

April 19, 1960

E. A. LEDERER
ELECTRON DISCHARGE DEVICE

2,933,634

Filed June 22, 1956

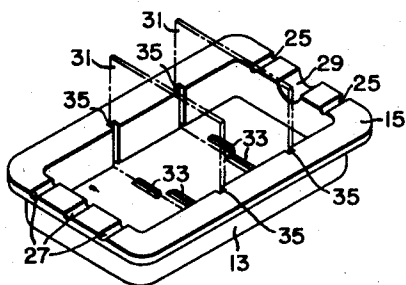


Fig. 2.

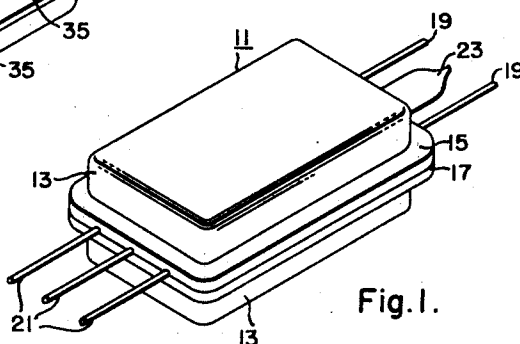


Fig. 1.

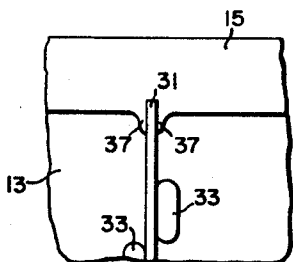


Fig. 3.

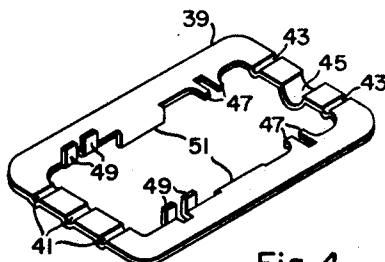


Fig. 4.

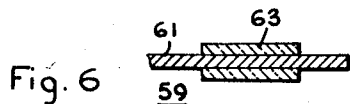


Fig. 6

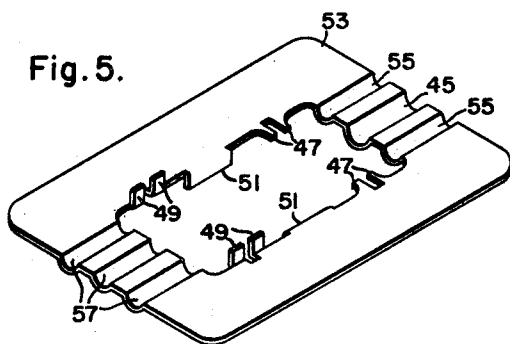


Fig. 5.

WITNESSES

Edwin E. Bassler

H. O. Blair

INVENTOR

Ernest A. Lederer

BY *J. E. Browder*
ATTORNEY

1

2,933,634

ELECTRON DISCHARGE DEVICE

Ernest A. Lederer, Essex Fells, N.J., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application June 22, 1956, Serial No. 593,259

5 Claims. (Cl. 313-331)

This invention relates to electron discharge devices and, more particularly, to electron discharge devices that have structures particularly adapted for use with printed circuitry and automatic assembly.

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.

It has also been found advantageous to utilize organic resin materials as seals for electron discharge devices. This sealing may be carried out at moderate temperature thus avoiding complicating machinery and processes. Also, the electrode structure of the electron discharge device is not exposed to high temperature dissipating conditions. However, disadvantages of the presently available organic resin materials are due to the fact that even the best materials do not permit degassing electric discharge apparatus at temperatures higher than about 200-250° C. As a result the moisture film on the envelope is only partially removed. Therefore, it can readily be seen that during the life of the tube a certain amount of gas evolution is to be expected, which gas may not be satisfactorily removed by the getter.

In general, my invention involves an electron discharge device which does not require a socket, which is readily adaptable to automatic assembly, and which is suitable for use with organic resin sealing materials.

Accordingly, it is an object of my invention to provide an improved electron discharge device which provides better space utilization with printed circuitry.

It is a further object to provide an improved electron discharge device utilizing a resinous or low melting point glass solder seal.

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

It is a different object to provide an improved method of making an electron discharge device in which a resinous seal is utilized.

It is still another object to provide an improved gettering method for an electron discharge device in which a resinous seal is utilized.

2

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

Figure 1 is a perspective view of a triode having a rectangular shaped envelope constructed according to one embodiment of my invention;

Fig. 2 is a perspective view of an envelope portion according to one embodiment of my invention;

Fig. 3 is a top view of a portion of the envelope portion shown in Fig. 2;

Fig. 4 is a perspective view of a metal flange member which may be inserted in the seal portion of an electron discharge device according to one embodiment of my invention; and

Fig. 5 is a perspective view of a metal flange member which may be inserted in a seal portion of an electron discharge device according to another embodiment of my invention; and

Fig. 6 is a side sectional view of a prebeaded lead wire utilized in one embodiment of our invention.

In Fig. 1 there is shown a perspective view of an electron discharge device using a rectangular shaped envelope according to one embodiment of my invention. In this particular embodiment a triode is shown in which the envelope member 11 is comprised of two envelope portions 13. Each envelope portion 13 has a flange portion 15. The seal portion 17 of the envelope member 11 is also shown. In this particular embodiment heater lead members 19 are shown at one end of the device while the active electrode lead members 21 are shown at the other end of the device. It will be noted that the lead members leave the device through the seal portion 17. Also shown is a tipped-off exhaust tubulation 23.

In Fig. 2 there is shown an envelope portion 13 which may be made of glass, if desired. The flange portion 15 of the envelope portion 13 is shown including heater lead grooves 25, electrode lead grooves 27 and an exhaust tubulation groove 29. The dotted lines indicate where spacer members 31, preferably made of a substance such as mica, may be inserted in the envelope portion 13. The spacer member 31 may be positioned by spacer positioning members 33 and/or by spacer groove portions 35.

Another method of positioning which may be used in combination with the spacer positioning member 33 and the spacer groove portions 35 is shown in Fig. 3 in which spacer positioning protuberances 37 are shown. These spacer positioning protuberances 37 are made from surplus portions of the sealing material.

As can be seen, the envelope portion shown in Fig. 2 is particularly adaptable to an automatic or mechanized assembly process. A completed electrode structure, which may be of the conventional type, is assembled in a suitable manner and is placed in an envelope portion 13. Another envelope portion 13, which may be identical with the other envelope portion 13, is then placed so that the two envelope portions 13 may be sealed together. In one embodiment of my invention the sealing material is a glass solder material having a working point substantially below the softening point of the envelope member 11. After the solder is applied the electrode 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 23 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 13 to press tightly against the soft glass and solder and results in a hermetic seal. The temperature is then reduced and the

electron discharge device may be removed. The exhaust process is continued for several minutes while the metal parts are being degassed and the cathode is being activated and finally the exhaust tubulation 23 is tipped off. During the initial heating step, if desired, an inert gas such as argon may be injected through the tubulation 23 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 member 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 coated 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 a 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 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-diphenylmethane. 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 polyether 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 and 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 15 of the envelope portion 13 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.

However, as these epoxy resins and silicone resins may not be heated as high as might be desirable during the degassing process, it has sometimes been found desirable to insert a metal flange member 39 similar to that shown in Fig. 4 or 5 between the two envelope portions 11 before they are sealed together. This flange member 39 should be made of a material having a high heat conductivity, for example, aluminum, copper, silver or molybdenum. The flange member 39 is covered on both sides with the resin where it will come in contact with the flange portions 15 of the envelope portions 13. The seal is made by applying heat and pressure in a manner similar to that described above.

As shown in Figs. 4 and 5, the metal flange member 39 may include electrode lead grooves 41, heater lead grooves 43 and an exhaust tubulation groove 45. Various spacer support members may be utilized such as a notch type spacer support member 47 and/or a cleat type spacer support member 51. Also shown is the metal flange support and positioning member 51. If desired, small interior projections may be made on the flange member 38 or 53 which may be utilized in various ways such as supporting getters. The metallic flange member 39 shown in Fig. 4 is particularly useful when utilized to heat the resinous sealing material by use of induction heating. If it is desired to maintain the resinous seal material at a comparatively low temperature during the processing or operation of the electron discharge device the metallic flange member 53 which is shown in Fig. 5 may be utilized in which the flange member itself protrudes considerably beyond the envelope member 11 of the electron discharge device. Thus, during the operation the processing of operational procedures the metallic flange member 53 may be cooled in such a manner to keep the temperature of the resin seal considerably below that reached by envelope portions 11. This cooling may be done by attaching suitable water or air-cooled fixtures to the metal flange member 53. Such an arrangement may be called a "heat-sink." The flange member 53 therefore conducts the heat away from the resinous seal. It is possible that some of the glass surface of the envelope 11 adjacent to the seal may not be adequately degassed because of this cooling but because the surface is a very small fraction of the inner surface of the en-

velope portions 13, it does not affect the quality of the tube perceptively. However, it may be desirable to utilize a gettering method such as described below to aid in removing gases which are not adequately removed during the heating and cooling processes.

It is possible that if the lead-in wires are in direct contact with the resinous seal material an overheating of the lead wire during use would result in an air leak through the resinous seal material. Also, if the metallic flange found in Figs. 4 and 5 is utilized there may be actual contact between the lead-in wires and the metallic flange member or, if not actual contact, there may be a capacitance between the lead-in wires and the metallic flange members. Therefore, it may be desirable to use "prebeaded" lead members 59, as shown in Fig. 6, to avoid direct contact between the metal flange members 39 and the lead members 61 and also to avoid the possibility of air leaks through the resinous seal material. Prebeaded lead wires 59 are made by enclosing a portion of an ordinary lead wire 61, similar to lead wire 21 and 19, in a glass sleeve 63 and may be made on an automatic machine. When the prebeaded lead wires 59 are utilized the heater lead grooves should be made bigger than the heater lead grooves 43 shown in Fig. 4, thus resulting in heater lead grooves 55 shown in Fig. 5. Of course, the metallic flange members 39 and 53 may be useful with solder seals or seals of other materials as well as the resinous seal. If the use of the metallic flange member 39 or 53 is not desirable the resinous seal may be cooled by other means such as air blasts or by placing the seal portion in contact with a cooled heat conductor or by a combination of the above means.

It is sometimes found to be desirable, particularly if a resin seal material is used, not to heat the envelope portions 13 above a temperature which is suitable for the seal material. As a result of heating at this comparatively low temperature the moisture film on the interior of the glass envelope portion 13 and other occluded gases are only partially removed. This results in a certain amount of gas evolution during the life of the tube which gas may not be adequately removed by the ordinary getter. I have found that these moisture films may be removed by the bombardment by charged particles, such as electrons or ions, or through moderate heat. Both these processes are accelerated under reduced pressure conditions. In order to satisfactorily remove the moisture and accumulated gases, I have found it desirable to coat the inside of the envelope portion 13 with a suitable metallic layer. Preferably, this layer should exhibit an affinity for water vapor so that the moisture may be absorbed and removed by chemical combination. I have also found it to be desirable to coat portions of the seal so that no decomposition of the seal material occurs due to particle bombardment. Of course, the metallic layer should be applied so that the leads will not be connected by the metal film.

This protective metal film may be evaporated at a lower temperature than the maximum envelope temperatures reached during the degassing processes. Suitable materials which react readily with water but not with the resinous seal material and have a desirably low vapor pressure include magnesium, calcium, lithium, zirconium, hafnium, titanium, aluminum, zinc, manganese and vanadium. Such a protective metallic film may be electrically connected to the cathode or to another grounded electrode.

The hydrogen evolved in the performance of the previous step may be removed by a hydrogen-removing getter material which is evaporated in the envelope after it has been sealed and tipped off. Suitable hydrogen getter materials include beryllium, thorium, cerium, lanthanum, tantalum, columbium and zirconium. Of course, the protective metallic film and the hydrogen-removing getters are not limited to the above materials.

Particular electron discharge apparatus shown in Fig. 1 and the various parts shown in Figs. 2 through 5 are suitable for use in a triode having a rectangular shaped envelope. I have found that the same principles may be utilized in numerous other structures such as pentodes, twin triodes, triode pentodes, twin pentodes, etc. Also, other envelope structures may be utilized such as square and circular envelopes. While I have found identical envelope portions 13 to be very satisfactory and desirable the same principles utilized in this invention are found to be present when non-identical envelope portions are used.

The particular lead arrangement shown in Fig. 1 has the advantage of reducing the lead capacitances since the coupling of the heater lead members 19 to the electrode lead members 21, particularly the control grid lead members, is practically eliminated. Also the hum pick-up of the control grid lead member from the heater lead members 19 is 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. As all the leads are in one plane, automatic or mechanized welding of the lead wires to the electrode structure or cage is facilitated and inspection is simplified. Also the heater lead members 19 of several electrode discharge devices may be oriented to a common heater bus on a printed circuit board which further reduces hum pick-up and, in general, simplifies the layout of the circuit. Random noise originating in mechanical contacts is diminished. Socket elimination permits the use of more single purpose tubes designed for maximum utility and located at the proper place in the circuit. In addition, the reliability of tubes in respect to noise, microphonic heater cathodes, shorts and open heaters is considerably reduced. As the envelope portion 13 may be pressed from glass material it can be mass produced to exact dimensions, insuring better fits between the electrodes and the envelope.

As an example of the specific sizes we have made, the dimensions of the triode envelope shown in Figs. 1 and 2 may be as follows: 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 sealing process described in this application can be accomplished in a conveyor belt furnace containing an inert atmosphere in order to prevent oxidation of the tube part. I have also found that although the exhaust tubulation is usually made of glass, a metallic exhaust tubulation may be employed resulting in certain advantages.

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.

I claim as my invention:

1. An electron discharge device comprising an envelope member having a first portion and a second portion, a hermetic seal portion joining said first portion to said second portion, said electron discharge device having a plurality of lead members, said lead members extending from inside said envelope member to outside said envelope member, a portion of each of said lead members passing through said seal portion, said electron discharge device including insulating spacer members, said envelope member including recessed portions, said insulating spacer members being positioned in said recessed portions, said seal portion including a plurality of protuberances, said protuberances being positioned adjacent said insulating spacer members to aid in positioning said insulating spacer members.

2. An electron discharge device comprising an envelope member having a first portion and a second por-

tion, said envelope member being comprised of a first material, a hermetic seal portion joining said first portion to said second portion, said seal portion being comprised of an insulative second material, said second material having a melting point substantially below the melting point of said first material, said electron discharge device having a plurality of lead members, said lead members extending from inside said envelope member to outside said envelope member, a portion of each of said lead members passing through said seal portion, said electron discharge device including insulating spacer members, said envelope member including recessed portions, said insulating spacer members being positioned in said recessed portions, said seal portion including a plurality of protuberances, said protuberances being comprised of said second material, said protuberances being positioned adjacent said insulating spacer members to aid in positioning said insulating spacer members.

3. An electron discharge device comprising an envelope member having a first portion and a second portion, said envelope member being comprised of a first material, a hermetic seal portion joining said first portion to said second portion, said seal portion being comprised of an insulative second material, said second material having a melting point substantially below the melting point of said first material, said electron discharge device having a plurality of lead members, said lead members extending from inside said envelope member to outside said envelope member, a portion of each of said lead members passing through said seal portion, a bead member enclosing said portion of each of said lead members so that said lead member does not contact said second material, said bead member being comprised of a third material.

4. An electron discharge device comprising an envelope member having a first portion and a second portion, a hermetic seal portion joining said first portion to said second portion, said electron discharge device having a plurality of lead members, said lead members extending from inside said envelope member to outside said envelope member, a portion of each of said lead members passing through said seal portion, at least a part of said seal portion and at least a part of said envelope member being internally coated with a protective layer, said pro-

5. A method for making an electron discharge device having an envelope member comprised of a first material, said envelope member including a first envelope portion, a second envelope portion and a seal portion between said first envelope portion and said second envelope portion, said seal portion being comprised of an insulative second material having a melting point substantially below the melting point of said first material, at least part of said seal portion and at least part of said envelope member being internally coated with a protective layer, said protective layer comprising a first metal material having a comparatively low vapor pressure, said method including the steps of hermetically sealing said first envelope portion to said second envelope portion by means of said seal portion, heating said envelope member, exhausting said envelope member for at least a portion of said heating step, internally coating said part of said seal portion and said part of said envelope member with said protective layer and evaporating a hydrogen-removing getter material within said envelope member.

5. A method for making an electron discharge device having an envelope member comprised of a first material, said envelope member including a first envelope portion, a second envelope portion and a seal portion between said first envelope portion and said second envelope portion, said seal portion being comprised of an insulative second material having a melting point substantially below the melting point of said first material, at least part of said seal portion and at least part of said envelope member being internally coated with a protective layer, said protective layer comprising a first metal material having a comparatively low vapor pressure, said method including the steps of hermetically sealing said first envelope portion to said second envelope portion by means of said seal portion, heating said envelope member, exhausting said envelope member for at least a portion of said heating step, internally coating said part of said seal portion and said part of said envelope member with said protective layer and evaporating a hydrogen-removing getter material within said envelope member.

References Cited in the file of this patent

UNITED STATES PATENTS

1,895,855	Lockwood	Jan. 1, 1933
1,991,174	Rose	Feb. 12, 1935
2,030,187	Salzberg	Feb. 11, 1936
2,184,841	Katsch	Dec. 26, 1939
2,264,183	Nash	Nov. 25, 1941
2,268,670	Ronci	Jan. 6, 1942
2,411,548	Laico	Nov. 26, 1946
2,459,487	Beggs	Jan. 18, 1949
2,460,201	Trump et al.	Jan. 25, 1949
2,528,217	Dussaussoy	Oct. 31, 1950
2,528,547	Reilly et al.	Nov. 7, 1950
2,656,404	Walsh	Oct. 20, 1953
2,731,579	Weiss	Jan. 17, 1956
2,843,777	Szegho	July 15, 1958