No. 855,484. PATENTED JUNE 4, 1907.

C. P. STEINMETZ.

CONSTANT CURRENT GENERATOR.

APPLICATION FILED AUG. 7, 1905.

2 SHEETS—SHEET 1.

Fig. 1.

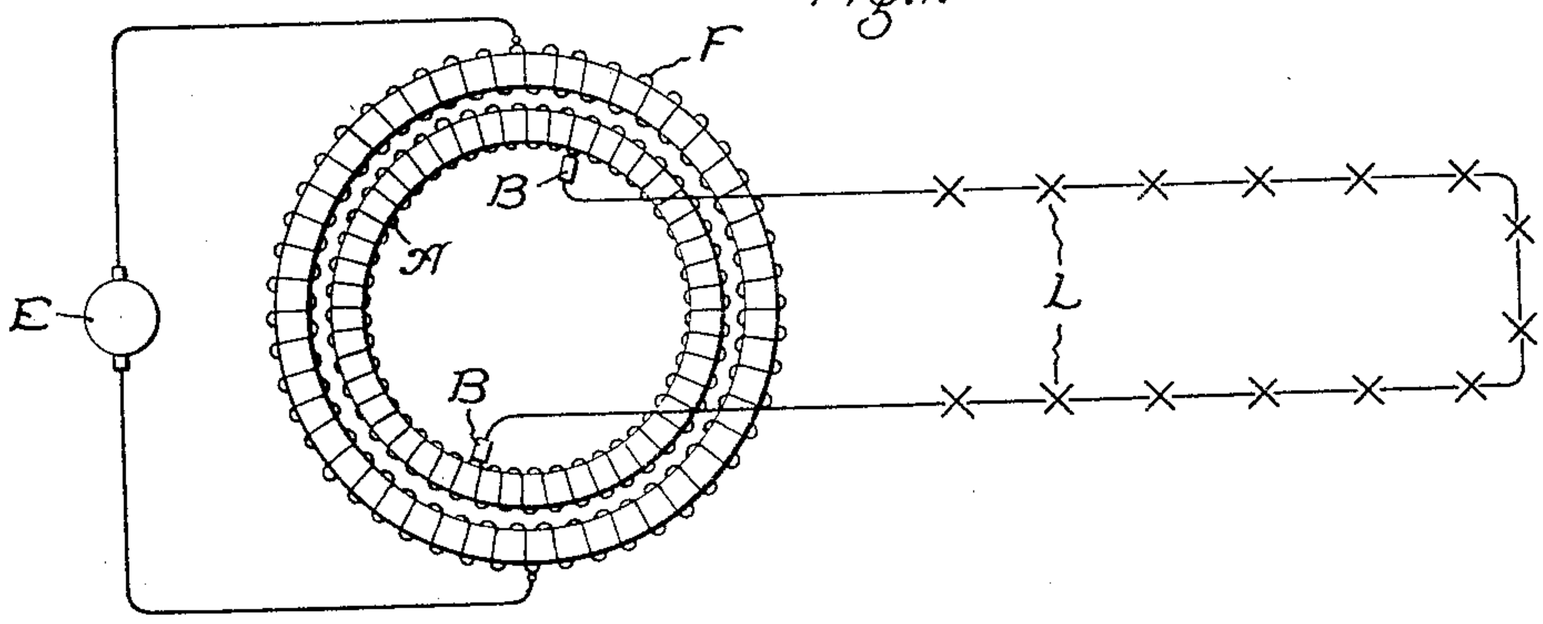


Fig. 2.

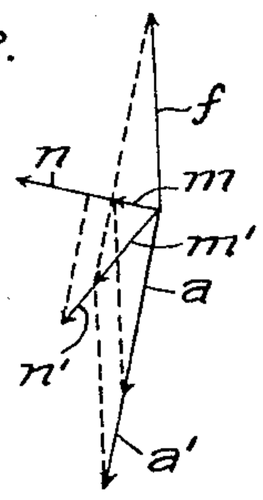


Fig. 3.

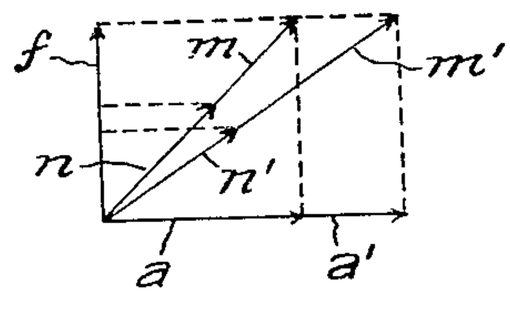
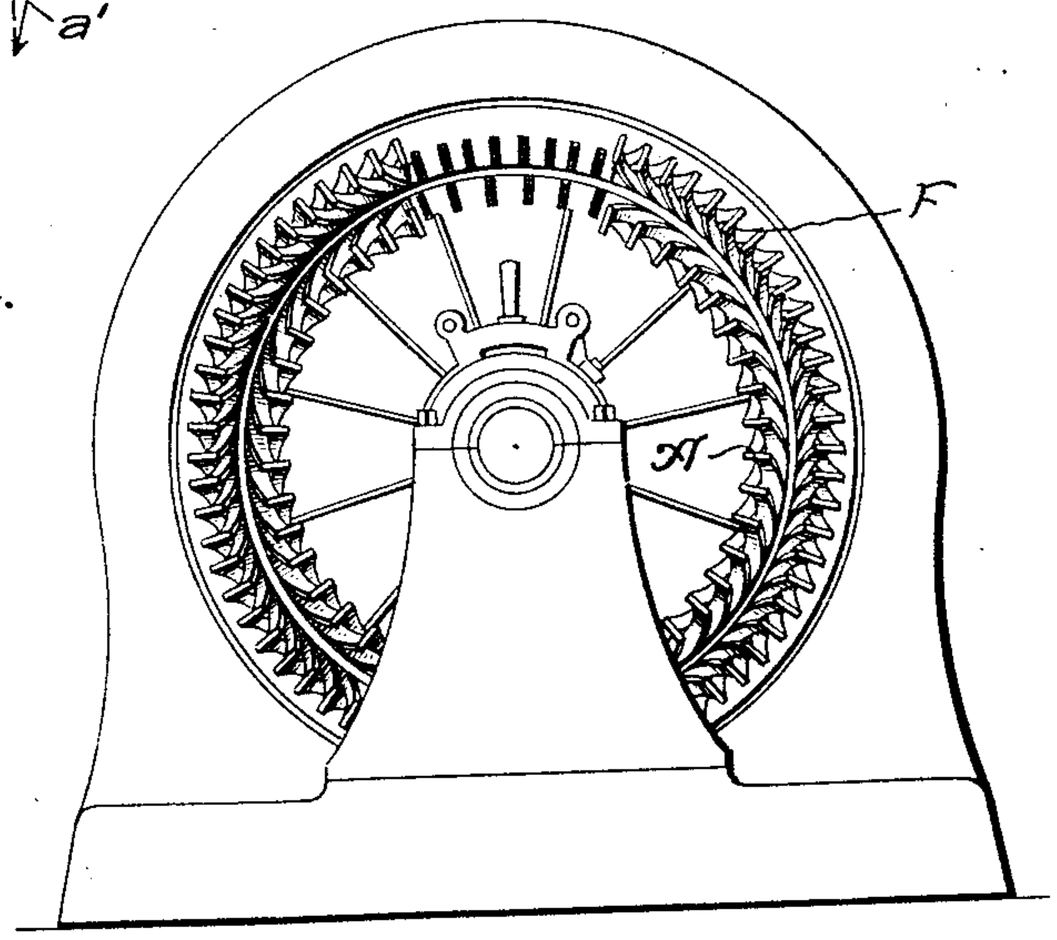


Fig. 4.



Witnesses:
Marcus L. Byng.
J. Ellis Glen.

Inventor:
Charles P. Steinmet.
by Allen Ab. Davis
Att'y.

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2 SHEETS—SHEET 2.

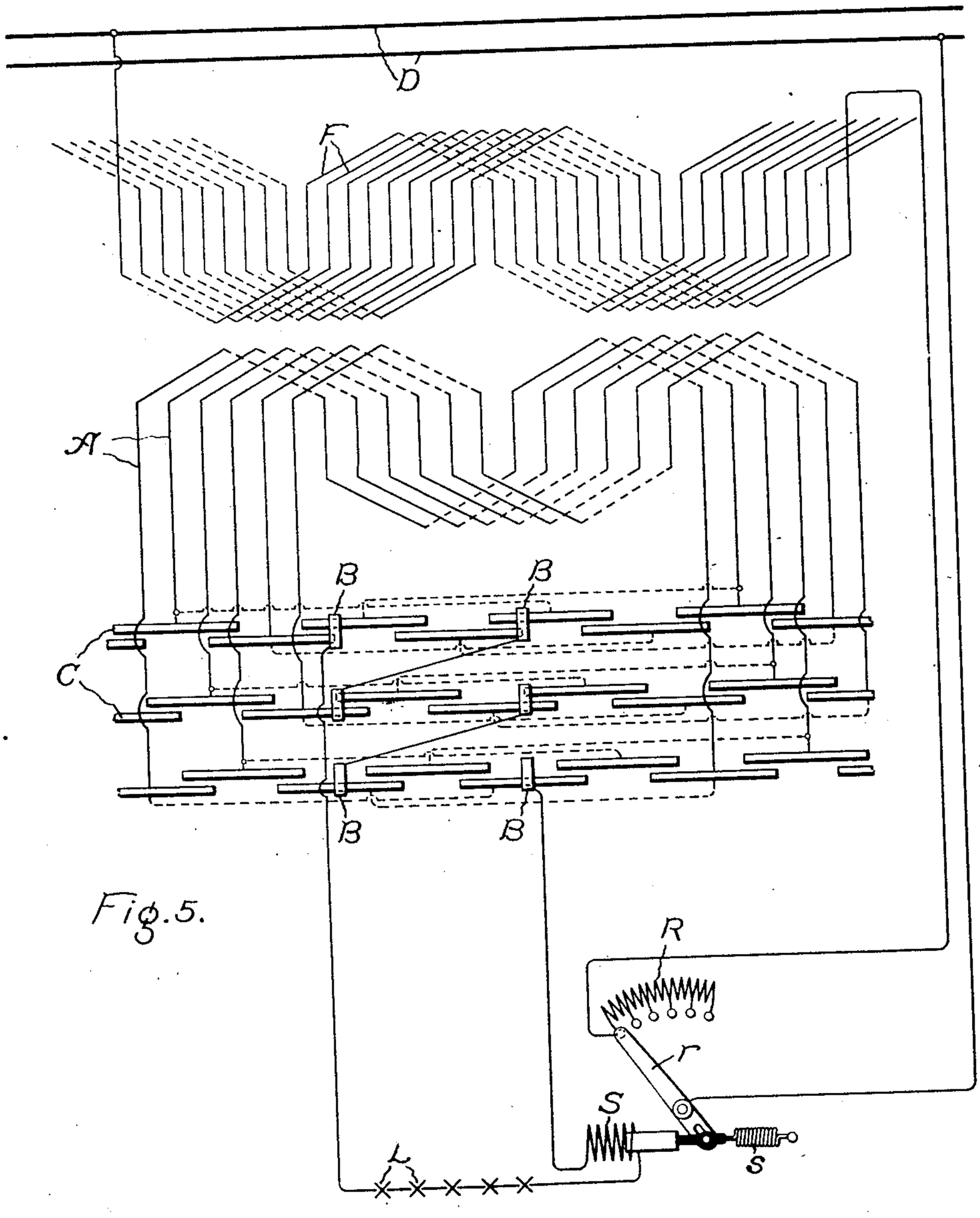

Fig. 5.

Witnesses
Marcus L. Byng.
B. Hull

Inventor:
Charles P. Steinmetz.
by Albert G. Davis
Atty.

UNITED STATES PATENT OFFICE.

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

CONSTANT-CURRENT GENERATOR.

No. 855,484. Specification of Letters Patent. Patented June 4, 1907.

Application filed August 7, 1905. Serial No. 272,979.

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 Constant-Current Generators, of which the following is a specification.

My invention relates to dynamo-electric machines, and its object is to provide a novel form of self-regulating constant-current generator.

My invention in its broadest aspect consists in so arranging the machine that the resultant magneto-motive force of the armature and field ampere-turns is small compared to the two component magneto-motive forces and in arranging the machine so that it will be saturated by a magnetization corresponding to a resultant magneto-motive force corresponding to normal armature current. I produce the desired relation of the resultant magneto-motive force of armature and field to its components by so arranging the armature brushes that the line of magnetization of the armature makes a comparatively small angle with the line of magnetization of the field. With such an arrangement a comparatively small increase in the armature current produces a considerable change in the resultant magneto-motive force both in amount and in direction; and since the machine is saturated the useful component of the resultant flux is decreased automatically to compensate for the tendency to increased armature current.

My invention further comprises arranging the generator with a structure similar to that of the ordinary induction motor,—that is, with a small air-gap between the armature and field with the two windings thoroughly distributed in slots on the armature and field structures. This structure produces the maximum interlinkage of flux between the armature and field windings, and assists materially in obtaining the desired result.

My invention will best be understood by reference to the accompanying drawings, in which

Figure 1 shows diagrammatically a constant current generator arranged in accordance with my invention; Figs. 2 and 3 are explanatory diagrams; Fig. 4 shows a side elevation of a constant current generator with a portion of the windings broken away arranged in accordance with my invention and Fig. 5 shows a development on a plane surface of the windings of a machine.

In Fig. 1 F represents the field and A the armature winding of a constant current generator arranged in accordance with my invention. For the sake of simplicity in this diagram both windings are shown mounted on Gramme rings. The field winding is connected to any suitable source of direct current indicated by the exciter E. This exciter, if operating at constant potential, will supply a current constant in amount to the field-winding. The armature winding is provided with brushes B B which are placed on a line making a comparatively small angle with the line of magnetization of the field winding, and are connected to the load-circuit L. The resultant effect of the armature and field ampere turns, with the brushes thus placed, is shown diagrammatically in Fig. 2. In this figure f represents the field ampere turns and a represents the armature ampere turns, and m may consequently represent the resultant magneto-motive force. Now, if the armature current should increase, as indicated by a', the resultant magneto-motive force would change in direction and magnitude, as represented by m'. It will be seen from this diagram that the resultant magneto-motive force is small compared to its two components, the armature and field ampere turns, and that a slight increase in the armature current produces a marked variation in phase and amount of the resultant. Now if the machine is arranged to be saturated by a magneto-motive force corresponding to m, the resultant flux cannot increase directly with the magneto-motive force, and would consequently have a value smaller than that indicated by m'. That is, if the flux due to the magneto-motive force m be represented in magnitude and direction by the line n, the flux due to the magneto-motive forces m' may be indicated by the line n', which, since the machine is saturated, is substantially equal in length to the line n, and the component of the line n' at right-angles to the line a is the projection of the line n' on the line n, which is much smaller than the line n. And since it is this component which produces the induced electro-motive force in the armature winding, the tendency

to increase of the armature current is offset, and to a large extent balanced, by the decrease in the effective component of the resultant flux due to the shifting in position of the resultant.

The action of the machine may be further understood by comparing Fig. 2 with Fig. 3, which latter figure shows the corresponding diagram for the machine arranged in the ordinary way,—that is, with the armature brushes displaced substantially ninety electrical degrees from the line of field magnetization. The several lines representing the several magneto-motive forces and fluxes are lettered the same in Fig. 3 as in Fig. 2. It will be seen by comparing the figures that whereas an increase of fifty per cent. in the length of line *a* of Fig. 2 results in an increase of more than one hundred per cent. in the length of line *m*, a similar increase in the line *a* in Fig. 3 will produce an increase in the line *m* considerably less than fifty per cent. Consequently, while saturation has a marked effect with a machine arranged as indicated in the diagram of Fig. 2, it would have comparatively little effect in a machine as indicated in the diagram of Fig. 3.

In order to obtain the results indicated by the above diagrams, it is desirable that there should be as complete an interlinkage of flux as possible between the armature and field windings. For this reason I arrange the machine as shown in Fig. 4. The structure is very similar to that of an ordinary induction motor. The air-gap is made as small as mechanical considerations permit, and the armature and field windings are placed in slots in their respective cores. This arrangement gives as complete interlinkage as possible of the armature and field fluxes, and the small air-gap renders it possible to magnetize the machine with a resultant magneto-motive force small compared with the field and armature magneto-motive forces without making the component magneto-motive forces excessive in amount. Any portion of the machine structure may be arranged to be saturated at normal load. For instance, the teeth between the slots on stator or rotor, or both, may be proportioned to be saturated.

In Fig. 5 I have shown a development of one arrangement of windings suitable for use in a machine of the character described. The field winding F is shown as a distributed winding excited from any suitable current source from which a current constant in amount may be supplied to the winding, such as a separate exciter or constant potential bus-bars, indicated at D. The armature winding A is shown as composed of a plurality of open-coil windings connected in the usual manner to a segmental commutator C. Each of the open-coil windings A is indicated by a single line, but it will be understood that in practice each winding would be composed of distributed coils. The several segments of the commutator C are properly connected in series by means of commutator brushes B, which are connected to the load circuit L. The inherent regulating characteristic of the machine may be supplemented, if desired, by any suitable form of constant current regulator, such as has heretofore been employed with constant-current machines, such as those used for arc lighting. In the drawing I have indicated a regulating rheostat comprising a variable resistance R in the field circuit controlled by a rheostat arm *r*. The rheostat arm is actuated by a solenoid S in the load circuit, which is opposed by tension spring *s*. It will be understood that this illustration is purely diagrammatic, and any well known form of regulator may be employed.

I do not desire to limit myself to the particular construction and arrangement of parts here shown, but aim in the appended claims to cover all modifications which are within the scope of my invention.

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

1. In a constant-current generator, a field winding, and an armature winding provided with commutator and brushes, said brushes being arranged on a line at an angle of less than forty-five electrical degrees to the line of magnetization of the field winding and connected to the load-circuit, said generator being arranged to be saturated at normal load.

2. In a constant-current generator, a field winding, and an armature winding provided with commutator and brushes, said brushes being connected to the load circuit and so arranged that the resultant of armature and field magneto-motive forces is small as compared with the component magneto-motive forces, said generator being arranged to be saturated by the resultant magneto-motive forces corresponding to normal armature current.

3. In a constant-current generator, field and armature structures arranged with a small air-gap, distributed field and armature windings carried in slots in said structures, a commutator connected to the armature winding, and brushes arranged on the commutator on a line making an angle of less than forty-five electrical degrees with the line of field magnetization and connected to the load circuit, said generator being arranged to be saturated at normal load.

In witness whereof I have hereunto set my hand this 4th day of August, 1905.

CHARLES P. STEINMETZ.

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