March 15, 1966 B. M. C. DRIARD 3,240,976

ELECTRON TUBE CONSTRUCTION

Filed Dec. 2, 1963 2 Sheets-Sheet 1

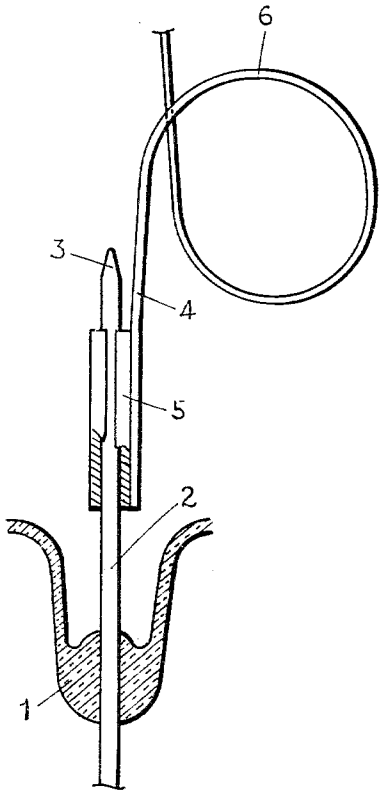

FIG. 1

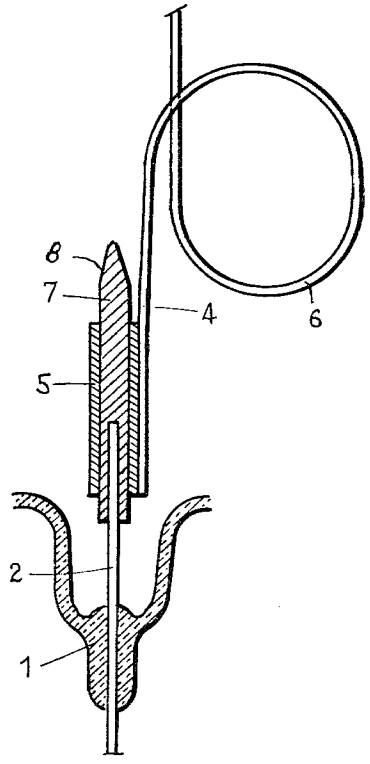

FIG. 2

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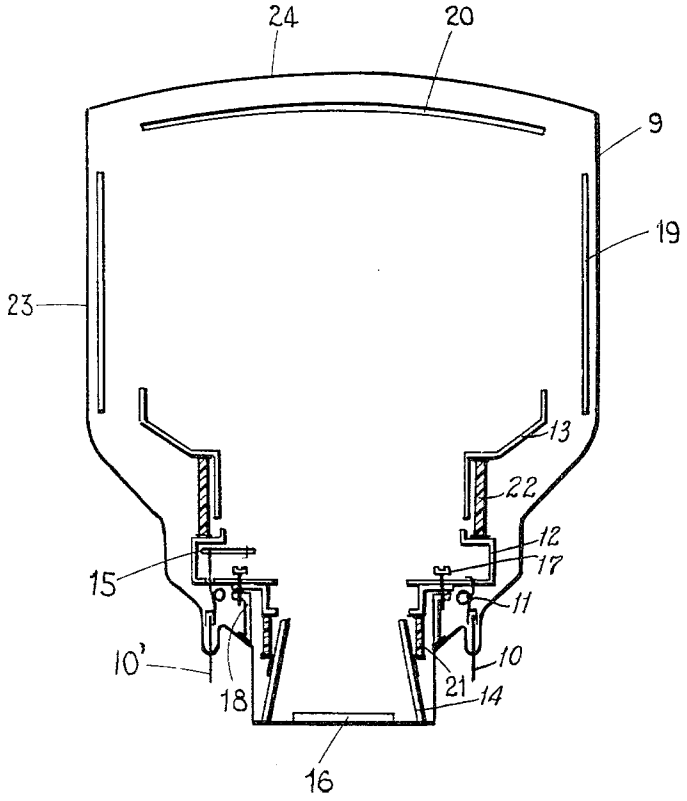
Fig. 3



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ELECTRON TUBE CONSTRUCTION

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Claims priority, application France, Dec. 4, 1962, 917,455, Patent 1,352,175
7 Claims. (Cl. 313—237)

This invention relates to electron tubes having improved means connecting one or more of the electrodes therein with the lead-in or lead-out conductors of the tube. The term "electrode" as used in the specification and claims is to be understood as designating any one of the internal component elements of an electron tube requiring to be connected with external circuit conductors for the operation or in the course of the manufacture of the tube.

In conventional electron tubes, both of the vacuum and the gas-filled varieties, the electrodes are usually permanently connected by spot welding with conductor rods extending through and sealed in the envelope of the tube, which rods at their outer ends constitute or connect with the respective electrode terminals of the tube. With many of the more elaborate types of tubes used in present-day electronics such construction possessess distinct disadvantages. The internal structure of such tubes may be intricate and require a relatively great number of welded connections at closely-spaced points which are difficult of access to a welding tool. Moreover such tubes are frequently large and expensive and their process of manufacture is often complex and delicate and hence conducive to a relatively high percentage of defective tubes which are apt to be detected only in a final inspection step. In such cases it would be desirable to able to dismantel the defective tube and recover valuable components of it, including the glass envelope, rather than scrapping the tube as a whole. The permanent electrode connections inside the tube make such recovery difficult or impossible without damage to the costly glass envelope. The afore-mentioned difficulties are at least as serious when a plurality of electrodes or other construction parts are joined in order to constitute a complete sub-assembly. But it is precisely the condition in which the recovery of the parts of the tube is of a particular interest.

Objects of this invention include the provision of an improved method of electron tube construction whereby the assembly, and where desired the disassembly, of the internal components of the tube will be considerably facilitated; the provision of an improved electrode tube assembly containing within its sealed envelope one or more self-supporting sub-assemblies mounted in an improved manner achieving simpler construction and allowing the recovery of the electrodes and their sub-assemblies as well as of the main part of the envelope. Other objects and advantages of the invention will appear.

According to a feature of the invention, means for connecting an internal tube electrode with an external tube terminal comprises in combination a conductor rod extending through and sealed in the tube envelope and externally connected with said terminal, a resiliently flexible conductor wire connected to said electrode internally of the tube, and means for connecting said wire and rod comprising a resiliently expansible sleeve member on said

wire engageable with a complementary end portion of said rod within the tube envelope. According to a further feature, an improved electron tube assembly comprises, within a sealed envelope at least one mechanically self-supporting sub-assembly comprising at least one tube electrode, means such as screw means for removably securing the sub-assembly to a support provided within the envelope, at least one conductor rod extending through and sealed in the envelope, a resiliently flexible conductor wire extending from the, or each, electrode of said sub-assembly, and means including an expansible sleeve for detachably interconnecting said conductor wire with a related conductor rod.

Further features of the invention will appear from the ensuing description, relating to exemplary embodiments of the invention illustrated in the accompanying drawings wherein:

FIG. 1 is a large-scale view, mainly in section, showing part of an envelope of an electron tube and internal structure according to the invention for connection with an electrode to be included in a sub-assembly, which electrode and sub-assembly are not shown.

FIG. 2 is a similar view relating to modified structure; and

FIG. 3 is a simplified sectional view of an X-ray image intensifier tube embodying features of the invention.

Referring to FIG. 1, reference **1** designates a portion of the glass envelope of an electron tube. A conductor rod **2** extends through a nipple of the glass wall **1** and is sealed therein in a conventional manner. The inner end of conductor rod **2**, within the tube envelope **1**, i.e., the upper end as shown in the drawing, is provided with a taper tip as at **3**. A conductor wire **4** has its one, upper, end connected to an electrode, not shown, and has a slotted tubular sleeve member **5**, made, e.g., of spring bronze, or other metal composition having good electrical conductivity as well as resiliency, so as to be resiliently expansible, welded to the other end of wire **4**. Preferably the wire **4** is welded to the outer surface of the slotted sleeve **5** along the full length of a generatrix of the sleeve, as shown, which generatrix is angularly spaced around the circumference of the sleeve from the generatrices limiting the slot of said sleeve. Sleeve **5** is so dimensioned and formed as to be engageable with a firm friction fit around the rod **2** and so that the radial resiliency of the slotted sleeve when thus fitted will ensure excellent electric contact with the rod **2** over a relatively large surface area. The end taper **3** of the rod facilitates engagement of the sleeve **5** thereover. The wire **4** is relatively stiff yet flexibly deformable and is desirably formed with at least one coil loop **6** therein, to increase its natural flexibility. Thus in the assembly of the tube a connector sleeve **5** can easily be brought into alignment with the tapered end **3** of a conductor rod **2** and engaged thereover. This arrangement is especially convenient where the conductor wire **4** forms part of a sub-assembly including more than one electrode and associated connector wires such as **4**, to be respectively connected with related conductor rods such as **2** extending through spaced points of the tube envelope. In such an assembly it will be realized that manufacturing tolerances may introduce variations in the relative spacing as between the conductor rods and other components. Thus the deformability of the connector wires **4** of the sub-assembly prevents any strain on the conductor rods while the tapers at the ends

of these rods allow a smooth insertion of all the conductor rods in all the sleeves.

In the modified construction shown in FIG. 2 parts corresponding to parts shown in FIG. 1 are designated with the same reference numerals. The difference over the first embodiment described lies in the fact that the conductor rod **2** has a conductive insert member **7** of enlarged diameter fitted over its upper part by way of an axial recess in the lower end of the insert member. The insert member **7** is tapered at its upper end and is adapted to receive the slotted connecter sleeve **5** projecting from wire **4** tightly fitted thereover. This modification is useful in cases where the conductor rod **2** is of small diameter in that the enlarged insert member **7** will facilitate connection with the sleeve.

In the embodiment of the invention shown in FIG. 3 the invention is applied to an X-ray image intensifier tube comprising a glass envelope **9** of relatively large dimensions. This glass envelope comprises a generally cylindrical portion **23** and a cover **24**; the two portions are bonded only after the assembly of the internal parts of the tube. At the upper end of the envelope **9** there is a primary image-receiving screen **20** provided with fluorescent and photoemissive layers. At the lower end of the tube there is a smaller, secondary fluorescent screen **16** on which an intensified image is to be formed. An annular electrode **19** is provided around a large diameter cylindrical intermediate portion of the tube, preferably in the form of a metal coating deposited on the tube wall, and is adapted to be connected through means not shown with a relatively low potential for accelerating the photoelectrons emitted from the photoemissive under side or photocathode of the primary screen **20**. The tube further includes a set of three annular electrodes **13**, **12** and **14**, coaxially aligned along the optical axis of the tube and constituting an electron-optical lens system for concentrating the photoelectrons from the photocathode towards the secondary screen **16**. The intermediate annular electrode **12** is provided with a plurality of evaporator elements such as **15** which serve exclusively during the manufacture of the tube for vaporizing alkali metals and other substances initially introduced into the tube and serving to form the photocathode layer on the under side of primary screen **20**. The construction of an electrode **12** of this type is described in greater detail in co-pending application Serial No. 327,185, filed December 2, 1963.

In accordance with the present invention, the electrodes **12**, **13** and **14** together with the evaporator elements **15** and other components forming part of electrode **12** are previously assembled to provide a self-supporting unit or sub-assembly, ceramic posts such as **21** and **22** being used for binding together the three electrodes which are carried to different potentials. This sub-assembly is then secured by way of screws **17** to an annular supporting member **18** sealed to the inner surface of envelope **9** adjacent to a restricted lower end of it. Lead-in conductors are provided in the form of a number of conductor rods extending through and sealed in nipples of the glass envelope **9** at suitable positions. Only two such conductor rods are shown at **10** and **10'**, but it will be understood that as many such rods would be provided as there are connections to be made from internal tube components to external tube terminals. In FIG. 3 rod **10** is shown connected to annular electrode **12** and rod **10'** to the heater elements **15**. The connection, generally designated **11**, between each lead-in rod provided, such as **10**, **10'**, and the related electrode is similar to what was described with reference to FIG. 1 or 2, including a looped flexible wire extending from the electrode and an expansible sleeve welded thereto for engagement over a tapered upper end portion of the related conductor rod **10** or **10'**. The connecting means are only illustrated in a general manner in FIG. 3, since they were shown and described in detail earlier herein.

The advantages of the invention will be readily appreciated from the foregoing disclosure. After the above described sub-assembly has been inserted in position in the envelope **9** and secured therein by means of the screws **17**, the connection from each component electrode to the associated lead-in rod such as **10**, **10'** can be very easily effected in the manner earlier described with reference to FIGS. 1 and 2 without requiring the difficult manipulation of a welding electrode under the cramped conditions present, and without requiring any great degree of precision in the relative positioning of the conductor rods **10**, **10'** and other parts of the tube assembly or electrode sub-assembly, owing to the resilient deformability of the connecting wires as earlier explained. In addition, in the event of any defect in the tube assembly, during or after manufacture thereof, the electrode sub-assembly can be easily removed from the defective tube, as by severing the cover **24** and by unscrewing the screws **17** and disengaging the slotted sleeve members such as **5** (FIGS. 1 and 2) from the related lead-in rods such as **10**, **10'** (FIG. 3), so that the expensive components can be re-used partly or wholly in a different tube. Moreover the most costly parts of the glass envelope of the tube remains undamaged.

It will be evident that various changes and modifications may be introduced without exceeding the scope of the invention. Thus instead of the conductor rods being tapered as at **3** (FIG. 1) or **8** (FIG. 2), or in addition to such taper, the slotted sleeve members **5** may be provided with an enlarged, tapered entrance at their free or lower end. The X-ray image intensifier device shown in FIG. 3 constitutes but one example of the many types of electron tubes to which the invention may be usefully applied.

I claim:

1. An electron tube having a sealed enclosure, a mechanically self-supporting inner sub-assembly comprising at least one tube electrode, supporting means within the enclosure, means detachably securing said sub-assembly to said supporting means, at least one lead-in conductor rod extending through and sealed in the wall of said enclosure independent of said supporting means and connectable to a terminal externally thereof, and means connecting said at least one electrode with a related conductor rod inside the tube and comprising a resiliently flexible connecting wire extending from said said electrode and a radially expansible slotted tubular sleeve of conductive material secured to one of a free end part of said wire and an inner end part of said conductor rod and engageable with a tight fit over said other end part.

2. The electron tube claimed in claim **1**, wherein said connecting wire has substantial stiffness and is looped to impart resilient flexibility thereto.

3. An electron tube having a sealed enclosure, at least one mechanically self-supporting electrode assembly detachably secured to supporting means within the enclosure, at least one lead-in conductor rod extending through and sealed in the wall of the enclosure independent of said supporting means and connectable to a terminal externally thereof, and means connecting said at least one electrode with an associated conductor rod within the tube comprising a relatively stiff, resiliently flexible connecting wire extending from the electrode, and a radially-expansible slotted tubular sleeve of conductive material secured to a free end part of said wire and engageable with a tight but removable fit over inner end part of said conductor rod.

4. The electron tube claimed in claim **3**, wherein said conductor rod is tapered at its free end to facilitate engagement of said slotted sleeve thereover.

5. The electron tube claimed in claim **3**, wherein said sleeve is formed with an entrance taper to facilitate engagement thereof over said conductor rod.

6. The electron tube claimed in claim **3**, wherein said

conductor rod is provided with an enlarged upper portion over which said sleeve is engageable.

7. The electron tube claimed in claim 3, wherein said connecting wire is looped intermediate its one end and said sleeve member.

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