March 22, 1960 C. F. MILLER ET AL 2,929,668

ELECTRON DISCHARGE DEVICE

Filed Oct. 31, 1956 4 Sheets-Sheet 1

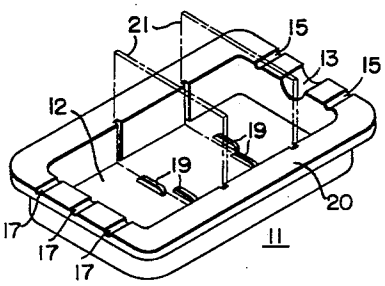


Fig. 1.

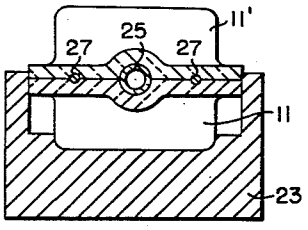


Fig. 3.

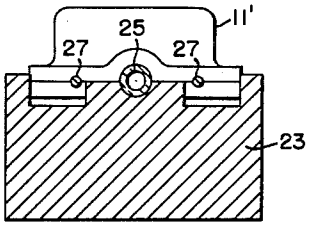


Fig. 4.

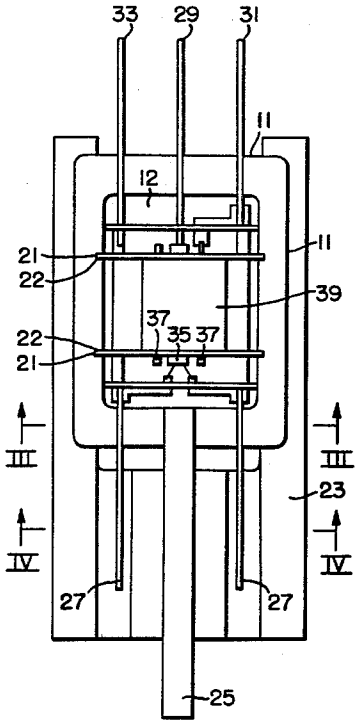


Fig. 2.

WITNESSES

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ELECTRON DISCHARGE DEVICE

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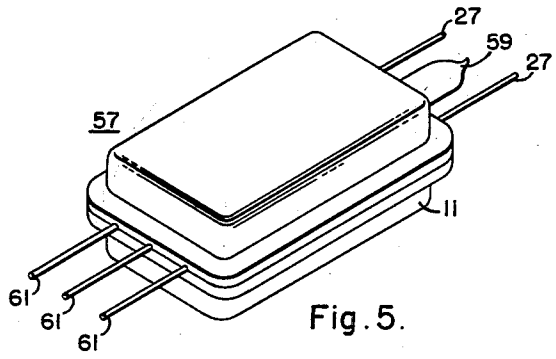


Fig. 5.

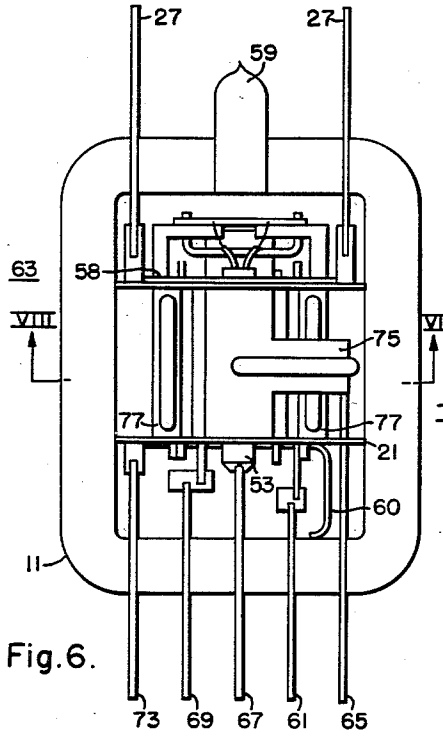


Fig. 6.

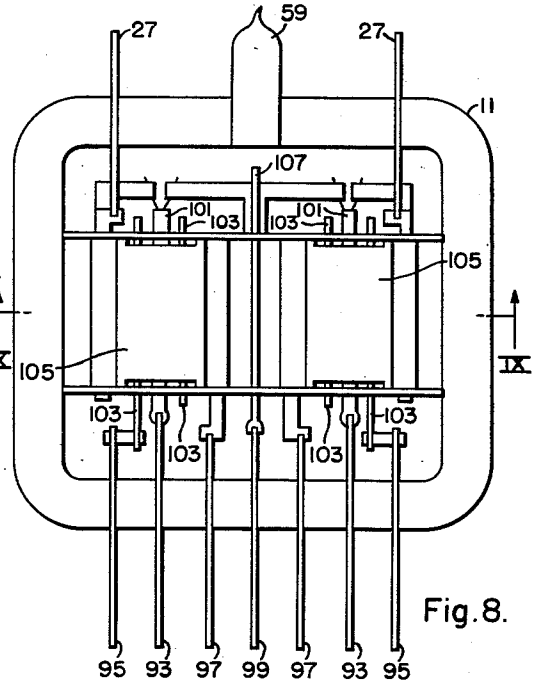


Fig. 8.

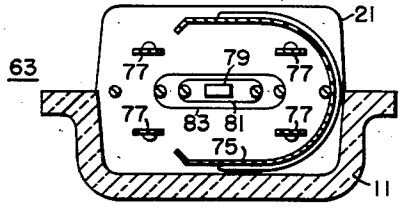


Fig. 7.

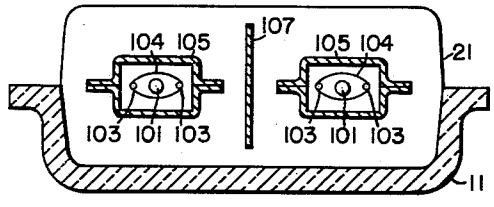


Fig. 9.

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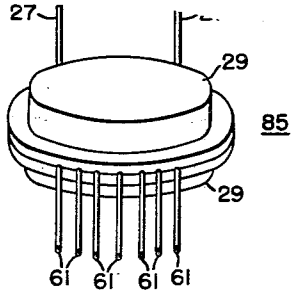


Fig. 10.

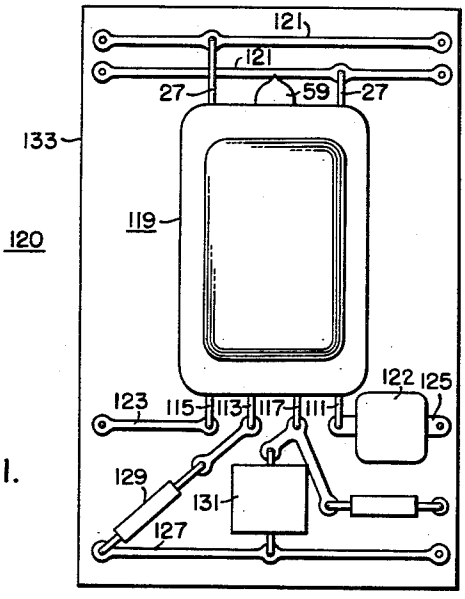


Fig. 11.

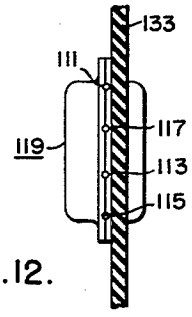


Fig. 12.

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ELECTRON DISCHARGE DEVICE

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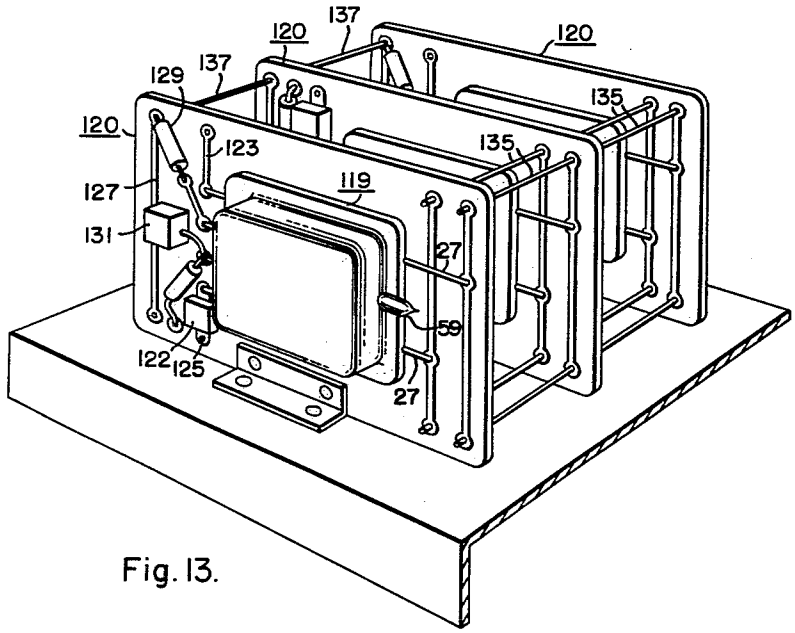


Fig. 13.

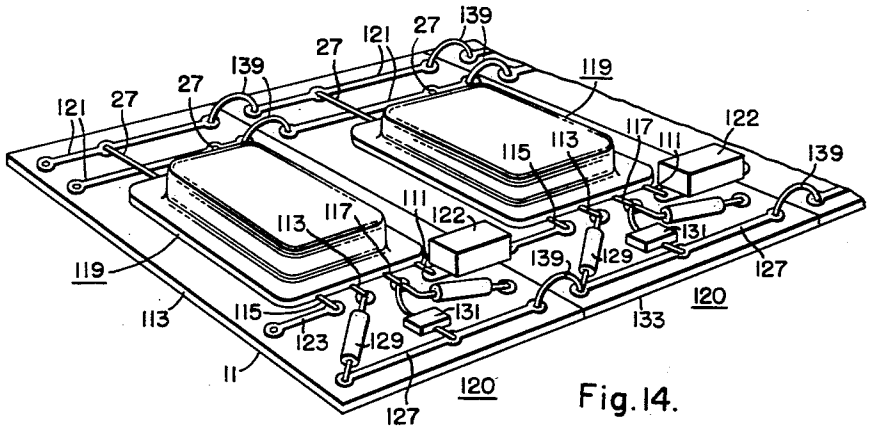


Fig. 14.

United States Patent Office 2,929,668
Patented Mar. 22, 1960

2,929,668

ELECTRON DISCHARGE DEVICE

Carl F. Miller, Bath, and William H. McCurdy, Horseheads, N.Y., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application October 31, 1956, Serial No. 619,586

2 Claims. (Cl. 316—19)

This invention relates to electron discharge devices and methods of making them and more particularly, to electron discharge devices which require no sockets, may be made by automatic assembly methods, and are suitable for use with printed circuitry.

In prior art manufacture of electron discharge devices, particularly receiving tubes, an electrode structure is attached by leads to a glass "button" or stem which in turn is sealed to a "bulb" or envelope. Finally the envelope is exhausted and sealed off. The sealing of the "button" or stem to the envelope is usually done with gas burners which are difficult to control and adjust properly. Also burners have the disadvantage of oxidizing the metallic parts of the device. In order to minimize this burner difficulty, most prior art tubes have had the general outline of a cylinder so they could be rotated during the heating and sealing operations.

Therefore, we propose an electron discharge device which may have outlines other than cylindrical and which is suitable for use with automatic assembly techniques, as well as a method for making this tube which provides for the sealing to be done without burners and which combines the attaching of the electrode structure to the envelope, the envelope sealing, and the exhausting into one continuous operation.

In addition our electron discharge device and method of manufacture do not require the use of sockets when the device is used.

In current printed circuit techniques, the inclusion of electron tube sockets in the printed circuits involves considerable alignment difficulty and additional time and expense. For example, 9-pin electron tube sockets must be carefully aligned with 9 radial strips on the printed circuit board and 9 soldered connections to the socket lugs must be made. Frequently, one or more of these connections later proves to be weak or faulty and an open circuit results.

Also, when sockets are used, the electron tube axis is perpendicular to the plane of the printed circuit board which causes the electron tube to project a considerable distance above the circuit board and results in poor space utilization. The electron tube acts as a cantilever which results in considerable vibration, thereby limiting the vibrational forces to which the tube may be submitted, especially when used in military equipment.

In addition, the tube socket introduces extra capacitances, inductances and couplings which result in hum, other pickup difficulties and circuit losses.

Accordingly it is an object of our invention to provide an improved electron discharge device.

It is another object to provide an improved method of manufacturing an electron discharge device.

It is a further object to provide an improved electron discharge device which does not require a socket.

It is an additional object to provide an electron discharge device which may be made by automatic assembly techniques.

It is still another object to provide an improved electron discharge device in which the lead sealing, envelope sealing and exhausting steps in the manufacturing process may be done in one continuous operation and without gas burners.

It is still a further object to provide an improved electron discharge device which provides better space utilization in printed circuitry.

It is still an additional object to provide an improved electron discharge device in which the heater lead members may have the envelope through one portion and remaining lead members leave the envelope through another portion.

It is another object to provide an improved electron discharge device in which the lead members may leave through different portions of the seal portion of the device.

It is a further object to provide an improved method of manufacturing an electron discharge device with the characteristics mentioned in the above objects.

These and other objects of our invention will be apparent from the following description taken in accordance with the accompanying drawings throughout which like reference characters indicate like parts, which drawings form a part of this application, and in which:

Figure 1 is a perspective view of an envelope portion according to one embodiment of our invention;

Fig. 2 is a top view of a partially assembled electron discharge device according to one embodiment of our invention;

Fig. 3 is a sectional view along line III—III for the device shown in Fig. 2 with the addition of a top envelope portion;

Fig. 4 is another sectional view along line IV—IV of the device shown in Fig. 2 with the addition of a top envelope portion;

Fig. 5 is a perspective view of a triode having a rectangular-shaped envelope constructed according to one embodiment of our invention;

Fig. 6 is a top view of a partially assembled pentode having an envelope similar in shape to that shown in Fig. 5;

Fig. 7 is a sectional view along the line VII—VII of the partially assembled pentode shown in Fig. 6;

Fig. 8 is a top view of a partially assembled twin triode in a square-shaped envelope;

Fig. 9 is a sectional view along the line IX—IX of the partially assembled twin triode shown in Fig. 8;

Fig. 10 is a perspective view of a twin triode having a circular-shaped envelope constructed according to one embodiment of our invention;

Fig. 11 is a top view of an embodiment of our invention as adapted to printed circuitry;

Fig. 12 is an end view of an electron discharge device constructed according to one embodiment of our invention in which the electron discharge device is placed in an opening in a printed circuit board;

Fig. 13 is a perspective view of an embodiment of our invention as adapted to printed circuitry; and

Fig. 14 is a perspective view of another embodiment of our invention as adapted to printed circuitry.

In our invention the envelope member of an electron discharge device may be comprised of envelope portions **11** which may be recessed and flanged as shown in Fig. 1. The envelope portions **11**, which may be made of glass, if desired, include a number of grooves which allow various parts of the electron discharge device to be connected from outside the envelope. For example, there is shown an exhaust tubulation groove **13**, heater lead grooves **15** and electrode lead grooves **17**. The dotted

lines indicate where spacer members 21, preferably made of a substance such as mica, may be inserted in the envelope portion 11. As can be seen, the spacer members 21 may be readily fixed in position by spacer holder members 19. If desired the envelope portion may be equipped with grooves suitable for positioning the spacer members 21, although the spacer holder members 19 may prove more desirable if grooves less than 0.005 inch wide are difficult to make. Also, the spacer members 21 may be positioned by a slight surplus of the material used to seal the envelope portions together in the sealing operation to be described later. Peripheral edge portions, shown here in the form of flange portions 20, are adjacent to and surround a recess portion 12.

The particular envelope portion 11 pictured in Fig. 1 is suitable for use in a triode and is rectangular in general outline. As will be shown later, numerous variations of the design of the envelope portion 11 may be made and envelope portions adapted for use with pentode electrode structures, twin triode electrode structures, etc., are also feasible.

An electron discharge device may be constructed according to our invention as shown in Figs. 2 through 4. A completed electrode structure which may be of the conventional type is assembled in a suitable manner and is placed in a recess portion 12 of an envelope portion 11 which has been previously positioned in an envelope support member 23. The electrode structure may include a cathode electrode 35, an anode electrode 39, and a grid electrode (not shown). Grid electrode support members 37 are shown. It may be advantageous to have some of the lead members leave the envelope at one end and the rest leave at the other end, or at various other places on the sides. In this particular embodiment two heater lead members 27 leave the envelope through one end of the envelope member and electrode leads including a cathode lead member 29, a control grid electrode member 31 and an anode lead member 33, leave through the other end of the envelope member. This particular lead arrangement has the advantage of reducing the internal input capacitance of the tube, since the coupling of the heater lead members 27 to the control grid electrode lead member 31 is practically eliminated. Also, the hum pickup by the control grid electrode lead member 31 from the heater lead members 27 is also markedly reduced. This structure further results in having the terminals of the active circuit located at one end of the envelope, thus making them easily recognizable and simple to insert and solder to the proper connections. Also, the heater lead members 27 of several electron discharge devices may be oriented to a common heater bus on a printed circuit board which further reduces hum pickup and in general simplifies the layout of the circuit. As shown, the spacer members 21 may be inserted in spacer member grooves 22 in the envelope portion 11. An exhaust tubulation 25 is placed in the exhaust tubulation groove 13.

In Figs. 3 and 4 there are shown sectional views of Fig. 2 along lines III—III and IV—IV, respectively, after the addition of an envelope portion 11'. This envelope portion 11', which may be identical with the above-described envelope portion, is then sealed to the envelope portion 11. In one embodiment of our invention the sealing material is glass solder material having a working point substantially below the softening point of the material of the envelope. After the sealing material is applied to the edges of the envelope portion 11 and the envelope portion 11 is properly positioned, the electron discharge device is inserted in an oven and heated to a temperature of 450–550° C. for 8–10 minutes. As soon as the solder softens, the exhaust tubulation 25 is connected to an exhaust pump and exhausted for 3 minutes until a desirable vacuum is established which, due to external atmospheric pressure, causes the two envelope portions 11, 11' to press tightly against the soft solder resulting in a hermetic seal. The temperature is then reduced and the electron discharge device may be removed from the envelope support member 23. The exhaust process is continued for 10 minutes while the metal parts are being degassed and the cathode is being acttvated and finally the exhaust tubulation 25 is tipped off. If desired during the initial heating step an inert gas such as argon may be injected through the tubulation 25 to avoid oxidation of the metal parts of the electrode structure.

It is important that the solder-glass used have a working temperature that is below the strain point of the glass used in the envelope portion 11 in order to avoid introducing strains into the envelope. Also, the coefficient of thermal expansion of the solder-glass must closely match the coefficients of various lead members and the envelope itself. For example, we have found that a soda lime glass having a strain point of 478° C., a coefficient of thermal expansion of 92×10^{-7} per °C., a working point of 1000° C., and a softening point of 696° C., is suitable for use as an envelope material with a solder glass seal material which has a softening point of 440° C. and a coefficient of thermal expansion of 84×10^{-7} per °C. We have found that a material known as dumet (a copper plated alloy of 42% nickel and 58% iron) is suitable for use in the various lead members with the above materials. Another alloy suitable for use in lead members is composed of 42% nickel, 6% chromium and 52% iron.

Another suitable combination involves the use of envelope material of a glass having a strain point of 459° C. and a coefficient of thermal expansion of 101×10^{-7} per ° C. A suitable solder glass seal material may have a coefficient of thermal expansion of 101×10^{-7} per ° C. and softening point of 425° C. With these materials, suitable lead members have been made of chrome-iron alloys or of dumet. Other envelope materials may be used, such as hard glass, for example borosilicate glasses, or ceramic materials with suitable sealing materials.

We have also found that suitable sealing materials may include those known as epoxy resins. These epoxy resins are glycidyl polyethers and may be prepared by reacting predetermined amounts of at least one polyhydric phenol and at least one epihalohydrin in an alkaline medium. Phenols which are suitable for use in preparing such resinous polymeric epoxides include those which contain at least two phenolic hydroxy groups per molecule. Polynuclear phenols which have been found to be particularly suitable include those wherein the phenol nuclei are joined by carbon bridges, such for example as 4,4'-dihydroxy-diphenyl-dimethyl-methane (referred to hereinafter as bis-phenol "A") and 4,4'-dihydroxy-diphenyl-methane. In admixture with the named polynuclear phenols, use also may be made of those polynuclear phenols wherein the phenol nuclei are joined by sulfur bridges such, for example, as 4,4'-dihydroxy-diphenyl-sulfone.

While it is preferred to use epichlorohydrin as the epihalohydrin in the preparation of the resinous polymeric epoxide starting materials of the present invention, homologues thereof, for example, epibromohydrin and the like also may be used advantageously.

In the preparation of the resinous polymeric epoxides, aqueous alkali is employed to combine with the halogen of the epihalohydrin reactant. The amount of alkali employed should be substantially equivalent to the amount of halogen present and preferably should be employed in an amount somewhat in excess thereof. Aqueous mixtures of alkali metal hydroxides, such as potassium hydroxide and lithium hydroxide, may be employed although it is preferred to use sodium hydroxide since it is relatively inexpensive.

The resinous polymeric epoxide, or glycidyl polyester of a dihydric phenol, suitable for use in this invention has a 1,2-epoxy equivalency greater than 1.0 By epoxy

equivalency reference is made to the average number of 1,2-epoxy groups



contained in the average molecule of the glycidyl ether. Owing to the method of preparation of the glycidyl polyethers and the fact that they are ordinarily a mixture of chemical compounds having somewhat different molecular weights and contain some compounds wherein the terminal glycidyl radicals are in hydrated form, the epoxy equivalency of the product is not necessarily the integer 2.0. However, in all cases it is a value greater than 1.0. The 1,2-epoxy equivalency of the polyethers is thus a value between 1.0 and 2.0.

Resinous polymeric epoxides or glycidyl polyethers suitable for use in accordance with this invention may be prepared by admixing the reacting from one to two mol proportions of epihalohydrin, preferably epichlorohydrin, with about one mol proportion of bis-phenol "A" in the presence of at least a stoichiometric excess of alkali based on the amount of halogen.

The epoxy resins may be applied to the flange portions **20** of the envelope portion **11** in the form of powder or paste. The material softens upon heating and the seal is formed in a manner similar to the solder glass seal described above. Silicone resins have also been found to be suitable sealing materials. These resin materials have polymerization points substantially below the softening point of the envelope material.

We have found that occasionally a slight heating of a lead member sealed in an epoxy resin results in an air leak through the seal. To remedy this condition, it may sometimes be advisable to use prebeaded wires for lead members.

In Fig. 5 there is shown a perspective view of a completed triode device **57** using a rectangular-shaped envelope according to one embodiment of our invention. Also shown are a tipped off exhaust tubulation **59** and heater lead members **27** leaving the envelope at one end, and the electrode lead members **61** leaving the envelope at the other end. As can be seen, the envelope portions **11** utilized in this particular embodiment are identical. However, if desired, non-identical envelope portions may be used in this embodiment or in other embodiments.

In Figs. 6 and 7 there is shown a partially-assembled pentode device **63** in which a rectangular-shaped envelope is utilized. In Fig. 6 one envelope portion has not been attached and the remaining envelope portion **11** is shown including a tipped off exhaust tubulation **59**. Heater lead members **27** are shown projecting from one end of the envelope while an anode lead member **65**, a cathode lead member **67**, a control grid electrode lead member **69**, a screen grid electrode lead member **61** and a suppressor grid electrode lead member **73** are shown projecting from the other end. We have found this particular lead member arrangement to be advantageous but, if desired, the various lead members in this or other embodiments may leave the envelope through other parts of the seal. Also shown are an anode electrode **75**, a cathode electrode **53**, a suppressor grid electrode **77**, and electrostatic shield members **58** and **60**. The shield members **58** and **60** which may be made of sheet metal, reduce the coupling between the anode electrode **75** and the control grid electrode to a minimum. These shield members **58** and **60** are necessary if the pentode is used in an I.F. or R.F. amplifier.

A sectional view taken along the line VII—VII in Fig. 6 is shown in Fig. 7 including the envelope portion **11** and spacer member **21**. Also shown are a cathode electrode **79**, a control grid electrode **81**, a screen grid electrode **83**, a suppressor grid electrode **77**, and an anode electrode **75**.

Another embodiment of our invention is shown in Figs. 8 and 9 in which a partially-assembled twin triode device utilizes a square-shaped envelope. A tipped off exhaust tubulation **59** and the heater lead members **27** again project from one end of the envelope and the remaining lead members project from the other end of the envelope. The electrode structure has been placed in an envelope portion **11** having a tipped off exhaust tubulation **59**. Cathode electrode **101** and anode electrode **105** are shown as well as control grid support members **103**. An electrostatic shield member **107** separates the two triodes. Heater lead members **27** project from one end of the envelope while cathode lead members **93**, control grid lead members **95**, anode lead members **97** and an electrostatic shield lead member **99** project from the other end. The sectional view taken along the line IX—IX of Fig. 8 as shown in Fig. 9 includes an envelope portion **11**, a spacer member **21**, the electrostatic shield member **107**, the anode electrode **105**, the cathode electrode **101**, the control grid electrode **104** and control grid electrode support members **103**.

Another embodiment of our invention, namely, a twin triode device **85** in a circular-shaped envelope, is shown in Fig. 10. Also shown are heater lead members **27**, envelope portions **29** and the remaining lead members **61**. A suitable electrode structure for this type of device has been previously shown in Figs. 8 and 9.

As an example of specific sizes we have made, the dimensions of the triode envelope shown in Figs. 1–4 and 5 may be: length, 1.5 in.; width, $1\frac{5}{16}$ in.; height, 0.62 in.; lead wire diameter, 0.022 in.; and spacing between centers of electrode leads, 0.28 in. The dimensions of the pentode shown in Figs. 6 and 7 may be: length, $1\frac{7}{16}$ in.; width, $1\frac{5}{16}$ in.; height, 0.54 in.; length, including exhaust tip, $1\frac{9}{16}$ in; lead wire diameter, 0.022 in.; and spacing between centers of electrode leads, 0.140 in. The dimensions of the circular twin triode shown in Fig. 10 may be: diameter of envelope, 1.25 in.; diameter plus exhaust tip, $1\frac{5}{8}$ in.; height, 0.50 in.; lead wire diameter, 0.022 in.; and spacing between centers of electrode leads, 0.105 in. The dimensions of the square twin triode shown in Figs. 8 and 9 may be: width, 1.25 in.; length, $1\frac{1}{8}$ in.; length, including exhaust tip, 1.5 in.; height, 0.50 in.; lead wire diameter, 0.022 in.; and spacing between centers of electrode leads, 0.125 in. Of course, these dimensions are merely examples, may be changed to fit circumstances and do not limit our invention.

It should also be noted that a distinct advantage of the envelope and electrode configurations used, is that the electrodes may be welded to the leads in a line or by so-called "in-line" welding. This has the advantage of providing cheaper, quicker and better assembly of tubes.

As has been previously pointed out, one advantage of using envelope portions shaped as those in Figs. 1–10 is that they lend themselves to automatic production and assembly. For example, a conventional electrode structure may be placed in a lower envelope portion. The assembly may be completed by placing an upper envelope portion over the electrode structure and sealing to the lower envelope portion as described previously.

If desired, the lower envelope portion may serve as a receptacle into which an assembly machine places the component parts of the electrode structure in a desired sequence. Such an electrode assembly is described in a copending patent application by E. A. Lederer, entitled "Automatic Assembly of Radio Tube Mounts," Serial No. 375,524, filed August 20, 1953 and assigned to the same assignee as the subject application.

An adaptation of an electron discharge device made according to our invention is shown in Figs. 11 through 14 in which an electron discharge device, in this case a pentode device **119** in a rectangular-shaped envelope, is mounted upon printed circuit boards. As can be seen in the module **120** shown in Fig. 11, the heater lead members **27** are connected to heater bus members **121**. An input connection **123** is connected to a control grid lead

member 115 while an output connector 125 is connected to an anode lead member 111 through a transformer 122. In this particular embodiment, the suppressor grid electrode has been internally connected to the cathode and the joint cathode-suppressor grid lead member 113 may be directly grounded or connected to a ground bus member 127 through a cathode-dropping resistor 129. The screen grid electrode lead member 117 may be bypassed to the ground bus member 127 through a capacitor 131. Also shown is the tipped off exhaust tubulation 59.

In Fig. 12 there is shown the pentode device 119 which is inserted in an opening in a printed circuit board member 133. This particular embodiment has the advantage of giving shorter leads to the circuit elements, improves the rigidity of the connections to the circuit elements and provides for an improved utilization of space. The module 120 shown in Fig. 11 or the embodiment shown in Fig. 12 may be utilized in a number of ways, such as shown in Figs. 13 and 14. In Fig. 13 the modules 120 are stacked and main heater lead members 135 and ground lead members 137 are utilized. In Fig. 14 the modules 120 are placed side-by-side and connector members 139 connect the heater bus members 121 to each other and the ground bus members 127 to each other. These modules 120 provide a very flexible system which is both space saving and rigid. Loose wiring and cross-over wiring between printed circuit boards is eliminated.

The envelope portions, such as shown in Figs. 1, 5 and 10 have the advantage that they may be mass produced in large quantities by a pressing process. Thus, the mechanical accuracy of the dimensions of the envelope portion is higher than that obtained by the ordinary blown glassware as utilized in present electron discharge devices. Also, because these envelope portions may be produced by a pressing process, the envelope design may include a number of variations, such as recesses for retaining spacer members, thus adding to the ruggedness and reliability of the tube. In general, because of their rectangular cross section, as shown in Figs. 3, 7, 9 and 12, the tube may be mounted close to the printed circuit, thus providing an improved utilization of the space available.

The sealing process described in this application may be accomplished very cheaply in a conveyor belt furnace containing an inert atmosphere, such as argon, in order to prevent oxidation of the tube parts. We have also found that although the exhaust tubulation is usually made of glass, a metallic exhaust tubulation can be easily utilized in our invention.

The shielding of tubes laying on printed circuit boards, such as shown in Figs. 11 through 14, may be easily done and requires in most cases only a strap of sheet metal. In cases where poor air circulation exists, the heat from the envelope may be absorbed by a close fitting heat shield which may be provided with cooling means, such as fins, or which may be strapped to the chassis. As can readily be seen, the lead structures in tubes in the electron discharge devices of our invention are considerably simpler and are cheaper than the leads utilized in the ordinary socket tube because they need not be as heavy.

While the present invention has been shown in several forms, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit and scope thereof.

We claim as our invention:

1. A method of making an electron discharge device, said electron discharge device comprising an envelope member made of a first material having a first envelope portion and a second envelope portion, said envelope member also having a first end section and a second end section, said first envelope portion having a recess portion and a peripheral edge portion adjacent to and surrounding said recess portion, said method including the steps of placing a sealing material upon said edge portion of said first envelope portion, said sealing material having a flow point below the strain point of said first material, positioning said first envelope portion upon a support member, positioning an internal electrode structure, which has at least four lead members, within said recess portion of said first envelope portion, positioning said second envelope portion so that an edge portion of said second envelope portion is in contact with said sealing material, thereby, in conjunction with said sealing material and said edge portion of said first envelope portion, forming a seal portion, a first part of said seal portion being located in said first end section of said envelope member and a second part of said seal portion being located in said second end section of said envelope member, said internal electrode structure having been positioned in the above positioning step so that at least two of said lead members pass through said first part of said seal portion and at least two of said lead members pass through said second part of said seal portion, heating said electron discharge device so that said sealing material is heated to its flow point but so that said first material is heated below its strain point, exhausting said electron discharge device through an exhaust tubulation, and sealing said exhaust tubulation.

2. A method of making an electron discharge device, said electron discharge device comprising an envelope member made of a first material and having a first envelope portion and a second envelope portion, said envelope member also having a first end section and a second end section, said first envelope portion having a recess portion and a peripheral edge portion adjacent to and surrounding said recess portion, said method including the steps of placing a sealing material upon said edge portion of said first envelope portion, said sealing material having a flow point below the strain point of said first material, positioning said first envelope portion upon a support member, positioning an internal electrode structure, which has at least four lead members including heater lead members, within said recess portion of said first envelope portion, positioning said second envelope portion of that said edge portion of said second envelope portion is in contact with said sealing material, thereby forming in conjunction with said sealing material and said edge portion of said first envelope portion, a seal portion, a first part of said seal portion being located in said first end section of said envelope member and a second part of said seal portion being located in said second end section of said envelope member, said internal electrode structure having been positioned in the above positioning step so that said heater lead members pass through said first part of said seal portion and the remaining lead members pass through said second part of said seal portion, heating said entire electron discharge device in an oven so that said sealing material is heated to its flow point but so that said first material is heated below its strain point, exhausting said electron discharge device through an exhaust tubulation, and sealing said exhaust tubulation.

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