

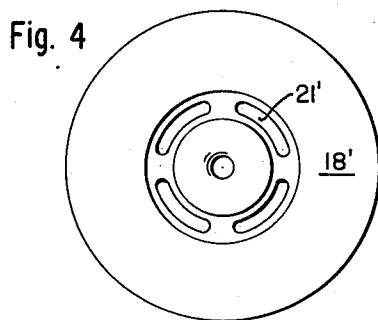
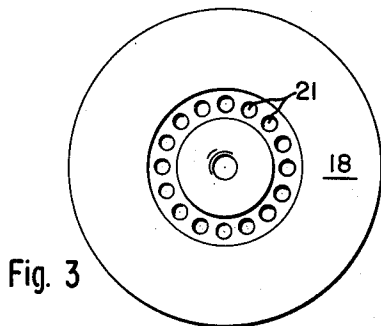
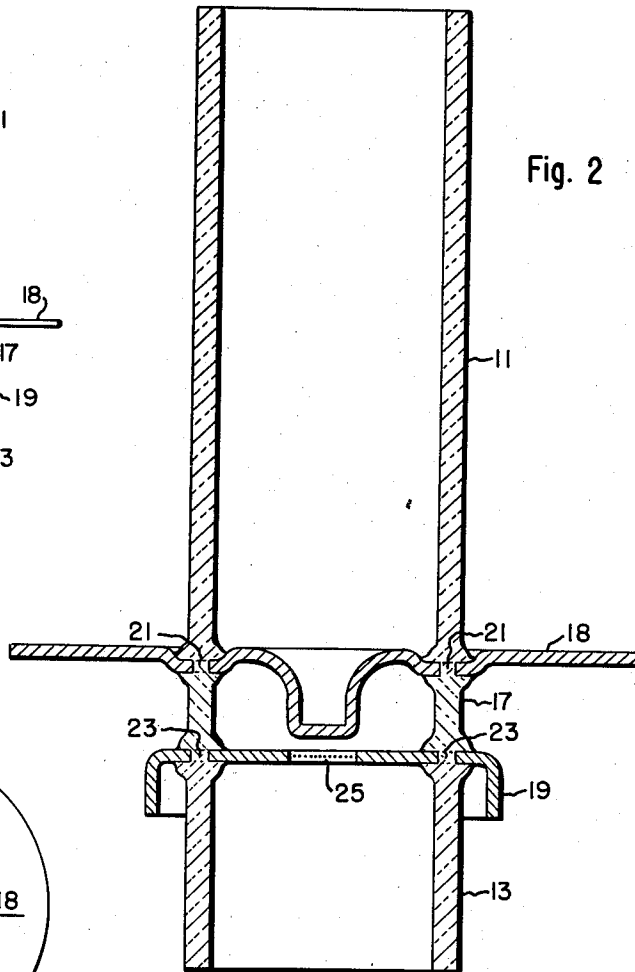
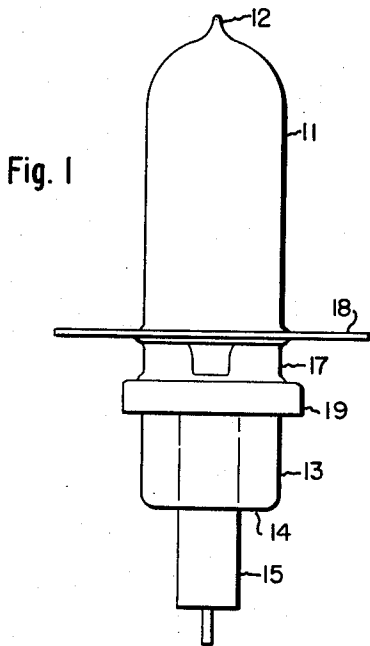
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J. S. HARVEY, JR

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ELECTRON TUBE

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INVENTOR.
JOSEPH S. HARVEY, JR.

BY
Genney, Genney, Miller & Aldrich

ATTORNEYS

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2,912,794

ELECTRON TUBE

Joseph S. Harvey, Jr., Medfield, Mass., assignor, by mesne assignments, to Sylvania Electric Products Inc., Wilmington, Del., a corporation of Delaware

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1 Claim. (Cl. 49—92.5)

This invention relates in general to glass-to-metal seals and in particular, to electron tubes having such seals.

Conventional electron tubes have long been made in a manner closely resembling that used in the manufacture of incandescent lamps. Although additional electrodes not found in lamps are usually incorporated in electron tubes, the techniques for introducing electric potentials into the bulb have been and are quite similar. Normally, a "stem" is prepared which includes a "press" of glass through which a plurality of lead wires are sealed. Elements which constitute the operating electrodes of the tube, or the filament of the lamp, are welded to the ends of these lead wires. The opposite ends of the lead wires extend through the press. The entire stem is sealed into a bulb and the bulb is evacuated to provide the vacuum necessary for operation. If a gas fill is desired, the gas fill is introduced after evacuation of air in the bulb and the atmosphere is then sealed out. Occasionally, where voltage considerations or need for isolation of leads exists, one or more leads are led out through the wall of the bulb at points removed from the stem.

As the electronic art developed, there arose a necessity for different types of structures of electron tubes. The primary factor giving rise to this necessity was the increasing use of electron tubes at higher frequencies. At such frequencies it became impossible to use a conventional press because the capacities existing between lead wires and electron transit time between electrodes became of significance in successful operation of the tube. In other words, the inherent capacities between leads, although small, were great enough to by-pass input signals from input circuit to output circuit. Similarly, electron transit times approached the period of the signals being generated or applied. For all practical purposes, conventional tubes were abandoned for high frequency applications.

Perhaps the earliest structural expedient designed to avoid the difficulties arising from excess capacity existing between leads, was the so-called "planar tube." To reduce capacity in these tubes, a disc is used to connect the working elements of the tube through the glass to external potential sources. It has also proven possible with these structures to further minimize capacity and electron transit time by bringing the various elements of the tube into very close relationship within the tube because of the superior strength and rigidity of support provided. In this fashion successful high frequency operation has been achieved.

In more recent years, with the increasing use of microwave devices, it has become necessary to utilize resonant cavities as tank circuits. Some tubes developed for this type of operation have had their own built-in resonant cavities. However, incorporation of cavities into the tubes themselves is not the most economical approach to the problem. Obviously, a tube failure due to a burned-out heater or other simple fault means discarding the entire tube, resonant cavity included. For this and other reasons of convenience in building microwave equipment, tubes have been developed to fit into resonant cavities, the tubes being so designed that their elements actually form a continuation of the cavity when the tube is assembled therein. One of the simpler devices designed for incorporation into a resonant cavity, is the transmit-re-

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ceive switch tube for radar equipment. Other tubes such as velocity-modulation oscillators of the Klystron type, pencil tubes, rocket tubes, and lighthouse tubes are also usually incorporated in resonant cavities.

In common with the planar tubes, the microwave tubes have included one or more discs of metal against which cylinders of glass are sealed. Material such as a well-known alloy of iron, nickel and cobalt known as "Kovar" has been used for some of the metal discs and the glass which is sealed to the Kovar has a coefficient of expansion which closely matches that of the Kovar. In other tubes where, for example, the requirements for a high Q have demanded it, copper has been used and in some cases, the copper has been silver-plated to provide an even higher Q. Because the coefficient of expansion of copper is quite different from that of any glass which can be successfully used therewith in an electron tube, successful construction of the tubes has depended upon the ability of the copper disc to "give" when the sealed assembly is heated or cooled and expansion or contraction takes place. In the usual structure, the copper disc is a thin sheet and is sandwiched between two cylinders of glass. In this fashion, the butt seals are balanced; the glass cylinders normally being placed opposite each other on the disc. Several techniques have been developed to enhance the structural strength of seals made in this fashion. One of the techniques which has been developed is to oxidize the copper disc prior to sealing the glass thereto. It is believed that the oxide coating on the copper provides a sort of transition between the copper itself and the glass which is being sealed thereto. Inasmuch as the copper oxide adheres tenaciously to the copper, and also is dissolved to a certain extent in the glass, a successful seal has resulted. In addition, it has been the practice to form ripples or flanges in the copper disc to add to its structural strength and resistance to distortion. Despite these precautions, however, there has been some difficulty with seals which break apart especially when they are subjected to sharp changes in ambient temperature. The point of rupture of the seal is usually at the junction of the oxide and the copper, and the inherent physical weakness of such butt seals even when they are balanced by similar seals on the opposite side of the metal is thus exemplified.

Therefore, it is an object of the present invention to improve glass-to-metal seals.

It is another object of the present invention to provide electron tubes of superior physical construction.

It is another object of the present invention to provide disc-seal electron tubes which are not subject to failure over wide ranges of ambient temperature.

Still another object is to provide a disc-seal which retains the advantages of conventional butt-seals without the disadvantages normally encountered.

In general, the present invention is concerned with composite structures including a thin metal element having tubular glass sections sealed to opposite faces of the element. Apertures are provided in the metallic member to permit the flow of molten glass through the metallic member during the sealing operation. The apertures are so disposed that melting of the glass during the sealing process provides a glass-to-glass seal. For a better understanding of the present invention, together with other and further advantages, features, and objects, reference should be made to the accompanying drawing of a preferred embodiment thereof wherein:

Fig. 1 is a view in front elevation of a completed tube made in accordance with the teaching of the present invention,

Fig. 2 is a sectional view of the cylindrical glass members and metallic discs after sealing,

Fig. 3 is a view of one embodiment of an apertured metallic disc used in the tube, and

Fig. 4 is a view of an alternative form of the metallic disc.

In Fig. 1 the invention is shown in connection with a disc-seal electron tube for purposes of illustration only. It includes a tubular glass envelope which is formed of three cylindrical glass sections between which are sandwiched two metal discs. These discs may be of various metals known to be suitable for use in making glass-to-metal seals, but in the embodiment hereinafter described and illustrated in the accompanying drawing, the discs are of copper. The uppermost cylindrical glass section 11 is terminated in a tip 12. The lower glass section 13 is sealed to a header 14 through which a tubular metallic member 15 passes. The third cylindrical glass section 17 is sealed between the metallic discs 18 and 19. Within the tubular metallic member 15 there is disposed a heater and a cathode. These are of minor importance in the present invention and are not shown. However, the cathode is disposed at the extreme upper end within the tube 15 with its active surface facing upwardly. A metallic disc 19 which is closely spaced from the cathode at the end of tubular member 15 serves as a grid in the structure. The second metallic member 18 serves as an anode in the electron tube.

The resonant cavity into which the tube may be inserted is provided with axial openings. The tube is plugged into one of the axial openings in such a manner that the tubular metallic member 15 passes out through the opposite axial opening, the disc 19 is engaged by resilient fingers, and the outwardly extending flange of disc 18 butts against the outer wall of the cavity. As shown in Fig. 2, a central opening is provided in disc 19 and this opening may, if desired, be screened by grid wires 25. The central portion of anode disc 18 is depressed conically and the furthest extension of the conical portion is in close proximity to the grid disc 19.

In Fig. 2, the tube shown in Fig. 1 is illustrated in an early stage of construction. The metallic discs 18 and 19 may first be coated with an oxide by heating the discs to red heat in open air. The three cylindrical sections of glass 11, 13 and 17 may be cut from a continuous run of tubing in order that they may have approximately the same internal and external diameters, although that is not necessary to the invention but only desirable in the interests of symmetry and balance of the seals to be made.

The three sections of glass with the copper discs sandwiched therebetween are assembled in axial alignment. The entire assembly is then placed in an induction coil in such a fashion that either sequentially or simultaneously, the copper discs are heated by eddy currents induced in the copper discs by the induction coil. The end surfaces of the glass cylinders which abut the copper discs begin to melt as the discs approach red heat. Either by reason of gravity or because of externally applied compression, the glass softens and flows laterally from the ends of the cylinders adjacent the heated discs over the surfaces of the discs. The apertures as at 21 in disc 18 and at 23 in disc 19 permit molten glass to flow through the discs. Thus, portions of glass cylindrical section 11 become joined to portions of glass cylindrical section 17. In similar fashion, portions of glass cylindrical section 13 become joined to portions of glass cylindrical section 17. Upon cooling of the assembly, the glass hardens and a strong hermetic seal results.

The disc 18 as best shown in Fig. 3 includes a circular array of circular openings. The diameter of the array and the diameters of the respective openings are chosen so that the openings lie completely within the area of the completed glass-to-metal seal. With reasonably well matched tubing on both sides of the disc, no possibility of leakage through the disc into the tube is possible.

The array of openings in disc 19 is similar to the array provided in disc 18.

In Fig. 4, a disc is shown having openings 21' which are substantially reniform in shape and arrayed circularly. Here also, the minor dimensions of the openings are chosen so that the bond between the metal disc and the glass sections completely surrounds each of the openings.

Either openings of the type shown in Fig. 3 or those shown in Fig. 4 may be used in discs 18 or 19. Combinations of the two types of openings may also be used. Other openings of various shapes may also be used, the only requirements being that sufficient metal be left in the discs for proper electrical properties as is explained below. It may be clearly seen that a glass-to-glass bond exists for a considerable portion of the seal between adjacent ends of the glass tubing, when any of the embodiments shown or suggested is utilized.

Ideally, any resonant cavity in microwave practice would have substantially continuous metallic surfaces. In tubes incorporating the present invention, the apertures in the discs constitute interruptions of the continuity, but the interruptions are slight in a radial direction. No significant operational difficulties are encountered because of the disposition and size of the apertures. More important, the inherent structural weakness of the metal-to-glass butt seals of the prior art is avoided because, in fact, the seals are no longer entirely seals of this nature. On the contrary, for a considerable distance about the periphery of the tube, a glass-to-glass seal is provided.

Although the present invention has been described with reference to an electron tube, it is obvious that the technique of providing openings through a metal element to opposite sides of which a glass member is to be sealed, is applicable in many areas. Numerous examples from the electronic art could be cited, and those skilled in the art of fabricating other apparatus and devices which include both metal and glass parts will also appreciate the advantages of the present invention. Hence, the invention should not be limited in any sense to the details shown, but only by the spirit and scope of the appended claim.

What is claimed is:

In an electron tube of the planar electrode type, a circular copper disc having a plurality of relatively closely spaced like openings therethrough arranged in a circle coaxially with said disc and confined within the area of said disc, and at least a first and a second section of glass tubing each having a diameter approximately equal to the diameter of said circle and each having a wall thickness greater than the dimension of said openings measured along a radius of said disc in axial alignment with said disc integrally joined to each other by a glass-to-glass bond through said openings, the wall thickness of said first and second sections of glass tubing being sufficiently greater than the radial dimension of said openings as to be also respectively sealed to opposite surfaces of said disc with a glass-to-metal bond in a continuous annular area within which said openings are confined.

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