

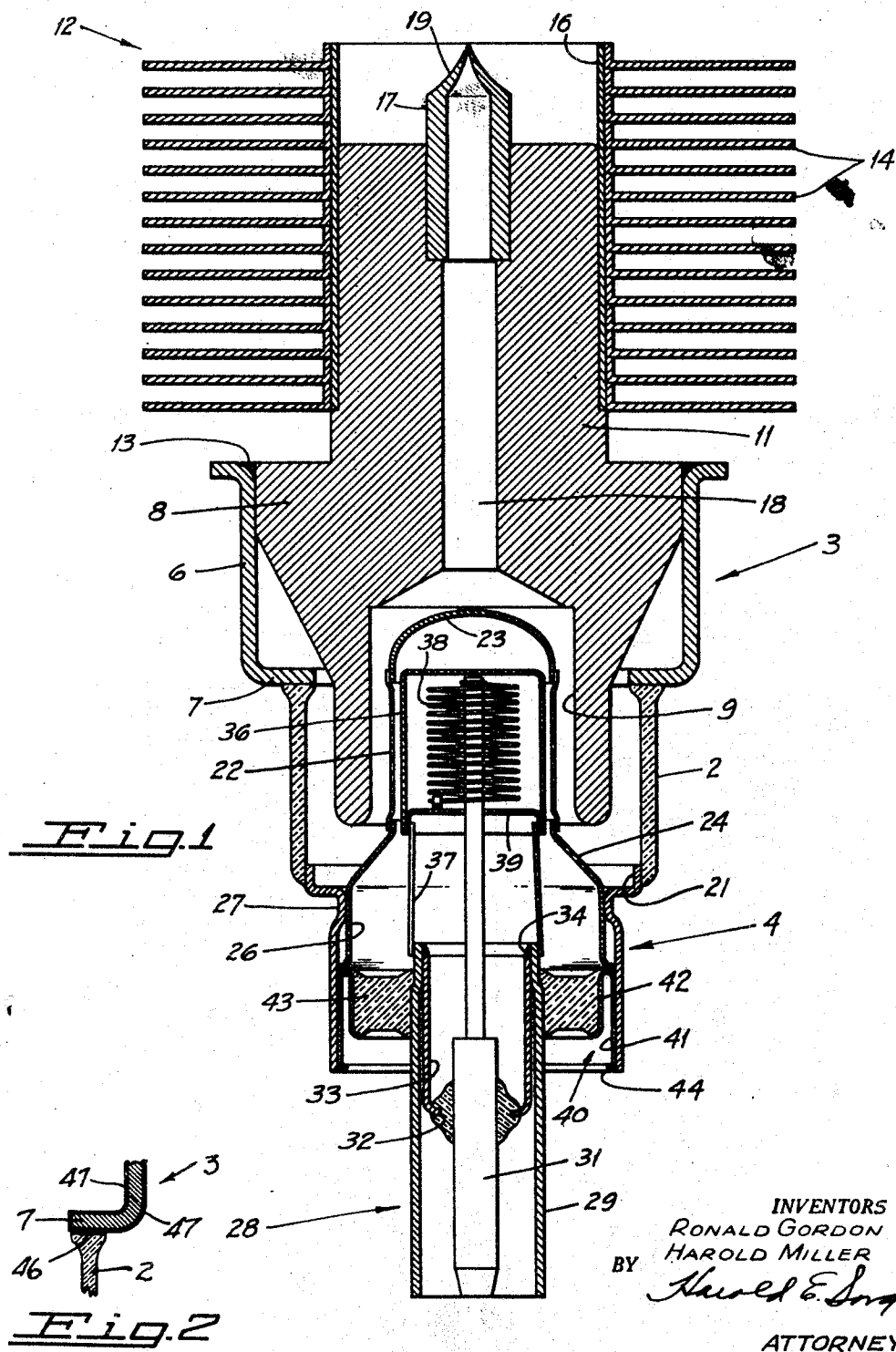
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ELECTRICAL DEVICE HAVING GLASS-TO-METAL SEAL

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ELECTRICAL DEVICE HAVING GLASS-  
TO-METAL SEAL

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Our invention relates to electrical devices in which a metallic member is sealed to glass, such as vacuum tubes and the like having a lead-in conductor extending through a glass wall of an envelope.

The trend in the design of electron tubes, particularly for high frequency work, is toward structures in which the tube envelope is made up of metallic members or sections sealed to glass sections. This trend is dictated by the need for a short, direct path from an external circuit to an electrode within the envelope. As a result, an increasing number of new tubes are appearing wherein the electrodes are supported on annular and disk-like metallic members forming part of the tube envelope.

This type of construction introduces several problems, one of which is the oxidation of exposed metal surfaces when the envelope sections are sealed together. This oxide is difficult to remove, particularly from inside surfaces of the envelope, requiring special chemical cleaning operations which are frequently inadequate. Any oxide of this kind left in the envelope is bad because it contaminates the electrodes and makes it difficult to achieve and maintain good electron emission from the cathode.

It is among the objects of our invention to provide a structure and method which precludes the formation of undesired oxides and eliminates the need for any special cleaning operations.

Another object is to provide an electrical device of the character described having improved current conducting capabilities and better mechanical strength at the seal.

A further object is to provide an electron tube having superior electrical properties, particularly for higher frequency operation.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of our invention. It is to be understood that we do not limit ourselves to this disclosure of species of our invention as we may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawing:

Figure 1 is a vertical sectional view of a vacuum tube structure embodying the improvements of our invention; and

Figure 2 is an enlarged detail sectional view of the glass-to-metal seal structure at the anode support.

In terms of broad inclusion, our electrical device comprises an envelope including a section of

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glass sealed to a metallic member having an oxide sealing surface and an exposed metal surface. The sealing and exposed surfaces of the member are so constituted that the seal may be perfected while leaving the exposed metal surface free of oxide. We prefer to make the sealing surface of a metallic oxide which is stable in a reducing atmosphere such as hydrogen, and the exposed surface of a metal whose oxide is unstable in such an atmosphere. The metallic member is composed mainly of a material having an expansion characteristic matching that of the glass, and the sealing and exposed surfaces are preferably formed by electro-depositing suitable metals on selected areas of the member. The metal of the sealing surface is then oxidized, after which the glass is sealed to the member in the presence of the reducing atmosphere. An electrical device, such as a vacuum tube, made in this way presents an oxide free metal surface. In our preferred construction the metal used for the exposed surface is a low resistance metal so that it functions as a current conducting layer, this layer preferably extending under the oxide at the seal to provide a continuous conducting path to an electrode within the envelope.

In greater detail, and referring to the drawing, Figure 1 shows a triode type of vacuum tube embodying our invention, it being understood that this is merely for purposes of illustration and that the improvements may be incorporated in other types of tubes and other kinds of electrical devices such as vacuum condensers and the like. The tube illustrated comprises an envelope including a tubular section 2 of glass sealed at one end to an anode supporting member 3 and at the other end to a grid terminal member 4.

Anode support 3 is a cup-shaped piece having a cylindrical wall 6 and a flange 7 to which the glass is sealed. The anode is preferably of a metal having good heat conductivity, such as copper, and comprises an inwardly projecting anode portion 8 having a recess 9 into which other electrodes extend, and an outwardly projecting portion 11 carrying the cooler 12. This anode unit is secured to its supporting member 3, as by a copper braze 13 at the rim of wall 6.

Cooler 12 may be of any suitable construction, such as one having radial fins 14 on a sleeve 16 attached to anode portion 11. The tube is exhausted through a metal tubulation 17 secured to anode projection 11 and communicating with the interior of the envelope through passage 18. After exhaust, the envelope is sealed by mechanically pinching off the tubulation at tip 19.

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Grid terminal member 4 is preferably tubular, and has a flange 21 to which glass section 2 is sealed. Grid 22 has vertical bars secured at the top to cap 23 and at the bottom to a conical bracket 24 having a sleeve 26 secured, as by spot welding, to reduced neck portion 27 of member 4.

Cathode stem 28 projects into tubular member 4 from which it derives its support. The stem comprises a pair of concentric stem members including an outer tubular part 29 and an inner rod-like part 31. These stem members are joined by a glass bead 32 sealed between rod 31 and the lower end of a sleeve 33, which sleeve is fitted into tubular stem part 29 and secured thereto by braze 34.

The cathode comprises a can-shaped element 36 having a cylindrical side wall carrying an active cathode coating of the type commonly used for indirectly heated cathodes. Cathode element 36 is supported on outer stem member 29 by bracket arms 37, and extends concentrically with grid 22 into anode recess 9. The cathode heater comprises a spiral 38 connected at one end to inner stem member 31 and at the other end to a base plate 39 of the cathode element. Heating current may thus be supplied to the heater through the stem members.

The cathode and its stem structure is supported by a U-shaped sleeve 40 fitted into tubular member 4 and having an outer flange 41 and an inner flange 42. A glass washer 43 is sealed between outer stem member 29 and inner flange 42 of the supporting sleeve. Final braze 44 is made at the outer edge of flange 41 and the adjacent rim of tubular member 4.

The structure above described illustrates the complexity of the glass-to-metal seals involved in this type of tube. Metallic members 3, 4, 40, 29, 33 and 31 all make sealing engagement with the various glass components 2, 43 and 32, these glass and metal parts forming sections of the tube envelope to maintain a vacuum-tight closure. It is apparent that the several metallic sealing members present a considerable area of exposed metal within the envelope, which exposed surfaces are subject to oxidation when the seals are made.

An important feature of our invention is that the sealing members are so constructed that glass may be sealed to them under conditions which will leave the exposed metal surfaces of the members free of oxide. This feature enables the tube to be sealed together without having to subsequently clean the metal surfaces. Figure 2 is an enlarged detail view of a portion of the envelope including glass section 2 and metallic member 3, which serves to illustrate the invention, it being understood that other portions of the envelope embodying glass-to-metal seals are similarly assembled.

Sealing member 3 is composed mainly of a material having an expansion characteristic similar to or matching that of the glass in section 2. A hard glass, such as a boro-silicate glass, is preferably used for the envelope because of its higher melting point. Certain alloys, particularly those of the iron base type, such as the nickel-steels, have been developed to match the hard glasses. For example, an iron-nickel-cobalt alloy matching Corning 705-2 glass is widely used in the electron tube industry, and this combination may conveniently be employed in our structure. Other metals or alloys selected to match a particular glass may, of course, be used.

The usual practice is to oxidize the sealing

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member in air and then fuse the glass to the oxide layer thus formed. As a consequence, the entire member becomes more or less oxidized, which oxide must subsequently be cleaned off the exposed surfaces by chemical means. It is not possible to reduce this oxide because that would also reduce the oxide under the glass and destroy the seal.

We provide a sealing surface 46 of a stable metallic oxide, such as chromium oxide, and an exposed surface 47 of a metal, such as copper, whose oxide is less stable than the oxide of the sealing surface. The exposed surface is preferably formed as a layer coated over the exposed areas of the member, and the sealing surface is preferably formed as a layer overlying only the sealing area of the member. Other relatively stable metallic oxides, such as nickel oxide, may be used in sealing layer 46, but chromium oxide makes a particularly good bond to hard glass and is preferred.

Copper is preferred in surface layer 47 because, in addition to the desirable properties of its oxide, it has low electrical resistance and therefore additionally functions as a conductor layer. This improves the electrical properties of the member, particularly for high frequency currents. In order to maintain its continuity, layer 47 preferably extends under sealing layer 46, as shown in Figure 2. Other metals, such as silver, may be used in layer 47.

The nature of the sealing and exposed surfaces is such that oxidation of the exposed surface may be inhibited by a selected atmosphere without disintegrating the oxide of the sealing surface. Thus, in our preferred structure the chromium oxide used in layer 46 is stable in a reducing atmosphere, such as hydrogen, whereas any copper oxide that might be formed on layer 47 is reducible in such an atmosphere. It is therefore possible to seal the envelope sections together and then anneal the envelope in hydrogen, so that any copper oxide formed during the sealing operations is removed during the annealing operation.

We prefer however, to also make the seals in a reducing atmosphere. This is possible because an oxide such as chromium oxide is stable in hydrogen at the sealing temperature of the glass. A convenient method is to heat the parts to sealing temperature by high frequency induction in a hydrogen bell jar. No oxidation of the copper can take place, and the exposed surfaces of the member stay bright and clean during the glass sealing operations. Subsequent annealing is also preferably done in hydrogen.

If desired, the glass sealing and annealing operations may be effected in an oxygen free atmosphere such as nitrogen, but a reducing atmosphere is preferred because it positively insures freedom from undesired oxides.

Our preferred method of forming the surfacing and sealing layers is to first electrodeposit a coating of say 1 or 2 mils of copper over the entire member. A second coating of say ½ mil of chromium is then electrodeposited over the copper on only that area which is to underlie the glass. This restriction of the chromium layer is easily done by masking off other areas with wax or the like before immersing the member in the final plating bath. After plating, the masking wax is removed and the member is ready for oxidizing the chromium layer.

Oxidation of the sealing layer is preferably accomplished by heating the member in an at-

mosphere containing moisture, as by heating to say 1000° C. in an atmosphere of wet hydrogen. Under these conditions the copper will not oxidize, but the catalytic action of the chromium will disassociate enough water adjacent its surface to effect oxidation of the sealing layer. Oxidation of the sealing layer may be accomplished in other ways, and if oxidation of the copper layer occurs such oxide may later be removed by subsequent heating in a reducing atmosphere. Heating in wet hydrogen is preferred however, because only the metal of the sealing surface is oxidized. The member is then ready for the glass sealing operation, which is preferably carried out in a hydrogen atmosphere as hereinbefore described.

In connection with the electroplating operation, it is to be understood that the copper layer 47 may be applied either before or after the member is shaped. It may be desirable to copper coat the body metal as sheet stock before the member is formed. Thus, a sheet of the body metal may be copper plated and subsequently shaped by suitable dies. Blanking out the part leaves uncoated edges which may be replated after the member is formed. In other cases, depending on the shape of the member, it is more convenient to copper plate the part after formation. In most cases it is desirable to apply the chromium layer after shaping the member, as it is then easier to accurately position the sealing surfaces.

One method of making the tube shown in Figure 1, utilizing the principles of our invention, is as follows: Sealing members 3, 4, 40, 29, 31 and 33 are shaped from a sheet of the body metal. These members are next completely plated with copper, then the sealing areas only plated with chromium, and then the members fired in wet hydrogen to oxidize the sealing surfaces. The main portion of the envelope is assembled by brazing the anode to member 3 in hydrogen, and then sealing glass section 2 to members 3 and 4 in hydrogen as hereinbefore described. The grid structure is next inserted and spot welded in place.

Cathode stem 28 is fabricated by sealing glass bead 32 between rod 31 and sleeve 33, inserting sleeve 33 and brazing at 34, and then sealing glass washer 43 between members 29 and 40, all of these sealing and brazing operations being done in a hydrogen atmosphere. After mounting the cathode and heater, the cathode stem is inserted and brazed at 44 in a hydrogen atmosphere. It will be noted that the brazing operations are carried out in a reducing atmosphere, to maintain the copper surfaces free of oxide.

The tube is now ready for exhaust. Since the metal surfaces are clean, no intermediate step of chemical cleaning is required. Furthermore, the absence of undesired oxides, and the elimination of contaminants and damage which might occur in chemical cleaning, makes it much easier to obtain and maintain good electron emission from a cathode in our tube. This is especially true of tubes having oxide coated type of cathodes on account of these cathodes being very susceptible to poisoning by foreign agents.

Our improved tube has excellent electrical properties, particularly at high frequencies, because of the low resistance layer 47, which layer provides a continuous conducting path from an external circuit to an electrode within the envelope. Thus, considering the anode structures, high frequency currents (due to the skin effect of conduction) flow along the outer surface of anode portion 8, along the inner surface of wall 6, 75

under the seal at flange 7, and then along the outer surface of wall 6. Layer 47 of our sealing member provides good conduction along this tortuous path.

Similar benefits are derived from our improved structure and method in any electrical device wherein glass is sealed to a metallic member. A vacuum condenser having an electrode secured to a metallic portion of an envelope is a good example.

We claim:

1. An electrical device comprising an evacuated envelope including a section of glass sealed along an edge to a metallic member, said member forming part of the envelope wall and having its major surface portion exposed and with only a narrow portion underlying the glass at the seal, said member being composed mainly of a material having an expansion characteristic similar to that of said glass, a band-like sealing layer of metallic oxide stable in a reducing atmosphere on only that narrow portion of the member which underlies the glass, and a surface layer on said exposed portion of a low resistance metal whose oxide is reducible in said atmosphere, said last mentioned layer extending under said sealing layer.

2. An electrical device comprising an evacuated envelope including a section of glass sealed along an edge to a metallic member, said member forming part of the envelope wall and having its major surface portion exposed and with only a narrow portion underlying the glass at the seal, said member being composed mainly of a material having an expansion characteristic similar to that of said glass, a sealing layer of chromium oxide on only that narrow portion of the member which underlies the glass, and a surface layer on said exposed portion of a low resistance metal whose oxide is less stable than that of chromium, said last mentioned layer extending under said sealing layer.

3. An electrical device comprising an evacuated envelope including a section of glass sealed along an edge to a metallic member, said member forming part of the envelope wall and having its major surface portion exposed and with only a narrow portion underlying the glass at the seal, said member being composed mainly of a material having an expansion characteristic similar to that of said glass, a sealing layer of chromium oxide on only that narrow portion of the member which underlies the glass, and a surface layer of copper on said exposed portion, said last mentioned layer extending under said sealing layer.

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