Feb. 20, 1940. M. A. EDWARDS 2,190,775

ELECTRIC VALVE CIRCUIT

Filed June 16, 1937

Fig. 1.

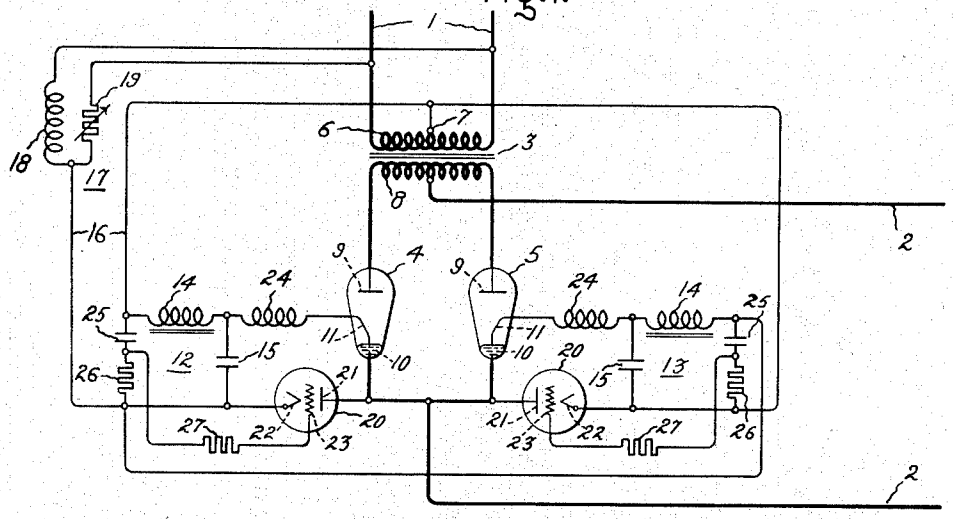


Fig. 2.

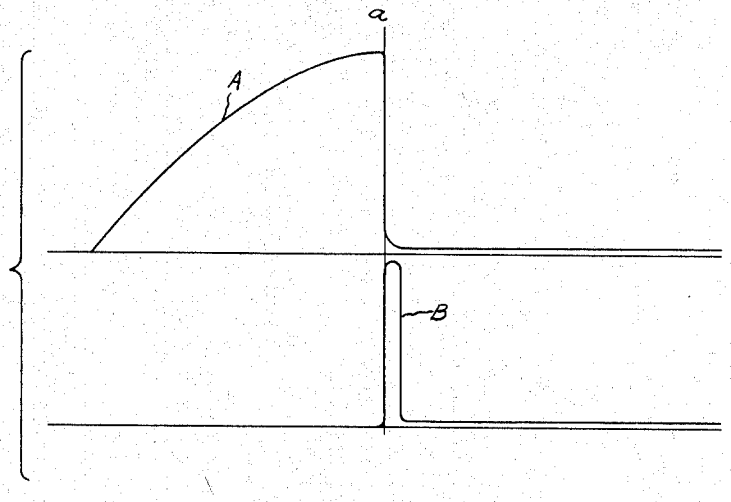
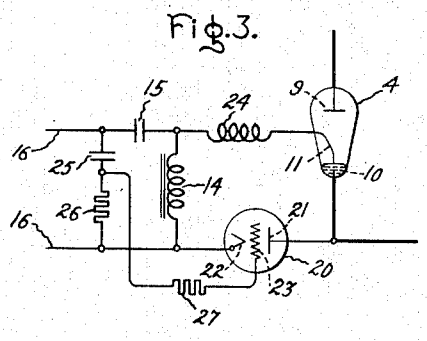


Fig. 3.



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ELECTRIC VALVE CIRCUIT

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Application June 16, 1937, Serial No. 148,518

10 Claims. (Cl. 250—27)

My invention relates to electric valve circuits and more particularly to control systems for electric valve apparatus employing ionizable mediums.

In the control of electric valve apparatus employing ionizable mediums, and particularly those having control members of the immersion-ignitor type for initiating the arc discharge, it has been found that it is highly important to provide control systems susceptible of supplying control voltages of substantially perpendicular wave front to effect precise and positive control of the electric valve apparatus. Furthermore, it is highly desirable to employ control circuits which may be energized from commercial sources of alternating voltage and which are simple in construction and reliable in operation. More particularly, it has been found important to use circuits which apply to the immersion-ignitor control members relatively high voltages of predetermined wave form, preferably of perpendicular wave front, to assure positive initiation of the arc discharge at the desired times in the cycle of operation of the electric valve apparatus. Heretofore, the control circuits have necessitated the use of apparatus of inordinate size and rating relative to the amount of energy transmitted by the electric valve apparatus.

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

It is another object of my invention to provide a new and improved electric valve control system for electric valve apparatus of the type employing ionizable mediums and control members of the immersion-ignitor type.

In accordance with the illustrated embodiment of my invention, I provide a control circuit for energizing an immersion-ignitor control member of an electric valve means whereby the electrical discharges are initiated in a positive and reliable manner at accurately determinable instants in the cycle of operation. More specifically, I provide a control system including a source of alternating current and a resonant circuit, which may be linear or nonlinear, energized from the source of alternating current. A controlled electric valve is employed to impress on the immersion-ignitor control member a unidirectional voltage of substantially perpendicular wave front derived from one of the elements of the resonant circuit. The controlled electric valve is provided with a control member which renders the electric valve conductive at a predetermined time to impress on the immersion-ignitor control member a voltage of predetermined magnitude and wave form. In one modification of my invention, the controlled electric valve effects discharge of the capacitance of the resonant circuit to energize the immersion-ignitor control member, and in another modification of my invention the controlled electric valve impresses on the immersion-ignitor control member a voltage derived from the inductance in the resonant circuit.

For a better understanding of my invention, reference may be had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims. Fig. 1 of the drawing diagrammatically shows an embodiment of my invention in which an immersion-ignitor control member of an electric valve apparatus is energized by employing a voltage derived from a capacitance of a resonant circuit, and Fig. 2 represents certain operating characteristics thereof. Fig. 3 represents another embodiment of my invention in which the immersion-ignitor control member is energized in accordance with a voltage derived from the inductance of the resonant circuit.

Referring now to Fig. 1 of the accompanying drawing, my invention is diagrammatically shown as applied to an electric valve translating system for transmitting energy from an alternating current circuit 1 to a direct current circuit 2, through a transformer 3 and electric valve means 4 and 5. The transformer 3 is provided with a primary winding 6 having an electrically intermediate connection 7 and a secondary winding 8. Each of the electric valve means 4 and 5 includes an anode 9, a self-reconstructing cathode, such as a mercury pool cathode 10, and an associated control member 11 which may be of the immersion-ignitor type. The immersion-ignitor control member 11 may be of a material such as boron-carbide or silicon-carbide, or of a material such as that described and claimed in U. S. Patent 1,822,742 granted to Karl B. McEachron September 8, 1931, and assigned to the assignee of the present application.

I provide control circuits 12 and 13 which are associated with electric valve means 4 and 5, respectively, to impress on immersion-ignitor control members 11 thereof unidirectional voltages of substantially perpendicular wave front. Each of the control circuits 12 and 13 includes a resonant circuit, which may be either linear or nonlinear, and comprises an inductance 14, which may or may not be self-saturating, and a capacitance 15 which, as illustrated, are connected in

series relation with each other and are connected across any suitable source of alternating current 16. The source of alternating current 16 may be derived from any suitable circuit, and in the arrangement shown in Fig. 1 circuit 16 is shown as being energized from the alternating current circuit 1 through any suitable phase shifting circuit 17 which may include an inductance 18 and a variable resistance 19. One terminal of the alternating current circuit 16 is connected to the electrically intermediate terminal 7 of primary winding 6 of transformer 3. Considering circuit 12, a suitable unidirectional conducting device, such as an electric valve 20, is connected between a point of the resonant circuit and cathode 10 to impress on immersion-ignitor control member 11 a voltage derived from one of the elements of the resonant circuit, as, for example, the voltage appearing across the terminals of capacitance 15. The electric valve 20 is preferably of the type employing an ionizable medium, such as a gas or a vapor, and includes an anode 21, a cathode 22 and a control member 23. An inductance 24 is connected in series relation with the control member 11, cathode 10 and electric valve 20 to extend, in the direction of the time axis, the current transmitted to the control member 11 when the electric valve 20 effects discharge of the capacitance 15. The feature of the arrangement of Fig. 1, whereby a resonant circuit and a unidirectional conducting device are employed to energize a control member of an electric valve, is disclosed in my copending application Serial No. 148,517, filed June 16, 1937, and assigned to the assignee of the present application.

To obtain a control voltage to render electric valve 20 conductive and to effect energization of immersion-ignitor control member 11 of electric valve 4 at a predetermined time in the cycle of voltage applied to anode 9, I provide a suitable phase shifting circuit such as a serially-connected capacitance 25 and a resistance 26 which are connected to the source of alternating current 16. A suitable current limiting resistance 27 may be connected in series relation with the control member 23 of electric valve 20.

The operation of the embodiment of my invention shown in Fig. 1 will be considered when the system is operating to transmit unidirectional current to the load circuit 2 from the alternating current circuit 1, through transformer 3 and electric valve means 4 and 5. As will be well understood by those skilled in the art, the electric valves 4 and 5 will be rendered conductive by the control circuits 12 and 13 and will conduct current alternately to transmit unidirectional current to load circuit 2. Adjustable resistance 19 of phase shifting circuit 17 is adjusted to impress on the resonant circuit, including inductance 14 and the capacitance 15, an alternating voltage having a predetermined phase displacement relative to the voltage impressed on anodes 9 of electric valve means 4 and 5. Inductance 14 and capacitance 15 operate as a resonant circuit tuned to the frequency of the alternating current circuit 16. Under these conditions, it is to be understood that the voltages appearing across the inductance 14 and capacitance 15 rise to values several times that applied to the resonant circuit, and these voltages are employed to impress on the control members 11 voltages which assure positive initiation of the arc discharges.

The operating characteristics represented in Fig. 2 may be considered to facilitate the explanation of the operation of the control circuits 12 and 13 of the arrangement of Fig. 1. Curve A may represent the voltage appearing across the terminals of capacitance 15 in circuit 12. The electric valve 20 is energized by the excitation circuit therefor to be rendered conductive at a time *a* to impress on control member 11 a unidirectional voltage of substantially perpendicular wave front to render electric valve means 4 conductive. Curve B represents the current transmitted to the control member 11 by the discharge of the capacitance 15. The circuit for energizing control member 11 includes capacitance 15, inductance 24, immersion-ignitor control member 11, cathode 10 and electric valve 20. The inductance 24 serves to extend, in the direction of the time axis, the current transmitted to the control member 11 to assure positive initiation of the arc discharge and to effect precise control of the time at which the electric valve means 4 is rendered conductive. After electric valve 20 is rendered conductive, the resonant circuit will be unbalanced, that is, rendered dissonant thereby limiting the current transmitted to the circuit 12 from the source of alternating current 16.

It is to be understood that, by the proper design and proportioning of the self-saturating inductance 14, the resonant circuit may be made to operate as a non-linear resonant circuit. Under this condition of operation, the voltage appearing across the capacitance 15 will be one of rectangular wave form having a substantially perpendicular wave front, and the voltage appearing across the self-saturating inductance 14 will be of substantially peaked wave form. It is to be understood that my invention in its broader aspects applies to the control circuit when it is operating either as a linear resonant circuit or as a nonlinear resonant circuit.

The arrangement of my invention diagrammatically shown in Fig. 3 is substantially the same as that shown in Fig. 1 and corresponding elements have been assigned like reference numerals. In the arrangement of Fig. 3, the immersion-ignitor control member 11 is energized in accordance with the voltage appearing across the inductance 14. The resonant circuit, including inductance 14 and capacitance 15, may be arranged to operate either as a linear resonant circuit or as a nonlinear resonant circuit. The inductance 14 may be designed to be self-saturating.

The operation of the arrangement of Fig. 3 is substantially the same as that of Fig. 1. The resonant circuit including inductance 14 and capacitance 15 resonates to the frequency of alternating current circuit 16, and the electric valve 20 is rendered conductive at a predetermined time in the cycle of voltage appearing across the terminals of inductance 14 to impress on immersion-ignitor control member 11 an impulse of unidirectional voltage of substantially perpendicular wave front. When the circuit is operating as a linear resonant circuit, the voltage appearing across the inductance 14 will, of course, be sinusoidal and the electric valve 20 may be rendered conductive at about the maximum value of applied voltage to impress on the control member 11 a relatively large voltage of steep wave front. When the circuit is operating as a nonlinear circuit, the voltage appearing across the terminals of inductance 14 will be of peaked wave form and the electric valve 20 may be rendered conductive at substantially the peak value

of this voltage to impress a corresponding voltage on the control member 11.

One of the principal advantages of the control circuits constructed in accordance with my invention is the operation of these circuits in the event the electric valve 20 fails to transmit the current to the immersion-ignitor control member during a particular half cycle of applied voltage. During the next half cycle of applied voltage of the same polarity, the circuit will automatically increase its voltage due to the resonating condition of the circuit, assuring ignition of the arc during that half cycle. The direction of change of voltage under these conditions tends to cause the electric valve 4 to be rendered conductive. Another important feature of my invention is the feature of the control circuits by virtue of which relatively large currents are supplied to the control members 11 without imposing on the supply circuit, such as supply circuit 1 or circuit 16, heavy current conditions. This feature is of particular importance where it is desired to effect positive control by supplying relatively large currents to the control members, and where it is undesirable to obtain these currents directly from the supply circuit.

While I have shown and described my invention as applied to a particular system of connections and as embodying various devices diagrammatically shown, it will be obvious to those skilled in the art that 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 valve means having a control member, a source of alternating current, a resonant circuit connected to be energized continuously from said source for producing a voltage substantially greater than that applied to said resonant circuit, and means for impressing on said control member a component of voltage derived from said resonant circuit and for rendering said electric valve means conductive during half cycles of voltage of predetermined polarity of said source and comprising a controlled electric valve connected between said resonant circuit and said control member, said resonant circuit serving to increase said component of voltage accumulatively in the event said controlled electric valve fails to conduct current to said control member during each half cycle of voltage of said predetermined polarity.

2. In combination, an electric valve means having a control member, a source of alternating current, a resonant circuit connected to be energized continuously from said source and including an inductive impedance and a capacitive impedance for producing voltages substantially greater than the voltage applied to said resonant circuit, and means comprising a controlled electric valve for impressing on said control member a voltage derived from one of said impedances and for rendering selectively resonant and dissonant said resonant circuit, said resonant circuit serving to increase said component of voltage in the event said controlled electric valve fails to conduct current to said control member during each half cycle of voltage of predetermined polarity of said source.

3. In combination, an electric valve means employing an ionizable medium having a control member for initiating an arc discharge, a source of alternating current, a resonant circuit connected to be energized continuously from said source and including a serially-connected inductance and a capacitance for producing a voltage substantially greater than the voltage applied to said resonant circuit, and a controlled electric valve connected to impress on said control member a component of voltage derived from said capacitance to render said electric valve means conductive during each half cycle of voltage of predetermined polarity of said source and for rendering said resonant circuit dissonant when in a conducting condition.

4. In combination, an electric valve means having a control member, a source of alternating current, a resonant circuit continuously energized from said source and including a serially-connected capacitance and an inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, an electric valve having a control member and being connected to energize said first mentioned control member in accordance with a component of voltage derived from said resonant circuit, and means for energizing said control member of said electric valve to impress on said first mentioned control member through said electric valve a voltage of substantially perpendicular wave front to render said electric valve means conductive during each half cycle of predetermined polarity of said source, said electric valve serving to render said resonant circuit dissonant when in a conducting condition.

5. In combination, an electric valve means having a control member, a source of alternating current, a resonant circuit continuously energized from said source and including a serially-connected capacitance and an inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, an electric valve having a control member and being connected to energize said first mentioned control member in accordance with the voltage appearing across said capacitance and to render said resonant circuit selectively resonant or dissonant, and means for energizing said control member of said electric valve to render said valve conductive when the voltage appearing across said capacitance attains a predetermined value thereby rendering said electric valve means conductive.

6. In combination, an alternating current circuit, electric valve means connected to be energized from said circuit and having an anode, a cathode and a control member, a source of alternating voltage having a predetermined phase displacement relative to the voltage of said alternating current circuit, a resonant circuit connected to be energized continuously from said source and comprising a serially-connected capacitance and an inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, an electric valve connected to energize said control member by discharging said capacitance through said control member thereby rendering said resonant circuit dissonant, and means for rendering said electric valve conductive at the maximum instantaneous value of voltage during each cycle.

7. In combination, an alternating current circuit, an electric valve means connected to be energized from said circuit and including an anode, a cathode and an immersion-ignitor control member associated with said cathode, a source of alternating voltage having a predeter-

mined phase displacement relative to the voltage of said alternating current circuit, a resonant circuit connected to be energized continuously from said source and comprising a serially-connected capacitance and inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, an electric valve connected in series relation with said control member and said cathode to supply unidirectional current to said control member from said resonant circuit thereby rendering said resonant circuit dissonant, said electric valve having a control member and said resonant circuit serving to effect an accumulative increase in the voltage derived from said capacitance or said inductance in the event said electric valve fails to conduct current to said control member during each half cycle of voltage of predetermined polarity, and a phase shifting circuit for energizing said last mentioned control member to render said electric valve conductive to effect energization of said immersion-ignitor control member at the maximum instantaneous value of voltage during each cycle.

8. In combination, an electric valve means having a control member, a source of alternating current, a nonlinear resonant circuit connected to be energized continuously from said source and including a serially-connected capacitance and a self-saturating inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, and means comprising an electric valve for impressing on said control member a component of voltage derived from said resonant circuit and to render said resonant circuit dissonant when in a conducting condition.

9. In combination, an electric valve means having a control member, a source of alternating current, a nonlinear resonant circuit connected to be energized continuously from said source and including a serially-connected capacitance and a self-saturating inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, and means comprising an electric valve for impressing on said control member a component of voltage of perpendicular wave front derived from said inductance and to render said resonant circuit dissonant when said second mentioned electric valve is in a conducting condition.

10. In combination, an electric valve means having a control member, a source of alternating current, a resonant circuit continuously energized from said source and including a serially-connected capacitance and an inductance for producing a voltage substantially greater than the voltage applied to said resonant circuit, an electric valve having a control member and being connected to energize said first mentioned control member in accordance with a component of voltage derived from said resonant circuit, said resonant circuit serving to increase accumulatively the voltage derived from said resonant circuit in the event said electric valve fails to conduct current to said control member during each half cycle of voltage of predetermined polarity of said source and means comprising a phase shifting circuit for energizing said control member of said electric valve to render said electric valve conductive at a predetermined time during each cycle of voltage of said source.

MARTIN A. EDWARDS.