July 24, 1934. T. FECKER 1,967,877

ELECTRIC VALVE CONVERTING APPARATUS

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Fig. 1.

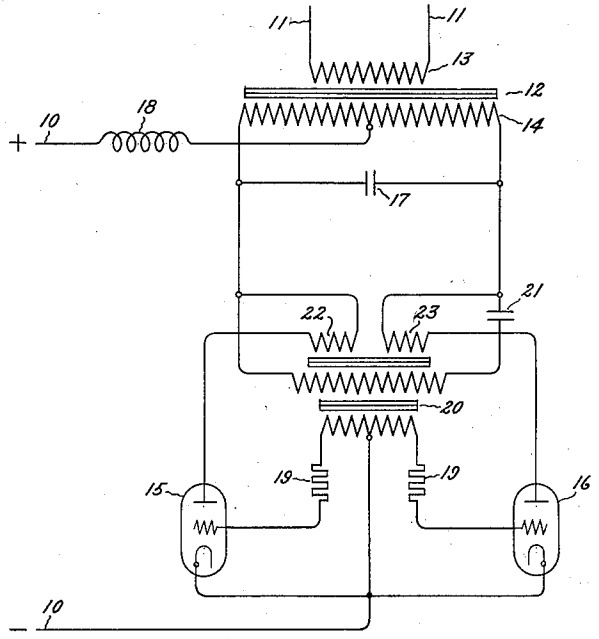
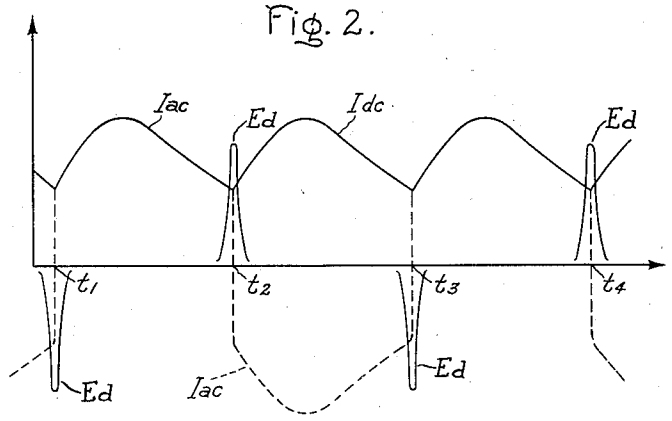


Fig. 2.



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ELECTRIC VALVE CONVERTING APPARATUS

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4 Claims. (Cl. 175—363)

My invention relates to electric valve converting apparatus and more particularly to such apparatus utilizing valves of the vapor electric discharge type.

There are now well known in the art several types of electric valve converting apparatus for transmitting energy between direct and alternating current circuits, between direct current circuits of different voltages, or between independent alternating current circuits. The use of gaseous or vapor electric discharge valves in apparatus of this type has found particular favor because of the relatively high apparatus economy and efficiency. It is well understood that in this type of apparatus the current is commutated between the electric valves by forcing the anode potential of one of the valves negative with respect to its cathode for a short interval of time to interrupt the current therein, and simultaneously making the control electrode negative to maintain the valve non-conductive for the succeeding time interval. In order for the control electrode, or grid, to maintain control over the conductivity of the valve, however, it is necessary for the valve to become deionized. Heretofore, there has been a rather definite frequency limitation upon the operation of such electric valve converting apparatus utilizing valves of the vapor or gaseous discharge type because of the fact that, at the higher frequencies, an insufficient time was available for deionizing the valves.

It is an object of my invention, therefore, to provide an improved electric valve converting apparatus employing gaseous or vapor electric discharge valves 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 converting apparatus employing gaseous or vapor electric valves in which the upper frequency limit of operation may be considerably extended.

It is a further object of my invention to provide an improved electric valve converting apparatus employing gaseous or vapor electric valves by means of which the deionization of the electric valves will be greatly accelerated.

In accordance with my invention, there is provided an electric valve converting apparatus including a pair of vapor or gaseous electric discharge valves having control electrodes or grids. There is provided means for commutating the current between the valves, as for example, a commutating capacitor connected in a well known manner, and a control circuit is connected to the control electrodes of the valves for normally rendering them alternately conductive and non-conductive. This control circuit includes a control transformer which may be energized from the output of the apparatus, in case it is desired to make the apparatus self-exciting, or may be energized from any suitable source of alternating potential of the desired frequency. In order to produce a rapid deionization of the electric valves during or immediately following the commutating period, the control transformer is provided with one or more auxiliary windings connected in series relation with the current flowing in the apparatus during the commutating period. During this period the current is commutated very rapidly between the electric valves and induces potential transients of large amplitude in the secondary winding of the control transformer which are effective to rapidly deionize the electric valve, or valves, from which current has been commutated.

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. In the drawing, Fig. 1 diagrammatically illustrates my invention as applied to a parallel inverter utilizing valves of the vapor or gaseous electric discharge type, while Fig. 2 represents certain operating characteristics of the apparatus shown in Fig. 1.

Referring now to Fig. 1 of the drawing, there is illustrated an arrangement for transmitting energy from a direct current circuit 10 to a single phase alternating current circuit 11, which may operate at a relatively high frequency. This apparatus comprises a transformer 12 provided with a secondary winding 13 connected to the circuit 11 and a primary winding 14 having an electrical midpoint connected to the positive side of the direct current circuit, and end terminals connected to the negative side of the direct current circuit through electric valves 15 and 16. The electric valves 15 and 16 are each provided with an anode, a cathode and a control electrode or grid, and are of the vapor or gaseous electric discharge type, in which the starting of current in a valve is controlled by the potential on its control electrode but in which the current in the valve may be interrupted only by reducing its anode potential below the critical value. In case the alternating current circuit 11

is not provided with an independent source of electromotive force for commutating the current between the valves 15 and 16, a commutating capacitor 17 may be connected across the winding 14 as illustrated. A smoothing reactor 18 is preferably included in the direct current circuit.

In order periodically to render the valves 15 and 16 alternately conductive and non-conductive, the control electrodes or grids of these valves are connected to their respective cathodes through current limiting resistors 19 and opposite halves of the secondary winding of a grid transformer 20, the primary winding of which may be energized from any suitable source of alternating current of the frequency of which it is desired to supply the circuit 11, or it may be connected directly across the winding 14 through a phase advancing capacitor 21, as illustrated, in case the apparatus is to be self-excited. The control transformer 20 is also provided with auxiliary windings 22 and 23, connected, respectively, in series with the electric valves 15 and 16.

The general principles of operation of the above described inverter will be well understood by those skilled in the art. In brief, if one of the electric valves, for example, the valve 15, is initially rendered conductive, current will flow through the left-hand portion of the winding 14 and electric valve 15 inducing one half cycle of alternating current in the transformer 12. During this interval the capacitor 17 becomes charged with the potential appearing across the winding 14, which is substantially twice that of the direct current circuit 10. When the grid potential supplied by the transformer 20 reverses polarity, rendering the valve 16 conductive, the potential of the capacitor 17 is effective to initiate the current in the valve 16 and interrupt it in the valve 15 so that the current now flows through the right-hand portion of the winding 14 inducing a half cycle of alternating current of opposite polarity in the transformer 12. In this manner, the current is successively commutated between the valves 15 and 16 and alternating current is supplied to the circuit 11.

When electric valve 16 is rendered conductive, the capacitor 17 is effective to initiate the current in the valve 16 and interrupt that in the valve 15 by momentarily making the cathode of the valve 15 positive with respect to its anode. However, the capacitor 17 discharges relatively rapidly and will hold the cathode of the valve 15 positive with respect to its anode for only a very short interval. During this time it is necessary completely to deionize the valve 15 or, when the anode of the valve 15 again becomes positive, current will immediately restart in the valve 15, resulting in a short circuit on the direct current circuit 10.

In Fig. 2 are illustrated wave forms of the currents appearing in the direct and alternating current circuits of the apparatus. In this figure the solid line curve I_{dc} represents the unidirectional current flowing in the circuit 10, while the solid-dotted line curve I_{ac} indicates the wave of alternating current supplied to the load circuit 11. In these curves, the actual period of commutation between the valves has been neglected and it has been assumed that the commutation is instantaneous, since in many applications this time required for the transfer of current between the valves is of a negligible value. As is well understood by those skilled in the art, the amount of ripple in the curve I_{dc} may be controlled by properly selecting the smoothing reactor 18, which is effective to smooth out the pulsations in the unidirectional current. From these curves it is seen that the rate of change of current at the instants of commutation, that is, at the points t_1, t_2, etc., in the diagram, is much greater than at any other time during the cycle of operation. By passing the valve currents through the windings 22 and 23, respectively, this sudden transfer of current between the valves is effective to induce very high transient voltages in the secondary winding of the transformer 20, which are impressed upon the grids of the electric valves 15 and 16. The curves E_d represent these deionization voltages as applied to the grid of one of the electric valves, for example, the electric valve 15 during the commutating periods, while that for the other valve is not shown. By giving the windings 22 and 23 a relatively few number of turns, their impedance as referred to the power circuit may be of negligible value. At the same time, the voltage induced in the secondary winding of the control transformer 20 by the auxiliary windings 22 and 23 during the remaining portions of the cycle of operation may be inappreciable relative to the magnitude of the control voltage supplied by the primary winding of this transformer. These impulses of negative voltage impressed upon the grid of the electric valve 15, for example, during the intervals t_1, t_3, etc., when current has just been interrupted therein, are effective to collect rapidly all of the positive ions in the enclosed space; that is, to deionize the electric valve rapidly. This acceleration of the deionization of the electric valves enables the apparatus to operate at considerably higher frequencies than would otherwise be the case.

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 an electric valve converting apparatus including an inductive winding, a pair of vapor electric valves provided with control electrodes, means for commutating the current between said valves, and a control circuit for normally controlling the conductivity thereof, means for accelerating the deionization of said valves comprising means responsive to the flow of current during the commutating period for impressing a negative impulse upon the grid of the valve which is to be deionized.

2. In an electric valve converting apparatus including an inductive winding, a pair of vapor electric valves provided with control electrodes, means for commutating the current between said valves, and a control circuit for normally controlling the conductivity thereof including a control transformer, means for producing a deionization voltage during the commutating periods comprising an auxiliary winding for said control transformer connected in series relation with the current flowing in the apparatus during the commutating period.

3. In an electric valve converting apparatus including an inductive winding, a pair of vapor electric valves provided with control electrodes, means for commutating the current between said valves, and a control circuit for normally controlling the conductivity thereof including a con-

trol transformer, means for producing a deionization voltage during the commutating periods comprising a pair of auxiliary windings for said control transformer, each connected in series with one of said valves.

4. In combination, a direct current supply circuit, an alternating current load circuit including an inductive winding, a pair of vapor electric valves interconnecting said circuits through said winding, each of said valves being provided with a control electrode, means for commutating the current between said valves, a control circuit for normally controlling the conductivity thereof including a control transformer, and means for producing a deionization voltage during the commutating periods comprising an auxiliary winding for said control transformer connected in series relation with the load current of said apparatus.

THEO FECKER.