C. P. POOLE.

AUTOMATIC REGULATION FOR ELECTRICAL APPARATUS.

APPLICATION FILED APR. 13, 1912.

1,112,833. Patented Oct. 6, 1914.

3 SHEETS—SHEET 1.

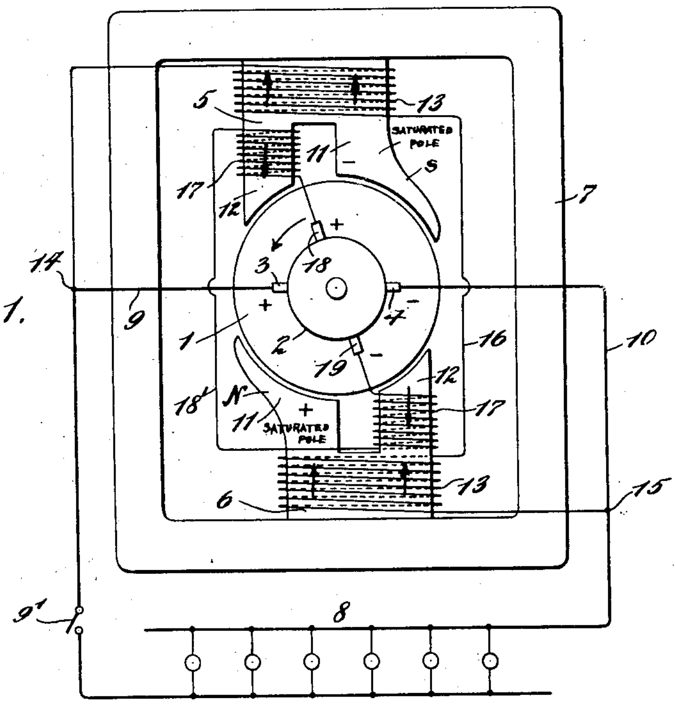

Fig. 1.

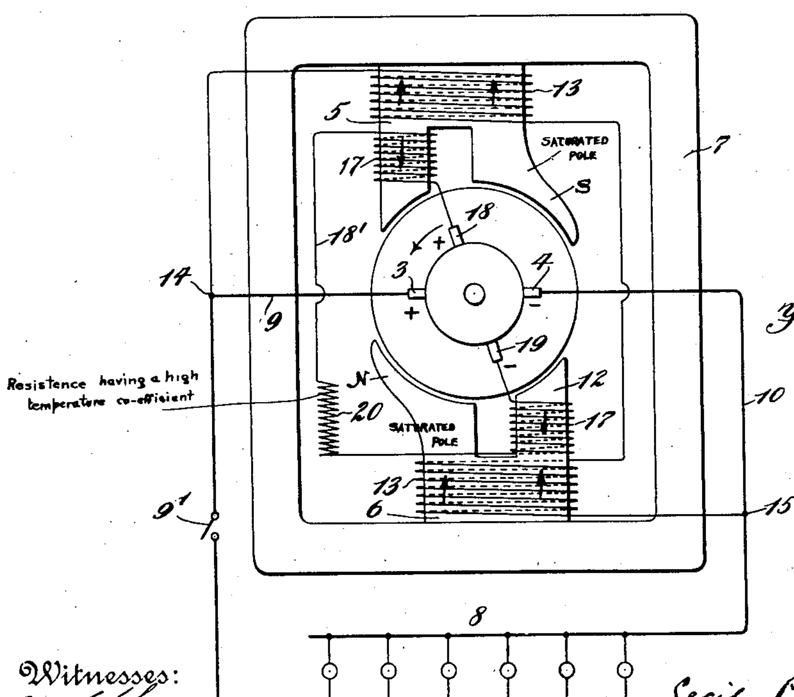

Fig. 2.

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3 SHEETS—SHEET 2.

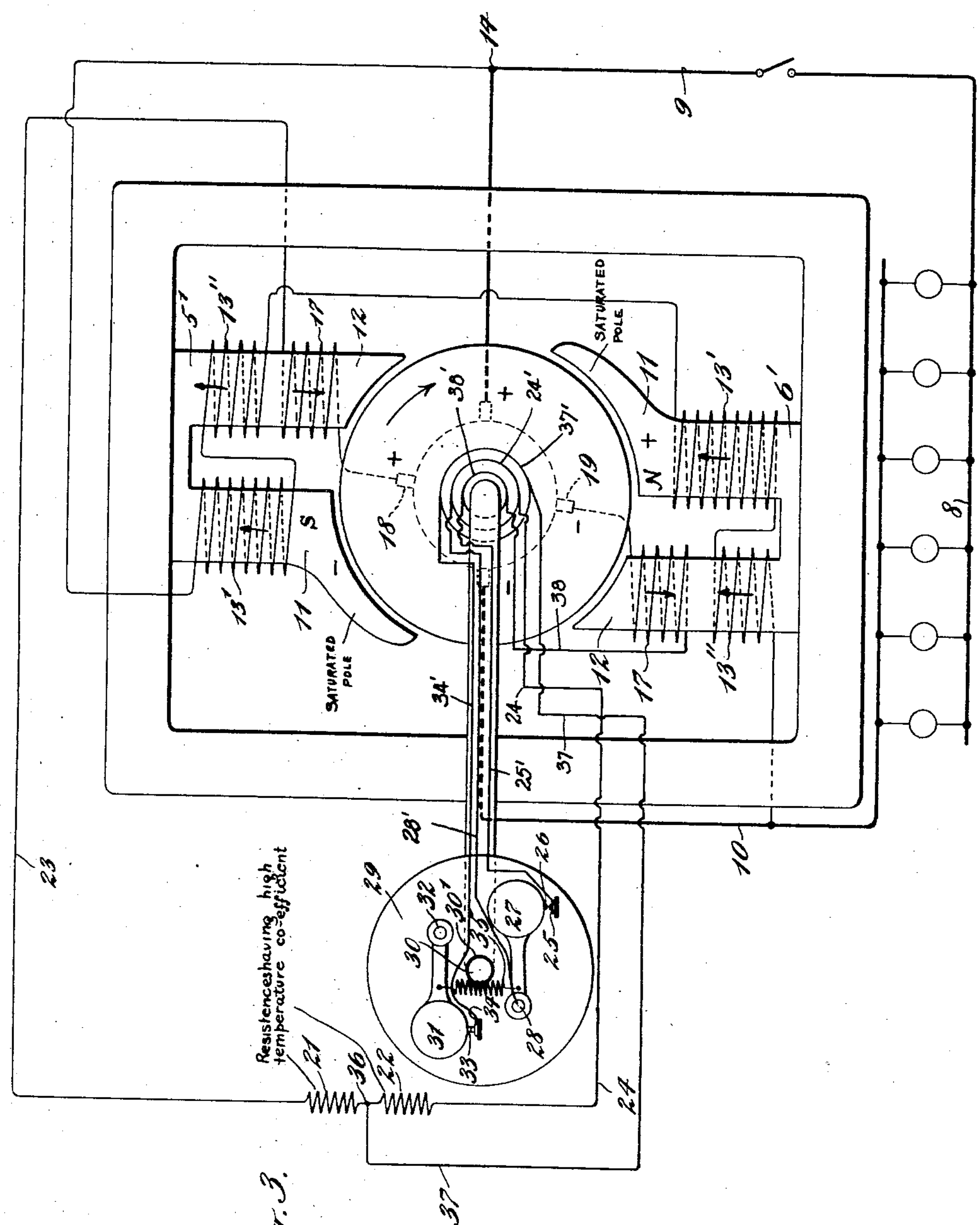

Fig. 3.

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3 SHEETS—SHEET 3.

Fig. 4.

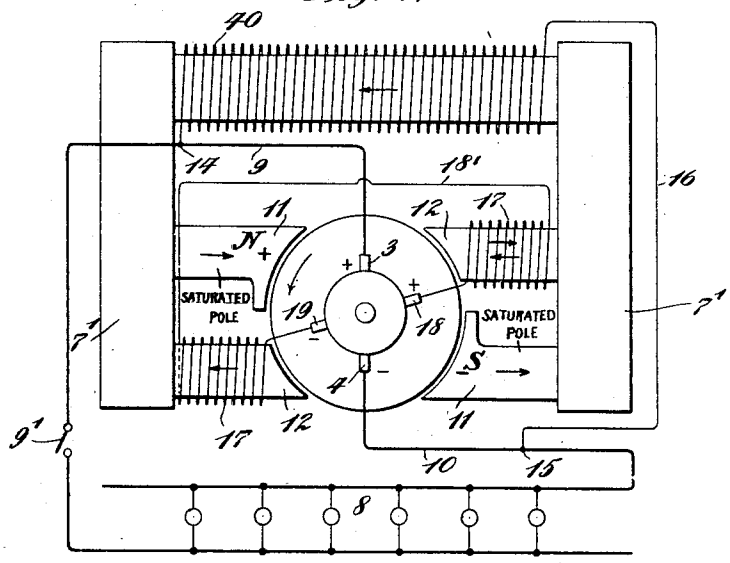
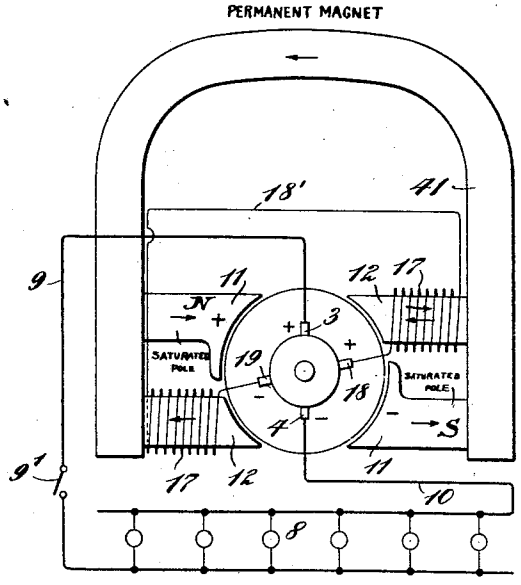


Fig. 5.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC REGULATION FOR ELECTRICAL APPARATUS.

1,112,833. Specification of Letters Patent. Patented Oct. 6, 1914.

Application filed April 13, 1912. Serial No. 690,584.

To all whom it may concern:

Be it known that I, CECIL P. POOLE, a citizen of the United States, residing at South Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Automatic Regulation for Electrical Apparatus, of which the following is a full, clear, and exact description.

This invention relates to electric motors and generators and has for its principal object the provision of improved means for regulating the action of devices of this character.

By way of exemplification I hereinafter describe my invention in connection with a dynamo or generator of the shunt type, to which it is particularly adapted, but I do not wish to be limited thereto in any way; and may here state further that I am aware of various modifications and changes which may be made in the apparatus without departing from the spirit of my invention and hence desire to be limited only by the scope of the appended claims.

Another object of my invention is to maintain, when desired, a substantially constant E. M. F. at the brushes after the initial rise in voltage, without shifting either the main, or other and auxiliary brushes of any description.

Still another object of my invention is to provide means for automatically shifting the general course of the magnetic field traversing the armature of a dynamo, with respect to the main brushes of said dynamo, whereby to regulate the E. M. F. at said brushes.

These and other objects will be hereinafter referred to and the novel elements and combinations of elements whereby they may be attained will be more particularly pointed out in the said claims.

In the accompanying drawings, which form a part hereof, and in which like reference characters designate like parts throughout the several views, I have somewhat diagrammatically illustrated several dynamos of the type in question each embodying one or more features of the present invention.

Figure 1 is a diagrammatic elevation of a simple bifurcated-pole, shunt wound machine; Fig. 2 is a similar view of a machine embodying a resistance in circuit with the auxiliary coils, hereinafter referred to; Fig. 3 shows a still further development of the invention, and exemplifies diagrammatically an electrical mechanism, *e. g.* a shunt wound dynamo, embodying the several features of the invention in combination. Fig. 4 is a view similar to Fig. 1, but showing a modified generator construction. Fig. 5 is a similar diagrammatic view of still another modification.

Referring first to Fig. 1, the machine proper herein shown comprises the usual armature 1, provided with a commutator 2, or the like, and main brushes 3 and 4, the former being in the present case the positive brush and the latter the negative. Two pole-pieces shown have been respectively designated 5 and 6 and the magnetic circuit is completed through the usual yoke or frame 7. The work circuit has been broadly designated 8 and comprises a positive lead 9 which is connected to the brush 3 and a negative lead 10 connected to the brush 4. A switch 9′ has been indicated in position in the lead 9.

Each of the pole-pieces is in the present instance bifurcated and comprises a major leg 11 and a minor leg 12, these legs preferably, but obviously of course not necessarily, having the conformation shown; the pole face of the major leg extending circumferentially over the surface of the armature a greater distance than the minor leg in each case. A main exciting coil 13 is shown for the sake of clearness, as encircling in this particular form of the device, the un-furcated portion of each pole-piece; the coil of pole 5 being connected to the positive lead 9 at 14 and the corresponding coil of the pole 6 being connected to the negative lead at 15 in the usual manner. These coils, therefore, are in shunt with the work circuit and are connected together by a wire 16 or the like. The armature is assumed to be rotated in the direction of the arrow indicated thereupon, and both legs of the pole-piece 5 would, in the construction shown, normally be negative; while the legs of the pole-piece 6 would correspondingly normally be positive. About each of the minor legs, however, is disposed an auxiliary or bucking coil 17, these coils preferably being connected together in series as at 18′, the respective extremities thereof being connected to the auxiliary brushes 18 and 19.

Brush 18 will, under the conditions pre-

scribed in the drawing, be positive and current will pass thence through the auxiliary coil upon the minor leg of pole-piece 5, thence via the connection 18′ to the corresponding coil upon the pole-piece 6, returning to the commutator through brush 19. Brushes 18 and 19 are spaced substantially, but preferably not quite, 90° away from the main brushes 3 and 4 respectively. The magnetic effect of the coils 17 is opposed to that of the main coils 13 and the legs of the magnetic poles are so proportioned that with normal excitation of the main field winding and with the auxiliary winding on open circuit, the major leg 11 of each pole-piece is normally highly over saturated and therefore does not respond readily to changes in excitation; while the respective minor legs are fluxed to relatively low density and therefore respond almost proportionately to variations in excitation.

At the minimum speed for which the machine is designed, the E. M. F. at the brushes 18, 19, is so small that the demagnetizing effort of the coils 17 is negligible, and the machine operates practically in the same manner as a shunt wound dynamo. As the speed increases, the E. M. F. delivered to the brushes increases, but that at the auxiliary brushes increases more rapidly than that at the main brushes, owing to the fact that the minor pole legs are more responsive than the major legs, and the weakening of the minor legs shifts the axis of the resultant field backward; or in other words, clockwise as viewed in Fig. 1. This shifting of the axis of the field is the equivalent of shifting both sets of brushes forward, but obviously is much preferable, in that there is no necessity for the provision of special mechanism and moving parts which require lubrication and more or less care; while it is further markedly more sensitive to slight variations in the E. M. F. induced in the armature winding. Shifting of the field in the manner described, it may here be noted, increases the E. M. F. at the auxiliary brushes 18, 19, and decreases that at the work-circuit brushes 3, 4.

In practice, with the most favorable proportions of the magnetic circuit and relations between the two field windings, the E. M. F. at the main brushes rises somewhat as the speed is increased beyond the minimum speed for which the machine is designed, and then falls with any further increase in speed. When the conditions of operation require it, in order to counteract this drop in potential at high speed, I may insert in series with the auxiliary field winding 17, a resistor 20, which is shown in circuit with the said coils in Fig. 2, being interposed in the lead or connection 18. Except for this resistor the parts shown in Fig. 2 are substantially identical with those in Fig. 1, so that no further detailed description of this figure need be given. It should be observed, however, that the resistor 20 is preferably made of material such as iron, having a high temperature-resistance coefficient at high temperatures and so proportioned that its resistance begins to increase very rapidly when the current in the auxiliary winding reaches the value which causes the main potential to fall with increase in speed.

By suitably proportioning the windings and the resistor, I obtain, up to a certain point, a substantially constant E. M. F. at the main brushes, after the initial rise, regardless of speed, and without having to shift the brushes. It is obvious that various other instrumentalities may be employed in lieu of the automatically variable resistance 20 above described, but owing to the simplicity of this construction and to the close approximation to constant E. M. F. at the main brushes which may be obtained by the use thereof at moderately high speeds, at least, it is preferred in such cases.

It is evident that a resistance which will properly regulate the amount of current passing through the bucking coils at the lower speed of the machine should be wound with a sufficiently low resistance to permit sufficient current to pass through the bucking coils at these lower speeds. If such a resistance is chosen, the amount of current passing through these coils at the higher speeds would be excessive and would cut down the voltage of the main line so that there will be a material drop of the main voltage, even with an increase of speed. By making the resistance of an automatically variable type which increases with the increase of current passing through it, it is evident that a proper regulation may be maintained for all speeds of the machine and the main voltage of the machine will remain practically constant.

Where the speed is liable to become excessive, as when racing, the construction shown in Fig. 3 may be employed to advantage. Herein the resistor 20 is replaced by, for example, a plurality of resistors 21, 22, one of which may normally be maintained in circuit with the bucking coils and a second of which may be automatically thrown into circuit therewith when the speed of the machine attains a determined point. The effect of cutting in the resistance in steps is similar to the effect produced by the use of an automatically variable resistance, but when the speed becomes excessive as when the machine races, it has been found that the variation of the resistance of a wire having a high temperature resistance co-efficient, is not sufficiently flexible and it becomes necessary to positively cut in more resistance after the machine begins to race. The bucking coils in this case have again been designated 17

and their respective auxiliary brushes 18 and 19; said brushes and the commutator being shown in dotted lines in the present instance, since for convenience of illustration the machine is viewed from the opposite side. A lead 23 corresponding to the lead 18′ extends from the coil 17 of the pole-piece 5′ around to the resistor 21, the latter being connected in turn to the resistor 22 and a connection 24 extending to a stud 28 hereinafter referred to. A fixed contact 25 is adapted for engagement with a movable contact 26 carried upon the weighted arm 27 of what is in effect a centrifugal governor; and this arm 27 is pivoted upon a stud 28 which projects laterally from a revoluble support 29; the latter being preferably carried upon the armature shaft 30 and being insulated therefrom as at 30′. The connection 24 above referred to extends to slip ring 24′, through wire 28′, to stud 28 and as the arm 27 is conductive, is in electrical communication with the contact 26. A second arm 31 is correspondingly pivoted at 32 upon the support or disk 29 and carries a contact 33 adapted for engagement with a fixed contact 34. Contacts 33 and 34 are normally in engagement, while those designated 25 and 26 are normally out of engagement; the means employed to this end being, in the present instance, a spring 35 which connects the said arms.

It will be observed that the effective leverage of spring 35, on arm 31 is greater than the effective leverage of said spring on arm 27. Hence, as the weights are equal and otherwise symmetrical with respect to the axis of rotation of the disk 29, the arm 27 will be displaced outwardly by centrifugal force before the arm 31, while as the speed slows down the latter will be first to move back into the position shown in Fig. 3.

The arms 27 and 31 may be electrically connected through the disk 29 and their respective studs 28 and 32; and the fixed contact 34 is connected to a point 36, intermediate the resistors 21 and 22, by means of a wire 37, slip ring 37′ and wire 34′. As long as the armature is rotated below a determined speed, the spring 35 will hold the contacts 25, 26, 33 and 34 in the position shown in Fig. 3. At such times the circuit from the auxiliary brushes 18 and 19 is open and the generator operates as a simple shunt wound machine. When, however, the armature speed is in excess of a first determined limit, contacts 25 and 26 will be driven into engagement through the action of centrifugal force and thereafter the current will flow from the brush 18 through the bucking coil 17 of pole 5′, lead 23, resistor 21, wire 37, slip ring 37′, wire 34′, contacts 34 and 33, arm 31, pivot 32, disk 29, pivot 28, arm 27, contacts 26 and 25, wire 25′, slip ring 38′, wire 38, bucking coil 17 of pole 6′ and thence back to the armature via brush 19. Assuming now that the speed of rotation of the armature continues to accelerate until a second determined speed is attained, the arm 31 of the centrifugal governor will be swung outwardly interrupting the electrical connection through the contacts 33 and 34. The electrical circuit will now include both of the resistances 21 and 22, so that current flowing over the lead 23 toward and through the resistor 21, will now pass successively through resistor 22, connection 24, slip ring 24′, wire 28′, stud 28, arm 27, contacts 26 and 25, wire 25′, slip ring 38′, wire 38, bucking coil 17 of pole 6′, and thence back to the armature via brush 19. The effect of this second action of the centrifugal governor, hence has been to throw yet further resistance into the bucking coil circuit. In general, therefore, the increase in speed of rotation of the armature beyond a first determined amount, will automatically throw into circuit the bucking coils and a resistance 21, which may, if desired, be an automatically variable one like resistor 20 previously described; and when a still further increase in speed takes place up to a second determined amount, an additional resistance is thrown into circuit with the bucking coils and this second resistance or resistor 22 may also be an automatically variable one.

In the present instance, in place of having a single main coil upon each of the pole pieces, I have employed what may be termed a divided main winding consisting of two sections or coils respectively designated 13′ and 13″. The section 13′ in each case preferably involves a considerably larger number of turns than does the corresponding section or winding 13″; the former being upon the major leg 11 of the pole-piece and the latter upon the minor leg 12 of the same. Of course the direction of winding in both sections 13′ and 13″ must be the same so that the effect of these windings when energized, is to magnetize both legs of the pole-piece in the same direction; negatively at the extremities of the pole 5′, while correspondingly the extremities of the pole 6′ are normally positive. In this case as in the former, the major leg 11 of the pole-piece is maintained substantially saturated while the minor legs are but partially so. The ampere turns in the bucking coils or windings 17 will neutralize to a greater or less extent the magnetizing effort of the coils or windings 13″, and the remaining connections may be substantially the same as in the preceding case.

Referring now to Fig. 4, I have shown a modification of the system which includes a dynamo or generator, the pole-pieces of which are very similar to those shown in Figs. 1, 2 and 3 save that in the present in-

stance the major and minor legs of each pole-piece are separately inserted into the yoke 7'; the forking or bifurcation of the pole-pieces extending to the roots thereof. In place of disposing the windings which correspond to those designated 13 or 13'—13'' upon the pole-pieces or upon portions of the same, I have in the present instance placed the main winding 40 around a portion of the yoke 7' which is relatively remote from said pole-pieces. In this case as in the former, however, the bucking coils or windings 17 are disposed around the minor legs of the pole-pieces, and the connections may be otherwise substantially the same as in the apparatus shown in Fig. 1; so that they need not be further described.

In Fig. 5, I have shown my system as applied to a generator having a permanent magnet 41 in lieu of the yoke 7' and winding 40 shown in Fig. 4. The bucking coils 17 are again shown in position upon the minor legs 12 of the pole-pieces of this permanent magnet and the remaining connections are substantially the same as those indicated in Fig. 4 except that there is no main winding and of course no connections thereto.

Having thus described my invention, I claim:

1. An electrical apparatus comprising a magnetizable structure with a plurality of furcated pole pieces, an armature adapted to co-act with said pole pieces, a commutator carried by said armature, a plurality of sets of brushes adapted for contact with said commutator, a main winding for exciting at least one leg of each of said pole pieces, an auxiliary winding for oppositely exciting another leg of each of said pole pieces, electrical connections between one set of said brushes and said main coils, and electrical connections between another of said sets of brushes and said auxiliary coils.

2. An electrical machine comprising a magnetizable structure having a determined number of pole-piece parts, an armature structure adapted to co-act with said parts to complete a magnetic circuit, one of said structures being rotatably mounted, means for establishing a magnetic flux through said parts, and auxiliary means for opposing said flux in a number of said pole-piece parts less than said determined number, said auxiliary means including a magnetizing winding and a resistor, in series therewith, composed of material adapted to automatically offer a markedly increased resistance to the passage of current therethrough as the current flow increases in relatively small degree beyond a relatively determined value.

3. An electrical machine comprising a magnetizable structure having a determined number of pole-piece parts, an armature structure adapted to co-act with said parts to complete a magnetic circuit, one of said structures being rotatably mounted, means for establishing a magnetic flux through said parts, and auxiliary means for opposing said flux in a number of said pole-piece parts less than said determined number, said auxiliary means including a magnetizing winding, resistance in circuit therewith, and means for varying said resistance when the speed of rotation of said rotatably mounted structure exceeds a determined amount.

4. An electrical machine comprising a magnetizable structure having a determined number of pole-piece parts, an armature structure adapted to co-act with said parts to complete a magnetic circuit, one of said structures being rotatably mounted, means for establishing a magnetic flux through said parts, and auxiliary means for opposing said flux in a number of said pole-piece parts less than said determined number, said auxiliary means including a magnetizing winding, a resistance in circuit therewith, and means including a centrifugal governor for varying said resistance when the speed of rotation of said rotatably mounted structure exceeds a determined amount.

5. A dynamo electric machine having a plurality of pole piece parts, an armature, means for maintaining a substantially constant magnetic flux through some of said parts, means for varying the magnetic flux in other of said parts, said means including a magnetizing winding and a resistance automatically controlled by the speed of the machine.

6. A dynamo electric machine having a plurality of pole piece parts, an armature, means for substantially saturating some of said parts, means for varying the magnetic flux in other of said parts, said means including a magnetizing winding and a resistance automatically controlled by the speed of the machine.

7. A dynamo electric machine having a plurality of pole piece parts, an armature, means for establishing a substantially constant magnetic flux through some of said parts, and means of varying the flux in other of said parts, said last named means including a magnetizing winding and a resistance having a high temperature resistance coefficient.

8. A dynamo electric machine having a plurality of pole piece parts, an armature, means for establishing a substantially constant magnetic flux through pairs of said parts including a set of main brushes on said armature, and means for varying the flux in other pairs of said parts, said means including a set of auxiliary brushes at substantially 90 electrical degrees from said main brushes.

9. A dynamo electric machine having a plurality of pole piece parts, an armature, main brushes thereon, means for establishing a substantially constant flux through a pair of said parts, said means including said main brushes, means for varying the flux in another pair of said parts, said means including windings on said other parts, and auxiliary brushes, said windings being connected in series and with said auxiliary brushes.

10. A dynamo electric machine comprising a pair of split pole pieces, an armature, main brushes thereon, field coils on each part of said pole pieces, said coils being connected in series to said main brushes, opposing coils on one part of each pole piece, auxiliary brushes on said armature at substantially 90 electrical degrees from said main brush, said opposing coils being connected in series with said auxiliary brushes.

11. A dynamo electric machine comprising a pair of split pole pieces, an armature, main brushes thereon, means on each part of said pole pieces, for magnetically saturating one part of each of the pole pieces, and coils on the non-saturated parts of each of the pole pieces for setting up a flux opposing the main flux, auxiliary brushes on said armature, said second named coils being connected in series and with said auxiliary brushes.

In witness whereof, I subscribe my signature, in the presence of two witnesses.

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