May 29, 1934. O. W. LIVINGSTON 1,961,057

ELECTRIC VALVE CIRCUITS

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Fig. 1.

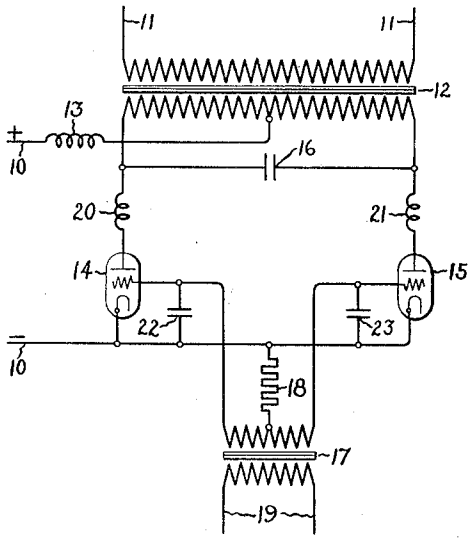
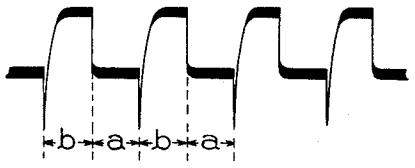


Fig. 2.



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ELECTRIC VALVE CIRCUITS

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4 Claims. (Cl. 175—363)

My invention relates to electric valve circuits and more particularly to such circuits including valves of the vapor electric discharge type.

Heretofore, there have been devised numerous apparatus including electric valves for transmitting energy between direct current circuits, direct and alternating current circuits, or alternating current circuits of different frequencies, voltages, phases, etc. In such electric valve converting apparatus, it has been found particularly advantageous to use valves of the vapor electric discharge type because of the relatively large amounts of power which may be handled at ordinary operating voltages. In the majority of the arrangements of the prior art, however, the several electric valves are adapted to be rendered conductive periodically for short intervals of time and to be maintained non-conductive periodically for other intervals of time. In such apparatus it has been customary to maintain the valves non-conductive during the desired intervals by impressing a negative potential upon the control grid, this potential being either a periodic potential, each cycle of which has an appropriate negative period, or a unidirectional negative bias potential upon which is superimposed a periodic potential, the positive periods of which are sufficient to render the grids positive during intervals in which the valve is to be made conductive.

In many of the electric valve converting apparatus, it has been found that periodic transients of very steep wave front are set up in the apparatus due to the sudden transfer of load current between the several electric valves. In case these transients are impressed across a non-conducting electric valve with such a polarity that the anode is made positive with respect to the cathode, it has been found that the internal capacity between the grid and anode of the electric valve is often sufficient to permit a potential to be electrostatically induced upon the grid of such a magnitude as to overcome the grid bias and render the valve conducting; that is, the grid of the electric valve loses control of its conductivity. Such an occurrence usually causes a short circuit upon one or more of the parts of the apparatus with consequent damage thereto and interruption of service.

It is an object of my invention, therefore, to provide an improved electric valve circuit for valves of the vapor electric discharge type which will overcome the above mentioned disadvantages of the arrangements of the prior art and which will be simple and reliable in operation.

It is another object of my invention to provide an improved electric valve circuit including a valve of the vapor electric discharge type which will avoid the possibility of the grid losing control of the conductivity of the valve upon the occurrence of transients in the valve circuit.

In accordance with my invention, the effect of the transient positive voltages in the anode circuit of a vapor electric discharge valve on the grid of the device, tending to deprive the grid of control over the conductivity of the valve, is substantially eliminated by connecting an inductance in the anode circuit of the valve immediately adjacent the valve. An inductance so connected serves to suppress potential transients of steep wave front from the anode of the valve. This inductance should preferably be so small as not to affect appreciably the normal operation of the apparatus, but, due to the steepness of the wave front of the disturbing transients, its reactance to these transients will be sufficient to suppress them substantially from the anode of the valve.

For a better understanding of my invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims. Referring now to the drawing, there is illustrated in Fig. 1, an electric valve converting apparatus of the type known in the art as a parallel inverter in which my invention is embodied, while Fig. 2 is a copy of an oscillogram illustrating certain operating characteristics of the apparatus of Fig. 1.

In Fig. 1 of the drawing there is illustrated an electric valve converting apparatus embodying my invention adapted to transmit energy from a direct current supply circuit 10 to an alternating current load circuit 11. This apparatus comprises a transformer 12 having a secondary winding connected to the alternating current 11 and a primary winding provided with an electrical midpoint connected to one side of the direct current circuit 10 through a smoothing reactor 13 and a pair of end terminals connected to the other side of the direct current circuit 10 through vapor electric discharge valves 14 and 15. A commutating capacitor 16 is connected between electric valves 14 and 15. The vapor electric discharge valves 14 and 15 are each provided with an anode, a cathode and a control grid for controlling the starting of current in the anode cathode circuit.

The grids of the valves 14 and 15 are connected to their common cathode circuit through

opposite halves of the secondary winding of a grid transformer 17 and a current limiting resistor 18. The primary winding of the grid transformer 17 may be energized from any suitable alternating current circuit 19 of the frequency which it is desired to supply to the circuit 11, or, in case the circuit 11 is connected to an independent source of electromotive force for determining its frequency, the primary winding of the transformer 17 may be energized therefrom through any suitable phase advancing condenser, as will be well understood by those skilled in the art.

In order substantially to eliminate the effect of transients in the anode circuits of the electric valves upon the valves, there are included in the anode circuits of the valves 14 and 15 reactors 20 and 21, respectively, each being connected immediately adjacent the anode of its respective valve. These inductances are preferably of such a low value that they have no appreciable effect upon the operation of the apparatus at its normal frequency. However, due to the very steep wave front of the transients in the anode circuits these inductances present a very high reactance and substantially suppress these disturbing transients from the anodes of the electric valves. The inductances 20 and 21 should preferably have a very low distributed capacity in order to obtain their maximum effectiveness. If desired, capacitors 22 and 23 may be connected between the grids and cathodes of the valves 14 and 15, respectively, although this feature of connecting a capacitor between the grid and cathode of a vapor electric discharge valve to eliminate the effects of transients in the anode circuit forms no part of my present invention, but is disclosed and claimed in a copending application of Alan Howard, Serial No. 566,376, filed October 1, 1931, and assigned to the same assignee as the present application.

The general principles of operation of the above described apparatus will be well understood by those skilled in the art or may be found explained in detail in United States Letters Patent No. 1,800,002, granted April 7, 1931, upon the application of E. F. W. Alexanderson. In brief, if one of the electric valves, for example valve 14, is initially made conductive by a positive half cycle of grid potential from the transformer 17, current will flow from the positive side of the direct current circuit through the left hand portion of the primary winding of the transformer 12 and electric valve 14 to the other side of the direct current circuit. During this interval, capacitor 16 will become charged to a potential substantially twice that of the direct current circuit and, when electric valve 15 is made conductive, the potential of this capacitor is effective to transfer the current from the valve 14 to the valve 15. The current will now flow through the right hand portion of the primary winding of the transformer 12 and electric valve 15 to the other side of the direct current circuit. In this manner current is successively commutated between electric valves 14 and 15 flowing in opposite directions through the primary winding of transformer 12 and supplying an alternating potential to the circuit 11. In case the alternating current circuit 11 is connected to an independent source of electromotive force, it will be understood that the capacitor 16 may be omitted and the primary winding of the grid transformer may be energized from the alternating current circuit 11, in which case the electromotive force of the transformer 12 is effective to commutate the current between the electric valves.

In Fig. 2 there is illustrated a copy of an oscillogram of the potential appearing across one of the electric valves in a circuit of the type illustrated in Fig. 1. The portions *a* of this curve represent intervals during which the valve is conducting current so that the potential across the valve is only the arc drop of the valve, which remains substantially constant. The intervals *b* of this curve represent the periods during which the valve is non-conductive. It will be seen that, during the initial portions of these intervals *b*, the anode potential of the valve rises very rapidly to a high positive value. As explained in more detail in the copending application of Alan Howard, Serial No. 566,376, referred to above, the capacity between the grid and anode of each of the valves 14 and 15 causes a potential to be electrostatically induced upon the control grid, the magnitude of which depends upon the inter-electrode capacities of the valves. By means of the capacitors 22 and 23, connected between the grids and cathode of the valves, the value of the potential electrostatically induced upon the control grids may be reduced substantially. However, I have found that the reliability of the grid control circuits may be substantially improved by means of the inductances 20 and 21 connected in the anode circuit, these inductances tending to absorb the potential transients of steep wave front by offering a very high impedance to the charging currents for the inter-electrode capacities of the valves and the additional capacitors connected between the grids and cathodes of the valves. That is, during the intervals *b* of the curve of Fig. 2, when a positive potential transient appears in the anode circuit of the electric valve, the danger of the valve being rendered conductive due to the grid being deprived of its control by potentials electrostatically induced on the grid, is substantially eliminated.

While I have described what I at present consider the preferred embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention, 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 with an electric power converting apparatus including a plurality of vapor electric discharge valves, each provided with an anode, a cathode and a control grid, the grid and anode of each of said valves forming a substantial internal capacity, means for rapidly transferring the load current of the apparatus between said electric valves, the anode circuit of certain of said valves being subject to transient potential waves of steep wave front upon each sudden transfer of current between said valves, and means for substantially eliminating the effect on said control grids of said transients in the anode circuits comprising an inductance included in each of the anode circuits.

2. In combination with an electric power converting apparatus including a plurality of vapor electric discharge valves each provided with an anode, a cathode, and a control grid, the grid and anode of each of said valves forming a substantial internal capacity, means for rapidly and periodically transferring the current between said electric valves, the anode circuits of said valves

being subject to periodic potential waves of steep wave front dependent upon the periodic transfer of current between said valves, a control circuit for said grids, and means for substantially eliminating the effect on said control circuit of said periodic potentials in the anode circuits comprising an inductance of low distributed series capacity included in each of said anode circuits.

3. In combination with an electric power converting apparatus including a plurality of vapor electric discharge valves each provided with an anode, a cathode, and a control grid, the grid and anode of each of said valves forming a substantial internal capacity, means for rapidly transferring the current between said electric valves, the anode circuits of said valves being subject to periodic potential waves of steep wave front dependent upon the periodic transfer of current between said valves, a control circuit for said grid for successively maintaining said valves non-conductive for predetermined intervals, and means for substantially eliminating the effect of said periodic potentials in the anode circuits tending to render said valves conductive against the action of said control circuit comprising an inductance in each of the anode circuits immediately adjacent the anode of its respective valve.

4. In combination, a direct current supply circuit, an alternating current load circuit, an inductive winding and a plurality of vapor electric valves interconnecting said circuits, each of said valves being provided with an anode, a cathode, and a control grid, the grid and anode of each of said valves forming a substantial internal capacity, a capacitor for commutating the current between said valves and thereby subjecting said anodes to periodic potentials of steep wave form, a control circuit for said grids for successively maintaining said valves nonconductive for predetermined intervals, and means for substantially eliminating the effect of said periodic potentials in the anode circuits tending to render said valves conductive against the action of said control circuit comprising an inductance device included in the anode circuit of each of said valves.

ORRIN W. LIVINGSTON.