May 23, 1939. H. E. ROWE 2,159,770

STARTING ELECTRODE FOR POOL TUBES

Filed April 16, 1936

Fig. 1.

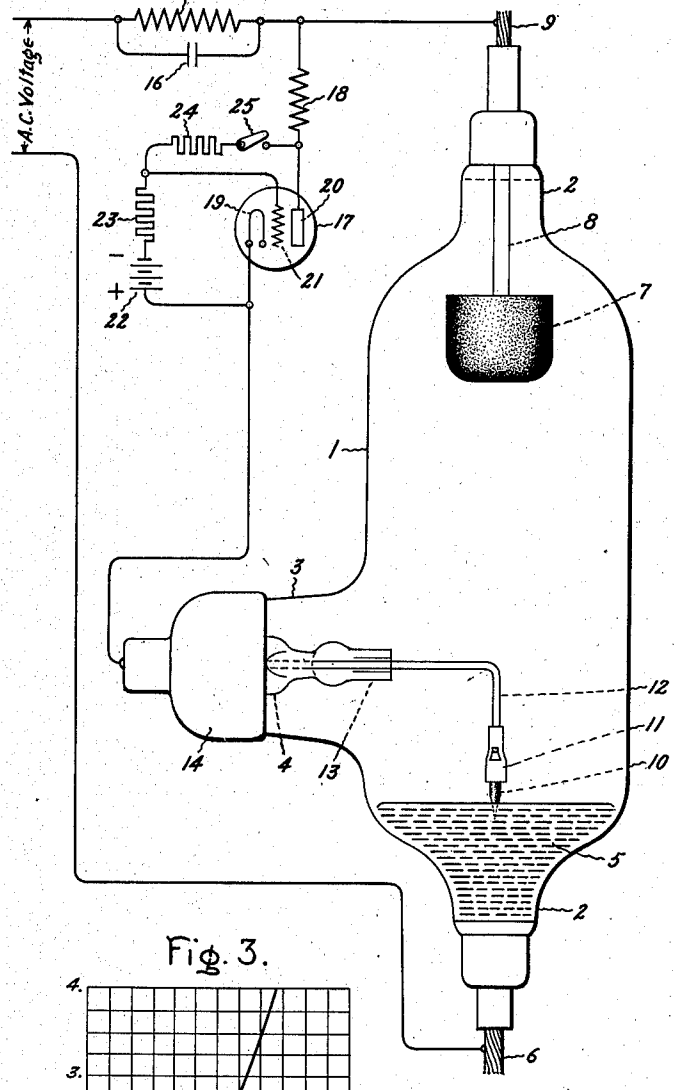


Fig. 2.

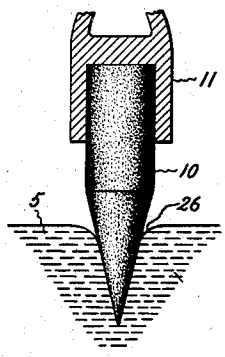


Fig. 4.

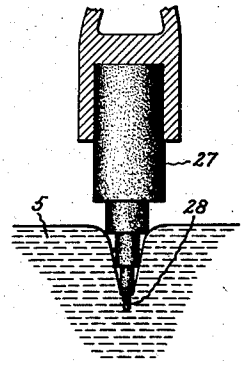
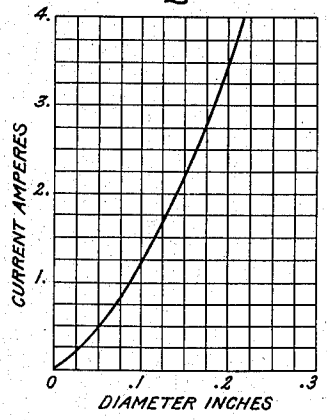


Fig. 3.



Inventor:
Hobart E. Rowe,
by Harry E. Dunham
His Attorney.

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STARTING ELECTRODE FOR POOL TUBES

Hobart E. Rowe, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application April 16, 1936, Serial No. 74,653

1 Claim. (Cl. 250—27.5)

The present invention relates to pool type discharge devices in which an arc discharge is controlled by a starting electrode projecting below the surface of the pool. More particularly, my invention provides a starting electrode of an improved type.

In the prior vapor electric devices, more especially those which contain an excess of vapor-producing material in the form of a liquid which serves as a pool cathode, a great deal of power is wasted in initiating the discharge. The starting current is usually low but the voltage necessary to produce a hot spot on the pool cathode is often high and excessive. I have found in accordance with my invention, that the excessive starting voltage is due, at least in part, to the configuration of that portion of the starting electrode which is immersed in the pool.

One of the objects of the present invention is to provide vapor electric apparatus in which the power required for initiating the discharge is a minimum, and more particularly, to reduce the starting voltage of those devices which employ starting electrodes of semi-conducting material which permanently project into a vapor-producing liquid. In carrying out this object, I modify the configuration of the starting electrode. Whereas prior starting electrodes generally take the form of a cylinder or rod of a uniform and relatively small diameter, the electrode as improved in accordance with my invention is made very large at its upper end and is tapered to a very small diameter, even to a point, at the end which extends into the pool. The invention will be more clearly understood when reference is made to the following description and the accompanying drawing in which Fig. 1 is a diagrammatic view of typical starting and load circuits, also of a vapor electric tube which contains a starting electrode of the improved type; Fig. 2 is an enlarged view in cross-section of the starting electrode shown in Fig. 1; Fig. 3 is a graphical representation of a relationship which explains the nature of my invention; and Fig. 4 shows a modified form of starting electrode.

Referring more particularly to Fig. 1, numeral 1 designates an evacuated envelope which terminates at each end in stem portions 2 of reduced size. Projecting from the side of the envelope 1, there is a tubular extension 3 which is provided with a reentrant stem 4. In the lower end of the envelope, is collected a quantity of vapor-producing liquid 5 such as mercury, gallium, or tin which serves as the cathode of the main discharge through the device. An external connection is brought out from the mercury by means of a leading-in conductor 6, suitably sealed in the envelope.

The main anode 7 of the device may take the form of a cylinder of refractory material such as graphite or metal and is mounted in place by means of a rigid rod 8 which is secured to the stem 2 opposite from the cathode. A leading-in conductor 9 is connected to the rod 8.

For starting the arc between the main electrodes and more particularly for producing a cathode spot on the mercury, there is provided a starting electrode 10 which fixedly projects below the surface of the mercury 5 during operation. As shown more clearly in Fig. 2, this starting electrode is mounted in position by means of a cylindrical support member 11 having a counterbored portion which receives the electrode.

The starting electrode is preferably composed of a semi-conducting material such as tungsten carbide or silicon carbide, suitably combined with clay or a similar binder, and takes the form of a cylindrical member which for reasons given presently, has a taper over that portion of its length which comes into contact with the mercury.

The material found most suitable for this purpose is composed of 55 per cent silica, flint or quartzite in ground or finely divided form, 25 per cent clay, and 20 per cent graphite, thoroughly mixed in the presence of a small quantity of water. It will, of course, be understood that satisfactory starting electrodes can be made of other moldable materials and in different proportions than those stated. The silica or similar material is used as a "filler", suitable from the stability of operation standpoint, as well as cheap in cost, to render the mixture less critical to small changes in composition of the other constituents. The clay constitutes a dispersing agent for the graphite and as a binder to bond the mixture into a suitable material. The graphite provides the electrical conducting medium. The mixture forms a paste and may be either cast in a mold or extruded through a die to provide a rod, preferably of cylindrical shape. These rods are then packed in graphite powder, placed in a hydrogen furnace, and raised in temperature to 1250 or 1300° C. They are held at this temperature approximately 30 minutes to ensure complete sintering. A longer or shorter time for sintering could be used if precision measurements of temperature are made. After firing, the parts are allowed to cool in the furnace to room tempera-

ture. If fired at a temperature in excess of 1300° C., an undesired glazed surface of silicon carbide results. On the other hand, if the rods are fired at a temperature lower than 1250° C., the sintering is incomplete and the clay renders the material soft and fragile. The material made in this manner is found to be reasonably free from gas during the regular exhaust of the tube. The material is also unaffected by the normal operation of the tube. These rods may be cut into sections of proper length, the ends of which are tapered, preferably to a point by grinding, to a close tolerance in order to ensure reproducibility of the operation of the tube.

The support member 11 is preferably held in a vertical position in such a manner that the starting electrode 10 extends in a direction substantially normal to the level of the mercury when the tube 1 is in its operating vertical position. The support member may be either swaged or welded to a rigid rod 12 having a transversely extending portion which is sealed in the stem 4. If desired, a pant-leg 13 may be provided around the rod at the place where it enters the stem 4 to prevent condensation of the mercury and hence reduce electrical leakage at this point. A cap 14 is secured to the outside surface of the glass arm 3, and a connection is made between this cap member and the rod 12.

The external circuit for the main electrodes includes a source of alternating current, as indicated, and a load generically represented by a resistance 15 which is preferably shunted by a smoothing condenser 16. This circuit is connected to the leading-in conductors 6 and 9.

The starting electrode circuit includes a thermionic device 17 and a current limiting resistance 18, this circuit being connected between the cap 14 and the leading-in conductor 9. The thermionic device includes a filamentary cathode 19, heated in any suitable manner, and an anode 20, the filament being connected directly to the starting electrode so that the device permits current to flow to the starting electrode only during that time when the main anode is positive with respect to the main cathode. If desired, a grid 21 may be provided between the cathode and the anode of the thermionic device in order to control the time at which the starting electrode will be energized. A shunt circuit is provided between the grid and the cathode, this circuit including a battery 22 and a current limiting resistance 23, the battery being so poled, as indicated, to provide a constant negative bias on the grid. This bias is so high that no current normally flows between the anode and cathode of the thermionic device, and to permit current to flow at the desired time, a shunt circuit is provided between the grid and the anode through a current limiting resistance 24 and a control switch 25. When the switch 25 is closed, the negative bias on the grid is dissipated and the potential of the latter approaches that of the positively charged anode 20, thus providing a path of relatively low impedance between the anode 20 and cathode 19.

As explained hereinbefore, the object of the present invention is to reduce the necessary power and more particularly, the voltage applied to the starting electrode for initiating the arc discharge. Referring now to Fig. 3, which is a curve plotted against the starting current in amperes as ordinate and the diameter of the starting electrode at the line of contact with the mercury surface, as abscissa, it will be noted that the starting current steadily reduces as the size of the starting electrode is decreased. Consequently, in order to keep the starting current as low as possible, it is desirable to have the diameter of the starting electrode at the line of contact with the mercury surface as small as possible, even as small as a point. On the other hand, when the starting electrode is of very small diameter, the voltage drop in the electrode becomes considerable. It is apparent that because of its semi-conducting character, the starting electrode acts as a resistance element in series with the starting circuit, the value of which changes in accordance with the length of electrode between the surface of the mercury and the metal support member. Under these conditions, if the voltage drop in the body of the starting electrode is high, the potential difference between the starting electrode and the mercury at the place of contact might be too low to initiate a discharge, unless impractically high voltages were applied to the starting electrode.

However, in accordance with my invention, the advantage of a starting electrode of relatively small diameter at the line of contact with the mercury and its desirable property of requiring a low starting current are obtained and at the same time, the voltage drop in the starting electrode is minimized by providing a starting electrode which has a diameter considerably greater than is ordinarily used and tapering the electrode to a point, or substantially so, along that portion of its surface which actually is in contact with the mercury or is likely to be in contact when the level of the mercury changes due to movements of the mercury surface during operation.

For the purpose of my invention, i. e. to obtain as small a voltage loss in the starting electrode as possible, and hence, provide an electrode which requires the minimum starting potential, the taper is preferably straight, as indicated in Fig. 2. The present invention, therefore, contemplates a starting electrode for pool types of tubes in which the upper or shank end of the electrode is made considerably larger than the corresponding portion of the prior art starting electrodes and notwithstanding this greater volume of electrode material, the starting current is still maintained at a relatively low value by reducing the diameter, or in any other manner decreasing the cross-sectional area of the electrode at the line of contact with the mercury, even to a point, although under practical conditions, the electrode need not be tapered to such a degree. The degree of taper may be determined by experiment based on operating conditions. The diameter of the upper or shank end of the starting electrode depends on the kind of material used for the electrode and its specific resistance; the greater the resistance the larger should be the diameter. There are no limitations other than practical considerations as to the size of the upper end of the electrode insofar as the operation of the tube is concerned because obviously, only the dimensions of the electrode at the line of contact with the mercury affect the current starting conditions. In general, the larger the diameter at the upper end of the starting electrode, the less voltage drop there will be in this member and hence; the less starting voltage will be necessary to initiate a discharge.

I have successfully used starting electrodes composed of various combinations of materials including tungsten carbide and clay, as well as those set forth hereinbefore, formed into a rod of

.25 inch diameter which was tapered over a length of .5 inch to substantially a point.

In addition to providing a smaller voltage drop through the body of the electrode, the increased size of the upper end of the starting electrode is of marked advantage in offering a better support at this end. A more rigid joint is provided between the starting electrode and the metal supporting member due to the larger area in contact, and the electrical contact between these members is corresponding enhanced.

In addition to offering a reduced starting voltage, the over-sized tapered form of starting electrode actually assists in other ways to produce the necessary hot spot on the mercury pool. It is well known that the meniscus of the mercury pool at the place of contact with the starting electrode tends to bend downwardly and outwardly, due to capillary attraction or otherwise, and in general, to take on a convex shape at this position. This phenomenon is shown in Fig. 2 and is indicated at **26**. The taper of the electrode might therefore be designed, if desired, to match as far as possible, and without departing from a straight taper, the convexity of the mercury surface at this position so as, in effect, to provide a greater area of contact between the mercury and the starting electrode. The increased area of contact appears to encourage the production of minute sparks in large numbers between the mercury and the starting electrode and thus further tends to facilitate starting under reduced voltage and current conditions.

While I have explained my invention more especially in connection with a tapered starting electrode, the invention is not limited to an electrode of this configuration. As stated hereinbefore, the invention contemplates a starting electrode in which the upper or shank end is over size and is made considerably larger than the starting electrodes of the prior art. The electrode is then tapered from the over size portion to such a size at the line of contact with the mercury that the starting current is reasonably low. This taper may be gradual or may constitute an abrupt change in diameter. Thus the starting electrode may be constituted of any number of portions or sections having different and constant diameters over each portion or section so that the electrode takes the form of a "stepped-down diameter" configuration, approaching a point in size. An electrode of this type is shown in Fig. 4, the uppermost portion **27** of which is of a relatively large diameter so as to produce little or no voltage drop therein and thus bring to the lowermost or immersed portion **28** of the electrode, substantially all of the available voltage by which to start the arc. It will be noted that the diameter of the portion **28** is sufficiently small to minimize the starting current and the electrode as a whole tapers down substantially to a point. Hence, as in the case of the starting electrode shown in Fig. 2, the electrode illustrated in Fig. 4 offers the double advantage of requiring the minimum starting voltage and starting current for initiating an arc discharge.

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

An electron discharge device comprising a pool-type cathode, an anode, and a starting electrode in the form of a semi-conducting member having a portion thereof immersed in the cathode material during the normal operation of the device, said member being constituted of a plurality of cylindrical sections of varying diameters joined in end-to-end relationship, the sections being arranged in order of decreasing diameters so the section of least diameter forms the tip of the said immersed portion of the member.

HOBART E. ROWE.