Sept. 28, 1948. H. K. ISHLER 2,450,197

ELECTRIC DISCHARGE DEVICE

Filed Dec. 29, 1945

FIG. 1

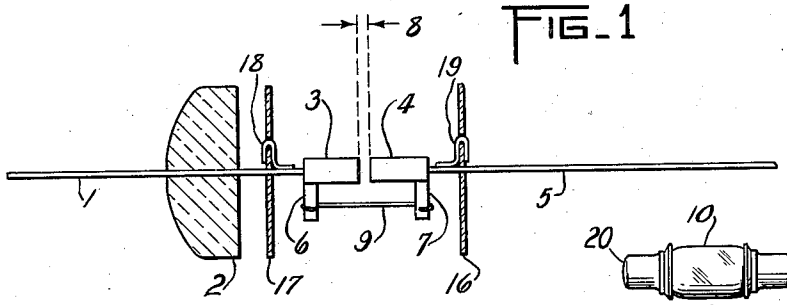


FIG. 6

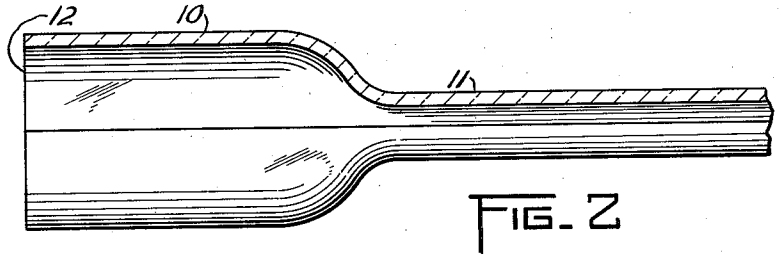


FIG. 2

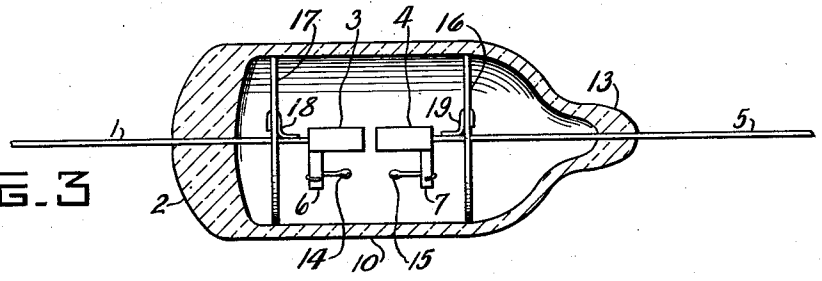


FIG. 3

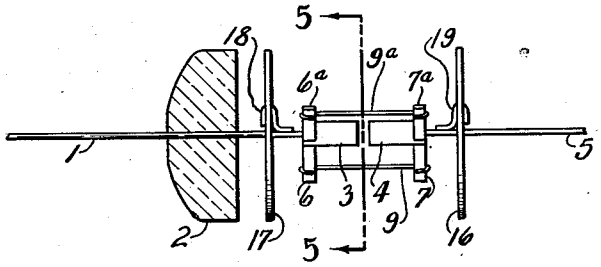
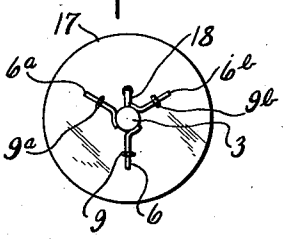


FIG. 4

FIG. 5



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ELECTRIC DISCHARGE DEVICE

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17 Claims. (Cl. 250—27.5)

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This invention relates to electric discharge devices and more particularly to methods of constructing such devices to secure the desired spacing between electrodes.

Formerly, in order to secure the required precise spacing between the electrodes of an electric discharge device, it was necessary to include within the envelope of the device a mount or supporting structure which held the discharge electrodes in the desired spatial relationship. Since this supporting structure was also required to insulate the electrodes electrically, relatively complex arrangements were required.

In order to eliminate this interior mount or supporting structure, it would be desirable to support the electrodes entirely by their seals to the glass envelope. This again, however, is a difficult and expensive undertaking, since during the glass sealing operation the electrodes must be held in the desired position. The securing of precise dimensions is always difficult in the making of glass-to-metal seals.

It is the object of the invention, therefore, to provide an interior structure which will eliminate the need for internal insulating supports and at the same time maintain the electrodes at the proper spacing during the glass sealing operation.

The invention accomplishes this result by providing a spacer of conducting material which holds the electrodes during the sealing operation, and then eliminating the conducting spacer by melting and vaporizing it with an application of electrical energy.

A feature of the invention is the improved gas clean-up or absorption of residual gases left in the envelope by the exhaust pump which may be secured by covering the conducting spacer with the getter material which absorbs or combines with these residual gases when it is vaporized as the spacer is heated. Alternatively, the spacer itself may be composed of a getter material which will absorb or combine with the residual gases when it is melted and vaporized.

A feature of one embodiment of the invention is the relatively simple guides which may be mounted on the electrodes or on the lead-in wires to hold them in alignment with each other and with the walls of the envelope.

The method of the invention may be employed in the construction of a wide variety of electric discharge tubes with various numbers and arrangements of electrodes and lead-in wires. It will be described as used in making a small spark gap in a tubular glass envelope, the gap electrodes

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being mounted on and supported by lead-in wires sealed through the ends of the envelope.

In the drawings, Fig. 1 is a sectional view of the electrodes and lead-in wires, one of which is sealed through the header which closes one end of the envelope; Fig. 2 is a sectional view of the bulb with the exhaust tube attached; Fig. 3 is a sectional view of the complete tube; Fig. 4 is a sectional view showing the parts corresponding to Fig. 1 of an embodiment using a plurality of spacers; Fig. 5 is a sectional view along line 5—5 of Fig. 4; and Fig. 6 is a side view of the complete device constructed from the assembly of Fig. 1.

The assembly before the sealing on of the inclosing bulb is shown in Fig. 1. One of the lead-in wires 1 is sealed through the wafer header 2 and has one of the discharge electrodes 3 welded to its inner end. The other discharge electrode 4 is welded to one end of the other lead-in wire 5.

The supporting structure for the discharge electrodes includes brackets 6 and 7 which are welded to the discharge electrodes 3 and 4. To secure the proper spacing between the electrodes, the lead-in wires 1 and 5 are clamped into a jig so that their adjacent ends are separated by the desired distance 8. A small wire 9 is stretched parallel to the axis of the lead-in wires 1 and 5 and is welded to brackets 6 and 7. This assembly of Fig. 1 is now removed from the jig and inserted into the open end 12 of bulb 10 in Fig. 2, the lead-in wire 5 extending into the exhaust tube 11 which is sealed to one end of bulb 10. The open end 12 of the bulb 10 is sealed to the periphery of the wafer header 2.

The exhaust tube is connected to a suitable vacuum pump and any desired processing of the tube, such as baking the bulb or heating the electrodes, may be performed while the air is being exhausted. If the spark is to operate in a gaseous atmosphere, the exhaust tube may finally be connected to a supply of gas and the bulb filled to the required pressure.

The final step in the exhaust procedure is the sealing off of the exhaust tube 11 to form the tip 13 of Fig. 3. In this construction the lead-in wire 5 extends into the exhaust tube 11 and is sealed through the tip 13.

During this procedure of forming the tip 13, the exhaust tube 11 is heated near the bulb 10, and as the glass is pushed inward by the external atmospheric pressure, the seal between the glass and the lead-in wire 5 begins to be formed. If the spacer 9 is composed of stiff wire the seal may be completed without special attention. It may be preferable in some cases, however, to use a

flexible wire, and then the spacing can be maintained by the following procedure. After the glass has begun to adhere to the wire, but while the glass is still hot, the bulb 10 and the exhaust tube 11 are pulled apart until the wire spacer 9 is straightened to its full length. When this wire spacer 9 straightens out the distance 8 between the electrodes 3 and 4, as originally spaced in the jig, is reproduced inside the glass bulb and accurately maintained when the tip 13 hardens.

A suitable voltage is now applied to the leads 1 and 5 and the wire spacer 9 is disposed of by melting and vaporizing it with this application of electrical energy. In this construction, with the wire spacer 9 attached to brackets 6 and 7 which are joined to the electrodes 3 and 4 at points removed from the actual discharge surfaces, there is no danger that the ends 14 and 15 of the wire spacer 9 will be closer together than the discharge electrodes 3 and 4. Such a condition, of course, would prevent the tube from having the required electrical characteristics.

The process of removing the spacer, which in this description has been referred to as melting and vaporizing, would ordinarily be termed "burning out" by workers in the electrical art. This term is misdescriptive because ordinarily in an electric discharge tube there is no oxygen present in which the wire could burn. The process is probably one in which some of the metal is melted, some is vaporized, and some is first melted and then vaporized.

The invention is not limited by any theory of the molecular action in this process nor by the relative amounts of melting and vaporizing which take place. The magnitude of the voltage and the consequent speed of the process is a matter of choice within the scope of the invention. In the embodiment described, a suitable voltage was determined by experiment which melted and vaporized the spacer without excessive vaporization which might scatter the metal to undesirable places in the tube. The remaining ends of the spacer were rounded off into neat balls as shown at 14 and 15 in Fig. 3.

The burning out or melting and vaporizing of the wire spacer 9 provides an effective means of vaporizing the getter or active material which is designed to combine with residual gases not removed from the tube by the exhaust pump. The getter material may be coated on the wire spacer 9 and is then automatically vaporized when the wire is melted, or the wire spacer 9 itself may be composed of a getter material such as magnesium ribbon.

If additional means are required to hold the electrode and the lead-in wires in alignment with each other and with the axis of the bulb, spacers 16 and 17 may be attached to lead-in wires 1 and 5. The peripheries of these spacers touch the interior of the bulb and hold the lead-in wires in alignment during the tipping operation. In this embodiment the aligning spacers 16 and 17 were made of mica and fastened to the lead-in wires 5 and 1 by tabs 19 and 18 welded to the lead-in wires.

After the tip seal is made and the spacer is eliminated so that the tube is at the substantially completed stage of manufacture shown in Fig. 3, the lead-in wires 1 and 5 may be cut to a suitable length and soldered to end caps cemented to the envelope. The final product is shown in Fig. 6, in which the end caps are designated by numerals 20 and 21.

It should be understood that the necessity for pulling the bulb 10 and the exhaust tube 11 apart during the final sealing operation is a feature of this particular embodiment of the invention only when a flexible wire is used to space the electrodes. In other applications it may be more desirable to use a rigid wire or a rigid spacer of any shape necessary to meet the requirements of the particular design. The dimensions and composition of the spacer are limited only in that they must be so chosen that the heating current through the lead-in wires and the spacer will melt and vaporize the spacer without overheating the lead-in wires.

Furthermore, the method is not limited to the construction of devices with only two electrodes or with tubular envelopes. It may be applied to tubes with bulbs of any shape and with any number of electrodes, spaced from each other in pairs, all spaced from a single electrode, or all spaced from a dummy electrode or some part of the tube mount. Those skilled in the art of fabricating electron tubes and faced with the problem of constructing a tube of any particular design will be able, from the foregoing description, to apply the method of this invention in those cases in which it would be more precise or more economical.

In some applications it may be desirable to use more than one spacer between two electrodes. In one form of the embodiment described, for example, three sets of brackets 6 and 7 were spaced 120 degrees apart around the electrodes and three spacing wires stretched between them. This construction is shown in Figs. 4 and 5 in which the three sets of brackets are 6 and 7, 6*a* and 7*a*, and 6*b* and 7*b*, the two members of each set being initially joined by the three spacers 9, 9*a*, and 9*b*. Arrangements of this nature are sometimes useful in securing better alignment of the electrodes.

Therefore, although I have shown and described particular embodiments of my invention, I do not desire to be limited to the embodiments described, and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of my invention.

What I claim is:

1. The method of securing the desired spacing between the electrodes of an electric discharge tube which comprises spacing the electrodes with conducting spacers during the construction of the tube, said spacers being joined to the discharge electrodes at points remote from the discharge surface thereof, and subsequently melting and vaporizing the spacers with the application of electrical energy.

2. The method of securing the required spacing between the electrodes of an electrical discharge device which comprises spacing the electrodes with conducting spacers during construction of the device, said spacers including getter material and being joined to the discharge electrodes at points remote from the discharge surfaces, and subsequently melting and vaporizing the spacers by application of electrical energy.

3. The method of securing the desired spacing between the electrodes of an electric discharge tube which comprises spacing the electrodes with conducting spacers during the construction of the tube, said spacers being mounted on brackets which are joined to the discharge electrodes at points remote from the discharge surfaces, and subsequently melting and vaporizing the spacers with the application of electrical energy.

4. The method of securing the required spacing between the electrodes of an electric discharge

device which comprises spacing the electrodes with conductng spacers during construction of the device, said spacers being composed of getter material mounted on brackets which are joined to the discharge electrodes at points remote from the discharge surfaces, and subsequently melting and vaporizing the spacers by the application of electrical energy.

5. The method of securing the required spacing between the electrodes of an electric discharge device which comprises spacing the electrodes with flexible conducting spacers during construction of the device, sealing one electrode through the envelope of the device, and stretching the flexible spacer to its full length during the sealing operation, and melting and vaporizing the spacers by the application of electrical energy.

6. The method of securing the desired spacing between the two electrodes of an electric discharge tube including two lead-in wires sealed through an enclosing envelope with discharge electrodes mounted on the interior ends of the lead-in wires which comprises attaching brackets to the discharge electrodes at points remote from the discharge surfaces, attaching a wire spacer to the brackets, utilizing the wire spacer during the sealing and exhaust process to set the spacing between the discharge electrodes, and applying a potential difference between the external ends of the lead-in wires to force a current through the wire spacer large enough to melt and vaporize the wire.

7. The method of securing the desired spacing between the two electrodes of an electric discharge tube including two lead-in wires sealed through an enclosing envelope with discharge electrodes mounted on the interior ends of the lead-in wires which comprises attaching brackets to the discharge electrodes at points remote from the discharge surfaces, attaching a wire spacer coated with getter material to the brackets, utilizing the wire spacer during the sealing and exhaust process to set the spacing between the discharge electrodes, and applying a potential difference between the external ends of the lead-in wires to force a current through the wire spacer large enough to melt and vaporize the wire and the getter material.

8. The method of securing the desired spacing between the two electrodes of an electric discharge tube comprised of two lead-in wires sealed through an enclosing envelope with discharge electrodes mounted on the interior ends of the lead-in wires which comprises attaching brackets to the discharge electrodes at points remote from the discharge surfaces, attaching a wire spacer composed of getter material to the brackets, utilizing the wire spacer during the sealing and exhaust process to set the spacing between the discharge electrodes, and applying a potential difference between the external ends of the lead-in wires to force a current through the wire spacer large enough to melt and vaporize the wire.

9. The method of securing the desired spacing between the two electrodes of an electric discharge tube consisting of two lead-in wires sealed through an enclosing envelope with discharge electrodes mounted on the interior ends of the lead-in wires which comprises holding the lead-in wires and electrodes in alignment and in the desired spacing, attaching wire brackets to the discharge electrodes at points remote from the discharge surfaces, stretching a spacing wire between the brackets and attaching its ends to the brackets, releasing the assembly from the means

which hold the lead-in wires and electrodes in fixed spatial relationship, sealing one of the lead-in wires through the containing envelope, sealing the second lead-in wire through the envelope while simultaneously pulling apart the lead-in wires to stretch the spacing wire to its full length and duplicate the original electrode spacing, and melting and vaporizing the spacing wire by applying a potential difference between the external ends of the lead-in wires.

10. The method of securing the desired spacing between the two electrodes of an electric discharge tube including two lead-in wires sealed through an enclosing envelope with discharge electrodes mounted on the interior ends of the lead-in wires which comprises sealing a header to one of the lead-in wires, mounting the discharge electrodes on the ends of the lead-in wires, holding the lead-in wires in alignment and at the desired spacing, attaching brackets to the discharge electrodes at points remote from the discharge surfaces, stretching a spacing wire between the brackets and attaching the ends of the wire to the brackets, removing the assembly from the means holding the members in fixed spatial relationship, introducing the assembly into the open end of an elongated bulb sealed to an exhaust tube at the other end, the lead-in wire without the header extending into the exhaust tube, sealing the header on the other lead-in wire to the open end of the bulb, connecting the exhaust tube to a pump and exhausting the air from the bulb, heating the glass at the juncture of the exhaust tube and the bulb to cut off the exhaust tube and to form a tip seal, pulling the bulb away from the exhaust tube while the glass is soft and thereby stretching the wire spacer to its full length to duplicate the original spacing when the seal is finally made, and melting and vaporizing the spacing wire by applying a potential difference to the external ends of the lead-in wires.

11. The method of spacing and aligning the two electrodes of an electric discharge tube including two lead-in wires sealed through an enclosing envelope with discharge electrodes mounted on the interior ends of the lead-in wires which comprises sealing a header to one of the lead-in wires, mounting the discharge electrodes on the ends of the lead-in wires, holding the lead-in wires in alignment and at the desired spacing, attaching brackets to the discharge electrodes at points remote from the discharge surfaces, stretching a spacing wire between the brackets and attaching the ends of the wire to the brackets, removing the assembly from the means holding the members in fixed spatial relationship, mounting alignment discs on the lead-in wires, introducing the assembly into the open end of an elongated bulb sealed to an exhaust tube at the other end, the lead-in wire without the header extending into the exhaust tube and the peripheries of the said alignment discs engaging the inner surface of the bulb and holding the electrodes in alignment, sealing the header on the other lead-in wire to the open end of the bulb, connecting the exhaust tube to a pump and exhausting the air from the bulb, heating the glass at the juncture of the exhaust tube and the bulb to cut off the exhaust tube and to form a tip seal, pulling the bulb away from the exhaust tube while the glass is soft and thereby stretching the wire spacer to its full length to duplicate the original spacing when the seal is finally made, and melting and vaporizing the spacing wire by applying a potential difference to the external ends of the lead-in wires.

12. The method of securing the required spacing between the electrodes of an electric discharge device which comprises spacing the electrodes with conducting spacers during construction of the device and melting and vaporizing the spacers by the application of electrical energy.

13. An electric discharge device including a pair of spaced electrodes, a hermetically sealed envelope enclosing the electrodes, and a conductive spacer connected from a point on one electrode to a point on the other electrode, said points being away from adjacent parts of said electrodes, said conductive spacer serving to accurately space said electrodes during fabrication of the device, said spacer being adapted to be removed upon application of a potential difference to said electrodes.

14. The method of fabricating a vessel enclosing a pair of electrodes having portions spaced apart accurately, comprising the steps of connecting a fusible link to the electrodes at points spaced further apart than said portions, enclosing the electrodes within a vessel, and parting the link by fusing it.

15. The method of fabricating an envelope enclosing a pair of electrodes mutually oriented accurately, comprising the steps of connecting a fusible link between the electrodes to fix the desired orientation, said link being connected at points on said electrodes which are more remote from one another than the adjacent portions of said electrodes enclosing said electrodes within an envelope part of which is fusible, said enclosing step including the fusing of at least part of the envelope to prevent forcible change of the orientation, and parting the link by fusing it.

16. The method of fabricating a vessel enclosing a pair of electrodes spaced apart accurately, comprising the steps of connecting a fusible link between the electrodes to fix the desired spacing, said link being connected at points on said electrodes which are more remote from one another than the adjacent portions of said electrodes enclosing said electrodes within an envelope with one electrode fixed to the envelope and the other electrode supported by said link, fusing the envelope to support the latter electrode without disturbing its orientation with respect to the first electrode, and electrically fusing said link.

17. The method of fabricating an evacuated envelope enclosing a pair of electrodes having juxtaposed portions spaced apart accurately, comprising the steps of connecting a fusible link to the electrodes at points remote from said portions, at least part of said link being of getter material, enclosing said electrodes in an envelope, the latter step including a fusing operation to avoid deformation of said link, evacuating the envelope, and electrically parting the link and simultaneously flashing the getter material.

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