Aug. 10, 1943. A. H. MITTAG 2,326,550

ELECTRIC VALVE TRANSLATING CIRCUITS

Filed Oct. 1, 1941

Fig. 1.

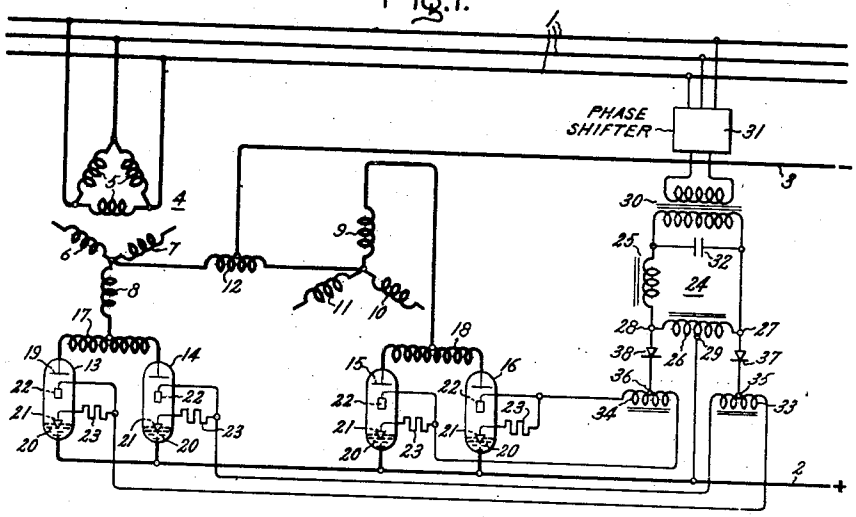


Fig. 2.

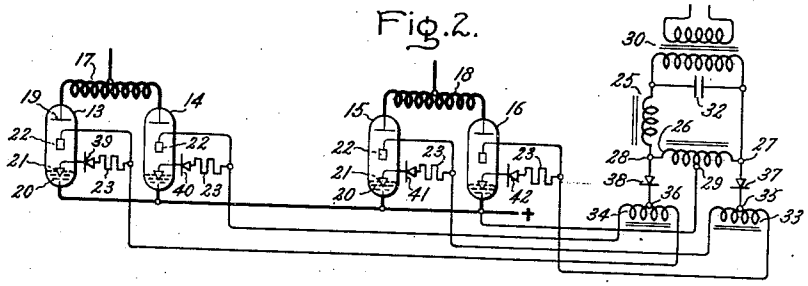


Fig. 3.

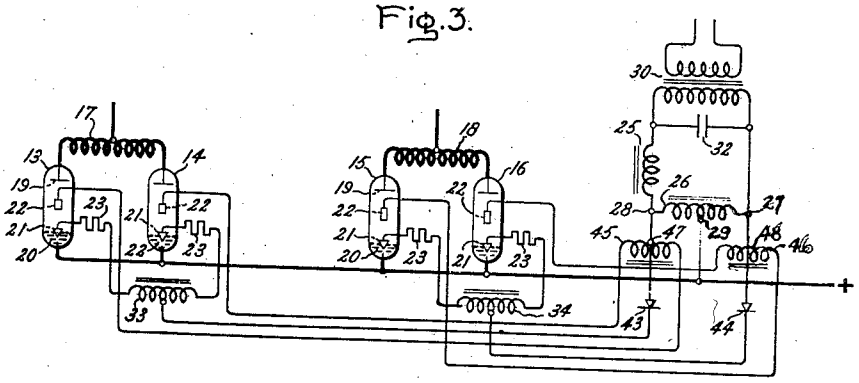
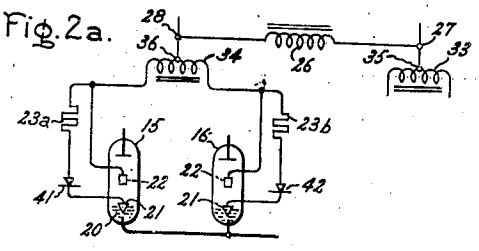


Fig. 2a.



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ELECTRIC VALVE TRANSLATING CIRCUITS

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Application October 1, 1941, Serial No. 413,231

5 Claims. (Cl. 175—363)

My invention relates to electric valve translating circuits and more particularly to electric circuits having electric valve means of the type employing an ionizable medium.

In electric translating circuits which employ electric valves of the controlled type, such as those having control members which determine the time of initiation of conduction of current through the electric valve means to control an electrical condition of an associated circuit, it is of importance to provide control circuits which not only control the electrical condition precisely in response to a controlling influence, but which are of a simple and rugged construction and which do not require frequent repair or replacement in order to assure continuity of service. In accordance with the teachings of my invention described hereinafter, I provide new and improved control or excitation circuits for electric valve translating apparatus which afford advantages not obtainable by the use of prior art arrangements.

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 or excitation circuits for electric valve translating apparatus.

It is a further object of my invention to provide new and improved excitation circuits for electric valve apparatus which are intended to operate in parallel relationship during predetermined intervals of time.

It is a still further object of my invention to provide new and improved control and excitation circuits for electric valve means of the type which employ an ionizable medium, such as a gas or a vapor, and which include immersion-ignitor type control members.

Briefly stated, in the illustrated embodiments of my invention I provide new and improved excitation circuits for electric valves comprising immersion-ignitor type control members and which are intended to operate in parallel relationship during accurately determinable intervals of time to energize an associated load circuit. I provide an excitation means or circuit which generates an alternating voltage of peaked wave form having symmetrical positive and negative peaks. The excitation circuit is connected to the immersion-ignitor control members through suitable current dividing reactors in order to assure the simultaneous transmission of impulses of current to the control members of electric valves which are connected to operate in parallel. The use of the current dividing reactor serves to increase the voltage which is applied to one of the electric valves if that electric valve fails to become conductive at the desired instant. In this way, the electric valve in each pair which tends to lag the other valve is controlled by impressing on its control member an increased voltage.

Another aspect of my invention relates to an improved arrangement including electric valves which are provided with relieving anodes which effect the transmission of the excitation current to the relieving anodes as soon as an arc discharge is established within the electric valve means due to the proper energization of the associated immersion-ignitor control member. In one of the modifications, a second current dividing reactor is employed to relieve the duty imposed on the unidirectional conducting device which is connected between the excitation means or circuit and the control members. In this manner, the life of the excitation system is substantially increased due to the reduction of the duty imposed on the unidirectional conducting devices.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims. Figs. 1, 2, 2a and 3 diagrammatically illustrate embodiments of my invention as applied to polyphase electric valve rectifying equipment.

Referring now to Fig. 1 of the accompanying drawing, my invention is there illustrated as applied to an electric valve translating system, such as a rectifying system, for transmitting power from a polyphase alternating current supply circuit 1 to a direct current load circuit including a positive conductor 2 and a negative conductor 3. The translating system including an electrical network having a plurality of electrically displaced phase windings, at least two of which are displaced or arranged to conduct current during intervals of time displaced 180 electrical degrees. In the particular embodiment of the invention illustrated, I have chosen to show the inductive network as comprising a transformer 4 having a plurality of primary windings 5 and two groups of electrically displaced secondary windings 6, 7, 8 and 9, 10, 11. The two groups of secondary phase windings may be connected in the conventional double Y relationship by the employment of an interphase transformer 12 having an intermediate point connected to the negative

conductor 3 of the direct current load circuit. The translating system also includes a plurality of pairs of electric valve means, each pair of which is connected to a different one of the phase windings 6–11, inclusive. The pairs of electric valves are intended to conduct current in parallel relationship. For the purpose of illustrating my invention, only electric valve means 13, 14 and 15, 16 connected with the phase windings 8 and 9 are illustrated. It will be understood, of course, that other pairs of electric valves are also connected to windings 6, 7, 10 and 11. I employ current dividing or current balancing means, such as auto-transformers 17 and 18, connected between the phase windings 8 and 9 and the pairs of electric valve means 13, 14 and 15, 16 in order that the respective pairs conduct current in parallel relationship.

Although in the various embodiments of my invention described, I have shown the pairs of electric valve means as being interconnected through a current dividing means, such as auto-transformers 17 and 18, I have found that by using the control or excitation circuits described hereinafter that pairs of electric valve means may be operated in parallel relationship without employing auxiliary current dividing auto-transformers or reactors. Therefore, it is not necessary to employ the current dividing means unless these elements are required.

The electric valve means 13–16, inclusive, are preferably of the type each comprising an anode 19, a cathode such as a mercury pool cathode 20, and an immersion-ignitor control member 21. The immersion-ignitor control members 21 are preferably of a material such as boron carbide or silicon carbide and which serve to establish an arc discharge between the anode and the cathode upon the transmission of a predetermined minimum critical value of current between the control member and the cathode. If desired, the electric valves 13–16 each may be provided with an auxiliary or relieving anode 22 which is connected to the associated control member 21 through a current transfer resistance 23. Due to the current in resistances 23, there is impressed on relieving anodes 22 a substantial voltage and upon the establishment of an arc discharge or the establishment of a cathode spot on cathodes 20, this voltage will cause most of the excitation current to be transferred to the relieving anodes 22, thereby relieving the duty imposed on the control member.

I provide an excitation system for energizing the control members 21 of the electric valve means. Only the excitation system for the electric valves 13, 14 and 15, 16 is illustrated. It is, of course, to be understood that similar excitation means are intended for the pairs of electric valves (not shown) associated with the electrically displaced phase windings 6, 10 and 7, 11. The excitation system comprises an excitation means 24 which produces a periodic or alternating voltage of peaked wave form having symmetrical positive and negative peaks. This excitation means 24 comprises a saturable inductive reactance or device 25, which may be self-saturable, and which includes an impedance element, such as an inductance 26, having terminal connections 27 and 28 and an electrically intermediate connection 29. The electrically intermediate connection 29 may be positioned to be an exact center tap, if desired. The excitation means 24 is energized from any suitable source of alternating current of the desired frequency and may be energized from the alternating current supply circuit 1 through a transformer 30 and a phase shifting device 31. If desired, the excitation means may also comprise a capacitance 32 which is connected across the secondary winding of transformer 30 and which serves to increase the impulse of voltage produced across the terminals of inductance 26.

While I have illustrated the impedance element or inductance 26 as being a specific type, such as an autotransformer, I may employ within the scope of my invention other impedance elements such as various combinations of resistances, capacitances, or inductances in place of the inductance 26. Furthermore, the impedance element may comprise an asymmetrical conducting device, such as a rectifier of the contact type or a plurality of rectifiers of the contact type poled in a manner to permit the desired alternate energization of electric valves which are intended to operate 180° out of phase. An arrangement of this type is described and claimed in the copending patent application Serial No. 374,716, filed January 16, 1941, by E. F. W. Alexanderson and me, and which is assigned to the assignee of the present application.

It will be noted that the excitation system illustrated supplies excitation current to control members 21 of the pairs of electric valves connected to windings 8 and 9 which are connected to phase windings displaced 180 electrical degrees with respect to the voltage of the alternating current circuit 1. Furthermore, the electric valves of each pair are intended to conduct current simultaneously, and consequently the impulses of current transmitted to the control members 21 of each pair must be transmitted thereto substantially simultaneously and must be displaced 180 electrical degrees with respect to the impulses transmitted to the control members of the pair of electric valves associated with the diametric winding.

In order to accomplish the above stated desired result, I provide a pair of current dividing reactors 33 and 34 which are connected to the control members 21 and relieving anodes 22 of the pairs of electric valve means 13, 14 and 15, 16, respectively. The current dividing reactors 33 and 34 are provided with intermediate connections 35 and 36, respectively, and are connected to terminal connections 27 and 28 of the inductance 26 through suitable unidirectional conducting devices 37 and 38. The employment of unidirectional conducting devices 37 and 38 assures the transmission of only unidirectional current to immersion-ignitor control members 21, and by virtue of the employment of current dividing reactors 33 and 34 only one unidirectional conducting device is required for each pair of electric valves.

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 polyphase rectifier to transmit direct current to the load circuit from the alternating current supply circuit. The various pairs of electric valve means conduct current in a predetermined order determined by the phase relationship of the voltage of secondary windings 6–11. Due to the phase voltage equalization of the interphase transformer 12, pairs of electric valves associated with the phase windings in the two groups of windings conduct current during common intervals of time; that is, each pair of electric valves conducts current during 120 electrical degrees but conducts current for only 60 electrical

degrees with any one other pair of electric valves associated with the other group. In addition, the electric valve means of each pair conduct current simultaneously and in parallel relationship. The excitation system controls the pairs of electric valves to conduct current in a predetermined order or sequence, and also energizes the control members 21 so that the electric valves of each pair conduct current during the same interval of time and, hence, conduct the same average value of current.

Considering the operation of the excitation system in more detail, the excitation means 24 including the saturable device 25, acting in conjunction with the inductance 26, produces an alternating voltage of peaked wave form and the positive and negative impulses or peaks are symmetrical. During one interval of time, for example in that interval of time during which it is desired to render the electric valve means 15 and 16 conducting, the voltage appearing across inductance 26 is such that the connection 28 is positive in potential relative to connection 27 and impulses of current of peaked wave form are transmitted to immersion-ignitor control members 21 of electric valve means 15 and 16 through the respective portions of the current dividing reactor 34 and unidirectional conducting device 38. The return path from the cathodes 20 includes the connection between the positive conductor 2 to the intermediate connection 29 of inductance 26. If for any reason one of the electric valves, such as electric valve 15, is rendered conducting prior to the electric valve 16, the flow of current through the right-hand portion of current dividing reactor 34 will effect an increase of voltage impressed on control member 21 of electric valve means 16. I have found, as a practical matter, that the voltage impressed on the control member 21 of the electric valve means 16 is substantially doubled if the electric valve means 16 does not begin to conduct current in substantial simultaneity with the electric valve means 15.

Upon initiation of arc discharges within the electric valve means 15 and 16, the current transmitted through the resistance 23 effects an increase of the voltage impressed on relieving anodes 21, thereby transferring the greater portion of the excitation current to the relieving anodes and reducing the load imposed on the control members.

During the next half cycle, that is 180 electrical degrees later, the terminal 27 of inductance 26 will be positive in potential relative to connection 28 and positive impulses of current will be transmitted to control members 21 of electric valve means 13 and 14, thereby rendering these electric valves conducting simultaneously.

Phase shifting device 31 may be adjusted or controlled to control the voltage impressed across the direct current load circuit. Adjustment of the phase shifter 31 controls the time during the respective positive half cycles of anode-cathode voltage at which the impulses of current are transmitted to control members 21 and, hence, controls the magnitude of the load voltage.

Fig. 2 represents a portion of the circuit shown in Fig. 1 and corresponding elements have been assigned like reference numerals. In the arrangement of Fig. 2, in addition to employing the unidirectional conducting devices 37 and 38, I connect unidirectional conducting devices 39–42 in series relation with control members 21 of electric valve means 13–16, respectively. By virtue of this connection, the relieving anodes 22 relieve the duty imposed on the unidirectional conducting devices 39–42 by transferring the excitation current from the control members 21 upon initiation of arc discharges. The system shown in Fig. 2 operates substantially the same as that explained above in connection with the arrangement of Fig. 1.

Fig. 2*a* diagrammatically illustrates a further embodiment of the arrangement shown in Fig. 2 and only a portion of the excitation system is shown. In the arrangement of Fig. 2*a*, the intermediate connections 35 and 36 of the current dividing reactors 33 and 34 are connected directly to the terminal connections 27 and 28 of inductance 26. Transfer resistances 23*a* and 23*b* are connected in series relation with the rectifiers 41 and 42 and serve to effect the transfer of most of the excitation current from the control members 21 to the relieving anodes 22 as soon as an arc discharge is established in the electric valve means 15 and 16. In the arrangement of Fig. 2*a*, it will be noted that the unidirectional conducting devices 37 and 38 are not employed.

The system shown in Fig. 2*a* operates to transmit unidirectional impulses of current of peaked wave form to the control members 21 of the pairs of electric valve means simultaneously. The unidirectional conducting devices 41 and 42 assure the transmission of only unidirectional current to control members 21, and the relieving anodes 22 are connected in a manner to transfer the excitation current from the control members 21 upon initiation of arc discharges within the electric valves.

The arrangement of Fig. 3 represents a portion of the circuit shown in Fig. 1 and corresponding elements have been assigned like reference numerals. In the arrangement of Fig. 3, I have provided an excitation system wherein simplicity of circuit construction is provided and wherein only a minimum number of unidirectional conducting devices are required in order to obtain satisfactory operation of the translating system. It will be appreciated that by reducing the number of unidirectional conducting devices, I provide an arrangement which not only reduces the cost of the excitation system but also reduces the probability of failure of the system due to the failure of operation of the unidirectional conducting devices. More specifically, in the arrangement of Fig. 3 the unidirectional conducting devices 43 and 44 are connected between terminals 28 and 27 of the inductance 26 and the intermediate connections of current dividing reactors 33 and 34. In addition, I provide a second pair of current dividing reactors 45 and 46 which have intermediate connections 47 and 48 connected to the terminal connections 28 and 27, respectively, of inductance 26. The current dividing reactors 45 and 46 are connected to the relieving anodes 22 and, by virtue of the connection in the system as illustrated, not only relieve the duty imposed on control members 21 but also serve to reduce the duty imposed on unidirectional conducting devices 43 and 44. That is, unidirectional conducting devices 43 and 44 are required to conduct current only until the arc discharges are established within the electric valve means. As soon as arc discharges are established, the excitation current is transferred immediately to the relieving anodes 22 and most of the excitation current then flows through current dividing reactances 45 and 46, effectively by-passing not only

the control members 21 but also by-passing the unidirectional conducting devices 43 and 44.

In explaining the operation of the arrangement shown in Fig. 3 let it be assumed that the terminal 26 of inductance 26 is positive in potential relative to terminal 27 at the time immediately preceding the transmission of positive impulses of current to control members 21 of electric valve means 13 and 14. Initially, the current is transmitted through the unidirectional conducting device 43, the two portions of the current dividing reactor 33 to the control members 21 of electric valve means 13 and 14. Upon the establishment of cathode spots and arc discharges within the electric valve means 13 and 14, current is transferred to the relieving anodes 22. This operation causes current to flow through the two portions of current dividing reactor 45 and effectively by-passing unidirectional conducting device 43, current dividing reactor 33, resistances 23 and control members 21. In like manner, the portion of the circuit associated with electric valve means 15 and 16 operates to relieve the duty imposed on unidirectional conducting device 44, current dividing reactor 34, resistances 23 and control members 21 of electric valve means 15 and 16 as soon as arc discharges are initiated.

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 direct current load circuit, electric translating apparatus connected between said circuits and comprising a pair of electrically displaced phase windings and two pairs of electric valve means each associated with a different one of said phase windings, current dividing means connected between each pair of electric valve means and the associated phase winding, said electric valve means each being provided with a control member for controlling the conductivity thereof, an excitation means for energizing the control members for causing the electric valve means in each pair to conduct current in parallel and for causing the pairs of electric valve means to conduct current during intervals of time displaced 180 electrical degrees and including means for producing a periodic voltage having symmetrical peaks displaced 180 electrical degrees and comprising a saturable inductive reactance comprising a winding connected in series relation with an impedance element provided with terminal connections and a connection electrically intermediate the terminal connections, said intermediate connection being connected to one terminal of said direct current circuit, and individual means connected between each of said terminal connections and the control members of a different one of the pairs of electric valve means for supplying impulses of current simultaneously to the electric valve means in the respective pairs.

2. In combination, an alternating current circuit, a direct current load circuit, electric translating apparatus connected between said circuits and comprising a pair of electrically displaced phase windings and two pairs of electric valve means each associated with a different one of said phase windings, current dividing means connected between each pair of electric valve means and the associated phase winding, said electric valve means each being provided with a control member for controlling the conductivity thereof, an excitation means for energizing the control members for causing the electric valve means in each pair to conduct current in parallel and for causing the pairs of electric valve means to conduct current during intervals of time displaced 180 electrical degrees and comprising means for producing a periodic voltage having symmetrical peaks displaced 180 electrical degrees and including a saturable inductive reactance comprising a winding connected in series relation with an impedance element provided with terminal connections and a connection electrically intermediate the terminal connections, said intermediate connection being connected to one terminal of said direct current circuit, means for transmitting to the control members of the electric valves in each pair impulses of current of peaked wave form to render the electric valves in each pair conducting simultaneously and during corresponding intervals of time and including a unidirectional conducting device and a current dividing reactor.

3. In combination, an alternating current circuit, a direct current load circuit, electric translating apparatus connected between said circuits and comprising a pair of electrically displaced phase windings and two pairs of electric valve means each associated with a different one of said phase windings, current dividing means connected between each pair of electric valve means and the associated phase winding, said electric valve means each being provided with a control member for controlling the conductivity thereof, an excitation means for energizing the control members for causing the electric valve means in each pair to conduct current in parallel and for causing the pairs of electric valve means to conduct current during intervals of time displaced 180 electrical degrees and comprising means for producing a periodic voltage having symmetrical peaks displaced 180 electrical degrees and comprising a saturable inductive reactance comprising a winding connected in series relation with an impedance element provided with terminal connections and a connection electrically intermediate the terminal connections, said intermediate connection being connected to one terminal of said direct current circuit, means for transmitting to the control members of the electric valves in each pair impulses of current of peaked wave form to render the electric valves in each pair conducting simultaneously and during corresponding intervals of time and comprising a pair of current dividing reactors each having an intermediate connection and a pair of unidirectional conducting devices, means connecting one of said devices between one of said terminal connections and the intermediate connection of one of the current dividing reactors, and means connecting the other of said devices between the other of said terminal connections and the intermediate connection of the other of said current-driving reactors.

4. In combination, an alternating current cir-

cuit, a direct current circuit, electric translating apparatus connected between said circuits and comprising a pair of electric valve means, said electric valve means each comprising an anode, a cathode, an immersion-ignitor type control member and a relieving anode, excitation means for producing a periodic voltage of peaked wave form and comprising a saturable inductive reactance, a current dividing reactance connected to the control members, a unidirectional conducting device connected between said excitation means and said current dividing reactor, and a second current dividing reactor connected between said excitation means and the relieving anodes.

5. In combination, an alternating current circuit, a direct current circuit, electric translating apparatus connected between said circuits and comprising a pair of electric valve means, said electric valve means each comprising an anode, a cathode, an immersion-ignitor type control member and a relieving anode, excitation means for producing a periodic voltage of peaked wave form and comprising a saturable inductive reactance, a current dividing reactance connected to the control members, a unidirectional conducting device connected between said excitation means and said current dividing reactor, and a second current dividing reactor connected between said excitation means and the relieving anodes and arranged to relieve the duty imposed on said control members and said unidirectional conducting device upon initiation of arc discharges in said electric valve means.

ALBERT H. MITTAG.