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ELECTRIC VALVE CONTROL SYSTEM

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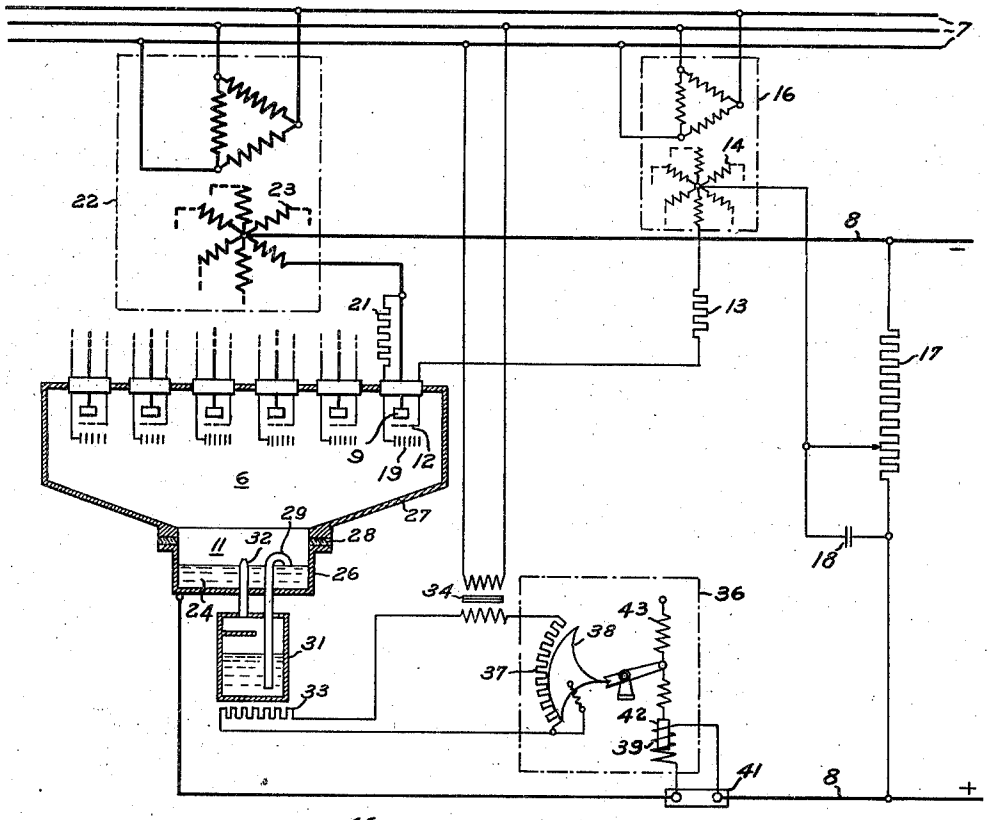


Fig. 1

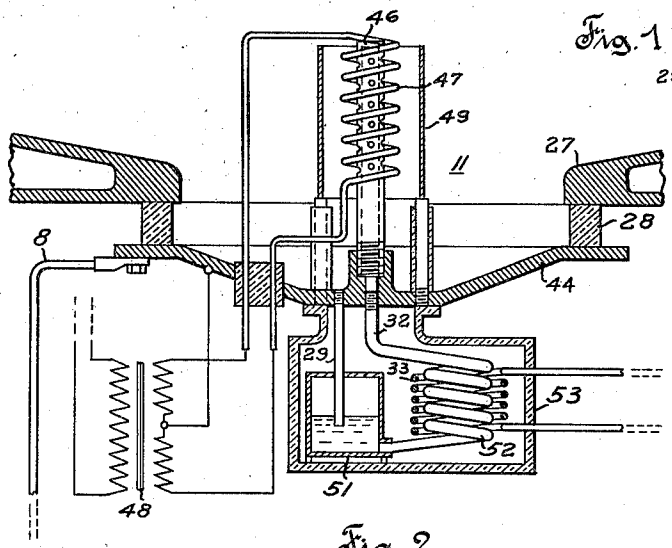


Fig. 2

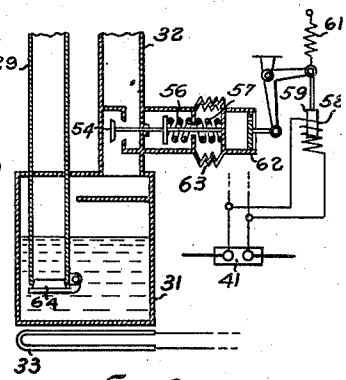


Fig. 3

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ELECTRIC VALVE CONTROL SYSTEM

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This invention relates in general to the control of electric valves, and more particularly to means for regulating the conductivity of the space within a valve of the condensable vapor type.

In electric valves having electrodes including a cathode and one or more anodes, and in which the flow of current is conducted through a condensable operating vapor, it is generally desirable to limit the density of the vapor within the space adjacent the anode or anodes of the valve to thereby maintain the dielectric strength of such space at a high value. The danger of occurrence of discharges between anodes or of a reverse flow of current between the cathode and an anode of the valve is thereby materially decreased. At the same time, it is generally found advantageous to introduce a blast of operating vapor within the valve, such blast being directed into a suitable portion of the space within the valve container, and becoming increasingly attenuated towards the walls of the container whereon such vapor condenses to reform the operating fluid. The space subjected to such blast is usually adjacent the cathode of the valve, and the presence of the vapor blast within such space increases the conductivity thereof to a material extent, thereby greatly facilitating the establishment of the flow of current between each anode of the valve and the cathode and also reducing the voltage drop resulting from such flow of current. Such results are particularly desirable when the flow of current through the anodes of the valve is controlled by means of control electrodes which may render the establishment and the maintenance of such flow of current somewhat difficult and may even tend to render such current unstable if the walls of the valve are at a relatively low temperature. Another result of the increase of density of the vapor within the space adjacent the cathode is that the dielectric strength of such space, in the absence of current therethrough, is greatly decreased, so that an arc may be established between an anode and the cathode of the valve by impressing a suitable potential on such anode or on another electrode of the valve. It is then unnecessary to provide the cathode with means for maintaining such cathode continuously in electron emitting condition.

The production of the blast of operating vapor however requires a certain amount of energy, and such blast may cause the vapor density within the space adjacent the anodes of the valve to become excessive, hence the rate of vaporization of the operating fluid should be maintained at a minimum value. The minimum amount of vapor required for conducting current through the valve under a reduced voltage drop is generally variable and depends upon the intensity of such current, and it is therefore advantageous to control the rate of vaporization of the operating fluid in response to the magnitude of the flow of current through the valve.

It is therefore one of the objects of the present invention to provide a control system for an electric valve of the vapor type by which the conductivity of a portion of the space within the valve is controlled.

Another object of the present invention is to provide a control system for an electric valve of the vapor type by which a variable blast of operating vapor is produced within a portion of the space enclosed by the valve.

Another object of the present invention is to provide a control system for an electric valve of the vapor type by which the conductivity of a portion of the space within the valve is varied in response to an operating condition 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 drawing, in which:

Fig. 1 diagrammatically ilustrates one embodiment of the present invention applied to the control of a blast of operating vapor in a valve having a cathode consisting of condensed operating vapor;

Fig. 2 is a cross-sectional elevation of a cathode of material other than the condensed operating material of the valve and adapted to receive a blast of operating vapor controlled as in the embodiment illustrated in Fig. 1; and

Fig. 3 diagrammatically illustrates a boiler provided with a throttle valve responsive to changes in the value of the current through the associated cathode.

Referring more particularly to the drawing by characters of reference, reference numeral 6 generally designates a valve structure constituting part of a translation system such as, for example, a system for transmitting energy from an alternating current line or circuit 7 to a direct current line or circuit 8. Valve structure 6 may be of any structure, known in the art, of the low pressure vapor type utilizing a condensable vapor, and is herein illustrated as consisting of a so-called rectifier comprising a plurality of valves severally provided with anodes 9 and having the cathodes thereof joined into a single cathode structure 11. The anodes and the cathodes of the valves are contained in a common evacuated casing but it will be understood that each of the valves may also be provided with a separate cathode enclosed with the associated anode in a separate casing.

Cathode 11 may be provided with suitable means for bringing and maintaining such cathode in electron emitting condition, such means being well known and therefore not shown. The

conductivity of valves 6 may be controlled by means of control electrodes 12 severally associated with anodes 9. The control electrodes may be energized in any known manner, and are preferably connected with cathode 11 through resistors 13 and through energizing means such as the phase displaced portions of the secondary winding 14 of a transformer 16 energized from line 7 serving as a source of potential therefor. Winding 14 is provided with a neutral point connected with the movable tap of a voltage divider 17 connected across line 8. A capacitor 18 may be connected between the tap and the positive terminal of the voltage divider to render the voltage therebetween substantially uniform. Control electrodes 12 may be of any type known in the art and operable to alternately prevent and release the flow of current through the associated anode, but the present system is particularly applicable to valves provided with control electrodes operable to also interrupt the flow of current between the associated anodes 9 and cathode 11. An example of construction of such control electrode is disclosed in U. S. Patent 1,999,764 issued April 30, 1935, to E. Kern. Each such control electrode is preferably associated with an auxiliary electrode 19 connected with the associated anode through a resistor 21.

Anodes 9 are energized from line 7, constituting a source of potential therefor, through a transformer 22 having a star connected secondary winding 23 provided with a neutral point connected with the negative conductor of line 8, cathode 11 being connected with the positive conductor of such line. The cathode is diagrammatically illustrated as consisting of a body of operating fluid 24, such as mercury, retained within a well 26 forming part of the casing of valve 6 and sealed against the main portion 27 of such casing in insulated relation therewith by an insulator 28 and suitable well known sealing means (not shown). Fluid 24 is maintained at a predetermined level by an overflow pipe 29 which syphons the excess fluid into a boiler 31 provided for vaporizing such fluid. The boiler is provided with an outlet pipe 32 shaped as a nozzle penetrating through well 26 and fluid 24 for introducing vaporized fluid into the space adjacent the cathode. Boiler 31 is heated by means of a suitable heating element, such as a resistor 33, energized from a transformer 34 connected with line 7. The flow of current in heater 33 is varied in response to an operating condition of valve 6, such as the magnitude of the flow of current therethrough, by means of a regulator generally designated by 36 to thereby control the rate of vaporization of the fluid within boiler 31. The regulator may comprise, for example, a resistor 37 serially connected with transformer 34 and heater 33, such resistor having a movable tap in the form of a sector 38 operable to short circuit a variable portion of the resistor. Sector 38 is actuated in response to the magnitude of the flow of current through valves 6 by means of a solenoid 39 energized from a shunt 41 inserted in line 8 and acting on an armature 42 against the action of a spring 43.

In operation, line 7 being energized, heater 33 receives current from transformer 34 through resistor 37 to maintain the fluid within boiler 31 in ebullition. A blast of operating fluid is thus produced within the space adjacent cathode 11, the operating vapor diffusing from such space throughout the chamber defined by casing 27 to condense on the walls thereof. The condensed vapor returns by gravity to cathode 11 and to boiler 31. The blast of vapor thus produced increases the conductivity of the space adjacent cathode 11 for the flow of current therethrough by way of arcs established between anodes 9 and cathode 11, and also decreases the dielectric strength of such space in the absence of such arcs.

Cathode 11 may then be brought to electron emitting condition and maintained in such condition by the means provided therefor. During the operation of valves 6, each anode 9 and the associated electrode 19 receive alternating voltages from one of the phase portions of winding 23. When one of the electrodes 19 becomes positive with respect to the potential of cathode 11, such electrode functions as an anode carrying a current limited in magnitude by resistor 21. Such current ionizes the discharge path between the associated anode 9 and cathode 11. When the associated control electrode 12 is brought, by winding 14, to a potential positive with respect to substantially the potential of cathode 11, a discharge occurs between the control electrode and the cathode to release the flow of current between the associated anode and the cathode. The flow of current through such anode is greatly facilitated by the prior establishment of a discharge between electrode 19 and cathode 11. Such flow of current continues until a flow of current is released through another anode which is then momentarily at a more positive potential than the previously operating anode, or until control electrode 12 becomes negative with respect to substantially the potential of cathode 11 to cause the flow of current through the operating anode to be interrupted. Upon such interruption, the magnetic energy stored in the core of the portion of winding 23 associated with the anode 9 considered is dissipated by a discharge between electrode 19 and cathode 11. Such operation is sequentially repeated for each of the anodes 9 of valves 6, the flow of current through the several anodes combining at cathode 11 to form a substantially uniform unidirectional current supplied to line 8.

When cathode 11 is not provided with the usual discharge igniting and maintaining means, valves 6 may operate if electrodes 19 receive from winding 23, voltages of sufficiently high value to cause a dielectric breakdown of the space between such electrodes and cathode 11. The operation of anodes 9 and of control electrodes 12 then remains substantially the same as above described. If the periods of current flow through anodes 9 are consecutive, the dielectric strength of the space about cathode 11 needs to be overcome only after each period of inactivity of valves 6. If such periods of current flow are non-consecutive, cathode 11 must be rendered conductive at the inception of each such period.

During such operation, shunt 41 receives the entire flow of current through cathode 11, which differs only by an immaterial amount from the flow of current between anodes 9 and cathode 11. Solenoid 42 accordingly causes operation of sector 38 in dependence upon the variation of such flow of current to vary the amount of current supplied to heater 33. In this manner, when the flow of current through valves 6 is at a low value, the supply of current to heater 33 is reduced, thus reducing the amount of energy dissipated by the operation of the system. The amount of vapor injected by nozzle 32 within valves 6 is reduced so that the pressure in the

space adjacent anodes 9 is reduced to a low value. When the flow of current through valve 6 is large, regulator 36 increases the flow of current to heater 33 to cause boiler 31 to vaporize operating material in larger amounts to the extent required for the conduction of current by way of arcs established between anodes 9 and cathode 11. The dielectric strength and the density of the vapor in the space adjacent cathode 11 is always maintained within a range of values such that the arc drop between anodes 9 and cathode 11 remains at a minimum value regardless of the temperature of the walls of casing 27.

The cathode illustrated in Fig. 1 may be replaced by a cathode of the solid incandescent type such as the cathode represented in Fig. 2. In such figure, well 26 is replaced by a plate 44 supporting the cathode structure proper. Such structure comprises for example a hollow cylindrical member 46 screwed on plate 44 and consisting of suitable conductive material impregnated with a material for increasing the electron emissivity thereof, such as barium oxide. Member 46 is brought to a temperature at which it becomes materially emissive by means of a coiled filament heater 47 receiving current from line 7 through a transformer 48. A heat radiation shield 49 of conductive material supported on plate 44 surrounds member 46 and filament 47 to reduce the dissipation of heat by radiation therefrom and to cooperate with member 46 in the conduction of current. The operating fluid condensed on the walls of casing 27 is received on plate 44 and is stored thereon or in a reservoir 51 communicating with the boiler and forming an extension of the casing. In the present embodiment, the boiler is illustrated as consisting of a coil of tubing 52 in heat exchanging relation with heater 33. Such construction is to be preferred for the reason that the volume of fluid in the boiler is reduced a minimum, thus permitting the rate of vaporization of the fluid to vary more rapidly in dependence upon the variations of the magnitude of the flow of current through line 8. Boiler 52 and reservoir 51 may be provided with an enclosure 53 of heat insulating material to reduce the amount of energy dissipated from heater 33. Tubing 52 connects with the bore of member 46, the vaporized fluid flowing through the member and issuing therefrom through a plurality of apertures distributed over the surface thereof. Heater 33 is connected as in the embodiment illustrated in Fig. 1 and the operation of valves provided with the cathode illustrated in Fig. 2 remains substantially as that above described.

Even a boiler such as 52 may have a thermal inertia such that the rate of vaporization of the fluid contained therein does not vary sufficiently rapidly in response to the variations of the current in the associated cathode and in heater 33. If solenoid 39 and armature 42 were used for controlling the opening of a throttle valve inserted in pipe 32 instead of controlling the flow of current in heater 33, such valve would be operated instantly in response to changes in the magnitude of the current in shunt 41. The effect of such operation would, however, be only temporary, as the pressure within boiler 31 or 52 would thereafter rise or fall to reestablish the flow of vapor through pipe 32 at substantially the initial value thereof under the action of the constant heat flow from heater 33 to the boiler.

It is therefore more advantageous to combine the control of heater 33 with the control of a throttle valve such as that illustrated in Fig. 3. In such figure, pipe 32 is provided with a throttle valve 54 normally maintained partially open by springs 56 and 57. Such valve is arranged to be actuated by a solenoid, 58, energized from shunt 41 jointly with solenoid 39, and which acts on an armature 59 against the action of a spring 61. Armature 59 preferably transmits its movement to valve 54 through a dashpot 62 and through suitable sealing means such as a sylphon bellows 63. Pipe 29 may be provided with a check valve 64 if the pressure within boiler 31 is apt to rise to a value causing operating fluid to return to cathode 11 through pipe 29. In operation, when the flow of current through shunt 41 remains substantially constant or varies slowly, valve 54 is maintained in the position shown by springs 56 and 57; armature 59 is moved into positions depending upon the momentary magnitude of such current and may slowly move the piston of dashpot 62 within the cylinder thereof without imparting movement to valve 54. Regulator 36 is then always able to regulate the action of heater 33 to cause boiler 31 to deliver the proper amount of operating vapor at every instant.

If the current in cathode 11 and shunt 41 suddenly increases largely, for example, regulator 36 immediately increases the current in heater 33, without immediately affecting the rate of vaporization of the fluid within boiler 31. Solenoid 58 suddenly moves armature 59, which transmits its movement to valve 54 to open such valve before air may escape to a material extent from dashpot 62. Such opening of valve 54 permits operating vapor to pass therethrough in increased amount, at the expense of the vapor stored under pressure within boiler 31, and thus to be delivered to rectifier 6 immediately at the desired increased rate. While the rate of vaporization of the operating fluid increases as a result of the increased flow of current in heater 33, spring 57 gradually causes valve 54 to return to the position shown in a length of time depending upon the rate of escape of the air contained within dashpot 62. By proper adjustment of the dashpot the movement of the valve may be so regulated as to remain substantially uniform from the time of opening of valve 54 until the rate of vaporization of the fluid within boiler 31 reaches a constant value.

The operation of valve 54 upon decrease of the flow of current through cathode 11 is opposite to that above set forth, and need therefore not be specifically described.

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. In combination, an electric valve of the condensable vapor type having an anode and a cathode, means other than said anode and cathode for vaporizing operating fluid condensed within said valve, means for introducing the vaporized fluid within the space adjacent said cathode, and means responsive to the magnitude of the flow of current through said valve for controlling the first said means.

2. In combination, an electric valve comprising an evacuated casing containing an electrode of vaporizable material, means other than said elec-

trode for vaporizing the material of said electrode, means for directing a jet of vaporized electrode material in a path adjacent the surface of said electrode to increase the conductivity of the space thereabout, and means operating in dependence upon the variations of the flow of current through said valve for controlling the operation of the first said means.

3. In combination, an electric valve comprising an evacuated container containing a plurality of electrodes and a body of vaporizable material, means for controlling the electrical conductivity of the space about one of said electrodes including means other than said electrodes for vaporizing said material to be introduced into said space, and means comprising an element other than the second said means responsive to an operating condition of said valve for controlling the rate of vaporization of said material.

4. In combination, an electric valve comprising an evacuated container containing a plurality of electrodes and a body of vaporizable material, means for increasing the conductivity of the space about one of said electrodes including means other than said electrodes for vaporizing said material to be introduced in said space, and means responsive to the magnitude of the flow of current between said electrodes for controlling the operation of the second said means.

5. In combination, an electric valve of the condensable vapor type having a plurality of electrodes including an anode and a cathode, means for vaporizing operating fluid condensed within said valve, means for introducing the vaporized fluid within the space adjacent said cathode to increase the conductivity of such space, a source of potential connected between one of said electrodes and said cathode to initiate a discharge therebetween, a second source of potential connected between said anode and said cathode to cause a flow of current to occur therebetween upon initiation of the discharge from the first said source, and means responsive to the magnitude of the flow of current through said valve for controlling the first said means.

6. In combination, an electric valve of the low pressure vapor type having electrodes including an anode associated with a control electrode and a cathode, means for increasing the conductivity of the space adjacent said cathode, energizing means connected with said cathode for impressing potential on said anode and on said control electrode to initiate discharges between said control electrode and said cathode and to cause a flow of current to occur between said anode and said cathode upon initiation of said discharges, and means responsive to the magnitude of the flow of current through said cathode for controlling the operation of the first said means.

7. In combination, an electric valve of the low pressure vapor type having electrodes including an anode associated with a control electrode and an auxiliary anode, means for increasing the conductivity of the space adjacent said cathode, energizing means connected with said cathode for impressing potential on said anode, on said auxiliary anode and on said control electrode to cause a flow of current to occur between said auxiliary anode and said cathode to ionize the discharge path between said anode and said cathode, to initiate discharges between said control electrode and said cathode, and to cause a flow of current to occur between said anode and said cathode upon initiation of said discharges, and means responsive to the magnitude of the flow of current through said cathode for controlling the operation of the first said means.

8. In combination, an electric valve of the low pressure vapor type having electrodes including an anode associated with a control electrode and a cathode, means for increasing the conductivity of the space adjacent said cathode, means for ionizing the discharge path between said anode and said cathode, energizing means connected with said cathode for impressing potential on said anode and on said control electrode to initiate discharges between said control electrode and said cathode and to cause a flow of current to occur between said anode and said cathode upon initiation of the discharges, and means responsive to the magnitude of the flow of current through said cathode for controlling the operation of the first said means.

9. In combination, an electric valve of the vapor type having an anode and a cathode operable to carry current by way of arcs established therebetween, a control electrode associated with said anode operable to release and to interrupt the arcs when energized at suitable potentials, means for increasing the conductivity of the space adjacent said cathode to facilitate the establishment and the maintenance of the arcs, and means responsive to the magnitude of the flow of current between said anode and said cathode to control the operation of the first said means.

10. In combination, an electric valve comprising an evacuated casing containing a body of vaporizable material, means for vaporizing said material, and means responsive to the magnitude of the flow of current through said valve for controlling the rate of vaporization of said vaporizing means and for controlling the flow of vaporized material within said casing.

11. In combination, an electric valve comprising an evacuated casing, a body of operating fluid for said valve, means for converting said operating fluid into vapor, means responsive to the flow of current through said valve for controlling the operation of said fluid vaporizing means, means for conducting said vapor from said vaporizing means into said casing, and means responsive to the flow of current through said valve for controlling the flow of said vapor through said vapor conducting means.

12. In combination, an electric valve of the condensable vapor type having electrodes including an anode with an associated control electrode and a cathode, means for vaporizing operating fluid condensed within said valve, means for introducing the vaporized fluid within the space adjacent said cathode to increase the conductivity of said space, means connected with said cathode for impressing potential on said anode for causing a flow of current between said anode and said cathode, means connected with said cathode for impressing potential on said control electrode to control said flow of current, and means responsive to variations in the magnitude of the flow of current through said cathode for controlling the operation of said vaporizing means.

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