Oct. 24, 1944. C. H. WILLIS 2,361,254

ELECTRIC VALVE APPARATUS

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Fig. 1.

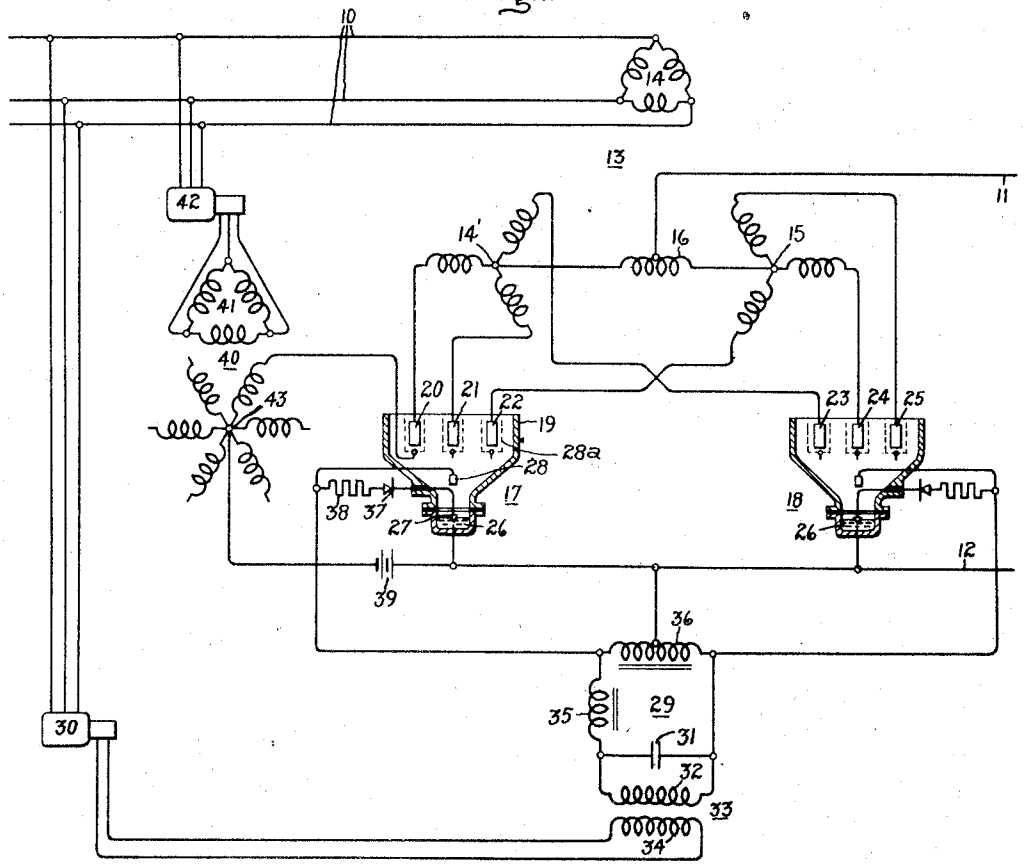
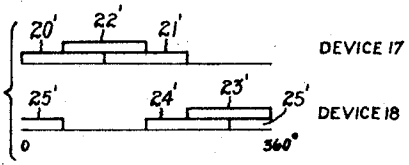


Fig. 2.



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ELECTRIC VALVE APPARATUS

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6 Claims. (Cl. 175—363)

My invention relates to electric valve apparatus and more particularly to electric valve apparatus adapted for transferring power between a plurality of circuits, at least one of which is a polyphase alternating-current circuit.

Electric valve apparatus has been widely used in industrial applications for transferring controlled amounts of power between supply and load circuits of different electrical characteristics. The valve means employed have been of two general types, one, the multianode tank in which a plurality of anodes supported within a container or vessel cooperate with a single mercury pool cathode and the other of which is commonly called a single-anode tank and comprises a single anode, and a single mercury pool-type cathode. The multianode units have had some advantages with respect to the number of units required and the cost of construction. However, these units have been subject to certain operating disadvantages, such as a tendency for the arc to form between one of the anodes and a wall of the container. As a result of these disadvantages, the trend has been toward the single-anode unit. While these single units have in many respects exhibited superior operating characteristics, the control and excitation equipment required for establishing a cathode spot once each cycle for each of the anode-cathode circuits has required a large amount of equipment of sizable electrical rating. This is particularly true in installations utilizing the immersion-ignitor type of control member for initiating the cathode spot. In accordance with the teachings of the present invention, I provide new and improved electric valve apparatus utilizing electric valve means of the multianode type which, to a considerable extent, combines the advantages of both the multianode and single-anode types of electric valve means.

It is an object of my invention to provide new and improved electric valve apparatus.

It is another object of my invention to provide a new and improved electric valve system having dependable operating characteristics and, at the same time, requiring a minimum of excitation and control equipment in its operation.

In accordance with the illustrated embodiment of my invention, I have shown a double three-phase electric valve system interconnecting alternating and direct-current circuits. Two electric valve means, each including three anodes and a mercury pool cathode, are employed and the anodes of each valve means are connected with the phase terminals of the supply in such a manner that there is a considerable period during each cycle of alternating-current voltage that each of the valve means is dark, or, in other words, during which all of the discharge paths of the valve means are nonconductive. An immersion-ignitor type of control member is associated with each of the valve means for establishing a cathode spot once during each cycle of the alternating-current voltage. Control members or grids are associated with each of the anodes to control the instant of initation of conduction in each of the discharge paths.

My invention will be better understood by reference to the following description taken in connection with the accompanying drawing and the scope will be pointed out in the appended claims. In the drawing, Fig. 1 is a schematic representation of one embodiment of my invention and Fig. 2 represents the conducting periods of the various anodes of the electric valve means illustrated in Fig. 1.

Referring now to the drawing, I have shown my invention embodied in an electric valve system for transferring current between a polyphase alternating-current circuit 10 and a direct-current circuit comprising conductors 11 and 12. Throughout the remainder of the specification, the system will be described as a rectifier operating to transfer energy from the alternating-current circuit 10 to the direct-current circuit 11, 12, although it will be understood that the system may readily be operated to transfer energy in either direction. A transformer 13 having a delta-connected primary winding 14 energized from the alternating-current circuit 10 is provided with two groups of Y-connected secondary windings 14' and 15 having the neutral terminals thereof interconnected by an interphase transformer 16. The direct-current line 11 is connected to an intermediate terminal on the interphase transformer 16. The phase terminals of the windings 14' and 15 are arranged to be connected selectively with the direct-current conductor 12 by means of the discharge paths of electric valve means 17 and 18 which are identical in construction and each comprises a container 19 which provides a housing for the electrodes. As illustrated in the drawing, the valve means 17 and 18 each include three anodes which have been designated 20, 21, 22 and 23, 24, 25 respectively, a mercury pool cathode 26, a make-alive electrode 27 which has been illustrated as the immersion-ignitor type, and a relieving anode 28 and control members or grids 28a. As is well understood by those skilled in the art, the containers 19 are either permanently sealed off to form a vacuum-tight

enclosure or are arranged to be connected with an evacuating system.

In order to provide a cathode spot in the devices 17 and 18 once each cycle, the starting electrodes 27 and relieving anodes 28 are energized from a suitable peaked voltage-producing circuit 29 which, as illustrated, may be energized from the alternating-current supply circuit through any suitable phase-shifting device which has been illustrated schematically at 30. The excitation circuit 29 comprises a capacitor 31 connected across the secondary winding 32 of a transformer 33 having the primary winding 34 thereof energized from the adjustable single-phase output of the phase-shifting device 30. A self-saturating inductive reactance 35 and a midtapped linear inductive reactance 36 are connected in series relation across the terminals of the capacitor 31. The midtap of the reactor 36 is connected to the cathodes 26 of valve means 17 and 18 through the direct-current line 12 and the end terminals of reactor 36 are connected with the relieving anodes 28 and the starting electrodes 27 of the valve means 17 and 18, respectively. Connected in series with each of the starting electrodes 27 is a unilaterally conducting device 37 and a resistor 38 which aids in transferring current from the starting electrode to the relieving anode upon the formation of a cathode spot. The excitation circuit just described is disclosed in detail and claimed in the copending Alexanderson et al. application, Serial No. 374,716, filed January 16, 1941, and assigned to the assignee of the present invention. As will be readily appreciated by those skilled in the art, the excitation circuit is effective to impress voltages of peaked wave form on the starting electrodes 27 of devices 17 and 18 at intervals displaced 180 electrical degrees and that the phase position of the peaked voltages may be adjusted with respect to the supply circuit 10 by means of the phase-shifting device 30.

In order that the instant of initiation of conduction of each of the discharge paths of the electric valve devices 17 and 18 may be accurately controlled, I provide a biasing battery 39 and a transformer 40 for energizing the control members or grids 28*a*. The transformer 40 is provided with a primary winding 41 energized from the alternating-current circuit 10 through a suitable phase-shifting device 42 and with a secondary winding 43. The winding 43 is provided with a neutral terminal connected with the cathodes 26 through battery 39 and with six phase terminals for connection with the control members 28*a* associated with anodes 20 to 25, respectively, only one has been shown connected in order to simplify the drawing. The battery 39 impresses a negative voltage on each of the control members to maintain each of the electric discharge paths nonconductive until a predetermined instant in the cycle of anode-cathode voltage thereof determined by the adjustment of the phase-shifting device 42.

It will be noted from an inspection of the drawing that anodes 20 and 21 are connected with phase terminals of winding 14' while the anode 22 is connected with the phase winding of the secondary winding 15. In other words, the three anodes of the electric valve device 17 are connected to be energized with voltages having such a phase relation that all of the conduction in the device 17 takes place within a period of substantially 240 electrical degrees duration. As a result, there will be no arc in the device 17 for substantially 120 electrical degrees. The anodes of the valve device 18 are similarly connected to provide a substantial period during which all of the discharge paths are nonconductive. This arrangement of connections is illustrated schematically in Fig. 2 in which the periods of conduction of each of the anodes of the devices 17 and 18 have been designated by the primed numeral designating the corresponding anode. It has been found that such an arrangement wherein the arc is initiated every cycle overcomes the tendency of the arc to form between one of the anodes and the wall of the container which exists in conventional multianode electric valve circuits utilizing multianode electric valve units. At the same time, the excitation or control equipment required for forming the cathode spot has been materially reduced, inasmuch as one double peak-producing circuit furnishes the excitation for the ignitors of a six-phase or six-anode system as compared with three times this equipment required for the excitation of six single-anode electric valve means. The power consumed by the control members or grids 28*a* is comparatively small and this equipment is of much smaller electrical rating than the excitation equipment required for the starting or immersion-ignitor electrode.

Although the illustrated embodiment of my invention relates to a double three-phase rectifier circuit, it will be understood that my invention in its broader aspects is applicable to any polyphase electric valve system regardless of the number of phases or whether an interphase transformer is employed.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In combination, a polyphase alternating-current circuit, a second circuit, electric translating apparatus interconnecting said circuits and including electrically displaced windings for producing two symmetrical polyphase systems of voltage, and a plurality of electric valve means each including a plurality of anodes and a single cathode, means connecting the anode-cathode circuits of said electric valve means with different phases of said windings in such a manner that the system of voltages impressed on the anode-cathode circuits of each of said valve means is unsymmetrical so that during normal operation there is a substantial period during each cycle of said alternating-current circuit that all of the anodes of one of the electric valve means are simultaneously negative with respect to the cathode thereof.

2. In combination, a polyphase alternating-current circuit, a direct-current circuit, a plurality of electric valve means interconnecting said circuits, each of said valve means including a plurality of anodes and a single cathode, means connecting the anode-cathode circuits of said electric valve means with phases of said polyphase circuit displaced with respect to each other by such an amount that all of the anode-cathode circuits of one of the valve means are simultaneously non-conducting as a result of the anode-cathode voltages for a substantial portion of

each cycle of voltage of said alternating-current circuit.

3. In combination, a polyphase alternating-current circuit, a second circuit, a plurality of groups of electrically displaced phase windings, a plurality of electric valve means each including a plurality of anodes and a single cathode, means connecting the phase windings of each of said groups with certain anodes of each of said valve means so that during each cycle of voltage of said alternating-current circuit there is a substantial period during which more than one anode-cathode circuit in each of said valve means are conducting simultaneously and a substantial period during which there is no conduction in each of said valve means.

4. In combination, a polyphase alternating-current circuit, a second circuit, electric translating apparatus interconnecting said circuits including a pair of electric valve means each having a plurality of anodes, a control member associated with each anode, a cathode, and an electrode associated with the cathode for forming a cathode spot, means for energizing the anode-cathode circuits from said polyphase alternating-current circuit with voltages having such a phase relation that there is a substantial period during each cycle of voltage of said alternating-current circuit during which all of the anodes of one of the electric valve means are simultaneously negative with respect to the cathode thereof, means for energizing the electrode associated with said cathode to form a cathode spot during each cycle of voltage of said alternating-current circuit, means for impressing a voltage on the control members associated with said anodes for maintaining all of the anode-cathode circuits nonconductive, and means for impressing a second voltage on said control members for rendering the anode-cathode circuits selectively conductive.

5. In combination, a polyphase alternating-current circuit, a second circuit, electric translating apparatus interconnecting said circuits, including at least four electrically displaced phase windings, a pair of electric valve means each including at least two anodes, a single cathode, an electrode associated with said cathode, and a control member associated with each of said anodes, means connecting said anodes with said electrically displaced phase windings in such a manner that the voltages impressed on the anode-cathode circuits of each of the electric valve means are unequally displaced electrically with respect to one another, means for energizing the electrode associated with said cathode to establish a cathode spot, and means for energizing the control members associated with said anodes for controlling the instant of initiation of conduction of each of the anode-cathode circuits of said valve means.

6. In combination, a polyphase alternating-current circuit, a direct-current circuit, electric translating apparatus interconnecting said circuits including a plurality of groups of electrically displaced phase windings and a plurality of electric valve means each having a number of anodes equal to the number of phase windings in one of said groups and a single cathode, means connecting said phase windings and said valve means between said circuits to operate as a double polyphase valve-converting system, the anodes of each of said valve means being connected with respective phases of more than one of said groups of windings so that the voltages impressed on the anodes of any one of said valve means are not equally displaced electrically with respect to one another, means for establishing a cathode spot in each of said valve means once during each cycle of voltage of said alternating-current circuit, and means associated with each of said anodes for determining the instant of initiation of conduction in each of the anode-cathode circuits.

CLODIUS H. WILLIS.