

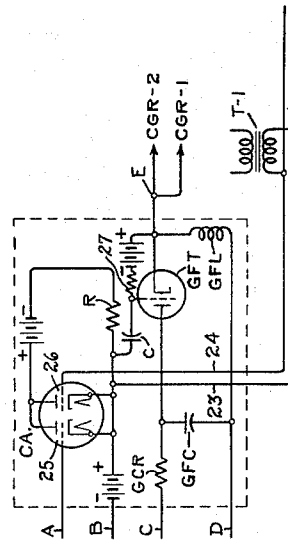
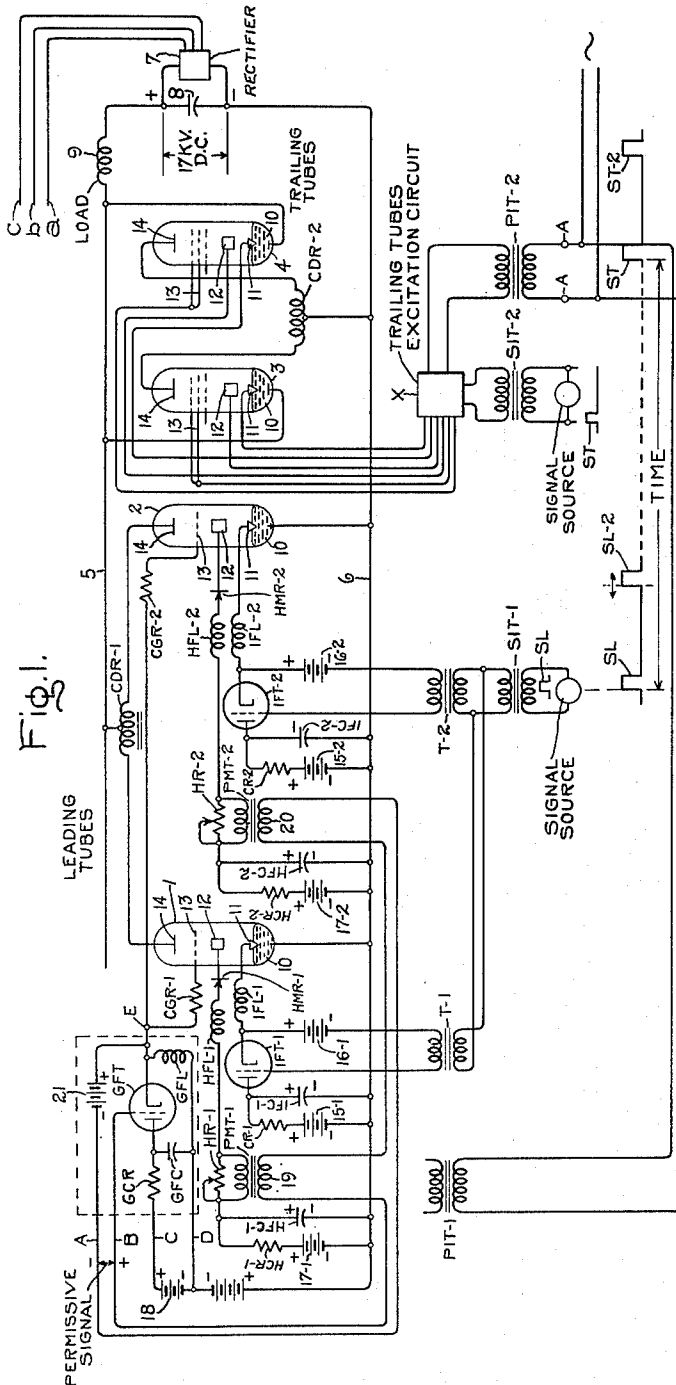
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ELECTRIC VALVE EXCITATION AND CONTROL CIRCUIT

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ELECTRIC VALVE EXCITATION AND  
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My invention relates to electric valve excitation and control circuits and more particularly to an arrangement of such a circuit for insuring proper operation in parallel circuit relationship of two or more valves of the ignitron type provided with an immersion ignitor, an excitation anode and a control grid.

Where two or more electronic valves of the ignitron type are operated in parallel, failure of one of the valves causes an excessive current to flow through the parallel connected valve or valves which do not fail. Excessive current will cause damage to the valve or valves through which it flows and repeated operation of a valve at excessive currents will eventually result in complete failure thereof.

It is an object of my invention to provide an improved excitation and control circuit for parallel connected electric valves which will prevent operation of all the parallel connected valves when one or more of the parallel connected valves fails to operate.

Another object of my invention is to provide improved means for determining the precise instant at which an electronic valve of the ignitron type is rendered conductive together with means for preventing energization of the control grid unless the cathode spot is maintained for a long enough time to insure conduction through the valve upon application of a control signal to the control grid.

In accordance with my invention, means are provided for deriving an electrical quantity from the excitation anode circuit of each parallel connected valve and for applying a composite electrical quantity to the control grids of all the valves the magnitude of which is dependent upon the flow of current in each excitation anode circuit. The value of the composite quantity which is required to actuate the control grids is such that none of the parallel tubes will conduct if the excitation anode of any one of the tubes is not energized. In this way, all the tubes will be held off by their grid bias if the holding anode of one of the tubes fails to fire. In accordance with a modification of my invention, precise timing of the unidirectional current pulses through the valves is obtained in addition to the feature whereby a signal which is dependent upon excitation anode current is required to render the associated valve conductive.

My invention will be better understood from the following description taken in connection with the accompanying drawings in which Fig. 1 is a diagrammatic representation of my invention

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wherein a composite quantity dependent upon the excitation anode current in each of the parallel connected valves is utilized to energize the grid circuit of all of the valves, and Fig. 2 is a diagrammatic representation of an alternative arrangement for a portion of the arrangement shown in Fig. 1 whereby precise timing of the flow of current through the valves is obtained.

With reference to Fig. 1, a pair of leading valves 1 and 2 as well as a pair of trailing valves 3 and 4 are shown connected in parallel circuit relation to the conductors 5 and 6. Tubes 1 and 2 are arranged with their cathodes connected to conductor 6 and their anodes connected through reactor CDR-1 to conductor 5 while tubes 3 and 4 are arranged with their cathodes connected to conductor 5 and their anodes connected to conductor 6 through reactor CDR-2. Polyphase power is supplied from a suitable source through conductors a, b, and c to a suitable charging rectifier 7. The output of rectifier 7 charges capacitor 8 with predetermined polarity so that operation of valves 1 and 2 allows the discharge of current from capacitor 8 through the reactive load 9. Subsequent operation of valves 3 and 4 causes the energy stored in the reactive load 9 to be resupplied to capacitor 8. It will be understood that the charging rectifier 7 merely supplies the losses incurred.

In order to simplify the drawing, the excitation and control circuits for the trailing valves 3 and 4 have not been shown in detail but have been represented by the block diagram X. These circuits are identical to those for the leading valves 1 and 2 except for the timing (phase) of the applied control signal.

Suitable power for these leading tube circuits is supplied through the power insulating transformer PIT-1, and in like manner for the trailing tubes (3 and 4) through PIT-2. A control signal such as is indicated by SL is supplied by known means to the leading tubes (1 and 2) through the signal insulating transformer SIT-1, and in like manner to the trailing tubes (3 and 4) by ST through SIT-2. The direct current power and bias sources indicated in connection with the control circuits for tubes 1 and 2 in practice would be derived from a power insulating transformer in a well-known manner such as that indicated by PIT-1 together with suitable transformers and rectifiers.

All the valves 1-4 are identical in construction. The ignitor circuit and the excitation anode circuit of all the valves 1-4 are identical. In Fig. 1 the suffix "1" is used in connection with the com-

ponents for tube 1 while the suffix "2" is used to designate the components used with tube 2.

Each valve is provided with a cathode 10 comprising a mercury pool, an ignitor 11, an auxiliary electrode in the form of an excitation or holding anode 12, a grid 13 and an anode 14. As is well known, additional grids would be used and would be desirable for certain purposes but since these form no part of my invention, they are not shown.

The ignitor firing circuits comprise an ignitor firing reactor IFL, an ignitor firing tube IFT, an ignitor firing capacitor IFC, and a charging resistor CR. Energy for charging ignitor firing capacitor IFC is obtained from a suitable source of potential 15 while the grid bias for ignitor firing tube IFT is obtained from a suitable source 16. The ignitor firing circuits of the leading tubes 1 and 2 are controlled by a signal insulating transformer SIT—1. When a suitable signal such as SL is supplied to transformer SIT—1, signal transformers T—1 and T—2 respectively cause the ignitor firing circuits of tubes 1 and 2 to conduct current by causing the grid of the ignitor firing tubes to become less negative as is well known. Upon firing of the ignitors mercury vapor is established within the tubes which because of a high degree of ionization allows the excitation or holding anode 12 to become conductive. The excitation anode circuits comprise a unidirectional conducting device HMR, a reactor HFL, an adjustable resistor HR in parallel with one winding of a permissive transformer PMT, a charging resistor HCR, and a firing capacitor HFC. Firing capacitor HFC is charged by a suitable source of potential such as is indicated at 17. When the space within the envelope of each of the tubes 1 and 2 is ionized by the igniter 11, excitation anode firing capacitor HFC is allowed to discharge through resistor HR, the primary winding of permissive transformer PMT in parallel therewith, through the firing reactor HFL, and unidirectional conducting device HMR. In this way, the cathode spot established by the ignitor 11 is maintained for a predetermined time until a control signal is supplied to the control grid 13.

The control grids 13 of tubes 1 and 2 are controlled by a common grid firing tube GFT, a grid firing capacitor GFC and a grid firing reactor GFL. Capacitor GFC is charged by a source of potential indicated at 18 through charging resistor GCR. When the grid of grid firing tube GFT becomes less negative due to the application of an appropriate signal thereto, the grid firing capacitor GFC discharges through the grid firing tube GFT thus rendering point E less negative. When this occurs, the grids 13 of tubes 1 and 2 are rendered less negative and hence conducting and a current flows from the capacitor 8 through load 9, reactor CDR—1 through valves 1 and 2, and conductor 6 to the capacitor 8, the duration and characteristics of this impulse of current being predetermined. Thereafter, the tubes 3 and 4 are rendered conductive so that current flows from the capacitor 8 through reactor CDR—2, through valves 3 and 4, conductor 5 and load 9 to the capacitor 8.

In order to insure that neither of the tubes 1 or 2 will pass current if either of these tubes fails to operate, I provide in accordance with my invention suitable means for controlling the grid of the grid firing tube GFT which controls the firing of tubes 1 and 2. Likewise, similar means, not shown, are provided for so controlling the

grid of a grid firing tube utilized to control tubes 3 and 4 so that neither of these tubes will pass current if either one of these tubes fails. To this end, the permissive transformer PMT—1 is provided with a secondary winding 19 and permissive transformer PMT—2 is provided with a secondary winding 20 arranged in series circuit relation with the winding 19. The circuit comprising windings 19 and 20 includes a suitable source of grid bias 21 for tube GFT and is connected to the grid of that tube. The negative bias required to hold tubes GFT off is such that energization of either one, but not both, of the windings 19 or 20 will not cause the grid of tube GFT to become sufficiently less negative to render the tube conductive. A signal from both windings 19 and 20 will, however, cause tube GFT to fire. Since the presence of a signal in windings 19 and 20 is dependent upon the flow of current through the excitation anode circuits comprising a primary winding of permissive transformer PMT—1 and PMT—2, tube GFT cannot be rendered conductive unless the excitation or holding anodes of both tubes 1 and 2 have been rendered conductive so as to establish a suitable cathode spot. In order to provide for adjusting the effective signal derived from windings 19 and 20, I provide adjustable resistors HR—1 and HR—2 in parallel with the primary windings of permissive transformers PMT—1 and PMT—2 respectively.

The arrangement shown in Fig. 1 and described thus far is actuated by a signal such as is indicated at SL for the leading tubes and such as is indicated at ST for the trailing tubes. Such a signal would be supplied by any known impulse source and would be effective to operate the associated ignitor and excitation anode circuits and due to the operation of the permissive transformers would subsequently cause actuation of the control grids so as to cause the tubes 1 and 2 on the one hand or tubes 3 and 4 on the other hand to conduct. It may be desirable to provide means for timing precisely the exact instant at which the leading tubes and the trailing tubes are rendered conductive. For example, if the leading tubes are assumed to be delivering the positive half cycle of current to the load 9 and if the trailing tubes are assumed to be delivering the negative half cycle of current to the load 9, it may be desirable to adjust these two half cycles of current with respect to each other in point of time in a predetermined fashion. Furthermore, tubes such as 1—4 would have characteristics such that best performance would be obtained if a particular instant could be chosen for rendering the tubes conductive. In accordance with a modification of my invention such as is indicated in Fig. 2, the ignitor and excitation anode circuits of paralleled tubes such as 1 and 2 would be actuated by an impulse such as SL and the bias of grid firing tube GFT would be adjusted so that the aggregate signal received from transformers PMT—1 and PMT—2 would not be sufficient to render the tube GFT conductive and a second impulse time delayed with respect to impulse SL would be required to actuate tube GFT and tubes 1 and 2. Such a signal could be supplied from any known source and may be represented by the impulse shown in the drawing and represented by the designation SL—2. To obtain the exact instant at which tube GFT is rendered conductive, it would only be necessary to determine the instant at which the impulse SL—2 would be supplied to signal

insulating transformer SIT—1 after the signal SL is supplied thereto. This signal SL—2 would be delayed with respect to signal SL by a time which would be of the same order of magnitude as the duration in time of a half cycle of current supplied to the excitation anodes 12 by the circuits composed of HFL—1 and HFC—1 or HFL—2 and HFC—2.

The circuit shown in Fig. 1 could be modified to utilize the precision timing of Fig. 2 by substituting Fig. 2 for that portion of Fig. 1 which is enclosed by dotted lines and by adding the conductors 23 and 24 to the circuit of Fig. 1. Upon energization of transformers PMT—1 and PMT—2 which would indicate that the excitation anodes of tubes 1 and 2 had been energized, a signal would be supplied through conductors A and B to the grid 25 of combining amplifier CA. The resulting current flow through resistor R would be insufficient however, to actuate grid firing tube GFT. The signal SL—2 would be supplied through conductors 23 and 24 to the grid 26 of tube CA. When grid 26 renders its associated cathode and anode conductive, the current through resistor R would then be sufficient to cause a change in the potential applied to capacitor C which in turn would momentarily nullify the negative bias of source 27 so as to cause tube GFT to conduct. Resistor R—1 merely prevents the flow of appreciable current through potential source 27. Conduction of tube GFT would then be effective to render the control grids 13 of tubes 1 and 2 less negative so that tubes 1 and 2 would thereby be rendered conductive at the desired instant. Thus, by the arrangement shown in Fig. 2, the ignitor and anode excitation circuits would be energized by a signal such as SL and the subsequent firing of the ignitrons 1 and 2 would be determined by determining the time when signal SL—2 would be supplied to the transformer SIT—1 after the signal SL is supplied thereto. If desired, a pair of signal spaced apart in time could be supplied to the signal insulating transformer SIT—2 so that the exact instant of firing tubes 3 and 4 could be predetermined.

The precision timing feature of Fig. 2, together with the control signal from transformer PMT could be used in conjunction with a single ignitron tube to obtain precise control thereof and to insure that the control negative bias supplied to control grid 13 would not be removed unless the cathode spot were established and prolonged sufficiently to insure conduction through the ignitron upon the application of positive potential to grid 13.

While I have shown and described particular embodiments of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from invention in its broader aspects and I, therefore, intend 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, a plurality of electric discharge devices connected in parallel, each device being of the type employing an enclosing envelope and comprising therein an ionizable medium, an anode, a cathode and a control electrode, means for initiating electron emission at each of said cathodes, an auxiliary electrode within each of said envelopes, an energizing circuit connected to each of said auxiliary elec-

trodes for establishing a path for electron emission from each of said cathodes to the corresponding one of said auxiliary electrodes, an energizing circuit connected to each of said control electrodes, means responsive to current flow in each of said auxiliary electrode circuits for producing a voltage variable in accordance with such current flow, inductive coupling means responsive to the voltages produced by the flow of current through the auxiliary electrode circuits for deriving an electrical quantity the magnitude of which is dependent upon the number of the auxiliary electrode circuits which are conducting current normally, and means controlled by said derived quantity for preventing effective energization of all of said control electrodes when the magnitude of said quantity is indicative that at least one of the auxiliary electrode circuits is not conducting current normally.

2. A control arrangement for a plurality of parallel connected electronic devices each of which comprises a control grid, a cathode, an ionizable medium, and an excitation anode, said arrangement comprising an excitation circuit for each of said excitation anodes, first means for deriving an electrical quantity from each of said excitation circuits which is dependent upon the flow of current therethrough, series circuit means interconnecting said first means, and means connected with said circuit means and controlled by said derived quantities for impressing an operating voltage on said control grids, said last-named means being ineffective operably to energize said control grids when current fails to flow in the excitation circuit of one or more of said excitation anodes.

3. A control arrangement for a plurality of parallel connected electronic devices each of which comprises a control grid, a cathode, an ionizable medium, and an excitation anode, said arrangement comprising an excitation circuit for each of said excitation anodes, a permissive transformer for each device, each transformer having a primary winding and a secondary winding, the primary winding of each transformer being energized by the flow of current through the excitation circuit for the corresponding one of said devices, the secondary windings of said transformers being connected in series so as to derive a composite electrical quantity dependent upon the current flow in all of said excitation circuits, and means controlled by said composite quantity for impressing an operating voltage on said control grids, said last-named means being rendered inoperable when current fails to flow in the excitation circuit of one or more of said excitation anodes.

4. A control arrangement for a plurality of parallel connected electronic devices each of which comprises a control grid, a cathode, an ionizable medium, and an excitation anode, said arrangement comprising an excitation circuit for each of said excitation anodes, inductive means for each device for deriving an electrical quantity from each of said excitation circuits which is dependent upon the flow of current therethrough, series circuit means interconnecting said inductive means, and electronic valve means connected to said circuit means and responsive to the aggregate of said derived quantities for impressing an operating voltage on said control grids, said valve means being rendered inoperable upon the failure of current to flow in the excitation circuit of one or more of said excitation anodes.

5. A control arrangement for a plurality of parallel connected electronic devices each of which comprises a control grid, a cathode, an ionizable medium, and an excitation anode, said arrangement comprising an excitation circuit for each of said excitation anodes, a permissive transformer for each device, each transformer having a primary winding and a secondary winding energized by the flow of current through the excitation circuit for the corresponding one of said devices, the secondary windings of said transformers being connected in series so as normally to derive a composite electrical quantity dependent upon the current flow in all of said excitation circuits, and electronic valve means responsive to said composite electrical quantity for impressing an operating voltage on said control grids, said valve means being rendered inoperable in response to a deviation from the normally derived value of said composite quantity caused by the failure of current to flow in the excitation circuit of one or more of said excitation anodes.

6. A control arrangement for a plurality of parallel connected electronic devices each of which comprises a control grid, a cathode, an ionizable medium, and an excitation anode, said arrangement comprising an excitation circuit for each of said excitation anodes, first means for each device for deriving an electrical quantity from each of said excitation circuits which is dependent upon the flow of current there-through, circuit means interconnecting said first means, control means connected with said control grids for controlling the energization thereof, means for generating a timed control signal impulse, and a combining device connected with said circuit means and said means for generating said signal and operable in response to said derived quantities and to said signal for rendering said control means operable, said combining device being ineffective to render said control means operable when one or more of said excitation circuits fails to conduct current.

7. A control arrangement for a plurality of parallel connected electronic devices each of which comprises a control grid, a cathode, an ionizable medium, and an excitation anode, said arrangement comprising an excitation circuit for each of said excitation anodes, first means for deriving an electrical quantity from each of said excitation circuits which is dependent upon the flow of current therethrough, an electronic valve for controlling the energization of said control grids, a signal source for generating a first signal impulse and a second signal impulse, the time interval between said impulses being adjustable, and a combining device connected with said first means and said signal source and controlled by said derived quantity and said second signal, said first signal being effective to initiate ionization of said ionizable medium.

8. A control arrangement for an electronic valve having a control grid, a cathode, an ionizable medium and an excitation anode, said arrangement comprising means for initiating electron emission at said cathode, an excitation circuit for said anode, means for deriving an electrical quantity from said excitation circuit which is dependent upon the flow of current therethrough, control means for controlling the energization of said control grid, means for supplying a control signal to said control means at an instant which is predetermined in time with respect to operation of said means for initiating electron emission at said cathode, means for supplying the quantity derived from said excitation circuit to said control means, said control means being rendered operable to impress a control voltage on said control grid when the quantity derived from said excitation circuit and said control signal are simultaneously supplied to said control means.

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No references cited.