Sept. 13, 1949. A. L. CHILCOT ET AL 2,481,906

MOUNTING OF ELECTRODES IN ELECTRIC DISCHARGE TUBES

Filed Dec. 24, 1943

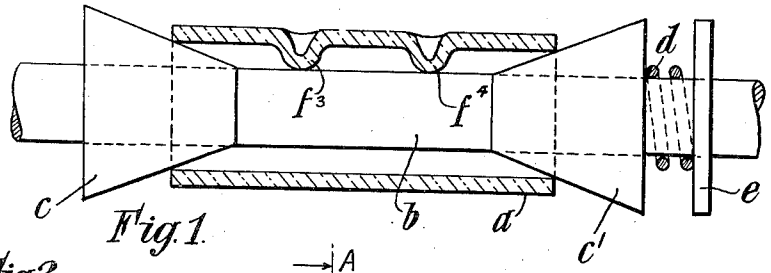


Fig. 1.

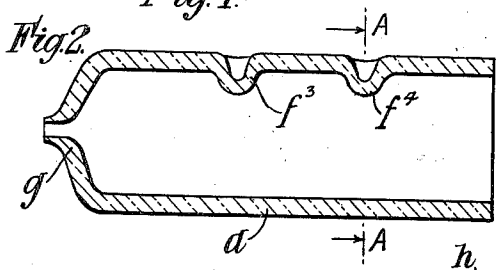


Fig. 2.

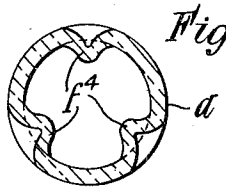


Fig. 3.

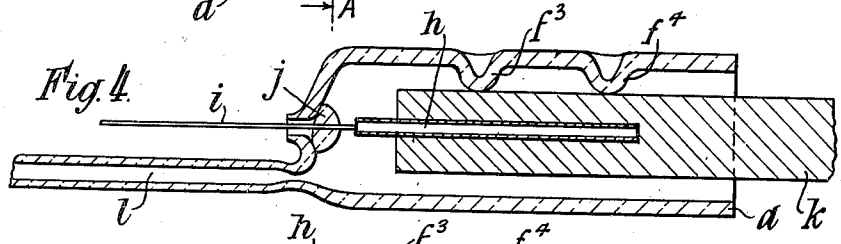


Fig. 4.

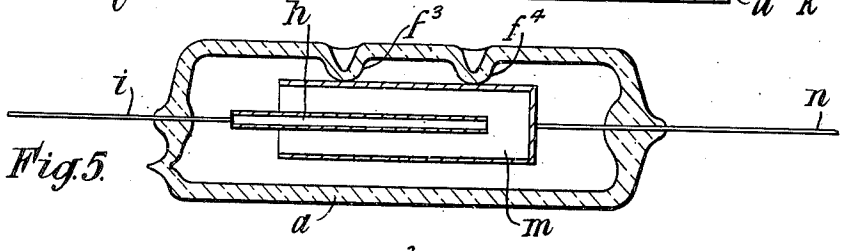


Fig. 5.

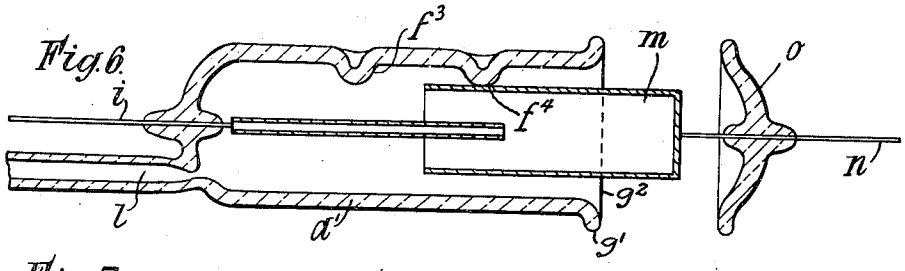


Fig. 6.

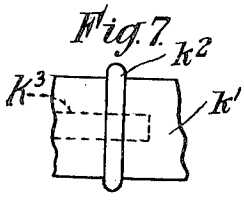


Fig. 7.

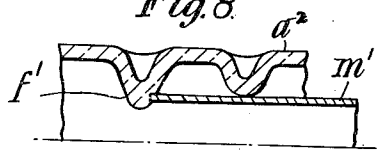


Fig. 8.

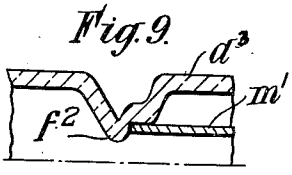


Fig. 9.

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Patented Sept. 13, 1949

2,481,906

UNITED STATES PATENT OFFICE

2,481,906

MOUNTING OF ELECTRODES IN ELECTRIC DISCHARGE TUBES

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Application December 24, 1943, Serial No. 515,500
In Great Britain April 18, 1942

Section 1, Public Law 690, August 8, 1946
Patent expires April 18, 1962

8 Claims. (Cl. 49—78)

1

This invention relates to electric discharge tubes of the type in which at least one electrode is mounted at each end of the envelope, one electrode wholly or partially surrounding the other electrode or electrodes.

For certain purposes discharge tubes of the usual type, in which all the electrodes are carried by a common pinch, or foot, are undesirable. Examples of such purposes are where discharge tubes are required to withstand high mechanical stress, or to operate under such a condition, or for short-wave work, where inter-electrode capacity must be as low as possible; for these purposes the type of tube in which an electrode is mounted at each end of the envelope is to be preferred. Where the tube has a cathode activated by the deposition thereon of an alkali metal, it is also highly desirable that the tube be of the double-ended type in order that the cathode may be maintained at low temperature whilst other parts of the tube are heated to ensure that the alkali metal is deposited only on the cathode.

Furthermore, the invention is concerned only with discharge tubes in which, in order to minimise the effect of electric charges on the inner wall of the tube, one electrode wholly or partially surrounds the other electrode or electrodes.

Where such discharge tubes are produced in quantity by mass production it has been found necessary to use such means as insulating inter-electrode spacers in order to obtain products having characteristics which vary as little as possible from one another. If such means are not employed wide variations of characteristics are difficult to avoid due to relatively small variations of transverse spacing. Where the cathode is to be activated as described above, such spacers are objectionable owing to the likelihood of the formation thereon of conducting films which would cause electrical leakage between the electrodes held by the spacers.

The main object of the present invention is to provide a form of construction of electric discharge tube of the type stated which ensures that all products of the same manufacturing process are as nearly identical as possible to one another in respect of their characteristics, and which avoids the use of inter-electrode spacers.

The characteristics of such tubes are to a very great extent dependent on the transverse spacing between electrodes and the aim of the invention is to ensure that such spacing is determined accurately without the use of inter-electrode spacers. Thus, any variations in the characteristics which may still occur between the several

2

products made in accordance with the invention are mainly those which arise from other factors, such as the chemical nature of the cathode surfaces and will be relatively small.

The invention is particularly useful for so-called midget tubes.

According to the invention an electric discharge tube has an envelope formed wholly by a glass tube sealed at both ends and provided at pre-selected parts with internal protuberances. By means of the apices of said protuberances at least one electrode, which is mounted at one end of the said envelope, has been and is accurately located by an interposed jig. Said apices serve to prevent both lateral and tilting displacement of another electrode by contact therewith, said other electrode being mounted at the other end of the said envelope, in such a manner as at least partially to surround the said first-mentioned electrode, whereby the said electrodes are accurately located in desired transverse spatial relationship to one another.

Also in accordance with the invention a method of constructing an electric discharge tube includes the formation on pre-selected parts of the inner surface of a glass tube of protuberances the apices of which are disposed in such a manner that when a jig holding at least one electrode is located by contact therewith, said jig is prevented from undergoing both lateral and tilting displacement, sealing one end of said tube to mount the said electrode whilst the said jig is so located, replacing the said jig by another electrode adapted at least partially to surround the said first-mentioned electrode and of such configuration as to be prevented by contact with the said apices from undergoing both lateral and tilting displacement and sealing the other end of the said glass tube to mount the said latter electrode, whereby the said electrodes are accurately located in desired transverse spatial relationship to one another.

The invention includes the method of constructing an electric discharge tube of the type having a glass envelope in which is a first electrode mounted at one end of the envelope wholly or partially surrounded by a second electrode mounted at the other end of the envelope, wherein the envelope is deformed inwardly at small areas to a gauge so as to provide locating protuberances for the said second electrode, and wherein the said first electrode is temporarily located from such protuberances of the envelope whilst it is mounted in its end of the envelope, the second electrode being then inserted and mounted at the other end

whilst held in accurate transverse location relative to the first electrode by the said protuberances.

The term "protuberances" used herein is intended to mean projections of an approximately conical or hemi-spherical form.

Referring to the accompanying drawings:

Figs. 1, 2, 4, and 5 are longitudinal sectional views of a diode valve at various stages of its manufacture, in accordance with one embodiment of the invention;

Fig. 3 is a cross-sectional view on the line A—A of Fig. 2, looking in the direction of the arrows;

Fig. 6 is a longitudinal sectional view of a stage in the manufacture of a diode valve in accordance with another embodiment of the invention;

Figs. 7, 8, and 9 are further details of modifications.

The invention may be carried into effect, according to one form by way of example, in the manufacture of a diode valve having a tubular anode or first electrode and a surrounding hollow cylindrical cathode or second electrode. A glass tube a of suitable dimensions, which is to form the envelope, see Fig. 1, is placed on a mandrel b the diameter of which is that of the cathode, and is held coaxially with the mandrel by means of cones c and c^1 fitted into the two ends; the cone c is attached rigidly to the mandrel whilst the cone c^1 is slidable on the mandrel, being held against the end of the tube a by a spring d bearing against a rim e on the mandrel. Six internal protuberances, two of which are shown at f^3, f^4, are formed in the tube in two sets of three, each set of protuberances being symmetrically disposed on a circle and the distance between the two circles being less than the length of the cathode. The arrangement of protuberances will be apparent from Figs. 1 and 3. The tube a is softened locally by the application of heat and each protuberance is formed separately by indentation with a suitable tool; the glass is allowed to cool between each operation in order to avoid unwanted distortion of the glass tube. The protuberances are formed to a height such that their apices f^4 come into contact with mandrel b. After removal from the mandrel one end g of the tube is closed and a hole blown in the middle of this end as shown in Fig. 2.

The anode h, see Fig. 4, consists of a small tube of nickel welded to a wire i of suitable material upon which a glass bead j has been fused. This anode is held in a jig k having a diameter equal to that of the mandrel b and therefore also to that of the cathode, and the jig is inserted in contact with the protuberances, f^3, f^4, in the glass tube a so that the wire i passes through the hole in the end g of the tube and with the bead j adjacent thereto. Since the jig has a diameter equal to that of the mandrel it is located positively by the protuberances. The bead is now fused to the end g of the glass tube, thus mounting the anode h rigidly and sealing the hole in that end of the tube. An exhaust tube l is also fused into this same end. When cool, the jig k is removed through the other end of the tube leaving the anode accurately located with respect to the apices of the protuberances.

The cathode m, see Fig. 5, is in the form of a hollow cylinder having one end closed. A wire n of suitable material, welded to the centre of this end, carries a glass bead. This glass bead is not shown as such, but appears only as an extra thickness after fusing. The cathode is inserted into the tube a and is located by the apices of the protuberances f^3, f^4, thus being brought into

accurate spatial relationship with the anode h. The open end of the glass tube is sealed to the cathode bead thus mounting the cathode. The tube is exhausted and activated by any method.

According to a modified construction, see Fig. 6, the cathode support wire n is fused into a flanged glass dish-shaped member o and the glass tube a^1 is provided with a co-operating flange g^1 at its open end g^2. The cathode m is located by the apices of the protuberances f^3, f^4, and the tube is sealed by fusing the flanges together. This method of construction has certain manufacturing advantages.

If it is desired to determine or fix the relative positions of the electrodes in an axial direction the jig k^1 used to mount the anode may be provided as shown in Fig. 7 with a shoulder k^2 to locate the anode axially against the protuberances f^4 nearest the open end of the tube. As can be seen from Fig. 7 the jig k^1 has a recess k^3 adapted to receive and locate the anode, the inner end of such recess being used to determine the axial position of the anode. Obviously if used for example in place of the jig k of Fig. 4, it will be inserted from the right hand end of the tube and its shoulder k^2 will engage and provide location against the protuberances nearest to such end. Similarly axial location may be provided for the cathode, thus (as shown in Fig. 8) the cathode m^1 may be inserted to a distance determined by a protuberance f^1 on tube a^2 of greater height than the protuberances on the inner wall of the envelope provided at the correct position. A protuberance as shown at f^2 on tube a^3 in Fig. 9 for this latter purpose may also constitute one of the protuberances serving to locate the cathode radially, thus forming a single "stepped" or "shelved" protuberance. After said electrode is sealed in, the jig is removed from the open end of the tube, and said end is then sealed.

The anode may be mounted asymmetrically with relation to the cathode by using an appropriately asymmetrical jig. The hollow cylindrical electrode may be the anode instead of the cathode. Furthermore, one or more additional electrodes may be inserted, being held in the same or other jigs having a diameter equal to that of the cylindrical electrode so that all such electrodes are located during mounting from the protuberances. The cathode may be of either the cold or hot emissive variety and the tube may be gas-filled or evacuated to any required degree.

The operation of fusing the glass envelope at small areas and deforming the same to produce the protuberances with or without subsequent shaping to form such protuberances requires only local heating of short duration which may be done without producing general distortion of the envelope, esepcially where such fusing is done one at a time. Consequently, such locating protuberances may be formed to a high degree of accuracy which they will maintain whilst the envelope is subjected elsewhere to further processing.

Since only the apices of the protuberances touch the cylindrical electrode, the latter may be heated for de-gassing purposes without fusing or cracking the glass envelope; especially is this so where a borosilicate glass is employed.

Instead of using six protuberances arranged as described above, any other suitable arrangement or number of protuberances which prevents both lateral and tilting displacement of the jig or of the electrode in contact therewith, as the case may be, may be employed.

It will be appreciated that whilst variations may occur in the dimensions of glass tubing, the dispositions of the apices of the protuberances in the several products, being formed against an accurately machined mandrel, are reproduced accurately. Since the jig and the hollow cylindrical electrode, being of metal, may also be formed with considerable accuracy, it is possible them having identical inter-electrode spatial relationships and hence uniformity of characteristics subject only to any slight variation due mainly to other factors, such as the chemical nature of the cathode surface.

What we claim is:

1. A method of constructing an electric discharge tube which comprises forming protuberances on pre-selected parts of the inner surface of a glass tube, the apices of said protuberances being disposed in such a manner that when a jig holding at least one electrode is located by contact therewith, said jig is prevented from undergoing both lateral and tilting displacement, inserting said jig to so contact with said apices, fusing to seal one end of said tube to mount a first electrode whilst said jig is so located, removing said jig and inserting in place thereof a second electrode to at least in part surround said first electrode, contacting said second electrode with said apices so as to prevent both lateral and tilting displacement, and fusing the other end of said tube to seal the same and to mount said second electrode, whereby said electrodes are accurately located in desired transverse spatial relationship to one another.

2. A method of constructing an electric discharge tube which comprises forming protuberances on pre-selected parts of the inner surface of a glass tube, said protuberances being symmetrically disposed on a circle, the apices of said protuberances being disposed in such a manner that when a jig holding at least one electrode is located by contact therewith, said jig is prevented from undergoing both lateral and tilting displacement, inserting said jig to so contact with said apices, fusing to seal one end of said tube to mount a first electrode whilst said jig is so located, removing said jig and inserting in place thereof a second electrode to at least in part surround said first electrode, contacting said second electrode with said apices so as to prevent both lateral and tilting displacement, and fusing the second end of said tube to seal the same and to mount said second electrode, whereby said electrodes are accurately located in desired transverse spatial relationship to one another.

3. A method of constructing an electric discharge tube which comprises forming two sets of three protuberances on pre-selected parts of the inner surface of a glass tube, the protuberances of each set being symmetrically disposed on different circles the apices of said protuberances being disposed in such a manner that when a jig holding at least one electrode is located by contact therewith, said jig is prevented from undergoing both lateral and tilting displacement, inserting said jig to so contact with said apices, fusing to seal one end of said tube to mount said electrode whilst said jig is so located, removing said jig and inserting in place thereof another electrode to at least in part surround said first electrode, said second electrode being of a length greater than the distance between said circles, contacting said other electrode with said apices so as to prevent both lateral and tilting displacement, and fusing the other end of said tube to seal the same and to mount said other electrode, whereby said electrodes are accurately located in desired transverse spatial relationship to one another.

4. A method of constructing an electric discharge tube which comprises forming protuberances on pre-selected parts of the inner surface of a glass tube, said protuberances being formed by inserting a mandrel in said tube, locally softening said tube, exteriorly indenting said softened areas to cause contact of said protuberances with said mandrel and removing said mandrel, the apices of said protuberances being disposed in such a manner that when a jig holding at least one electrode is located by contact therewith, said jig is prevented from undergoing both lateral and tilting displacement, inserting said jig to so contact with said apices, fusing to seal one end of said tube to mount a first electrode whilst said jig is so located, removing said jig and inserting in place thereof a second electrode to at least in part surround said first electrode, contacting said second electrode with said apices so as to prevent both lateral and tilting displacement, and fusing the other end of said tube to seal the same and to mount said second electrode, whereby said electrodes are accurately located in desired transverse spatial relationship to one another.

5. A method of constructing an electric discharge tube of the type having a glass envelope in which a first electrode mounted at one end of the envelope is at least partially surrounded by a second electrode mounted at the other end of the envelope which comprises inserting a mandrel within said envelope, forming protuberances for said second electrode on the inside of said envelope at small areas and to an extent determined by said mandrel, removing said mandrel, inserting said first electrode at said one end and adjusting the position thereof relative to said protuberances, fusing said first electrode in place, then inserting said second electrode in the opposite end of said envelope into contact with said protuberances and fusing said second electrode in place.

6. A method of constructing an electric discharge tube of the type having a glass envelope in which a first electrode mounted at one end of the envelope is at least partially surrounded by a second electrode mounted at the other end of the envelope which comprises inserting a mandrel within said envelope, forming protuberances for said second electrode on the inside of said envelope at small areas and to an extent determined by said mandrel, said protuberances being symmetrically disposed on a circle, removing said mandrel, inserting said first electrode at said one end and adjusting the position thereof relative to said protuberances, fusing said first electrode in place, then inserting said second electrode in the opposite end of said envelope into contact with said protuberances and fusing said second electrode in place.

7. A method of constructing an electric discharge tube of the type having a glass envelope in which a first electrode mounted at one end of the envelope is at least partially surrounded by a second electrode mounted at the other end of the envelope which comprises inserting a mandrel within said envelope, forming protuberances for said second electrode on the inside of said envelope at small areas and to an extent determined by said mandrel, said protuberances being formed in two sets of three protuberances, the

protuberances of each set being symmetrically disposed on a circle and the distance between the two circles being less than the length of said second electrode, removing said mandrel, inserting said first electrode at said one end and adjusting the position thereof relative to said protuberances, fusing said electrode in place, then inserting said second electrode in the opposite end of said envelope into contact with said protuberances and fusing said second electrode in place.

8. A method of constructing an electric discharge tube of the type having a glass envelope in which a first electrode mounted at one end of the envelope is at least partially surrounded by a second electrode mounted at the other end of the envelope which comprises inserting a mandrel within said envelope, forming protuberances for said second electrode on the inside of said envelope at small areas and to an extent determined by said mandrel, said protuberances being formed by locally softening said envelope, exteriorly indenting said softened areas to cause contact of said protuberances with said mandrel, removing said mandrel, inserting said first electrode at said one end and adjusting the position

thereof relative to said protuberances, fusing said first electrode in place, then inserting said second electrode in the opposite end of said envelope into contact with said protuberances and fusing said second electrode in place.

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