May 20, 1941. K. H. KINGDON ET AL 2,242,786

POOL-TYPE DISCHARGE DEVICE

Filed March 30, 1939 2 Sheets-Sheet 1

Fig. 1.

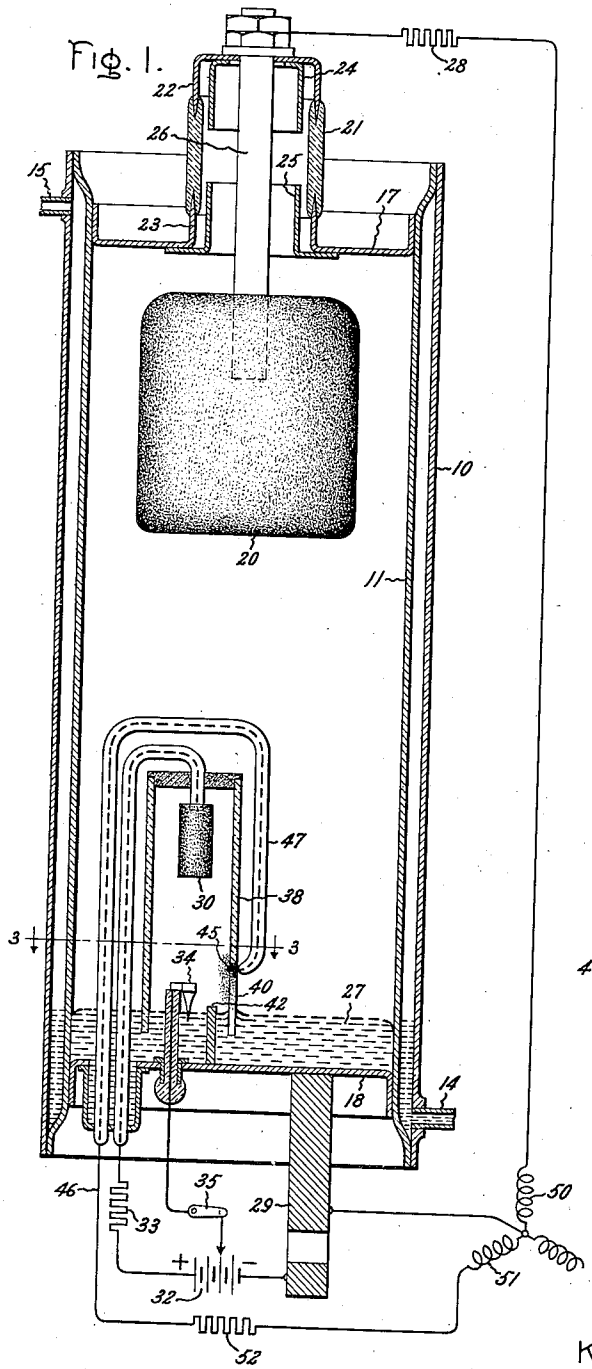


Fig. 2.

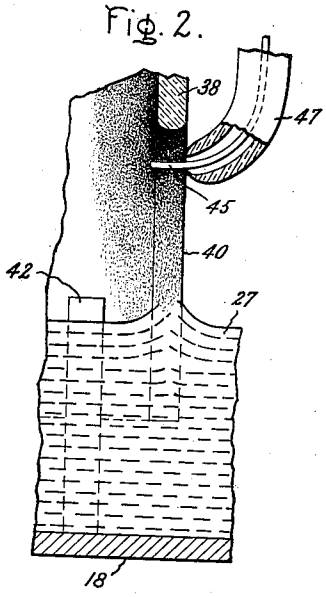
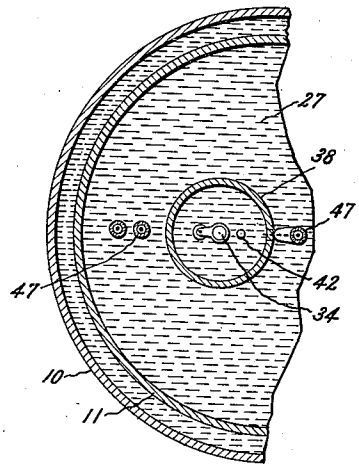


Fig. 3.



Inventors:
Kenneth H. Kingdon,
Elliott J. Lawton,
by Harry E. Dunham
Their Attorney.

May 20, 1941. K. H. KINGDON ET AL 2,242,786

POOL-TYPE DISCHARGE DEVICE

Filed March 30, 1939 2 Sheets-Sheet 2

Fig. 5.

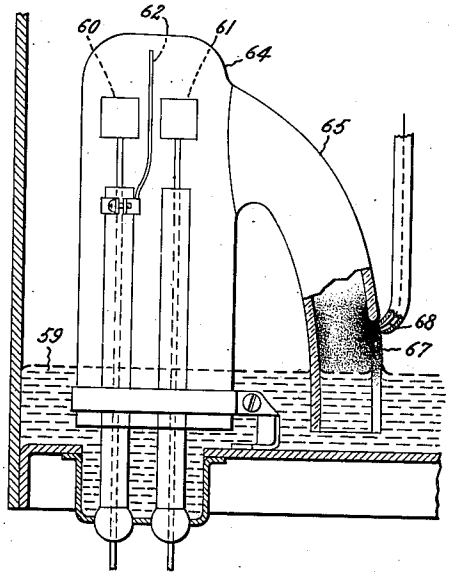


Fig. 6.

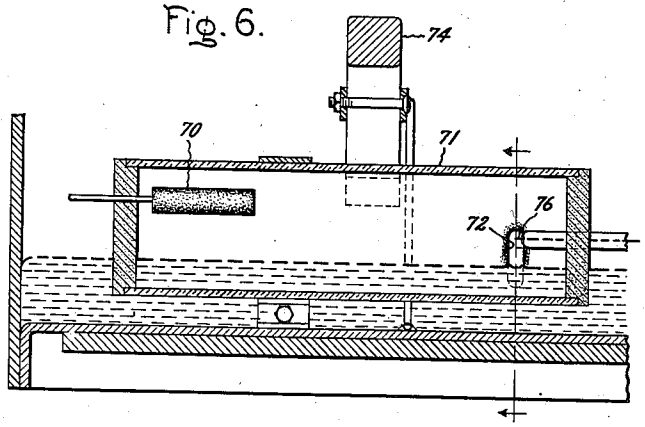


Fig. 7.

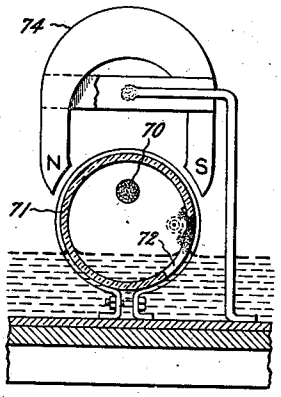
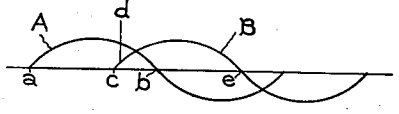


Fig. 4.



Inventors:
Kenneth H. Kingdon,
Elliott J. Lawton,
by Harry E. Dunham
Their Attorney.

Patented May 20, 1941

2,242,786

UNITED STATES PATENT OFFICE

2,242,786

POOL-TYPE DISCHARGE DEVICE

Kenneth H. Kingdon, Schenectady, and Elliott J. Lawton, Scotia, N. Y., assignors to General Electric Company, a corporation of New York

Application March 30, 1939, Serial No. 264,950

8 Claims. (Cl. 250—27.5)

The present invention relates to improved means for initiating a discharge between the principal electrodes of a pool-type discharge device, such as a mercury rectifier. While not limited thereto, the invention is primarily applicable to single anode devices, in which the main discharge requires to be reinitiated at cyclically recurrent intervals.

In common with certain known systems our invention utilizes a continuously maintained holding-arc from which the main discharge may be intermittently ignited. The invention differs from arrangements previously employed, however, in the provision of novel means for guarding the holding-arc from extinguishment. In this connection an important aspect of the invention consists in the combination of a shielding housing for the holding-arc with means for assuring the positive and independent ignition of a separate cathode spot for the main discharge.

The features which we desire to protect herein are pointed out with 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 drawings in which Fig. 1 shows in longitudinal section a discharge device suitably embodying the invention; Fig. 2 is an enlarged detail view of a fragmentary portion of the device of Fig. 1; Fig. 3 is an incomplete sectional view taken on line 3—3 of Fig. 1; Fig. 4 is a diagrammatic representation useful in explaining the operation of the invention; Fig. 5 shows one possible modification of the invention; and Figs. 6 and 7 are different sectional views of a second modification.

Referring particularly to Fig. 1 there is shown an elongated cylindrical envelope comprising two spaced metal cylinders 10 and 11. These form a chamber or jacket for receiving a cooling fluid which is introduced and withdrawn by means of inlet and outlet connections 14 and 15.

The envelope is closed at its ends by means of transversely extending circular headers 17 and 18 which are peripherally joined to the wall member 11 as by being welded thereto. At the upper end of the envelope there is provided an anode 20 which is insulatingly supported from the header 17 by means of a glass-to-metal seal. The glass element of the seal comprises a ring 21 which is joined at its extremities to cooperating metal parts 22 and 23. The points of conjunction of the glass and metal are protected against the destructive effects of the discharge by means of shielding members 24 and 25. A heavy conducting rod 26 serves both to support the anode and to connect it with an external circuit which includes a load device, illustrated as a resistor 28.

For cooperating with the anode 20 in conducting a discharge through the envelope there is provided a pool-type cathode 27 consisting, for example, of a body of mercury. This is in direct contact with the header 18 and therefore is electrically continuous with the whole body of the envelope. It may be connected to a source of potential 50 by means of a heavy conducting stud 29 which is affixed directly to the bottom of the header 18.

Assuming that the device illustrated is intended as a rectifier, it must function to conduct a cyclically interrupted discharge between the anode 20 and the cathode 27. In order to make possible the reinitiation of the discharge after each non-conducting half-cycle, there is provided means for maintaining a holding-arc to the surface of the cathode. While such means is shown as comprising a single anode 30, energized by connection to a direct current source 32, it may alternatively comprise two electrodes connected to a source of alternating potential. The magnitude of the arc-current is limited by the provision of a series resistor 33.

The holding-arc is ignited during initial starting of the discharge device by means of an immersion starting electrode as shown at 34. In accordance with known practice, this electrode may consist of a body of semi-conducting material having its tip portion maintained in contact with the cathode 27. It may be energized by being connected through a switch 35 to an appropriate terminal of the battery 32.

It is desirable to provide means to prevent the cathode spot of the holding arc from becoming attached to the metal wall of the envelope. To this end there is provided a housing structure which substantially encloses the discharge path for the holding-arc and segregates it from the main discharge space. By this means the cathode spot of the holding arc is prevented from wandering freely over the cathode surface, and at the same time the holding arc is effectively shielded from extinction by events taking place in the main discharge space.

The particular housing construction which is shown in Fig. 1 comprises a cylindrical member 38 which extends from a point below the cathode surface up to and around the holding anode 30. The housing is closed at the top by means of a circular plug consisting, for exam-

ple, of an insulating material such as lava. A restricted opening in the form of a narrow slot 40 extending normally to the cathode surface provides substantially the only communication between the interior of the housing 38 and the main discharge space. This slot may be on the order of a few millimeters in width. For reasons which will be explained more fully in the following, it is desirable that at least the portion of the housing surrounding the opening 40 be constituted of insulating material. This being so, it is convenient to make the entire housing of a refractory insulator, for example, quartz.

We are aware that it is known to use a shielding housing for the protection of the holding arc. In the prior art arrangements with which we are familiar, however, successful operation depends upon having the cathode spot of the holding arc relatively accessible to the outside space so as to permit the ready ignition of the main discharge therefrom. For example, in the shielded holding-arc arrangement which is described and claimed in Patent No. 2,152,201, granted March 28, 1939, to L. D. Miles, the cathode spot for the main anode is formed by sub-division of the cathode spot for the holding arc. In such an arrangement there is some tendency for the latter cathode spot to be drawn outside the shielding enclosure and, under unfavorable conditions, extinguished. Our present invention is distinguished by the inclusion of means by which the cathode spot for the holding arc may be retained at all times at a point which is well shielded from the main discharge space. In the present case, for example, we prefer to use an anchoring body 42 which may consist of a clean molybdenum rod projecting slightly above the surface of the mercury so as to provide an anchorage for the holding arc cathode spot at a point which is relatively displaced from the slot 40.

In order to assure the ready ignition of the main discharge in spite of the confinement of the holding arc cathode spot, our invention provides means for causing the mercury to wet at least the portion of the insulating housing 38 which surrounds the opening 40. This expedient, which results in a reversal of the mercury meniscus, is effective to cause striking of a separate cathode spot for the main discharge at the line of intersection of the mercury and the surface of the housing. The spot, once started, is free to spread as required to supply the current demands of the main discharge.

In order to obtain the result indicated in the foregoing, the portion of the housing 38 which surrounds the opening 40 is made of insulating material and is provided with a coating of a finely divided metal which is capable of being wet by mercury but which is not appreciably attacked by it. Numerous materials may serve in this connection, and molybdenum, iron and tungsten may be mentioned as examples. The first of these is considered preferable.

The arrangement referred to above is illustrated in greater detail in Fig. 2 which shows an enlarged section of the slot 40. The shading of the surface of the housing in the vicinity of the slot is intended to designate a finely divided metallic deposit. It will be seen that as a result of the presence of this deposit the mercury tends to creep up the housing wall so as to form a tapered contact therewith. It has been found that a contact of this nature is very helpful in making possible the ready initiation of a cathode spot at the line of intersection of the mercury and the housing. While we do not wish to be bound to any particular explanation of this phenomenon, we consider that it is due to the fact that the metallic coating provided on the housing results in the existence of a surface area in which small conducting elements are interspersed with small insulating elements. Under these conditions the accumulation of charges on the insulating surfaces may produce extremely high potential gradients sufficient to initiate a discharge by the mechanism of field emission. If such a discharge is once initiated at a point close to the mercury surface, it may readily spread to such surface, as previously suggested.

A metallic coating of the desired character may advantageously consist of metal which has been sputtered on the surface of the housing. It is found, however, that unless such a coating is maintained in some fashion, it tends to be automatically removed after a brief period of discharge operation. In order that this may not occur, our invention further provides means for restoring the sputtered coating of metal. In the arrangement shown such means comprises a metallic member in the nature of a probe electrode 45 positioned in the opening 40. This electrode, which preferably is constituted of a molybdenum wire, may be connected with an external source of potential through a lead-in conductor 46 which comprises a continuous extension of the electrode itself. In order to protect this conductor from the effects of the arc discharge it is covered with a suitable insulating sheath 47 consisting for example of glass or quartz. By virtue of the arrangement indicated additional material may be sputtered from the surface of the electrode 45 as required to maintain a metallic coating on the surface of the housing 38.

The electrode 45 serves a further function in the operation of the apparatus in assisting the cyclical initiation of the main discharge from the holding-arc. In order to explain this feature a full cycle of starting operation will be described.

With the holding-arc to the anode 30 in operation, a positive potential impressed on the electrode 45 will initiate a glow discharge from this electrode to the surface of the cathode 27. Because of the ionization provided in the opening 40 by this discharge, the main anode 29 is enabled to pick up current from the anchored holding-arc cathode spot. This current flows through the slot 40 and exposes the walls of the housing in the vicinity of the slot to intense ionization. When the current drawn by the main anode has reached an appreciable value, say several amperes, a new cathode spot will be struck adjacent to the line of intersection of the mercury and the housing, as previously described. This new cathode spot is free to move over the surface of the cathode outside the housing 38. The holding-arc spot, on the other hand, remains anchored at 42 throughout the entire starting period.

In order to assure fulfillment of both the functions described in the foregoing, it is desirable that the electrode 45 be energized in an appropriate fashion. To this end, if it be assumed that the main discharge receives its energy from the first phase 50 of a three-phase alternating current source, then the electrode 45 may suitably be energized from a second phase 51, which is a leading phase with respect to the phase 50. Under these circumstances the cycle of opera-

tion will be as indicated in the diagrammatic representation of Fig. 4. In this figure, the curve A is assumed to represent the potential applied to the electrode 45, while the curve B represents the main anode potential. In normal operation a glow discharge to the electrode 45 will be initiated at the point *a* or shortly thereafter. This discharge will continue to the point *b*, at which time the potential of the electrode becomes negative. At an intermediate point *c* the anode 20 will become positive and start to draw current and at a fourth point, say *d*, a new cathode spot for the main discharge will be struck. Normal conduction will then occur throughout the remainder of the half-cycle. It will be understood also that the time of starting of the main discharge may be to a certain extent controlled by controlling the phase relationship of the potential applied to the electrode 45. We therefore consider the use of the electrode 45 as a control element to be within the scope of our invention. To this end the current-limiting resistor 52 may be replaced by appropriate phase-shifting means.

As a result of the fact that the electrode 45 is at a negative potential during an appreciable portion of the main discharge cycle, that is to say, between the points *b* and *e*, it will be subjected to substantial positive ion bombardment during this period. The sputtering which thus results serves to renew the metallic coating on the surface of the housing and to assure continued operation of the device in the desired manner.

Since the arrangement described permits the cathode spot of the holding arc to be maintained at all times at a point relatively remote from the slot 40, it is effectively shielded from the effects of occurrences in the main discharge space. Consequently there is little likelihood that the holding-arc will be extinguished at any time, and the operation of the apparatus as a whole is rendered highly reliable.

An alternative arrangement which results in still more complete shielding of the holding arc is shown in Fig. 5 of the drawings, which illustrates only the holding arc assembly. In this case the holding arc is maintained to the cathode 59 by means of a pair of cooperating keep-alive electrodes 60 and 61 which are separated by means of a suitable baffle 62. Both keep-alive electrodes are enclosed in an inverted cuplike housing 64 consisting of quartz or the like. Substantially the only communication between the interior of the housing and the main discharge space is provided through a tubulation 65 which extends laterally from the side of the housing. The extremity of this tubulation is positioned beneath the surface of the mercury, but it is provided with a slot 67 which opens to the discharge space in a manner similar to the slot 40 of Fig. 1. There is also provided in connection with the slot 67 a sputterable electrode 68 which corresponds in nature and function with the electrode 45 previously described. The mechanism of discharge initiation is precisely the same in the arrangement of Fig. 5 as in that of Fig. 1.

Figs. 6 and 7 illustrate a still further variation of the invention in which magnetic means are provided for retaining the holding-arc cathode spot at a point which is thoroughly shielded from the main discharge. In this case there is provided in connection with the holding anode 70 an elongated insulating housing 71, which is provided at one end with a narrow slot 72. Outside the housing and in a region between the anode 70 and slot 72 there is mounted a magnet 74 having its respective poles disposed on opposite sides of the housing. This magnet produces a field transverse to the axis of the housing and thus serves to prevent the cathode spot associated with the holding arm from approaching the slot 72. (The use of a magnetic field in confining the motion of a cathode spot on the surface of a pool-type cathode is fully described and claimed in L. D. Miles application, Serial No. 254,156, filed February 2, 1939.)

In connection with the slot 72 there is provided a metallic electrode 76 which serves to maintain a sputtered coating on the wall of the housing adjacent the slot and also to facilitate the picking up of the main discharge. Except for the structural differences emphasized in the foregoing, the arrangement of Figs. 6 and 7 is similar in function to that of Fig. 1.

While we have described our invention in connection with particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art. We, 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 we claim as new and desire to secure by Letters Patent of the United States, is:

1. An electric discharge device comprising a main anode, a mercury pool cathode, means for maintaining a holding-arc having a cathode spot on the mercury pool surface, a housing substantially enclosing the discharge path for the holding-arc except for a restricted opening near the cathode surface, at least a portion of the housing surrounding the opening being constituted of insulating material, and a coating of finely divided metal in mutual contact with the said insulating material and with the cathode at its surface, the said metal serving in conjunction with the said insulating material to facilitate the establishment of a separate cathode spot for the main anode upon the application to the anode of a discharge-favoring potential.

2. An electric discharge device comprising a main anode, a pool-type cathode, an auxiliary anode for maintaining a holding arc having a cathode spot on the cathode surface, a housing enclosing the discharge path for the holding arc except for a restricted opening at the cathode surface, the portion of said housing surrounding the opening being constituted of insulating material, and means for maintaining a thin coating of finely divided metal on the surface of the said portion of the housing, thereby to facilitate the initiation of a cathode spot for the main anode in the vicinity of the opening.

3. An electric discharge device comprising a main anode, a pool-type cathode, an auxiliary anode for maintaining a holding-arc having a cathode spot on the surface of the cathode, a housing enclosing the discharge path for the holding-arc except for a restricted opening at the cathode surface, the portion of said housing surrounding the opening being constituted of insulating material, a coating of finely divided metal applied to the said portion of the housing for facilitating the establishment of a separate cathode spot for the main anode upon the occurrence of ionization in the vicinity of the coated region, and a metallic electrode in the vicinity of the said opening and assisting the initiation of an ionization-producing discharge to the main anode from the holding-arc cathode spot.

4. An electric discharge device comprising a main anode, a pool-type cathode, an auxiliary anode for maintaining a holding arc to the cathode surface, a housing enclosing the discharge path for the holding arc except for a restricted opening at the cathode surface, a portion of said housing surrounding the opening being constituted of insulating material, and a metallic electrode positioned in the vicinity of the opening, said electrode serving the dual purpose of assisting the initiation of a discharge to the main anode from the cathode spot associated with the holding-arc and of maintaining a coating of sputtered metal on the said portion of the housing, thereby to facilitate the formation at the coated region of a separate cathode spot for the discharge to the main anode.

5. An electric discharge device comprising a main anode, a pool-type cathode, an auxiliary anode for maintaining a holding-arc to the cathode surface, a housing enclosing the discharge path for the holding-arc except for a restricted opening at the cathode surface, a portion of said housing surrounding the opening being constituted of insulating material, and an electrode body consisting of molybdenum positioned in the vicinity of the opening, said electrode body serving the dual purpose of assisting the initiation of a discharge to the main anode from the cathode spot associated with the holding arc and of maintaining a coating of sputtered molybdenum on the said portion of the housing, thereby to facilitate the formation at the coated region of a separate cathode spot for the discharge to the main anode.

6. An electric discharge device comprising a main anode, pool-type cathode, an auxiliary anode for maintaining a holding arc to the cathode surface, a housing enclosing the discharge path for the holding-arc except for a restricted opening at the cathode surface, at least a portion of said housing surrounding the opening being constituted of insulating material, means for confining the cathode spot of the holding-arc to a region of the cathode surface relatively remote from the said opening and means for maintaining a coating of sputtered metal on the surface of the said portion of the housing, thereby to facilitate the initiation of a cathode spot for the main anode in the vicinity of the opening.

7. An electric discharge device comprising a main anode, a pool-type cathode, an auxiliary anode for maintaining a holding-arc having a cathode spot on the surface of the cathode, a housing enclosing the discharge path for the holding-arc except for a restricted opening at the cathode surface, a portion of said housing surrounding the opening being constituted of insulating material, means including a metallic electrode positioned in the vicinity of the opening for maintaining a coating of sputtered metal on the said portion of the housing, thereby to facilitate the establishment of a separate cathode spot for the main anode upon the occurrence of ionization in the vicinity of the coated region and lead-in connections for the said electrode, whereby the potential of the electrode may be varied in such fashion as to control the initiation of an ionization-producing discharge to the main anode.

8. An electron discharge device comprising a main anode, a mercury pool cathode, means for maintaining a holding-arc having a cathode spot on the surface of the mercury pool, a housing substantially enclosing the discharge path for the holding-arc except for a restricted opening at the cathode surface, means providing insulating surfaces continuous with the cathode in proximity to the said opening, and means applied to said surfaces for reversing the normal meniscus of the mercury to bring the same into tapering contact with the surfaces, whereby ionization produced in the vicinity of the said surfaces by current drawn from the holding-arc cathode spot to the main anode may readily establish a separate cathode spot for the main anode at the region of reversed meniscus.

KENNETH H. KINGDON.
ELLIOTT J. LAWTON.