April 24, 1945. J. P. LAICO 2,374,546

MANUFACTURE OF ELECTRON DISCHARGE DEVICES

Filed Jan. 21, 1941

FIG. 1

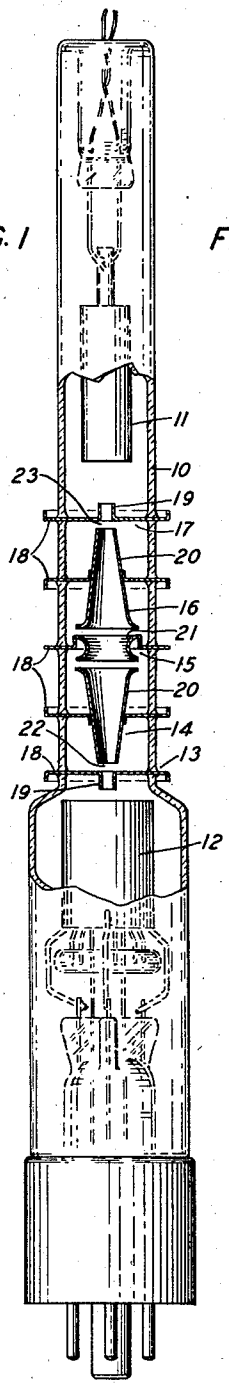


FIG. 2

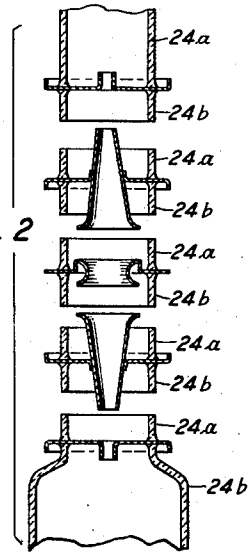


FIG. 6

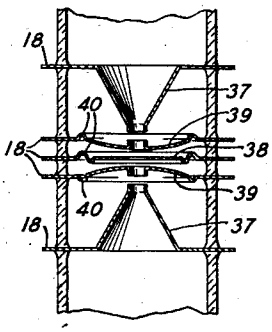


FIG. 7

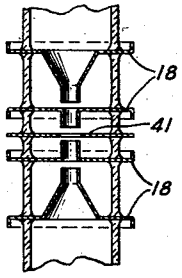


FIG. 5

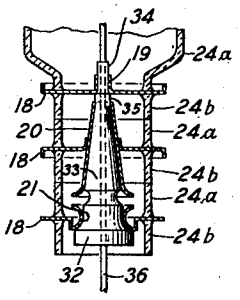


FIG. 8

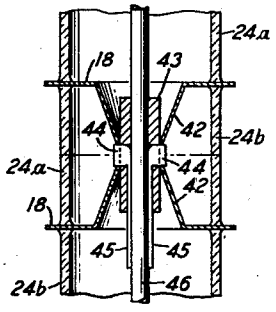


FIG. 3

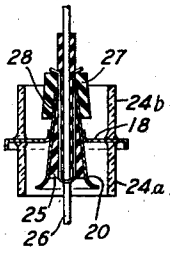
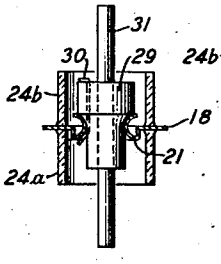


FIG. 4



INVENTOR
J. P. LAICO

BY
Walter C. Kiesel

ATTORNEY

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MANUFACTURE OF ELECTRON DISCHARGE DEVICES

Joseph P. Laico, Brooklyn, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application January 21, 1941, Serial No. 375,110

5 Claims. (Cl. 250—27.5)

This invention relates to the manufacture of electron discharge devices and more particularly to methods of manufacturing electron beam discharge devices such, for example, as beam devices of the velocity variation type.

Electron beam discharge devices of the type to which this invention pertains usually comprise two or more electrodes in energy transferring relation with the electron beam. The attainment of desired operating characteristics, efficient operation, and operation at ultra-high frequencies requires that these electrodes be mounted in exact predetermined relation and extremely close to one another. For example, in some velocity variation devices, the requisite spacing between electrodes defining the input and output gaps is extremely small and the allowable tolerances are but a few ten thousandths of an inch and, in cases where these electrodes are apertured, for example annular, the electrodes must be in exact alignment. Such electrodes may be mounted in spaced relation by insulating members, for example of vitreous material, to or in which they are sealed.

The exact spacing of such electrodes mounted in this manner heretofore has been extremely difficult to obtain due to the fact that exact determination of the spacing by viewing has been impossible and due to the further fact that the working of the vitreous material and the contraction and expansion thereof during the making of the seals thereto has not been accurately controllable to enable the realization within extremely close limits of the ultimately desired space relation of the electrodes.

One object of this invention is to facilitate the manufacture of electron discharge devices including a plurality of closely spaced electrodes. More specifically, one object of this invention is to facilitate the mounting of a plurality of electrodes in an electron discharge device in exact alignment and in accurate and extremely close space relation.

In accordance with one feature of this invention, the several electrodes are provided with annular mounting or supporting portions and tubular vitreous members are hermetically sealed in coaxial relation to opposite faces of the mounting portions. The electrodes to be mounted in adjacent relation are then fitted upon a tool or guide with the tubular vitreous members of the two in abutting relation, the tool locating the two electrodes in exact coaxially and allowing relative longitudinal movement of the electrodes. The abutting vitreous members are then heated to seal them together, the necessary working of the vitreous material being accomplished by relative longitudinal movement of the electrode. The tool is so constructed that the electrodes are located accurately in the exact space relation desired, when the vitreous material cools and the seal is formed.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a view in elevation of an electron beam discharge device of the velocity variation type constructed in accordance with this invention, a portion of the device being shown in section to illustrate the form and relation of certain of the electrodes more clearly;

Fig. 2 is a detail view in section of a portion of the discharge device illustrated in Fig. 1, showing the various electrode and insulator assemblies to be mounted, prior to the sealing together thereof;

Fig. 3 is a detail view in section of one of the electrodes and a tool used in conjunction therewith during the sealing of the insulating members thereto;

Fig. 4 is another detail view mainly in section illustrating the mounting of another of the electrodes during the sealing of the insulating members thereto;

Fig. 5 is still another detail view in section illustrating the manner of positioning several of the electrode and insulator assemblies during the joining thereof;

Figs. 6 and 7 are fragmentary views in section illustrating other electrode assemblies constructed in accordance with this invention; and

Fig. 8 is a view in section illustrating another way of positioning electrode and insulator units during the joining thereof.

Referring now to the drawing, the electron beam discharge device comprises an evacuated enclosing vessel having an elongated cylindrical portion 10, an anode or target electrode 11 mounted near one end of the cylindrical portion 10 and an electron gun 12, which may be of the construction disclosed in Patent 2,303,166, granted November 24, 1942, to Joseph P. Laico, mounted opposite the other end of the cylindrical portion 10.

Mounted between the electron gun 12 and the anode or target electrode 11 are a plurality of coaxial electrodes 13 to 17, inclusive, each of which includes an annular metallic, e. g., copper,

disc portion 18 extending normal to the longitudinal axis of the enclosing vessel and hermetically sealed to, and extending through, the wall of the cylindrical portion 10 of the enclosing vessel. As shown clearly in the drawing, the end electrodes 13 and 17 include central cylindrical portions 19, the electrodes 14 and 16 include central frusto-conical portions 20, and the electrode 15 includes a central, annular inwardly curved portion 21. The electrodes 13 and 14 are spaced to define an input or control gap 22 and the electrodes 16 and 17 are spaced to define an output gap 23.

The operating characteristics of the device are dependent in a large measure upon these gaps. For example, efficient operation and electrical symmetry of the electrodes with respect to the beam whereby uniform transfer of energy between the electrodes and the beam may be realized require that the electrodes be in exact coaxial relation. Furthermore, particularly at ultra-high frequencies, gaps of extremely short length and great accuracy, for example with tolerances of the order of five ten thousandths of an inch, are required. Both the requisite exact coaxiality and accurate close spacing are attained facilely in devices constructed in accordance with this invention.

As illustrated in Fig. 2, in manufacturing devices in accordance with this invention, the annular portion 18 of each of the electrodes 13 to 17, inclusive, has hermetically sealed to opposite faces thereof lengths of cylindrical, e. g., vitreous, tubing 24*a* and 24*b* which are coaxial with one another and the electrode to which they are sealed. The sealing between the annular portions 18 and the vitreous tubing 24*a* and 24*b* may be effected as illustrated in Figs. 3 and 4. As shown in the former figure, the frusto-conical member 20 of the electrode 14 or 16 is fitted on a metallic or insulating guide 25 which is mounted slidably on a rod 26 coaxial therewith and which may be supported between chucks, not shown. The electrode may be clamped to the guide 25 by a collar 27 having an inner frusto-conical wall conforming to the frusto-conical member 20 and which is detachably locked to the guide 25 by a hairpin shaped wire 28 having outwardly bent ends as shown. The vitreous tubings 24*a* and 24*b* are positioned by the chucks, in coaxial relation with the rod 26 so that when the tubing is hermetically sealed to the annular portion 18 by the application of heat thereto in known ways, the coaxiality of the electrode and the lengths of tubing is maintained and in the unit formed thereby the annular portion 18 extends normal to the longitudinal axis of the unit. After the seals have been made, the hairpin wire 28 is withdrawn and the guide 25 and collar 27 are removed as is also the guide 26.

The seals between the electrode 15 and the lengths of tubings 24*a* and 24*b* associated therewith may be made in the same manner, as shown in Fig. 4. The electrode 15 is mounted on a guide 29 and detachably locked thereto by one or more spring wires 30 having bent-over ends as shown. The guide 29 is fitted slidably on a rod 31 in coaxial relation with the electrode 15, the rod and the insulating tubing being mounted in coaxial relation by chucks, not shown. As in the unit shown in Fig. 3, when the unit illustrated in Fig. 4 is completed the annular portion 18 of the electrode 15 extends normal to the longitudinal axis of the unit. After the seals between this portion 18 and the insulating tubes 24*a* and 24*b* have been made, the spring wires 30 are withdrawn and the guide 29 and rod 31 are removed.

The lengths of insulating tubing may be sealed to the annular portions 18 of the electrodes 13 and 17 in the same manner, a suitable rod fitted in the cylindrical portions 19 being utilized as a guide for maintaining the electrodes and associated tubing in coaxial relation during the sealing operation.

After the several electrode and insulator units have been constructed as described above, the units are joined to one another in a manner which assures the attainment of both exact coaxiality of the electrodes and accurate spacing thereof. These ends may be realized through the use of a positioning or guide member or tool, for example of tungsten or stainless steel, which, as illustrated in Fig. 5, includes an end portion 32 having a surface which conforms accurately to the central portion 21 of the electrode 15, a frusto-conical portion 33 which fits accurately within the portion 20 of the electrode 14 (or 16), an end portion 34 accurately fitted within the cylindrical portion 19 of the electrode 13 (or 17) and an intermediate portion 35 forming a seat against which the electrode 13 (or 17) abuts. The positioning member or tool is slidably mounted upon a rod 36.

In joining the units, the electrodes 16 and 17 together with the associated insulating tubes may be mounted upon the insulating member or tool with the tube 24*b* of the former in end-to-end relation with the tube 24*a* of the latter. The facing ends of the two lengths of tubing are then heated, as by flames played thereon, to render them plastic, and these lengths are then sealed to one another. During the sealing operation, relative longitudinal movement of the two units is possible, as is apparent, to allow the necessary working of the vitreous material at the plastic ends without altering the coaxial relation of the two units being joined. After the vitreous material has been worked properly, the electrode 16 is positioned so that the frusto-conical portion 20 thereof is firmly fitted upon the portion 33 of the tool and the electrode 17 is moved toward the electrode 16 until it abuts the seat on the intermediate portion 35 of the tool and this position of the two electrodes is maintained while the seal between the abutting tubings 24*a* and 24*b* forms. The portions 33 and 35 are so dimensioned that when the electrode 17 abuts the seat therefor, the spacing between the electrodes 16 and 17 is exactly that desired for the gap 23.

A seal is then made in a similar manner between the tubing 24*b* associated with the electrode 16 and the tubing 24*a* associated with the electrode 15, the portions 32 and 33 of the tool being so dimensioned that when the electrode members 21 and 20 respectively are in firm engagement therewith, the electrodes are in exactly the space relation desired in the completed device.

After the three electrode-insulator units have been joined as described, the tool and rod 36 are withdrawn. A similar assembly is formed in like manner of the electrodes 13 and 14 and the insulating tubings associated therewith. The two assemblies are then mounted upon a guide rod, not shown, slidably fitted in the cylindrical portions 19 of the electrodes 13 and 17, whereby the two assemblies are mounted in coaxial relation, and the tubing 24*a* associated with the electrode 14 is joined to the tubing 24*b* associated with the electrode 15. The two assemblies may

be located longitudinally during the making of the final seal by an external spacer engaging the annular portions 18 of the electrodes 14 and 15.

It will be apparent that in the assembly thus formed, all of the electrodes are in exact coaxial relation and the spacings between adjacent electrodes are accurately fixed so that a device of which this assembly forms a part will have the desired operating characteristics and efficient operation thereof is assured.

The method described hereinabove is not limited in its application to the fabrication of electrode assemblies including electrodes of the particular forms illustrated in Fig. 1. It may be utilized also in the manufacture of assemblies including electrodes of other forms, such as shown, for example, in Figs. 6 and 7. As shown in Fig. 6, the endmost electrodes of the assembly include central frusto-conical portions 37, the central electrode includes an annular central portion 38 and the intermediate electrodes include centrally apertured dished portions 39. As shown, several of the electrodes may be provided with an annular corrugation 40 to allow expansion and contraction thereof during the fabrication and operation of the device and thereby to prevent the setting up of deleterious stresses at the seals between the annular disc portions 18 of the electrodes and the tubular portion 10 of the enclosing vessel and also to minimize variations in the space relation of the electrodes.

In the construction illustrated in Fig. 7, the central electrode is an annular disc 41 and the other electrodes are provided with coaxial central cylindrical portions as shown.

In cases where the electrodes are of such configuration that the longitudinal spacing thereof cannot be fixed by a guide or tool of the general construction shown in Fig. 5, apparatus of the construction shown in Fig. 8 may be employed during the joining of two electrode-insulator units to one another. In the construction illustrated in this figure, the electrodes comprise central frusto-conical portions 42 in end-to-end relation and annular portions 18 sealed to vitreous tubings 24*a* and 24*b* in the manner described heretofore. The two electrodes, together with the insulating tubing associated therewith, are mounted in coaxial relation by a cylindrical guide 43 having openings in its wall through which spacers 44 extend, the spacers being dimensioned accurately so that when the electrode portions 42 abut thereagainst, these portions will be in exactly the space relation desired in the discharge device. The spacers 44 are carried by resilient supports 45 fitting in internal grooves in the guide 43. The guide 43 is slidably fitted upon a rod 46 which is insertable between the supports 45 and when thus inserted separates the spacers 44 so that they project from the guide 43. After the tubings 24*a* and 24*b* are sealed to one another, during which operation the electrode portions 42 are located accurately with respect to one another by virtue of the abutment thereof against the spacers 44, the rod 46 is withdrawn, the spacers 44 are forced within the guide 43 by pressing the supports 45 toward each other, and the guide 43 is withdrawn. In the assembly thus formed, it is apparent that the two electrodes are mounted in exact coaxiality and are accurately spaced the distance desired.

Although specific methods and apparatus have been described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. In the manufacture of electron discharge devices including a tubular insulating member and a plurality of electrodes within said member and having conductive portions hermetically sealed to said member, the method which comprises sealing tubular lengths of insulating material to opposite faces of each of said conductive portions, mounting several of the assemblies thus formed in alignment, axially movable with respect to one another and with tubular lengths of successive of the assemblies in abutting relation, and hermetically sealing the abutting tubular lengths to one another.

2. The method of constructing a unitary assembly for electron discharge devices including a tubular insulating member and a plurality of electrodes within said tubular member and having conductive portions sealed thereto, which method comprises sealing coaxial tubular lengths of insulating material to opposite faces of each of said conductive portions and in coaxial relation therewith, mounting several of the assemblies thus formed in coaxial relation, longitudinally movable with respect to one another and with the tubular lengths of successive assemblies in abutting relation, locating said assemblies so that the electrodes included therein are in fixed, coaxial space relation, and hermetically sealing the abutting tubular lengths to one another.

3. In the manufacture of an electron discharge device including a tubular insulating member and a plurality of electrodes within said tubular member and having annular disc portions hermetically sealed to said member, the method of assembly which comprises sealing tubular lengths of insulating material in coaxial relation to opposite faces of each of said disc portions, mounting several of the assemblies thus formed in relative longitudinally movable relation upon a guide having portions for locating the assemblies in coaxial relation and for determining the spacing between the electrodes in said assemblies, with tubular lengths of successive assemblies in abutting relation, softening the ends of said abutting tubular lengths, shifting adjacent assemblies longitudinally to engage the electrodes thereof with said spacing determining portions, sealing abutting tubular lengths to one another, and withdrawing said guide.

4. The method of manufacturing an electron discharge device including a tubular insulating portion and a pair of electrodes within said portion, each of said electrodes having a central portion and an outer annular disc portion hermetically sealed to said insulating portion, which method comprises sealing tubular lengths of insulating material in coaxial relation to opposite faces of each of said disc portions, mounting the assemblies thus formed upon a guide having coaxial portions adapted to fit said central portions of said electrodes and having thereon locating means for positioning the electrodes in predetermined relation, said assemblies being mounted on said guide so as to be relatively movable longitudinally and with one tubular length of one assembly in juxtaposed relation with one tubular length of the other assembly, heating the juxtaposed ends of said tubular lengths to render them plastic, sliding said assemblies longitudinally on said guide until the electrodes therein abut said locating means, hermetically sealing said juxtaposed ends together, and withdrawing said guide.

5. In the manufacture of an electron discharge device including a tubular vitreous member and a pair of spaced electrodes within said member, each of said electrodes having a central apertured portion and an annular supporting portion hermetically sealed to said vitreous member, the method which comprises sealing tubular lengths of vitreous material to one face of each of said annular portions, mounting the assemblies thus formed in coaxial and longitudinally movable relation upon a guide having portions adapted to fit within said apertured portions of said electrodes and having also removable spacing means, said assemblies being mounted on said guide with said tubular lengths in juxtaposition, softening the juxtaposed ends of said tubular lengths, moving said assemblies toward one another with said softened ends in contact until said electrodes abut said spacing means, sealing said lengths to one another, and withdrawing said guide.

JOSEPH P. LAICO.