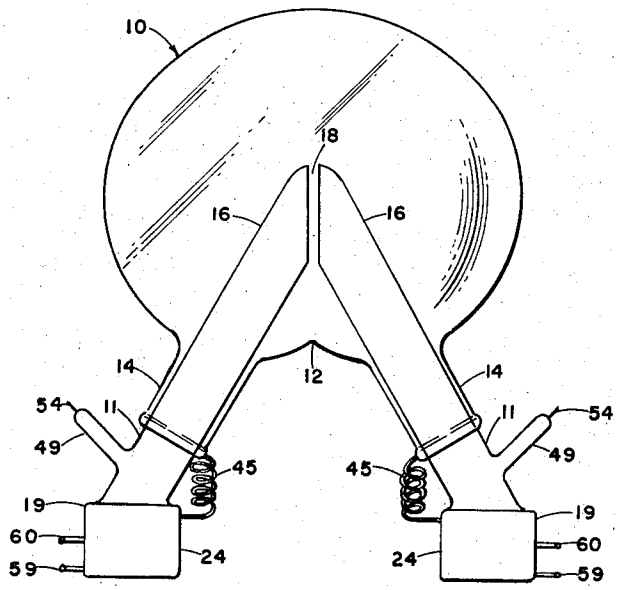
March 10, 1959 A. VANG 2,877,367

MEANS AND METHODS FOR IGNITING MERCURY POOL IN ARC DISCHARGE SWITCHES AND FOR ELIMINATING MISFIRE IN OPERATION, ETC

Filed Jan. 29, 1957

2 Sheets-Sheet 1

FIG. 1



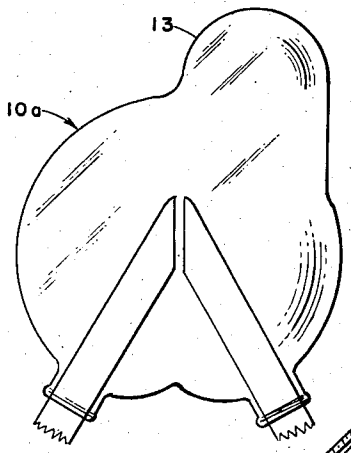


FIG. 2

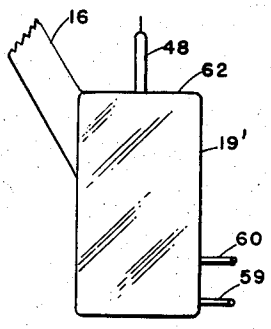


FIG. 4

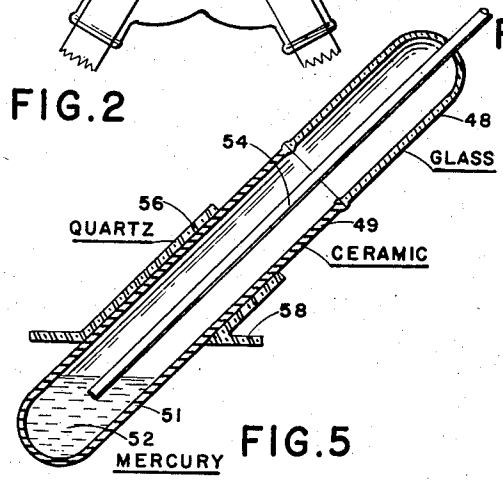


FIG. 5

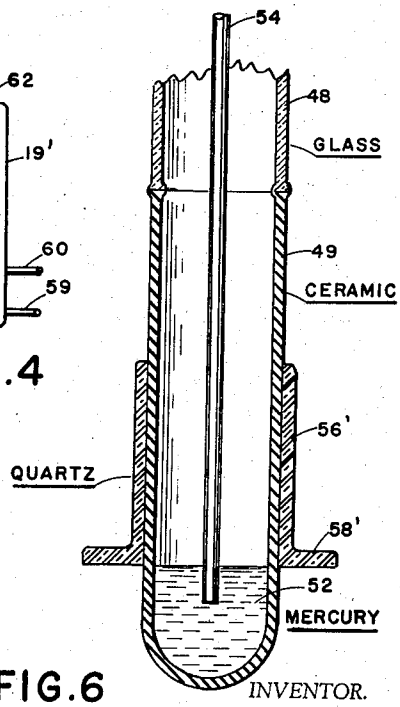


FIG. 6

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2 Sheets-Sheet 2

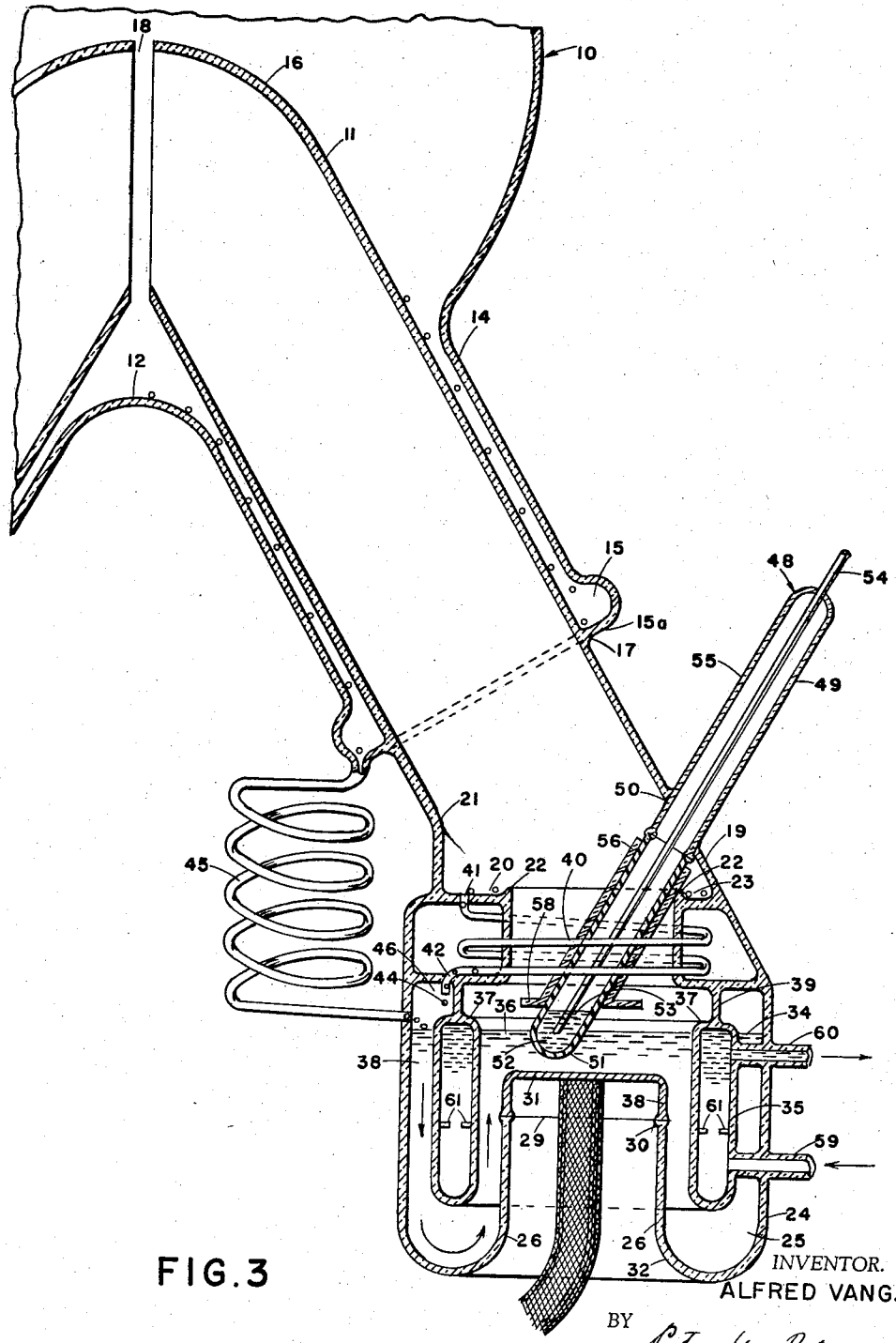


FIG. 3

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United States Patent Office 2,877,367
Patented Mar. 10, 1959

2,877,367

MEANS AND METHODS FOR IGNITING MERCURY POOL IN ARC DISCHARGE SWITCHES AND FOR ELIMINATING MISFIRE IN OPERATION, ETC.

Alfred Vang, Rancho Santa Fe, Calif.

Application January 29, 1957, Serial No. 636,935

16 Claims. (Cl. 313—29)

This invention relates to means and methods for igniting a mercury pool in arc discharge switches or transductors and for eliminating causes of misfire or erratic operation thereof. Heretofore igniters have generally been of two fundamental types. One type is the external igniter employing a trigger electrode disposed against an exterior surface of the transductor envelope to form a capacitor with the adjacent mercury pool. Examples of externally fired switches or transductors shown in my United States Patents Nos. 2,287,541, 2,425,858, and 2,432,219. The other type of igniter employs a trigger electrode of solid metal dipping slightly into the mercury pool. Transductors having this type of electrode are known as "Ignitrons" and are said to be internally fired.

Both types of igniters have advantages and disadvantages as employed heretofore. Internal ignition does not generally affect the material of the envelope which is usually glass. However the current required for internal ignition is relatively quite large compared with that required for external ignition since the latter is more of the nature of an accumulation of static charges. Moreover, the presence of the metal electrode in the mercury pool and envelope contaminates the mercury and causes variations in ionization characteristics.

Externally fired transductors do not usually present these problems, especially in early life, but they do tend to vary in characteristics due to pitting or localized breakdown of the glass envelope after extended use. Ordinarily this is of little consequence when the moment of firing is not critical. However, if the firing potential varies with time, as it frequently does, say, in a sinusoidal manner, it can easily be realized that an increase in required firing potential will cause a delay in firing. Thus, alteration of the envelope material at the igniter electrode varies the operation of the tube over a period of time. Worse than this, a pitted glass transductor fires erratically even within a few cycles. The cause of this is not fully known, but it is hardly unexpected, since any hard glass contains such a diversity of atoms which when situated on sharp points or edges will behave differently from their action at smooth surfaces, especially with highly localized changes of temperature.

Another cause of erratic firing seems to be due to the return of condensed or liquid mercury to the pool. This is true to a certain extent even with new envelopes, and is more pronounced with pitted ones, especially when trigger electrodes in the form of bands are used. Moreover such liquid mercury has often picked up inevitable impurities and so deposits them on the active surface of the electrode pools. Furthermore these droplets may carry charges so that their contact with or even varying proximity to, the active cathode surface may disturb smooth firing.

Also the flow of positive ions to the cathode surface is a disturbance to be minimized.

An object is therefore to improve the regularity of ignition of a mercury discharge transductor.

A further object is to increase the effective life of such transductor.

Still another object is to provide an igniter that will cause no pitting of the envelope, and yet operate by the mere application of static charges.

And yet another object is to provide a replaceable igniter.

Still another object is to make more uniform the normal conditions of active cathode surface on which "hot spots" form.

Secondary aims for accomplishing this last mentioned object include the division of the electrodes into relatively active and inactive zones, the return of any condensed mercury to an inactive zone where the impurities therein may be trapped, and the provision of a shield to protect the cathode from ions moving toward it.

The attainment of these objects and aims is reached in a discharge device, which briefly stated, includes an envelope having separated drainage portions with an arc tube therein, the arc tube having a mercury electrode in a bottom portion thereof. Partition means divide the pool surface into inner and outer zones but the pool is continuous below the partition. An igniter comprising a tubular insert of heat resisting dielectric material dips into the inner zone, the firing electrical charge is applied to an auxiliary pool in the bottom of the insert. Thus for firing a high difference in potential is set up between the two pools separated by the dielectric of the insert. Means are provided to return any condensate from the walls of the envelope and arc tube to the said outer zone of the main mercury electrode. Said drainage portions of the envelope, as well as the body of the envelope surround a substantial length of the arc tube to keep same hot and aid in deionizing any droplets which might tend to condense thereon. The conductive arc is largely surrounded by the arc tube, but the interior of the latter is open to the interior of the envelope.

In the accompanying drawing showing, by way of example, several of many possible embodiments of the invention,

Figure 1 is a front elevation of the device.

Figure 2 is a front elevation of another form of envelope for the device.

Figure 3 is a fragmental sectional view showing details of an electrode portion of the device.

Figure 4 shows a modification of an electrode portion of the device.

Figure 5 shows a detailed sectional view of one form of the igniter, and

Figure 6 shows another form of igniter.

The invention includes an envelope **10** provided with one or more arc tubes **11** therein in which the major portion of arc occurs, the interior of the envelope is in communication with the interior of the arc tube or tubes so that gas or vapor pressures are substantially equalized.

The lower portion of the envelope is provided with a dividing ridge **12** to form two down streams of any mercury condensing on the inner walls of the envelope so that the streams flow toward necks **14** surrounding, but spaced from, the arc tubes. The envelope **10** is shown as symmetrical but this need not be, for unless there is special cooling provided for one side of the envelope, in particular near the anode, such a side tends to lose mercury. Consequently, the envelope may have larger heat conductive surface to the ambient air in one portion than another as shown by the dome as shown on the envelope **10***a* of Figure 2.

For convenience the invention is first described as in the form of that shown in Figures 1 and 3 wherein the mercury vapor discharge device comprises the envelope **10** substantially symmetrical with respect to a given ver-

tical plane with a pair of downwardly turned open ended necks 14 on opposite sides of the plane of symmetry. The envelope has a mid portion, the lower zone of which is provided with the upwardly directed ridge portion 12 substantially in and along said plane to divide the downfall of the condensing mercury substantially equally between zones on opposite sides of the plane so as to fall substantially equally into the respective necks, the neck being situated in the lowest portion of the envelope. Each neck has an inwardly open annular recess 15 at the lower end thereof.

The generally round arc tube 11 in each neck is coaxial therewith within the neck and spaced therefrom except where it is sealed to the recess lip 15*a* at 17. The tube has an upper end portion 16 which may be curved slightly, and is open toward the plane of symmetry, the upper ends of the arc tubes being slightly spaced from each other as at 18. The lower portion 19 of each arc tube is provided with a normally axially vertical hollow annular ledge 20 projecting from the inner wall 21 of the arc tube, the ledge having an upstanding rim 22 to form a shallow trough 23 thereon, while the bottom end 24 of the tube is in the form of an annular pocket 25 having an upwardly turned inner wall member 26.

A contact member 28 closes the lower end of the tube, the contact member being of conductive material in the form of an inverted cup having a rim portion 29 welded as at 30 onto said wall member 26 substantially as a continuation thereof, and a somewhat circular horizontal portion 31 integral with the rim portion. A mercury pool electrode 32 in the pocket 25 covers the contact member 28 but the mercury level 34 is preferably at a ¼ inch below said ledge 20.

A hollow annular cooling element 35 dips into the mercury and pocket and is generally coaxial with the latter and has an effective cooling surface 37 projecting above the surface of the mercury level 34. The element divides a substantial upper portion of the mercury into inner and outer liquid zones 36 and 38 completely separated at the level surface of the mercury. Suspension means 39 depending from the ledge and secured to the cooling element help to support the cooling element and may have other functions as mentioned below.

A conduit 40 is disposed in the ledge, coiled about the vertical axis thereof, and is in communication with the trough 23 thereon as at 41 and has an outlet portion 42 outer of said cooling element for conducting globules 44 of mercury from the trough to the vapor space above the mercury in said outer liquid zone, the conduit outlet portion passing downwardly through the ledge. A second conduit 45 coiled about a vertical axis to increase the length and electrical impedance of mercury therein connects said recess 15 in the neck and the vapor space 46 above said outer zone for the return of condensate from the envelope to the outer zone of the mercury.

An igniter 48 passes gas-tight through the arc tube for igniting the mercury electrode. The igniter comprises a tubular insert 49 of insulating material, and closed at each end, and passing through the wall 50 of the arc tube above the ledge. The insert has a lower end portion 51 dipping into the inner zone of the liquid mercury, the insert containing an auxiliary pool of mercury 52 and a solid conductor 54 substantially concentric with the insert fast on the exterior end portion 55 and dipping into the auxiliary pool and extending in the exterior of the insert for connection to a source of control current. The upper level 53 of pool 52 is preferably at least ¼ of an inch or so above the level 34. A sheath 56 of high temperature resistant material such as quartz and provided with a circular skirt 58 may be disposed about the insert so that the skirt is spaced above the level of the inner zone of mercury, the skirt having an outer periphery substantially coaxial with the ledge but radially spaced therefrom.

Advantages and further details of construction are now elucidated in a description of the operation of the device. Effective control of a mercury discharge depends to a great extent on purity of the mercury, cathode temperature, and the action of the mercury and other ions.

The present device is especially adapted to the removal of impurities from the hot spot areas, for all mercury washing down the envelope and tube walls and carrying impurities, returns to the active cathode area through a trap. Since virtually all mercury impurities, such as its oxides and other metals or compounds, are lighter than the liquid they will float on the surface of the liquid zone 38 outer from the cooling element or partition, for this element is a continuous annuli projecting above the main electrode pool. The impurities are kept in the outer zone, away from the active area, and at low temperature. The one or more coils of the conduit within the ledge afford a long slope for returning globules so that the stream is highly attenuated into separate globules and there is virtually no change for the mercury in the conduit to become conductive. It was noted that returning mercury discharged from the outlet of the conduit into the vapor space rather than the liquid space of the outer zone. This is even greater insurance against electrical contact between the mercury pool and mercury in the conduit.

Likewise, the second conduit is preferably of considerable length and/or coiled to increase the electrical resistance and even self inductance between the neck recess and the cathode and it, too, discharges into the outer vapor space. This second conduit also functions as an air cooled condenser. Impurities in particular are condensed and deposited in the outer zone.

Since almost all condensate returns to the outer zone of the liquid and all evaporation takes place at the inner zone there is a continued flow of liquid, down outer of the cooling element, then under, and up inner of the element, to the active inner zone above the contact member 28. The contact member being of metal aids in the dissipation of heat to the exterior.

The cooling element is of high temperature resistant material such as glass, as is the suspension means 39 which is preferably annular to aid in the separation of the mercury into the inner and outer zones 36 and 38.

The cooling element extends as at 37 above the level of the mercury 34 to aid in lowering the temperature of the dross on the outer zone 38 of the mercury, but more in particular to cool any droplets that may tend to travel radially out from the hot spot over the level of the inner mercury zone. It must be kept in mind that although glass is considered a poor conductor of heat, mercury is also a rather poor conductor so that an exposed cool surface 37 of the cooling element is especially desirable for contact with droplets.

The cooling element is provided with a flow of coolant liquid, such as water, by means of inlet and outlet members 59—60, passing through the pocket portion of the tube. It has been found that a mercury mass temperature of about 140–150° F. is quite satisfactory. Baffles 61 or similar means are preferably provided in the cooling element so that the temperature of the element, especially in the region near the liquid level of the mercury is kept substantially constant about its periphery.

In practice, when the device is in continuous service, very little mercury condenses within the arc tube in the neck of the envelope since it is surrounded by the neck which is spaced therefrom and the arc tube is exposed to the vapor in the neck. The neck may thus be considered as a heating sleeve for the arc tube and enables the deionization of charged particles therein which might cause misfires and backfires in the device.

The igniter insert is sealed through the cathode arc tube and so the upper or outer portion 55 may be of glass. However for long life, glass is not satisfactory for the lower portion 51 which dips into the cathode pool, since glass becomes pitted after long use. For

this reason, the lower portion of the insert is made of much more inert material, such as ceramic like material, for example fused alumina, zirconia or artificial sapphire. The space above the auxiliary pool 52 may be substantially vacuous or substantially atmospheric pressure. Thus far, neither pressure seems to show outstanding advantage over the other.

The skirt and sleeve are normally kept about a ¼ of an inch above the mercury level and are made of quartz, for example, preferably integral. The skirt protects the active inner zone of the liquid from ions.

Those skilled in the art are familiar with metals having the suitable coefficients of expansion where metal is sealed to glass.

The geometry of the arc tubes may be changed to permit simpler fabrication. For instance, while the igniter is shown inclined in Figure 3, it need not be so if there is sufficient distance between the recess lip seal at 17 and the ledge 20. Also the lower portion 19 may be lengthened as at 19' in Figure 4 and provided with a cap 62 through which the igniter passes vertically and the upper portion 16 be a lateral extension. Vertical disposition of the igniter is advantageous when a skirt on the igniter is desirable. Thus while the axis of the sleeve 56 is inclined in Figure 5 to the plane of the skirt, so as to have the latter uniformly spaced from the mercury level, the axis of sleeve 56 is perpendicular to the plane of skirt 58' in Figure 6. The latter combination is much simpler to produce.

Generally it is expedient to provide each arc tube or main electrode therein with an igniter if for no other reason than for use as a "spare" which may be used if the polarity of the device is changed. Thus Figure 1 is completely symmetrical. The construction of the lower portions 19 may be the same for anode and cathode alike. Trapping of impurities in the anode portion of the device removes them from the system just as over in the cathode portion.

The current carrying ability of the device is enormous. A sample which has extreme dimensions of about a foot can carry 5,000 amps, for a short length of time.

Other changes will be apparent to those skilled in the art. For example, if one electrode is to regularly function as the anode, which heats up to a greater extent than the cathode, the lower portion of its arc tube may be increased in size to allow increased heat transfer surfaces, and the conduits for returning mercury to the outer zone may be modified either in number or dimension to give greater capacity, yet to retain the functional properties mentioned.

The invention claimed is:

1. In a mercury vapor discharge device, an electrode in the form of a mercury pool, structure for holding said pool, a hollow dielectric member consisting essentially of a metal oxide taken from the group consisting of fused alumina, zirconia, and artificial sapphire having a pocket therein and partially immersed in the pool, an auxiliary pool of mercury in the pocket and separated from the first mentioned pool by said member, and means for connecting a terminal of a supply of ignition current to the auxiliary pool.

2. A mercury discharge device comprising a tubular member closed at one end thereof to form a pocket, a mercury electrode pool in the pocket, a continuous partition vertically disposed in the pocket and spaced from the member to divide the pocket and pool into an outer zone adjacent the member and an inner zone, the zones of the pool being continuous with each other at a depth substantially below the top level of the pool, and an igniter dipping into one of said zones of the pool.

3. A device as claimed in claim 2 said partition being provided with means for cooling same.

4. A device as claimed in claim 2, said partition being of electrically insulating material.

5. A mercury arc discharge device comprising, an arc tube having a pocket portion and an arc portion thereabove, a mercury cathode pool in the pocket portion, an envelope having a neck portion in a low part thereof and extending in a downward direction, said arc portion extending into the envelope and being in said neck and spaced therefrom to form a sleeve around the arc portion of the tube, mercury vapor in the arc tube and envelope and free to pass from one into the other, means for closing off the arc tube and envelope from the exterior, and an anode in contact with said vapor.

6. A device as claimed in claim 5 and conduit means in addition to the arc tube for conducting fluid from the space between arc tube and envelope to said cathode pool.

7. A device as claimed in claim 6, said conduit means tapping the space between said neck portion and arc portion.

8. A device as claimed in claim 7 said conduit means being exposed to the atmosphere.

9. A device as claimed in claim 8 said pool having a partition of electrically insulating material therein to divide the pool into an inner zone and an outer zone around the inner zone, said conduit means having a discharge outlet portion opening into the outer zone.

10. In a mercury arc discharge device, an arc tube having a pocket in a low end thereof, a mercury electrode in the pocket, an internal ledge within the tube and above the electrode, a partition dividing the electrode into an inner zone and an outer zone thereabout, said ledge being provided with a trough therein to collect fluid descending from the inner walls of the tube, conduit means having gentle slope to promote the breaking up of liquid mercury into discontinuous droplets for tapping the trough and discharging into space outer of said partition and to said pool.

11. In a device as claimed in claim 10 said conduit means being helical.

12. In a device as claimed in claim 11 the ledge containing the helical conduit means therein.

13. In a mercury arc tube structure forming a pocket, an electrode of mercury in the pocket, an annular cooling element partially immersed in the pool dividing same into an inner zone and an outer zone therearound, an igniter element dipping into the inner zone, said element projecting above the level of the pool to cool spattered particles from the inner zone.

14. In a mercury arc device, structure forming a pocket and an anode in the structure, a mercury cathode in the pocket, an elongated igniter element projecting to touch the electrode, a sleeve of high temperature resistant insulating material covering the element above the pool and having an outstanding skirt portion projecting laterally therefrom substantially parallel with the top level of the cathode and spaced therefrom to protect the cathode from ions emanating from the zone of the anode.

15. A mercury vapor discharge device comprising an envelope having a pair of downwardly turned open ended necks on opposite sides of the envelope, the envelope having a mid portion the lower zone of which is provided with an upwardly directed ridge portion to divide the downfall of condensing mercury between zones on opposite sides of the plane so as to fall into the respective necks, the neck being situated in the lowest portion of the envelope; a generally round arc tube sealed gas-tight into each neck and coaxial therewith and spaced therefrom and having an upper end portion curved slightly and open toward and near each other within the envelope, each said tube having a closed lower end portion and a mercury electrode therein, and means for leading mercury from the space between the necks and tubes to the respective electrodes.

16. A mercury arc discharge device comprising an arc tube and a mercury pool electrode, means dividing the pool into inner and outer zones; an igniter passing gas-tight through the arc tube for igniting the mercury elec-

trode; the igniter comprising a tubular insert of insulating material and closed at each end and passing through the wall of the arc tube and having a lower end portion dipping into the inner zone of the pool, the insert containing an auxiliary pool of mercury and a solid conductor substantially concentric with the insert fast on the exterior end portion and dipping into the auxiliary pool and extending in the exterior of the insert for connection to a source of control current; a sheath of high temperature resistant material about the lower portion of the insert and provided with a skirt uniformly spaced above the level of the inner zone of mercury and having an outer periphery radially spaced inner from that of the inner zone.

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