

Nov. 29, 1949

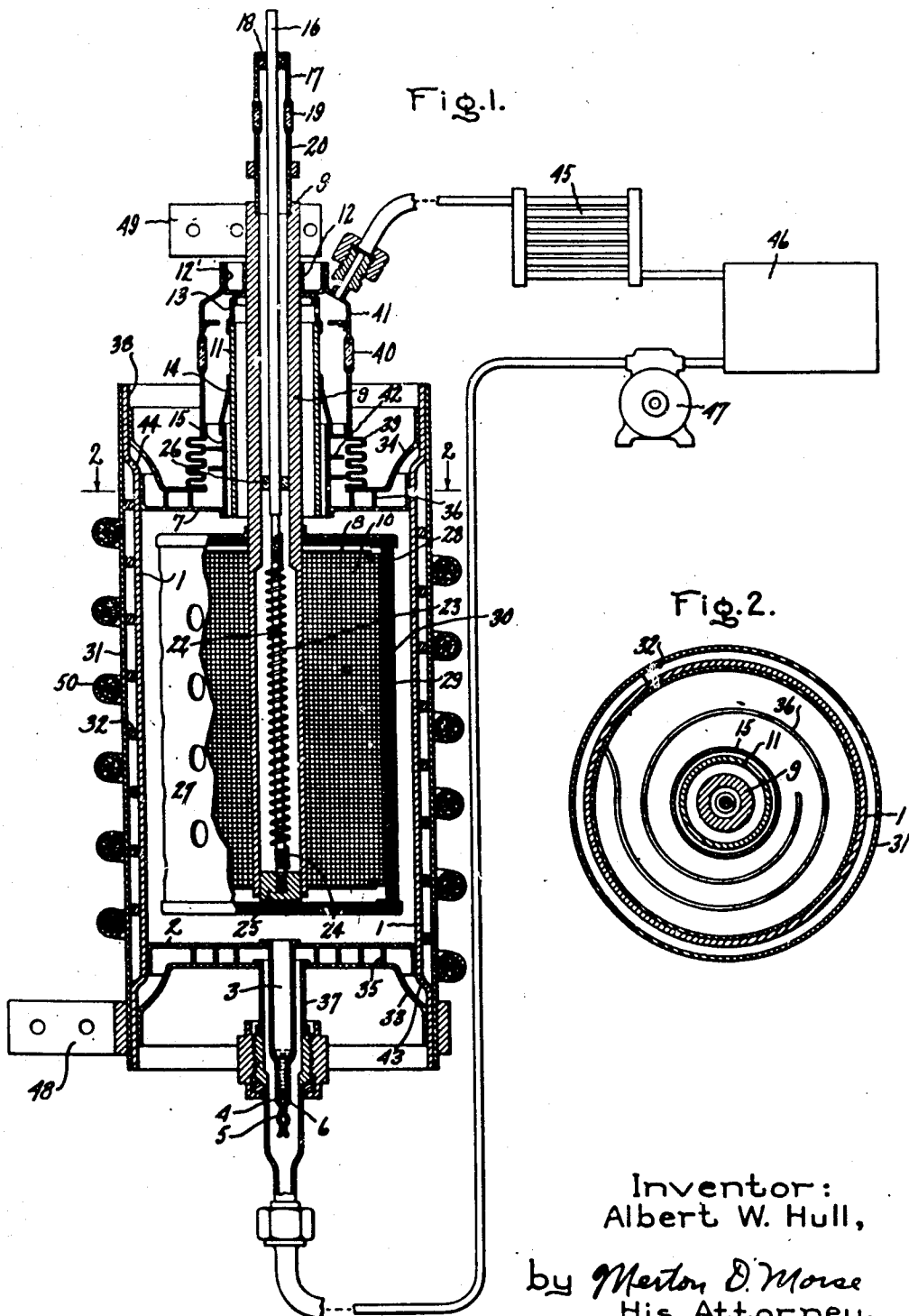
A. W. HULL

2,489,891

CAESIUM ELECTRIC DISCHARGE DEVICE

Filed Dec. 27, 1948

2 Sheets-Sheet 1



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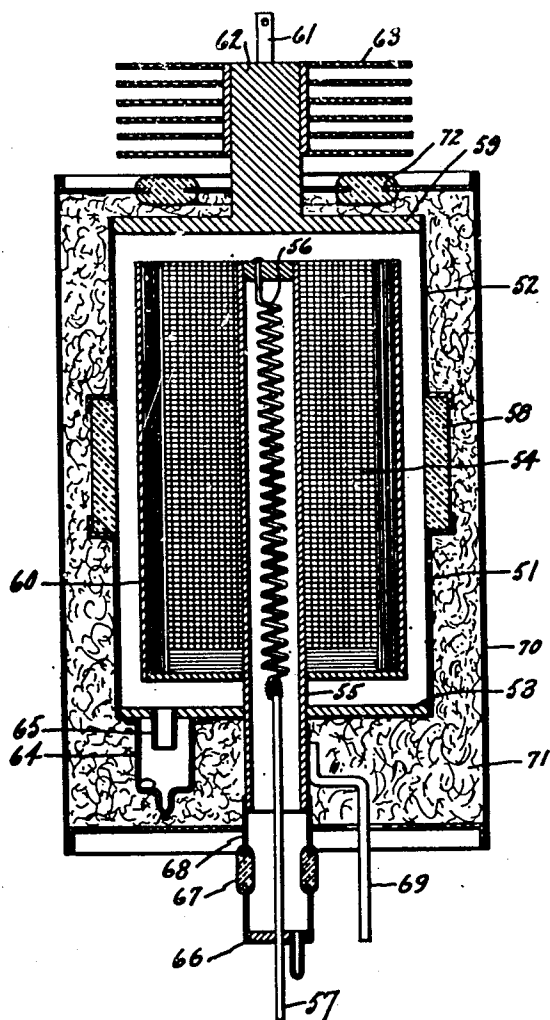
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Fig. 3.



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UNITED STATES PATENT OFFICE

2,489,891

CESIUM ELECTRIC DISCHARGE DEVICE

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Application December 27, 1948, Serial No. 67,475

9 Claims. (Cl. 250—27.5)

1 The present invention relates to electric discharge devices of the type utilizing an ionizable medium and particularly to improved devices of this character employing caesium or rubidium as the material to be ionized.

Mercury vapor electric discharge devices have been widely used for controlling electric current through a space discharge. Many attempts have been made to substitute caesium for mercury since caesium possesses many properties more advantageous than the corresponding properties of mercury. There have been practical difficulties in making a successful caesium device because of certain characteristics of the caesium. For example, the caesium is very active and attacks many materials, particularly insulators, such as the glasses which are commonly employed in making the hermetically sealed envelope. Also, the readiness with which caesium is ionized to produce conduction in a desired direction with a low arc drop is a disadvantage with respect to unwanted discharges in the inverse direction.

In accordance with an important aspect of the present invention, I provide an improved discharge device employing caesium as an ionizable medium in which commercial life is provided and in which unwanted discharges within the device are minimized.

It is an object of my invention to provide a new and improved electric discharge device of the type employing caesium as an ionizable medium.

It is another object of my invention to provide an improved temperature controlling system for electric discharge devices of the caesium type to insure adequate control of the ionization of the caesium.

Further objects and advantages of the present invention will become apparent as the following description proceeds, reference being had to the accompanying drawing in which Fig. 1 is an elevational view in section of an electric discharge device embodying my invention; Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1, and Fig. 3 is an elevational view in section of a modification of my invention.

Referring now to the drawing, I have shown my invention embodied in a discharge device comprising an hermetically sealed envelope including a cylindrical metal member 1 the inner surface of which, in the preferred embodiment illustrated, also provides the anode of the device. The lower end of the cylinder 1 is closed by a header 2 provided with a central opening from which a tubulation 3 extends. An extension 4 of the tubulation is sealed off as indicated at 5 after

2 exhaust of the device and provides a well within which the caesium employed in the tube as an activator for the cathode and as an ionizable medium is received. The liquid caesium is indicated by the numeral 6. The upper end of the cylinder 1 is closed by a header 7 having a larger central opening through which the cathode support and lead-in conductors are sealed. As illustrated in the drawing, the cathode includes a plurality of vanes 8 which extend radially from a metal cylinder 9. The cylinder and vanes are preferably formed of nickel and the active surface of the cathode may be increased if desired by covering the vanes with a nickel mesh 10. The cathode is supported from the header 7 by means of an insulating seal including an elongated cylinder 11 of a ceramic which is not attacked by caesium, such as one of the alumina or one of the magnesium silicate ceramics. As shown in the drawing, the metal cylinder 9 of the cathode assembly is bonded to a metal collar 12 which is joined to the outer end of the ceramic cylinder 11 by means of a metal sleeve 13. The junction between the sleeve 13 and the ceramic cylinder 11 is preferably formed by one of the relatively new methods of bonding ceramics to metal in vacuum tight relationship and to advantage may be produced by the manganese-molybdenum method described and claimed in copending Nolte application Serial No. 722,029, filed January 14, 1947, and assigned to the assignee of this application. At a point on the exterior of the cylinder 11, spaced substantially from the inner end of the cylinder, another metal sleeve 14 is bonded in the same manner as the sleeve 13. This sleeve 14 is brazed to a sleeve 15 which is in turn brazed or welded to the header 7 in the region surrounding the central opening.

As indicated in the drawing, the ceramic sleeve 11 extends to the inner surface of the header 7 and is spaced from the sleeves 14 and 15. It is apparent that this construction provides a very long surface leakage path on the surface of the ceramic insulator and, as will be described in more detail at a later point in the specification, facilitates the desired control of the operating temperature of this cathode insulator which is an important aspect of this invention.

The metal cylinder 9, in addition to supporting the cathode vanes provides an hermetically sealed enclosure for a cathode heater assembly including a central support and lead-in conductor 16 which is supported from the outer end of the cylinder 9 by means of a cap 17 of a suitable glass sealing alloy, such as one of the iron-nickel-

silicate or aluminum oxides withstand caesium very satisfactorily. Also prior art tube constructions have failed to provide a structure and temperature controlling system for maintaining the proper absolute and relative temperatures of the various parts of the tube to permit conduction in a forward direction but at the same time substantially to eliminate conditions tending to establish conduction in the inverse direction. For example, it is necessary that some portion of the insulating path on the inner surface of the cathode insulator 11 be maintained at a temperature above the temperature of the liquid caesium to prevent condensation of caesium on this surface and the destruction of its value as an insulator. A temperature of 50°-100° C. in excess of the liquid caesium temperature has been found very satisfactory for this purpose. With higher temperatures, the surface leakage resistance of the insulator may decrease rapidly.

With the temperature of the anode surface above 400° C., the tendency of the anode to become an emitter becomes marked and the possibility of arc back becomes substantial. In accordance with important aspects of the present invention, the construction of the present device incorporates positioning of the various components in a manner to take advantage of the heat available during normal operation of the device which together with a novel temperature controlling system insures the relative and absolute temperatures indicated above for optimum operating conditions. The caesium well 3 is also placed out of the region of the electric field between the anode and cathode. The liquid caesium is, as a result, not subjected to ion bombardment during the inverse voltage cycle and the possibility of arc back is substantially reduced. In the operation of a device constructed in accordance with the illustrated embodiment of my invention and with a tube substantially twice the physical size of the one illustrated in the drawing, the heat generated with a load of 200 amperes average in the anode-cathode circuit and with a cathode heating input of 200 watts was just sufficient to maintain the temperature of the various parts of the device at optimum value. In other words, the heat loss from the cooling liquid was equal to the losses in the rectifier. The efficiency at 200 amperes and 250 volts was approximately 98% and the arc drop about three volts.

In Fig. 3, I have shown an air-cooled modification of my invention which is particularly suited for tubes of smaller rating, for example, in tubes having 100 amperes peak rating or less. In accordance with the embodiment of my invention illustrated in Fig. 3, an envelope is provided by a pair of metal cylinders 51 and 52 which may, to advantage, be formed of an iron-nickel sealing alloy. The cylinder 51 is closed at its lower end by an iron header 53 which supports a cathode assembly very similar to the cathode assembly described in detail in connection with Fig. 1 and which includes a plurality of nickel vanes 54 supported from a tube 55 also preferably of nickel. A heater 56 is supported within the tube 55 in insulated relation with respect thereto and is provided with an externally accessible lead-in conductor 57. The cylinders 51 and 52 are hermetically joined at their inner ends by a cylindrical insulator 58 consisting of a suitable ceramic material.

The upper end of the envelope is completed by a disk 59 preferably of copper which forms

the anode of the device. The cathode is provided with a cylindrical heat shield 60 which is open at its upper end only to provide discharge openings between adjacent vanes which face the active surface of the anode. A suitable anode connection is provided by terminal 61 supported from a stud 62 which also supports an anode cooling radiator 63. A well for receiving the caesium is provided by a tubulation 64 extending from the lower header 53 of the envelope. As illustrated a smaller tube 65 extends into the tubulation 64 to provide a re-entrant orifice which substantially eliminates any escape of liquid caesium due to motion or inclination of the tube. The lower end of the cathode tube 55 extends through the header 53 of the envelope and is hermetically sealed by a cap 66 which is joined to the tube 55 by a glass sleeve 67 and a metal sleeve 68. A suitable terminal 69 for the cathode circuit is bonded to the lower end of the tube 55. The envelope is enclosed by a larger housing 70 which provides space for the reception of a suitable insulating material 71, such as glass wool. As illustrated, the housing 70 is joined to the sleeve 68 and to the anode stud 62. A ring of glass 72 is interposed in the upper end of the housing to maintain the insulated relationship of the anode and cathode circuits. The quantity of glass wool employed in different parts of the insulating jacket is proportioned to maintain the desired relative temperatures of the operating parts as described in connection with Fig. 1. It will be apparent from the illustrated embodiment that the insulator 54 receives substantial heat from the cathode and will be maintained at a higher temperature than the well 54 for the caesium thereby insuring that the caesium will not condense on the insulator. The anode radiator is also proportioned to maintain the operating temperature of the anode at 400° C. or lower. A fan may be employed in cooperation with the radiator if desired.

In the foregoing description, the invention has been described in connection with a device employing caesium. It is to be understood that for the purposes of the invention rubidium is to be considered as an alternative or equivalent of caesium.

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

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

1. An electric discharge device comprising an hermetically sealed metal envelope, a quantity of liquid metal selected from the group consisting of caesium and rubidium within said envelope, a cathode assembly, means supporting said cathode assembly within said envelope in insulated relation with respect thereto including a ceramic insulator forming part of the envelope wall and positioned to receive substantial heat from said cathode structure during operation of the device to maintain the temperature of the insulator above that of the liquid metal.

2. An electric discharge device comprising an hermetically sealed metal envelope, a quantity of liquid caesium within said envelope, a cathode assembly, means supporting said cathode assembly within said envelope in insulated relation with

respect thereto including a ceramic insulator forming part of the envelope wall and positioned to receive substantial heat from said cathode structure during operation of the device to maintain the temperature of the insulator above that of the liquid caesium, and means surrounding the insulator for controlling the heat transfer from said insulator.

3. An electric discharge device comprising an hermetically sealed metal envelope, a quantity of liquid caesium within said envelope, a cathode assembly within said envelope in insulated relation with respect thereto including a ceramic insulator forming part of the envelope wall and positioned to receive substantial heat from said cathode structure during operation of the device to maintain the temperature of the insulator above that of the liquid caesium, a second insulator secured to said cathode assembly and engaging an inner wall of said envelope to position said cathode assembly, the heat transferred to said insulator during operation of said device being sufficient to insure that the temperature of said insulator is above that of the liquid caesium.

4. An electric discharge device comprising an hermetically sealed envelope, a quantity of caesium in the envelope, a cathode assembly within the envelope supported in insulated relation with respect to said envelope, a receptacle forming a part of said envelope for receiving liquid caesium, said receptacle being positioned out of the electric field existing between the cathode and anode surface during operation of the device and heat exchange controlling means surrounding at least a part of said envelope to maintain said receptacle at a lower temperature during operation of the device than any other interior surface of the device.

5. An electric discharge device comprising a metal envelope, a quantity of caesium within the envelope, a cathode supported within said envelope and including a lead-in conductor extending through an opening in said envelope, an elongated cylindrical ceramic insulator extending through said opening and bonded at one end to said lead-in conductor and at a point remote from the other end of said insulator to said envelope, a well extending from the end of said envelope opposite said cathode and means defining cooling

passages in heat exchanging relation with said well, the wall of said envelope, and said ceramic cylinder in series so that cooling fluid may be directed in heat exchange relation with these elements in the order named.

6. An electric discharge device comprising a metal envelope, a quantity of caesium within the envelope, a cathode assembly supported within said envelope in insulated relation with respect thereto by means including an insulator forming a part of the envelope, a well extending from said envelope at a point remote from said insulator for receiving condensed caesium and means defining a path for cooling fluid in heat exchanging relation with both said well and said insulator so that said well may be maintained at a lower temperature than said insulator by fluid circulating in heat exchange relation with said well and with said insulator in the order named.

7. An electric discharge device comprising a metal envelope, a quantity of caesium within the envelope, a cathode assembly within the envelope and including a lead-in conductor extending through an opening in the envelope, an elongated ceramic cylinder joined at one end to said lead-in conductor and to said envelope at a point spaced from said one end.

8. An electric discharge device comprising a metal envelope, a quantity of caesium within the envelope, a cathode supported within said envelope in insulated relation with respect thereto and including a lead-in conductor extending through an opening in said envelope, a well extending from the end of said envelope opposite said cathode and an opening communicating with the well and the interior of the envelope defined by a re-entrant member to minimize the passage of liquid caesium into said envelope due to motion or the position of said envelope.

9. An electric discharge device comprising an envelope including a pair of cylindrical metal members, a ceramic cylinder joined to the inner ends of the cylinders, an anode surface provided at one end of said envelope, a cathode supported from the other end of said envelope and substantially filling said envelope so that said ceramic cylinder is heated by said cathode.

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No references cited.