April 27, 1937. F. S. McCULLOUGH 2,078,892

VACUUM TUBE AND METHOD OF MAKING THE SAME

Filed Aug. 10, 1933

Fig. 1.

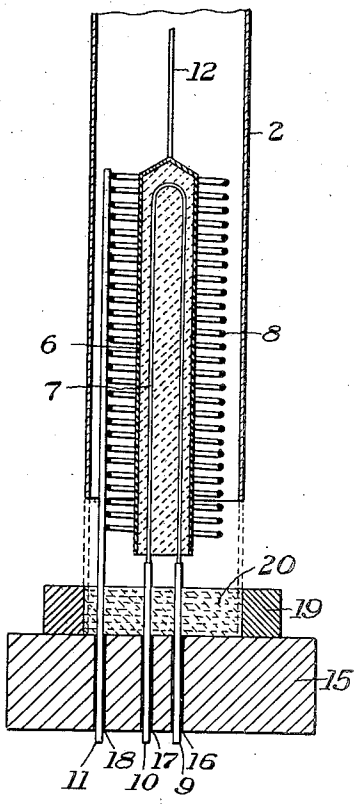


Fig. 2.

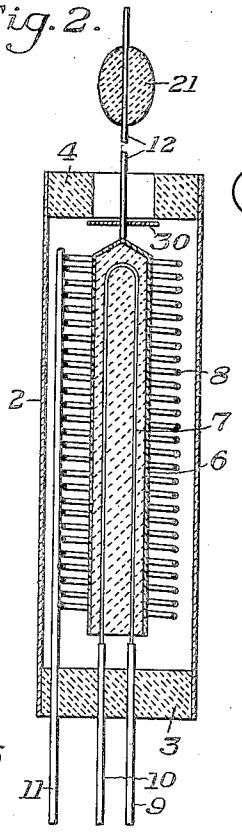


Fig. 3.

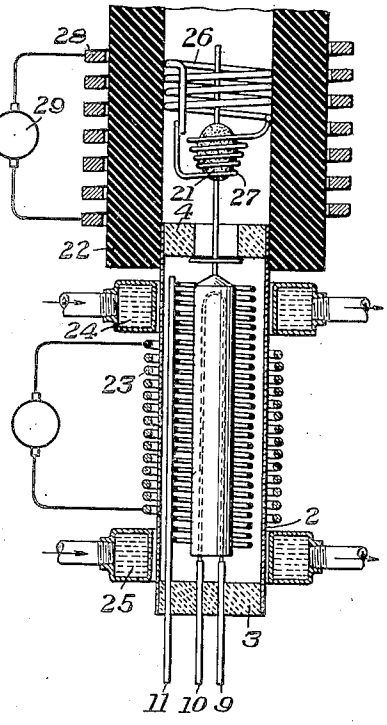


Fig. 4.

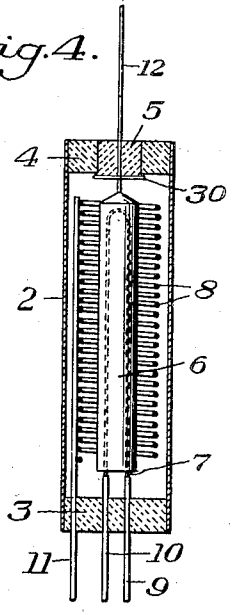


Fig. 5.

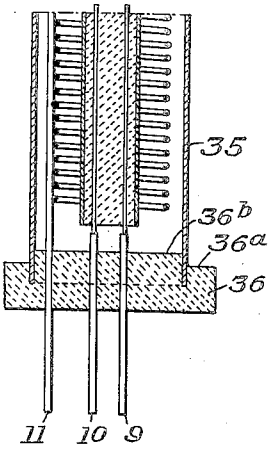
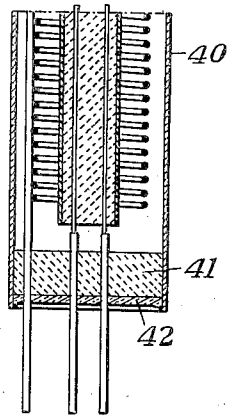


Fig. 6.



INVENTOR

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by his attorneys

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UNITED STATES PATENT OFFICE

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VACUUM TUBE AND METHOD OF MAKING THE SAME

Frederick S. McCullough, Ontario, Canada; The Union National Bank of Pittsburgh executor of said Frederick S. McCullough, deceased

Application August 10, 1933, Serial No. 684,518

5 Claims. (Cl. 250—27.5)

This invention relates to vacuum or space discharge tubes and to the manufacture thereof, and is especially applicable to tubes of the type in which the greater portion of the envelope of the tube is formed of metal so that the envelope also constitutes the anode of the tube. The invention is for an improvement over the invention shown in my prior applications, Serial No. 571,578, filed October 28, 1931, and Serial No. 676,418, filed June 19, 1933.

In the first of my said applications I have disclosed a tube having a metal envelope which is closed at one end and which has a ceramic seal at the open end, the ceramic seal serving as a support for the lead-in wires on which the electrodes inside the tube are supported. In the second application above referred to I have shown a tube having an envelope in the form of a metal tube constituting the anode of the vacuum tube with a ceramic seal at each end. A special arrangement is provided for closing an exhaust opening in the seal at one end of the tube while the tube is connected with the pump. Each of the applications contemplates that there be a ceramic element at one or both ends of the tube which is separately made and then sealed into the tube by means of some low fusing ceramic composition.

According to the present invention it is proposed to cast the closure of insulating material directly into one or both ends of the tube, this material being cast about the lead-in wires that go to the electrode inside the tube so that when the insulating material sets it will adhere to the metal envelope and also adhere to the electrode lead-in wires which pass through it, and in this way permanently position the various elements with respect to one another so as to facilitate the further work upon the tube, and at the same time materially reduce the expense of assembling the tubes.

The insulating material contemplated is preferably a non-porous liquid moistened cement or it may comprise any other type of plastic material which can be molded in situ and which will have a strong adhesion to the metal. If it is of itself of a porous nature the invention contemplates that it may be rendered gas-tight by the application of a surface coating of sealing material to the outside thereof.

The invention may be readily understood by reference to the accompanying drawing in which:

Figure 1 illustrates a method of assembling a tube in accordance with the invention, showing the cementitious material in a plastic state in a mold with the envelope of the tube positioned above it for insertion into the mold;

Figure 2 is a vertical transverse section similar to Fig. 1 showing the tube completely assembled ready to put on the pump for evacuation;

Figure 3 is a more or less schematic view showing the manner of exhausting and sealing the tube;

Figure 4 is a transverse longitudinal section through the assembled tube;

Figure 5 is a view of a tube similar to Fig. 4 showing a slightly modified form of an insulating plug at one end of the tube; and

Figure 6 is a view similar to Fig. 5 illustrating the manner of sealing the tube where the plastic material itself is not sufficiently gas-tight.

Referring first to Fig. 4, which shows the assembled tube, 2 designates a metal sleeve constituting the principal portion of the envelope of the tube and also constituting the anode of the tube. It is closed at its lower end by an insulating plug 3 and it is closed at its upper end by an insulating plug 4 with a central mass of sealing material 5 therein. Within the tube I have shown a more or less conventional type of indirectly heated cathode having a cylindrical cathode 6 within which is a looped heater wire 7. Surrounding the cathode is a grid 8. The lead-in wires for the heater are designated 9 and 10 and they pass through the plug 3. The grid supporting lead-in wire 11 also passes through the plug 3. In the particular tube shown the cathode has a lead-in wire 12 that extends through the opposite end of the tube.

The tube is different from the tube shown in my copending application Serial No. 676,418 in the fact that the plug 3, and preferably the plug 4, is molded directly in the end of the envelope and has a close adhesion to the metal of the envelope. Moreover, it is preferably of a material which is molded cold.

The manner of assembling the tube in accordance with the present invention is illustrated in Figs. 1 to 3, inclusive. Referring first to Fig. 1, 15 designates a supporting member or jig having openings 16, 17 and 18 therein for the reception of the lead-in wires 9, 10 and 11, respectively, the electrodes being supported on these lead-in wires at the time they are inserted in the jig. On the top of the supporting member or jig 15 and properly positioned with respect to the lead-in wires is a mold ring 19. When the electrodes are in the jig and the mold ring is in place, a mass of plastic cement 20 is introduced into the mold to substantially fill the same. This cement

may be any one of a large number of commercially available cements, as for example, those known as silicate cements or dental cements. This cement is preferably formed of very finely pulverized materials.

After the mold has been filled with plastic cement and before the cement has had an opportunity to set, the envelope is placed around the electrodes and the lower end thereof forced around the mold so that the cementitious material flows up inside the lower end of the tube.

The cement is then allowed to harden or set, preferably until all of the moisture or volatile ingredients thereof have evaporated and the cement has taken its permanent set. In setting, the cement adheres to the metal and it also adheres to the lead-in wires **9**, **10** and **11**. Thus in a single operation the electrodes and the envelope are permanently positioned with respect to one another, and if the cement is of a suitable character and is not porous a gas-tight seal is at the same time formed in the end of the tube. This is of advantage over the arrangement specifically described in the said copending applications wherein the ceramic plug is preformed and the relation of the electrodes and the envelope is not fixed until some sealing material has been applied over the ceramic plug.

Referring to Fig. 2, after the seal has been completed at the lower end of the tube the plug **4** is molded into the opposite end of the tube, the plug **4**, however, preferably having a central opening around the cathode lead-in wire **12** in order to provide for the evacuation of the tube.

When the tube has been assembled to this extent a gob of low fusing ceramic material **21** is placed about the cathode lead-in wire **12** and the assembly is ready to be placed on the pump to be evacuated and finally sealed.

The operation of evacuating the tube and sealing it is the same as that described in my said copending application Serial No. 676,418. According to this method, the upper end of the tube, that is, the end of the tube in which there is an opening for the evacuation of the tube, is fitted into the hose **22** leading to an exhaust pump. Surrounding the tube below the hose **22** is a coil **23** which is connected with a source of high frequency oscillating current, as diagrammatically indicated. Above and below the coil **23** there are fluid-cooled rings **24** and **25** through which the tube passes, the upper ring **24** serving to prevent overheating of that portion of the tube adjacent the upper plug **4**, the lower cooling ring **25** serving to prevent overheating or baking of the plug **3**. Within the exhaust tube **22** there is a coil **26** having several turns **27** of smaller diameter which fit about the gob of low fusing ceramic material **21**. The coil **26** is in inductive relation with an external coil **28** adapted to be connected across a high frequency oscillator circuit **29**.

The evacuation and the baking of the tube is effected in the usual manner, the gas being pumped out of the tube, and as a high degree of vacuum is approached the coil **23** is energized to inductively heat the parts within the tube to drive out those gases from the parts of the tube which become hot in the operation of the tube. The cementitious plugs **3** and **4** are protected from overheating,—first, for the reason that they are non-inductive themselves, and secondly, because the heat which would normally be conducted to these plugs is dissipated by the cooling rings **24** and **25**. Upon completion of the evacuation and baking of the tube, the coil **28** is energized to inductively heat the convolutions of wire **27** and thereby fuse the low melting point material **21**. This material drops into the central opening in the plug **4** where it sets, adhering to the plug and to the wire **12**, and forming a permanent seal in the upper end of the tube. I have shown the tube as being provided with an internal shield **30** to prevent the sealing material from falling too far through the opening in the plug.

The tube may then be removed from the pump as a completed tube, it then being completely assembled as previously described in connection with Fig. 4.

The embodiment shown in Fig. 5 is substantially the same as that shown in Fig. 4 except that I have shown the cementitious plug in the lower end of the tube as being of a larger diameter than the tube itself so that it overlaps the end of the tube, making a more perfect seal and at the same time providing a more finished base on the tube. In this figure **35** designates the metal envelope of the tube and **36** is the cementitious plug at the bottom of the tube. The sleeve **35** projects only part way through the plug **36** so that the portion **36*a*** of the plug overlaps the outside of the end of the tube, a mass of the cementitious material **36*b*** projecting up inside the tube. This arrangement utilizes a larger amount of cementitious material and furnishes a more effective seal because of the overlapping of the ends of the metal tube with the cement. The manner of assembly is substantially the same as that shown in Fig. 1.

Instead of the plug of cementitious material being of a very dense and non-porous nature as contemplated in Figs. 4 and 5, the cement may be of a more porous nature and subsequently rendered gas-tight by the application of an external coating thereto. This is illustrated in Fig. 6 in which **40** designates the metal envelope and anode of the tube and **41** is a plug of cold setting cement molded into the end of the tube about the various lead-in wires. This cement adheres to the metal tube **40** and to the lead-in wires so as to permanently position the various parts with relation to one another. Since the cement itself is of a relatively porous nature, it is sealed by the application of a non-porous coating **42** to the exterior thereof. The non-porous coating **42** may, for instance, be an extremely low melting point enamel, or a suitable liquid coating composition, such for instance, as a cellulose acetate coating material, or it may be a relatively finer liquid setting cement than the main body of the plug **41**. In any event, the function of the cementitious plug is to support the electrodes inside the metal tube and cement them against relative movement with respect to one another.

As one cement which may be used, I suggest a white cement sold under the trade name "Meclusa", but there are many other types of cements which are free from moisture upon setting and after moderate baking which may be used.

The invention as herein described is particularly applicable to the manufacture of very small radio tubes intended for use in radio receiving circuits, and the figures of the drawing, which are more or less diagrammatic, show the tube very much enlarged. The invention, however, is not confined to any particular size of tube.

It will also be understood that the invention is not restricted to tubes having any definite

number of electrodes, although it has been illustrated in connection with a tube of the familiar three-electrode type. It will also be understood that the invention is not limited to the particular construction and arrangement of parts herein particularly illustrated and described, but may be otherwise embodied.

I claim:

1. A space discharge tube comprising a metal envelope, electrodes in the envelope having lead-in and supporting wires projecting beyond the end of the envelope, a mass of liquid setting cement adhering to the metal envelope and to said lead-in and supporting wires and holding the same in fixed relation, and means on the outer surface of said cement for rendering the same impervious to the passage of gases therethrough.

2. The method of making vacuum tubes of the type having an electrode within a metal sleeve, which sleeve constitutes the envelope of the tube and wherein the electrode is supported in spaced relation to the interior of the sleeve and is provided with lead-in and supporting wires projecting beyond the ends of the sleeve, which comprises assembling the electrode within the sleeve and then casting a cementitious insulating material in the end of the sleeve and about said lead-in and supporting wires and allowing the same to set, thereafter evacuating and baking the tube, and cooling the tube during the baking operation adjacent the cement to protect the same from heat.

3. In the manufacture of a space discharge tube having a cathode and a grid and having an anode which constitutes the envelope of the tube, the steps which comprise supporting the cathode and the grid by means of lead-in wires in proper relation with one another, positioning the anode over the grid and cathode assembly, thereafter molding a mass of liquid setting cement in one end of the tube around said lead-in and supporting wires and allowing the cement to set, the cement adhering to the sleeve and to the lead-in and supporting wires, rendering the cementitious material after it has set impervious to the passage of gas therethrough, and thereafter evacuating the tube and sealing it at the other end of the tube.

4. The method of manufacturing electron tubes of the type having an exposed tubular metal shell, which comprises arranging and holding electrodes and their supporting wires in a predetermined desired relation, forming a pool of sealing material of predetermined depth about the supporting wires for the electrodes, moving the tubular shell positioned about the electrodes down until its edges project to a predetermined depth into the pool, and keeping the said lowermost edge of the tubular shell in the pool until the sealing material has set.

5. The method of manufacturing electron tubes of the type having an exposed tubular metal shell, which comprises arranging and holding electrodes and their supports in a predetermined desired relation, providing a confined mass of a liquid setting cementitious material about the supporting wires for the electrodes of a desired depth, moving the tubular shell positioned above the electrodes down until its edges project to a predetermined depth into the mass of liquid setting cement, and maintaining the parts in this position until the cement sets.

FREDERICK S. McCULLOUGH.