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H. FORSSELL ET AL

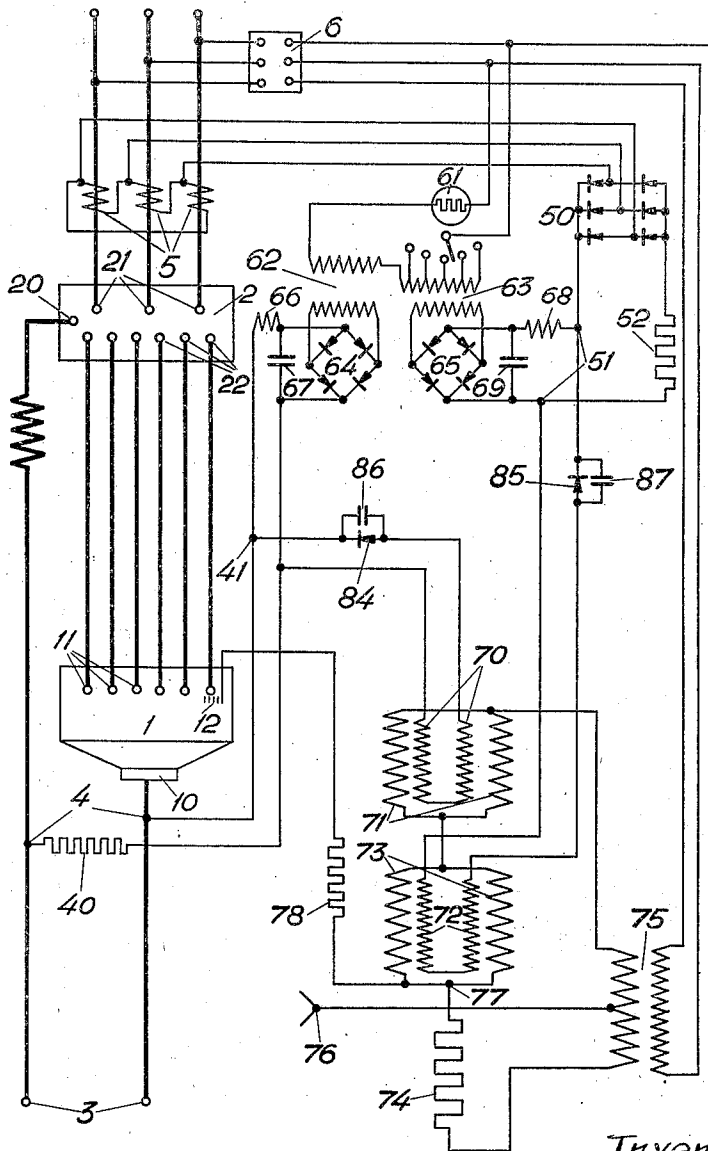
2,128,771

REGULATING MEANS FOR CURRENT RECTIFYING OR CONVERTING APPARATUS

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2 Sheets-Sheet 1

Fig. 1



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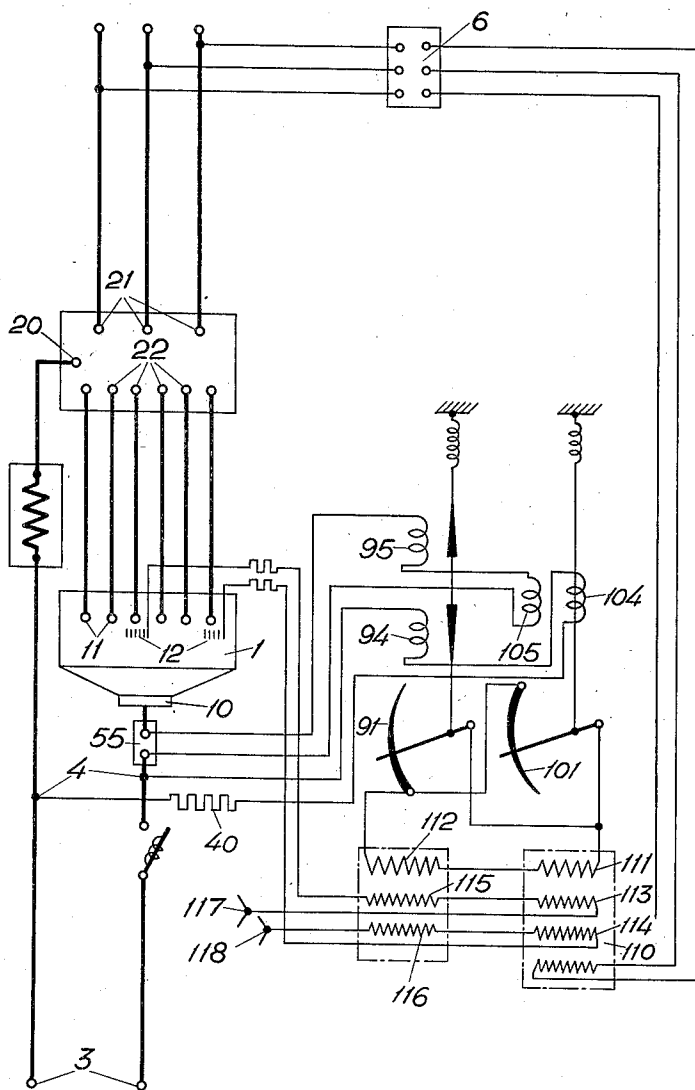
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2 Sheets-Sheet 2

Fig. 2



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UNITED STATES PATENT OFFICE

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REGULATING MEANS FOR CURRENT RECTIFYING OR CONVERTING APPARATUS

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It is possible by grid-controlled ionic valves, as is known, to regulate a motor or other load automatically so that the latter will obtain certain characteristic properties. It is rather frequently desirable that these properties should present a certain discontinuity, for instance that a motor should operate at constant voltage up to a certain current load, but then begin to operate at constant current. This may occur for instance for motors co-operating with fly wheels. As another example may be mentioned a regulation to constant voltage up to a certain amount of power and therefrom to constant power, which may occur especially in transmission from one power network to another.

The present invention relates to an arrangement for creating such a discontinuous characteristic of the load by employing a grid control of the kind known per se, in which the phase of the grid voltage is displaced by means of a combination of impedance elements of different reactive properties, one of said elements being variable in size.

According to the invention, the said variable impedance element is composed of two or more component elements of substantially the same reactive properties, the magnitude of each of said component elements varying under the influence of the difference between a predetermined standard quantity and an individual characteristic quantity of the load different from the load quantities influencing the magnitudes of the other component elements. At first sight, it would appear that this would give a rather continuous regulation under the common influence of all the influencing quantities, but a narrower examination shews that even at any dimensioning of the impedance elements of equal reactive properties a regulation is obtained, which at first essentially follows one and from a certain point substantially follows the other quantity.

If the voltage on the divided and regulable impedance element of the combination leads the voltage of the other in phase, for instance if the former element consists of an inductance and the latter of an ohmic resistance, the former is preferably composed of series-connected parts, while on the other hand a regulable resistance co-operating with a constant reactance is preferably composed of parts connected in parallel. It is found that in this way a phase displacement in the right sense is most easily obtained for reasons which it should not be necessary to specify in detail.

Two forms of the invention according to the

aforsaid two types are diagrammatically shewn in Figures 1 and 2 of the accompanying drawings.

In Figure 1, 1 is the ionic valve of a rectifier with cathode 10, anodes 11 and anode grids 12, only one of the latter being shewn for the sake of simplicity. 2 represents the main transformer of the rectifier, which is only diagrammatically indicated with primary terminals 21, secondary terminals 22 and a neutral point terminal 20. Between the latter and the cathode the load, which is not shewn, is connected over the terminals 3.

For the automatic regulation of the load according to the desired principle, the D. C. voltage over the load is obtained at the points 4, and a current proportional to the primary alternating current is obtained over current transformers 5. From the points 4, a current proportional to the voltage is led over a great resistance 40 to a pair of Kirchhoff points 41, in which it is compared with a predetermined standard current in such a manner, that the difference between the latter and the former current is led through the phase-displacing impedance. From the current transformer 5 the current is led over a dry rectifier group 50, from which the direct current is led over a resistance 52 to a corresponding pair of Kirchhoff points 51, where it is compared with a standard current in a similar manner.

The primary source of the two standard currents is common and consist of a voltage transformer 6 connected to the alternating current network. From one phase of this transformer a current is led through an iron wire lamp 61, which keeps it practically constant, and further through the primary windings of two transformers 62, 63, one of which is shewn with an adjustable ratio. The secondary windings of the said transformers are connected each to a Graetz-polygon of dry rectifiers 64, 65, respectively, from which the standard currents to the points 41, 51 are led over series inductances 66, 68 in parallel with condensers 67, 69 for eliminating higher harmonics.

The difference between the standard current from the polygon and the current proportional to the D. C. voltage from the points 4 is led through a D. C. winding 70 influencing by saturation an inductance 71 of an essentially known type forming part of an impedance combination for displacing the phase of the grid voltage. The current from the points 51 is led in a similar manner through a D. C. winding 72 influencing by saturation an inductance 73 in series with in-

ductance 71. In series with both, there is finally an ohmic resistance 74, and the entire arrangement is connected to the secondary winding of a transformer 75, the primary winding of which is connected to the voltage transformer 6. For a three- or six-phase rectifier, three such impedance combinations are employed, connected each to one phase of the transformer 6 and preferably having their D. C. windings connected in series. The middle point of the secondary winding of the transformer 75 is connected to a grid neutral 76, which may be free-balanced according to the copending patent application of Uno Lamm, No. 679,344, filed July 7, 1933, issued December 8, 1936 as Patent No. 2,063,106, or for instance connected to the cathode over a resistance, and the point of junction between the inductance 73 and the resistance 74 is connected to one or more grids 12 over resistances 78.

In series with the D. C. windings 70, 72, there are connected dry rectifiers 84, 85, respectively, for preventing a return of current, which would cause instability. In parallel to these dry rectifiers are connected condensers 86, 87, respectively, which serve to admit an alternating current, which may be superposed over the direct current, so that this alternating current is not rectified when the main current approaches or reaches zero, whereby an additional D. C. component would be created which would disturb the regulation.

The arrangement described operates in the following manner. The current through the winding 70 defined by the deviation of the direct current voltage from a standard value defined by the members 61, 62, 64 influences the grid control in such a direction as nearly to restore the normal value of the said voltage. At the same time, the current in the winding 72 defined by the deviation of the primary current rectified by the member 50 from a standard value defined by the members 61, 63, 65 makes an effort to regulate in such a sense as to make the said primary current approach the said standard value, but as far as the current lies considerably below the said value, the winding 72 reduces the value of the inductance 73 to so low a value that it may be entirely neglected in comparison with the larger inductance 73 connected in series therewith. Only when the current approaches the standard value so much that the deviation will be within the predetermined degree of irregularity, does the inductance 73 begin to rise appreciably and thereby acquire some influence on the regulation. Meanwhile, the inductance 71 has been lowered corresponding to the permissible degree of irregularity of the voltage, and the inductance 73 now gradually begins to predominate, and when the voltage is further lowered, the inductance 73 takes over practically the whole regulation, which then is effected to constant current.

In the form shewn in Figure 2, the transformer and ionic valve of the rectifier are designated in the same way as in Figure 1. The regulation here is effected to substantially constant voltage although compounded to a certain degree so as to rise with the current until a certain limit of power is reached and from this limit the regulation is effected to constant D. C. power. For the grid control, combinations of resistances and inductances are employed here as in Figure 1, but here the inductances are constant, while the resistances are regulated by mechanical means.

As is evident from the following, the two resistances should then be connected in parallel.

The D. C. voltage is obtained as before between two points 4 and acts through a resistance 40 on a winding 94 on the voltage regulator and on a winding 104 on the power regulator. The direct current is obtained over a shunt 55 and acts on a compounding winding 95 on the voltage regulator and on a winding 105 on the power regulator. Each of the two regulators acts on a resistance 91, 101, respectively, said resistance being connected in parallel and forming part of an impedance combination for displacing the grid voltage. This combination is of the same main type as in Figure 1, but the voltage is transformed therefrom to the grids by way of transformation instead of directly. The transformer 110 for feeding the combination, which is in its turn fed by an intermediary transformer 6, thus carries not only the secondary winding 111, to which the inductance 112 and the parallel resistance 91, 101 are connected in series, but also two tertiary windings 113, 114, which together with two additional windings 115, 116 on the iron core of the inductance 112 give voltages, which will coincide in phase and be proportional to the voltage between the middle point of the winding 111 and the point of junction between the inductance 112 and the resistances. These voltages are connected between grid neutrals 117, 118 and the grids 12.

The arrangement now described operates in the following manner. The regulators are so connected that an increase of voltage or power causes a reduction of the resistance 91 or 101, which in its turn causes a displacement of the grid voltage in the sense of retarded ignition. When the power is low, the power regulator tries to increase the resistance 101 as far as possible, but as the resistance 91 is at the same time low on account of the small drop of voltage, the larger one of the two parallel resistances has very little influence, but the regulation then tends to constant (compounded) voltage. When the power is high and the voltage drop therefore great, the power regulator will on the contrary predominate, the resistance 101 thereof then being essentially lower than the resistance 91.

The invention is of course equally useful if the regulable impedance does not act directly on the grid voltage, but is for instance, in a manner known per se, connected in an exciting circuit for a synchronous generator or motor, by which it acts to displace the phase of the grid voltage.

We claim as our invention:—

1. In current rectifying or converting apparatus, an ionic discharge valve, grids for controlling the current passage through said valve, means for impressing an alternating voltage on said grids, means, including two magnetizing windings interlinked with different iron paths, for regulating the phase of said grid voltage, and means for determining the currents in said two magnetizing windings individually and each in dependence of one of two different electric load quantities of said rectifying or converting apparatus.

2. In current rectifying or converting apparatus, an ionic discharge valve, grids for controlling the current passage through said valve, means for impressing an alternating voltage on said grids, means, including two magnetizing windings interlinked with different iron paths, for regulating the phase of said grid voltage, and means

for keeping the current in one of said two magnetizing windings proportional to the difference between one standard quantity and one electric load quantity of said rectifying and converting apparatus and for keeping the current in the other of said magnetizing windings proportional to the difference between another standard quantity and another electric load quantity of said rectifying and converting apparatus.

3. In current rectifying or converting apparatus, an ionic discharge valve, grids for controlling the current passage through said valve, means for impressing an alternating voltage on said grids, two impedance groups each comprising a variable impedance element for regulating the phase of said grid voltage, and means whereby said impedance elements are each varied automatically and individually in dependence of one of two different electric load quantities of said rectifying or conveying apparatus.

4. In current rectifying or converting apparatus, an ionic discharge valve, grids for controlling the current passage through said valve, means for impressing an alternating voltage on said grids, two series-connected impedance groups each comprising an inductance with a saturating D. C. winding for regulating the phase of the voltage impressed on said grids, and means for varying the D. C. saturation of said inductances individually in dependence of two different electric load quantities of said rectifying or converting apparatus.

5. In current rectifying or converting apparatus, an ionic discharge valve, grids for con-

trolling the current passage through said valve, means for impressing an alternating voltage on said grids, two parallel-connected impedance groups each comprising a variable resistance for regulating the phase of the said grid voltage, and means for varying said resistances individually in dependence of two different electric load quantities of said rectifying or converting apparatus.

6. In current rectifying or converting apparatus, an ionic discharge valve, grids for controlling the current passage through said valve, means for impressing an alternating voltage on said grids, means, including two magnetizing windings interlinked with different iron paths, for regulating the phase of said grid voltage, and means for determining the currents in said two magnetizing windings individually, the one in dependence of the voltage and the other in dependence of the current given off by said rectifying or converting apparatus.

7. In current rectifying or converting apparatus, an ionic discharge valve, grids for controlling the current passage through said valve, means for impressing an alternating voltage on said grids, means, including two magnetizing windings interlinked with different iron paths, for regulating the phase of said grid voltage, and means for determining the currents in said two magnetizing windings individually in dependence of the voltage and of the power given off by said rectifying or converting apparatus.

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