S. R. BERGMAN.

DYNAMO ELECTRIC MACHINE.

APPLICATION FILED JUNE 20, 1919.

1,340,004. **Patented May 11, 1920.**

2 SHEETS—SHEET 1.

Fig. 1.

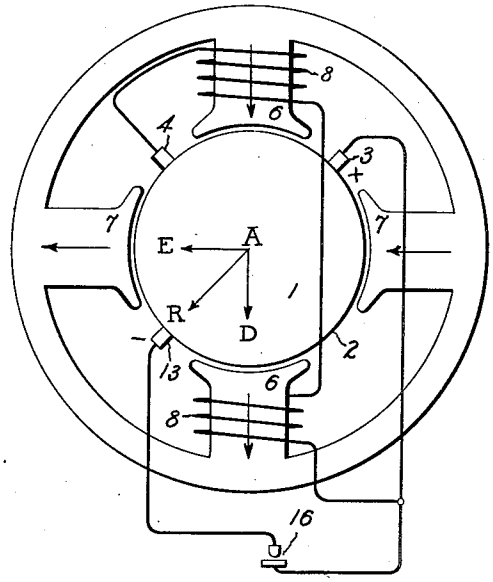


Fig. 2.

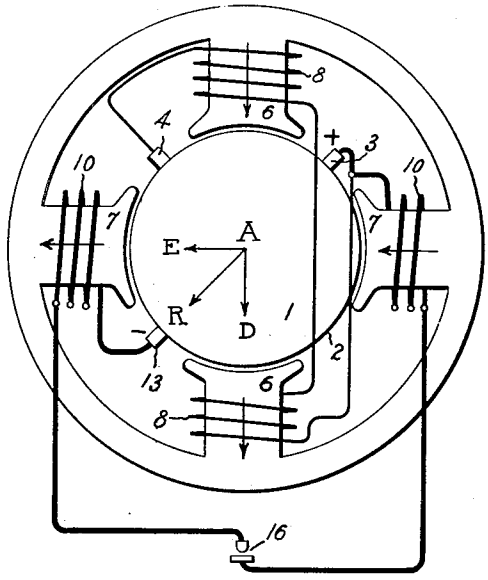


Fig. 3.

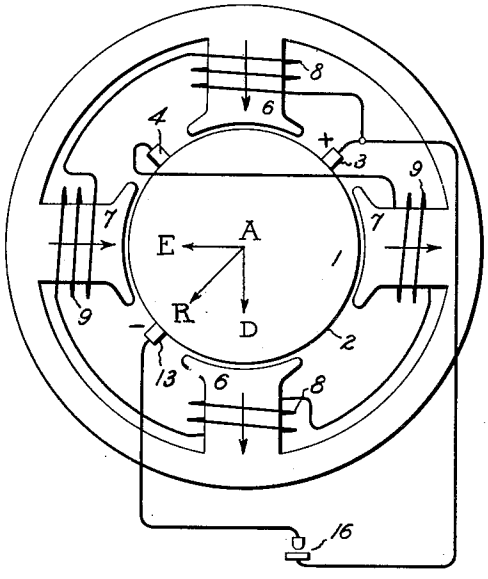
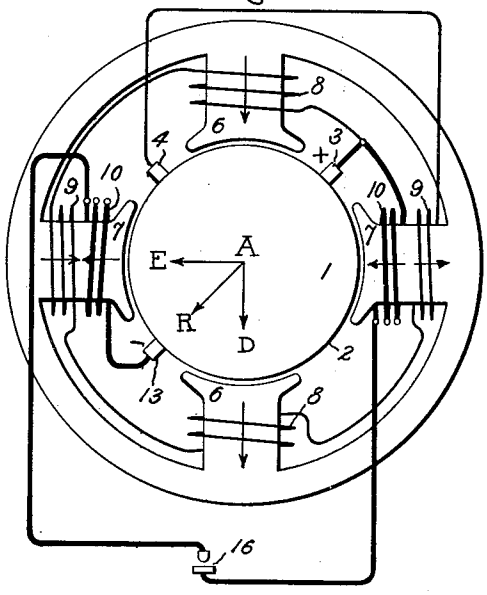


Fig. 4.



Inventor:
Sven R. Bergman,
by Albert G. Davis
His Attorney.

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2 SHEETS—SHEET 2.

Fig. 5.

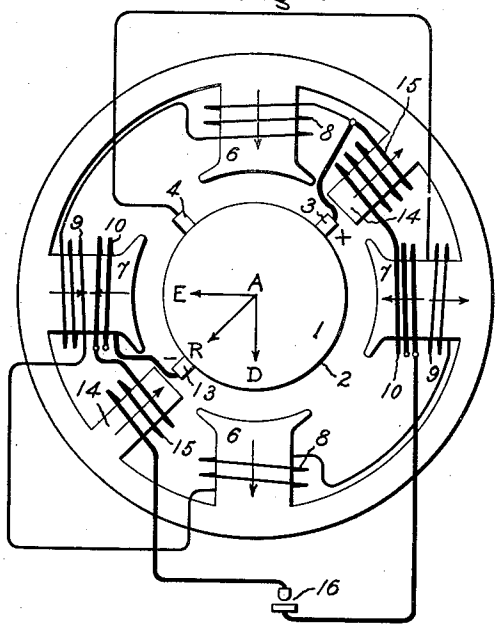
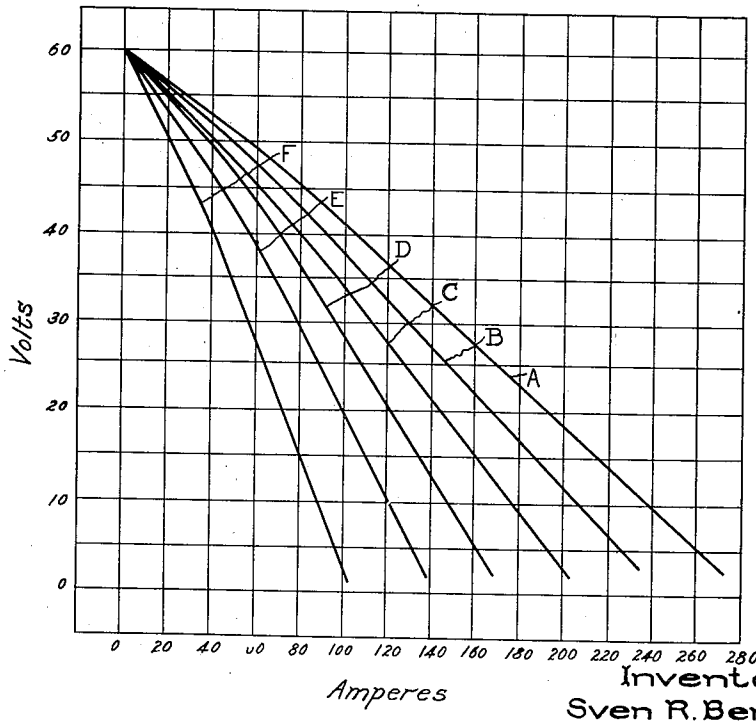


Fig. 6.



Inventor:
Sven R. Bergman,
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

SVEN R. BERGMAN, OF NAHANT, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

DYNAMO-ELECTRIC MACHINE.

1,340,004. Specification of Letters Patent. Patented May 11, 1920.

Application filed June 20, 1919. Serial No. 305,554.

To all whom it may concern:

Be it known that I, SVEN R. BERGMAN, a subject of the King of Sweden, residing at Nahant, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Dynamo-Electric Machines, of which the following is a specification.

My invention relates to dynamo-electric machines and particularly to dynamo-electric machines which supply electrical energy at different potentials, depending upon the load.

My invention is especially applicable to dynamo-electric machines which supply electrical energy for arc welding. In order to obtain the best results in arc welding a peculiar voltage-current characteristic of the source supplying electrical energy to the arc is required. If an electric arc is fed from a constant potential source, the action of the arc is very erratic, because the resistance of an arc decreases with an increase in current which results in a tendency for the current to become infinite if the potential across the terminals of the arc is maintained constant. Similarly if the current in the arc begins to decrease the resistance thereof increases and if a constant potential is maintained across the terminals of the arc, a further decrease in the current results until the arc goes out.

It is, therefore, desirable to have an arrangement which will cause the voltage across the terminals of the arc to decrease as the current in the arc increases so as to overcome the tendency of the current to approach an infinite value, and which will cause the voltage across the art to increase as the current in the arc decreases, in other words, an arrangement for automatically keeping the energy at the arc substantially constant within limits.

It is also necessary to limit the maximum current on short-circuit so as to prevent excessive heating and the maximum voltage on open circuit so as to protect the welder from injury and prevent the drawing of too long an arc.

The object of my invention is to provide a self-regulating dynamo-electric machine having a voltage characteristic which varies inversely as the current, and the maximum current and voltage of which are limited.

In accordance with my invention, I provide a commutator type dynamo-electric machine having an n-pole armature winding in a field structure comprising $2n$ mechanical poles, arranged in two sets with an equal number of poles in each set, with adjacent poles in the separate sets arranged to be of like polarity. At least three brushes are arranged to bear upon the commutator, this being the smallest number possible with a two pole armature. I am thus enabled to derive from the armature three electromotive forces, one of which is the resultant of the other two. Two of the brushes are spaced substantially 180 electrical degrees apart and arranged with respect to said poles so that the voltage between said brushes is dependent on the flux in both sets of poles. One set of poles is arranged to produce a voltage between the third brush and one 180 degree brush and the other set is arranged to produce a voltage between the third brush and the other of the 180 degree brushes. By constructing a machine in this way, and properly controlling the flux in each set of poles the machine may be designed with any desired operating characteristic. This type of dynamo electric machine is disclosed and claimed broadly in my application Serial No. 112,940, filed August 3, 1916. The voltage between the 180 degree brushes, for example, is equal to the algebraic sum of the voltages induced in the armature by the respective sets of poles and by arranging the sets of poles to produce voltages varying at different rates with variations in the output of the machine I am enabled by the inherent action of the machine to supply a load circuit connected to these brushes with a voltage which varies inversely with the current while at the same time the open circuit voltage and the short circuit current are limited to any desired values. In the preferred embodiment of my invention, I arrange one set of poles to be substantially saturated so that

the flux therein is substantially unaffected by armature reaction, and the voltage induced by this set of poles substantially constant at any given speed. I operate the other set of poles unsaturated and arrange them so that the flux therein is varied in amount and direction by the armature reaction due to load current, the arrangement being such that the voltage between the load brushes decreases when the load current increases.

Other features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of my invention reference may be had to the following description taken in connection with the accompanying drawing in which Figures 1 to 5 inclusive show diagrammatically several embodiments of my invention, and Fig. 6 is an explanatory diagram.

Referring to Fig. 1 of the drawing, 1 is the armature of a dynamo-electric machine having a commutator 2 on which bear the load brushes or sets of brushes 3 and 13 which are placed 180 electrical degrees apart, and an auxiliary brush or set of brushes 4 located between the load brushes. The armature 1 is preferably rotated at substantially constant speed by any well known means (not shown) such for example, as an induction motor, synchronous motor, D. C. shunt or compound motor, or other driving means.

A field magnet structure having two sets of field poles 6 and 7 surround the armature. The field poles 6 are arranged to produce a voltage between the auxiliary brush 4 and the load brush 3, and the field poles 7 are arranged to produce a voltage between the auxiliary brush 4 and the load brush 13. Preferably the voltage between brushes 4 and 3 remains substantially constant, and the voltage between brushes 4 and 13 varies with the load current. The voltage between the load brushes 3 and 13 is equal to the algebraic sum of the voltages between brushes 4 and 3 and brushes 4 and 13. In order that the voltage produced in that part of the armature connected between brushes 4 and 3 by the poles 6 shall remain substantially constant, the poles 6 are arranged to be operated at or near magnetic saturation. In order that the voltage produced in that part of the armature connected between brushes 4 and 13 by the poles 7 shall vary approximately with the load, these poles 7 are arranged to be operated substantially unsaturated by which is meant, the magnetic circuits of these field poles only approaches saturation when the load circuit is short-circuited.

The field poles 6 are excited by shunt field windings 8 which are connected between the auxiliary brush 4 and the load brush 3. Arrows indicate the direction of the flux produced by the various windings on the drawings. The armature is preferably series wound and has one-half as many poles as the field structure, that is, the number of poles in the armature corresponds to the number of poles in each set of the field poles. The arc welding equipment indicated at 16 is connected across the mains which are connected to the load brushes 3 and 13.

The operation of the dynamo-electric machine of Fig. 1 is as follows: Since the field magnetic circuit comprising the poles 6 is saturated, the voltage generated in the armature due to the flux in these poles, that is, that portion of the armature connected between auxiliary brush 4 and load brush 3 is substantially constant, and since the windings 8 are connected between these brushes the exciting current also remains constant.

Since the load current is taken from the main brushes 3 and 13 there exists an armature reaction AR which is substantially in line with these brushes. This armature reaction AR may be resolved into two components AD and AE. Since the magnetic circuit comprising poles 6 is saturated the component AD will not set up any additional flux therein. The component AE however will set up a flux through the field poles 7 in such a direction that the voltage generated between brushes 4 and 13 is of opposite polarity to the voltage generated between brushes 4 and 3. Since the voltage between the load brushes 3 and 13 is equal to the algebraic sum of the voltages between brushes 4 and 3 and brushes 4 and 13 the line voltage is equal to the voltage between brushes 4 and 3 minus the voltage between brushes 4 and 13, the machine can be so designed that the no-load voltage can be any desired value. Since the armature reaction varies with the load current, it will be apparent that line voltage decreases with an increase in load current.

In order to regulate the rate at which the voltage between brushes 4 and 13 increases with an increase in load it is preferable to use series windings 10 on the poles 7 as shown in Fig. 2. These series windings are wound so as to aid the component AE of the armature reaction. It will be apparent that by changing the number of turns of the series windings 10 any desired rate of change in the voltage between brushes 4 and 13 can be obtained. It is preferable therefore to provide the series winding 10 with a number of taps so that the rate can be readily changed.

Fig. 3 shows a modification of the machine shown in Fig. 1. In this figure the field poles 7 are provided with shunt windings 9 connected in series with the shunt windings 8 on the field poles 6. Since the

shunt windings 8 and 9 are connected to the brushes 4 and 3 the exciting current flowing through them is substantially constant. The field windings 9 are wound so that the flux set up by them is in opposition to the component AE of the armature reaction. Therefore, at no-load, the voltage between the load brushes 3 and 13 is equal to the voltage between brushes 3 and 4 plus the voltage 4 and 13. When, however, current is being supplied to the arc welding equipment 16 the component AE diminishes the flux through the magnetic circuit comprising the field poles 7 which results in a drop in the voltage between brushes 4 and 13 causing a corresponding drop in the voltage between brushes 3 and 13.

Since the armature reaction is usually not strong enough to obtain the desired regulation it is preferable to place the series windings 10 on the field poles 7, these series windings being wound in the same manner as in Fig. 2 so that the flux set up thereby is in such a direction as to aid the component AE of the armature reaction. Fig. 4 shows a machine wound in this manner. It will be noticed that the poles 7 carry a compound excitation, the shunt windings 9 and the series windings 10 acting differentially. These windings are so wound that at a certain value of load current, preferably about half load, the resultant flux in the poles 7 is zero. Then the voltage between the load brushes 3 and 13 is equal to the voltage between brushes 3 and 4 because the voltage between brushes 4 and 13 is zero at this time. When the line current increases above this value the resultant flux in the poles 7 builds up in the opposite direction so that the voltage between brushes 4 and 13 increases but with the opposite polarity to that between brushes 3 and 4. Therefore the voltage between brushes 3 and 13, instead of being equal to the voltage between brushes 3 and 4 plus the voltage between brushes 4 and 13, is equal to the voltage between brushes 3 and 4 minus the voltage between brushes 4 and 13. My machine is so designed that when the load circuit is short-circuited, the voltage between brushes 3 and 4 is substantially equal to the voltage between brushes 4 and 13.

In order to obtain perfect commutation, commutating poles 14 provided with windings 15 connected in series with the armature may be added as shown in Fig. 5. The commutating poles do not interfere with the regulation and are merely added in order to eliminate sparking. It has been found in practice that perfect commutation can be obtained in this way.

In order that a large number of welding currents can be obtained from a single machine, it is preferable to provide the series windings 10 with a number of taps, as shown in Figs. 2, 4 and 5. It will be evident that if only a small number of turns of the series winding are used a much larger current will have to flow to produce the necessary flux in poles 7 to give the desired regulation than in the case where a large number of turns of the series winding are used. By selecting the proper taps, any desired welding current within limits can be obtained. Fig. 6 shows the voltage-current characteristics of a machine when a different number of series turns are used. Curve A is the voltage-current curve of the machine when no series turns are used, curve B is the voltage-current curve when a few series turns are used. Curve C, D, E and F are similar curves where a larger number of series turns are used.

It is apparent that while I have provided a self-regulating generator which has voltage current characteristics which are especially adapted for arc-welding, certain features of my invention are capable of use in other relations and I desire to cover all such modifications and variations thereof which fall within the scope of my invention which is set forth in the appended claims.

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

1. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, and the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes and an exciting winding for said saturated poles connected between said auxiliary brush and one of said load brushes.

2. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush

and each of said load brushes, an exciting winding for said saturated poles connected between said auxiliary brush and one of said load brushes, and field windings on said unsaturated field poles wound so as to set up flux therein in the proper direction to aid the flux produced by the armature reaction.

3. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between said load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes, and field windings on said unsaturated field poles connected betwen said auxiliary brush and one of said load brushes and arranged to set up a constant flux in said poles in an opposite direction to the flux produced in said poles by armature reaction.

4. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltage between said load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes, field windings on said unsaturated field poles connected between said auxiliary brush and one of said load brushes and arranged to set up a constant flux in said poles in an opposite direction to the flux produced in said poles by armature reaction, and other field windings on said unsaturated field poles connected in series with the armature and wound differentially with respect to the first mentioned field windings.

5. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes, field windings for all of said poles connected between said auxiliary brush and one of said load brushes, the field windings on said unsaturated poles being arranged to set up a flux in an opposite direction to the flux produced in said poles by armature reaction.

6. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes, field windings for all of said poles connected between said auxiliary brush and one of said load brushes, the field windings on said unsaturated poles being arranged to set up a flux in an opposite direction to the flux produced in said poles by armature reaction, and other field windings on said unsaturated poles connected in series with the armature and wound differentially with respect to first mentioned field windings.

7. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes, the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes, and field

windings for all of said poles connected between said auxiliary brush and one of said load brushes and across that portion of the armature which has a voltage induced therein by the saturated poles, the field windings on said unsaturated poles being arranged to set up a flux in an opposite direction to the flux produced in said poles by armature reaction.

8. In a dynamo electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being saturated so that the flux in said set is unaffected by armature reaction and produces a constant voltage between said auxiliary brush and one of said load brushes and the other of said sets of poles being unsaturated so that the flux therein is varied by the armature reaction so that the voltage produced between the load brushes decreases when the load current increases, the voltages between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes, field windings for all of said poles connected between said auxiliary brush and one of said load brushes and across that portion of the armature which has a voltage induced therein by the saturated poles, the field windings on said unsaturated poles being arranged to set up a flux in an opposite direction to the flux produced in said poles by armature reaction, and other field windings on said unsaturated poles connected in series with the armature and wound differentially with respect to first mentioned field windings.

9. In a constant speed dynamo-electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field-magnet structure having two sets of field poles, one of said sets of poles being arranged to produce a substantially constant voltage between said auxiliary brush and one of said load brushes and the other of said sets of poles being arranged so that the armature reaction varies the flux therein and produces a voltage between said auxiliary brush and the other load brush which varies with the armature reaction, the voltage between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes and varying when the load current varies and a field winding on said first mentioned set of poles connected between said auxiliary brush and one of said load brushes.

10. In a constant speed dynamo-electric machine, an armature provided with a commutator, load brushes and an auxiliary brush bearing on said commutator, a field magnet structure having two sets of field poles, one of said sets of poles being arranged to produce a substantially constant voltage between said auxiliary brush and one of said load brushes and the other of said sets of poles being arranged so that the armature reaction varies the flux therein and produces a voltage between said auxiliary brush and the other load brush which varies with the armature reaction, the voltage between the load brushes being equal to the algebraic sum of the voltages between said auxiliary brush and each of said load brushes and decreasing when the load current increases, and a field winding on said first mentioned set of poles connected between said auxiliary brush and one of said load brushes.

11. An electrical system comprising an inherently regulated self-excited dynamo-electric machine having an n pole armature winding and field structure comprising 2 n mechanical field poles arranged in two sets with an equal number of poles in each set, adjacent poles of separate sets being arranged to be of like polarity, at least three brushes coöperating with said armature, two of said brushes being spaced substantially 180 electrical degrees apart and arranged with respect to said poles so that the voltage between said brushes is dependent on the flux in both of said sets of poles, the third brush being arranged with respect to said poles so that the voltage between said third brush and one of said 180 degree brushes is dependent of the flux in one only of said sets of poles, an exciting winding for the set of poles last mentioned connected to two of said brushes, a load circuit connected across one pair of said brushes, the other set of poles being arranged to have the direction of the flux therein controlled by armature reaction.

12. An electrical system comprising an inherently regulated self-excited dynamo-electric machine having an n pole armature winding and a field structure comprising 2 n mechanical field poles arranged in two sets with an equal number of poles in each set, adjacent poles of separate sets being arranged to be of like polarity, at least three brushes coöperating with said armature, two of said brushes being spaced substantially 180 electrical degrees apart and arranged with respect to said poles so that the voltage between said brushes is dependend on the flux in both of said sets of poles, the third brush being arranged with respect to said poles so that the voltage between said third brush and one of said 180 degree brushes is dependent on the flux in one only of said sets of poles, an exciting winding for the set of poles last men-

tioned connected to be supplied by two of said brushes, a load circuit connected across said 180 degree brushes, the machine being constructed and arranged so that the flux in said set of poles last mentioned is not varied by cross magnetization due to load current, the other set of poles being arranged to have the direction of the flux therein controlled by cross flux due to load current and means for adjusting the value of the cross magnetization.

In witness whereof I have hereunto set my hand this 18th day of June, 1919.

SVEN R. BERGMAN.