

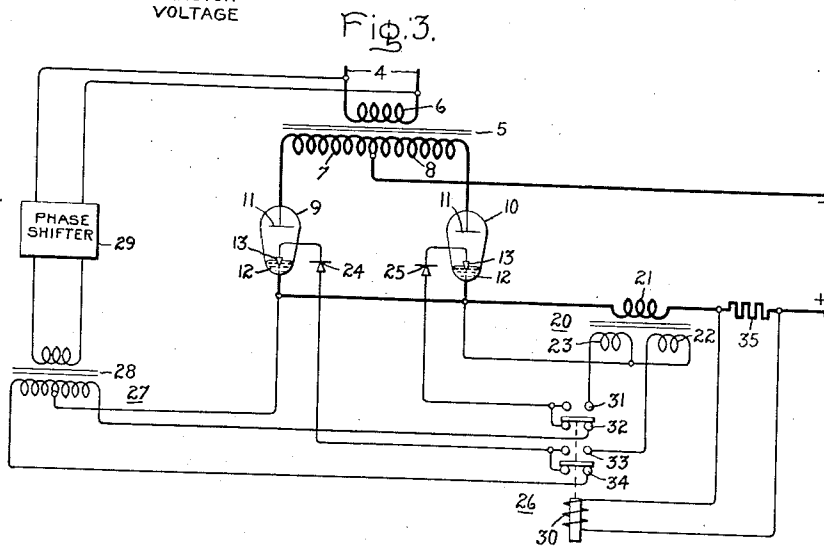
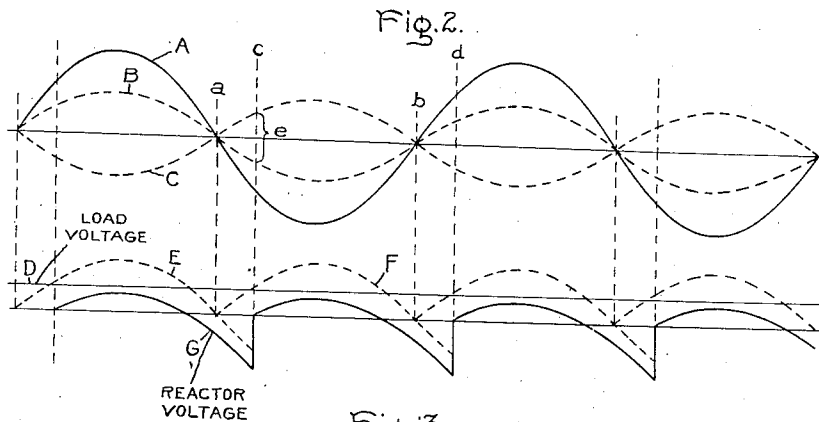
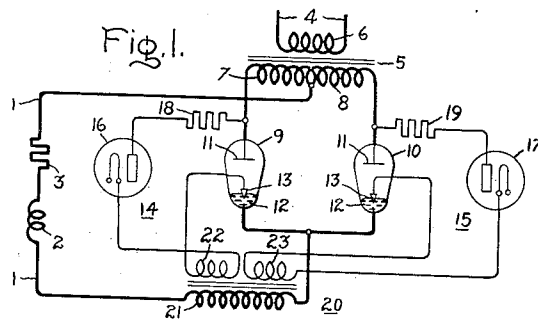
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EXCITATION CIRCUIT FOR ELECTRIC VALVE APPARATUS

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EXCITATION CIRCUIT FOR ELECTRIC VALVE APPARATUS

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My invention relates to electric valve translating apparatus, and more particularly to control and excitation circuits for electric valve means of the type employing an ionizable medium such as a gas or a vapor.

It is important in many electric valve applications to control accurately the frequency or the time at which the electric valve means is rendered conducting, in order to obtain the desired precision of control of an electrical condition such as the voltage or current of an associated circuit. For example, in electric valve systems employing apparatus such as electric valves using ionizable mediums such as gases or vapors, it is important to effect energization of the control member at a desired time during a cycle of voltage of alternating current so that the arc discharge is initiated at a precise instant. In accordance with the teachings of my invention described hereinafter, I provide new and improved control circuits whereby the precision of control is obtained without involving the use of expensive and elaborate associated control equipment.

It is an object of my invention to provide new and improved electric valve translating apparatus.

It is another object of my invention to provide new and improved control and excitation circuits for electric valve means employing control members which control the conductivity or control the amount of current conducted thereby.

It is a further object of my invention to provide new and improved control and excitation circuits for electric valve means of the type using immersion-ignitor control members.

Briefly stated, in the illustrated embodiments of my invention I provide new and improved control circuits wherein positive control and ignition of electric valve apparatus is afforded. The electric valve means is of the type comprising an ionizable medium, such as a gas or a vapor, and may include a control member of the immersion-ignitor type associated with the cathode and which when properly energized establishes an arc discharge between the anode and cathode. In one embodiment of my invention, an excitation circuit responsive to the anode voltage of the associated electric valve is employed to supply an impulse of current to the control member when the anode voltage is of a predetermined or positive polarity and when it attains a predetermined magnitude. In order to assure positive ignition of the electric valve means, I provide inductive means or a reactor which is connected in circuit with the anode-cathode circuit of the electric

valve means for producing a voltage to assist the control member voltage derived from the anode-cathode circuit. In other embodiments of my invention, excitation means is provided for starting the electric valve means and after the system is initiated in its operation the control voltage for energizing the control member is derived exclusively from the reactor which is connected in series with the anode-cathode circuit 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 is pointed out in the appended claims. Fig. 1 diagrammatically illustrates an embodiment of my invention as applied to a biphas rectifier, and Fig. 2 represents certain operating characteristics thereof. Fig. 3 represents a modification of the arrangement shown in Fig. 1 wherein an auxiliary source of excitation current is employed for initiating operation of the system.

Referring now to Fig. 1 of the drawing, I have there illustrated my invention as applied to an electric valve translating system, such as an electric valve converting system, for energizing a direct current load circuit 1, which may be of the inductive type comprising an inductive reactance 2 and a resistance 3, from an alternating current supply circuit 4. The translating apparatus comprises an inductive network having a plurality of electrically displaced phase windings. The inductive network may comprise a transformer 5 having a primary winding 6 and a pair of diametrically electrically displaced phase windings 7 and 8 which are respectively associated with electric valve means 9 and 10. The arrangement illustrated constitutes a bi-phase rectifier. It will, of course, be understood that my invention in its broader aspects may be applied to electric valve circuits of a greater number of phases if desired.

The electric valve means 9 and 10 are preferably of the type employing an ionizable medium, such as a gas or a vapor, which is capable of supporting an arc discharge, and each includes an anode 11, a cathode 12 such as a mercury pool cathode, and each may comprise a control member 13 of the immersion-ignitor type constructed of a material such as boron carbide or silicon carbide and which has an electrical resistivity substantially large compared with that of the associated mercury of the cathode into which it extends. Arc discharges are established between associated anodes and the cathodes upon

the transmission of a predetermined current to control members 13. To control electric valve means 9 and 10, I provide excitation circuits 14 and 15, respectively, and which may be connected to be responsive to the magnitude and polarity of the anode voltage of the respective associated electric valves. More particularly, the excitation circuits 14 and 15 may include poled unidirectional conducting devices or rectifiers 16 and 17 which are connected to the anodes 11 of electric valve means 9 and 10 through current limiting resistances 18 and 19, respectively.

In order to assure positive ignition of electric valve means 9 and 10 by adding another component of firing voltage to the control member voltages derived from the anode-cathode circuits of the electric valve means, I provide an inductive means or a reactor 20 having a primary or main winding 21 which is connected in series relation with the electric valve circuits of electric valve means 9 and 10, and which is also provided with a pair of secondary windings 22 and 23 which are connected in series relation with the rectifiers 16 and 17, respectively. These windings are poled so that positive voltages are applied to the control members 13 in response to the voltage across the reactor 20 occasioned by the commutation of current between the electric valve means 9 and 10.

The operation of the embodiment of my invention shown in Fig. 1 will be explained by considering the system when it is operating as a bi-phase rectifier to transmit unidirectional current and voltage to the load circuit 1. The electric valve means 9 and 10 conduct current alternately during the positive half cycles of applied anode-cathode voltage, and the time when each electric valve means is rendered conducting during its positive half cycle of applied anode-cathode voltage is determined by that time in the half cycle at which the anode-cathode voltage rises to a value sufficiently high to cause the transmission of a predetermined minimum critical current through the control member 13 and through the associated rectifier. The reactor 20, by virtue of windings 22 and 23, also adds an additional positive component of voltage to the component derived from the anode-cathode circuit to assure positive ignition of electric valve means 9 and 10.

The operation of the arrangement shown in Fig. 1 may be more fully appreciated by referring to the operating characteristics illustrated in Fig. 2. Curve A represents the alternating voltage impressed across the primary winding 6 of transformer 5, and curves B and C represent the voltages provided by the secondary winding sections 7 and 8. Consequently, curve B represents the voltage applied to electric valve means 9, and curve C represents the anode-cathode voltage applied to electric valve means 10.

If the load circuit connected to the bi-phase rectifier is purely resistive, the current through the electric valve means 9 and 10 will decrease to zero at times *a* and *b*. However, if the load circuit contains inductive reactance, the load current will tend to persist through the electric valve means into the region where the phase voltage goes negative and will persist during a period of time corresponding to the power factor angle or until the other electric valve means is rendered conducting. If it be assumed that the electric valve means 10 and 9 are rendered conducting at times *c* and *d*, respectively, and if the load circuit is inductive, it will be appreciated

that the current through the electric valve means will continue throughout the respective negative regions *a-c* and *b-d*. Inasmuch as considerable inductance is present in the load circuit, the current supplied to the load circuit will remain substantially constant and the voltage variation due to the sinusoidal variation of the positive or rectified voltages derived from windings 7 and 8 will be absorbed across the primary winding 21 of the reactor 20. For example, at the time of commutation of current from electric valve means 9 to electric valve means 10, the difference in anode-cathode voltages represented by the quantity *e* is absorbed by the reactor 20. It is this variation of voltage which is utilized by the reactor 20 to produce voltages which assist the components of voltage derived from the respective anode-cathode circuits of electric valve means 9 and 10 and which are applied to the control members 13.

Curve D of Fig. 2 represents the voltage applied to the load circuit 1. Curves E and F represent the positive or rectified half cycles of the alternating voltages furnished by secondary windings 7 and 8 of transformer 5. The difference between the voltages represented by curves E and F and the load voltage D is the ripple voltage which appears across the primary winding 21 of reactor 20. This difference voltage is represented by curve G and is the voltage which induces the additive or assisting voltages in windings 22 and 23.

Fig. 3 diagrammatically illustrates a modification of the arrangement shown in Fig. 1, and corresponding elements have been assigned like reference numerals. In this modification, the control members 13 are energized exclusively by utilizing the variation in voltage appearing across reactor 20 to energize control members 13 through rectifiers 24 and 25. In order to initiate the operation of the system and to supply exciting current to control members 13 in timed relationship in order to assure alternate conduction by the electric valve means, I provide relay means 26 which connects an auxiliary source 27 of excitation current to the control members 13. The auxiliary source of excitation 27 may include a transformer 28 and a suitable phase shifting device 29, so that the time of application of energizing voltage to control members 13 is controllable. Relay 26 comprises an actuating coil 30 and may include pairs of contacts 31-34, inclusive. Relay 26 is arranged so that when in the deenergized position the auxiliary source of excitation 27 is connected to control members 13 of electric valve means 9 and 10 through contacts 34 and 32, respectively. When relay 26 is in the closed or energized position, the auxiliary source of excitation 27 is disconnected and the secondary windings 22 and 23 of the reactor are connected to control members 13 of the electric valve means 9 and 10, through contacts 31 and 33 respectively.

I also provide current responsive means for actuating the relay 27 in response to an electrical condition of the load circuit such as the current conducted by the electric valve means 9 and 10 to disconnect the auxiliary source of excitation 27 from the control members 13 as soon as the current begins to flow in the anode-cathode circuit or the load circuit. This current responsive means may comprise means such as a shunt 35 which supplies a voltage to the actuating coil 30 of relay 26 when current is transmitted to the load circuit 1.

The embodiment of my invention illustrated in Fig. 3 operates in substantially the same way as that explained above in connection with the arrangement in Fig. 1. During the initiating operation of the system, impulses of positive unidirectional current are transmitted to the control members 13 of electric valve means 9 and 10 in timed relation to render the electric valve means 9 and 10 conducting alternately. As soon as current is transmitted to load circuit 1, relay 26 is energized, thereby disconnecting the auxiliary source of excitation 27 from the control members 13, and connecting secondary windings 22 and 23 to the control members 13 through rectifiers 24 and 25. The variation in voltage appearing across the reactor 21, as explained above in connection with the operation of Figs. 1 and 2, is utilized to produce voltages which are sufficient to render the electric valve means 9 and 10 conducting at the desired times.

It will be appreciated that the magnitude of the voltage which is supplied to control members 13 in the arrangements shown in Figs. 1 and 3 may be controlled, adjusted, or determined by the design of the reactor with particular regard to the ratio of turns of the primary winding 21 and the secondary windings 22 and 23.

While I have shown and described my invention as applied to particular systems 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 alternating current circuit, a load circuit, bi-phase electric valve translating apparatus connected between said circuits and comprising a pair of windings displaced 180 electrical degrees relative to the voltage of said alternating current circuit and including a pair of electric valve means each associated with a different one of the windings, said electric valve means each being of the type comprising an anode, a cathode and a control member of the immersion-ignitor type associated with said cathode, and an inductive device connected in series relation with the anode-cathode circuits of both of said electric valve means and said load circuit and comprising a pair of secondary windings respectively connected to the control members of the pair of electric valve means for producing voltages to energize said control members.

2. In combination, an alternating current circuit, a load circuit, electric translating apparatus connected between said circuits and comprising an inductive network including a plurality of electrically displaced windings and a plurality of electric valve means each associated with a different one of the windings, said electric valve means being of the type comprising an anode, a cathode and a control member, an inductive device connected in series relation with the anode-cathode circuits of said electric valve means and said load circuit, means responsive to the variation in voltage across said inductive device for producing a voltage to energize said control members, an auxiliary source of excitation current for energizing said control members, and means for selectively disconnecting and con-

necting said auxiliary source to said control members.

3. In combination, an alternating current circuit, a load circuit, electric translating apparatus connected between said circuits and comprising an inductive network including a plurality of electrically displaced windings and a plurality of electric valve means each associated with a different one of the windings, said electric valve means being of the type comprising an anode, a cathode and a control member, an inductive device connected in series relation with the anode-cathode circuits of said electric valve means and said load circuit, means responsive to the variation in voltage across said inductive device for producing a voltage to energize said control members, an auxiliary source of excitation current for energizing said control members, and means responsive to the flow of current in the anode-cathode circuits of said electric valve means for selectively disconnecting and connecting said auxiliary source to said control members.

4. In combination, an alternating current circuit, a load circuit, electric translating apparatus connected between said circuits and comprising an inductive network including a plurality of electrically displaced windings and a plurality of electric valve means each associated with a different one of the windings, said electric valve means being of the type comprising an anode, a cathode and a control member, an inductive device connected in series relation with the anode-cathode circuits of said electric valve means and said load circuit, means responsive to the variation in voltage across said inductive device for producing a voltage to energize said control members, an auxiliary source of excitation current for energizing said control members, and means for selectively connecting said auxiliary source and said last mentioned means to said control members in response to the current transmitted to said load circuit.

5. In combination, an alternating current circuit, a load circuit, electric translating apparatus connected between said circuits and comprising an inductive network including a plurality of electrically displaced windings and a plurality of electric valve means each associated with a different one of the windings, said electric valve means being of the type comprising an anode, a cathode and a control member, an inductive device connected in series relation with the anode-cathode circuits of said electric valve means and said load circuit, means responsive to the variation in voltage across said inductive device for producing a voltage to energize said control members, an auxiliary source of excitation current for energizing said control members, and means for selectively connecting said auxiliary source or said last mentioned means to said control members in response to an electrical condition of said load circuit.

6. In combination, an alternating current circuit, a load circuit, electric translating apparatus connected between said circuits and comprising an inductive network including a plurality of electrically displaced windings and a plurality of electric valve means each associated with a different one of the windings, said electric valve means being of the type comprising an anode, a cathode, an immersion-ignitor type control member associated with said cathode and employing an ionizable medium capable of supporting an arc discharge, a plurality of means each asso-

ciated with a different one of said electric valve means for energizing the associated control member in response to the voltage of the associated anode, and means responsive to the current conducted by said electric valve means and utilizing the voltage during the commutation of current from one electric valve means to another for adding a voltage to the control member voltage derived from the anode-cathode circuit thereby assuring positive ignition of the electric valve means.

7. In combination, an alternating current circuit, a direct current circuit, electric translating apparatus connected between said circuits and comprising a plurality of electrically displaced phase windings and a plurality of electric valve means each connected to a different one of said phase windings, said electric valve means each comprising an anode, a cathode, an immersion-ignitor type control member in contact with said cathode and employing an ionizable medium capable of supporting an arc discharge, a plurality of means each associated with a different one of said electric valve means and each connected between the anode and the control member for transmitting thereto unidirectional current for initiating an arc discharge within the electric valve means, and means connected in the direct current circuit and responsive to the voltage thereacross occasioned by the commutation of current among the electric valve means

for producing a voltage to assist the control member voltage derived from the anode-cathode circuit of the various electric valve means thereby assuring positive ignition of the electric valve means.

8. In combination, an alternating current circuit, a direct current circuit, electric translating apparatus connected between said circuits and comprising a pair of diametrically displaced phase windings and a pair of electric valve means each connected to a different one of said phase windings, said electric valve means being of the type comprising an anode, a cathode, an immersion-ignitor type control member associated with said cathode and employing an ionizable medium capable of supporting an arc discharge, a pair of rectifiers each connected in circuit with the anode of a different one of said electric valve means and poled to transmit positive current to the associated control member, and means for supplying to each of the control members a voltage to assist the control member voltage derived from the anode-cathode circuit and comprising an inductive device having a main winding connected in circuit with said direct current circuit and having a pair of poled secondary windings each connected in series relation with the control member and associated rectifier of the electric valve means.

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