

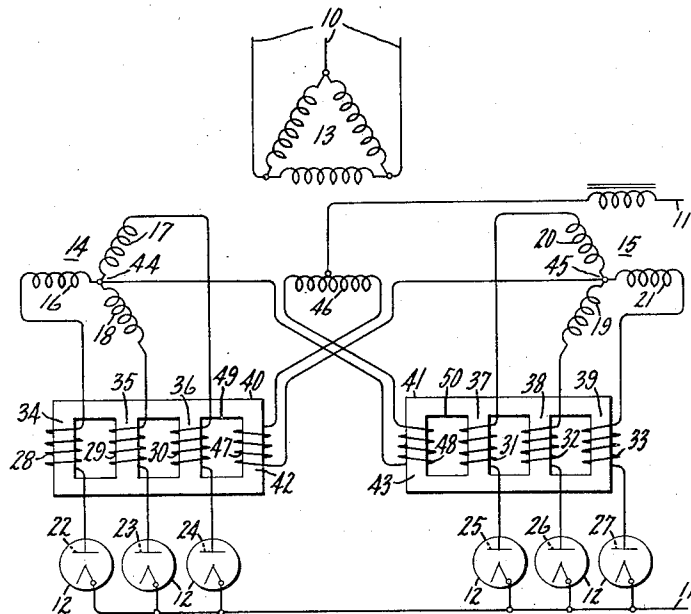
June 16, 1936.

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2,044,593

BALANCING MEANS FOR RECTIFIERS

Filed Feb. 8, 1936



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UNITED STATES PATENT OFFICE

2,044,593

BALANCING MEANS FOR RECTIFIERS

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Application February 8, 1936, Serial No. 62,916

4 Claims. (Cl. 175—363)

The present invention relates to electric systems wherein power is interchanged between direct and alternating current circuits through means comprising an electric discharge apparatus, particularly to such systems including polyphase transformer secondary windings interconnected by an interphase transformer, and one of its objects is to provide an improved means for compensating or preventing unbalance in the currents flowing from the transformer secondary windings in such systems.

In rectifier systems or like systems comprising main supply transformer means including polyphase secondary windings interconnected by an interphase connection or transformer, unbalancing difficulties due to various causes have been encountered. In certain cases the reactive voltage of the main supply transformer has tended to cause unequal distribution of the load between the interconnected secondary windings, one of the secondaries being subjected to the larger load when the phase rotation of the main transformer was in one direction and the other secondary having the larger load when the phase rotation of the main transformer was in the other direction. In other cases the cause of the unbalance has been traced to differences in the voltage drop in the arc discharge paths associated respectively with the interconnected transformer secondary windings. Other causes, more or less obscure, have been found to contribute to the unbalance.

Various means have been suggested to overcome the tendency to unbalance in the above mentioned power systems, including the provision of reactance in the connections associated with that one only of the secondary windings the output of which tended to rise above the output of the other secondary. This method of preventing the unbalance, which is set forth, in connection with the compounding system described in Lennox Patent No. 1,783,804, in Sabbah Patent No. 1,923,749, assigned to the same assignee as the present application, has however been found to be inadequate in certain cases due to the random shifting of the unbalance from one of the transformer secondaries to the other during operation. The shifting was due apparently, among other causes, to change in transformer temperature, the balance being impaired after a period of operation on heavy overload. In other cases, the shift was apparently caused by changes in the voltage drop through the arc discharge apparatus with age and temperature, under which conditions the unbalance between the transformer secondaries tended to be reversed.

In accordance with the present invention the foregoing difficulties are obviated by the provision in power systems of the above described character of sets of reactors connected respectively between each of the polyphase transformer secondaries and the corresponding anodes of the arc discharge apparatus, and saturating windings operatively associated with the sets of reactors, each saturating winding being energized from the opposite transformer secondary, thereby to vary the reactance of the reactors in such manner as to compensate for the unbalance tending to occur in the currents flowing from the polyphase transformer secondaries.

The invention will be better understood from the following description when considered in connection with the accompanying drawing and its scope will be set forth in the appended claims.

Referring to the drawing, the single figure thereof is a diagrammatical representation of a rectifier system in which the invention has been embodied.

In the figure, the rectifier system includes alternating current supply terminals 10 and direct current terminals 11 between which power is transmitted through an electric discharge apparatus, such as constituted by separate rectifiers 12, and a main supply transformer provided with a primary 13 and with two three-phase secondary windings 14 and 15.

To prevent unbalance in the system, the phase terminals 16 to 21 of secondaries 14 and 15 are connected respectively to anodes 22 to 27 of the discharge apparatus 12 through anode reactor windings 28 to 33 mounted respectively on legs 34 to 36 and 37 to 39 of reactor cores 40 and 41 each having a fourth or extra leg 42, 43 to permit a required degree of saturation. The neutral terminals 44, 45 of the transformer secondary windings 14, 15 are interconnected through an interphase transformer 46 and through reactor saturating windings 47, 48, preferably of a relatively large number of turns. The saturating windings 47, 48 are mounted respectively on the extra legs 42, 43 of the reactor cores 40, 41, and are so connected that saturating winding 47 of core 40 associated with transformer winding 14 is energized by current flowing from transformer winding 15, and saturating winding 48 of core 41 associated with transformer winding 15 is energized by current flowing from transformer winding 14. The extra or saturating windings 47, 48 are wound in such sense that, upon increased flow of current therethrough, the saturation of the reactor cores

40, 41 increases. To prevent complete saturation of the reactors 28 to 33 air gaps 49, 50 are preferably provided in the cores 40, 41.

In operation of the system shown for illustrative purposes in the drawing, assuming that conditions in the system are such that the current from one of the transformer secondary windings, as 14, increases over normal, and the current from the other windings, 15, correspondingly decreases, the current through saturating winding 48 thereupon increases and the current through saturating winding 47 decreases. The saturation of the reactor system associated with transformer windings 15 and including reactance 31 to 33 therefore increases, with consequent decrease of the reactance in the connections between transformer winding 15 and the corresponding anodes 25 to 27. At the same time the saturation of the reactor system associated with transformer windings 14 and including anode reactors 28 to 30 decreases, with consequent increase of the reactance of the connections between transformer windings 14 and the corresponding anodes 22 to 24. The increase of current through windings 14 and the decrease through windings 15 are therefore checked and the unbalance tending to occur in the system is compensated.

Assuming that conditions in the system change in such manner that the current from the transformer secondary windings 15 increases above normal while the current from secondary windings 14 decreases, the unbalance therefore being opposite to that above described, it will be evident that the saturating windings 47, 48 then operate to check the current increase through windings 15 and the decrease through windings 14 and to compensate the unbalance as before. In general, by the means set forth in accordance with the present invention, unbalance arising from any of the causes herein-above mentioned or other causes, in the current flowing from the interconnected transformer secondaries, is compensated to a desired degree or substantially prevented.

While the present invention has been shown and described with reference to an electric discharge apparatus of the heated cathode type in which pairs of anodes and cathodes are enclosed in separate vessels, the invention is not to be limited thereto since any other suitable arrangement of electric discharge apparatus in which current is caused to flow unidirectionally between a negative conductor and a plurality of anodes, for rectifiers for like purposes, for example, a multi-anode electric discharge device of the single cathode, mercury pool type, may be employed.

The invention has been described herein in a particular embodiment for purposes of illustration. It is to be understood, however, that the invention is susceptible of various changes and modifications and that by the appended claims it is intended to cover any such modifications as fall within the true spirit and scope of the invention.

What is claimed as new and desired to secure by Letters Patent of the United States is:

1. The combination of a polyphase system provided with two polyphase main transformer secondary windings, an interphase connection connected between the neutral terminals of said secondary windings, a plurality of reactor windings, an electric discharge apparatus comprising

a plurality of anodes each connected to a different phase of said transformer windings through a different one of said reactor windings, and means responsive to the current flowing between each of said polyphase transformer windings and said interphase connection to vary simultaneously the reactance of the reactor windings connected to the other polyphase transformer windings, thereby to compensate for unbalance in the currents flowing from said two polyphase transformer windings.

2. The combination of a polyphase system provided with two polyphase main transformer secondary windings, an interphase transformer connected between the neutral terminals of said secondary windings, an electric discharge apparatus comprising a plurality of anodes, two sets of reactor windings connected respectively between different ones of said anodes and different phases of said secondary windings, two reactor cores having separate legs for the corresponding reactor windings and an extra leg, direct current terminals connected to said interphase transformer and through said discharge apparatus and said reactor windings to said transformer windings, two saturating windings mounted respectively on said extra core legs, and means to supply current to a given one of said saturating windings corresponding to a given one of said secondary windings from the other of said secondary windings, to prevent unbalance in the current flowing from said two secondary windings.

3. The combination of a six-phase system provided with two three-phase main transformer secondary windings, an interphase connection connected between the neutral terminals of said secondary windings, six reactor windings, an electric discharge apparatus comprising six anodes each connected to a different phase of said transformer windings through a different one of said reactor windings, and means responsive to the current flowing between each of said transformer windings and said interphase connection to vary simultaneously the reactance of the three reactor windings connected to the other of said transformer windings, thereby to compensate for unbalance in the currents flowing from said two three-phase transformer windings.

4. The combination of a polyphase system provided with two three-phase main transformer secondary windings, an interphase transformer connected between the neutral terminals of said secondary windings, an electric discharge apparatus comprising six anodes, two sets of three reactor windings connected respectively between different ones of said anodes and different phases of said secondary windings, two reactor cores each having three legs for the corresponding reactor windings and an extra leg, direct current terminals connected to said interphase transformer and through said discharge apparatus and said reactor windings to said transformer windings, two saturating windings mounted respectively on said extra core legs, and means to supply current to a given one of said saturating windings corresponding to a given one of said three-phase secondary windings from the other of said three-phase secondary windings, to prevent unbalance in the current flowing from said three-phase secondary windings.

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