June 8, 1937. H. WINOGRAD 2,083,133

ELECTRIC VALVE SYSTEM

Filed Nov. 5, 1934 3 Sheets-Sheet 1

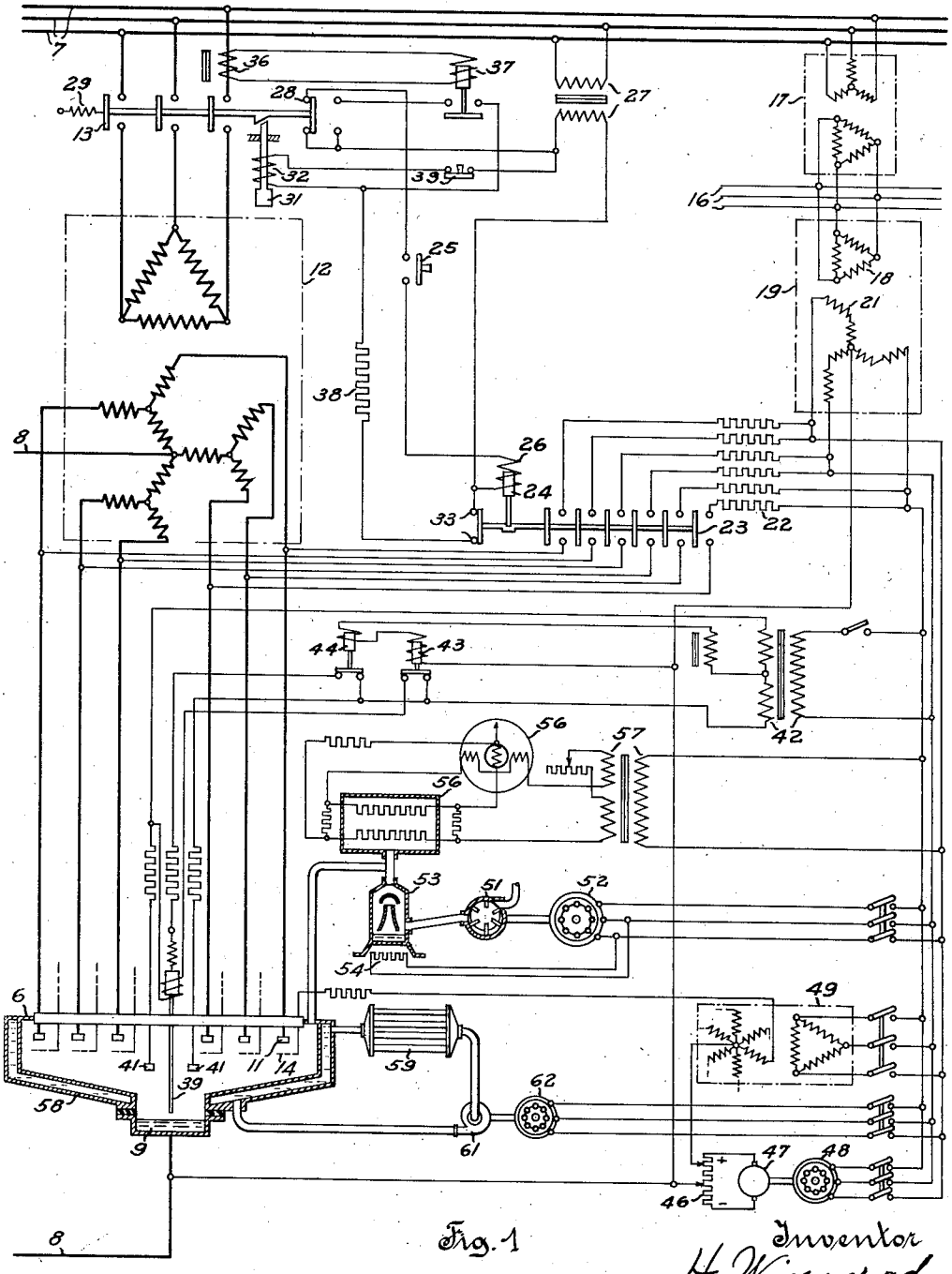


Fig. 1

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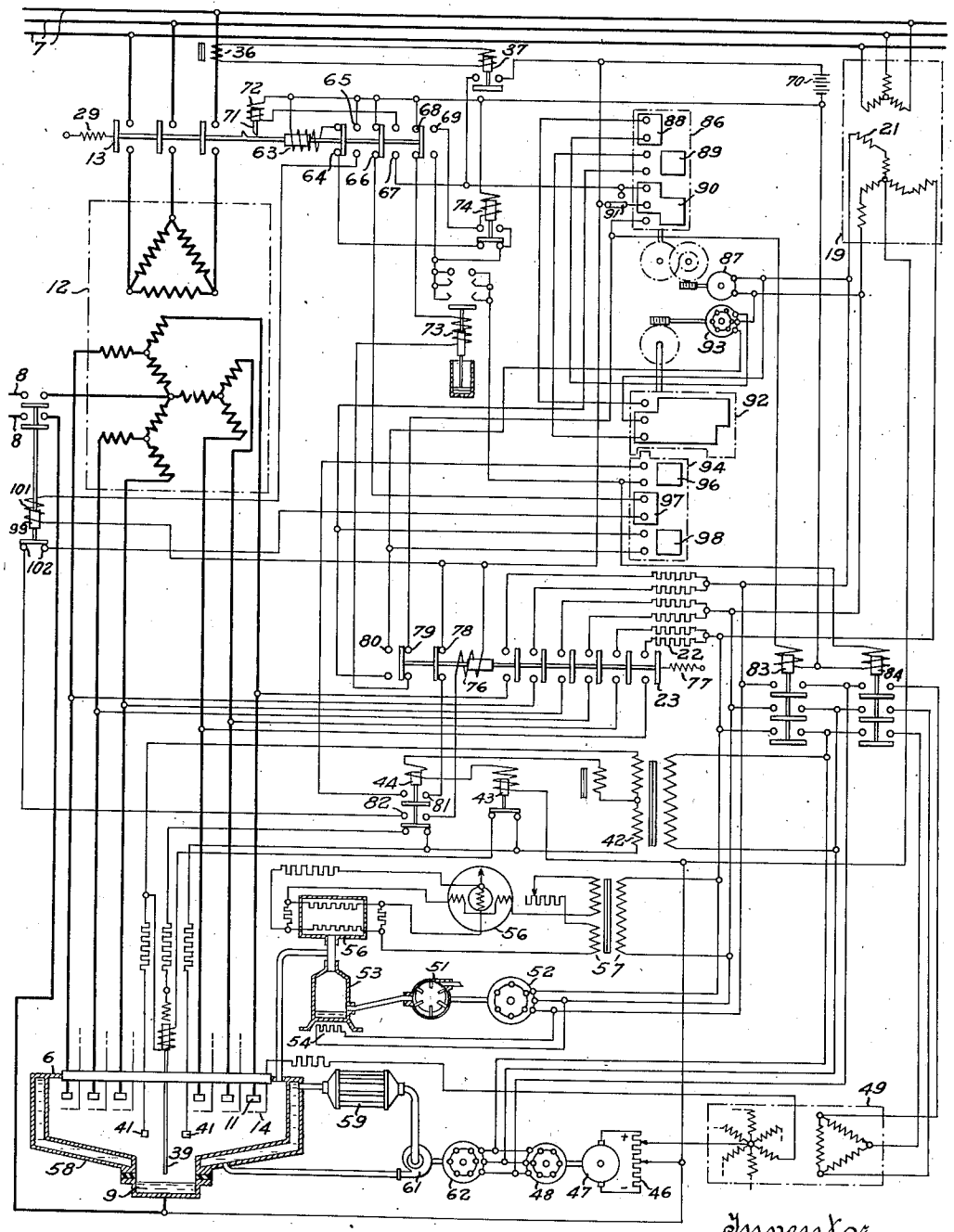


Fig. 2

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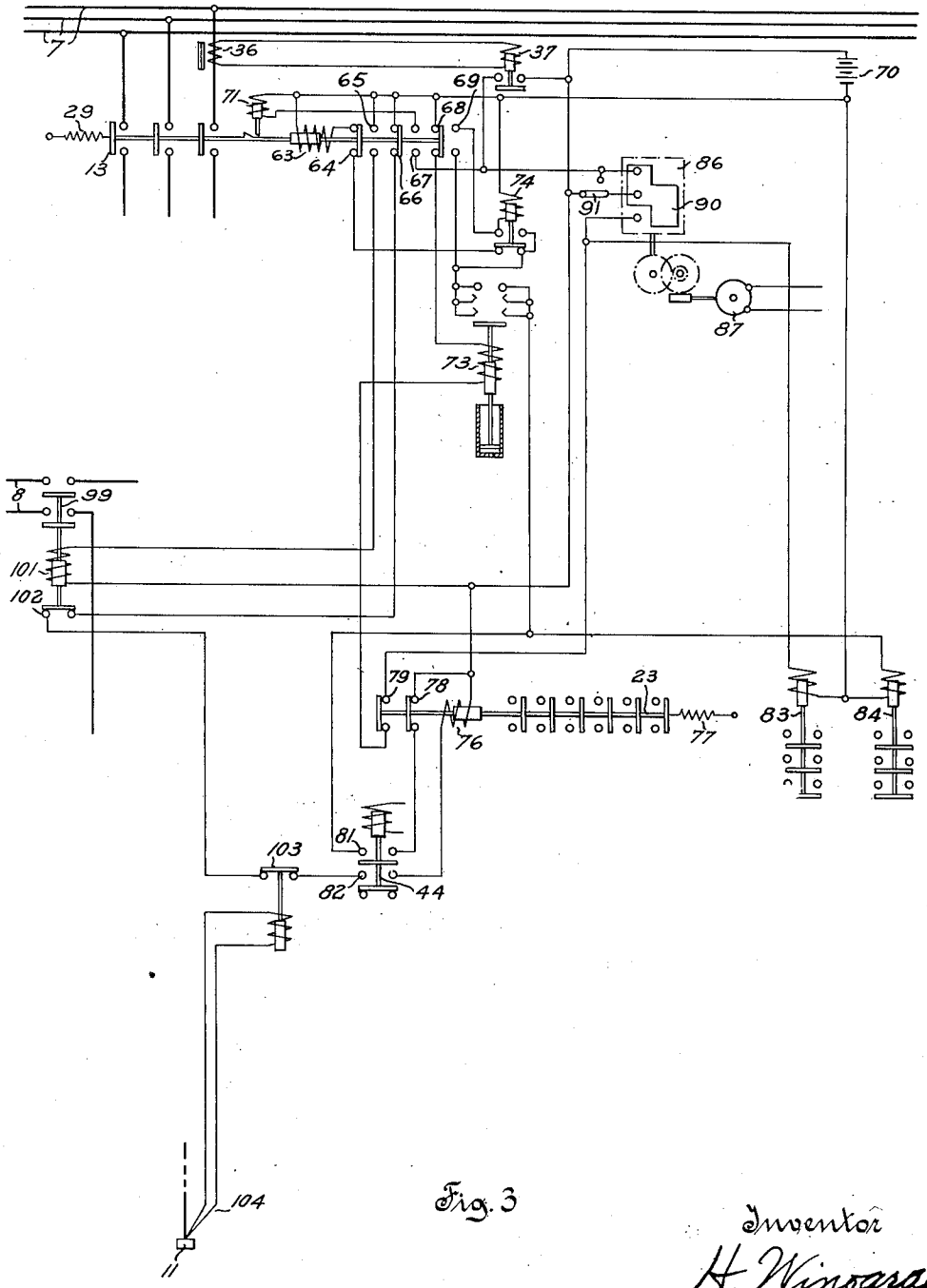


Fig. 3

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2,083,133

ELECTRIC VALVE SYSTEM

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Application November 5, 1934, Serial No. 751,492

16 Claims. (Cl. 175—363)

This invention relates in general to electric valve systems, and more particularly to a system for producing proper operating conditions in an electric valve structure before connecting such valve with the working circuit thereof.

Electric valves are generally designed to operate in the most efficient manner and with the highest degree of safety when in the temperature condition reached thereby upon continued operation. When the operation of the valve is initiated, the valve is generally not in the most favorable condition of temperature, and it is then frequently desired to raise the temperature of the valve, and more particularly the temperature of its electrodes, to a predetermined value before putting the valve into operation. To avoid the complications inherent in the installation of heaters in or about the valve, it is generally preferred to heat the electrodes of the valve by causing a flow of current to occur therebetween. Such flow of current is preferably brought about at a voltage considerably lower than the normal operating voltage to reduce the amount of losses in the heating circuit, and also to avoid disturbances in the operation of the valve which might result from operation thereof at too high a voltage before the electrodes reach a suitable temperature. Such heating of the valve may be attained by inserting a suitable transformer in series with the transformer normally supplying operating current to the valve to reduce the voltage impressed across the electrodes, but such a method of connection presents the disadvantage that the heating transformer must have a comparatively high output voltage to overcome the reactance drop in the main transformer, which may have a comparatively high value if the valve normally operates at a high voltage.

It is therefore preferred to connect the heating transformer directly with the anode or anodes of the valve through a comparatively simple and inexpensive switch, and to leave the anodes of the valve connected with the supply transformer associated therewith, the valve being then disconnected from the supply circuit thereof by means of the usual switch. Suitable interlocks should then be provided to avoid simultaneous connection of the valve with the heating circuit and with the supply circuit. In addition to the heating circuit, the valve generally requires a plurality of auxiliary circuits for controlling the operation thereof, such circuits being either conductively or inductively connected with the valve, and it is then necessary to insulate such circuits from the source of supply therefor to avoid transmitting to such source the potential of the valve electrodes or of the valve casing. Such auxiliary circuits generally include a plurality of auxiliary transformers and of auxiliary motors in which the introduction of insulation for the whole potential of the elements of the valve would lead to a bulky construction of excessive cost. It is therefore preferable, and certainly more economical, to supply all the auxiliary circuits of the valve from the secondary winding of the heating transformer; only the secondary winding of the heating transformer then needs to be insulated for the full voltage of the valve against ground or against the associated primary winding, thereby reducing the cost of obtaining such insulation. The connection of the heating transformer with the valve may be automatically controlled as a function of time or as a function of the temperature of an electrode of the valve.

It is therefore one of the objects of the present invention to provide an electric valve system in which proper operating conditions are produced in the valve by flow of current therethrough.

Another object of the present invention is to provide an electric valve system in which the valve heating transformer is utilized for insulating the auxiliary circuits of the valve from the current source.

Another object of the present invention is to provide an electric valve system in which the heating circuit and operating circuit of the valve are interlocked to prevent simultaneous completion thereof.

Another object of the present invention is to provide an electric valve system in which the valve receives heating current for a predetermined length of time before being connected with the working circuit therefor.

Another object of the present invention is to provide an electric valve system in which the operation of the valve heating circuit is controlled in response to the temperature of an electrode of the valve.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawings, in which:

Fig. 1 diagrammatically illustrates one embodiment of the present invention in which the heating current circuit of the valve is controlled manually;

Fig. 2 diagrammatically illustrates a modified

embodiment of the present invention in which the heating circuit of the valve is automatically controlled in function of time; and

Fig. 3 diagrammatically illustrates the modified interlocks to be provided for the control elements of the embodiment illustrated in Fig. 2 when the heating circuit is to be controlled in response to the variations of the temperature of an anode of the valve.

Referring more particularly to the drawings by character of reference, reference numerals 6 designates an electric valve utilized for controlling the flow of current between an electric line 7 and another electric line 8. In the embodiment illustrated, line 7 is assumed to be an alternating current line and line 8 a direct current line, valve 6 then being utilized for supplying line 8 with rectified current obtained from line 7 or for supplying line 7 with inverted current obtained from line 8, such operations being alternately obtainable by suitable adjustment of the control circuits of the valve as is well known in the art. Valve 6 is herein represented as being of the type having a reconstructing cathode 9 connected with one of the conductors of line 8 and with a plurality of anodes 11 severally connected with line 7 by means of a transformer 12. The connections between lines 7 and 8 by way of valve 6 are completed by suitable switches such as a switch 13 inserted in the connection between line 7 and transformer 12. The operation of valve 6 is controlled by means of suitable control electrodes 14 which may be of any suitable type such as grids severally associated with the anodes 11 of the valve. The operation of valve 6 then depends upon the energization of control electrodes 14 at suitable potentials considered relative to the potential of cathode 9, the potential of the cathode being taken as datum.

The operation of the valve requires the use of different auxiliary circuits which differ with the type of valve utilized, and which may be supplied with current from an auxiliary supply source of alternating current such as an auxiliary line 16 which may be energized from line 7 through a transformer 17. The connection of the auxiliary circuits with line 16 is effected through a transformer 19 having a primary winding 18 connected with line 16, and having a secondary winding 21 preferably connected in star or in zigzag and having a neutral point connected with cathode 9. Even when winding 21 is not provided with a neutral point, a point thereof should be connected with cathode 9 to thereby avoid building up of dangerous potentials between valve 6 and the auxiliary circuits by electrostatic induction. Transformer 19 is also utilized as a heating transformer for valve 6, and each phase of winding 21 is accordingly connected with a plurality of load devices such as resistors 22, each resistor being connected with one of the anodes 11 of the valve through one of the contacts of a switch 23. Closure of switch 23 is normally prevented by a latch 24 which is withdrawn by energization of a solenoid 26. The solenoid is energized from line 7 through a transformer 27, the circuit thereof being completed by a push button 25 and by auxiliary contacts 28 of switch 13, thus providing an interlock which prevents closure of switch 23 when switch 13 is closed. Switch 13 may be closed manually against the action of a spring 29, and is held closed by means of a latch 31 maintained in engagement therewith by means of a coil 32 energized from transformer 27 through auxiliary contacts 33 of switch 23 and in series with resistor 38. Switch 13 is preferably of the trip-free type so that the switch cannot be closed manually when solenoid 32 is not energized, thus providing an interlock which prevents closure of switch 13 when switch 23 is closed. Upon occurrence of a disturbance in the system causing an excessive flow of current to occur between line 7 and transformer 12, solenoid 32 is deenergized to allow switch 13 to open. Such result is obtained by means of a current transformer 36 connected between line 7 and switch 13 to energize a relay 37 to short circuit the solenoid 32. Switch 13 may also be tripped manually by opening the circuits of solenoid 32 by means of a push button 39.

Before connection of valve 6 with either the heating circuit or the working circuit therefor, the valve is made conductive by suitable means which, in the type of valve illustrated, comprise an ignition anode 39 and excitation anodes 41 as is well known. Such electrodes receive current from winding 21 through a transformer 42 and through relays 43 and 44. Control electrodes 14 receive a unidirectional voltage component from a voltage divider 46 connected with cathode 9 and receiving current from a suitable source of direct current such as a generator 47 driven by a motor 48 connected with winding 21. Valve 6 is maintained in suitably evacuated condition by means of a mechanical pump 51 driven by a motor 52 energized from winding 21 and by a diffusion pump 53 having a heater element 54 also energized from winding 21. The degree of evacuation of valve 6 is indicated by means of an electric vacuum gauge 56 energized from winding 21 through a transformer 57. Valve 6 is generally provided with a water jacket 58 of suitable construction, and the heat transmitted thereto by operation of valve 6 is dissipated in a radiator 59 by circulation of the cooling water therethrough under the action of a pump 61 driven by a motor 62 energized from winding 21. Motors 48, 52 and 62 and transformers 42, 43 and 57 are connected with the casing or with electrodes of valve 6 and therefore need to be insulated against line 16 or against ground for the voltage of valve 6, such insulation being provided between windings 21 and 18 and between winding 21 and ground. Transformer 19 being of comparatively high rating when compared to the rating of the individual auxiliary circuits, the insulation thereof for the voltage of valve 6 does not materially increase its cost, whereas considerable complications and expense would result from insulation, for the voltage of valve 6, of the comparatively small transformers 42, 57 and 49 and especially of motors 48, 52 and 62. The auxiliary circuits are preferably severally connected with windings 21 through knife switches, to permit sequential closures thereof at the proper times during operation of valve 6, with the exception of transformer 57 which is permanently connected with winding 21 to give a continuous indication of the vacuum condition within the valve.

When it is desired to put valve 6 in operation, line 7 being energized, the switches connecting the auxiliary circuits with winding 21 are closed, with exception of the switch controlling the energization of transformer 49. Connection of transformer 42 with winding 21 causes a discharge to be initiated between anode 39 and cathode 9, such discharge being thereafter maintained between anodes 41 and cathode 9. The connections of voltage divider 46 are then so

adjusted that all control electrodes 14 of the valve receive, from generator 47, a positive unidirectional component to facilitate the undisturbed flow of current between anodes 11 and cathode 9. If switch 13 is open, push button 25 may then be closed to complete the circuit of solenoid 26 to withdraw latch 24 and thus permit manual closure of switch 23. Upon closure of such switch, winding 21 supplies current to the several anodes 11 of valve 6, each anode then carrying current while receiving a positive potential from the associated portion of winding 21, the several anode currents combining into a flow of direct current from cathode 9 to the neutral point of winding 21. To avoid the complication of building winding 21 with as many phases as valve 6 has anodes, each phase portion of winding 21 is connected with at least two anodes of valve 6 through separate resistors 22, such connections permitting the several parallel connected anodes to carry current simultaneously. During such operation, winding 21 is connected with the secondary winding of transformer 12 and therefore supplies magnetizing current to such winding to magnetize the core of transformer 12. In general, however, the voltage of winding 21 is very low compared to the voltage of the secondary winding of transformer 12, so that the amount of magnetizing current supplied by winding 21 may generally be neglected. A small amount of circulating current will also be present in each group of windings of transformer 12 connected with one of the terminals of winding 21, such circulating current being, however, limited to a small value by the load resistors 22 traversed thereby. During such operation however, line 8 should be disconnected from any generators connected therewith which would otherwise be short circuited through winding 21 and the secondary winding of transformer 12. It may also be found desirable to disconnect the current consuming devices supplied from line 8, although such disconnection is not generally essential.

When the flow of heating current through valve 6 has taken place for a length of time sufficient to bring the valve, and more particularly the anodes 11, to a temperature such as to permit normal operation of the valve at the desired voltage, switch 23 is returned to the position shown. Contacts 33 of switch 23 are thereby again closed and latch 31 is engaged with switch 13 by solenoid 32 so that the switch can be closed manually. Closure of switch 13 opens contacts 28, so that latch 24 remains in engagement with switch 23 and the switch can no longer be returned to the closed position. The flow of current between lines 7 and 8 is then established by way of valve 6, and transformer 49 may then be connected with winding 21 to cause impression on control electrodes 14 of suitable alternating voltage components to permit adjustment of the flow of current through the valve by adjustment of the connections of voltage divider 46 as is well known. It will be understood that transformer 49 and voltage divider 46 may also be provided with adjusting means operating in response to operating conditions of valve 6 to automatically regulate the flow of current therethrough.

In the embodiment illustrated in Figure 2, switch 13 is represented as being provided with a closing coil 63 and with auxiliary contacts 64, 65, 66, 67, 68 and 69. Switch 13 may be maintained in the closed position by a latch 71 which may be withdrawn by a solenoid 72 energized from a suitable auxiliary source of current such as a battery 70. The closure of switch 13 is controlled by a reclosing relay 73 and by an anti-pumping relay 74. Switch 23 is likewise provided with a closing coil 76 acting against the action of a spring 77. Switch 23 is provided with auxiliary contacts 78, 79 and 80 and relay 44 is provided with additional contacts 81 cooperating with contacts 78, and with contacts 82 connected in series with coil 76. In the present embodiment, transformer 57, motor 52 and heater 54 are shown as being all permanently connected with winding 21. Motors 62 and 48 are connected with winding 21 through the contacts of a relay or contactor 83, and transformer 49 is connected with winding 21 through the contacts of relay 83 and of another relay 84. The operation of the system is controlled by means of the segments 88, 89 and 90 of a drum controller 86, such controller being driven by a self-starting synchronous motor 87 energized from winding 21. The valve 6 is thus caused to operate periodically during predetermined time intervals, but it will be understood that controller 86 may also be caused to move at irregular intervals to cause operation of valve 6 to occur during arbitrary time intervals, such a result being obtained by intermittent energization of motor 87 or by manual operation of controller 86. Valve 6 may be disconnected from the working circuit thereof during time intervals of such short duration that the valve is still at operating temperature at the time of reconnection thereof with the working circuit. Under such circumstances it is then unnecessary to connect the valve with the heating transformer before connecting it with the working circuit and the direct connection with the working circuit may be effected as a result of the presence of a second controller 92 driven by a reversible split phase motor 93 energized from winding 21. Such controller is so driven as to move from the position shown to the other extreme position in the length of time required for heating of valve 6, such controller being so controlled as to return to the position shown upon disconnection of valve 6 from the working circuit thereof and to reach the position shown in the length of time required for valve 6 to reach a sufficiently low temperature to require reheating thereof before reconnection with the working circuit. For this purpose, controller 92 is arranged to be in intermittent engagement with another controller 94, the engagement being such that controller 92 reverses controller 94 when reaching the one or the other extreme positions. Controller 94 is provided with a plurality of conductive segments 96, 97 and 98 cooperating with the other control elements of the system as will appear hereinafter. Valve 6 is preferably connected with line 8 through a switch 99 provided with a closing and holding coil 101 energized through contacts 65 of switch 13, and provided with auxiliary contacts 102 cooperating with contacts 82 of relay 44. A double throw switch 91 connecting controller 86 with battery 70 is provided for permitting manual tripping of switch 13 and resetting of relay 73.

In operation, the system being connected as shown, motor 87 moves controller 86 at a predetermined rate, and the system remains inactive as long as the controller maintains the connections shown. After a predetermined length of time, controller 86 causes such connections to be

changed, and a circuit is established from battery 70 through switch 91, segment 90 and the coil of relay 83 back to battery 70. Relay 83 closes the contacts thereof, thereby connecting motors 62 and 48 with winding 21 and causing energization of transformer 42. Such energization results in the establishment of a discharge between excitation anodes 41 and cathode 9, relay 44 operating to close contacts 81 and 82 upon establishment of such discharge. Such action establishes a circuit from battery 70 through coil 76, contacts 82 and 102, segment 97 of controller 94, and contacts 66 of switch 13 back to the battery. Coil 76 thus being energized causes closure of switch 23, which connects winding 21 with anodes 11 to establish a flow of heating current therebetween.

The above considered movement of controller 86, and the resulting closure of switch 23 also cause a circuit to be established from winding 21 through the segment of controller 92, segment 89 of controller 86, contacts 80 of switch 23, to motor 93 and back to winding 21. Motor 93 being thus energized rotates in the forward direction and moves controller 92. After a predetermined length of time, controller 92 is moved to the extreme position opposite the position shown, and engages with controller 94 to reverse the position thereof. The circuit of motor 93 is then opened by controller 92 and such motor stops. Reversal of controller 94 causes opening of the circuit of coil 76 at segment 97, so that switch 23 opens under the action of spring 77. A circuit is then established from battery 70 through switch 91, segment 90, contacts 79, coil of closing and reclosing relay 73 and contacts 68 back to battery 70. After a predetermined time delay, relay 73 closes the first contact thereof, thereby closing a circuit from battery 70 through contacts 78 and 81, segment 96 of controller 94, first contact of relay 73, back contact of relay 74, contacts 64 and coil 63 back to battery 70. Coil 63 thus being energized, closes switch 13 which is maintained closed by latch 71. Closure of switch 13 opens contacts 68, thereby deenergizing the coil of relay 73 which returns to the position shown; it also closes contacts 65 connecting coil 101 with battery 70, thus causing switch 99 to close. Opening of switch 23 also establishes a circuit from battery 70 through contacts 78 and 81, segment 96 and coil of relay 84 back to battery 70. Relay 84 closes the contacts thereof to energize transformer 49 which supplies alternating voltage components to control electrodes 14 to regulate the flow of current through valve 6.

After a predetermined length of time, controller 86 reestablishes the connections shown in the figure. A circuit is then established from battery 70 through switch 91, segment 90, contacts 67, and trip coil 72 back to battery 70. Coil 72 being energized lifts latch 71 and switch 13 opens under the action of spring 29. Opening of switch 13 causes the circuit of coil 101 to be opened at contacts 65, and switch 99 opens in turn. Movement of controller 86 also opens the circuit of the coil of relay 83 and such relay returns to the position shown, thereby deenergizing transformer 42 and causing relay 44 to return to the position shown. Such action opens contacts 81 which interrupt the circuit of the coil of relay 84, and such relay returns to the position shown. Segment 88 also closes a circuit from winding 21 through the segment of controller 92, segment 88 and motor 83 back to winding 21 to cause motor 93 to rotate in the reverse direction. After a predetermined period of time which corresponds substantially to the time required by valve 6 to reach a temperature below the normal operating temperature thereof, controller 92 returns to the position shown and engages with controller 94 which is thereby also returned to the position shown. The circuit of motor 93 is then interrupted by controller 92 and the motor stops, the entire system being returned to the position shown in the figure.

If controller 86 is again moved away from the position shown before controllers 92 and 94 are returned to the position shown in the drawings, valve 6 will then still be at a temperature within the normal range of valve operating temperatures and may therefore be connected directly with the working circuit without first being connected with heating transformer 19. Such result is obtained by establishment of a circuit from battery 70 through switch 91, segment 90 and the coil of relay 83 back to battery 70, causing relay 83 to connect motors 63 and 48 and transformer 42 with winding 21. A discharge is thus established through valve 6 and relay 44 closes contacts 81 and 82. Closure of contacts 82, however, does not cause energization of the coil 76 of switch 23, the circuit of such coil then being opened at segment 97 of controller 94. Switch 23 therefore cannot close and a circuit is established from battery 70 through switch 91, segment 90, contacts 79, the coil of relay 73 and contacts 68 back to battery 70. After a predetermined time delay, relay 73 causes closure of switch 13 in the manner above explained, and valve 6 is put in normal operation without being previously heated by connection thereof with transformer 19. The coil of relay 84 is also energized as previously explained, thereby connecting transformer 49 with winding 21 to cause regulation of the flow of current through valve 6. Motor 93 is then energized from winding 21 through the segment of controller 92, segments 89 and 98, and rotates in the forward direction to move controller 92 to the position opposite to the position shown. Upon return of controller 86 to the position shown, motor 93 may then return controllers 92 and 94 to the position shown as above explained.

Upon occurrence of a disturbance in the system resulting in an excessive flow of current through current transformer 36, relay 37 closes the contacts thereof to connect battery 70 with coil 72 through contacts 67, thereby causing latch 71 to be withdrawn and switch 13 to open. Reclosing relay 73 and anti-pumping relay 74 then cause switch 13 to be reclosed and, in the event that the cause of disturbance is not removed, switch 13 will be tripped and reclosed two more times and will thereafter be locked in the open position. After the cause of the disturbance has been removed, relay 73 may be reset by manually reversing switch 91, and the system may be returned to the operative position by returning switch 91 to the position shown. Switch 99 being controlled by contacts 65 of switch 13, the two switches are always simultaneously open or closed during all sequences of operation.

In the embodiment partially illustrated in Fig. 3, the operation of switch 23 is controlled in response to the variations of temperature of one of the anodes 11 of valve 6, and controllers 92 and 94 are no longer necessary and are therefore omitted. The remaining switching elements of the system are those already illustrated in Fig. 2 and, to simplify the drawings, Fig. 3 was drawn including only the control circuits, the switching elements and the interlocks therebetween. In

the present embodiment, closure of switch 23 is controlled by a relay 103 having contacts in series with contacts 82, and operating in response to the electromotive force of a thermocouple 104 responsive to the temperature of one of anodes 11.

In the present embodiment, when controller 86 changes the connections of the circuit at segment 99, a circuit is established from battery 70, through switch 91, segment 90, and the coil of the relay 83 as in the previous embodiment. Such action ultimately results in closure of contacts 82 by relay 44, thereby establishing a circuit from battery 70, through coil 76, contacts 82, contacts of relay 103, contacts 102 and 66 back to battery 70, provided that switches 13 and 99 are open. Coil 76 thus being energized, closes switch 23. As a result of the flow of heating current between anodes 11 and cathode 9, the temperature of the anodes increases until the electromotive force of thermocouple 104 is sufficient to cause operation of relay 103 to open the contacts thereof. Such action of relay 103 opens the circuit of coil 76, thereby causing opening of switch 23. Such opening causes energization of the coil of relay 73 to cause closure of switches 13 and 99 as in the previous embodiment. It will be easily understood that if the temperature of anode 11 is within the normal range of operating temperatures at the time of reversal of the connection of controller 86, relay 103 will then have opened the contacts thereof and switch 23 will not close, thereby permitting relay 73 to cause closure of switches 13 and 99 after a predetermined time delay.

Although but a few embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. The combination with an electric current supply circuit, an electric current load circuit, electric valve means comprising an anode and a cathode constituting spaced electrodes for the flow of current between said circuits, and switch means having cooperating contacts for controlling the operative connection of one of said circuits with said electrodes, of means for heating said electrodes to facilitate the initiation of the said flow of current comprising a second supply circuit, switch means having cooperating contacts for controlling the connection of the said second circuit with said electrodes, and an interlock comprising means other than said cooperating contacts for preventing the simultaneous connection of said supply circuits with said electrodes.

2. In combination with an electric current supply line and an electric current output line, an electric valve having electrodes arranged to be connected with said lines to control the flow of current therebetween, switch means for controlling the connection between said lines by way of said valve, a circuit for heating said electrodes by flow of current therebetween including means for obtaining current from said supply line at a voltage materially lower than the voltage impressed on said output line from said supply line through said valve, switch means for completing said circuit, and an interlock between the first and second said switch means for preventing simultaneous closure thereof.

3. The combination with an electric current supply circuit, an electric current load circuit, one of said circuits being an alternating current circuit, electric valve means comprising an anode and a cathode constituting spaced electrodes for the flow of current between said circuits, and switch means having cooperating contacts for controlling the operative connection of one of said circuits with said electrodes, of means for heating said electrodes to facilitate the initiation of said flow of current comprising a transformer having a primary winding energized from the said one of said circuits and a secondary winding connectible with said electrodes, switch means having cooperating contacts controlling the connection of the said secondary winding with said electrodes, and an interlock comprising means other than said cooperating contacts for preventing the simultaneous connection of the said one of said circuits and said secondary winding with said electrodes.

4. The combination with an electric current supply circuit, an electric current load circuit, one of said circuits being an alternating current circuit, electric valve means comprising an anode and a cathode constituting spaced electrodes for the flow of current between said circuits, switch means having cooperating contacts for controlling the operative connection of said circuits with said electrodes, of means for heating said electrodes to facilitate the initiation of said flow of current comprising a transformer having a primary winding energized from said one of said circuits and a secondary winding having one terminal thereof connected with one of said electrodes, a plurality of auxiliary circuits for controlling the operation of said valve means energized from said secondary winding and insulated from said one of said circuits, another switch means having cooperating contacts controlling the connection of another terminal of said secondary winding with the other of said electrodes, and an interlock comprising means other than said cooperating contacts for preventing the circuit closing connection of the said cooperating contacts of either of said switch means when the said cooperating contacts of the other of said switch means are in circuit closing connection.

5. In combination with an electric current supply line and an electric current output line, one of said lines being a polyphase alternating current line, an electric valve having a plurality of anodes and a cathode connectible with said lines to control the flow of current therebetween, switch means for controlling the connection between said lines by way of said valve, a transformer having a polyphase primary winding connected with said alternating current line and a polyphase secondary winding connected with said cathode, a plurality of load devices connected into groups each connected with one of the phases of said secondary winding, and switch means for connecting each of said load devices with one of the anodes of said valve.

6. In combination with an electric current supply line and an electric current output line, one of said lines being a polyphase alternating current line, an electric valve having a plurality of anodes and a cathode connectible with said lines to control the flow of current therebetween, switch means for controlling the connection between said lines by way of said valve, a transformer having a polyphase primary winding connected

with said alternating current line and a polyphase secondary winding connected with said cathode, a plurality of auxiliary circuits for controlling the operation of said valve energized from said secondary winding and insulated thereby from said alternating current line, a plurality of load devices connected into groups each connected with one of the phases of said secondary winding, and switch means for connecting each of said load devices with one of the anodes of said valve.

7. In combination with an electric current supply line and an electric current output line, one of said lines being a polyphase alternating current line, an electric valve having a plurality of anodes and a cathode connectible with said lines to control the flow of current therebetween, switch means for controlling the connection between said lines by way of said valve, a transformer having a polyphase primary winding connected with said alternating current line and a polyphase secondary winding connected with said cathode, a plurality of auxiliary circuits for controlling the operation of said valve, said circuits being energized from said secondary winding and insulated thereby from said alternating current line, a plurality of load devices connected into groups each connected with one of the phases of said secondary winding, switch means for connecting each of said load devices with one of the anodes of said valve, and an interlock for maintaining either of said switch means in the open position when the other thereof is in the closed position.

8. In combination, an electric current supply line, an electric current output line, one of said lines being an alternating current line, an electric valve having an anode and a cathode, switch means for connecting said anode and said cathode with said lines, a transformer having a primary winding connected with said alternating current line and having a secondary winding connected with said cathode, a normally open switch for connecting said secondary winding with said anode, means for starting operation of said valve including means for closing said switch for a predetermined length of time to cause flow of heating current from said transformer through said valve, and means for closing said switch means upon reopening of said switch.

9. In combination, an electric current supply line, an electric current output line, one of said lines being an alternating current line, an electric valve having an anode and a cathode, switch means for connecting said anode and said cathode with said lines, a transformer having a primary winding connected with said alternating current line and having a secondary winding connected with said cathode, a normally open switch for connecting said secondary winding with said anode, means for starting operation of said valve including means for rendering said valve conductive, means responsive to operation of the third said means for closing said switch for a predetermined length of time, and means controlled by said switch for causing closure of said switch means upon reopening of said switch.

10. In combination, an electric current supply line, an electric current output line, one of said lines being an alternating current line, an electric valve having an anode and a cathode, switch means for connecting said anode and said cathode with said lines, a transformer having a primary winding connected with said alternating current line and having a secondary winding connected with said cathode, a normally open switch for connecting said secondary winding with said anode, means for starting operation of said valve including means for rendering said valve conductive, means responsive to operation of the third said means for closing said switch for a predetermined length of time, and acting only after opening of said switch means for another predetermined length of time, and time delay means controlled by said switch for closing said switch means when said switch is in the open position.

11. In combination, an electric current supply line, an electric current output line, one of said lines being an alternating current line, an electric valve having an anode and a cathode, switch means for connecting said anode and said cathode with said lines, a transformer having a primary winding connected with said alternating current line and having a secondary winding connected with said cathode, a normally open switch for connecting said secondary winding with said anode, means for starting operation of said valve including means responsive to the temperature of said anode for closing said switch until said anode reaches a predetermined temperature, and means for closing said switch means upon reopening of said switch.

12. In combination, an electric current supply line, an electric current output line, one of said lines being an alternating current line, an electric valve having an anode and a cathode, switch means for connecting said anode and said cathode with said lines, a transformer having a primary winding connected with said alternating current line and having a secondary winding connected with said cathode, a normally open switch for connecting said secondary winding with said anode, means for starting operation of said valve including means responsive to the temperature of said anode for closing said switch and for maintaining said switch closed only when the temperture of said anode is below a predetermined valve, and time delay means controlled by said switch for closing said switch means when said switch is in the open position.

13. The combination with an electric current supply circuit and an electric current load circuit, of electric valve means comprising an anode and a cathode connectible with said circuits and constituting spaced electrodes for the flow of current therebetween, switch means operable to one position thereof to effect thereat the connection of said circuits by way of said electrodes, means comprising a time delay device controlling the said operation of said switch means, a second electric current supply circuit connectible with said electrodes for rendering said valve means operative, a second switch means operable to one position thereof to effect thereat the connection of the said second supply circuit with said electrodes and operable to another position thereof to effect thereat the operation of said time delay device.

14. The combination with an electric current supply circuit and an electric current load circuit, of electric valve means comprising an anode and a cathode connectible with said circuits and constituting spaced electrodes for the flow of current therebetween, switch means operable to one position thereof to effect thereat the connection of said circuits by way of said electrodes, means comprising a time delay device controlling said operation of said switch means, a second electric current supply circuit connectible with said electrodes for rendering said valve means operative,

a second switch means operable to one position thereof to effect thereat the connection of the said second supply circuit with said electrodes and operable to another position thereof to effect thereat the operation of said time delay device, and a timing device controlling the operation of the said second switch means to limit the duration of operation to the said one position thereof.

15. The combination with an electric current supply circuit and an electric current load circuit, of electric valve means comprising an anode and a cathode connectible with said circuits and constituting spaced electrodes for the flow of current therebetween, switch means operable to one position thereof to effect thereat the connection of said circuits by way of said electrodes, means comprising a time delay device controlling the said operation of said switch means, a second electric current supply circuit connectible with said electrodes for rendering said valve means operative, a second switch means operable to one position thereof to effect thereat the connection of the said second supply circuit with said electrodes and operable to another position thereof to effect thereat the operation of said time delay device, a timing device for controlling the duration of operation of the second said switch means to the said one position thereof, and a second timing device for controlling the operation of the first said timing device and for controlling the duration of operation of the first said switch means to the said one position thereof.

16. The combination with an electric current supply circuit and an electric current load circuit, of electric valve means comprising an anode and a cathode connectible with said circuits and constituting spaced electrodes for the flow of current therebetween, switch means operable to one position to effect thereat the connection of said circuits by way of said electrodes, means comprising a time delay device controlling the said operation of said switch means, a second electric current supply circuit connectible with said electrodes for rendering said valve means operative, a second switch means operable to one position thereof to effect thereat the connection of the said second supply circuit with said electrodes and operable to another position thereof to effect thereat the operation of said time delay device, and means operable responsive to the temperature of said anode for controlling the duration of the operation of the said second switch means to the said one position thereof.

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