March 8, 1938. F. R. ELDER 2,110,700

ELECTRIC VALVE CIRCUITS

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Fig. 1.

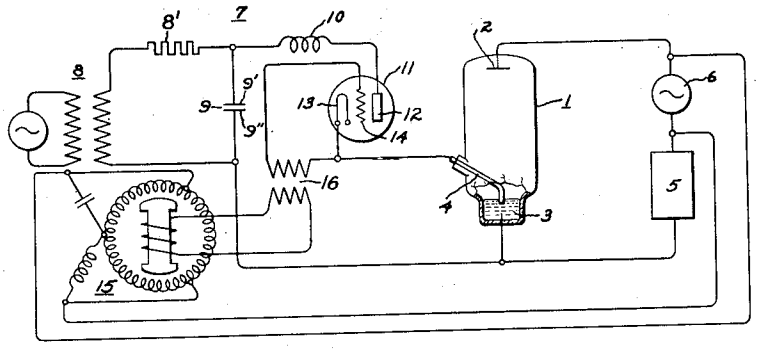
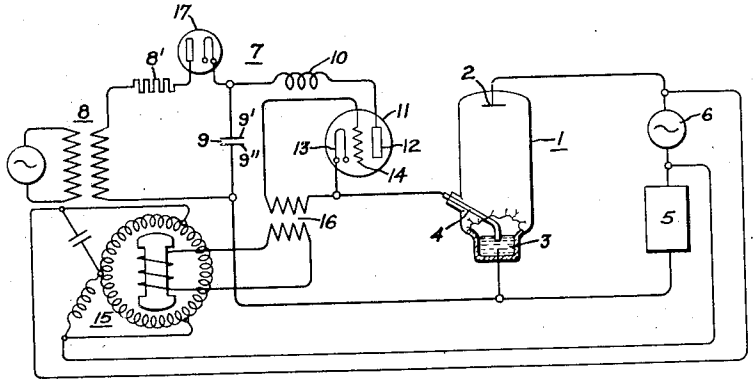


Fig. 2.



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ELECTRIC VALVE CIRCUITS

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8 Claims. (Cl. 175—363)

My invention relates to electric valve circuits and more particularly to excitation circuits for electric valves of the vapor electric discharge type.

In excitation circuits for electric valves of the vapor electric discharge type, it is desirable to have an excitation circuit which will provide a periodic control potential, the positive portions of which have a relatively steep wave front. It is further desirable to have an excitation circuit which will render the electric valve conductive at a predetermined point of the alternating current potential and which will furnish a suitable electric impulse to render the electric valve conductive with the desired precision and certainty.

The electric valve device utilized in the apparatus of the type to which my invention particularly applies, in general, comprises a plurality of principal electrodes between which an electric discharge is to pass. The electric discharge may be initiated by a suitable ionizing member located in the ionizable medium, or the discharge may be initiated by a control member associated with one of the principal electrodes.

Although not particularly limited thereto, in a specific type of electric valve to which my invention may readily be applied, at least one of the principal electrodes may be a conductive liquid or solid in which is immersed an associated control electrode. This type of control electrode, a portion of which is immersed in one of the principal electrodes, may be termed an immersion-ignitor since it effects ignition of the electric valve when a suitable current is passed through the immersion-ignitor to the associated principal electrode. More particularly, a suitable valve utilizing the immersion-ignitor is one in which the associated principal electrode is mercury and the immersion-ignitor is of a material of relatively high specific electrical resistivity as compared with the resistivity of mercury. In such an arrangement, of course, the mercury pool will form the cathode of the electric valve. To initiate the electric discharge and hence render the electric valve conductive, an electric current is transmitted through the immersion-ignitor into the mercury by the application of a voltage of suitable value and wave form. The polarity of the immersion-ignitor will be positive relative to the mercury.

It has been found that in order to provide suitable excitation for valves of the immersion-ignitor type with the desirable regularity and certainty, currents of relatively large, instantaneous values and relatively steep wave fronts must be transmitted through the immersion-ignitor to the mercury. Although the satisfactory operation of this type of electric valve is not dependent upon utilizing sources of potential having substantially perpendicular wave fronts or which have a so-called peaked characteristic, I have found that more precise and reliable ignition of the electric valves is provided when sources having such a wave form are employed. One of the means used heretofore to provide a suitable excitation potential for this type of electric valve is an arrangement in which the transient potential incident to the charge and discharge of a capacitance is impressed upon the control electrode of the valve. Electric valves of the high vacuum type have been used in excitation circuits of this nature to discharge the capacitance at certain predetermined points in the cycle of operation, but many of these arrangements have necessitated the use of auxiliary apparatus of a large rating relative to the rating of the valve controlled. It has been evidenced that there is a need for excitation circuits having the above-mentioned characteristics and the use of which will not be prohibitive because of the requirement of auxiliary apparatus having an electrical rating inordinate to the rating of the electric valve circuit in a particular application. Furthermore, it will be apparent that it is desirable to provide excitation circuits which are readily adaptable to the use of electric valves of the high vacuum type, as well as valves of the vapor electric type.

It is an object of my invention to provide for electric valves an improved excitation circuit and method of excitation which will have the above desirable characteristics, and which will be simple and reliable in operation.

It is another object of my invention to provide improved excitation systems for electric valves of the vapor electric discharge type which will provide an electric impulse to the control member to render the electric valves conductive at a predetermined point of the anode-cathode potential.

It is a further object of my invention to provide an improved excitation circuit for an electric valve of the vapor electric discharge type which will supply to the control member an excitation current of predetermined wave form and value to assure precise and satisfactory ignition of the electric valve during either the positive or negative half cycle of anode-cathode potential.

According to the illustrated embodiments of my invention, I provide an improved excitation cir-

cuit for an electric valve of the vapor electric discharge type having an immersion-ignitor control member. I provide an arrangement whereby energy is stored in a capacitance and is discharged through the excitation circuit for the immersion-ignitor at a predetermined point in the positive half-cycle of the potential applied between the principal electrodes of the main valve by means of an auxiliary control valve of either the high vacuum type or vapor electric type having its period of conductivity controlled by means in the anode circuit of the control valve. In one embodiment energization of the immersion-ignitor may be accomplished during only the positive half cycle of the auxiliary or principal source. In another embodiment of my invention I provide a similar excitation circuit for electric valves of the immersion-ignitor type wherein the capacitance is energized through a unidirectional conducting device which permits energization of the immersion-ignitor during either the positive or negative half cycle of alternating potential of the auxiliary or principal source.

For a better understanding of my invention, together with other and further objects thereof, reference is had to the following description taken in conjunction with the accompanying drawing, and its scope will be pointed out in the appended claims.

Fig. 1 of the accompanying drawing illustrates diagrammatically one embodiment of my invention as applied to an excitation circuit for an electric valve of the vapor electric discharge type having an immersion-ignitor control member, and which is arranged to provide suitable excitation of an electric valve from an auxiliary or principal source of potential during a positive half cycle of alternating potential. Fig. 2 is a modification of the embodiment of my invention shown in Fig. 1 in which control is effected at any point during either the positive or negative half cycle of alternating potential of an auxiliary or principal source.

Referring now to Fig. 1 of the drawing, there is shown diagrammatically an embodiment of my invention in which an electric valve 1 having an anode 2, a mercury pool cathode 3 and a control member or electrode 4 is employed to supply a unidirectional current to a load circuit 5 from an alternating current source 6. The control electrode 4 may be of the immersion-ignitor type comprising a material having a relatively high electrical resistivity as compared to the resistivity of mercury. The immersion-ignitor 4 may be composed of a suitable material having a relatively high electrical resistivity, as compared to the resistivity of mercury, such as boron, boron-carbide, silicon-carbide, or a material such as is disclosed and claimed in U. S. Patent No. 1,822,742, granted September 8, 1931, on an application of Karl B. McEachron and assigned to the same assignee as the present application. The material disclosed in the above-mentioned patent is commercially designated as "Thyrite". Some of the materials which may be used and which have proved satisfactory for this particular use have a very marked positive non-linear volt-ampere characteristic. The electric valve 1 will not be conductive until a suitable electrical impulse is impressed upon the control electrode 4. During a positive half cycle of potential impressed between the anode 2 and the cathode 3 from the alternating current source 6, it will be understood that the electric valve 1 may be rendered conductive by ionizing the ionizable medium which in this particular type of valve is occasioned by a transient current transmitted through the control electrode 4 to the cathode 3.

An excitation circuit 7 comprising an auxiliary source of alternating current 8, a capacitance 9, a reactive device such as an inductive device 10 and a control electric valve 11, shown in an arrangement particularly adapted for a valve of the vapor electric discharge type, is provided to supply a transient electrical impulse to the control electrode 4. A resistance 8' is used to prevent the charge on capacitance 9 from discharging through source 8. It will be understood that, instead of employing the auxiliary source 8, I may employ the source 6 to energize the excitation circuit. The capacitance 9, having plates 9' and 9'', is connected in parallel with the auxiliary source of alternating current and is employed to discharge through the electric valve 11 and the control electrode 4 at predetermined points of the positive half cycle of potential of the auxiliary source. The electric valve 11 is provided with an anode 12, a cathode 13 and a control member 14. Any suitable phase shifting arrangement 15 may be used to control the phase of the potential impressed upon the control electrode 14 of electric valve 11 relative to the potential impressed between the anode 12 and the cathode 13. A transformer 16 may be employed to impress upon control electrode 14 a potential of suitable magnitude and wave form.

In explaining the operation of the embodiment of my invention as illustrated in Fig. 1, let it be assumed that the potential impressed between anode 2 and cathode 3 of electric valve 1 by alternating current source 6 is such that anode 2 is positive relative to cathode 3. Let it further be assumed that the potential of the auxiliary source 8 is such that the anode 12 of electric valve 11 is positive relative to the cathode 13. During the positive half cycle it will be obvious to those skilled in the art that the capacitance 9 will be charged so that the plate 9' is positive relative to the plate 9''. If the potential impressed upon the control electrode 14 of electric valve 11 exceeds the critical potential for the particular valve employed, the capacitance 9 will discharge through the electric valve 11 and the control electrode 4. The circuit through which this discharge will flow is: inductive device 10, anode 12 and cathode 13 of electric valve 11, control electrode 4 and cathode 3 of electric valve 1. The wave form of the potential impressed upon the control electrode 4 will be substantially perpendicular and of relatively short duration. This discharge will tend to persist if the electric valve 11 does not interrupt the circuit when the potential of the auxiliary source 8 reverses polarity. In the prior art arrangements with an electric valve of the high vacuum type used for the control valve 11, the discharge was interrupted by impressing a negative potential of sufficient value upon the control electrode 14 to render the valve non-conductive. When an electric valve of the vapor electric discharge type is used for the control valve 11, the interruption of the anode current cannot be effected by impressing a potential of reasonable value on the control electrode but is accomplished by controlling an electrical condition of the anode circuit, such as by impressing upon the anode a potential to render the anode negative relative to the cathode for a time equal to, or greater than, the time of de-ionization of the electric valve. To provide an excitation circuit particularly adaptable to the use of electric

valves of the vapor electric discharge type and which may also be used with valves of the high vacuum type, I employ means to control an electrical condition of the anode circuit at the proper time. As illustrated, I connect an inductive device 10 in series with the capacitance 9 and the anode 12 of electric valve 11. The function of the inductive device 10 is to impress momentarily upon the anode 12 of electric valve 11 a negative potential during the latter part of the discharge period when capacitance 9 is discharging through the above described discharge circuit. By choosing a suitable value of inductance for the inductive device 10, I may control the magnitude of the negative potential impressed upon the anode 12, as well as the time of application of this negative potential.

Referring now to Fig. 2 of the accompanying drawing, there is shown diagrammatically a modification of the embodiment of my invention shown in Fig. 1, in which corresponding elements have been given like reference numerals. This modification differs from the embodiment of my invention illustrated in Fig. 1 by employing a unidirectional conducting device 17 connected in series with the source 8, the current-limiting resistance 8' and the capacitance 9.

The unidirectional conducting device 17, through which the capacitance 9 is energized from alternating current source 8, is provided to prevent the charge accumulated in the capacitance 9 during a positive half cycle from flowing out of the capacitance through the source 8' during the negative half cycle of potential. By this means I provide an arrangement in which the control member 4 may be energized during either the positive or negative half cycle of alternating potential of the auxiliary source 8.

Similarly to the arrangement illustrated in Fig. 1, I employ an inductive device 10 in the excitation circuit 7 to impress a suitable negative potential during the latter part of the discharge period upon the anode 12 of the vapor electric discharge valve 11, in this way providing a means for rendering the electric valve 11 non-conductive and hence making it possible to control the period of energization of the control electrode 4 of electric valve 1.

While I have shown and particularly described certain embodiments of my invention and certain methods of operation embraced therein for the purpose of explaining its principle and showing its application, it will be obvious to those skilled in the art that many modifications are possible without departing from my invention, and I aim, in the appended claims, to cover all such modifications and variations 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 comprising at least two principal electrodes and a control member of the immersion-ignitor type, and an excitation circuit for said control member for impressing a relatively large transient electrical impulse upon said control member comprising a capacitance, a source of alternating current for charging said capacitance, a second electric valve employing an ionizable medium and comprising an anode and a cathode for discharging said capacitance through said control member and reactive means for controlling an electrical characteristic of the anode circuit of said second valve to render said second valve non-conductive.

2. In combination, an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type, and an excitation circuit for said control member for impressing a relatively large transient electrical impulse upon said control member comprising a capacitance, a source of alternating current for charging said capacitance, an electric valve employing an ionizable medium and comprising an anode and a cathode for discharging said capacitance through said control member and means connected to the anode circuit of said second mentioned valve for introducing into said anode circuit a potential in opposition to said impulse for rendering said valve non-conductive.

3. In combination, an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type, and an excitation circuit for said control member for impressing a relatively large transient electrical impulse upon said control member comprising a capacitance, a source of alternating current for charging said capacitance, an electric valve employing an ionizable medium and comprising an anode and a cathode for discharging said capacitance through said control member and an inductive device associated with the anode circuit of said second-mentioned valve to permit said second-mentioned valve to control the period of energization of said control member.

4. In combination, an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type associated with one of said principal electrodes, and an excitation circuit for said control member for impressing a relatively large transient electrical impulse upon said control member comprising a capacitance, a source of alternating current for charging said capacitance, an electric valve of the vapor electric discharge type, means for rendering said second-mentioned electric valve conductive to effect discharge of said capacitance through said control member at a predetermined potential of said alternating current source and an inductive device connected in the anode circuit of said second-mentioned electric valve to permit said second-mentioned electric valve to control the energization of said control member.

5. In combination, an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type associated with one of said principal electrodes for rendering said electric valve conductive, and an excitation circuit for said control member comprising a capacitance, a unidirectional conducting device, a source of alternating current for energizing said capacitance through said unidirectional conducting device, an electric valve of the vapor electric discharge type for discharging said condenser through said control member to impress upon said control member a relatively large transient electrical impulse and an inductive device connected in the anode circuit of said second-mentioned electric valve to permit said valve to control the period of energization of said control member.

6. In combination, an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type associated with one of said principal electrodes, a source of alternating current for impressing an alternating potential between said principal electrodes, a direct current load circuit energized from said alternating current source through said electric valve, and an excitation circuit for said control member comprising a capacitance, a uni-

directional conducting device, a source of alternating current for energizing said capacitance through said unidirectional conducting device, an electric valve of the vapor electric discharge type having an anode, a cathode and a control electrode for discharging said condenser through said control member and for impressing upon said control member a relatively large transient electrical impulse and an inductive device connected in the anode circuit of said second-mentioned electric valve for momentarily impressing on said anode of said second-mentioned valve a transient negative potential.

7. In an excitation circuit for an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type, the method of energizing said control member from a source of electrical energy which comprises the storing of energy from said source in said excitation circuit, dissipating a portion of said energy in said control member, and introducing into said excitation circuit a potential to control the period of energization of said control member.

8. In an excitation circuit for an electric valve comprising at least two principal electrodes and a control member of the immersion-ignitor type, the method of energizing said control member from a source of alternating current which comprises the storing of energy from said source in a reactive element of said excitation circuit, dissipating a portion of said energy in said control member, and controlling the discharge of the reactive element to control the period of energization of said control member.

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