April 10, 1934. M. M. MORACK 1,954,680

ELECTRIC VALVE CIRCUIT

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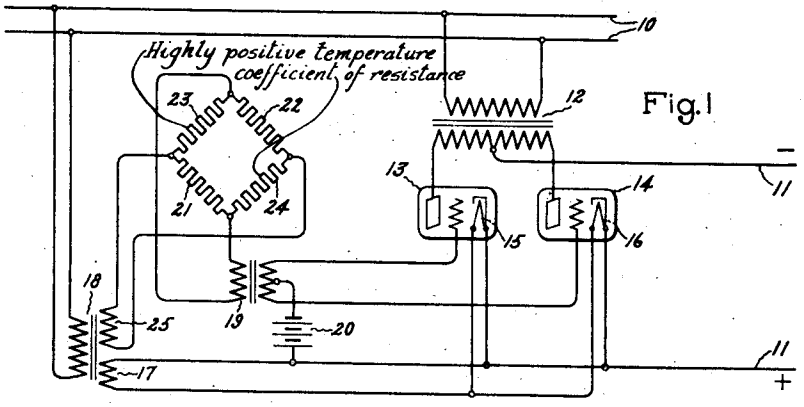


Fig. 1

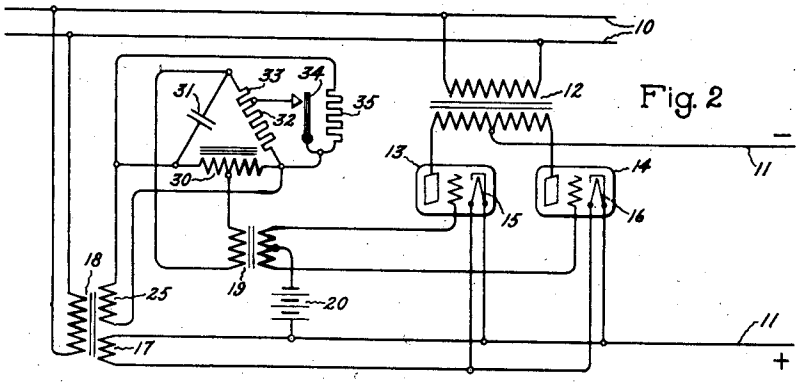


Fig. 2

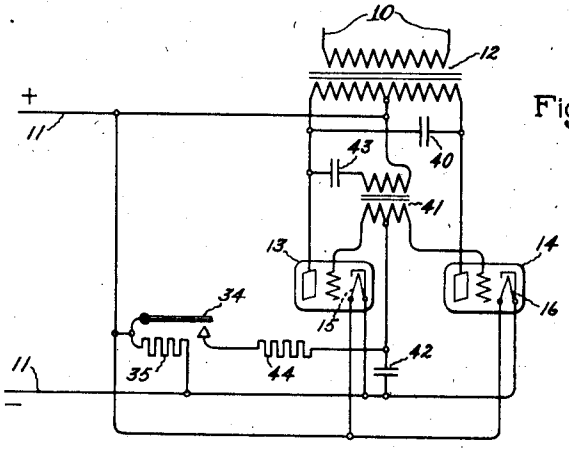


Fig. 3

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ELECTRIC VALVE CIRCUIT

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14 Claims. (Cl. 250—27)

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

In the operation of electric valves of the thermionic cathode type, such, for example, as those having incandescent cathodes or those provided with electron emitting cathodes heated from an independent heater, it is essential to the satisfactory operation of the valves that the cathodes shall have reached their normal operating temperature before the valves are energized to carry the current of the translating circuit in which they are connected and that the current in the valves should be interrupted in case their cathodes drop substantially below their normal operating temperature. This is especially true in the case of electric valves of the vapor electric discharge type which rely primarily for their operation upon the ionization of the contained vapor. If a valve of this type is energized to carry the current of a translating circuit before its cathode reaches its proper temperature, a large part of the potential of the translating circuit will be consumed in the valve, the effect of which is to destroy the electron emitting properties of the cathode by positive ion bombardment. In a copending application of Alan S. Fitz Gerald Serial No. 507,906, filed January 10, 1931, and assigned to the same assignee as the present application, there is disclosed an arrangement for preventing the operation of an electric valve in a translating circuit whenever the cathode is below normal operating temperature. According to the arrangement disclosed in that application the electric valve is disconnected from the translating circuit whenever its cathode is below its normal operating temperature. My invention relates more specifically to electric valve circuits of this type and constitutes an improvement upon the arrangement disclosed in the above-mentioned application.

It is an object of my invention to provide an improved electric translating circuit including an electric valve of the thermionic cathode type in which the flow of current in the valve will be delayed until the cathode reaches substantially its operating temperature and in which this result is accomplished without the use of contacts in the translating circuit. It is another object of my invention to provide an improved electric translating circuit including an electric valve of the thermionic cathode type in which the valve is maintained non-conductive upon initiation of the operation of the apparatus until the cathode reaches substantially its normal operating temperature. It is a further object of my invention to provide an improved electric translating circuit including an electric valve of the thermionic cathode type in which a thermal responsive means independent of the electric valves but having thermal characteristics similar to those of said cathode, acts to maintain the valve non-conducting upon energization of the translating circuit until the cathode of the valve reaches substantially its normal operating temperature.

In accordance with my invention I provide a thermal responsive means such as a thermostatic relay or a thermal resistance bridge which is energized in accordance with the energization of the heating circuit for the thermionic cathode. This thermal responsive device is designed to have thermal characteristics similar to those of the thermionic cathode; that is, it will reach the temperature at which a desired operation is produced at substantially the same time the thermionic cathode reaches its normal operating temperature although these operating temperatures may be widely different. The electric valve is provided with a control grid the excitation of which is controlled by the thermal responsive means to maintain the valve non-conducting until its cathode reaches its proper temperature.

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 accompanying drawing I have illustrated my invention as applied to an arrangement for delaying the time at which the electric valves of a controlled rectifier are made conducting until their cathodes reach their proper temperature; Fig. 2 illustrates a modification of my invention involving a different type of thermal responsive means and grid control, while Fig. 3 illustrates an embodiment of my invention as applied to a parallel inverter, i. e. an apparatus for converting direct current into alternating current.

Referring more particularly to Fig. 1 of the accompanying drawing, I have illustrated a translating circuit for receiving alternating current from the supply circuit 10, converting it into direct current, and delivering it to the receiving circuit 11. This translating circuit comprises a transformer 12, and electric valves 13 and 14 each provided with an anode, a control grid and a thermionic cathode. The valves 13 and 14 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 13 and 14 are provided with independent cathode heaters 15 and 16 respectively, energized from the secondary winding 17 of a transformer 18, the primary winding of which is connected across the alternating current circuit. The grids of electric valves 13 and 14 are connected to the common cathode connection through opposite halves of the secondary winding of a grid transformer 19 and a negative bias battery 20. In order to control the grid potential of valves 13 and 14 I have provided a thermal responsive bridge comprising resistors 21 and 22 which make up one pair of opposite arms of the bridge and resistors 23 and 24 which constitute the other arms. Resistors 21 and 22 and 23 and 24 have dissimilar temperature-resistance characteristics. For example, resistors 21 and 22 may have substantially zero temperature-resistance characteristics while one or both of resistors 23 and 24 may have highly positive temperature resistance characteristics and preferably have thermal characteristics similar to those of the cathodes of electric valves 13 and 14. One diagonal of the bridge is energized from a secondary winding 25 of the transformer 18 while the other diagonal of the bridge is connected to the primary winding of grid transformer 19.

The general operation of a full wave rectifier such as that comprising transformer 12 and electric valves 13 and 14 is so well understood by those skilled in the art that the explanation of the operation of the above described apparatus will be confined to the control of the grid potentials of electric valves 13 and 14. When the circuit 10 is first energized so that the temperatures of the several resistors making up the thermal bridge are at the ambient temperature, the bridge is so proportioned that the potential of the diagonal connected to the primary winding of the grid transformer 19 is zero so that no potential will be impressed upon the grids of the valves 13 and 14 from the transformer 19 and each of these grids will have a negative bias derived from the battery 20, i. e. both valves 13 and 14 are non-conducting. At the same time current is supplied from the secondary winding 17 to the heaters 15 and 16 of electric valves 13 and 14. As the temperature of the cathode heaters rises, the temperature of the resistors 23 and 24 of the thermal bridge will increase proportionally so as to unbalance the thermal bridge. The unbalanced potential of the thermal bridge is now impressed upon the primary winding of the grid transformer 19 which is so connected that this potential opposes the negative bias of the battery 20 and is sufficient in magnitude to substantially overcome it. When the resistors 23 and 24 reach a temperature corresponding to the normal operating temperature of the cathodes of the valves, although, as stated above, these temperatures need not be the same. The result is that an alternating potential in phase with the anode potential of electric valves 13 and 14 is impressed upon their grids and these valves are each rendered conducting during their respective positive half cycles of anode potential to deliver their full output to the receiving circuit 11. It will be apparent that, should the source of heating current be interrupted by failure of the transformer 18, deenergization of the circuit 10, or for any other cause, the reverse operation will take place, the resistors 23 and 24 cooling in accordance with cathode heaters 15 and 16, the balance of the thermal bridge being restored and the negative bias battery 20 again rendering the valves 13 and 14 non-conducting.

In the modification of my invention illustrated in Fig. 2, the grid potentials of the valves 13 and 14 are controlled by an impedance phase shifting circuit. This phase shifting circuit comprises a reactor 30 provided with an electrical mid-point and energized directly across the secondary winding 25 of the transformer 18, a capacitor 31 and a resistor 32, provided with an intermediate tap 33. In order to control the portion of the resistor which is effective in the phase shifting circuit, there is provided a thermostatic relay 34 provided with an independent heater 35 also connected directly across the secondary winding 25. The operation of this arrangement is similar to that described above in connection with Fig. 1. The heater 35 has thermal characteristics similar to those of the cathode heaters 15 and 16, and when it arrives at a temperature corresponding to the normal temperature of the heaters 15 and 16, the thermostatic relay 34 operates to short cricuit a portion of the resistor through the tap 33. The phase shifting circuit is normally so proportioned that the potential applied to the grid transformer 19 is in phase opposition to the anode potentials of electric valves 13 and 14. When the relay 34 operates, however, the resistance of resistor 32 is reduced to a very small value with the result that the grid potential is advanced approximately 180 degrees and is substantially in phase with the anode potentials of the valves 13 and 14. With this arrangement electric valves 13 and 14 are fully conductive during their respective half cycles of positive anode potential as in the arrangement illustrated in Fig. 1.

In Fig. 3 I have illustrated a modification for delaying the flow of current in an electric valve connected in a translating circuit for receiving energy from the direct current circuit 11, converting it into alternating current, and delivering it to receiving circuit 10. This circuit is of the type known in the art as a parallel inverter and comprises a transformer 12 provided with a primary winding having an electrical mid-point, the two halves of the primary winding being connected across the direct current circuit 11 through a pair of electric valves 13 and 14. A capacitor 40 is connected between anode circuits of the valves 13 and 14 in order to facilitate the transfer of current between them. The grids of the valves 13 and 14 are connected to a common cathode circuit through opposite halves of the secondary winding of a grid transformer 41 and a capacitor 42. The primary winding of the grid transformer 41 is energized from the alternating current circuit, illustrated in the drawing as a half of the secondary winding of transformer 12 through a capacitor 43, which together with capacitor 40, aids in determining the frequency of the alternating current delivered to the power transformer 12. The cathode heaters 15 and 16 of the valves 13 and 14, respectively, may be energized by connecting them directly across the direct current circuit 11. In order to delay the flow of current in valves 13 and 14 until their cathodes reach the proper operating temperature, there is provided a thermostatic relay 34, having an independent heater 35 connected across the direct current circuit 11. As in the arrangement described above, the heater 35 has thermal characteristics similar to those of the cathode heaters 15 and 16. Upon operation of the thermostatic relay 34, the grids of the valves 13 and 14 are

connected directly to the positive direct current line 11 through a resistor 44.

The general principles of operation of a translating circuit for converting direct current into alternating current will be well understood by those skilled in the art, or may be found described in more 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 electric valve 13 is first made conducting, current will first flow through the left-hand portion of the primary winding of transformer 12 and electric valve 13, at the same time inducing a half wave of alternating potential in the secondary winding of transformer 12. When electric valve 14 is made conducting, capacitor 40 tends to discharge through the valves 13 and 14 in series, interrupting the current in valve 13. Current now flows through the right hand portion of the primary winding of transformer 12 and electric valve 14, inducing a half cycle of opposite polarity in the secondary winding of transformer 12, and this cycle is repeated indefinitely, the frequency being determined by the reactive constants of the circuit. It will be noticed that, when no current is flowing in the translating circuit, the grids of the valves 13 and 14 are insulated from their cathodes by the capacitor 42. These valves preferably have positive critical grid potential characteristics, i. e. valves of the type in which current cannot be initiated through the valves unless the grid potential is positive. However, if valves having negative critical grid potential characteristics are used, the same effect may be obtained by including a negative bias battery in the grid circuit. With this arrangement, both valves are maintained non-conducting upon energization of the direct current circuit 11. However, as the cathode heaters 15 and 16 reach the normal operating temperature, the heater 35 will also increase its temperature to operate the thermostatic relay 34 and to shock the grids of the valves 13 and 14 with a positive potential. The value of the resistance 44 may be very high so as not to interfere with the normal operation of the apparatus described above, or any well known means may be provided for disconnecting the thermal relay 34 upon the initiation of the flow of current through the translating circuit.

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, an electric translating circuit including an electric valve provided with a thermionic cathode, and means for maintaining said valve-non-conductive after the energization of said circuit for a time sufficient for said cathode to reach substantially its normal operating temperature.

2. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode and a control grid, and means for maintaining the potential of said grid below its critical value whenever the energization of said cathode is below a predetermined value.

3. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode and a control grid, and means for maintaining said grid below its critical potential for a sufficient interval after the energization of said circuit for said cathode to reach substantially its normal operating temperature.

4. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode, and means having thermal characteristics similar to those of said cathode for maintaining said valve non-conductive for a sufficient interval of time after the energization of said circuit for said cathode to reach substantially its normal operating temperature.

5. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode, and thermal means energized from said circuit and having thermal characteristics similar to those of said cathode for maintaining said valve non-conductive, upon the energization of said circuit, until said cathode reaches substantially its normal operating temperature.

6. In combination, an alternating current translating circuit including an electric valve provided with an anode, a thermionic cathode and a control grid, a grid circuit energized from said translating circuit, and means for maintaining said grid potential substantially in phase opposition to the potential of said anode until said cathode reaches substantially its normal operating temperature.

7. In combination, an alternating current translating circuit including an electric valve provided with an anode, a thermionic cathode and a control grid, a grid circuit including a source of alternating potential of the same frequency as that of said translating circuit, and a source of negative bias potential, and means associated with said grid circuit for maintaining said alternating grid potential substantially in phase opposition to the potential of said anode until said cathode reaches substantially its normal operating temperature.

8. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode, a resistance bridge energized from said circuit, one of the elements of said bridge having thermal characteristics similar to those of said cathode, and means responsive to the balance of said bridge for controlling the conductivity of said valve.

9. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode and a control grid, a resistance bridge energized from said circuit, one of the elements of said bridge having thermal characteristics similar to those of said cathode, and a grid circuit for said valve connected across a diagonal of said bridge and including a source of negative bias potential.

10. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode, an impedance phase shifting circuit energized from said translating circuit, thermal means also energized from said translating circuit for controlling the constants of said impedance circuit, and a grid circuit for said valve energized from said impedance circuit.

11. In combination an electric translating circuit including an electric valve provided with a thermionic cathode, an impedance phase shifting circuit energized from said translating circuit, a thermal relay also energized from said translating circuit and having thermal characteristics similar to those of said cathode, one of

the elements of said impedance circuit being controlled by said relay, and a grid circuit for said valve energized from said impedance circuit.

12. In combination, an electric translating circuit including an electric valve provided with a thermionic cathode and a control grid, and a thermal relay having thermal characteristics similar to those of said cathode and energized from said circuit and connected to impress a positive impulse upon said grid when in operative position.

13. In combination, an alternating current supply circuit, a load circuit, an electric valve provided with a thermionic cathode for transmitting energy therebetween, and means for maintaining said valve non-conductive for an interval after the energization of said supply circuit sufficient for said cathode to reach substantially its normal operating temperature.

14. In combination, a direct current supply circuit, a load circuit means for transmitting energy therebetween including an electric valve provided with a thermionic cathode and a control grid, said control grid being below its critical potential when no energy is being transmitted, and means for impressing a positive potential on said grid when said cathode has reached substantially its normal operating temperature.

MARVIN M. MORACK.