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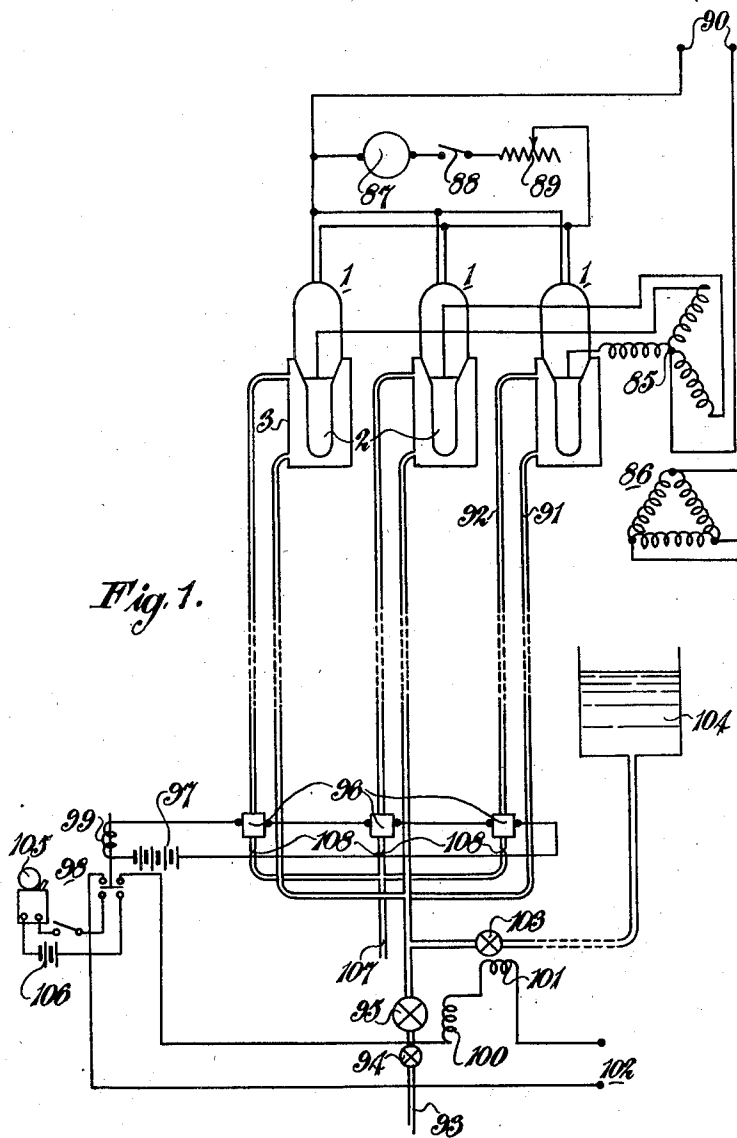
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ELECTRIC VACUUM TUBE DEVICE AND THE LIKE

Filed March 29, 1924

3 Sheets-Sheet 1



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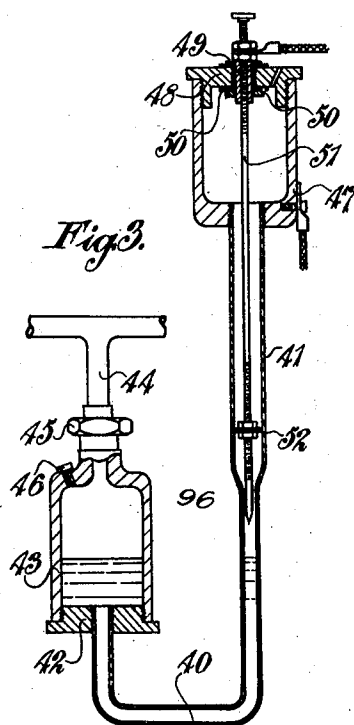
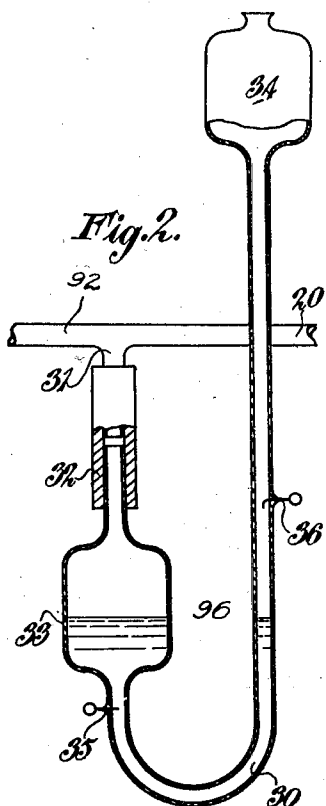
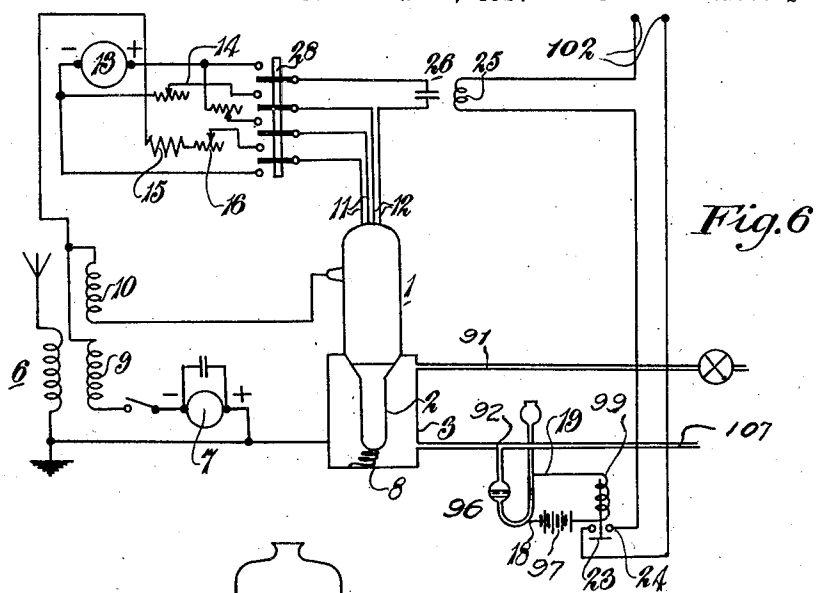
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ELECTRIC VACUUM TUBE DEVICE AND THE LIKE

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3 Sheets-Sheet 2



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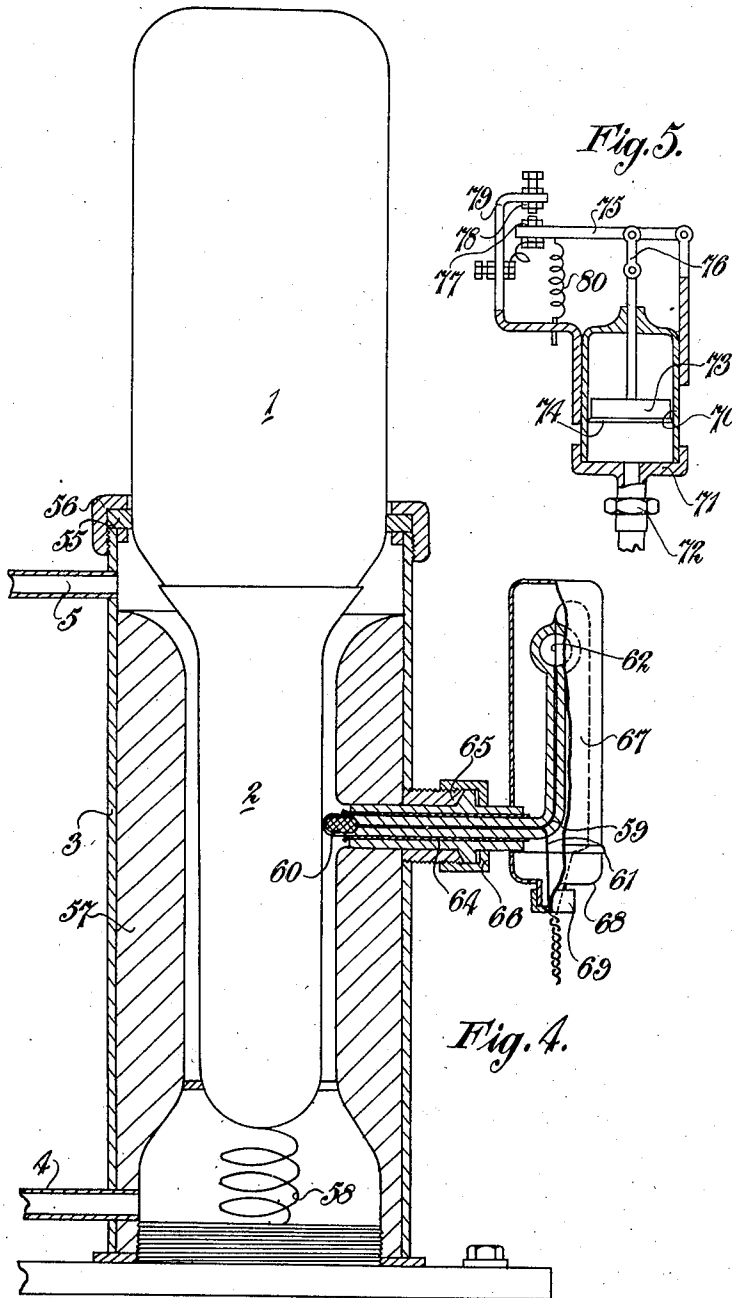
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ELECTRIC VACUUM TUBE DEVICE AND THE LIKE

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3 Sheets-Sheet 3



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ELECTRIC VACUUM-TUBE DEVICE AND THE LIKE.

Application filed March 29, 1924, Serial No. 702,907, and in England April 27, 1923.

This invention relates to vacuum electric devices such as thermionic valves and the like and more especially to such devices which are cooled during operation by means of fluid circulation, the invention being also applicable to valve devices which are continuously exhausted during operation by means of a vacuum pump such as a mercury vapour pump which is fluid cooled. In such devices it is essential that the supply of cooling fluid such as water should not fail since in the one case the part of the valve which is being cooled such as the anode would be overheated, and in the other case the vacuum would fail.

An object of the present invention is to provide means responsive to the condition of the supply of cooling fluid for protecting the vacuum tube or valve device against operation under undesirable conditions of said supply. More specifically, the object of the invention is to provide protective means which upon the occurrence of undesirable conditions of the normal fluid supply effect the connection to the tube valve or pump of a supply of cooling fluid from a reserve or stand-by source. In addition the protective means may effect the operation of a warning device such as a signal light or bell. Furthermore, protective means may be provided for stopping the operation of the valves, such as by cutting off the anode or the cathode supply, in case undesirable conditions in the auxiliary supply should also arise.

The invention is particularly applicable to valves in which the anode is operated as described in the specification of my co-pending application, Serial No. 699,185, filed March 14, 1924, in which case it is not necessary to employ means to provide an insulating column of cooling liquid between the source of the cooling liquid and the valve. It may, however, be applied to valves in which the anode is not operated at earth potential, either by arranging that the cooling liquid is one having a high insulation resistance, such for example as oil, or else when water is employed, especially water which is taken from a water main, it may be arranged that the inlet and outlet pipes are constructed of insulating material and are arranged to be of long length so that a

high resistance column of water is interposed between the anode and earth. This is of course a well known arrangement which has frequently been used to insulate water cooled parts, particularly of vacuum tube devices, from earth.

To enable the invention to be clearly understood it will now be described with reference to the accompanying drawings in which Fig. 1 is a diagrammatic representation of a vacuum tube protective system in accordance with the invention, Figs. 2 and 3 are sectional elevations of two forms of pressure relay, Fig. 4 is a sectional elevation of a cooling jacket with a thermal relay, Fig. 5 is a sectional elevation of another form of pressure relay, and Fig. 6 is a diagrammatic representation of arrangements giving further protection in case the auxiliary supply should also fail.

Referring first to Fig. 1, this illustrates an application of the invention to a three-phase half-wave rectifier, the valves 1 being of the type wherein a portion of the envelope is formed of metal, which portion constitutes the anode 2 which during operation is fluid-cooled. For this purpose it is placed in a jacket 3 through which water or other cooling fluid from a supply main 93, for example, is passed by means of inlet and outlet pipes 91 and 92 respectively, which pipes are of insulating material and of considerable length in order that the anodes 2 which operate at high potential may be effectively insulated from earth. The cathodes which operate substantially at earth potential are supplied with current from a direct current generator 87 through a switch 88 and a rheostat 89, the cathodes in this instance being of the type which are heated by the passage therethrough of an electric current. The anodes are supplied with three-phase alternating current from a star-connected secondary winding of a transformer 86 the primary of which is connected with a three-phase supply. The valves 1 supply rectified alternating current to the output circuit 90. Between the supply main 93 and the cooling system there is provided a manually operable valve 94 and an electrically operable valve 95; the control of which latter will be hereinafter described. The outlet water from the valves passes

through pressure relays 96 which may assume any of the forms hereinafter described and which are connected electrically in series with each other and with the battery or other source of current 97 and with the operating coil 99 of a relay 98, the common armature of which is adapted to cooperate with two pairs of contacts. When coil 99 of the relay 98 is energized the upper pair of contacts is bridged by the armature whereby a coil 100 and a second coil 101 in series connection therewith are energized from a suitable source of current 102. The second coil 101 controls the operation of a valve 103, provided in a pipe connection between an auxiliary supply of water 104 and the inlet pipes 91. The normal condition of the relay 98 when the water cooling is adequate is with the coil 99 energized and the upper contacts thereof closed. Under these circumstances the electrically operated valve 95 is open by reason of the energization of the coil 100 and the auxiliary valve 103 is closed by energization of its operating coil 101. The lower contacts of the relay 98 control the operation of a signalling device such as an electric bell 105 adapted to receive energy from a battery or other source 106.

With the system above described supposing that during the rectifying operation the water supply from the main 93 should fail or fall below a predetermined minimum, such that the electric circuit through one or more of the pressure relays 96 is broken, the armature of the relay 98 will fall so that the valve operating coils 100 and 101 will be de-energized whilst the circuit of the electric bell 105 is closed to provide an audible signal. The de-energization of the coils 100 and 101 will effect the closure of the valve 95 and the opening of the valve 103 and in this manner the main supply of cooling fluid is cut off and the auxiliary supply 104 brought into operation. To obtain a suitable pressure head for the operation of the relays 96, constrictions 108 may be provided between the said relays and the discharge pipe 107.

When the valves are continuously evacuated during operation by means of a water cooled pump such for example as a pump of the Langmuir type similar means may be provided for protecting the system against failure of the supply of cooling fluid to the pumps. The relays of such additional protective systems may be connected electrically in series with the relays of the system illustrated in Fig. 6. Furthermore when the valve is continuously evacuated during operation failure of the water supply will result in an increase in temperature of the anode which in turn will cause gas to be given off therefrom and render the valve soft. Thus as an alternative type of relay

a gas pressure gauge may be connected with the valve and arranged to operate a relay. For example an ionization gauge may be employed which when the gas pressure in the valve rises above a predetermined maximum will operate a protective relay. Such ionization gauge may be connected with the interior of the valve and the circuits of the gauge may be so arranged that when the positive ionic current collected by the electrodes exceeds a predetermined amount, the relay is tripped and the necessary protection effected. Alternatively, a relay of the thermostat type may be employed that will be hereinafter described.

Referring to Fig. 2 which illustrates one form of the relay 96 in detail, the U-tube 30 is formed of glass and partially filled with mercury and is connected to a T-branch 31 of the outlet pipe 92 by means of a rubber sleeve 32 or otherwise. The tube 30 is provided with bulbs or enlargements 33 and 34 for a purpose to be hereinafter explained. One of the contact electrodes 35 is inserted in the lower part of the U-tube whilst the other contact electrode 36 is inserted therein at a higher level which depends upon the pressure in the portion 20 of the outlet pipe when the flow of cooling fluid is normal. The bulbs or enlargements 33 and 34 are provided so that pressure fluctuations shall not disturb the adjustment of the relay since in the absence of the bulb violent fluctuations of the water supply might throw the mercury out of the region of the contact electrodes 35 and 36 and possibly even out of the tube. The contact electrodes 35 and 36 will be connected with the relay coil 99 and source of current 97 as described in Fig. 6.

The relay 96 illustrated in Fig. 3 is similar in principle to that described in connection with Fig. 2 but the U-tube 40 is of metal such for example as steel whereby a more robust construction is obtained. The upper end of the U-tube 40 is enlarged at 41. The other end thereof is secured to a plug 42 which is in turn secured within the end of a reservoir 43 which is connected to the T-connection 44 of the outlet pipe by means of a union 45. The reservoir 43 is provided with a plug 46 by means of which the mercury may be introduced into the tube. The enlarged portion 41 of the U-tube 40 is secured to the base of the second reservoir 47 the upper end of which is provided with a cap 48 which supports a metal bush nut 49 insulated from the cap 48 by means of bushes and washers 50 of insulating material. A screw-threaded metal rod 51 passes through the bush 49 and is provided with external terminal nuts as shown. The metal tube 40 constitutes one electrode of the device whilst the rod 51 constitutes the other electrode. The rod 51 may be spaced from the metal tube 40 by means of a fibre washer 52 which

is perforated or has a serrated periphery and which engages freely in the enlarged portion 41 of the tube. The position of the contact 51 is adjusted by screwing it within the bush 49.

Referring to Fig. 4 which illustrates the use of a thermal relay, the metallic anode envelope portion 2, of the valve 1 is supported within the jacket 3 by means of a rubber ring 55 which is clamped between the end of the jacket 3 and a cap-ring 56 which has screw threaded engagement with the jacket 3. The water entering by the inlet pipe 4 and leaving by the pipe 5 is given a high velocity through the jacket by the provision therein of an annular member 57. Electrical connection between the anode 2 and jacket 3 is provided by means of the flexible member 58. A glass tube 59 having a bulb 60 at one end is inserted through aligned openings in the jacket 3 and member 57 so that the bulb projects into the path of the cooling fluid passing through the jacket. The tube 59 contains a body of mercury and is provided with a contact 61 which is always immersed in the mercury and a second contact 62 which becomes immersed in the mercury when the latter rises within the normally unfilled portion of the tube 59 due to the heat in the jacket 3 after the manner of a thermometer. The upper electrode 62 is so located within the tube that when the temperature of the bulb 60 exceeds a predetermined limit the contacts 61 and 62 which are connected with the protective gear as described in connection with Fig. 1 are connected together by the mercury. In this case, however, the contacts on the relay controlled by the coil 99 will be altered so that they are normally closed instead of being normally opened as illustrated in Fig. 1. The thermal device is preferably removably mounted in the jacket and to this end it is secured in a metal sleeve 64 having a conical flange 65 whereby it may be secured in position by the flange nut or union 66. The vertical portion of the tube is protected against damage and mechanical shock by means of a metal cover which is constructed in two parts 67 and 68 as shown, the latter of which parts is soldered or otherwise permanently connected with the metal tube 64 whilst the portion 67 is tubular and arranged to fit upon and around the portion 68. The conductors connected with the electrodes 61 and 62 pass through a gland 69.

The modified form of pressure relay illustrated in Fig. 5 comprises a cylinder 70 connected to the supply pipe of the water jacket of the valve or the diffusion pump as the case may be by means of the perforated cap 71 and the union 72. An accurately fitting piston 73 operates within the cylinder 70 such piston preferably having a cup leather as indicated at 74. The piston rod is con-

nected with a pivoted arm 75 through a link or other parallel motion 76. The arm 75 carries a relay contact member 77 which co-operates with a second contact member 78 mounted upon but insulated from a bracket 79 which may be secured to the cylinder 70. The contacts are normally retained separated by means of a spring 80. In operation the water pressure acting on the underside of the piston 70 tends to close the contacts 77 and 78, thus controlling the protective gear in a manner similar to that previously described. In the event of the water pressure falling below a predetermined minimum the contacts open whereby the anode and cathode currents may be cut off or alternatively a reserve or stand-by source of cooling water connected to the jacket. The contacts 77 and 78 may control the operation of the contactor switch 26 directly that is to say, the intermediate relay 21 of Fig. 1 may be omitted.

Referring now to Fig. 6, which illustrates how protection against the operation of a valve may be provided in case the auxiliary supply also fails, the valve 1 is of the three electrode type and the anode is operated at earth potential in the manner described in the specification of my co-pending application, Serial No. 699,185, filed March 14, 1924, and the valve is arranged to generate oscillations in a circuit such as the antenna 6. Power is supplied to the valve by means of the direct current generator 7 the positive terminal of which is connected to the anode 2 and also to earth. As shown the generator 7 may be connected to the water jacket 3 to which the anode 2 is connected by means of a flexible or resilient conductor 8. The anode current passes through the anode coil 9 which is coupled to the antenna coil and thence passes to the cathode of the valve. The grid coupling coil is indicated at 10. In the present instance the valve 1 has a cathode of the type described in the specification of my co-pending application, Serial No. 653,544, filed 24th July, 1923 and consists of two metallic tubes mounted one within the other of which the inner tube is at negative potential with respect to the outer tube so that heating space current flows from the inner tube to the outer tube. The cathode is brought up to the temperature at which it will maintain itself due to the space current between its portions by means of an auxiliary filament cathode which is mounted within the inner tube. In Fig. 1 the conductors 11 supply current to the auxiliary filament cathode and the conductors 12 are connected to the aforesaid tubular portion of the cathode. The heating space current is supplied by the generator 13 which is connected through the variable resistance 14 to the conductors 12. The current for the auxiliary filament

cathode is supplied from the generator 13 through a fixed resistance 15 and a variable resistance 16 in series therewith.

The outlet pipe 92 from the water jacket 3 has connected to it a pressure relay 96 which may be in the form of a U-tube containing a body of mercury as illustrated in Figs. 2 and 3. Said tube is provided with two electrodes 18 and 19 which are so arranged that when the cooling fluid is flowing the mercury establishes connection between them owing to the pressure head in the portion 107 of the pipe which is remote from the relay 96 and jacket 3. When the electrodes 18 and 19 are thus connected together by the body of mercury the relay coil 99 is energized from a suitable source of current such as a battery 97 and the energization of the coil 99 operates a contact member 23 to bridge the relay contacts 24 thereby effecting the energization of the operating coil 25 of a contactor switch 26 from a suitable source of current 102. The energization of the coil 25 causes the contactor switch 26 to close and complete the circuit by which a heating current is supplied to the cathode of the valve 1, this circuit passing through a manually operated switch 28 the function of which will be hereinafter described. With this arrangement it will be observed that unless a predetermined pressure obtains within the portion 20 of the outlet pipe the contactor switch 26 will open after a time interval, whereupon the supply of current to the valve is cut off. Furthermore, in the event of the supply of water falling below a predetermined amount the pressure will fall and the contactor switch will be opened as above described so that both the anode current and cathode current are automatically cut off.

In order to start the operation of the cathode the switch 28 is pressed downwards whereby the auxiliary cathode is supplied with heating current and at the same time the inner tube of the cathode is made positive with respect to the auxiliary cathode. The resistances 15 and 16 provide such a voltage drop as to make the inner tube sufficiently positive with respect to the auxiliary cathode. Heating current from the generator 13 passes from the auxiliary cathode to the inner cathode tube which is additionally heated by radiation from the auxiliary cathode. When the inner cathode tube is raised to a sufficiently high temperature the switch 28 is moved to its upward position whereby a potential difference is established between the inner and outer cathode tubes and at the same time the supply of heating current for the auxiliary cathode is cut off. The generator 7 which supplies the anode current is connected to the positive terminal of the cathode heat-

ing system. A condenser is connected across the generator 7 in order to pass the high frequency component of the anode current.

Whilst in the above described arrangement the valve is provided with cathodes which are heated as described in the specification of my co-pending application, Serial No. 699,185, filed March 14, 1924, it will be understood that the cathode may assume other forms and may be heated in a different manner and also that the source of direct current for the anode may be a thermionic rectifier or battery of accumulators.

Alternatively to the above described arrangement it may be arranged that on operation of the relay the anode current only is cut off or both the anode and the cathode heating currents may be cut off by respective switching devices. When the gap between the anode and cathode is large it will generally be sufficient to interrupt the anode current only but when the gap is relatively small and when the cathode comprises a concentrated source of electrons such as a metallic tube the anode will be considerably heated by radiation from the cathode itself and in such cases it is necessary to cut off at least the cathode heating current.

Various other modifications may be made without departing from the scope of the invention. The pressure relays in Fig. 6 may be so constructed that when they operate, the electrical circuit is made instead of broken, in which case said relays will be connected in parallel with one another, with the battery or source of current and with the operating coil of the water valve controlling relay.

I claim as my invention:

1. In an electrical system, the combination with a vacuum electric tube device having a part thereof which is adapted to be fluid cooled during operation, and a supply of cooling fluid therefor, of an auxiliary supply of cooling fluid, and means which become operative to connect said auxiliary supply to the system when the condition of the first-mentioned supply of cooling fluid becomes undesirable.

2. In an electrical system, the combination with a vacuum electric tube device having a part thereof which is adapted to be fluid cooled during operation, and a supply of cooling fluid therefor, of an auxiliary supply of cooling fluid, and a fluid pressure operated relay adapted to connect said auxiliary supply to the system when the fluid pressure of the latter falls below a predetermined value.

3. In an electrical system, the combination with a vacuum electric tube device having a part thereof which is adapted to be fluid cooled during the operation, and a supply of cooling fluid therefor, of an auxiliary supply of cooling fluid, and a relay controlled by

the discharge pressure of the cooling fluid to control the connection of said auxiliary supply.

4. In an electrical system, the combination with a vacuum electric tube device having a part thereof which is adapted to be fluid-cooled during operation, and a supply of cooling fluid therefor, of an auxiliary supply of cooling fluid, and means which become operative to connect said auxiliary supply to the system when the condition of the first-mentioned supply of cooling fluid becomes undesirable, and means for protecting the system against operation when the condition of the supply of cooling fluid is undesirable.

5. In an electrical system the combination with a vacuum electric tube device having an anode thereof which is maintained at earth potential and is adapted to be fluid-cooled during operation, and a supply of

cooling fluid therefor, of an auxiliary supply of cooling fluid, and means which becomes operative to connect said auxiliary supply to the system when the condition of the main supply becomes undesirable.

6. In an electrical system, the combination with a plurality of vacuum electric tube devices having parts thereof which are adapted to be fluid cooled during operation, and a supply of cooling fluid therefor, of an auxiliary supply of cooling fluid, and a plurality of relays responsive to fluid pressure in the system for connecting said auxiliary supply when the conditions in the first-mentioned supply become undesirable, said relays being connected electrically in series.

In testimony whereof I have hereunto subscribed my name this 18th day of March, 1924.

ERNEST YEOMAN ROBINSON.