

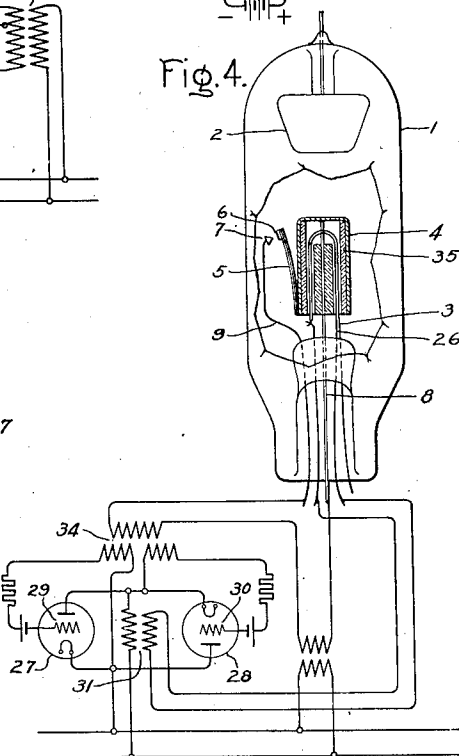
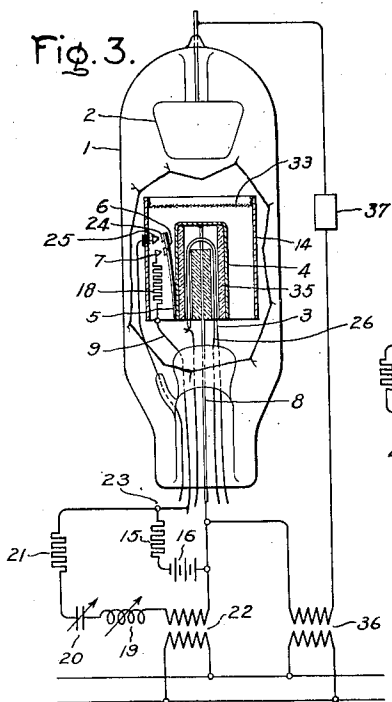
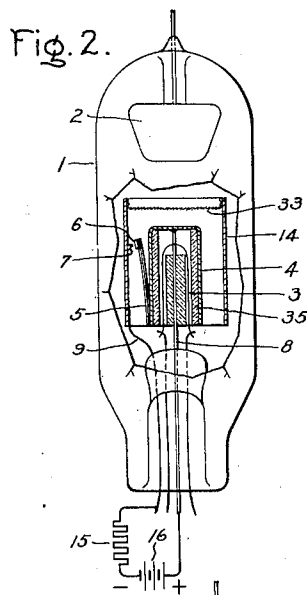
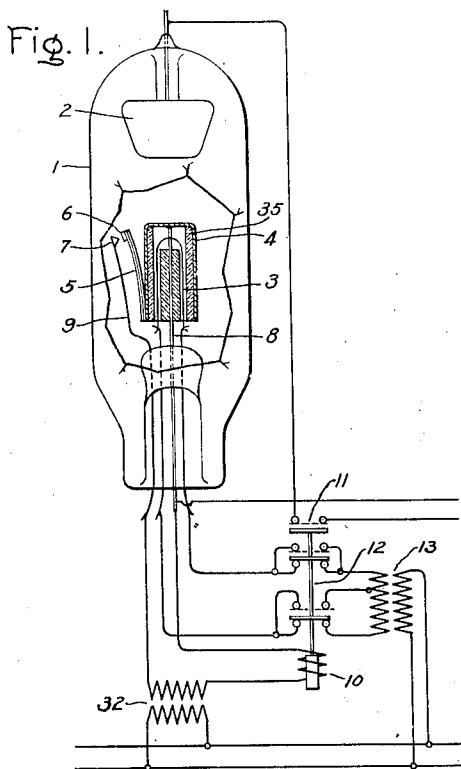
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ARC DISCHARGE APPARATUS

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ARC DISCHARGE APPARATUS

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17 Claims. (Cl. 250—27)

The present invention relates to arc discharge apparatus and more especially to devices for delaying the application of the anode voltage until the cathode has reached a predetermined and uniform temperature.

In arc discharge tubes provided with an incandescent cathode and containing an ionizable medium such as a gas or vapor, for the durability of the cathode it is important that before applying a voltage between cathode and anode the cathode should attain a temperature so high that it can emit sufficient electrons to ionize the discharge gap between the electrodes. As long as this does not occur, or only insufficiently, an arc with a concentrated cathode spot forms on the incandescent cathode. This spot takes on a considerably higher temperature than the other parts of the cathode surface on account of the energy of the ions striking the surface and of being accelerated by the large voltage drop in the region of the cathode. This energy is sufficient to bring the cathode spot up to the emission temperature. Since the arc does not leave this spot until the emitting substance and practically all of the foundation metal have evaporated and are destroyed, a rapid consumption of the cathode and a decrease in output of the discharge device occur.

Arrangements have therefore been proposed which have for their purpose to apply the voltage between the anode and cathode only when the entire emitting surface of the cathode has the necessary uniform temperature of emission. Such arrangements may consist, for example, of time relays which are controlled by the heating current. These known devices, however, have the drawback that they must be provided with a special time adjustment for each type of tube. These difficulties could be overcome by complicated adjusting devices. In all cases of the hitherto known constructions, there remains a disadvantage. Thus, it is practically impossible to construct a time relay acting thermally or otherwise, which, after any short interruption and reapplication of the heating current voltage, applies the anode voltage at the proper moment. Such recurring applications and disconnections of voltage frequently take place in operation. This difficulty may be overcome by providing an arrangement which causes the same amount of time interruption of the anode circuit, regardless of the length of the interrupted interval of the heating current circuit. However, when such an arrangement is employed with indirectly heated cathodes which may take approximately 15 minutes to heat up from the cold state, the arrangement on oc-

casion may operate inefficiently. For example, if the interruption of the heater circuit is only momentary and the delay device is set to apply the anode voltage at the end of 15 minutes, it is clear that considerable waste of time is involved. On the other hand, when it is desired to accelerate the application of voltage under these conditions, complicated and expensive apparatus is required.

An object of the present invention is to improve upon the prior art arrangements for delaying the application of anode voltage to arc discharge devices. In brief, the improvement contemplates the use of a thermal relay which is built into the tube and secured to the cathode so as to be directly under the influence of cathode temperature. This relay follows the temperature of the cathode surface which gives a measure of the emission and thereby adapts the discharge tube to all operating switching conditions.

These conditions are not fulfilled in the case of indirectly heated cathodes by an externally positioned relay for example, of the type actuated by the variation of the resistance of the heating wire. If, on the other hand, the thermal contact between the member sensitive to temperature and the emitting surface is so intimate that the relay is directly under the influence of the temperature of the cathode surface, then it conforms with corresponding rapidity to all the necessary operating requirements.

In the drawing, Fig. 1 shows one exemplary embodiment of the invention while Figs. 2, 3 and 4 represent other embodiments.

The member sensitive to temperature is preferably a bimetallic strip, as represented in Fig. 1 in the constructional example. In the envelope 1 are mounted the anode 2 and cathode 4 indirectly heated by the heating wire 3, and the surface of which is coated with an earth alkali-oxide. The envelope may be highly evacuated or contain gas or vapor at a pressure sufficient to support a glow or arc discharge at the impressed voltages. The bimetallic strip 5 which is secured to the cathode is adapted to bend under the influence of the temperature of the emitting layer. Its free end is provided with a contact surface 6 which, as soon as the necessary temperature has been reached, touches the back contact 7. Since, in this case, the switching movement occurs in vacuum or rarefied gas or vapor, it is not necessary to impart to the bimetallic strip a forced backward movement by means of an appropriate structure such as a spring, as is customary in the case of snap contacts in the usual switches.

The contact pair 6, 7 closes a circuit actuating a relay which consists of the cathode lead 8, the bimetallic spring 5, the contacts 6, 7, the lead 9, the transformer 32 and the relay coil 10. Outside the discharge tube is provided, for example, a relay 10 which is energized by the switching movements of the bimetallic spring 5 and closes other circuits with several contacts, especially the anode circuit, through the switch 11. The same relay effects the change-over of switch 12 from the position, represented in a full line, into that indicated in broken lines. The effect produced thereby is that the heating current, as a result of the change-over on the secondary winding of the heating transformer 13, is reduced. Thus, while a high voltage is applied to the heating wire 3 for a rapid heating, after the change-over, only a low heating voltage remains connected which is just sufficient to maintain the cathode at the proper operating temperature.

In Fig. 2, the application of the invention to a discharge tube provided with a grid in front of the cathode is shown. The discharge tube is the same as in Fig. 1; around the incandescent cathode, however, there is an additional enclosure 14 with openings, or a grid 33 or both. This enclosure is electrically insulated from the cathode and is connected with a conductor 8. The incandescent cathode and enclosure form parts of a circuit which includes a battery 16 and a series resistance 15. As long as the predetermined temperature of the incandescent cathode surface has not been reached, at least during the entire heating-up time, the enclosure 14, as a result of the battery 16, has a negative potential in relation to the incandescent cathode. Consequently, the starting of an arc between the cathode and anode is prevented. After attaining the proper temperature, a connection between the enclosure and the cathode is established by the thermal relay and contacts 6 and 7, so that the negative potential of the enclosure in relation to the cathode is neutralized or reduced. Then there is nothing to prevent starting of the tube. In other words the discharge is prevented by an electrode which normally is charged negatively so as to prevent ionization of the atmosphere and means for reducing the negative charge on the electrode to permit the discharge to occur only when the cathode has been heated sufficiently to prevent the oxide coating on the cathode from being destroyed by excessive positive ion bombardment. The magnitude of the negative bias voltage is determined according to the characteristics of the device, the distance of the grid from the cathode and the value of the anode voltage; under certain conditions, the necessity for a battery may be avoided. The battery may be replaced by a transformer, but in this case, the phase of the grid voltage is to be chosen at about 180° with respect to the anode voltage. Rectifying arrangements, for example dry or hot cathode devices may also be provided in place of the battery. Furthermore, it is not necessary to provide a special grid in the discharge tube for this purpose. The sheet-metal enclosure 14, serving for preventing current flow, may also contribute to stopping the discharge after it has started.

If now through temporary interruption of the heating current, for example, as a result of the absence of the primary voltage, the cathode cools down slightly, the contacts 6, 7 open and the grid 14, 33 again receives a negative potential in relation to the cathode. The starting of the arc from this moment, as well as during the cathode heat-

ing-up time is impossible. Thus if an alternating voltage or an intermittent voltage is applied to the anode of the discharge tube, then with the passage through zero, the arc is extinguished only to be started again when the cathode has a high temperature and the contacts 6, 7 touch.

In the case of discharge tubes provided with a control grid 14, as illustrated in Fig. 3, it is necessary to provide in the circuit closed by the contacts 6 and 7 an additional resistance 18. This resistance makes possible the regulation of the anode current even with the contacts 6, 7 closed, by applying an appropriate additional control voltage whose phase with respect to the anode voltage is such that the time at which the tube starts, is delayed. This is effected in the embodiment shown in Fig. 3 by taking the control voltage from a well-known device which varies the phase position of the control voltage and consists essentially of a choke-coil 19, a rotary condenser 20 and a resistance 21. The alternating voltage for control purposes may be taken from a transformer 22, and the anode voltage from a transformer 36. The rectified current load is indicated at 37.

By appropriate selection of the resistances 15, 18 and 21 and of the two components of the control voltage, the result can be obtained with contacts 6, 7 open, even when the anode voltage is positive in relation to the cathode, that no arc is started, because the potential of the point 23 and therefore of the grid 14 is negative. If, however, the contacts 6, 7 are closed, a current flows through the resistances 15 and 18 which increases the potential of the grid, that is to say, makes it less negative in relation to the cathode. With this reduced grid voltage, the discharge tube would be able to start if the second control voltage component did not postpone the starting until a moment determined by the phase displacement of the anode voltage in relation to the grid voltage.

With these various arrangements, an additional device may be combined for the changing-over from the heating-up current to the operating heating current. Such a device might consist in a simple manner of a further pair of contacts 24, 25 on the bimetallic strip 5 by means of which the current in the second heating wire 26 serving for the heating-up is interrupted after the necessary temperature is attained.

In the case of large discharge tubes with divided cathodes and in the case of installations with several discharge tubes dependent on the same source of heating current, it is only necessary that one cathode of the discharge tube or tubes be equipped with a switching member sensitive to temperature. Then the control of the anode current of the other tubes is effected also by the contacts in this one tube.

In such installations, it would also be of advantage in certain circumstances to conduct the primary current of the transformer 31 which energizes the heating-up filament 26, as shown in Fig. 4, through a pair of grid-controlled tubes 27, 28. This current, which normally flows through the control transformer 34, may be interrupted when necessary by the negative charge on grids 29, 30 and which charge is under the control of the contacts 6, 7.

It is, of course, not essential that the introduction and cutting out of the extra filament be effected at exactly the same temperature by the contacts arranged on the thermal relay. A certain latitude is permissible with respect to the heating and cooling intervals.

For increasing the amount of heat and pro-

longing the switching functions, the space between the heating filaments and the cap 4 may be filled with a ceramic mass, or a ceramic body 35 may serve as carrier for the heating wires (3 and 26) and the cathode cap. In the case of cathodes of small heat content and for avoiding connections in the event of slight heat variations, a retarding element should be used, for example, the relay 10 may constitute a time-delay device.

10 The voltage at the thermal relay contacts should be as small as possible, so that no discharge can take place from the incandescent cathode to the contact 7 if negative potential in relation to member 8 or to the incandescent cathode cannot be given to the contact through suitable polarization of the voltage.

15 The current in the relay circuit must also be as small as possible, or only a part of the current should be conducted through the thermal switching member, since otherwise, an additional heating of the switching member may occur through the relay current. The bimetallic spring can also be relieved from current by means of a flexible lead connected to the contact 6.

25 What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, an electric discharge device comprising an envelope containing a thermionic cathode and an anode, said cathode being heated 30 by an external source of current and the cathode-anode circuit being energized by an external source of current, and means for delaying the energization of the cathode-anode circuit for a length of time after the cathode is heated depending upon the time the cathode takes to reach the proper operating temperature, said means including a thermostatic switch contained within the envelope.

2. In combination, an arc discharge device 40 comprising an envelope containing a thermionic cathode and an anode, circuits for heating the cathode and for energizing the cathode-anode circuit, and means for closing the heating circuit prior to the closure of the cathode-anode energization circuit, the length of time 45 between the closure of said cathode heating circuit and the closure of said latter circuit being dependent upon the time interval the cathode takes in reaching the proper operating temperature, and said means including a thermostatic switch contained within the envelope.

3. In combination, an electric discharge device comprising a thermionic cathode, an anode, an external current source for heating said cathode, 50 an external current source for energizing the cathode-anode circuit, whereby conduction is produced in the device, a switch in each of said circuits, and a common means including a thermostat within the device for delaying the closing 55 of the cathode-anode energization circuit until after the cathode heating circuit has been completed.

4. In combination, an electric discharge device containing a thermionic cathode, an anode, an external current source for heating said cathode, 60 an external current source for energizing the cathode-anode circuit, whereby conduction is produced in the device, electromagnetic means for closing the cathode-anode circuit after the cathode heating circuit has been completed, said 65 means being controlled by a thermostatic switch contained within the device and operating under the influence of cathode temperature.

5. In combination, an electric discharge device 75 containing a cathode, an anode, an external cur-

rent source for heating said cathode, a current source for energizing the cathode-anode circuit, whereby conduction is produced in the device, a thermostatic switch in said device, means exterior to the device for closing the cathode-anode circuit after the cathode heating circuit has been 5 completed and for reducing the voltage of the energy supplied to the cathode, said means being controlled by said thermostatic switch and operating under the influence of cathode temperature. 10

6. In combination, an electric discharge device comprising an envelope containing a thermionic cathode and an anode, a heating circuit for said cathode, a source of current for energizing the anode-cathode circuit of said device, and a ther- 15 mostatic switch within said envelope in thermal relation to said thermionic cathode, and means including said thermostatic switch for preventing the flow of current in said anode-cathode circuit when said cathode is below a predetermined tem- 20 perature.

7. A thermionic discharge device comprising a sealed envelope containing an ionizable atmosphere, a thermionic cathode and an anode within said envelope, means for heating said cathode, 25 means for preventing a discharge from occurring between said cathode and anode, and means responsive to the temperature of said cathode for rendering said last-named means inoperative to prevent said discharge from occurring when 30 the temperature of said cathode has risen above a predetermined point.

8. A thermionic discharge device comprising a sealed envelope containing an ionizable atmosphere, a thermionic cathode, and an anode within 35 said envelope, means for supplying heating current to said cathode, means for preventing a discharge from occurring between said cathode and anode, and thermostatic means within said envelope for rendering said last-named means in- 40 operative to prevent said discharge from occurring until a definite time interval has elapsed after the heating current is first supplied to said cathode.

9. In combination, an electric discharge device comprising an envelope containing a cathode 45 and an anode, a source of electromotive force for heating the cathode, a normally energized anode-cathode circuit, means for preventing passage of current between the cathode and anode until the cathode has reached a predetermined tem- 50 perature, said means comprising an electrode normally charged negatively with respect to the cathode, and means including a thermostatic switch directly responsive to cathode temperature for reducing the negative charge on said electrode 55 when the cathode has reached the proper temperature whereby current through the device is permitted.

10. In combination, an electric discharge de- 60 vice comprising an envelope containing a cathode and an anode, a source of electromotive force for heating the cathode, a normally energized anode-cathode circuit, means for preventing pas- 65 sage of current between the cathode and anode until the cathode has reached a predetermined temperature, said means comprising an electrode normally charged negatively with respect to the cathode, and means including a thermostatic switch secured directly to the cathode surface, 70 for reducing the negative charge on said electrode when the cathode has reached the proper temperature whereby current through the device is permitted.

11. In combination, an arc discharge device 75

comprising an envelope containing a cathode, an anode and an ionizable medium, a source of electromotive force for heating the cathode, a normally energized anode-cathode circuit whereby ionization is adapted to be produced in the device, and means for preventing ionization in the device until the cathode has reached a predetermined temperature, said means comprising an electrode normally charged negatively with respect to the cathode, and means for connecting the electrode to the cathode when the latter has reached the predetermined temperature, whereby the negative charge is reduced and ionization in the device permitted.

12. In combination, an arc discharge device comprising an envelope containing a thermionic cathode, an anode and an ionizable medium, a source of electromotive force for heating the cathode, a normally energized anode-cathode circuit whereby ionization is adapted to be produced in the device, and means for preventing ionization in the device until the cathode has reached a predetermined temperature, said means comprising an electrode normally charged negatively with respect to the cathode, and means including a thermostatic switch responsive to cathode temperature for connecting the electrode to the cathode when the latter has reached the predetermined temperature, whereby the negative charge is reduced and ionization in the device permitted.

13. In combination, an arc discharge device comprising an envelope containing a cathode, an anode and an ionizable medium, said cathode having an electronically active surface, a source of electromotive force for activating said surface, an alternating current source for energizing the cathode-anode circuit whereby ionization normally would be produced in the device and the oxide coating destroyed by excessive positive ion bombardment, and means for preventing ionization until the cathode has reached the proper operating temperature whereby excessive positive ion bombardment is prevented, said means including a normally negatively charged electrode and thermostat responsive to cathode temperature, said negatively charged electrode being adapted to be energized by combined alter-

nating current and direct current voltages, and means for shifting the phase between the alternating current voltage applied to said electrode and the voltage applied between the cathode and anode.

14. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, controlling means interposed between said cathode and anode, means for impressing a negative charge upon said controlling means whereby a discharge between said cathode and anode is prevented, means responsive to the temperature adjacent the cathode for removing said charge when said temperature rises above a predetermined point.

15. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, means interposed between said cathode and anode for substantially shutting off the flow of electrons from the cathode to the anode, and means responsive to the temperature adjacent the cathode for rendering said last-named means inoperative to prevent said flow when the said temperature rises above a predetermined point.

16. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode and an anode within said envelope, a source of current for furnishing heating current to said cathode, a screen interposed between said cathode and anode, said screen being normally charged negatively with respect to said cathode, and means responsive to temperature adjacent said cathode for removing said negative charge.

17. A thermionic vapor discharge device comprising a sealed envelope containing a vapor, a thermionic cathode, and an anode within said envelope, a source of current for furnishing heating current to said cathode, a screen interposed between said cathode and anode, said screen being normally charged negatively with respect to said cathode, and means responsive to temperature adjacent said cathode for removing said negative charge by electrically connecting said screen to said cathode.

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