March 14, 1939. K. H. KINGDON 2,150,770

ELECTRICAL DISCHARGE DEVICE

Filed Jan. 26, 1937

Fig. 1.

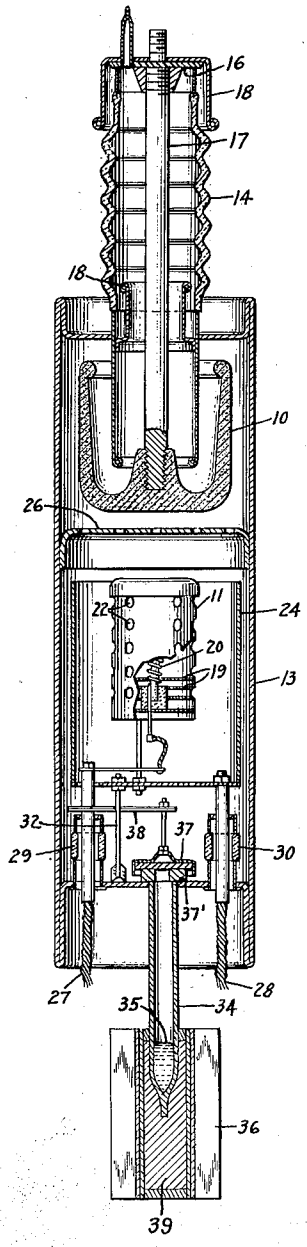


Fig. 2.

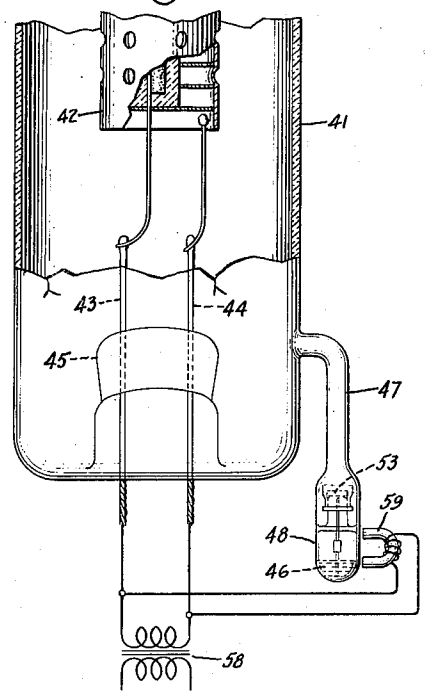
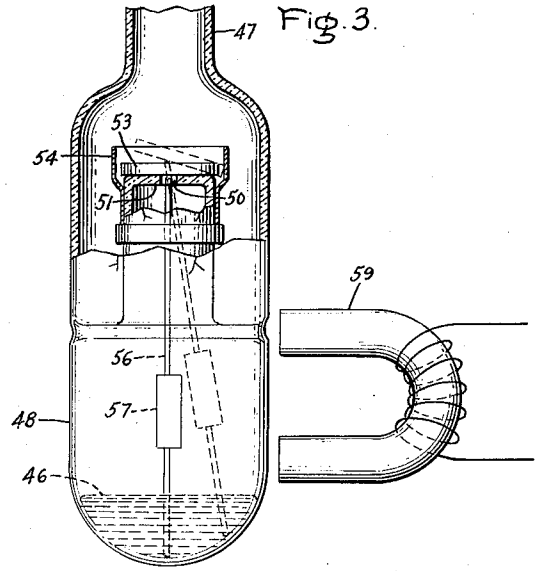


Fig. 3.



Inventor:
Kenneth H. Kingdon,
by Harry E. Dunham
His Attorney.

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ELECTRICAL DISCHARGE DEVICE

Kenneth H. Kingdon, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

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6 Claims. (Cl. 250—27.5)

The present invention relates to electrical discharge devices, and more particularly to devices which utilize a condensible ionizable medium as an operating atmosphere.

In the operation of discharge devices of the class mentioned it is important that the pressure of the operating atmosphere be maintained within predetermined limits. At pressures above a permissible maximum the device may lose its unidirectional characteristic if it is of the two-electrode type, or may cease to be controllable if it is of the three-electrode grid-controlled variety. In stable operation the pressure is customarily governed by the provision of some condensing point which is maintained at a temperature below that of the remaining parts of the device. This expedient limits the pressure existing in the discharge space by condensing all vapor in excess of that required to maintain a pressure corresponding approximately to the temperature of the condensing point.

While such a mode of regulation is satisfactory after a condition of stable operation has been attained, it is not entirely adequate to solve the problems presented in connection with restarting a discharge device after a prolonged period of disuse. After such disuse it is frequently found that by diffusion or otherwise the condensed vapor has become more or less uniformly distributed on the walls and electrodes in the discharge space. Under these conditions, initial operation will result in abnormally high pressures being produced by rapid vaporization of condensed medium from the heated parts. As a result, imperfect or uncontrollable operation may occur and persist for from one to several hours depending on the amount of time required to cause all the excess vapor to be condensed at the normal condensation point.

It is an object of the present invention to obviate this difficulty by preventing excess condensate from leaving the preferred condensation region during periods of disuse of the device. In one aspect of the invention this is accomplished by controlling the connection between such region and the main body of the discharge envelope in accordance with a predetermined condition of operation of the device. A preferred embodiment includes a valve interposed between the condenser and the envelope and thermostatic or electromagnetic means for controlling the position of the valve in dependence on the energization of one of the discharge electrodes.

The features of novelty desired to be protected herein will be pointed out with particularity in the appended claims. The invention itself may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 represents a longitudinal section of a discharge device suitably embodying the invention; Fig. 2 is a fragmentary view in partial section illustrating an alternative mode of application of the invention, and Fig. 3 is a view showing in greater detail certain of the operative parts of Fig. 2.

Referring particularly to Fig. 1 I have shown a three-electrode discharge device primarily intended for high voltage use. The main discharge electrodes of the device comprise an anode 10 and a separately heated cathode 11, these elements being enclosed in a sealed envelope 13. In the illustrated embodiment the envelope consists principally of metal and is constructed and arranged to serve as a control electrode for the main discharge. It should be understood, however, as far as the present invention is concerned, the arrangement of the electrodes is immaterial and that the envelope may be used as the anode, for example, without affecting the applicability of the invention.

The anode 10 is supported and insulated from the upper end of the envelope 13 by means of a corrugated sleeve 14, for example, of glass or another vitreous insulating material. The sleeve may be hermetically sealed to the metal of the envelope in a conventional fashion and may be closed at its upper end by means of a metal cap 16 joined thereto and to an anode mounting rod 17. The various glass-to-metal joints may be protected against ionic bombardment caused by the high electrostatic fields existing during operation by means of metal shields 18 suitably arranged for that purpose.

The cathode 11 is illustrated as being of the indirectly heated type in which the principal electron emission occurs from extended surfaces provided by a plurality of spaced disks 19. These disks may be coated with an activating substance, for example, an alkaline-earth metal oxide and are heated by radiation from an electrical resistance heater 20 arranged axially within the cathode. The cathode structure as a whole is enclosed in a metal casing (indicated by the leadline from the numeral 11) which casing is provided with a plurality of openings 22 to permit the passage of a discharge therethrough. Around the cathode and interposed between it and the walls of the envelope 10 there is provided a metal shield 24 adapted to control the electrostatic field between the cathode and the

envelope and to cause the normal path of electron travel to be in the direction of the anode. The controlling function of the envelope is supplemented by means of a transverse metal barrier 26 interposed between the cathode and anode and having a sufficient number of openings to permit the passage of a discharge to the anode.

The cathode and its heating elements are supplied with current by means of conductors 27 and 28 which are sealed through the lower wall of the discharge envelope. Each of these conductors is insulated from the envelope by means of a glass sleeve, such sleeves being numbered 29 and 30 respectively. The portion of the conductor 28 which is within the discharge envelope is connected to the shield 24 in such a way as to furnish support for the cathode structure as a whole. Additional support is provided by means of a tie rod 32 which rests on the bottom of the envelope and is connected at its upper end with the base of the shield 24.

The envelope 13 encloses a quantity of a condensible ionizable medium, for example, mercury, which is capable of supporting a low voltage discharge between the anode 10 and the cathode 11. Associated with the main body of the envelope 13 there is provided means for condensing vaporous ionizable medium in excess of that required to maintain a desired operating pressure within the envelope. In the present instance such means is illustrated as comprising a container 34 in the form of a tubulation depending from the bottom of the envelope and maintained in communication with the envelope interior by means of an opening in the envelope wall. As indicated this container or condenser is arranged outside the main discharge space and may if desired include heat-dissipating means associated therewith. In the present case such means are illustrated as comprising metal vanes 36 secured in good heat-exchanging relation with the lower end of the container 34 by a mass of solder 39 or other heat-conducting material. These vanes preferably have an area materially in excess of the cross-sectional area of the metal tube which connects with the bottom of the envelope. With this arrangement, which is fully described and claimed in application, Serial No. 19,867, filed May 4, 1935 in the name of Thomas A. Elder, the heat flow to the cooled portion of the condenser is limited, and that portion is enabled to be maintained at a temperature substantially below the average temperature of the envelope walls. The condensate thus collected in the container 34 is indicated by the numeral 35.

In the normal operation of the device the condenser 34 is intended to be in open communication with the interior of the envelope, so that when stable equilibrium is reached, the desired pressure will exist in the discharge space, this pressure being maintained by the action of the condenser. If such open communication is allowed to exist during periods of disuse of the discharge device, however, the mercury held in the container 34 may gradually diffuse into the main body of the envelope and become more or less uniformly distributed on the envelope walls. Thereafter in attempting to resume operation of the device the excessive vapor pressure created by vaporization of mercury from the high temperature points of the envelope will tend to make normal operation of the device impossible. As previously indicated, this excessive pressure may continue until substantially all the excess mercury has been condensed in the container 34, this procedure being a slow one and highly objectionable on that account.

In accordance with the present invention means is provided for interrupting the connection between the container 34 and the main body of the envelope during the periods of disuse of the device. Such means may comprise, for example, a valve operable either independently by the operator or automatically in accordance with a condition of operation of the device. In the particular arrangement illustrated in Fig. 1 a valve 37 is shown as being positioned to close the opening through which the container 34 communicates with the interior of the envelope 13. This valve is adapted to cooperate with a valve seat 37', the opposed faces of these two members being so formed as to constitute a relatively tight closure. Actuation of the valve 37 is controlled by a thermostatic element 38 which in turn is actuated in accordance with the energization of the cathode 11. Specifically, the thermostatic element 38 is supported on the upper portion of the conductor 27 so that it is in good heat exchanging relation with the cathode structure, or at least with that portion of the cathode structure which comprises the shield 24. With this arrangement as long as the cathode is at low temperature, as it is during its inoperative periods, the valve 37 will remain tightly closed, thus substantially preventing the escape of mercury into the envelope interior. However, as soon as the cathode heats up as a result of current being supplied to the resistance heater 20, the resultant flection of the thermostatic element will raise the valve 37 from its seat and establish a normal connection between the container 34 and the discharge space.

An alternative mode of application of the invention is illustrated in Figs. 2 and 3 in which for the sake of simplicity there is shown only a portion of the discharge device, such portion comprising the lower end of a glass envelope 41 and a cathode 42 corresponding in essential particulars to the cathode described in connection with Fig. 1. In this case the cathode 42 is supported and supplied with current by means of lead-in conductors 43 and 44 sealed through a press 45 formed at the base of the envelope.

Condensing means for the ionizable medium within the envelope is provided in the form of an offset tubulation 47 terminating at its lower end in an enlarged bulbous portion 48 adapted to receive the condensate 46. The bulbous portion or container 48 connects with the tubulation 47 and the main body of the envelope only by means of an orifice 50 formed in a separating wall 51 (see Fig. 3). During periods of disuse of the discharge device, this orifice is closed by means of a flattened disk 53 resting against the upper surface of the wall 51. This disk is held loosely in place by means of a retainer 54 but is capable of moving under the action of a mechanically separate push-rod 56. The rod 56 includes as an intermediate portion thereof a magnetic armature 57, and the rod as a whole is of sufficient length so that its lower end rests on the curved bottom of the container 48. Under normal conditions, that is, during periods of disuse of the discharge device, this rod assumes the position shown in full outline in Fig. 2.

When the cathode 42 is energized by the application of voltage to the energizing transformer 58 preparatory to using the discharge device, the armature 57 is drawn aside by the action of an electromagnet 59 also connected to the transformer. Under these conditions the push-rod as-

sumes the position indicated in dotted outline in Fig. 3. Furthermore, the action of its lower end in riding up the inclined surface of the wall of the container 48 is such as to cause the disk 53 to be lifted from its seat and to open the orifice 50. This operation places the container 48 in communication with the discharge space and assures the maintenance of the desired pressure conditions during the subsequent use of the device.

As a result of either of the arrangements described in the foregoing the escape of mercury or other vaporizable ionizable medium into the main body of the envelope during periods of disuse is substantially prevented. Consequently no appreciable delay in restarting the device is required in order to permit a normal condition of vapor equilibrium to be established.

The prevention of excessive accumulation of condensed vapor in the discharge space has other advantages in addition to those particularly emphasized in the foregoing. It has been noted, for example, that when mercury is employed as the operating medium, stripping of active material from the cathode surfaces is frequently caused by the chemical action of the mercury condensing on such surfaces when the device is not in operation. By limiting the mercury in the envelope to the relatively small quantity actually vaporized during active periods, this effect is almost entirely eliminated.

While I have shown particular embodiments of my invention, it will be understood by those skilled in the art that many modifications may be made without departing from the invention, and I aim by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

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

1. An electrical discharge device including a sealed envelope enclosing a quantity of condensible ionizable medium, electrodes including a separately heated cathode within the envelope adapted to be energized during the operation of the device, a cooling condenser outside the envelope for receiving excess ionizable medium, a connection between the cooling condenser and the interior of the envelope, a valve interposed in said connection, and means including a thermostatic element effective to open the valve upon energization of the cathode and to close the valve upon deenergization thereof.

2. An electrical discharge device comprising a sealed envelope consisting principally of metal and enclosing a quantity of mercury, electrodes within the envelope including a separately heated cathode, a hollow tubulation projecting outwardly of the envelope for condensing excess mercury, a valve controlling the connection between the tubulation and said envelope and a thermostatic element for controlling the opening and closing of said valve, said element being in good heat-exchanging relation with said cathode whereby said valve is opened only in response to energization of the cathode.

3. A discharge device including an envelope enclosing discharge electrodes and a quantity of a condensible medium, means outside the envelope for condensing excess medium during normal operation of the device, a connection between the condensing means and the interior of the envelope, means closing the said connection during periods when the device is not in use, and means including an electro-magnet which is energized automatically in response to energization of the device for opening the said connection.

4. An electrical discharge device including a sealed envelope enclosing a quantity of condensible ionizable medium, electrodes including a cathode, and means for heating the same, a condenser outside of the main body of the envelope for receiving excess ionizable medium, a connection between said condenser and said envelope, a valve controlling said connection, said valves being closed during periods when the device is not in use, and means including an electro-magnet for opening the said valve in response to the energization of said cathode heating means.

5. An electrical discharge device including an envelope, means within the envelope providing terminals for a discharge therethrough, an auxiliary container connecting with the envelope and enclosing a quantity of mercury, means responsive to an operating condition of the device for maintaining said container in substantially free communication with the interior of the envelope throughout the entire period of normal operation of the device, and means automatically effective in response to deenergization of the device to interrupt the connection between the envelope and the container during periods when the device is not in use.

6. An electrical discharge device including an envelope enclosing a quantity of condensible ionizable medium, electrodes within the envelope adapted to be energized during the operation of the device, a condensing chamber connected with the envelope for receiving excess ionizable medium, a vapor-conveying connection between the condensing chamber and the interior of the envelope, means closing said connection during periods when the device is not in use, and means operable automatically upon energization of the device for opening said connection and for maintaining it open throughout the operation of the device.

KENNETH H. KINGDON.