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G. M. ROSE, JR

2,412,836

ELECTRON DISCHARGE DEVICE

Filed Aug. 5, 1943

Fig. 1.

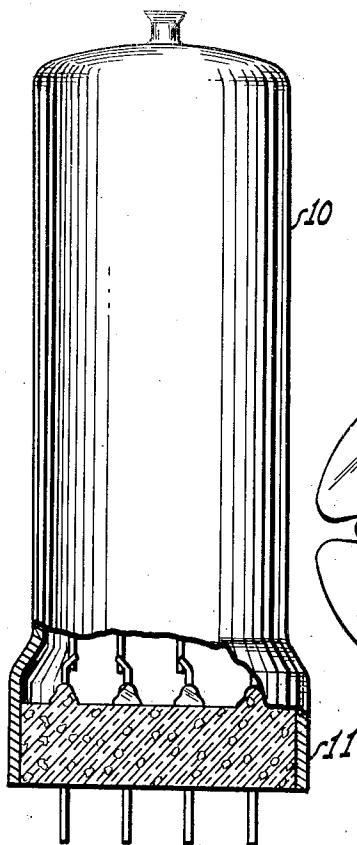


Fig. 3.

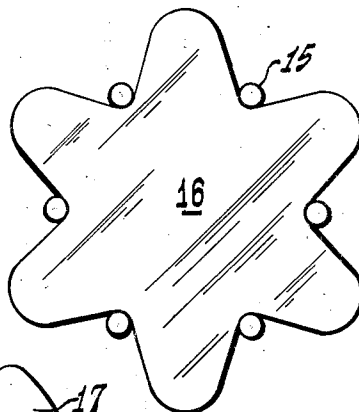


Fig. 4.

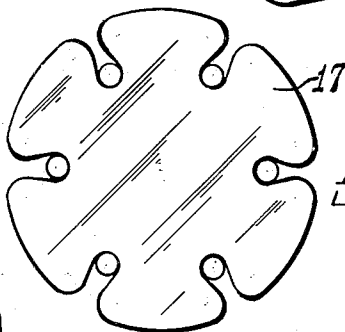


Fig. 5

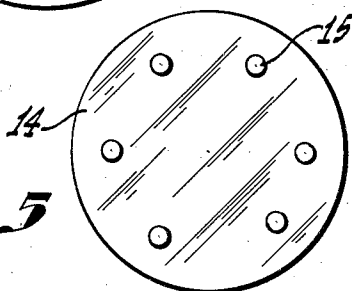


Fig. 6.

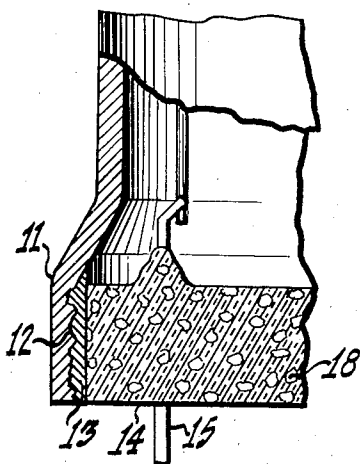
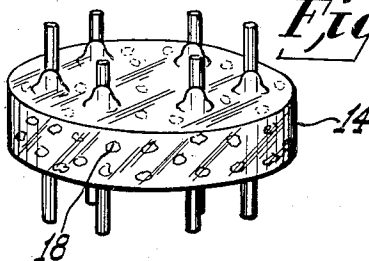


Fig. 2.

By

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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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3 Claims. (Cl. 250—27.5)

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My invention relates to vacuum devices in which a tubular member of ferrous metal, such as mild steel, is closed by a vitreous plug or glass stem fitted into and hermetically sealed at its edge to the tubular member, and more particularly to electron discharge devices having a deep drawn cup-shaped metal envelope closed by a disc stem of glass hermetically sealed into the neck of the envelope.

Some types of electron discharge devices comprise a cup-shaped envelope or shell drawn from a ferrous metal such as mild steel and closed by a planar or disc stem of glass hermetically sealed into the envelope. Some of these tubes are approximately one inch long and about three-eighths inch in diameter so that the envelope or bulb is a deep drawn cup or thimble of mild steel in which the metal, particularly near the rim, has been severely worked. Although the glass stems are known to be able to hold vacuum throughout the life of the tube under normal conditions of operation, such tubes often develop very slow leaks.

The principal object of my invention is to eliminate these very slow leaks, which I have found occur through the hermetic seal between the edge of the glass disc stem and the deep drawn mild steel shell.

In accordance with my invention I braze or sweat into the surface of the shell where the edge of the glass stem is sealed to it a metal of the copper class, such as copper or silver, which at a temperature somewhat lower than the softening point of mild steel will be quite liquid and will wet the ferrous metal and will sweat into or alloy with it in an inert or reducing atmosphere, such as hydrogen or forming gas. The conventional forming gas is a mixture of nitrogen and hydrogen in which from about 10% to 40% of the volume of the mixture is hydrogen. I have found that if a film of copper about one quarter thousandth of an inch thick is deposited on the inner surface of the neck of a deep drawn shell of mild steel about 10 or 12 mils thick over the zone where the edge of the glass disc is later sealed to the shell, and the shell with the copper film is heated for a few minutes in an atmosphere of hydrogen to a temperature of about 1100 or 1150° C., which is so much above the melting point of copper that the molten copper flows very freely, much like a thin liquid, the copper will sweat into and braze the metal of the shell, and will provide an even and continuous sealing surface. Tubes processed in this way were found to be completely free of air leaks through the

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seal between the glass stem and the metal shell.

I have found in the inner surface of the deep drawn mild steel shell microscopic longitudinal crevices which can be observed only under the microscope and which extend from the edge of the shell for a considerable distance along the inner surface. These flaws and crevices extend into the metal from one half to three thousandths of an inch, forming longitudinal fissures. Apparently the slow leaks which have been observed are due to very slow leakage of air through these crevices and fissures, which I have found are not filled by the glass of the stem even at the highest safe sealing-in temperature. The supermolten copper in the presence of hydrogen readily flows over and wets or alloys with the mild steel, but dissolves in it to only a slight extent. At the supermolten temperature the copper readily enters the microscopic crevices, apparently by capillary action, and fills them flush with the inner surface of the shell at the sealing zone. A slight excess of copper does no harm, as it forms a very thin copper coating on the inner surface of the neck of the bulb and does not interfere with the formation of a hermetic seal between the metal of the shell and the glass of the stem. I prefer to use copper for filling up the microscopic crevices and fissures, although any cuprous metal which will wet the iron at a temperature below the softening point of the iron and which at that temperature will be sufficiently liquid to enter the microscopic crevices by capillary action can be used.

I have also found that the making of the disc stem may to advantage be carried out by molding the stem from powdered glass with a suitable binder and fusing the powdered glass to form a disc through which the lead-in conductors are hermetically sealed. In a glass stem formed by fusing of a mass of powdered glass air bubbles entrapped in the mass usually cause the mass of glass to be opaque. Since these bubbles are discrete, they do not form pores or passages through the mass of glass and consequently the stem will be vacuum-tight when it is hermetically sealed into the neck of the bulb.

My invention will best be understood in connection with the accompanying drawing in which merely for purposes of illustration I have shown one embodiment of my invention and in which

Figure 1 is a view in perspective and partially in section at the lower end of an electron discharge tube made in accordance with my invention;

Figure 2 is a sectional view showing on a much

enlarged scale part of the neck of the metal shell with a crevice filled with copper over the sealing zone and with the glass stem hermetically sealed to the shell at that zone;

Figures 3, 4, and 5 show different stages of the molding and fusing of the powdered glass stem; and

Figure 6 is a view in perspective of the stem made from powdered glass and of cellular structure due to the presence of entrapped air bubbles.

In the drawing the shell or bulb 10 of the tube is a deep drawn cup-shaped member of ferrous metal preferably mild steel and having an annular or tubular portion, such as the neck 11, into which the glass stem is hermetically sealed. The inner surface of the neck 11 has longitudinally extending microscopic crevices, one of which, such as the crevice 12 is shown on a greatly enlarged scale and in longitudinal section in Figure 2. In accordance with my invention this crevice is completely filled so as to be flush with the inner surface of the neck 11 by a filling 13 of cuprous metal such as copper. The edge of the vitreous or glass 14 is hermetically sealed to the inner surface of the neck 11 which, owing to the presence of the copper 13, is free from microscopic crevices through which air can leak into the tube. A stem 14 made of glass of the kind commonly used in the art and in which the conventional lead-in conductors 15 are hermetically sealed may be hermetically sealed directly to the inner surface of the neck 11 by sealing-in methods and procedures well known in the art.

The filling 13 of the microscopic crevices 12 is best done by applying to the inner surface of the neck 11 a very thin coating of copper preferably by electro-plating on the inner surface of the neck a band or ring of copper about one mil thick and preferably as wide or wider than the thickness of the glass stem 14. The shell 10 with the copper plating on the inner surface of the neck is then heated in hydrogen, preferably by passing it through a hydrogen filled furnace, to a temperature above the melting point of the copper. I have found that under these conditions the supermolten copper will in the presence of hydrogen braze or wet the metal of the shell and fill up the microscopic crevices completely. The supermolten copper appears to be drawn into the crevices by capillary action and will permanently fill the crevices at least to the surface. The crevices are filled flush with the surface of the ferrous metal, thus providing an even continuous sealing surface to which the edge of the glass stem can be hermetically sealed over a sealing zone through which leakage does not occur.

The disc stem can be made of the conventional lamp glasses in the usual way, or by the procedure illustrated in Figures 3, 4, and 5, in which one way of making of a disc stem having six conductors sealed through it is illustrated. As indicated in Figure 3, powdered glass mixed with some ceresin wax or similar binder to form a somewhat plastic mass is rough molded into a disc 16 having six radially projecting arms 17 with the lead-in conductors 15 in the recesses between the arms. The disc is then pressed in a final mold into approximately the shape shown in Figure 4 with the arms 17 partially closing in around the leading-in conductors. Upon heating the disc until the glass is fused, the arms 17 draw together and coalesce, and the mass of glass becomes the solid disc or stem 14 shown in Figure 5. A convenient way to fuse the glass is to pass

the stem on a conveyor through a furnace heated to about 1000° C. The completed stem formed from a mass of powdered glass from which the binder is expelled during the heating of the stem is cellular in structure and contains, as shown in Figure 6, a multitude of minute bubbles 18 which are discrete and therefore do not cause leakage through the stem. This cellular structure due to the presence of the entrapped air bubbles results in a mass of glass in which the air bubbles usually constitute from 5 to 10 percent by volume of the mass of glass. As a result, the specific gravity of the mass is somewhat less than that of the solid mass of the same glass. In some cases the cellular mass of glass produced from powdered glass appears to make somewhat better hermetical seals with the lead-in conductors than solid glass.

In general, the edge of the glass disc can be sealed to the inner sealing surface of the neck 11 of the bulb by the conventional sealing-in procedure and at the usual sealing-in temperatures. In some cases I have found it advantageous to make the stem somewhat smaller than the opening in the neck of the bulb and to cement the stem in place in the bulb by a low melting glass or ferrous enamel which will fuse at temperatures considerably below the softening point of the stem glass. In such cases the low melting glass may be applied to the sealing surface of the neck and fused in place on the neck to form a thin coating of enamel. The stem can then be sealed into the neck by slightly softening the enamel and pushing the glass stem into place to make a firm juncture with the enamel. I have obtained good results with an enamel or low melting glass free from halogen compounds of the alkalis and the composition of which in general is by analysis from 72% to 80% lead oxide, with the remainder about equal parts of baric oxide and of silica.

I claim:

1. A vacuum device comprising a drawn annulus of severely worked ferrous metal having in its surface microscopic crevices extending through a sealing zone, a film of a metal of the copper class sweated into the inner surface of said annulus whereby the microscopic crevices in said ferrous metal underneath said film are filled flush with said surface, and a glass disc fitted into said annulus and hermetically sealed at its edge to said sealing zone by a glass-to-metal seal coextensive with the edge of said glass disc.

2. An electron discharge device comprising a bulb having a deep drawn ferrous metal neck with microscopic crevices in its surface, the inner surface of said neck being brazed with copper which fills flush with said surface the microscopic crevices in said ferrous metal to form an even and continuous sealing surface over a sealing zone and a stem comprising a glass disc fitted into and hermetically sealed at its edge to said sealing zone.

3. An electron discharge device comprising a highly evacuated bulb comprising a deep drawn mild steel shell having microscopic crevices in its inner surface next to the rim, the inner surface of said shell next to the rim having the microscopic crevices in said shell filled flush with copper sweated into the iron to produce an even and continuous sealing surface, and a glass disc stem fitted into and hermetically sealed at its edge to said sealing surface.

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