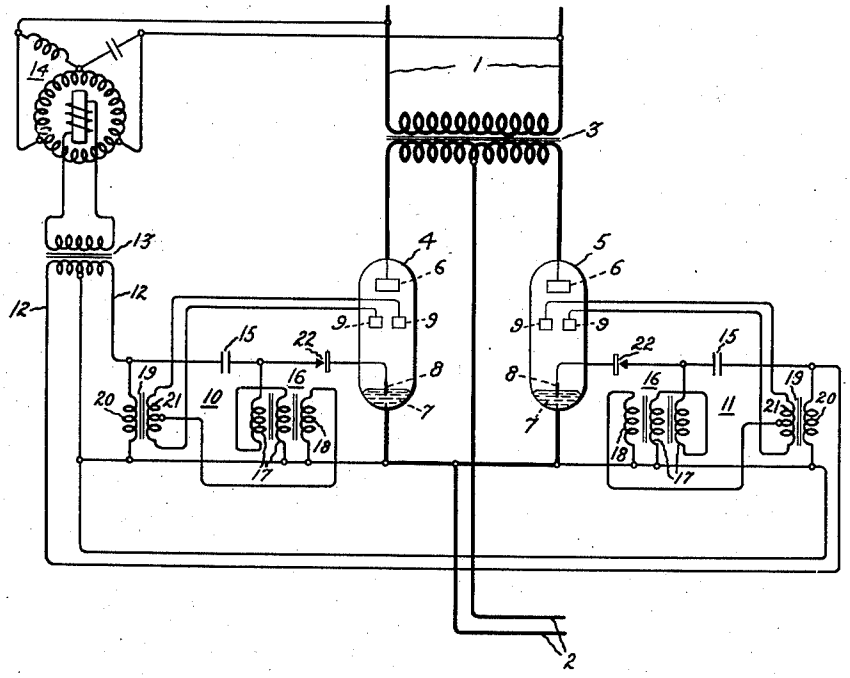
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ELECTRIC VALVE CIRCUIT

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ELECTRIC VALVE CIRCUIT

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My invention relates to electric valve circuits and more particularly to circuits for initiating electrical discharges in electric valve apparatus employing ionizable mediums.

In the control of electric valve apparatus employing ionizable mediums, such as mercury vapor, where the arc discharge is initiated by means of an auxiliary control or starting electrode, it has become evident that it is highly important to employ control circuits which do not impose excessively heavy duty requirements on the starting electrodes. For example, in electric valve apparatus employing self-reconstructing cathodes and associated control members of the immersion-ignitor type, it is highly desirable to provide control circuits which relieve the control members of the heavy duty imposed thereon by the prior art systems to effect thereby an increase in the life of 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 control circuit for electric valve apparatus.

It is a further object of my invention to provide a new and improved control circuit for electric valve apparatus of the type employing an ionizable medium and which includes liquid ionizable cathodes and associated control members of the immersion-ignitor type.

In accordance with the illustrated embodiment of my invention, I provide a control circuit for electric valve apparatus of the type employing an ionizable medium and which includes a self-reconstructing type of cathode, such as a mercury pool cathode, and an associated control member of the immersion-ignitor type which initiates an arc discharge when it is properly energized. The control circuit includes a source of alternating current and a circuit comprising a serially-connected capacitance and a saturable inductive reactance which effects energization of the immersion-ignitor control member when the electric valve means becomes non-conductive. More particularly, the saturable inductive reactance comprises two windings, one of which is connected in series relation with the capacitance across the source of alternating current and constitutes with the capacitance a tuned resonant circuit; and the other winding is employed to control the magnetization of the inductance to saturate the inductance and to render the circuit non-resonant when the electric valve means is in a conductive condition. The immersion-ignitor control member is energized through a unidirectional conducting device in accordance with the voltage appearing across the first mentioned winding and is thereby energized sufficiently to render the electric valve means conductive only when the circuit including the inductance and the capacitance is in a resonant condition.

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. The single figure of the accompanying drawing diagrammatically represents an embodiment of my invention as applied to an electric valve means including a mercury pool cathode and an associated immersion-ignitor control member.

Referring now to the single figure of the drawing, I have chosen to represent my invention 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 valves 4 and 5. Each of the electric valves 4 and 5 includes an anode 6, a self-resconstructing cathode such as a mercury pool cathode 7, an associated control member 8 of the immersion-ignitor type, and a pair of holding anodes 9. It is to be understood that the ionizable medium within the electric valves 4 and 5 is mercury vapor and that the control member 8 is arranged to have an extremity thereof permanently extending below the surface of the mercury pool cathode 7 and is of a material having a specific electrical resistivity substantially greater than the specific electrical resistivity of mercury. The immersion-ignitor control member 8 may be of a suitable material such as boron-carbide or silicon-carbide, or may be of a material such as the material disclosed and broadly 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 circuits 10 and 11 which are associated with electric valves 4 and 5, respectively, and which energize the control members or electrodes 8 in accordance with the state of ionization of the mercury vapor of the electric valves 4 and 5. Considering circuit 10 in particular, the circuit comprises a source of alternating current 12. The source of alternating current 12 may be derived from the alternating current circuit 1 through a transformer 13, and any conventional phase shifting arrangement such as the rotary phase shifter 14. A circuit including a capacitance 15 and a saturable inductive reactance 16

serves to effect the proper energization of the control member 8 of electric valve 4 in accordance with the state of ionization of the mercury vapor. The saturable inductive device, or the saturable reactor 16, includes a winding 17 which may be arranged in two sections which are connected in series relation with the capacitance 15 and constitute a tuned resonant circuit or a circuit in substantial resonance when the reactor 16 is in a desaturated condition. The capacitance 15 and reactor 16 may be designed to resonate to the frequency of the source 12. The saturable reactor 16 is also provided with a winding 18 which controls the magnetization of the reactor and which is connected in an energizing circuit including a transformer 19 having a primary winding 20 and a secondary winding 21. The energizing circuit for the winding 18 of reactor 16 includes the secondary winding 21 of transformer 19, holding anodes 9 and cathode 7, which supply unidirectional current to the winding 18 to effect saturation of the reactor 16 and to maintain circuit 11 in a nonresonant or dissonant condition so long as the electric valve 4 is in a conductive condition.

The arrangement for controlling the energization of a starting electrode by means of a resonant circuit, comprising a capacitance and a saturable reactor, in accordance with the state of ionization of an ionizable medium of the electric valve means, is disclosed and broadly claimed in a copending application of Elmo E. Moyer, Serial No. 148,519, filed concurrently herewith, and assigned to the assignee of the present application.

The immersion-ignitor control member 8 is energized in accordance with the voltage appearing across the terminals of winding 17 of the saturable reactor 16. To impress on the control member 8 only unidirectional voltages of the proper polarity relative to that of the cathode 7, I connect in series relation with the control member 8 a unidirectional conducting device 22 which may be of the contact-rectifying type if desired. The unidirectional conducting device 22 is connected so that only positive voltages are impressed on the immersion-ignitor control member 8.

While my invention has been described in connection with an electric valve employing a mercury pool cathode and in which the ionizable medium is mercury vapor derived from the mercury pool cathode, it is to be understood that my invention in its broader aspects is generally applicable to electric valve means employing cathodes of the self-reconstructing type in which the ionizable medium is derived from a liquid or solid cathode.

The operation of the embodiment of my invention diagrammatically shown in the single figure of the accompanying drawing will be considered when the electric valves 4 and 5 are operating as rectifiers to transmit unidirectional current to the load circuit 2 from the alternating current supply circuit 1 through transformer 3. As will be well understood by those skilled in the art, the electric valves 4 and 5 will conduct current alternately to supply unidirectional current to the circuit 2. Circuits 10 and 11 will initially energize control members 8 of electric valves 4 and 5 to initiate an arc discharge within these valves and to ionize thereby the mercury vapor derived from the mercury pool cathode 7. After the mercury vapor is ionized, the energizing circuit, including holding anodes 9, will transmit unidirectional current to winding 18 of reactor 16 to saturate the reactor. The holding anodes 9 in conjunction with the cathode 7 operate as a full wave rectifier to transmit unidirectional current to the winding 18. When the saturable reactor 16 is saturated, the circuits including capacitance 15 and winding 17 of reactor 16 are in a nonresonant condition and the voltage appearing across the terminals of winding 17 is not sufficient to supply an appreciable amount of current to the immersion-ignitor control member 8. Under these conditions of operation, the mercury vapor within the envelope of the electric valves 4 and 5 is maintained in an ionized condition by virtue of the operation of the holding anodes 9, and the electric valves 4 and 5 will conduct current alternately to effect the desired energization of the load circuit 2.

If for any reason the mercury vapor within the envelopes of electric valves 4 and 5 becomes nonionized, the circuits 10 and 11 will operate automatically to transmit sufficient current to the control member 8 to reestablish arc discharges within the envelopes and to ionize the mercury vapor. More specifically, if the mercury vapor of electric valve 4 becomes nonionized, the energizing circuit associated with circuit 10 including transformer 19 and holding anodes 9 fails to conduct unidirectional current to winding 18 of reactor 16, permitting desaturation of the reactor 16. When the reactor 16 is desaturated, the winding 17 thereof, in conjunction with capacitance 15, constitutes a tuned resonant circuit and increasing the voltage appearing across the terminals of winding 17 to supply an appreciable unidirectional current to control member 8 through the unidirectional conducting device 22. This unidirectional current is of sufficient magnitude to establish a cathode spot in the vicinity of the control member and initiates an arc discharge within the electric valve means. Of course, under these conditions the mercury vapor will be ionized, reestablishing the arc discharge between cathode 7 and the holding anodes 9 to furnish unidirectional current to winding 18 of reactor 16. Saturable reactor 16, upon becoming saturated, renders the circuit 10 nonresonant and thereby delays subsequent energization of the control member 8 until the mercury vapor becomes nonionized.

One of the principal advantages of my invention is the lessening of the duty imposed on immersion-ignitor control members whereby the immersion-ignitor control members are only required to initiate the ionization of the ionizable medium and in which the ionizable medium is maintained in an ionized state by auxiliary means. Moreover, the control system responds rapidly and precisely to reestablish the desired state of ionization of the medium in the event the medium becomes nonionized. By virtue of the connection of the unidirectional conducting devices 22 in series relation with the immersion-ignitor control members 8, I provide an arrangement which prevents rapid and needless deterioration of the control members occasioned by impressing on control members of this nature voltages which are negative relative to the cathode.

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

comprising an anode, a cathode and employing an ionizable medium and having an immersion-ignitor control member permanently in contact with said cathode for initiating an arc discharge, a source of alternating current, saturable inductive reactance and a capacitance energized from said source, means for controlling the magnetization of said reactance in accordance with the state of ionization of said medium, and means responsive to an electrical condition of said reactance for energizing said immersion-ignitor control member.

2. In combination, an electric valve means employing an anode, a self-reconstructing cathode, an immersion-ignitor control member associated with said cathode for initiating an arc discharge, a source of alternating current, a circuit including a capacitance and a saturable reactor having a winding connected in series relation with said capacitance across said source, a unidirectional conducting device connected in series relation with said control member and connected to transmit unidirectional current to said control member, said circuit being arranged to resonate when said reactor is desaturated, and means for saturating said reactor when said electric valve means is conductive.

3. In combination, an electric valve means employing an anode, a self-reconstructing cathode, an immersion-ignitor control member associated with said cathode for initiating an arc discharge, a source of alternating current, a capacitance and a saturable reactor having a winding connected in series relation with said capacitance across said source, said reactor being provided with a second winding, a circuit for energizing said second winding to control the magnetization of said reactor in accordance with the conductivity of said electric valve means so that said capacitance and said reactor constitute a tuned resonant circuit when said electric valve means is nonconductive, and means energized in accordance with an electrical condition of said reactor for energizing said control member to initiate an arc discharge when said capacitance and said reactor are in a resonant condition.

4. In combination, an electric valve means comprising an anode, a holding anode, a self-reconstructing cathode and an immersion-ignitor control member associated with said cathode, a source of alternating current, a circuit energized from said source comprising a capacitance and a saturable reactor having a winding connected in series relation with said capacitance and having a second winding inductively associated with said first mentioned winding, an energizing circuit for said holding anode, said second winding being energized in accordance with the current of said energizing circuit to control the saturation of said reactor in accordance with the conductivity of said electric valve means, and means responsive to the voltage of said first mentioned winding for energizing said immersion-ignitor control member to render said electric valve means conductive when said reactor is desaturated.

5. In combination, an electric valve means employing an ionizable medium and including an anode, a self-reconstructing cathode, a holding anode and an immersion-ignitor control member associated with said cathode for initiating an arc discharge, a source of alternating current, a circuit including a capacitance and a saturable reactor having a winding connected in series relation with said capacitance across said source and having a second winding for controlling the magnetization of said reactor, said circuit being arranged to resonate when said reactor is desaturated, a unidirectional conducting device connected in series relation with said control member and the first mentioned winding and being connected to impress on said control member only relatively positive voltages, and an energizing circuit including said holding anode for supplying unidirectional current to said second winding to maintain said circuit in a nonresonant condition when said electric valve means is conductive.

6. In combination, an electric valve means comprising an anode, a holding anode and an energizing circuit therefor to maintain said electric valve means in a conducting condition, a cathode and an immersion-ignitor control member associated with said cathode for initiating an arc discharge, a source of alternating current, a circuit comprising a capacitance and a saturable inductance having a winding connected in series relation with said capacitance across said source and having a winding energized in accordance with the current conducted by said energizing circuit to saturate said reactor when said electric valve means is conductive and to desaturate said reactor when said electric valve means is nonconductive so that said capacitance and said reactor constitute a resonant circuit, and means energized in accordance with the voltage appearing across said first mentioned winding for impressing on said control member a unidirectional voltage to render said electric valve means conductive when said circuit is in a resonant condition.

7. In combination, an electric valve means having a control member, a source of alternating current, a resonant circuit connected to said source for producing a component of voltage substantially greater than the voltage applied to said resonant circuit, and means comprising a unidirectional conducting device energized from said resonant circuit for impressing a unidirectional voltage derived from said component of voltage on said control member when said electric valve means is nonconductive.

8. In combination, an electric valve means employing an ionizable medium and having a control member, a source of alternating current, a resonant circuit connected to said source for producing a component of voltage substantially greater than the voltage applied to said resonant circuit, means for selectively rendering said circuit resonant and dissonant in response to the state of ionization of said medium, and means comprising a unidirectional conducting device energized from said resonant circuit for impressing a unidirectional voltage derived from said component of voltage on said control member when said medium is nonionized.

9. In combination, an electric valve means employing an ionizable medium and comprising means for initiating an arc discharge and means for maintaining an arc discharge after the initiation thereof, a source of alternating current, a unidirectional conducting device connected in series relation with the arc initiating means, and exclusively electrical voltage-impulse generating means for energizing the arc initiating means from said source through said unidirectional conducting device in response to the state of ionization of said medium.

10. In combination, an electric valve means employing an ionizable medium and comprising an immersion control member for initiating an

arc discharge and means for maintaining an arc discharge after the initiation thereof, a source of alternating current, a unidirectional conducting device connected in series relation with the arc initiating means, and exclusively electrical voltage-impulse generating means responsive to the state of ionization of said medium for energizing the control member from said alternating current circuit through said unidirectional conducting device.

11. In combination, an electric valve means having a control member, a source of alternating current, a resonant circuit connected to said source and comprising a serially connected capacitance and an inductance for producing a component of voltage substantially greater than the voltage applied to said resonant circuit, means for controlling the magnetization of said inductance to render said resonant circuit selectively resonant or dissonant, and means comprising a unidirectional conducting device energized from said resonant circuit for impressing a unidirectional voltage derived from said component of voltage on said control member when said electric valve means is nonconductive.

12. In combination, an electric valve means employing an ionizable medium and comprising an anode, a cathode, an immersion-ignitor control member permanently in contact with said cathode and an auxiliary electrode, an excitation circuit for supplying to said control member a periodic voltage to render said electric valve means conductive periodically, and a circuit connected between said excitation circuit and said auxiliary electrode for preventing the application of energizing voltage to said control member when said medium is ionized.

13. In combination, an electric valve means employing an ionizable medium and comprising an anode, a cathode and an immersion-ignitor control member permanently in contact with said cathode, an excitation circuit for supplying to said control member a periodic voltage to render said electric valve means conductive periodically, and means connected to said excitation circuit and responsive to the state of ionization of said medium for preventing the application of energizing voltage to said control member when said medium is ionized.

MARTIN A. EDWARDS.