. One-fourth of the armature current now passes through each pole winding instead of one-half as was the case in the next preceding position of the controller, and therefore, the field being weaker, the speed is further increased.

In the next position of the controller as indicated by the dotted lines 7—7 and 7′—7′, the stationary contacts 16′, 17′, 21′, 25′, 29′, 33′, 37′, 41′ and 45′ are connected together, while the stationary contacts 20′, 24′, 28′, 32′, 36′, 40′ 44′, 48′ and 49′ are connected together, otherwise the connections remain as before. The windings are now connected as shown in Fig. 6, from which it will be seen that the sections of the winding upon each main pole are divided into pairs, the members of which are connected in series, and that the several pairs are connected in

parallel with each other. This change in the connections of the windings of the main poles is the only change which has been made over the connections set forth in Fig. 5. The result of the new connections is to divide the armature current into eight parts and therefore the current flowing in the main pole windings is only half as great as where the connections were as shown in Fig. 5. There is therefore a still further weakening of the main field of the motor and a further increase in its speed.

In the next position of the controller as indicated by dotted lines 8—8 and 8′—8′, the stationary contacts 16′, 17′, 19′, 21′, 23′, 25′, 27′, 29′, 31′, 33′, 35′, 37′, 39′, 41′, 43′, 45′, and 47′ are connected together, while the stationary contacts 18′, 20′, 22′, 24′, 26′, 28′, 30′, 32′, 34′, 36′, 38′, 40′, 42′, 44′, 46′, 48′ and 49′ are connected together, otherwise the connections remain as before. The connecting of the contacts as described results in the connecting of each of the sections of the various pole windings in parallel with the remainder, as shown in Fig. 7. It will now be seen that the armature current is divided among sixteen paths and that therefore the current strength in the winding is one-half that in the next preceding position of the controller and the speed of the motor is correspondingly increased.

Up to the present point, it will be noted there has been no change in the relative connections of the windings or coils composing the windings of the commutating poles. From the first position of the controller up to the present point, the sections of each pole have been connected in parallel and the windings of the poles as wholes have been connected in series, and they have been connected in series with the armature so that the strength of the commutating field is varied only by reason of a change in the armature current. The changes in the speed of the motor have been brought about by varying the connections of the windings upon the main poles without changing the relative connections of the windings upon the commutating poles. The connections established by the controller in passing through the range which it traverses in the ordinary regulation of the motor have been explained in detail, and it is desirable that in the effecting of the usual control of the motor, the relative connections of the commutation pole windings should not be changed. It may be, however, that under certain conditions of operation, it may be desirable to change the relative connections of the commutation pole windings and therefore a set of contacts has been provided whereby the desired change may be brought about. As an instance of the conditions under which such a change would be desirable, reference may be made to the case where the motor is operating under an extremely heavy load and the sectional area of the commutation poles is sufficient to permit the increase of magnetism in proportion to the increase in load where the loads are within the limits marking the normal or usual operation of the motor, but is not sufficient to permit an increase of field in proportion to the armature current where the load is outside the normal limits on account of the approach of the commutation poles to saturation. In such a case, it is necessary to increase the magneto-motive force in a greater proportion than is necessary to produce the desired increase in magnetism at a point further removed from saturation. This disproportionate increase in the magneto-motive force may be effected by altering the relative connections of the field winding upon the commutation poles. The connections by which applicant, in the structure illustrated, accomplishes this result will be described with reference to the connections which are established when the controller is in its 9th position, as indicated by the dotted lines 9—9 and 9′—9′. In this position of the controller, the following stationary contacts are connected together in pairs, namely, 2′ and 3′, 4′ and 5′, 6′ and 7′, 8′ and 9′, 10′ and 11′, 12′ and 13′, 14′ and 15′. Otherwise the connections remain as before. The change in the connection of the contacts as noted operates to change the relative connections of the sections of each commutation pole winding from parallel to series, the other connections remaining unchanged as shown in Fig. 8. The effect of the change in connections is to cause the entire strength of armature current to flow through each section of the commutation pole windings which is twice the strength of current which flowed through those sections when they were connected in parallel.

In Figs. 9 to 15, is illustrated the application of the invention to a motor of a different type from that previously described. This motor belongs to that class of motors commonly known in the art as shunt motors and is characterized by the fact that the field winding is of comparatively high resistance and is connected across the terminals of the armature instead of in series therewith as in the case of a series motor.

Referring to the drawings, last mentioned, the motor comprises a frame A′, main poles B′, C′, D′, and E′, commutating poles F′, G′, H′, I′, armature R′ having a commutator S′ on which bear the brushes T′ and U′. Upon the main poles are placed the energizing windings J′, K′, L′, and M′ respectively, while upon the commutation

poles are respectively placed the windings N′, O′, P′ and Q′. The windings upon the main poles are respectively divided into sections a' and b', c' and d', e' and f', g' and h'. Similarly the windings upon the commutation poles are divided into sections p' and i', j' and k', l' and m', n' and o' respectively. Secured to the terminals of the sections of the windings upon the commutation poles are conductors 101 to 116 respectively, while the conductors 117 to 132 respectively are connected to the terminals of the sections of the windings upon the main poles. As in Fig. 1, the conductors are not shown in Fig. 9 in their entirety for the sake of clearness, but each of the conductors is connected to a stationary contact of the controller V′ which is designated by the number applied to the conductor primed. A reversing switch W′ is provided as in the case of the apparatus illustrated in Fig. 1, and it will be understood in the explanation that is to follow that this switch is thrown to the left as was the case in considering the circuit connections of the apparatus of the first figure. A starting resistance X′ is provided as in the preceding apparatus.

It being assumed that the controller is in a position as indicated in Fig. 9, if now the reversing switch be thrown to the left and the movable contacts be moved toward the right until the rows of stationary contacts lie respectively upon the lines 11—11 and 11′—11′, which mark the first position of the controller, the armature circuit may be traced as follows: from one side of the line through the starting resistance X′, to the stationary contact x', thence through the stationary contacts 101′ and 103′, which are connected together, through the conductors 101 and 103, sections p' and i' of the winding N′ upon the commutation pole F′, conductors 102 and 104 to stationary contacts 102′ and 104′, which are connected with the contacts 105′ and 107′. Thence the circuit passes through the conductors 105, 107, the sections j' and k' of the winding O′ upon the pole G′, conductors 106 and 108 to stationary contacts 106′ and 108′ which are connected with the contacts 109′ and 111′. Thence the circuit passes through conductors 109 and 111, sections l' and m' of the winding P′ of the pole H′, conductors 110 and 112 to the stationary contacts 110′ and 112′ which are connected together and to the contacts 113′ and 115′. Thence the circuit passes through the conductors 113 and 115, the sections n' and o' of the winding Q′, upon the pole I′, conductors 114 and 116 to the contacts 114′ and 116′, which are connected together and to the contact 133′. Thence the circuit passes through the conductor 133″ to the contact 133‴ and thence through the stationary contact 133⁗ of the reversing switch, conductor 133, brush T′, commutator S′, the winding of the armature R′, brush U′, conductor 134, stationary contact 134^4 of the reversing switch, thence through stationary contact 134‴, conductor 134″, stationary contact 134′ and stationary contact 135′, to the other terminal of the source.

The field circuit may be traced as follows: from one side of the source of supply to the stationary contact 136′ and thence to the stationary contacts 117′, 119′, 121′, 123′, 125′, 127′, 129′, and 131′, thence circuits may be traced through the conductors, 117, 119, 121, 123, 125, 127, 129 and 131 to one terminal of each of the sections of the main windings a', b', c', d', e', f', g' and h' through which the current passes to the conductors 118, 120, 122, 124, 126, 128, 130 and 132 to the stationary contacts 118′, 120′, 122′, 124′, 126′, 128′, 130′, and 132. The last mentioned stationary contacts are connected to each other and to the stationary contact 135′, the last mentioned contact being connected to the other side of the source of supply. It will be observed that in this position of the controller all the sections of the main windings are individually connected between the terminals of the source of supply and that the sections are connected in parallel. The current in the shunt field windings depending upon the ohmic resistance of those windings, the connections which have been described offer the least resistance to the passage of current and therefore the current will be relatively large and the field strong, which is a desirable condition at starting. The connections are then as shown in Fig. 10. Further movement of the controller to the right until the 4th position indicated by the dotted lines 14—14 and 14′—14′ operates to cut out the starting resistance X′ in a well known manner, and in the 4th position this resistance is entirely cut out, the connections being as shown in Fig. 11.

In the 5th position of the controller, the stationary contacts 117′, 119′, 121′, 123′ are connected together and to the contact 136′, the contacts 118′, 120′, 125′ and 127′ are connected together, the contacts 122′, 124′, 129′, and 131′ are connected together, and the contacts 126′, 128′, 130′, and 132′ are connected together and to the contact 135′ which is connected with the other side of the source of supply. The connections of the various windings are now as shown in Fig. 12. It will be observed that the windings of the main poles as wholes are connected in series in pairs and the pairs are connected in parallel across the line. Otherwise the relative connections of the windings and armature remain as before. The

main field windings in this position of the controller offer increased resistance to the passage of current and the field of the motor is weakened with a corresponding increase in speed.

In the next position of the controller, the contacts 117′ and 119′ are connected together and to the stationary contact 136′, the stationary contacts 118′, 120′, 125, and 127′ are connected together, the stationary contacts 126′, 128′, 121′ and 123′ are connected together, the contacts 122′, 124′, 129′, 131′ are connected together, and the contacts 130′ and 132′ are connected together and to the contact 135′ which is connected to the other side of the source of supply. Otherwise the connections remain unchanged. The connections now are as shown in Fig. 13. It will now be seen that the only change effected by this step in the connections has been the connecting of the main pole windings as wholes in series. The relative connections of the sections of a pole winding have not been changed, nor have the relative connections of the armature and the other windings been changed. The result therefore is to oppose a greater resistance to the flow of current through the field windings with a corresponding weakening of field and increase of speed.

In the 7th position of the controller, contacts 136′ 117′ are connected together, as are also 118′ and 119′, 120′ and 121′, 122′ and 123′, 124′ and 125′, 126′ and 127′, 128′ and 129′, 130′ and 131′, 132′ and 135′. Otherwise the connections remain as before and the relative connections are now as shown in Fig. 14. It will be seen that the only change effected in the relative connection of the windings has been to connect the sections of the main windings singly in series. The effect of this connection is to decrease the field current and occasion a still further increase in speed.

In the next and last position of the controller, the object is to change the relative connections of the windings of the commutation poles and to this end, contacts are provided which connect together the stationary contacts 101′ and x', and connect them with one side of the source of supply, contacts 102′ and 103′, 104′ and 105′, 106′ and 107′, 108′ and 109′, 110′ and 111′, 112′ and 113′, 114′ and 115′, and 116′ and 133′ are respectively connected together. Otherwise the connections remain as before and the total connections as established in this position of the controller are as shown in Fig. 15. The only change in connections effected over the next preceding position consists in the connection of the sections of each of the commutation poles in series instead of in parallel, to effect objects as described in connection with the apparatus of Figs. 1 to 5 inclusive.

The invention has been illustrated and described sufficiently to enable anyone skilled in the art to practise it. It will be understood, however, that equivalent apparatus may be employed for carrying out the method and that various relative connections of the windings of the machine to be controlled may be employed without departing from the spirit of the invention. It is also apparent (as indicated, for instance, in Figs. 2, 3, 4 and 5, by dotted lines) that the coils on the auxiliary poles may be single coils, instead of parallel coils, whenever it is of minor importance to have extremely close regulation.

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

1. The combination with a dynamo electric machine having main field poles and auxiliary poles creating a commutating field, an armature and conductors associated therewith, and sectional windings upon the said poles, of a controller having contacts connected with the individual sections of said windings and so arranged that the initial movements of the controller change the grouping of the windings of the main field poles with respect to one another to weaken the magnetic field created thereby, without changing the grouping of the windings of the auxiliary field poles, and subsequent movements of the controller change the grouping of the windings of the auxiliary field poles to strengthen the magnetic field created thereby, substantially as described.

2. The combination with a dynamo electric machine having main field windings and auxiliary windings creating a commutating field, an armature and conductors associated therewith, of a controller having contacts connected with the said windings so arranged that the initial movement of the controller changes the grouping of the main field windings with respect to one another to weaken the magnetic field created thereby, without changing the connections of the auxiliary field windings, and subsequent movements of the controller change the grouping of the auxiliary windings to strengthen the magnetic field created thereby, substantially as described.

3. The combination with a dynamo-electric machine having main field poles and auxiliary poles creating a commutating field, an armature and conductors associated therewith, and windings upon the said main field poles and auxiliary poles connected in series with one another and with the armature, of a controller having contacts connected with the said windings and so arranged that the initial movements of the controller change the grouping of the windings of the main field poles with respect to

one another to weaken the magnetic field created thereby, without changing the grouping of the windings of the auxiliary field poles, and subsequent movements of the controller change the grouping of the windings of the auxiliary field poles to strengthen the magnctic field created thereby, substantially as described.

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

GEORGE HERBERT CONDICT.

Witnesses:
JOHN C. PENNIE,
WALTER R. HERRICK.