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STARTING CIRCUIT FOR ELECTRIC VALVE APPARATUS

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Fig. 1.

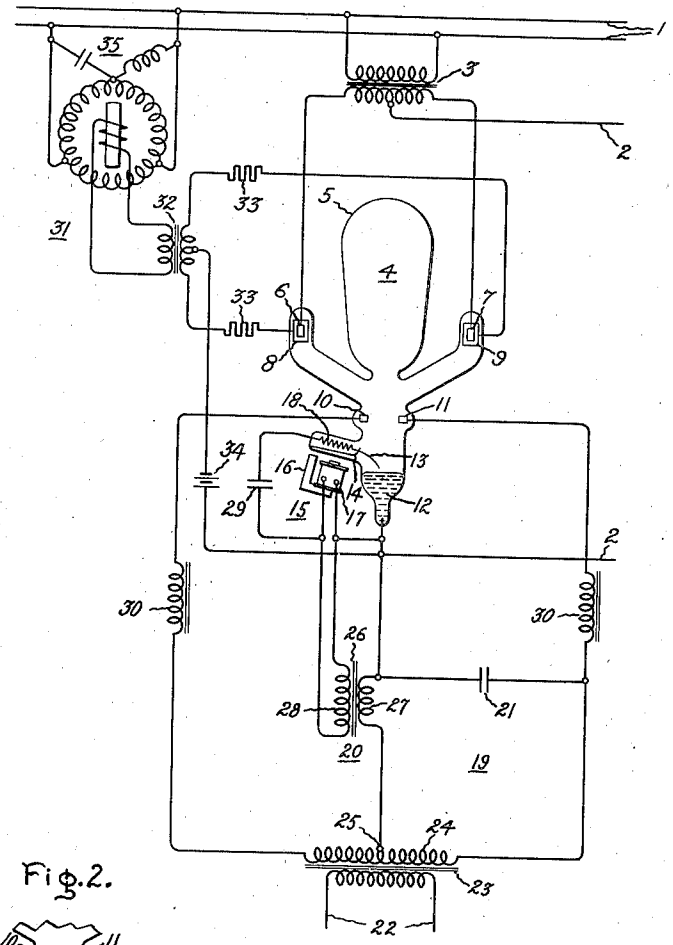
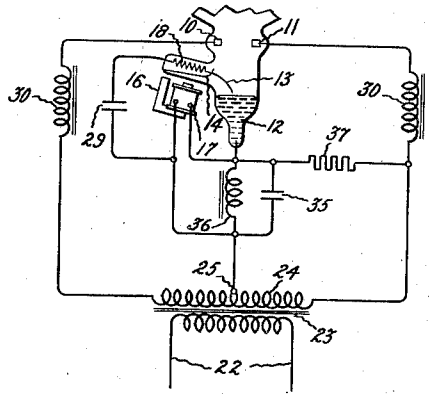


Fig. 2.



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STARTING CIRCUIT FOR ELECTRIC VALVE APPARATUS

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11 Claims. (Cl. 250—27)

My invention relates to starting circuits for electric valve apparatus and more particularly to arc starting arrangements for electric discharge devices employing ionizable mediums.

Heretofore there have been devised numerous arrangements for establishing arc discharges within electric valve apparatus or electric discharge devices employing ionizable mediums. For example, in electric valve apparatus employing mercury vapor as the ionizable medium, there have been proposed numerous circuits for actuating a starting electrode to establish an arc betwen an auxiliary starting electrode and an associated mercury pool cathode. There has been evidenced a decided need for starting apparatus which is responsive to the state of ionization of the ionizable medium to effect actuation or energization of the starting electrode only when the medium is nonionized. Moreover, it is imporant that the circuit be one which is readily adaptable to conventional type electric valve apparatus and which is susceptible of wide application without necessitating material changes or alterations in the main or power system.

It is an object of my invention to provide a new and improved starting circuit for electric valve apparatus employing ionizable mediums.

It is another object of my invention to provide a new and improved starting circuit for establishing an arc discharge within electric valve apparatus employing mercury vapor.

It is a further object of my invention to provide a new and improved starting circuit for mercury vapor discharge apparatus in which the circuit is responsive to the state of ionization of the mercury vapor to establish an arc discharge as soon as the vapor becomes nonionized.

In accordance with the illustrated embodiments of my invention, I provide new and improved control circuits for electric valve apparatus or electric discharge devices employing an ionizable medium. For the purpose of illustration, I have shown my invention as applied to electric valve means employing cathodes of the self-reconstructing type, such as mercury pool cathodes, in which the ionizable medium is mercury vapor derived from the cathodes. In the arrangements illustrated, I employ a starting electrode biased away from the mercury pool cathodes and adapted to be moved momentarily into engagement therewith to establish an arc discharge. The auxiliary starting electrode is actuated by an electromagnetic means which is energized by a resonant circuit comprising a saturable inductive device and a capacitance which are energized from a source of alternating current. When the inductive device is not saturated, the device and the capacitance constitute a tuned resonant circuit and effect actuation of the auxiliary starting electrode. In order to control the saturation of the inductive device in accordance with the state of ionization of the ionizable medium, a circuit including a holding anode energizes the device to control the saturation thereof so that the device is saturated when the medium is in an ionized state. When the medium is nonionized, the circuit resonates and reestablishes an arc discharge within the envelope of the electric valve means.

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 accompanying drawing diagrammatically illustrates my invention as applied to an electric valve employing a mercury pool cathode and an auxiliary starting electrode which is electro-magnetically operated by a resonant circuit of the series type, and Fig. 2 shows a similar arrangement in which a parallel resonant circuit is used.

Referring now to Fig. 1 of the drawing, I have chosen to represent my invention as applied to an electric valve translating system for transmitting energy between an alternating current circuit 1 and a direct current circuit 2 through a transformer 3 and an electric valve means 4. The electric valve means 4 comprises an envelope 5, anodes 6 and 7, associated control members or grids 8 and 9, holding anodes 10 and 11, and a mercury pool cathode 12. Of course, the ionizable medium within the electric valve means 4 is mercury vapor. As a means for initiating an arc discharge within the envelope 5 and as a means for controlling the state of ionization of the ionizable medium, I employ an auxiliary starting electrode 13 which is biased away from the mercury pool cathode 12 by a spring member 18 and which is adapted to be moved momentarily into engagement with the mercury pool cathode 12 by a suitable electro-responsive means, such as a relay device 15 comprising a core member 16 and an actuating or energizing coil 17 which acts on an armature member 14. A current limiting resistance (not shown) may be connected in series relation with the auxiliary starting electrode 13, if desired.

I provide a circuit 19, preferably a resonant circuit, including a saturable inductive device 20 and a capacitance 21 which are energized from a

suitable source of alternating current 22 through a transformer 23 having a secondary winding 24 provided with an electrically intermediate connection 25. The saturable inductive device 20 includes a core member 26, a primary winding 27 which is connected in series relation with the capacitance 21 across the right-hand portion of secondary winding 24 of transformer 23, and also includes a secondary winding 28 which is connected to coil 17 of device 15. By virtue of the winding 28, the auxiliary starting electrode 13 is energized in accordance with an electrical condition of the circuit 19, or in accordance with an electrical condition of the saturable inductive device 20. The secondary winding 26 of the inductive device 20 is also connected to the cathode 12 and to the auxiliary starting electrode 13 through a capacitance 29 which serves to supply to the auxiliary starting electrode 13 a pulse of current sufficient to establish an arc discharge when the electrode 13 is momentarily moved into engagement with cathode 12.

As an agency for controlling the magnetization or the saturation of the saturable device 20 in accordance with the state of ionization of the mercury vapor of electric valve means 4, I provide an energizing or holding circuit including holding anodes 10 and 11 and current limiting inductances 30 which are connected in circuit with primary winding 27 of saturable device 20 and winding 24. This circuit transmits unidirectional current to winding 27 when the medium is ionized. When the mercury vapor is nonionized no unidirectional current will be transmitted to the winding 27 and the inductive device 20 and capacitance 21 are resonant to the frequency of the alternating current circuit 22. When direct current is transmitted to the winding 27 through the circuit including holding anodes 10 and 11, the device 20 is saturated so that the circuit 19 becomes nonresonant.

An excitation circuit 31 may be employed to energize control members 8 and 9 and may include a transformer 32, current limiting resistances 33, and a source of negative unidirectional biasing potential such as a battery 34. The transformer 32 may be energized from any suitable source of alternating current, such as the circuit 1, through any conventional phase shifting arrangement such as the rotary phase shifter 35.

The operation of the embodiment of my invention shown in Fig. 1 of the drawing will be considered when the system is operating to transmit energy from the alternating current circuit 1 to the direct current circuit 2 through transformer 3 and electric valve means 4. When the mercury vapor is in an ionized state, the anodes 6 and 7 will conduct current alternately so that direct current is transmitted to the load circuit 2 in the manner well understood by those skilled in the art. Under these conditions, when the mercury vapor is in an ionized condition it will also be understood that the holding anodes 10 and 11 will conduct so that unidirectional current is transmitted from the cathode 12 through a circuit including winding 27 of inductive device 20, secondary winding 24 of transformer 23, inductances 30 and holding anodes 10 and 11. Under these conditions of operation, the undirectional current transmitted to winding 27 will effect saturation of the inductive device 20 so that the circuit 19 is made nonresonant. The voltage induced in secondary winding 28 of inductive device 20 will not be of sufficient magnitude to effect actuation of auxiliary starting electrode 13 through the device 15. If it be assumed that for any reason the mercury vapor within the envelope 5 of electric valve means 4 becomes nonionized, the circuit 19 will immediately respond to effect actuation of the starting electrode 13 to reestablish an arc discharge and to ionize the mercury vapor. More specifically, if the mercury vapor becomes nonionized the circuits for holding anodes 10 and 11 will not conduct current to winding 27 of saturable device 20, thereby increasing the inductance of this device to a value so that the inductive device 20 together with the capacitance 21 constitute a tuned resonant circuit. When the circuit 19 is in a resonant condition, the voltage of the secondary winding 28 of device 20 will be materially increased so that the starting electrode 13 is actuated by the electromagnetic device 15. As soon as the starting electrode 13 is brought into engagement with the mercury pool cathode 12, the coil 17 of electromagnetic device 15 is effectively shunted through a circuit including the mercury pool cathode 12, auxiliary electrode 13, spring 18 and capacitance 29. The electrode 13 will thereupon be moved away from the cathode 12 by the spring member 18, and due to the charge on the capacitance 29 an appreciable arc discharge will be drawn between the electrode 13 and the cathode 12 to effect ionization of the mercury vapor. As soon as the mercury vapor is ionized, direct current will be transmitted to winding 27 of device 20 to prevent subsequent actuation of the electrode 13. However, if the first arc fails to ionize the mercury vapor, the system will respond to actuate the electrode 13 until the mercury vapor becomes ionized.

Fig. 2 of the accompanying drawing diagrammatically illustrates another embodiment of my invention in which a resonant circuit of the parallel type is employed to effect energization of the control electrode of an electric valve means in accordance with the state of ionization of the medium employed. The parallel resonant circuit includes a capacitance 35, and an inductance 36, which may be of the self-saturating type, connected in parallel relation with the capacitance 35. A suitable impedance, such as a resistance 37, may be connected in series relation with the parallel connected capacitance 35 and inductance 36. Coil 17 of relay 15 is connected to be energized in accordance with the voltage appearing across the capacitance 35 and inductance 36.

The operation of the arrangement of my invention shown in Fig. 2 is substantially the same as that explained in connection wth the arrangement of Fig. 1. When the ionizable medium of the electric valve means 4 is nonionized, the parallel resonant circuit including capacitance 35 and inductance 36 will be in a resonant condition and the voltage appearing across these parallel connected elements will be sufficiently great to effect actuation of the electrode 13 by coil 17 of relay 15. As soon as the electrode 13 is moved into engagement with cathode 12, the coil 17 will be short circuited to effect deenergization of the coil 17, thereby releasing the anode 14 and permitting the electrode 13 to be moved away from the cathode 12 by spring 18, thereby drawing an arc and effecting ionization of the medium. When the ionizable medium is in an ionized state, direct current will be transmitted through saturable inductance 36 by the circuits including holding anodes 10 and 11, current limiting inductances 30 and secondary winding 24 of transformer 23. The direct current effects saturation

of the inductance 36 so that the resonant circuit is made dissonant, effecting thereby a material reduction in the voltage appearing across the parallel connected capacitance 35 and inductance 36. When the circuit is dissonant, the voltage appearing across parallel connected capacitance 35 and the inductance 36 is not sufficient to effect actuation of the electrode 13 so that the electrode is permitted to remain in the upper position so long as the medium is in an ionized state. As soon as the medium becomes nonionized, no unidirectional current is transmitted to the inductance 36, thereby restoring the circuit to the resonant condition and increasing the voltage impressed on coil 17 to effect actuation of the electrode 13. The intermittent actuation of the electrode 13 will be continued until the medium is ionized.

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 discharge device including an envelope, an ionizable medium, an anode, a cathode and an electrode for initiating an arc discharge within said envelope, a source of alternating current, a resonant circuit energized from said source, means for controlling the impedance of said resonant circuit in accordance with the state of ionization of said medium, and means energized in accordance with an electrical condition of said resonant circuit to control the energization of said electrode.

2. In combination, an electric discharge device including an envelope, an ionizable medium, an anode, a cathode and an electrode for initiating an arc discharge within said envelope, a source of alternating current, a resonant circuit energized from said source including an inductance and a capacitance, means for controlling said inductance in accordance with the state of ionization of said medium, and means energized in accordance with an electrical condition of said resonant circuit to energize said electrode when said medium is nonionized.

3. In combination, an electric discharge device including an envelope, an ionizable medium, an anode, a cathode and an electrode for initiating an arc discharge within said envelope, a source of alternating current, a resonant circuit energized from said source and comprising a parallel connected inductive impedance and a capacitive impedance, means for controlling one of said impedances in accordance with the state of ionization of said medium, and means energized in accordance with an electrical condition of said resonant circuit for controlling said electrode.

4. In combination, an electric valve means including an ionizable medium, an anode, a cathode, a holding anode and an auxiliary starting electrode, a source of alternating current, a circuit energized from said source including a serially connected saturable inductive device and a capacitance, said device and said capacitance being arranged to constitute a resonant circuit when said device is nonsaturated, a circuit including said holding anode for saturating said device when said medium is ionized, and means responsive to an electrical condition of said device for energizing said auxiliary electrode when said medium is nonionized.

5. In combination, an electric valve means including an ionizable medium, an anode, a cathode and an auxiliary electrode for initiating an arc discharge, a circuit including a source of alternating current and a serially connected inductance and a capacitance energized from said source, means responsive to the state of ionization of said medium for selectively controlling said inductance so that said inductance and said capacitance constitute a tuned resonant circuit when said medium is nonionized and for making said circuit nonresonant when said medium is ionized, and means energized in accordance with an electrical condition of said resonant circuit for energizing said auxiliary electrode to establish an arc discharge when said medium is nonionized.

6. In combination, an electric valve means having an anode, a cathode, a holding anode and an auxiliary electrode for starting an arc discharge, a circuit including a source of alternating current and a resonant circuit energized from said source including a serially connected inductance and a capacitance, said inductance being connected in circuit with said holding anode and said source and arranged to be saturated to make said circuit nonresonant when said medium is ionized, and means responsive to an electrical condition of said inductance for energizing said auxiliary electrode when said medium is nonionized.

7. In combination, an electric valve including an anode, a mercury pool cathode, a holding anode and an auxiliary starting electrode biased away from said cathode and adapted to be moved into engagement with said mercury pool cathode to initiate an arc discharge, a circuit for energizing said holding anode, a source of alternating current, a resonant circuit connected to said source including a serially connected saturable reactor and a capacitance, a circuit for said holding anode, said reactor being controlled in accordance with the current of said holding circuit, and means energized in accordance with an electrical condition of said reactor to actuate said electrode when said medium is nonionized.

8. In combination, an electric valve means including an anode, a mercury pool cathode, a holding anode and an auxiliary starting electrode, electromagnetic means for actuating said starting electrode to establish an arc discharge, a source of alternating current, a circuit energized from said source including a serially connected saturable reactor and a capacitance, an energizing circuit for said holding anode, said reactor being connected in circuit with said holding anode and arranged to constitute with said capacitance a resonant circuit when said electric valve means is nonconductive, and means responsive to an electrical condition of said reactor for energizing said electromagnetic means.

9. In combination, an electric valve means having an anode, a mercury pool cathode, a holding anode and an auxiliary starting electrode biased away from said cathode and adapted to be moved into engagement with said mercury pool cathode to initiate an arc discharge, a source of alternating current, a circuit energized from said source including a capacitance

and a saturable inductive device having a primary winding connected in series relation with said capacitance and a secondary winding for energizing said starting electrode, a circuit for said holding anode comprising said primary winding to control the inductance of said saturable device in accordance with the conductivity of said electric valve means, and means connected to said secondary winding for actuating said electrode when said electric valve is nonconductive.

10. In combination, an electric valve means empoying an ionizable medium and including an anode, a cathode and an electrode for initiating an arc discharge, a source of alternating current, a circuit energized from said source including a serially connected inductance and a capacitance, said circuit being resonant when said inductance is desaturated, a second circuit responsive to the state of ionization of said medium for controlling the magnetization of said inductance to desaturate said inductance when said medium is nonionized and to saturate said inductance when said medium is ionized, and means energized in accordance with an electrical condition of said inductance to energize said electrode when said medium is nonionized.

11. In combination, an electric valve means including an envelope, an ionizable medium, an anode, a cathode and an electrode for initiating an arc discharge within said envelope, a source of alternating current, a resonant circuit energized from said source including a parallel connected capacitance and an inductance, means for supplying unidirectional current to said inductance to control the magnetization thereof in accordance with the state of ionization of said medium, and means energized in accordance with the voltage appearing across said inductance and said capacitance for effecting energization of said electrode when said medium is nonionized.

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