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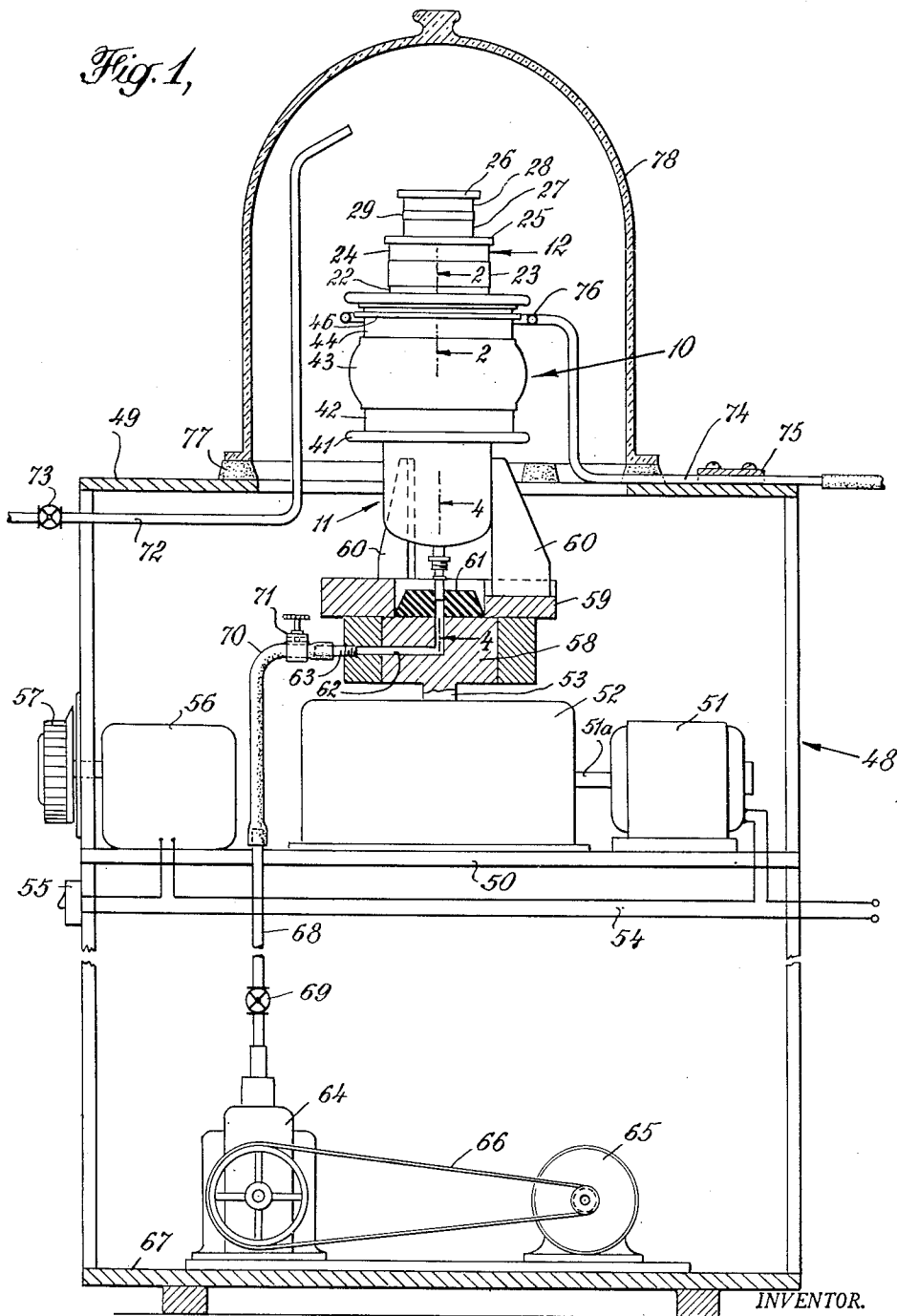
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METHOD OF SEALING THE ENVELOPES OF VACUUM TUBES

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2 Sheets-Sheet 1



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Fig. 2,

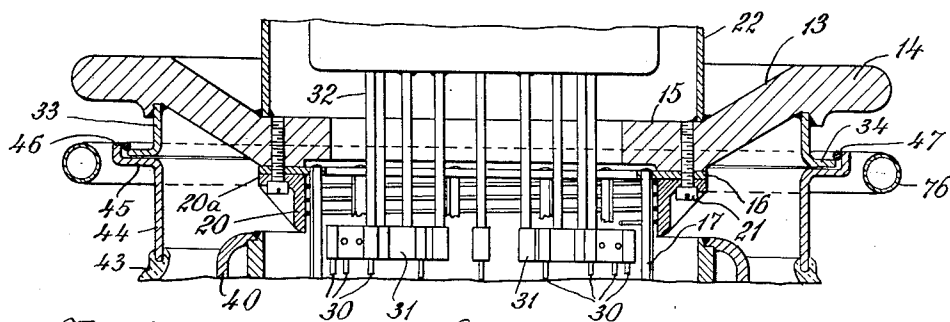


Fig. 3,

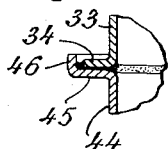


Fig. 4,

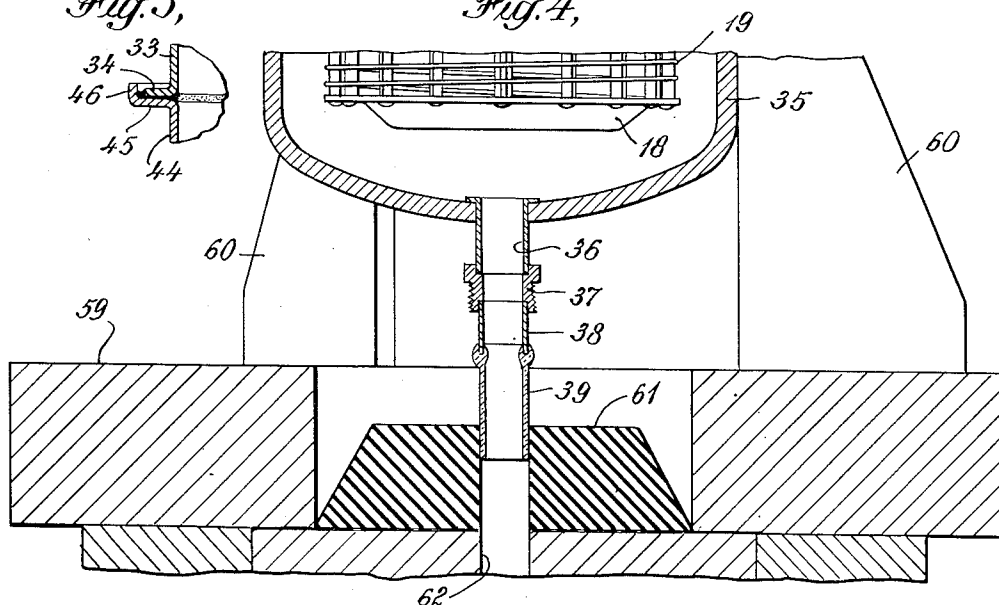
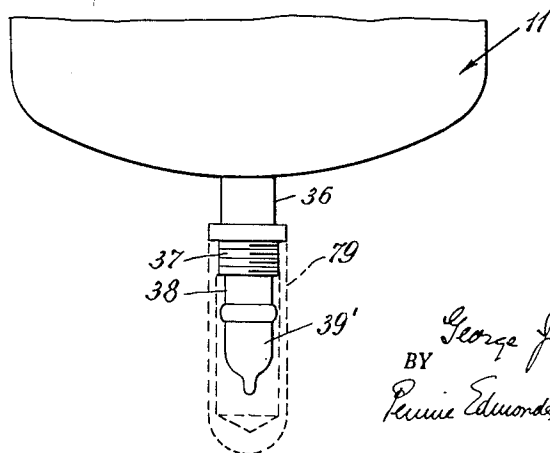


Fig. 5.



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METHOD OF SEALING THE ENVELOPES OF
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2 Claims. (Cl. 219—10)

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This invention relates to the manufacture of vacuum tubes, especially electron tubes, and is concerned more particularly with a novel method for making the final seal by which the envelope of such a tube is closed.

At the present time, the final seal of an electron tube envelope formed partly of glass and partly of metal is commonly made in the glass portion of the envelope by means of a torch. If, as is frequently the case, the heat for sealing must be applied directly over or near internal metal parts of the tube, which have been previously cleaned or outgassed, it is difficult to prevent some oxidation of these parts, even though protective atmospheres of nitrogen, forming gas, or carbon dioxide are maintained within the tube during the sealing operation. Cleanliness of the parts could be maintained, if it were possible to use hydrogen as the protective atmosphere, but that would be extremely hazardous because of the presence of the gas flame. Another disadvantage of the glass-to-glass sealing described is that the stresses in the glass caused by the heating and working during sealing must be removed by uniform annealing of the sealed tube and such annealing is difficult, since oven annealing is not desirable, especially when the tube contains heavy glass-supported parts, because of the possibility of such parts becoming misaligned.

The present invention is, accordingly, directed to a method of effecting the final seal of the envelopes of electron tubes, which is not subject to the disadvantages above set forth and can be practiced without oxidizing internal metal parts of the tubes and without the necessity of subsequent annealing. The new method is employed in connection with tubes, in which the anode and cathode sub-assemblies have similar marginal circumferential metallic parts adapted to be placed in contact and joined together, as by soldering, to make the final seal. In the practice of the method, the sub-assemblies are telescoped together to place the circumferential parts thereof in contact and solder, preferably, silver solder wire, is applied along the entire outer edge of one part and in contact with the other. The tube is then mounted for rotation on its axis and the parts to be joined are maintained in an atmosphere of a non-oxidizing gas and the air within the tube is replaced by the gas. The tube is rotated on its axis at a low speed and the circumferential parts of the sub-assemblies are heated inductively, while rotation continues, the heating being preferably carried on in stages of

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increasing temperature. After the solder has melted and entered between the parts to be joined, the heating is discontinued and the tube kept in position, until the solder has set.

For a better understanding of the method of this invention, reference may be had to the accompanying drawings, which show an apparatus by which the method may be carried out.

In the drawings:

Fig. 1 is an elevation, partly in section, of the apparatus with a vacuum tube mounted therein;

Fig. 2 is an enlarged sectional view of a part of the vacuum tube on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary sectional view through the joint forming the final seal of the tube;

Fig. 4 is an enlarged sectional view on the line 4—4 of Fig. 1 of the lower portion of the vacuum tube and its mounting; and

Fig. 5 is a view in elevation of the lower end of the completed tube.

The vacuum tube 10, shown in Fig. 1 mounted in the apparatus for final sealing in accordance with the method of the invention, comprises an anode sub-assembly 11 and a cathode sub-assembly 12. The cathode sub-assembly includes a main supporting ring 13 having offset flanges 14, 15, and the grid structure of the tube is secured to flange 15. This structure includes a flat ring 16, in which are mounted the upper ends of a plurality of rods 17 arranged in a circular series, the lower ends of the rods being mounted in the rim of a cup 18. A fine wire 19 is coiled around rods 17 to complete the grid. The ring 16 is secured to flange 15 by means of a member 20 having a cylindrical portion, through which the upper ends of rods 17 extend. Member 20 has a flange 20a engaging the lower face of ring 16 and the member is secured to flange 15 by bolts 21 passing through flange 20a and ring 16 and into threaded bores in flange 15.

The upper end of the cathode sub-assembly includes a cylindrical sleeve 22 secured to the upper surface of member 13 at the inner edge of flange 15 and having its upper end connected by a cylindrical glass section 23 to a cylindrical metal section 24, secured to a supporting ring 25. Ring 25 is connected to a metal disc 26, which closes the upper end of the sub-assembly, by cylindrical sections 27, 28 connected together by an intermediate glass section 29. The filaments 30 of the tube are attached by clips 31 to rods 32, which are alternately connected mechanically and electrically to ring 25.

and disc 26, the lower ends of the filaments being connected together in a manner well known in the art.

The main supporting ring 13 of the cathode structure is provided with a cylindrical metallic sleeve 33 extending downwardly from its lower end and formed with a radial flange 34. Flange 34 is the marginal circumferential part of the sub-assembly, which is to be joined to a similar part of the anode sub-assembly to make the final seal of the tube.

The anode sub-assembly 11 of the tube comprises an anode 35 of cylindrical form, which is closed at its lower end except for an opening, in which is sealed a tube 36 carrying a threaded bushing 37 at its lower end. A tube 38 is mounted in the lower end of the bushing and a length of glass tubing 39 is sealed to the lower end of tube 38. At its upper end, the anode is connected by an outer cylindrical member 40 to a ring 41, to the upper end of which a cylindrical metallic section 42 is secured. A glass section 43 connects the upper end of section 42 to the lower end of a cylindrical metallic section 44 having a radial flange 45 at its upper end. Flange 45 terminates in a circumferential flange 46, the inner diameter of which is slightly greater than that of flange 34 of section 33 of the cathode sub-assembly. Flanges 45, 46 constitute the marginal circumferential part of the anode sub-assembly employed in making the final seal of the tube.

In effecting the final seal of the tube in accordance with the method of the invention, the anode and cathode sub-assemblies are telescoped together, until flange 34 of the cathode sub-assembly rests upon flange 45 of the anode sub-assembly. A ring 47 of solder in wire form is then laid against the inner side of circumferential flange 46 at the outer edge of flange 34 and heated, until it flows.

The apparatus employed in the practice of the new method comprises a structure 48 having a top 49 with a central opening. A platform 50 is mounted on the structure below the top and carries a motor 51, the shaft 51a of which is connected through a speed reducer 52 to a vertical shaft 53. The motor is supplied with current from lines 54, containing a switch 55, through a voltage regulator 56 mounted on the platform and controllable by a handle 57. Vertical shaft 53 carries a block 58 at its upper end, on which is mounted a chuck 59 of the type used on glass lathes and provided with three jaws 60, which are movable radially. The base of chuck 59 has a central opening, in which is mounted a rubber stopper 61 cemented to the upper face of block 58 and having a central passage through it. Block 58 is formed with a passage 62, one portion of which extends axially and leads to the opening through the stopper, while the remainder of the passage extends radially through the outer face of the block and is provided with a short length of tube 63 mounted therein.

A vacuum pump 64, driven by motor 65 through belt 66, is mounted on a platform 67 on the structure below platform 50, and a tube 68 containing a valve 69 leads upwardly from the pump intake and passes through an opening in platform 50. A rubber hose 70, provided with a pinch clamp 71, connects the upper end of line 68 to tube 63. A line 72 for supplying a non-oxidizing gas, preferably hydrogen, and provided with a control valve 73, extends through a front wall of the apparatus and upwardly through the opening in top 49. Leads 74 of a high frequency induction

coil extend along the top 49 of the structure and are held in place by a clamp 75. The leads extend upwardly above the opening through the top 49 and terminate in a single turn coil 76 coaxial with shaft 53.

In the practice of the method of the invention by the apparatus described, the anode end of the tube is inserted in the chuck and the jaws of the chuck are closed to hold the tube securely in place. The length of glass tube 34 extending from the anode end of the tube is inserted into the opening in stopper 63, as the tube is inserted in the chuck. The cathode sub-assembly is then placed in position, with the grid and filament structure passing through the induction coil 76 and entering the anode, until flange 34 rests upon flange 45 of the anode sub-assembly. The ring 47 of solder is then put in place and the induction coil adjusted, until it is opposite the contacting flanges of the sub-assemblies. Rubber blocks 77 are then placed on top 49 around the opening therein and a bell jar 78 is mounted on the blocks to enclose the upper part of the tube, the induction coil, and the end of the gas supply tube 72.

With the apparatus set up as described, valve 73 is open to introduce a non-oxidizing gas, preferably hydrogen, into the bell jar and the vacuum pump is started to evacuate the tube. As the pumping continues, hydrogen from the interior of the jar is drawn into the tube between flanges 34 and 45, until the air within the tube has been replaced by hydrogen. When the tube is full of hydrogen, the clamp 71 is operated to pinch hose 70 and the hose is cut off on the pump side of the clamp. Pinching the hose permits the gas pressure within the tube and the bell outside the tube to equalize and, with the hose cut, the chuck may be rotated. The motor 51 is now started to rotate at a low speed of about 10 R. P. M. and coil 76 is energized at a low level to preheat the joint. After a period of the order of 5 minutes, the temperature of the seal is raised by increasing the supply of energy to the coil, until the solder begins to flow and, during this operation, when the effect of the heat is visible at the seal, the speed of rotation of the motor is adjusted, so that uniform heating is obtained. When the solder has begun to flow, the pinched length of hose connected to tube 63 is pulled off the tube, to prevent the building up of pressure in the tube, without stopping rotation of the chuck. When the solder has flowed completely, the current supply to the induction coil is cut off and the tube is allowed to cool with the seal in the hydrogen atmosphere.

It has been found in practice that final seals made by the method described are vacuum-tight and perfect in appearance, and, since the seal is made by metal parts, annealing operations required with glass seals are not necessary. After the seal is completed, the tube is subjected to its final processing operations, at the completion of which the length of glass tubing 39 is sealed off, as indicated at 39', and then protected by a metal cap 79 threaded on fitting 37.

I claim:

1. A method of making the final seal to close the envelope of a vacuum tube made up of a cathode sub-assembly and an anode sub-assembly provided with contacting marginal circumferential metal parts to be joined to form said seal which parts are well removed from dielectric portions of the envelope, one of said sub-assemblies having an outlet, which comprises mounting the

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tube with its axis vertical for rotation on said axis, applying solder along the entire outer edge of one of the parts adjacent the other part, maintaining an atmosphere of a non-oxidizing gas outside the tube and in contact with the parts, connecting the outlet to a source of vacuum and thereby removing air from within the tube and filling it with the gas drawn in between the parts, disconnecting the outlet from the source and closing the outlet, rotating the tube at low speed, inductively heating the parts and solder by means of an electrical induction coil positioned around the joint and within the surrounding non-oxidizing atmosphere and in a manner capable of limiting the heating of parts to a region immediately adjacent the seal, opening the outlet, after the solder has begun to flow and while the rotation is continuing, and discontinuing the heating, when the solder has flowed completely.

2. A method of making the final seal to close the envelope of a vacuum tube made up of a cathode sub-assembly and an anode sub-assembly provided with contacting marginal circumferential metal parts to be joined to form said seal which parts are well removed from dielectric portions of the envelope, one of said sub-assemblies having an outlet, which comprises mounting the tube with its axis vertical for rotation on said axis, applying solder along the entire outer edge of one of the parts adjacent the other part, maintaining an atmosphere of a non-oxidizing gas outside the tube and in contact with the parts,

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connecting the outlet to a source of vacuum by a severable connection to remove air from within the tube and fill it with the gas drawn in between the parts, closing the outlet and severing the connection near the outlet, rotating the tube at low speed, inductively heating the parts and solder by means of an electrical induction coil positioned around the joint and within the surrounding non-oxidizing atmosphere and in a manner capable of limiting the heating of parts to a region immediately adjacent the seal, opening the outlet, after the solder has begun to melt and while the rotation is continuing, and discontinuing the heating, when the solder has completely melted.

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