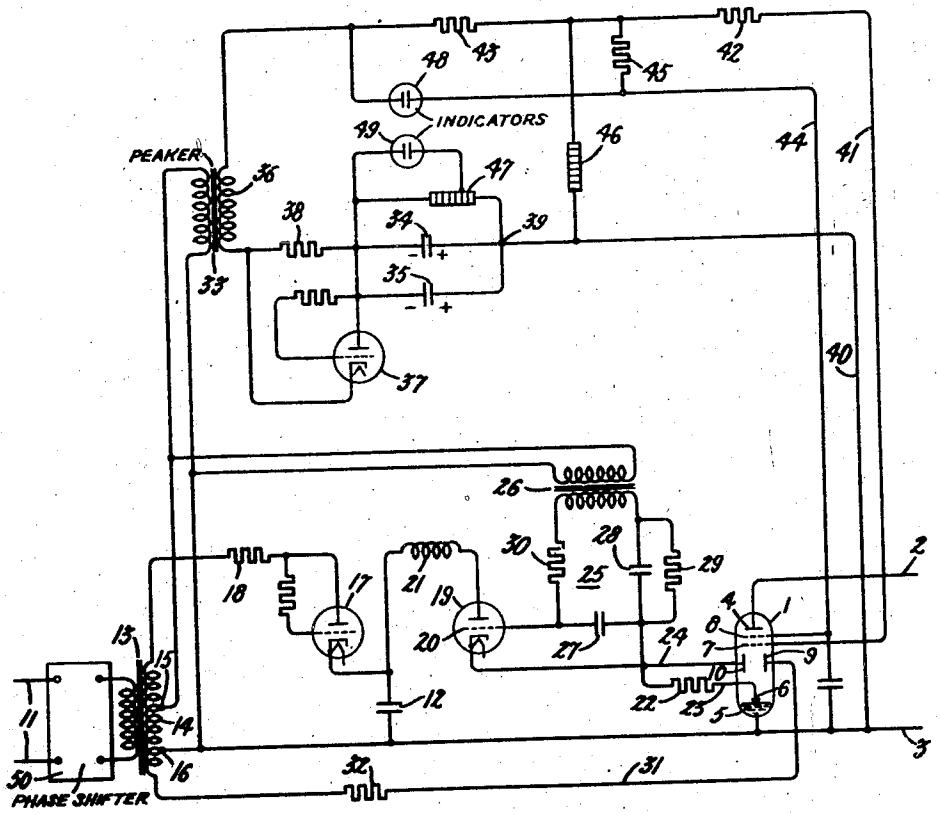
Nov. 26, 1946. M. M. MORACK 2,411,742

ELECTRIC VALVE SYSTEM

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Fig. 1.



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Fig. 2.

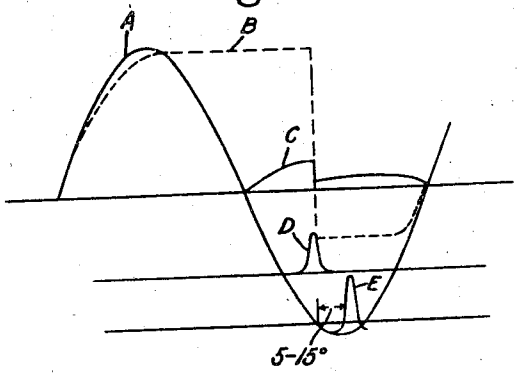
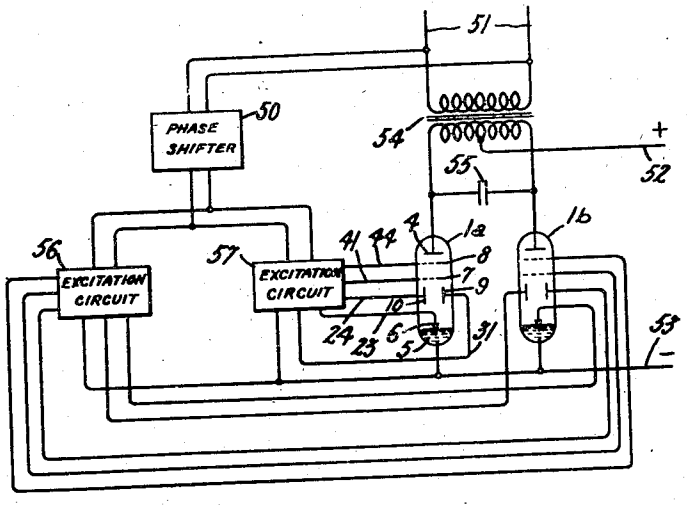


Fig. 3.



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UNITED STATES PATENT OFFICE

2,411,742

ELECTRIC VALVE SYSTEM

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Application September 1, 1942, Serial No. 456,887

13 Claims. (Cl. 175—363)

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My invention relates to electric valve circuits and more particularly to control or excitation circuits for electric valve translating apparatus.

Electric valve means of the type employing self-reconstructing type cathodes, such as mercury pool cathodes, have found rather wide application in many fields where it is desired to transmit relatively large currents due to the fact that cathodes of this nature are capable of supplying relatively large currents. In accordance with the teachings of my invention described hereinafter, I provide a new and improved control or excitation circuit and translating apparatus wherein electric valve means of this type are accurately and precisely controllable.

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

It is another object of my invention to provide new and improved electric valve translating apparatus and an improved control or excitation circuit therefor.

It is a further object of my invention to provide a new and improved control or excitation circuit for electric valve means of the type employing self-reconstructing cathodes and arc-ignition means, such as an immersion-ignitor control member, and wherein auxiliary control means or control electrodes are energized in a manner to assure and obtain precise initiation of current conduction between the anode and cathode of the electric valve means.

Briefly stated, in the illustrated embodiment of my invention I provide a new and improved control or excitation circuit for an electric valve means of the type which includes an immersion-ignitor control member associated with a mercury pool cathode, and which is provided with auxiliary control means which may comprise a pair of auxiliary grids or electrodes which are energized in a manner to obtain precise and reliable initiation of current conduction between the anode and cathode after the proper energization of the immersion-ignitor control member which initiates the arc discharge. I provide means for transmitting impulses of current to the immersion-ignitor control member having a timed relationship or predetermined phase relationship with respect to the voltage of an associated source of alternating current or an alternating current supply circuit. I also provide means for impressing impulses of voltage of peaked wave form on the auxiliary control means or the control electrodes having a constant predetermined lagging phase relationship with respect to the times of energization of the immersion-ignitor control member, thereby assisting in the propagation of the arc discharges from the cathode to the anode and obtaining precise control of the instant at which current conduction is initiated in the anode-cathode circuit.

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For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims. Fig. 1 of the accompanying drawings diagrammatically illustrates in detail the improved excitation circuit as applied to an electric valve means employing an immersion-ignitor control member, and Fig. 2 represents certain operating characteristics of the arrangement shown in Fig. 1. Fig. 3 diagrammatically illustrates the manner in which the excitation circuit shown in Fig. 1 may be applied to electric valve translating apparatus as, by way of example, to an electric valve inverter for transmitting energy from a direct current supply circuit to an alternating current load circuit.

Referring now to Fig. 1 of the accompanying drawings, I have there illustrated my invention as applied to an arrangement for controlling the operation of an electric valve means 1. The electric valve means 1 is connected to a circuit including conductors 2 and 3, and the current flow through the electric valve means 1 controls the energization of circuit 2, 3. The electric valve means 1 may be connected in an electric translating system such as that shown in Fig. 3 explained hereinafter.

Electric valve means 1 is preferably of the type employing an ionizable medium capable of supporting an arc discharge and includes an anode 4, a cathode 5 which may be of the self-reconstructing type such as a mercury pool cathode, and includes arc-ignition means such as an immersion-ignitor control member 6 which when properly energized initiates an arc discharge within the electric valve means by establishing a cathode spot. The immersion-ignitor control member 6 may be constructed of a material such as boron-carbide or silicon-carbide having an electrical resistivity which is large compared with that of the mercury of the associated pool. Electric valve means 1 also includes auxiliary control means, such as a pair of auxiliary electrodes or grids 7 and 8 which are spaced between anode 4 and cathode 5 and may be spaced from each other. These grids, upon proper energization in the manner explained hereinafter, assist in the propagation of the arc discharge from the cathode 5 to the anode 4, thereby precisely controlling the time of initiation of current flow through the anode-cathode circuit of the electric valve means. I also provide in the electric valve means a holding-anode 9, and a relieving anode 10 which serves to relieve the duty imposed on immersion-ignitor control member 6.

I provide excitation means for periodically transmitting impulses of current to the immersion-ignitor control member 6. The excitation means may be energized from a source of alter-

nating current 11 and may include a capacitance 12 which is charged from the source 11 through apparatus including transforming means or a transformer 13 having secondary winding means 14 provided with connections or taps 15 and 16. Capacitance 12 is charged from the upper portion of secondary winding means 14 through a circuit including a unidirectional conducting device, such as an electric valve 17, and a resistance 18. Although the electric valve 17 is shown as being of the type having an enclosing receptacle, it will be understood that rectifying units or devices of the dry type may be employed if desired.

Capacitance 12 is periodically discharged to transmit unidirectional impulses of current to the control member 6. The discharge circuit may include an electric discharge device 19, preferably of the type employing an ionizable medium, and includes a control member or grid 20 which determines the time at which the discharge of the capacitance 12 is initiated. An inductance 21 may be connected in series relation with the electric discharge device 19 and the discharge device 19 is connected to the immersion-ignitor control member 6 through a resistance 22 and a conductor 23.

Resistance 22 serves as a transfer resistance and is connected to the relieving anode 10 through a conductor 24. Due to the increased current flow through resistance 22, upon initiation of the arc discharge, the potential of the relieving anode 10 is raised to effect transfer of the greater portion of the excitation current to anode 10.

I provide means for impressing on grid 20 of electric discharge device 19 a periodic voltage of predetermined phase displacement relative to the voltage applied to the charging circuit for capacitance 12, thereby controlling the time of initiation of current conduction. This means may comprise a phase shifting circuit 25 including a transformer 26 which is energized from transformer 13 and may be connected across that portion of the secondary winding means 14 between taps 15 and 16. The phase shifting circuit also includes a reactive element, such as a capacitance 27, and may include self-biasing means such as a parallel connected capacitance 28 and a resistance 29. The phase shifting means may be of the type in which a non-reactive element, such as a resistance 30, is used in conjunction with the reactive element to produce a desired constant phase displacement between the voltage impressed on grid 20 and the voltage supplied to transformer 26.

I provide means for impressing on the holding anode 9 a voltage of predetermined polarity and magnitude in order to maintain an arc discharge within the electric valve means 1 for a predetermined interval of time after the initiation of the arc discharge. More particularly, I connect the holding anode 9 to a source having 180 electrical degrees phase displacement relative to the voltage applied to the charging circuit of capacitance 12. For example, the holding anode 9 may be connected to the lower portion of the secondary winding 13 of transformer 14 by means of a conductor 31 and a resistance 32.

In order to impress on the grids 7 and 8 of the electric valve means 1 periodic voltages, such as voltages of peaked wave form, thereby assisting in the propagation of arc discharges between the anode and cathode after the initiation thereof, I provide means, such as a saturable inductive peaking device 33, which may also be energized from transformer 13. Furthermore, I provide means for simultaneously impressing on the grids 7 and 8 of the electric valve means 1 only unidirectional impulses of voltage of peaked wave form. Referring to the circuit connected between grids 7 and 8 and the saturable inductive peaking device 33, I provide electrical impulse generating and transmitting means, such as a capacitance 34 or a pair of capacitances 34 and 35, which are connected in circuit with secondary winding means 36 of the inductive device 33 through a unidirectional conducting device such as an electric valve 37. An impedance, such as a resistance 38, of relatively large value may be connected across the anode-cathode circuit of the electric valve means 37 so that in the event the electric valve 37 fails the circuit will nevertheless serve to impress impulses of voltage on grids 7 and 8. It will be noted that the common juncture 39 of capacitances 35 and 36 is connected to the cathode 5 of electric valve means 1 through a conductor 40, and that grid 7 is connected to the upper terminal of secondary winding means 36 through a conductor 41 and resistances 42 and 43. Grid 8 is also connected to the upper terminal of secondary winding means 36 through a conductor 44 and resistances 43 and 45. Due to the fact that the interconnection between conductors 41 and 44 is nonreactive, it will be appreciated that the impulses of voltage impressed on grids 7 and 8 are in phase.

A voltage protective means, such as a resistance 46, is connected across the output circuit of the impulse generating means to limit the voltage thereof. The resistance 46 may be of the type having a negative nonlinear impedance-current characteristic, such as of the material disclosed and claimed in U. S. Patent No. 1,822,742, granted September 8, 1931, upon an application of Karl B. McEachron, and which is assigned to the assignee of the present application. Furthermore, I provide means for limiting the magnitude of the voltage appearing across capacitances 34 and 35, and this protective means may comprise a resistance 47 constructed of a material similar to that used for resistance 46.

I may also employ means for indicating the condition of the impulse generating means, such as glow discharge devices 48 and 49, which afford one luminescent condition for normal operation and a different luminescent condition for abnormal operation in the manner disclosed and claimed in U. S. Letters Patent No. 2,130,440, granted September 20, 1938, upon application of C. H. Willis et al., and which is assigned to the assignee of the present application.

I provide means for controlling the phase of the impulses of current transmitted to immersion-ignitor control member 6 and for maintaining a predetermined constant phase displacement, such as a lagging phase displacement, between the voltages supplied to grids 7 and 8 and holding anode 9 and the impulses of current transmitted to control member 6. This means may include a common phase shifting device 50 which is connected between the source of alternating current 11 and the transformer 12 and the phase shifting circuit 25. By these means, a constant degree of accuracy in the initiation of current conduction between the anode and cathode of electric valve means 1 is assured, irrespective of the time during the cycle of voltage applied to the anode-cathode circuit at which it is desired to initiate current conduction.

The operation of the system of my invention shown in Fig. 1 will be explained by considering

the system when it is desired to initiate current conduction through the anode-cathode circuit of electric valve means 1. If the circuit 2, 3 is an alternating current circuit, it will be appreciated that in order to obtain current flow during each cycle of applied anode-cathode voltage it will be necessary to effect energization of the immersion-ignitor control member 6 during each cycle.

Excitation circuit including capacitance 12 operates to transmit an impulse of current to the immersion-ignitor control member 6 during each cycle of voltage of source 11. Capacitance 12 is charged through the portion of secondary winding means 14 between the upper terminal and tap 16 through the electric valve 17 sufficiently prior to the time when it is desired to discharge the capacitance. At the predetermined time established by the phase shifting circuit 25 and the adjustment of phase shifting device 50, electric discharge device 19 is rendered conducting by the periodic voltage impressed on grid 20 so that capacitance 12 discharges through a circuit including inductance 21, discharge device 19, resistance 22, conductor 23, control member 6 and cathode 5. The transmission of current through control member 6 establishes a cathode spot and initiates an arc discharge within the electric valve means, whereupon the greater portion of the excitation current or the discharge current of capacitance 12 is transferred to the relieving anode 10. The holding anode 9 thereupon conducts current, serving to maintain the medium in an ionized condition by virtue of the voltage applied thereto by the lower portion of winding means 14.

The impulse generating means including saturable inductive reactance 33 impresses simultaneously on grids 7 and 8 impulses of voltage of peaked wave form, thereby assisting in the propagation of the arc discharge from cathode 5 to anode 4 and accordingly controlling precisely the time at which current flow in the anode-cathode circuit is initiated.

Due to the presence of the capacitances 34 and 35 and unidirectional conducting device 37, it will be appreciated that the impulses of voltage impressed on grids 7 and 8 will be of distinct or sharp wave form. Furthermore, due to the transmission of current through this circuit, capacitances 34 and 35 will be charged to the polarity indicated so that after the initiation of current conduction between the cathode and anode excessive current will not be transmitted through the grid circuits. It will be further noted that by virtue of the connections provided, the impulses of voltage impressed on grids 7 and 8 lag the time of occurrence of the impulses of current transmitted to control member 6.

The operation of the excitation circuit shown in Fig. 1 may be more fully appreciated by referring to the operating characteristics shown in Fig. 2, where curve A represents the voltage appearing between the upper terminal of secondary winding means 14 and tap 16 of transformer 13. The broken wave B represents the voltage of capacitance 12. Curve C represents the voltage applied between the holding anode 9 and cathode 5 and which is derived from the lower portion of secondary winding means 14. The peaked curve D represents the impulse of current transmitted to immersion-ignitor control member 6, and curve E represents the impulses of voltage impressed on grids 7 and 8. I have found that satisfactory operation is obtained when the voltages impressed on grids 7 and 8 lag the excitation current to control member 6 in the order of 5–15 electrical degrees.

In Fig. 3 I have illustrated in schematic form the manner in which my improved excitation circuit may be applied to an electric valve translating apparatus, such as an electric valve inverter for energizing an alternating current load circuit 51 from a direct current supply circuit including a positive conductor 52 and a negative conductor 53. A pair of electric valve means 1*a* and 1*b* may be connected to the system through a transformer 54. If a sufficient commutating voltage is not available in the alternating current load circuit 51, commutating means, such as a capacitance 55, may be connected in the manner illustrated to perform the commutating operation.

Excitation circuits 56 and 57 are similar in construction and arrangement to the excitation circuit shown in detail in Fig. 1, and corresponding elements and connections have been assigned like reference numerals. It will be appreciated that since it is desired to initiate arc discharges within electric valve means 1*a* and 1*b* at times displaced substantially 180 electrical degrees relative to the voltage of the load circuit 51, the excitation circuits will be arranged to transmit impulses of current to the immersion-ignitor control members 6 at times displaced substantially 180 electrical degrees.

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 electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an arc-ignition control member associated with said cathode and having a control grid, a source of alternating current, excitation means energized from said alternating current circuit for transmitting impulses of current to said control member and impulses of voltage to said control grid, phase shift means interposed between said alternating current circuit and said excitation means for controlling the phase of said impulses relative to the voltage of said source, means independent of said phase shift means and interposed between said excitation means and said control grid for maintaining a predetermined constant lagging phase displacement between the impulses of current to said control member and the impulses of voltage to said control grid, and means including an auxiliary electrode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

2. In combination, electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an arc-ignition control member associated with said cathode and having a control grid for assisting in the propagation of the arc discharge between said cathode and said anode, a source of alternating current, excitation means energized from said source for transmitting impulses of current to said control member

to initiate arc discharges, means for controlling the phase of said impulses relative to the voltage of said source, means interconnected with said last mentioned means for impressing on said grid a voltage having a predetermined constant lagging phase displacement relative to the impulses of current supplied to said control member and including a saturable peaking device energized from said source, and means including an auxiliary electrode within said valve means for maintaining the ionization initiated within said valve means by said control member until said voltage is impressed on said grid.

3. In combination, an alternating current circuit, a direct current circuit, electric translating apparatus connected between said circuits and comprising an electric valve means employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode and a control grid, excitation means for controlling an electrical condition of one of the first mentioned circuits and including phase shift means energized from said alternating current circuit for transmitting impulses of current to said immersion-ignitor control member and voltage impulses to said control grid for controlling the phase relation of said impulses relative to the voltage of said alternating current circuit, means interposed between said control member and said control grid and independent of said phase shift means for maintaining a predetermined constant phase displacement between the impulses of current transmitted to said immersion-ignitor control member and the voltage impulses to said grid, and means including an auxiliary electrode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

4. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode and a control grid, a source of alternating current, means for transmitting impulses of current of peaked wave form to said immersion-ignitor control member comprising a capacitance connected to be charged from said source and means for periodically discharging said capacitance, means connected to said source for impressing on said grid impulses of voltage of peaked wave form, means interconnecting said means for discharging said capacitance and said last mentioned means for establishing a predetermined constant phase displacement between the impulses of current transmitted to said control member and the impulses of voltage impressed upon said grid, and means including an auxiliary electrode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

5. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode and a control grid, a source of alternating current, means for transmitting impulses of current of peaked wave form to said immersion-ignitor control member and for initiating arc discharges and comprising a capacitance, means for charging said capacitance from said source and means for discharging said capacitance through said control member, means interconnecting said immersion-ignitor control member and said means for discharging said capacitance for impressing on said grid impulses of voltage having a predetermined constant phase displacement with respect to the impulses of current transmitted to said control member and comprising a saturable inductive peaking device connected to said source and said control grid, and means including an auxiliary electrode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

6. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and comprising an anode, a cathode, an immersion-ignitor control member associated with said cathode and a control grid, a source of alternating current, a phase shifting device connected to said source and having an output circuit, means connected to said output circuit for transmitting impulses of current of predetermined phase relation to said immersion-ignitor control member and impulses of voltage to said control grid, means independent of said phase shifting device and energized from said output circuit for maintaining on said grid impulses of voltage having a predetermined constant phase displacement with respect to said impulses of current, and means including a holding anode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

7. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode and a control grid, a source of alternating current, means energized from said source for transmitting impulses of current of predetermined magnitude to said control member in order to initiate arc discharges within said electric valve means, means for controlling the phase of said impulses relative to the voltage of said source, means interconnected with said immersion-ignitor control member for impressing on said grid impulses of voltage of predetermined constant phase displacement with respect to said impulses of current and comprising a saturable inductive peaking device, a capacitance, and unidirectional conducting means connected in series with said capacitance to establish a negative unidirectional biasing potential, and means including an auxiliary electrode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

8. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode, a control grid and an auxiliary electrode, a source of alternating current, means energized from said source for transmitting to said control member impulses of current to initiate arc discharges within said electric valve means, means for energizing said grid and said auxiliary electrode and for controlling the times of initiation of current conduction between said anode and said cathode comprising means for simultaneously impressing on said grid

and said electrode periodic voltages of peaked wave form, and means including a holding anode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

9. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode, a control grid and an auxiliary electrode, a source of alternating current, means energized from said source for transmitting to said control member impulses of current to initiate arc discharges within said electric valve means, means for energizing said grid and said auxiliary electrode in order to control the times of initiation of current conduction between said anode and said cathode comprising a saturable inductive peaking device energized from said source for simultaneously impressing on said grid and electrode periodic voltages of peaked wave form, and means including a holding anode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

10. In combination, an electric valve means employing an ionizable medium capable of supporting an arc discharge, and including an anode, a cathode, an immersion-ignitor control member and a control grid, a source of alternating current, means energized from said source for transmitting impulses of current of peaked wave form to said control member in order to initiate arc discharges within said electric valve means, impulse generating means connected to said grid for impressing thereon impulses of voltage of peaked wave form to assist in the propagation of the arc discharge between said anode and said cathode, means for maintaining a predetermined constant phase displacement between the impulses of current transmitted to said control member and the voltage impressed on said grid comprising a phase shifting device connected between said source and common to the energizing means for said control member and said grid, and means including a holding anode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

11. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode, a control grid and an auxiliary electrode, a source of alternating current, means energized from said source for transmitting impulses of current to said control member to initiate arc discharges within said electric valve means, means for impressing on said grid and said electrode impulses of voltage of substantial phase coincidence in order to assist in the propagation of the arc discharges between said cathode and said anode, means for maintaining a predetermined constant phase displacement between the impulses of current transmitted to said control member and the impulses of voltage impressed on said grid and said electrode comprising a common phase shifting means connected to said source of alternating current, and means including a holding anode within said valve means for maintaining the ionization initiated within said valve means by said control member until said impulse of voltage is impressed on said grid.

12. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode, a control grid interposed between said anode and said cathode, a second control grid interposed between said anode and said cathode and a holding anode, a source of alternating current, means energized from said source for transmitting impulses of current to said immersion-ignitor control member and comprising a transformer having primary winding means and secondary winding means, a capacitance, means for charging said capacitance from said secondary winding means and means for discharging said capacitance through said immersion-ignitor control member comprising an electric discharge device having a grid, means energized from said secondary winding means for impressing a voltage of predetermined phase relationship on the last mentioned grid, means for connecting said holding anode to said secondary winding means, means energized from said secondary winding means for impressing on the first mentioned grids impulses of voltage of peaked wave form, and phase shifting means connected between said source and said transformer for shifting by corresponding amounts the phase of the impulses transmitted to said control member, the first mentioned grids and said holding anode.

13. In combination, an electric valve means of the type employing an ionizable medium capable of supporting an arc discharge and including an anode, a cathode, an immersion-ignitor control member associated with said cathode, a grid interposed between said anode and said cathode for assisting in the propagation of the arc discharge between said anode and said cathode and having a holding anode, a source of alternating current, means for transmitting impulses of current to said immersion-ignitor control member comprising a transforming means having secondary winding means, a capacitance, means for discharging said capacitance, means for discharging said capacitance including an electric discharge device having a grid, a phase shifting circuit connected between said transforming means and the last mentioned grid for rendering said discharge device conducting at a predetermined time during each cycle of voltage of said source thereby effecting energization of said control member, means for impressing on said holding anode a voltage displaced substantially 180 electrical degrees relative to the voltage impressed on the charging means for said capacitance, means for impressing on the first mentioned grid an impulse of voltage of peaked wave form comprising a saturable inductive device energized from said transforming means, and phase shifting means connected between said source and said transforming means for shifting the phase of the current impulses supplied to said control member and the voltages applied to the first mentioned grid and said holding anode.

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