March 28, 1944. J. H. HUTCHINGS 2,345,397

ELECTRIC DISCHARGE DEVICE

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Fig. 1.

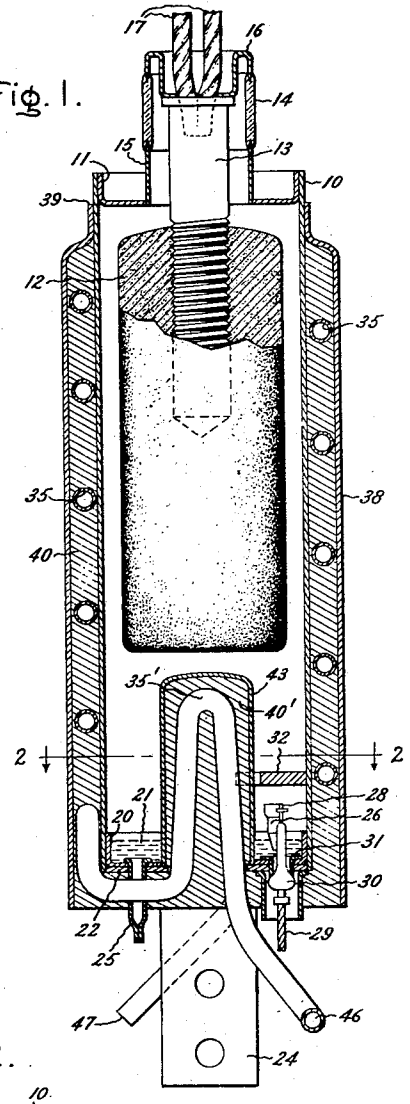
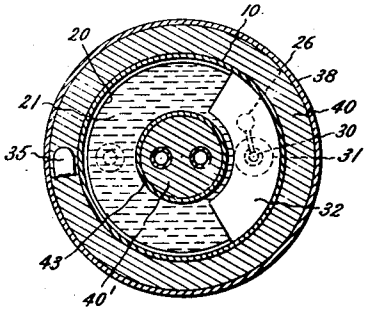


Fig. 2.



Inventor:
John H Hutchings,
by Harry E. Dunham
His Attorney.

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ELECTRIC DISCHARGE DEVICE

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

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5 Claims. (Cl. 250—27.5)

The present invention relates to improvements in electric discharge devices, more especially devices which employ a pool-type cathode, such as a cathode consisting of mercury.

Mercury pool tubes are well adapted for high current use because of the relatively unlimited electron emission which may be obtained from a mercury cathode. For this reason tubes of this type have found wide application in electrically controlled welding systems and the like.

Where very high current loading is involved, the mercury pool tube exhibits some tendency to arc-back, a condition which is a function of the temperature of the tube or of its internal parts. In order to minimize this difficulty resort has been had to water-cooling as an expedient for raising the safe operating limit. This approach is entirely satisfactory as long as relatively constant loads are involved; on the other hand, since water cooling, as normally employed, inherently functions to remove heat at a relatively uniform rate, corresponding to the average rather than to the maximum rate of energy dissipation of the cooled device, the use of such cooling does not automatically take care of temporary load peaks. Accordingly, in an application in which intermittent and intense loading is common, as is true in welding systems, for example, water cooling is not a complete answer to the problem of arc-back.

The present invention has as a principal object the provision of an improved pool-tube construction by which arc-back occurrences due to intermittent load peaks may be substantially avoided. In this connection, an important feature of the invention consists in using in combination with an artificially cooled tube a heat-absorbing structure of sufficiently large thermal capacity to "soak up" relatively large instantaneous increments of heat without permitting a significant rise in temperature.

A further important feature of the invention consists in the use of means for decreasing the deionization time of a mercury pool tube with the aim of eliminating arc-back occurrences due to the presence of positive ions and high vapor density in the discharge space during periods of inverse potential. In one embodiment such means comprises a cooled, massive conductive structure occupying the central region of the discharge path and affording a readily accessible collecting surface for positive ions and mercury vapor molecules.

The aspects of the invention which I desire to protect herein are pointed out with the particularity in the appended claims. The invention itself, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 is a longitudinal sectional view of a discharge device suitably embodying the invention, and Fig. 2 is a transverse section taken on line 2—2 of Fig. 1.

Referring particularly to Fig. 1, there is illustrated a mercury pool tube of a type which is particularly adapted for use in electronically controlled welding systems, or in any other application involving intermittent loading. This includes an elongated metal envelope having as one part thereof a cylinder 10 which is constituted of an appropriate structural metal such as low carbon steel. The cylinder 10 is closed at its upper extremity by means of a flanged header 11, and from this there is supported an anode 12 which extends for a substantial distance along the axis of the cylinder. The anode, which may suitably consist of graphite, is mounted on a heavy metal rod 13 and this, in turn, is insulatingly supported from the header 11 through a glass sleeve 14. The sleeve is joined to the header through a metal ring 15 and is closed at its upper end by means of a metal cap 16, these parts being formed of a metal such as nickel-iron-cobalt alloy which is capable of being sealed directly to glass. The central portion of the cap 16 is welded or otherwise solidly joined to the upper extremity of the rod 13, and a pair of flexible conductors 17 extend through an opening in the cap into a socket in the end of the rod, a solid joint being produced by soldering or otherwise.

The lower end of the cylinder 10 is closed by a second flanged header 20 which is in contact with a pool type cathode comprising a body of mercury 21. The header is reinforced by a relatively heavy disk 22 solidly affixed to its bottom surface and is provided with a terminal stud 24 for conducting current to the header 20 and thence to the cathode 21. A tubulation 25 which is welded into the header serves as a means for evacuating the tube during its manufacture.

In order to control the initiation of a discharge between the anode 12 and the cathode 21, there is provided in connection with the latter an immersion starting electrode 26. This comprises a body of high resistance material such as boron carbide and is supported in permanent contact with the cathode by means of a

rigid conductor 28. This conductor extends outwardly through the bottom of the header 20 so as to connect with a current supply wire 29 and is insulatingly mounted by means of a body of glass 30 and a cooperating metal eyelet 31.

In the use of the device in a system in which alternating potential is impressed between the anode 12 and the cathode 21, a discharge may be initiated by impressing voltage between the electrode 26 and the cathode at a time when the anode is positive. Accordingly the device may be made intermittently conducting so as to control the passage of current to a utilization device such as a welding apparatus. Moreover, by appropriate phasing of the control potential applied to the electrode 26 the periods of conductivity may be accurately regulated in such fashion as to produce precisely regulated welding conditions. In order to prevent excessive spraying of cathode material into the interelectrode space from the vicinity of the electrode 26 (that is, from the region where the cathode spot is established) a baffle 32 is provided in connection with the latter element.

In the application of the device to a welding system the current which the device is required to carry is variable within wide limits depending upon the type of weld being made. For this reason, it is essential that the device shall be able to carry for brief intervals loads materially in excess of its capacity in continuous operation. This means that such loads shall neither produce destructive heating of any of the parts of the device, nor result in defective operation. A particular consequence of heavy loading which must be avoided is the occurrence of arc-back, that is, a discharge of electrons from the anode 12 to the cathode 21 during periods of inverse potential. The likelihood of arc-back is in part a function of temperature conditions existing within the discharge space and tends to increase as the temperature is raised. Consequently, it is desirable to provide means for continuously cooling the walls of the discharge envelope, and this is accomplished in the present instance by the use of a cooling coil 35 having its turns in heat exchange relation with the cylinder 10. However, the rate of fluid flow through such a coil is, for reasons of economy, ordinarily fixed at a value correlated to the average rather than to the peak rate of heat dissipation of the cooled device. Accordingly, while a cooling coil thus supplied functions satisfactorily as long as the loading of the device with which it is associated does not depart materially from the rated average value, it is nevertheless not readily responsive to the rapid changes in condition which occur in a device subjected to intermittently varying loads.

In order to avoid difficulties arising from this latter circumstance, I provide in addition to the cooling coil 35 a mass of metal 40 of relatively high thermal capacity and conductivity so disposed that it is also in effective heat-exchanging relation with the internal parts of the discharge device. In the preferred construction illustrated in Fig. 1, this is accomplished by disposing the selected metal in an annular space provided between the outer surface of the cylinder 10 and a larger steel cylinder 38 which is arranged concentrically with it. In order to facilitate assembly of the various elements, the cylinder 38 is joined at one extremity to the cylinder 10 (i. e. as indicated at 39) so that the annular space between the cylinders is completely closed at one end. This makes it possible first to assemble the cylinders in the arrangement in which they are shown; next, to insert the cooling coil 35, and finally, after inverting the device as a whole, to fill the space between the turns of the coil by pouring in a molten mass of a selected metal. Preferably a sufficient amount of metal is used not only to fill the chamber between the cylinders 10 and 38, but also to cover the surface of the header 20 to a considerable depth. The ignitor electrode seal 30 may be protected during this last operation by the provision of a protective sleeve 41.

The metal 40 may be any one of the commonly available metals having good thermal capacity and thermal conductivity materially above that of iron, and in this connection one may use, for example, zinc, aluminum, brass or copper. Zinc is preferable in most instances because of its low cost.

With the construction specified the thermal capacity of the casing structure of the discharge device is very much increased. Accordingly, in the event of a sudden increase in the loading of the device, the heat generated may be absorbed by the metal 40 and the associated structure with only a very small rise in the temperature of the system as a whole, and the likelihood of arc-back due to excess vapor pressure or other causes associated with increasing temperature will be minimized. The heat "soaked up" by the metal mass 40 during the emergency period will, of course, be gradually removed by the circulation of cooling fluid through the coils 35 in the ensuing period of normal operation (or, in welding applications, of cessation of conduction) thus conditioning the device for the occurrence of another peak load.

While the occurrence of arc-back is a function of temperature as stated above, it may be somewhat more directly attributable to ions left in the discharge space in the period immediately following cessation of normal conductivity. If such ions are present in quantity when inverse potential is supplied to the anode, it is known that the likelihood of arc-back occurrence is relatively high, this being apparently a result of the tendency of such ions to collect at the anode surface and to initiate emission from it. A further aspect of the present invention consists in the provision of means for shortening the deionization time of a discharge device such as that shown in Fig. 1.

The particular means which is illustrated for this purpose comprises a conductive structure extending for a substantial distance along the discharge path between the cathode 21 and the anode 12 and occupying the central region of the discharge space. In the illustrated arrangement this structure consists of a hollow metal shell 43 which is welded into a corresponding opening in the header 20 and which forms, in effect, an upright column extending into close proximity to the lower surface of the anode 12. As a result of the presence of the shell 43 and in view of the fact that the anode occupies a major portion of the cross-section of the space enclosed by the cylinder 10 so that a straight line path exists between the outer parts of its lower surface and the exposed portion of the cathode, the discharge path is of essentially annular form. It is, moreover, relatively large areas so that there is no necessity for the discharge to be of contracted form with a consequent increase in the voltage drop through the device. At the same time, the distance from any point in the discharge path to

the nearest adjacent conductive and cooled surface is a small fraction of the radius of the discharge envelope, a condition quite different from that which would prevail in the absence of the shell **43**. Accordingly, any ions produced in the discharge space (i. e. between the anode and cathode) are reasonably certain to be collected within a brief interval after generation, so that the possibility of substantial numbers of residual ions being available to produce arc-back during periods of inverse potential is much reduced.

It is desirable that the temperature of the shell **43** be maintained at a low value during operation of the device and to this end a portion **35'** of the cooling coil **35** may advantageously be disposed within the shell.

Effective heat exchange between this part of the coil and the shell may be assured by pouring into the shell a quantity **40'** of the metal **40** which is employed between the envelope cylinders **10** and **38**, this metal being appropriately introduced into both spaces at the same time. Obviously, the presence of the part **43** and the enclosed metal **40'** still further increases the thermal inertia of the structure and thus tends to prevent any excessive temperature rise. With the arrangement described cooling fluid such as water may be circulated along a continuous path from inlet **46** through conduits **35** and **35'** and finally removed through an outlet **47**.

While the invention has been described by reference to a particular embodiment thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention, I, therefore, aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

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

1. An electric discharge device comprising a relatively elongated metal casing, a mercury pool occupying the lower portion of the casing, an anode supported directly above the cathode, a conductive structure extending for a substantial distance along the discharge path and disposed axially within the casing so as to occupy the central portion of the discharge space, and a mass of metal of high thermal capacity and conductivity in thermal contact with the lateral walls of said casing, the heat-absorbing effect of said metal mass and the deionizing tendency of said conductive structure serving conjointly to minimize the likelihood of arc-back of said device upon the occurrence of intermittent, intense loading.

2. An electric discharge device comprising a mercury pool cathode, an anode supported above the cathode, an envelope enclosing the anode and cathode, said envelope comprising a pair of concentric steel cylinders defining an annular space between them, a conductive shell extending from the cathode for a substantial distance along the discharge path between the anode and cathode and disposed axially within the discharge envelope, a metal of relatively high thermal capacity and conductivity filling said shell and occupying the said annular space between the envelope cylinders, and a duct for cooling fluid extending through said metal for removing heat from said envelope and said shell.

3. A vapor discharge device comprising a cylindrical metal casing, a mercury pool occupying the lower portion of the casing, an anode supported above the cathode and in cooperative relation with respect to it, and a conductive structure extending for a substantial distance along the discharge path between the anode and cathode and disposed axially within the casing so as to occupy the central portion of the discharge space whereby the distance from any point in the discharge space to a conductive surface is materially less than the radius of the said casing.

4. An electric discharge device comprising a cylindrical metal casing, a mercury pool occupying the lower extremity of the casing, an anode supported above the cathode and occupying a major portion of the cross sectional area of the casing, and a metallic column extending from the cathode into relatively close proximity to the anode, said column occupying the central portion of the discharge space between the anode and cathode and serving to facilitate rapid deionization of said space.

5. A vapor discharge device comprising an anode, a mercury pool cathode cooperating with the anode and a metal envelope enclosing the anode and cathode, said envelope comprising an inner steel cylinder directly surrounding the discharge space, an outer steel cylinder of larger diameter than the inner cylinder and joined thereto at one extremity only so as to provide between the cylinders an annular space which is closed at one end and open at the other, a cooling coil within said annular space of such configuration as to permit its introduction into the space through the said open end thereof, and a mass of metal of high thermal capacity and conductivity fused into said annular space in contact with said coil and with said inner cylinder.

JOHN H. HUTCHINGS.