Dec. 17, 1935. I. LANGMUIR 2,024,173

ELECTRIC TRANSLATING CIRCUIT

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Fig. 1.

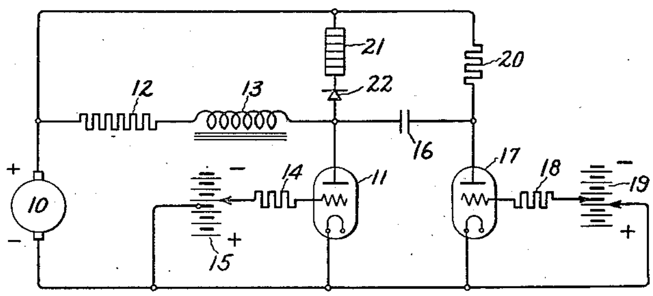
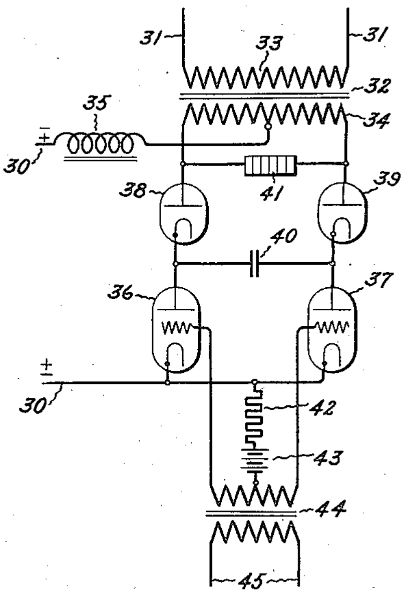


Fig. 2.



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ELECTRIC TRANSLATING CIRCUIT

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7 Claims. (Cl. 175—363)

My invention relates to electric translating circuits, and more particularly to such circuits including a vapor electric valve in which the current in the valve is suddenly interrupted or commutated to another portion of the circuit.

Heretofore there have been proposed numerous electric translating circuits or electric valve converting apparatus, including valves of the vapor electric discharge type, in which it is desired to interrupt the current in the valve or commutate it to another portion of the circuit. Due to the fact that the grid of a vapor electric valve is ordinarily ineffective to interrupt the current in the valve, it is necessary momentarily to depress the anode potential of the valve below its critical value. It has been found that this can be accomplished particularly satisfactorily by means of a condenser, connected to discharge through the vapor electric valve in a direction opposite to its normal conductivity. The interruption of current in a vapor electric valve in such a manner, however, is practically instantaneous with the result that excessive transient voltages may be set up in various portions of the circuit by any inductive elements included in the circuit.

It is an object of my invention, therefore, to provide an improved electric translating circuit including a vapor electric valve in which the current is suddenly interrupted, 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 translating circuit including a vapor electric valve in which the current in the valve may be suddenly interrupted or commutated to a different portion of the circuit, and in which the occurrence of excessive transient voltages will be prevented.

In accordance with one embodiment of my invention, an electric translating circuit including a vapor electric valve is provided with a capacitor connected to discharge through the valve in a direction opposite to its normal conductivity to interrupt the current in the valve or commutate it to a different portion of the circuit. In order to prevent the occurrence of excessive transient voltages in the translating circuit upon the sudden interruption of current in the vapor electric valve, there is provided a discharge path for any inductive elements of the translating circuit including a resistance element having a highly negative impedance-voltage characteristic. The effect of such an arrangement is to provide a relatively low impedance path for the high voltage transients and thus to limit their magnitude to a safe value.

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 Fig. 1 of the drawing there is illustrated an arrangement embodying my invention for interrupting a unidirectional current by means of a vapor electric valve, while Fig. 2 shows an electric valve inverter embodying my invention in which current is rapidly commutated between a pair of vapor electric valves.

Referring now to Fig. 1 of the drawing, there is illustrated an arrangement for supplying energy from a source of direct current 10 through an electric valve 11 to an inductive load circuit diagrammatically illustrated as comprising a resistance element 12 and a reactance 13 although it will be apparent that these two elements may together constitute a single load device. The electric valve 11 is provided with an anode, a cathode and a control grid and is of the vapor electric discharge type in which the starting of current in the valve is determined by the potential on its control grid, but in which the current in the valve can be interrupted only by means of the external circuit. In order to control the starting of the current in the valve 11, a control grid is connected to its cathode through a current limiting resistor 14 and a source of bias potential adjustable in magnitude and polarity, illustrated as a battery 15. A capacitor 16 is connected in parallel to the valve 11 through an auxiliary grid controlled electric valve 17 which may be of either the vapor electric or high vacuum pure electron discharge type. The conductivity of the valve 17 is controlled by a grid circuit including a current limiting resistor 18 and a source of bias potential variable in magnitude and polarity, illustrated as a battery 19. The capacitor 16 may be charged by any suitable arrangement such that its polarity is in a direction to tend to reverse the current flowing in the valve 11. In the arrangement illustrated, this is accomplished by connecting the capacitor across the load circuit 12—13 through a current limiting resistor 20.

In order to prevent disturbances in various parts of the translating circuit upon the sudden interruption of the unidirectional current in electric valve 11, a discharge circuit is provided for the load circuit 12—13 comprising a resistance device 21 having a highly negative impedance-voltage characteristic, such for example, as a resistance element composed of a material such as that described in United States Letters Patent No. 1,822,742, granted September 8, 1931, upon the application of K. B. McEachron. A unilaterally conductive device, such as a rectifier 22, is preferably included in series with the resistance device 21 to prevent the normal flow of current in this device and to prevent a discharge of the capacitor 16.

In explaining the operation of the above described apparatus, it will be assumed that initially the grids of the valves 11 and 17 are so negative that current is prevented from starting therein. In case it is desired to energize the load circuit 12—13, the grid of the valve 11 will be made positive for a short interval sufficient to allow the current to build up in this circuit and will thereafter be made negative again. While current is flowing in the above described circuit, the full voltage of the load circuit will be impressed across the resistor 20 and the capacitor 16 which will become charged to the load voltage in a relatively short time, the right hand terminal of the capacitor 16 being positive. During this same interval current is prevented from flowing through the parallel circuit including the resistance element 21 by means of the rectifier 22. Similarly, the rectifier 22 prevents the discharge of capacitor 16. When it is desired to interrupt the anode current in the valve 11, the grid of the valve 17 is made positive for a short interval so that the capacitor 16 discharges through the electric valve 11 in a direction opposite to that in which current normally flows therein, thus momentarily diverting the current from the valve 11. During the short interval in which current is diverted from the valve 11 the negative grid potential of this valve is effective to deionize the valve and to prevent the restarting of the current therein. The energy stored in the inductive element 13 will tend to cause disturbing or disruptive voltages in the translating circuit upon the sudden interruption of current. However, the voltage across the inductive element 13 will be limited to a safe value by the resistance device 21, which, as stated above, has a highly negative impedance-voltage characteristic so that for excessive voltages the energy will be dissipated rapidly in the discharge circuit. Obviously, the above described cycle may be repeated as desired to connect and disconnect the load circuit 12—13 and the source of direct current 10.

In Fig. 2 there is illustrated another embodiment of my invention for transmitting energy between a direct current circuit 30 and an alternating current circuit 31. This apparatus comprises a transformer 32 having a winding 33 connected to the alternating current circuit 31 and a winding 34 provided with an electrical midpoint connected to one side of the direct current circuit through a smoothing reactor 35. The end terminals of the winding 34 are connected to the other side of the direct current circuit through a pair of electric valves 36 and 37 connected in series with a pair of auxiliary electric valves 38 and 39. A commutating capacitor 40 is connected between the common connections of the serially connected valves. Each of the valves 36—39, inclusive, is provided with an anode and a cathode and may be of any of the several types well known in the art, although I prefer to use valves of the vapor electric discharge type. The valves 36 and 37 are also provided with control grids, by means of which the power factor on the alternating current circuit may be controlled and its frequency determined, in case it is not connected to an independent source of electromotive force. In order to prevent the occurrence of excessive transient voltages in the various portions of the circuit, which in this particular case may have a particularly detrimental effect upon the operation of the electric valves, there is connected between the outer terminals of the winding 34 a discharge element 41 having a highly negative impedance-voltage characteristic similar to the discharge element 21 of the arrangement of Fig. 1. The grids of the electric valves 36 and 37 are connected to their common cathode circuit through a current limiting resistor 42, a negative bias battery 43 and opposite halves of the secondary winding of a grid transformer 44. The primary winding of the grid transformer 44 may be connected to any suitable source of alternating potential of a frequency which it is desired to supply to the circuit 31, or in case the circuit 31 is energized from an independent source of electromotive force, the primary winding of the transformer 44 may be energized therefrom through any suitable phase shifting arrangement, as is well understood by those skilled in the art.

The general principles of operation of the apparatus described in the preceding paragraph will be well understood by those skilled in the art. In brief, assuming that the apparatus is operating as an inverter, transmitting energy from the direct current circuit 30 to the alternating current circuit 31, current will flow first from the positive side of the direct current circuit to the left hand portion of winding 34, electric valves 38 and 36 to the other side of the direct current circuit, inducing a half cycle of alternating current in the transformer 32. During this interval the capacitor 40 will be charged through the electric valve 39 to substantially twice the voltage of the direct current circuit 30. The charging circuit for the capacitor 40 may be traced from the upper terminal of the direct current circuit 30, the right-hand portion of the inductive winding 34, electric valve 39, capacitor 40, and electric valve 36, to the other side of the direct current circuit 30. The potential induced in the right-hand portion of the inductive winding 34 by the load current flowing in the left-hand portion will be substantially equal to that of the direct current supply circuit and this will act cumulatively with respect to the potential of the supply circuit in charging the capacitor 40 to a potential substantially twice that of the supply circuit. In case the current is not commutated from the valves 38 and 36 to the valves 39 and 37 until after the electromotive force of the winding 34 is reduced below its maximum value, the maximum potential of the winding 34 will be retained upon the capacitor 40 as it cannot discharge in reverse direction through the valve 39. When the grid potential supplied by the circuit 45 reverses polarity to render the valve 37 conductive, the potential of the capacitor 40 will be effective to transfer the current from the valve 36 to the valve 37 and current will now flow through the right-hand portion of the winding 34 and the valves 39 and 37 inducing a half cycle of alternating current of opposite polarity in the transformer 32. In this manner the current is successively commutated between the valves 38 and 36 and 39 and 37, and alternating current is supplied to the circuit 31. In case the capacitor 40 is relatively small or only sufficient to commutate the current between the valves 36 and 37, the inductive energy of the windings of the transformer 32 will, upon reversal of the current in the winding **34**, tend to charge the capacitor **40** to excessive voltages. These excessive transient voltages may adversely affect the several electric valves causing arc backs or failure of grid control. In the present instance they are eliminated by means of the resistance element **41** connected across the winding **34** and having a highly negative impedance-voltage characteristic. This resistance element **41** is effective to absorb the high transient voltages but draws an inappreciable current of fundamental frequency from the winding **34**.

While I have described what I at present consider the preferred embodiments 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. An electric translating circuit comprising a source of current, an inductance device, a load circuit, a vapor electric valve interconnecting said source and said load circuit and connected in circuit with said inductance device, means including a capacitor for suddenly interrupting the current in said vapor electric valve, and a resistance element having a highly negative impedance-voltage characteristic connected to absorb the transient voltages generated by said inductance device upon interruption of current in said valve.

2. An electric translating circuit comprising a source of unidirectional current, an inductive load circuit, a vapor electric valve interconnecting said source and said load circuit, means including a capacitor for interrupting the current in said valve to disconnect said load circuit from said source, and an energy consuming circuit having a highly negative impedance-voltage characteristic connected to absorb the inductive energy of said load circuit upon the interruption of current in said valve.

3. An electric translating circuit comprising a source of unidirectional current, an inductive load circuit, a vapor electric valve interconnecting said source and said load circuit, means including a capacitor for interrupting the current in said valve to disconnect said load from said source, a circuit for charging said capacitor from said source, an energy consuming circuit connected to absorb the inductive energy of said load circuit upon the interruption of current in said valve, and unilaterally conductive means included in said energy consuming circuit normally to prevent the flow of current therein.

4. An electric translating circuit comprising a source of unidirectional current, an inductive load circuit, a vapor electric valve interconnecting said source and said load circuit, a capacitor and circuit controlling means connected in parallel to said valve, a resistance device connecting said capacitor in parallel to said load circuit to charge said capacitor to such a polarity as to interrupt the current in said valve upon operation of said circuit controlling means, an energy consuming circuit connected in parallel to said load circuit to absorb the inductive energy thereof, and a rectifying device included in said energy consuming circuit normally to prevent the flow of current therein.

5. An electric translating circuit comprising a source of unidirectional current, an inductive load circuit, a vapor electric valve interconnecting said source and said load circuit, said valve being provided with a grid and a grid circuit for selectively rendering said valve conductive or maintaining it non-conductive, a capacitor and an auxiliary electric valve connected in parallel to said valve, means for controlling the conductivity of said auxiliary valve, a high resistance device connecting said capacitor in parallel to said load circuit to charge said capacitor to such a polarity as to interrupt the current in said vapor electric valve when said auxiliary electric valve is rendered conductive, a resistance device having a highly negative impedance-voltage characteristic connected in parallel to said load circuit to absorb the inductive energy thereof, and a rectifying device included in said energy consuming circuit normally to prevent the flow of current therein.

6. An electric translating circuit comprising a source of current, an inductance device, a load circuit, a plurality of vapor electric valves interconnecting said source and said load circuit and connected in circuit with said inductance device, means for controlling the conductivity of said valves, means for suddenly commutating the current from one of said valves to another, and a resistance element having a highly negative impedance-voltage characteristic connected in circuit with said inductance device to absorb the transient voltages generated thereby upon the commutation of current between said valves.

7. An electric valve converting apparatus comprising a direct current circuit, an alternating current circuit, an inductive winding, a pair of similarly disposed vapor electric valves connected to the end terminals of said inductive winding and interconnecting said circuits therethrough, means for periodically rendering said valves alternately conductive and non-conductive, a capacitor for rapidly commutating the load current between said valves, and a resistance element having a highly negative impedance-voltage characteristic connected across said inductive winding to absorb the transient voltages generated thereby upon the commutation of current between said valves.

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