H. K. SANDELL.

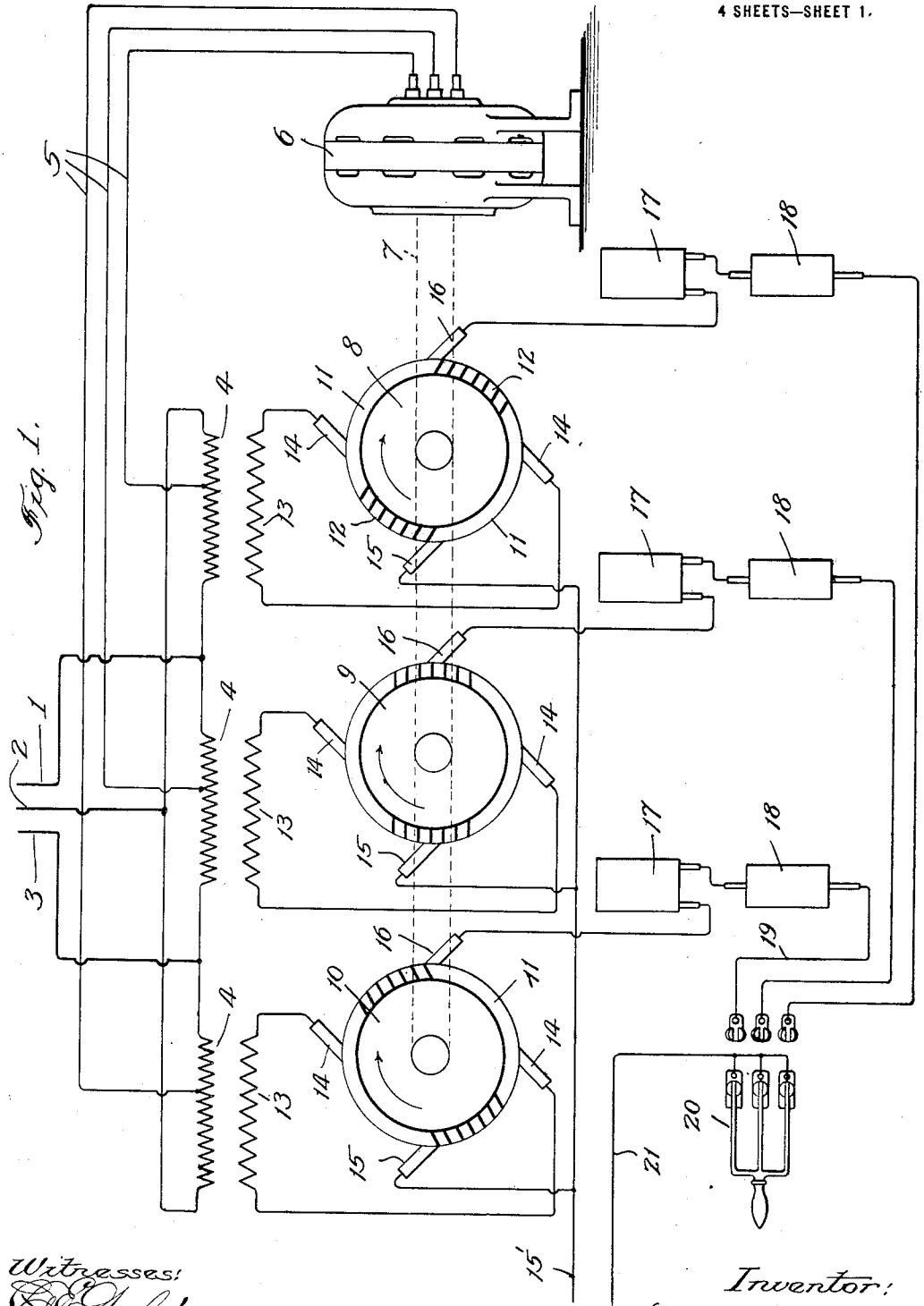
MEANS FOR IMPROVING THE COMMUTATION IN ROTARY RECTIFIERS.

APPLICATION FILED MAY 29, 1916.

1,286,795.

Patented Dec. 3, 1918.

4 SHEETS—SHEET 1.



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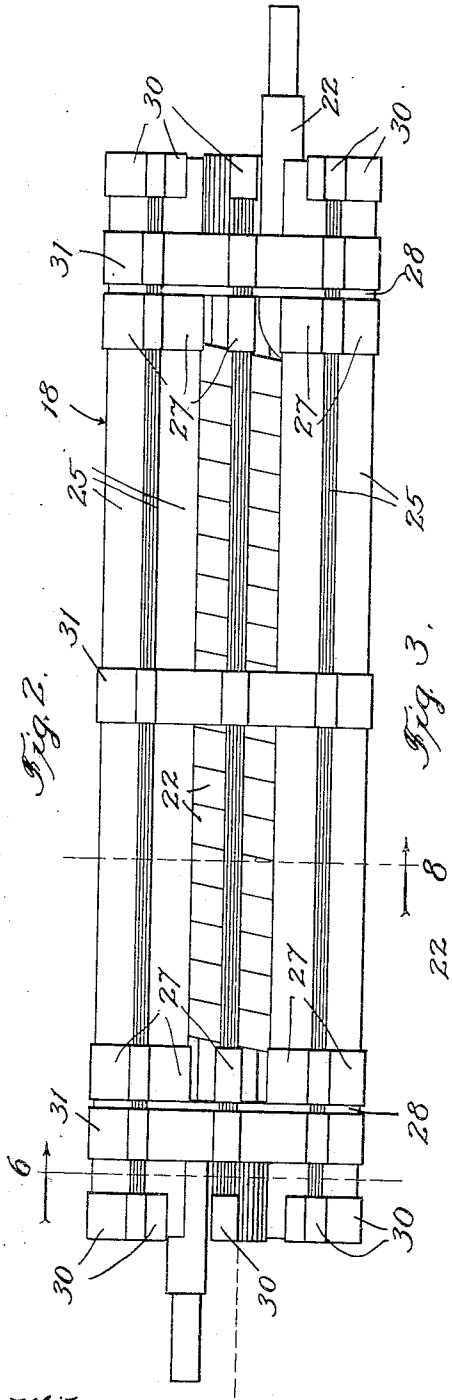


Fig. 2.

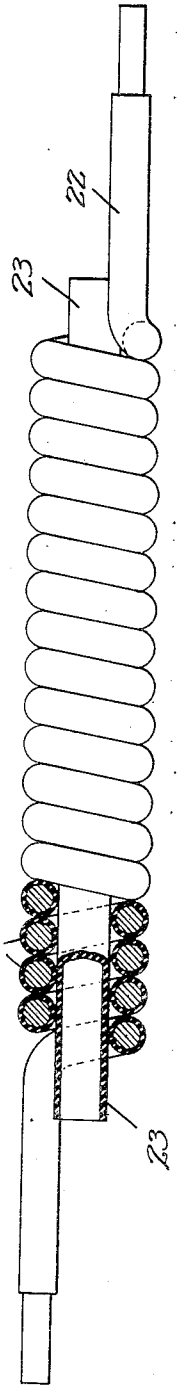


Fig. 3.

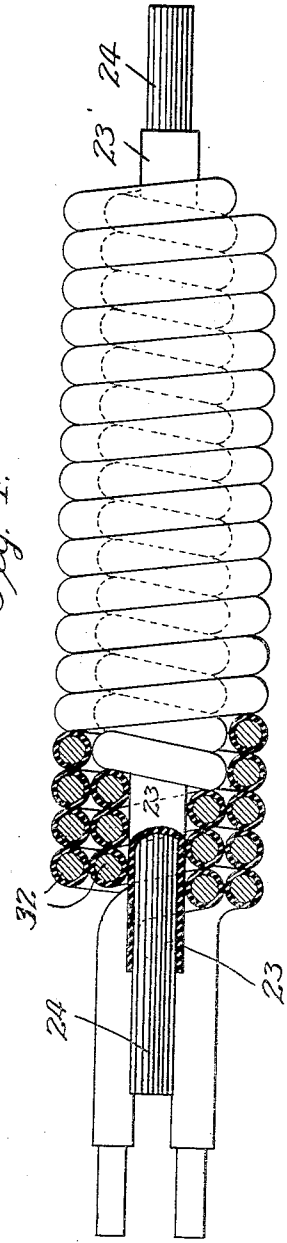


Fig. 4.

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4 SHEETS—SHEET 3.

Fig. 7.

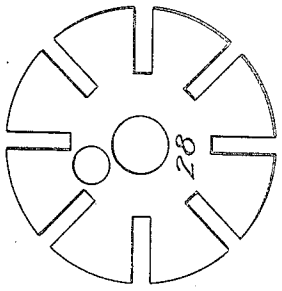


Fig. 9.

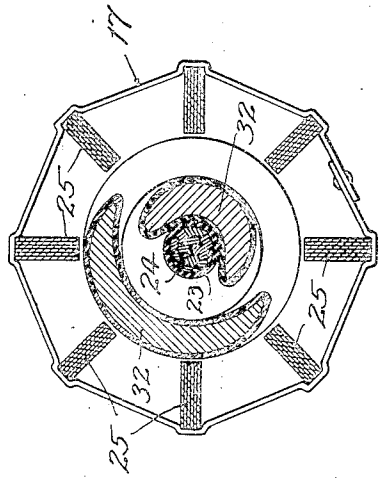


Fig. 6.

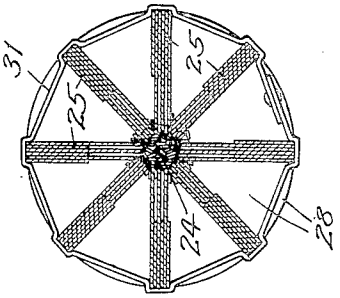


Fig. 5.

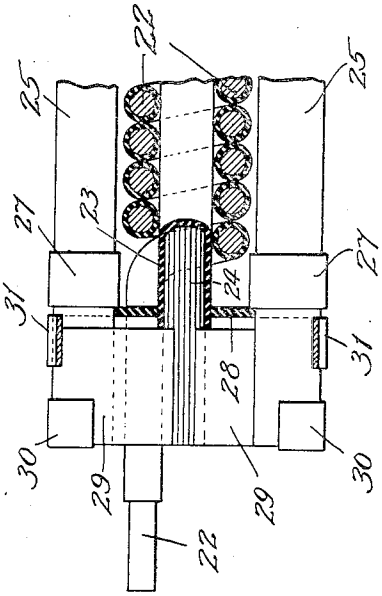
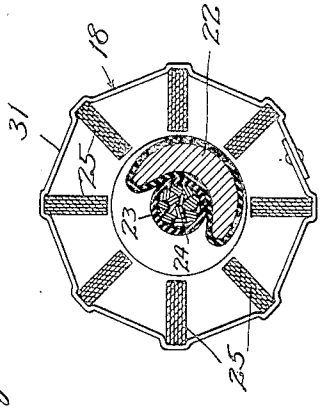


Fig. 8.



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H. K. SANDELL.

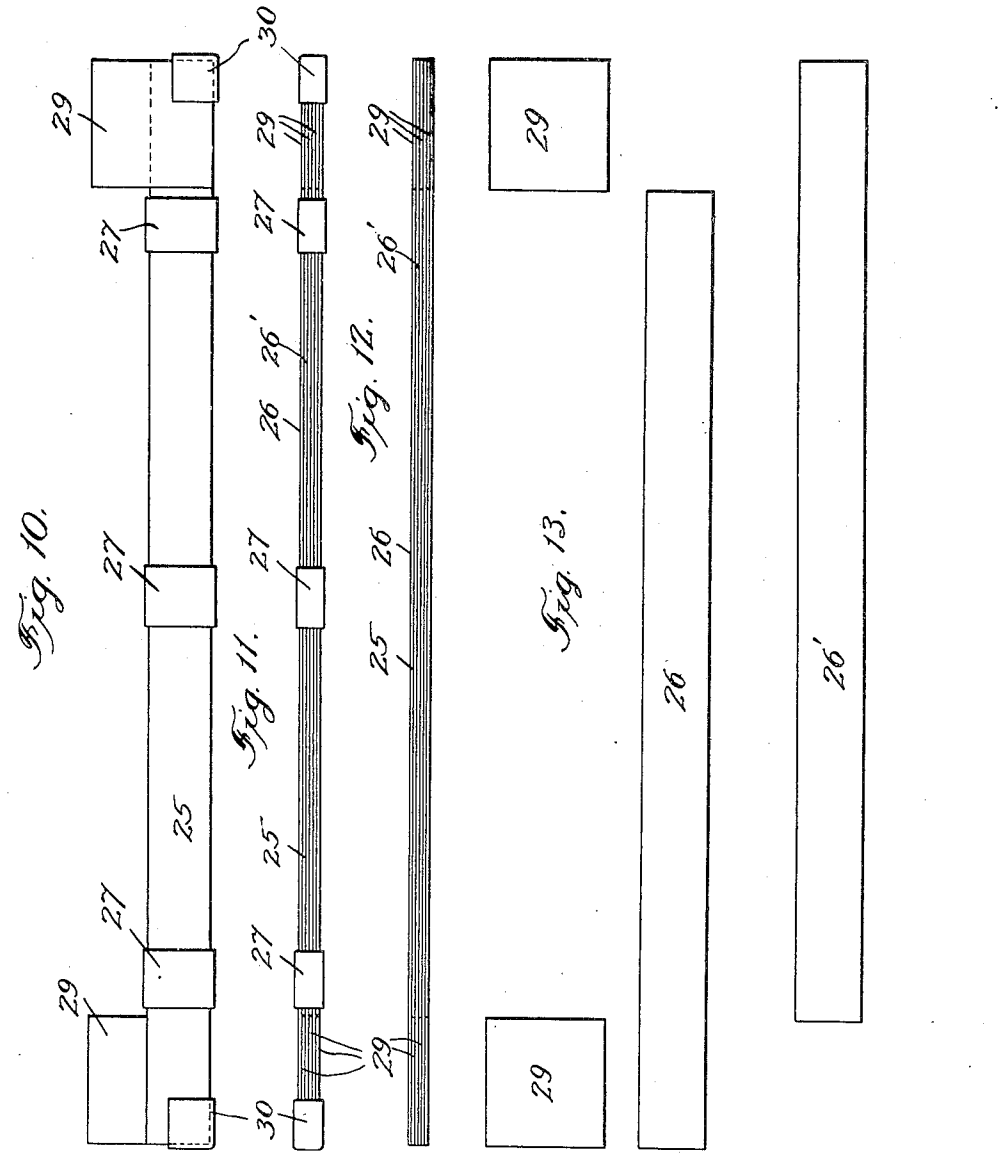
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APPLICATION FILED MAY 29, 1916.

1,286,795.

Patented Dec. 3, 1918.

4 SHEETS—SHEET 4.



Witnesses:
Chas. H. Buell.

Inventor:
Henry K. Sandell,
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Attys.

UNITED STATES PATENT OFFICE.

HENRY K. SANDELL, OF CHICAGO, ILLINOIS, ASSIGNOR TO HERBERT S. MILLS, OF CHICAGO, ILLINOIS.

MEANS FOR IMPROVING THE COMMUTATION IN ROTARY RECTIFIERS.

1,286,795. Specification of Letters Patent. Patented Dec. 3, 1918.

Application filed May 29, 1916. Serial No. 100,588.

To all whom it may concern:

Be it known that I, HENRY K. SANDELL, a citizen of the United States, residing at 221 South Green street, Chicago, in the county of Cook and State of Illinois, have invented a new and useful Means for Improving the Commutation in Rotary Rectifiers, of which the following is a specification.

My invention relates to improvements in rectifiers, and more particularly to that form of rectifier in which a synchronously driven motor drives a rectifying commutator, by the action of which latter alternating current is changed into uni-directional current. The specific object of the present invention is to provide a means by which the commutation will be improved.

The invention will be more fully understood from the following detailed description of a specific embodiment thereof, taken in connection with the accompanying drawings in which:

Figure 1 is a diagrammatic view of a rotary rectifier constructed in accordance with my invention; Fig. 2 is an enlarged detailed elevation of one of the reactance or choke coils; Fig. 3 is an enlarged detailed view of the winding of the coil shown in Fig. 2; Fig. 4 is an enlarged detailed view of the winding of the companion coil; Fig. 5 is an enlarged section, partly in elevation through the end of the coil shown in Fig. 2; Fig. 6 is a section on the line 6 of Fig. 2; Fig. 7 is a face view of one of the end plates for supporting and spacing the iron of the coil; Fig. 8 is a section on the line 8 of Fig. 2; Fig. 9 is a similar section through the companion coil; and Figs. 10 and 11, 12 and 13 are details showing the method of assembling the strips which constitute the magnetic circuit of the reactance coil.

Referring more particularly to the drawings, the numerals 1, 2 and 3 designate respectively the three lines of a three-phase alternating current distribution system. These lines are connected to a primary transformer winding 4, arranged according to the Delta connection, each serving also as an auto-transformer from which taps 5 are taken off for energizing a three-phase synchronous motor designated 6. The motor-shaft 7 illustrated in dotted lines in Fig. 1, carries three commutator sections 8, 9 and 10, each section being provided with a pair of conductor-segments 11, spaced apart by insulating segments 12.

Operatively related to each of the transformer primary windings 4 there is a secondary winding 13 to the two ends of which respectively are connected alternating current brushes 14, angularly spaced 180° bearing upon the commutator sections 8, 9 and 10. Angularly spaced 90° with reference to the alternating current brushes 14, and 180° with reference to each other, are a pair of direct-current brushes 15 and 16 which also bear upon each commutator section, the three brushes 15 for the sections 8, 9 and 10 respectively being connected in parallel to a single direct current distribution wire 15^1. Each of the brushes 16, however, is connected to my improved means for regulating the commutation, such means consisting of reactance, time, or choke members 17 and 18 connected in series with one another, and with the direct current brushes 16. From each of the reactance or time elements a conductor 19 leads to a three-pole switch 20 from which a single conductor 21 is led off to form with the conductor 15^1, the direct current lead wires from the machine.

Since my present invention resides particularly in these last named devices, and in their combination with the other elements of the rectifier, and for the additional reason that I have found considerable difficulty in devising a structure fulfilling all of the requirements of the present invention, I have illustrated in considerable detail in Figs. 2 to 13 of the drawing, the specific construction which I have adopted in the embodiments of my invention which I have manufactured and used up to the present time. Referring more particularly to these drawings the reactance or choke coil 18 consists of a winding 22 made up of a very few turns, approximately 20 turns of exceedingly heavy insulated conductor wire or rod wound upon a hollow insulating member 23 which is designed to receive a magnetic metal core. The preferred construction of the core is illustrated in Figs. 5, 6, and 8, from which it will be seen that this member consists of a large number of relatively small ribbons or strips of magnetic metal designated 24 and prefer-

ably made of the very highest quality of silica-steel used for transformers. A return magnetic circuit for connection with the two ends of the core 24 is formed by a plurality of bundles 25, each consisting of strips 26 and 26^1 of equal length, but arranged alternately with overlapping ends as shown in Fig. 13. Each bundle is tied together to form a unit as by means of a small non-conducting clip 27, and the bundles are held in the proper assembled position, illustrated by the sectional views of the drawing by suitably perforated spiders 28, arranged near the end of the coil as shown in Fig. 5. The lapping of the ends of the individual strips 26 and 26^1 in the various bundles serves to produce spaces between alternate strips, which spaces receive oblong pieces 29 which form magnetic connections between the bundles 25 of the return circuit and the core 24. To complete the mechanical assembly of the parts corner-clips 30 should be placed on the outside corners of each bundle and bands 31, preferably of non-conducting material, are employed to secure all of the parts in their assembled relationship.

The construction and assembly of the coil 17 is substantially the same as that heretofore described, saving that the winding shown in Fig. 4 comprises two layers 32 of insulated conductors.

Assuming that the cross-sections of the magnetic metal cores 24 of the coils 17 and 18 are the same, (and in practice I have preferred to make them the same) it will be seen that if one of these coils has twice as many turns as the other, the saturation current for one coil will be twice the saturation current of the other coil. It is further to be noted that the coil 18 which requires the highest saturation current is designed to become saturated with a relatively small flow of current. For instance if the direct current brush 16 carries a maximum of 300 amperes, coils 17 and 18 would be arranged to saturate respectively at 5 and 10 amperes. It will be understood that these figures are illustrative only, as typifying the desired operating conditions in a particular embodiment of my invention.

The operation of the rectifier *per se* which I have illustrated in my drawings is the same as that illustrated in my prior Patent No. 1,242,601, save that I have here used three commutator sections in parallel in order to rectify three-phase currents.

I shall therefore confine myself to the description of the manner in which the reactance or time members modify and coöperate with the system as a whole.

Since each of the series reactance members 17 and 18 becomes saturated at a relatively small current flow, and since the number of turns in these reactances is so very small, their combined effect upon the circuit is almost *nil* in the upper ranges of current flow and potential. During what might be called the normal operation of the machine therefor, that is during that interval of time in which the effective portion of the alternating current wave is being utilized to supply energy to the direct current leads, the reactance members exert no appreciable effect and this portion of the voltage or current wave will retain substantially the form of the impressed wave. Considering the commutator section 10, however, when by its revolution direct current brush 16 approaches the end of the conductor segment 11, the potential wave in the alternating current brush 14 will be dropping toward the critical value at which it is desired to break. Under these conditions the reactance members 17 and 18 become active, the drop of the current below the saturation value for the coil 18 first taking place, resulting in an inductive "kick" which endures for a certain determinable interval of time, and being succeeded by a second "kick" from the coil 17, as further drop in the current brings it below the saturation value for this coil. By the action of these coils therefore the wave is distinctly deformed just at the point of commutation, the effects of the coils being cumulative as to time. By this deformation of the wave at the point of commutation I find that I am able to effect commutation in a substantially sparkless manner, and that the necessity for minute exactness as to the time of breaking as between the brush 16 and its segment 11 is obviated. By practical test I find that variations in the load which require angular adjustment of the brushes amounting to about one-half of an inch on the periphery of a 14 inch commutator, without the use of the reactance members, are satisfactorily taken care of in an automatic manner when my reactance members are used.

In order that the desired results as to regulation of the commutation may be obtained, without sacrificing the efficiency of the machine as a whole, it is necessary that the reactance members 17 and 18 be designed and constructed with the greatest care, attention being given to all of those details which make for the efficiency of a transformer coil construction. It is further particularly necessary from my experience that the length of wire be as small as possible and the number of turns as great as possible, providing always that the cross-section of the coil-winding must be sufficient to carry the load without sensible heating. It is further essential that the steel used for the core and return circuit of the coil be of the very highest grade, showing a saturation curve with a very pronounced "knee", and that the operating conditions as to temperature be so maintained that the permea-

bility of the steel will remain at the highest figure. The skeleton coil construction which I have illustrated in the drawing is particularly suited to the demands of the present invention.

While I have shown and described in considerable detail one specific embodiment of my invention, it is to be understood that such showing and description is illustrative only, and for the purpose of making my invention more clear, and that the invention is not to be construed as limited to these details, nor to any of them, except in so far as such limitations are included within the terms of the following claims, in which it is my intention to claim all novelty inherent in my invention as broadly as is permissible in view of the prior art.

What I claim as new and desire to secure by Letters Patent is—

1. The combination with a rectifying commutator and a source of alternating current connected therewith, of means in a single series circuit for producing successive alterations of the wave form of the rectified current as the impressed electromotive force varies through its cycle.

2. The combination with a rectifying commutator of a reactance coil in circuit therewith, said coil having a magnetic metal magnetic circuit, proportioned to become saturated by a current flow substantially less than the average flow therethrough.

3. The combination with a rectifying commutator of a plurality of reactance coils in series with one another and with the said commutator, each of the said reactance coils having a magnetic metal magnetic circuit, and the said coils being so constructed as to become saturated under different current flows.

4. The combination with a rectifying commutator of a plurality of reactance coils in series with one another and with the said commutator, each of the said coils having a magnetic metal magnetic circuit, said coils being proportioned so that one of them becomes saurated under a lower current flow than the other, and all of the said coils become saturated under a current flow less than the average flow therethrough.

5. In combination, a polyphase rotary rectifier including a synchronous motor and a rectifying commutator driven thereby, and a reactance coil in series with the said commutator and with each of the phases to be rectified, each of said coils having a magnetic metal magnetic circuit designed to become saturated by a current flow substantially less than the average flow through the coil.

6. In combination, a polyphase rotary rectifier including a synchronous motor and a rectifying commutator driven thereby, and a plurality of reactance coils arranged in sets corresponding to each of the phases to be rectified, the coils in each set being in series with one another and with the said commutator, said coils each having a magnetic metal magnetic circuit and the individual coils in each set being so proportioned as to become saturated under different current flows.

7. In combination, a polyphase rotary rectifier, including a synchronous motor and a rectifying commutator driven thereby, and a plurality of reactance coils arranged in sets corresponding to each of the phases to be rectified, the coils in each set being in series with one another and with the said commutator, said coils each having a magnetic metal magnetic circuit, and the individual coils in each set being so proportioned as to become saturated under different current flows, all of the said coils becoming saturated under a current flow less than the average flow therethrough.

8. The combination with a rectifying commutator, and means for supplying an alternating current thereto, of a plurality of reactance coils connected in series in the direct current circuit fed by said commutator, said coils having progressively different saturation characteristics, whereby they become active successively to alter the wave form as the impressed electromotive force varies through its cycle.

HENRY K. SANDELL.