Sept. 1, 1964 G. N. PHELPS ETAL 3,147,053

METHOD OF SEALING VACUUM TUBES

Filed May 19, 1960 2 Sheets-Sheet 1

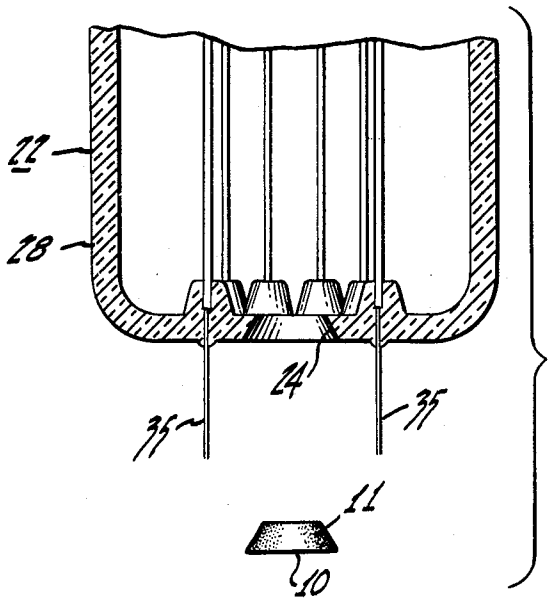



Fig. 1.

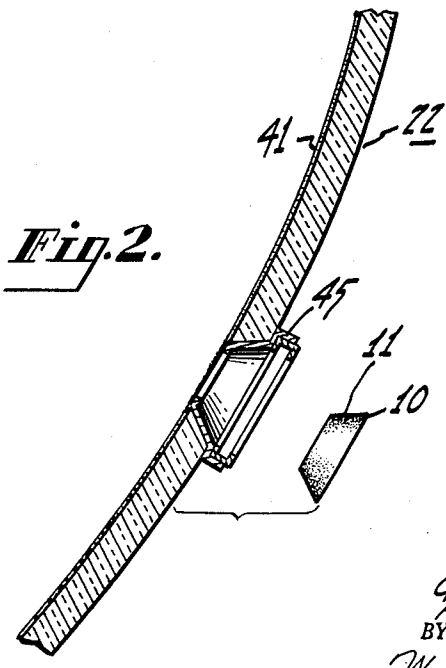



Fig. 2.

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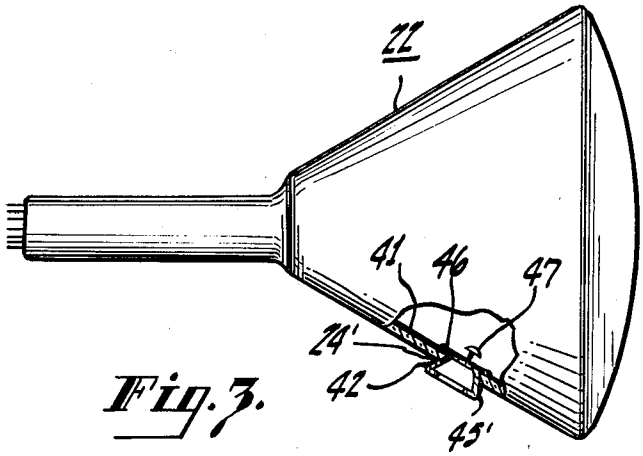



Fig. 3.

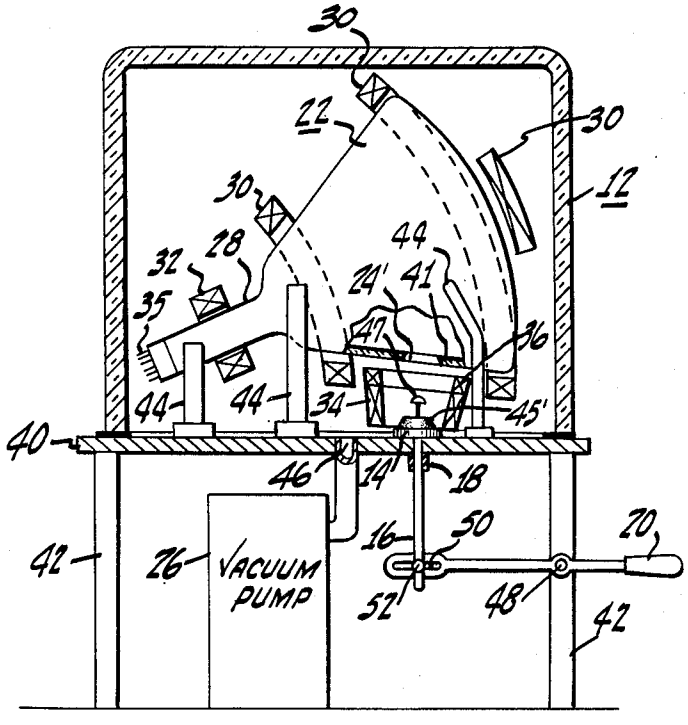



Fig. 4.

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# METHOD OF SEALING VACUUM TUBES

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Our invention relates to seals for and a method of evacuating and sealing vacuum tubes.

A presently used means for evacuating and sealing vacuum tubes involves an open tubulation connected to the tube envelope. At the proper time in the process of making the vacuum tube, after the gases in the tube enclosure have been exhausted through the tubulation, the tubulation is sealed off. A portion of the tubulation between the seal and the envelope projects from the tube envelope. Furthermore, this tubulation is a weak or vulnerable part of the tube envelope. In many forms of vacuum tubes and particularly in cathode ray tubes, the tubulation is positioned in the middle of the stem of the tube within the circular array of base pins. This tubulation is received within and protected by the base key or indexing means that indexes the tube and its pins with respect to the tube socket. The base key or centering lug adds to the overall length of the tube.

In the evacuation method involving the tubulation, the size of the inside diameter of the tubulation and the length thereof adds resistance to the flow of gases out of the tube enclosure, thus increasing the difficulty of evacuation.

In the presently used method of evacuating a cathode ray tube involving a tubulation, the tube is evacuated in an evacuation oven under proper temperature conditions for this purpose. It is inconvenient to seal the tubulation while the tube is in the oven, therefore, when the tube has been evacuated, it is removed from the oven during the sealing-off process. At that time, at least a portion of the tube envelope is exposed to lower than evacuation temperatures, resulting in concomitant chance of implosion or of cracking of the tube envelope, during the sealing-off operation.

The presently used evacuation method requires provision of the tubulation which involves supplying material in addition to the material used in the tube envelope.

It is therefore an object of our invention to provide means for and method of evacuating and sealing a vacuum tube not having the disadvantages of the presently used evacuating and sealing operation involving a tubulation.

It is a further object of our invention to provide a means for and a method of evacuation and sealing which results in a tube having a shorter overall length than the presently used tubes due to the omission of the tubulation.

It is a further object of our invention to facilitate evacuating an enclosure by providing an evacuation path through the tube envelope having a larger diameter and a shorter length than that possible using the tubulation method of evacuating and sealing.

It is an objecting of our invention to present less chance than heretofore of implosion or cracking of the tube envelope while sealing.

It is a further object of our invention to save material by omission of the presently used tubulation.

In accordance with our invention, we provide the envelope to be evacuated with a hole therein which is sealed after evacuation of the envelope with a plug which fits a hole, said plug being coated with a non-devitrifying frit. Various non-devitrifying frits are well known in the art. Such frits do not lose their vitreous character upon melting. The coated plug may be heated in air to a high temperature until the frit is molten and all the bubbles produced by this heating step are dissipated, whereby a



smooth frit covered plug results. The envelope and the frit-coated plug are put into a demountable evacuating enclosure. The enclosure, and therefore the envelope, is evacuated while the electrode elements mounted within the envelope may be subjected to bake out temperatures for purging the electrodes of undesirable gases. Sealing temperatures are then applied to the plug and to the portion of the tube envelope surrounding the hole with the plug inserted therein to seal the envelope. The complete tube may then be cooled to room temperature in the usual manner. This structure and technique eliminate the need for tubulation.

For further description of our invention, reference may be had to the detailed description thereof and to the accompanying drawing.

In the drawing:

FIG. 1 illustrates in section a stem portion of a cathode ray tube having a hole therein and a matching sealing plug to be inserted into said hole in accordance with our invention;

FIG. 2 illustrates a modified seal for a cathode ray tube and made according to our invention;

FIG. 3 illustrates a further modified sealing means using a contact button as the sealing plug and made according to our invention; and

FIG. 4 shows an elevational view of the apparatus used, partly in section, in accordance with our method of evacuation and sealing, applied to a cathode ray tube having an evacuation hole in the funnel portion thereof.

Referring to FIG. 1, we provide a vacuum tube **22**, of which only a portion is shown, which, by way of example, may be a picture or cathode ray tube, having a neck **28**. Pins **35** project from the end of the neck in a well-known manner. A hole **24**, having a tapered wall smaller inside than out, preferably frustro-conical opening, is provided in the neck in the midst of the pins **35**. Fitting this hole **24**, we provide a thin disk or plug **10** of frustro-conical shape having an angle between the longer base and the side thereof of approximately 60°. The disk, which fits the hole **24**, is covered, as by spraying with a non-devitrifying frit **11**, applied thereto in the usual carrier solution.

A modification of our sealing means is shown in FIG. 2. In this figure is shown a conductive contact button **45** which provides an external electrical connection to the conductive layer **41** on the inside of the funnel of the picture tube **22**. This button **45** is sealed in the funnel of the picture tube **22** in the usual manner, leaving a frustro-conical hole through the envelope of the tube. The plug **10** covered with non-devitrifying frit **11** is provided to fit this hole.

In a further modification of our invention as shown in FIGS. 3 and 4, the conducting button **45'** comprises the sealing plug that we use. In these figures, the picture tube **22** has a frustro-conical hole **24'** formed in the funnel thereof in the region of the resistive coating **41**. The dish-like metallic sealing plug **45'** is provided which fits the said hole **24'**. The peripheral edge of the plug **45'** is covered with a non-devitrifying frit **42**. Getter material **47** is fastened to the bottom of the conductive button **44** for a purpose to be described.

Our method of sealing a tube envelope using a plug of our invention comprises heating the plug coated with non-devitrifying in air to about 600 to about 650° C. until the frit is molten and all bubbles that are produced during the heating step are dissipated whereby a smooth frit covered plug is produced. We then place the tube envelope and the plug in an evacuation chamber. We exhaust the chamber applying bake out temperature of about 425 to 450° C. to the tube enclosure. We heat the plug and the portion of the tube surrounding the hole therein to about 500 to about 550° C., the rest of the tube being maintained at its said evacuation temperatures.

We then push the plug into the hole to seal the tube envelope. We then cool the tube at a suitable rate to avoid breakage due to thermal shock.

Apparatus for performing evacuation and sealing is shown in FIG. 4. As shown in this figure, we provide an evacuable chamber or enclosure **12** which may be supported by a table **40** having legs **42**, the top of the table **40** comprising a portion of the wall of the chamber. The table top also supports V-shape support means **44** for supporting the tube **22** to be evacuated, here shown as a picture tube having an evacuation hole **24'** in the funnel portion thereof. This tube has the usual neck **28** and circle of connecting pins **35** in the stem thereof. The table further supports resistive heating means **30** and **32** for heating the picture tube to the usual baking out temperatures as well as additional similar heating means **34**, for heating that portion of the tube envelope which surrounds the evacuation hole **24'** to a higher or sealing temperature. Inductive heating means **36**, also near the evacuation hole **24'**, are supplied for a purpose to be disclosed. An evacuation means, here shown as a pump **26**, is connected to the interior of chamber **12** to evacuate the same by means of the hole **46** in the table top. A platform **14** is supported on the end of the rod **16** that extends through the vacuum proof seal **18** surrounding a hole in the table top **40**. A lever **20**, rotatable about a pivot **48**, which supports said lever on the table leg **42**, has a slot **50** therein, slidably receiving a pin **52** in the end of the rod **16**.

The sealing plug **45'** carrying the getter **47** is supported on the platform **14** during sealing operations, and upon manipulation of the lever **20**, the platform and the plug thereon are raised to push the plug **44** into the hole **24'** without breaking the vacuum in the chamber **12**.

Our method of using our apparatus is as follows: The preheated frit covered plug **45'** is placed on the platform **14**. The tube **22** is placed on its support **44** with the hole **24'** therein in registry with the plug **45'**. The enclosure **12** is placed over the heaters **30**, **32**, **34** and **36** and over the tube **22**. The evacuable chamber so formed is evacuated in the usual manner by the vacuum pump **26**. The tube element and their enclosure are heated to bake out temperature by well-known resistance heating means indicated at **30** and **32**. Upon completion of the evacuation, the plug and the portion of the tube envelope surrounding the hole **24'** are heated to about 500° C. by the heating means **34**. By manipulation of the lever **20**, the plug **45'** is pushed into the hole **24'** of the tube envelope **22**. Any further bubbles that may be produced on the plug by this last-mentioned heating thereof are destroyed by this insertion of the plug in the hole in the tube envelope, by the pressure of the plug on the edges of the hole. These bubbles therefore do no harm to the seal between the plug and the envelope.

In the modification of our plug disclosed in FIGS. 3 and 4, the conductive plug **45'** is used not only as a sealing plug but also as a conductive connection to the conductive coating **41** on the inside of the picture tube **22** to the outside of the tube envelope. It is necessary, therefore, to produce electrical contact between the conductive plug **45'** and the said conductive coating **41**. Therefore, when the plug **45'** is coated with frit and heated in air, as described above in connection with each of our sealing plugs, care must be taken not to cover the smaller base of the plug **45'** with frit since such a cover would insulate the conductive plug **45**. Similarly, when the plug **45** has been inserted into the hole **24'** in the tube envelope, an electrical connection must be completed between the plug and the conductive coating **41**. The getter **47**, which is mounted on plug **44**, is flashed upon operation of the radio-frequency heater means **36** shown in FIG. 4. The getter material **46** (see FIG. 3), deposited on the conductive layer and on the plug **45**, completes the required electrical connection.

Our method of sealing and evacuating an envelope using a non-conductive plug is similar in all respects to that disclosed above in connection with FIG. 4 except where nonconductive plugs are used, the tube may be a getter in the usual manner.

Our method of sealing an evacuated container is not limited to vacuum tubes of any particular type and for that matter to an electron device. Our method obviously may be used to seal any evacuated enclosure for which it is adapted. The enclosure need have no neck since the plug may be put into a hole in any portion of the outside surface of any sealable enclosure.

Also, it will be understood, our method of sealing applies to sealing any suitable container, whatever its degree of evacuation and whether the remaining gaseous content of said envelope be air or any desired gas or mixture of gases.

A plug that we have used is a thin frustrum of a cone having a base angle of about 60°. As is understood, the base angle may differ from 60° and in an extreme case, the plug may be cylindrical. However, we prefer the frustro-conical plug since the bubbles on the edge or contact surface of the plug, which may be produced in the second heating of the plug will be destroyed by the pressure between the plug and the surface of the matching hole in the enclosure to be sealed when the plug is inserted.

The frit we use is any standard non-devitrifying frit which has a proper softening point and a thermal expansion to match the device with which it is to be used. It also must have the electrical properties and an environmental stability necessary for its use. The frit, in a suitable carrier such as nitro-cellulose, is sprayed onto the plug but may be applied otherwise as by brushing. The temperature applied to the frit while on the plug, but outside of the evacuation container is considerably higher than the temperature thereof at sealing to minimize bubbling of the frit while in the evacuation container. However, some bubbles may still occur in this frit upon reheating thereof at sealing and they are destroyed by the pressure developed between the sloped sides of the plug and similarly sloped surface of the hole in the envelope in the act of sealing.

What is claimed is:

1. The method of evacuating and sealing an envelope having a hole therein and using a plug which matches said hole, comprising the steps of applying frit to said plug, heating said plug and frit to an elevated temperature to coat said plug with a sealing film, placing said envelope and said plug in an evacuable chamber, evacuating said chamber, heating said plug and at least the portion of said envelope surrounding said hole to a lower temperature than said elevated temperature to soften the glass around said hole and said frit coating, and pushing said plug into said hole to seal said hole.

2. The method of evacuating and sealing a cathode ray tube having a stem with pins arranged in a pattern on said stem and having a hole in said stem within said pattern, and a plug which matches said hole, which comprises applying frit to said plug, heating said plug and frit to an elevated temperature, to melt said frit and drive off bubbles due to such heating, placing said envelope and said plug in an evacuable chamber, evacuating said chamber, heating said plug and at least that portion of the stem surrounding said hole to sealing temperature and pushing said plug into said hole.

3. The method of evacuating and sealing a cathode ray tube having a hole in the funnel portion thereof and having a plug which matches said hole, which comprises applying frit to said plug, heating said plug and frit to an elevated temperature to melt said frit and drive off bubbles due to such melting, placing said envelope and said plug in an evacuable chamber, evacuating said chamber, heating said plug and at least the portion of said funnel surrounding said hole to a sealing temperature and pushing said plug into said hole.

4. The method of evacuating and sealing an envelope

and providing an external electrical connection to a conductive coating on the inside of said envelope, there being a hole having a surface through said envelope and through said conductive coating, and having a conductive plug having a surface matching said hole surface which comprises applying frit to said matching surface of said plug, heating said plug and frit to an elevated temperature whereby said frit melts and coats the surface of said plug, placing said envelope and said coated plug in an evacuable chamber, evacuating said chamber, heating said plug and at least that portion of said envelope surrounding said hole to a sealing temperature, inserting said plug in said hole with said matching surfaces in contact and flashing a further conductive coating across at least a portion of said first conductive coating and at least a portion of the bottom of said plug.

5. The method of sealing an envelope and providing an external electrical connection to a conductive coating on the inside of said envelope, said envelope having a hole through said envelope and through said conductive coating, and having a conductive plug matching said hole which comprises applying frit to said plug edge, heating said plug and said frit to an elevated temperature whereby said frit melts and coats the edge of said plug, heating said plug and at least that portion of said envelope surrounding said hole to a sealing temperature, inserting said plug in said hole and providing a conductive connection between said plug and at least a portion of said conductive coating.

6. The method of evacuating and sealing an envelope which has a hole therein, the edges of the hole defining a frustro-conical surface having its larger diameter at the outside surface of the envelope, and having a plug which matches said hole, which comprises applying frit to said plug, heating said plug and frit to an elevated temperature, whereby said frit melts and bubbles produced by said melting are driven off, placing said envelope and plug in an evacuable chamber, evacuating said chamber and said envelope, heating said plug and at least the portion of the envelope surrounding said hole to a sealing temperature and pushing said plug into said hole.

7. The method of sealing an envelope having a hole defining a frustro-conical surface having its larger diameter at the outside surface of the envelope in said envelope, and having a plug matching said hole, which comprises applying frit to said plug, prefiring said plug and frit at an elevated temperature whereby said frit is melted over said plug and gases produced by said prefiring are dissipated, placing said plug and a portion of said envelope surrounding said hole in an evacuable chamber, evacuating said chamber, heating said plug and a portion of said envelope surrounding said hole to a sealing temperature, and then pushing said plug into said hole.

8. The method of evacuating and sealing a cathode ray tube having a stem with pins arranged in a pattern on said stem, and having a hole in said stem within said pattern, the edges of said hole defining a frustro-conical surface having its larger diameter at the outside surface of the envelope, and having a plug which matches said hole, which comprises applying frit to said plug, heating said plug and frit to an elevated temperature whereby said frit melts, placing said envelope and plug in an evacuable chamber, evacuating said chamber, heating said plug and at least a portion of the envelope surrounding said hole to a sealing temperature and pushing said plug into said hole.

9. The method of evacuating and sealing a cathode ray tube having a hole in the funnel portion thereof, said hole having edges defining a frustro-conical surface having its larger diameter at the outside surface of said funnel, and having a plug which matches said hole, which comprises applying frit to said plug, heating said plug and frit to an elevated temperature whereby said frit melts and gases produced thereby are dissipated, placing said envelope and said plug in an evacuable chamber, evacuating said chamber, heating said plug and at least a portion of said envelope surrounding said hole to a healing temperature and pushing said plug into said hole.

10. The method of evacuating and sealing an envelope and providing an external electrical connection to a conductive coating on the inside of said envelope, said envelope having a hole having an edge through said envelope, said edge defining a frustro-conical surface having its larger diameter at the outside surface of the envelope, said hole extending through said conductive coating, and having a conductive plug having an edge matching said hole edge, which comprises applying frit to said plug edge, heating said plug and frit to an elevated temperature whereby said frit melts and coats the edge of said plug, placing said envelope and said coated plug in an evacuable chamber, evacuating said chamber, heating said plug and at least that portion of the envelope surrounding said hole to a sealing temperature, inserting said plug in said hole with said matching edges in contact and providing a conductive coating across at least a portion of said first-mentioned coating and at least a portion of the bottom of said plug.

11. The method of sealing an envelope and providing an external electrical connection to a conductive coating on the inside of said envelope, said envelope having a hole therethrough and through said conductive coating, said hole having an edge defining a frustro-conical surface having its larger diameter at the outside surface of the envelope, and having a conductive plug having an edge matching said hole edge, which comprises applying frit to said plug edge, heating said plug and frit to a temperature whereby said frit melts and coats the edge of said plug, heating said plug and at least that portion of said envelope surrounding the hole to a sealing temperature, inserting said plug in said hole with said matching edges in contact and providing an electrical connection between at least a portion of said coating and a portion of said plug.

12. The method of evacuating and sealing an envelope having a contact button in the wall thereof, said contact button having an opening therethrough, and having a plug fitting into the contact button, which comprises applying frit to said plug, heating said plug and frit to an elevated temperature whereby said frit melts and coats said plug, placing said envelope and said coated plug in an evacuable chamber, evacuating said chamber, heating said plug and at least said contact button to a sealing temperature and inserting said plug into said button to seal said opening.

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