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[54] **METHOD FOR THE MANUFACTURE OF PHOTOELECTRON MULTIPLIERS**

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[51] **Int. Cl.** **H01j 9/18**
[58] **Field of Search** 316/19, 18, 27, 30, 17

[56] **References Cited**

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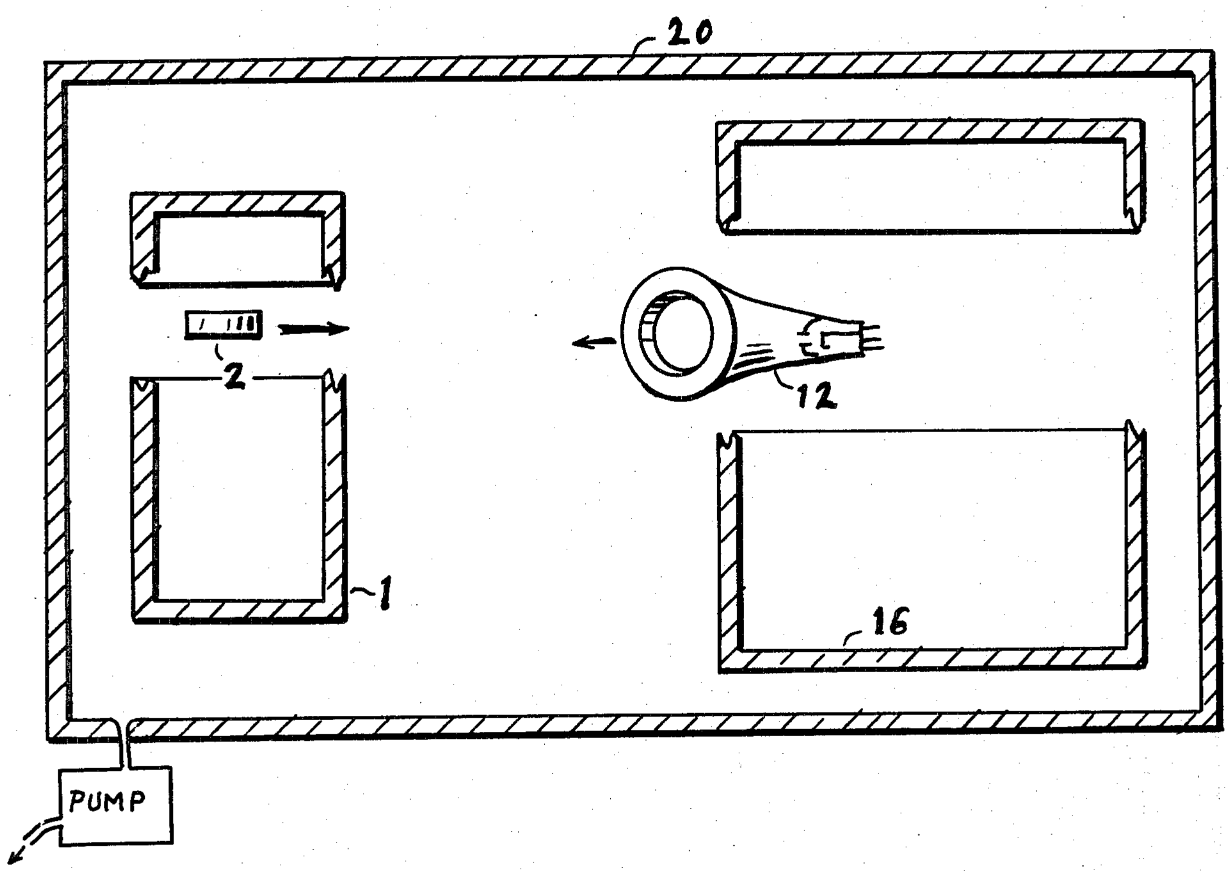
[57] **ABSTRACT**

A method for manufacturing electron tubes in which a photosensitive layer is manufactured in one evacuated vessel, the electrode structure is manufactured in another evacuated vessel, and assembly of the photosensitive layer and electrode structure is accomplished by first placing the first two vessels in a third evacuated vessel, opening the first two vessels, and assembling the contents.

9 Claims, 6 Drawing Figures



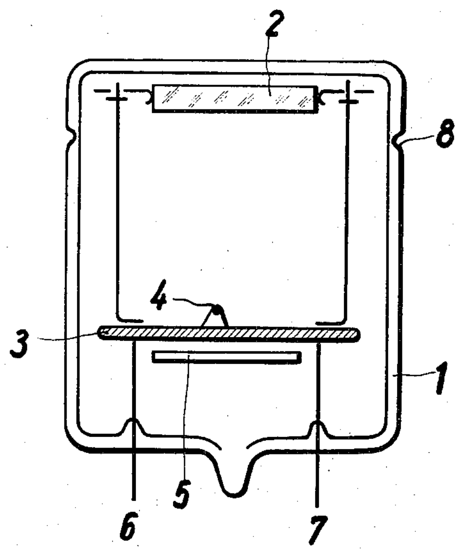


Fig.1

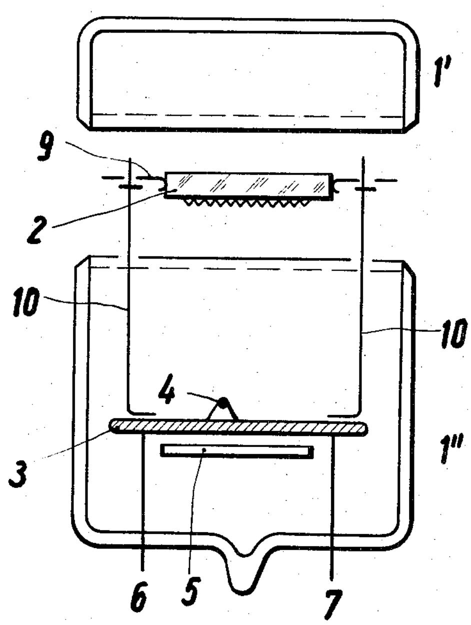


Fig.2

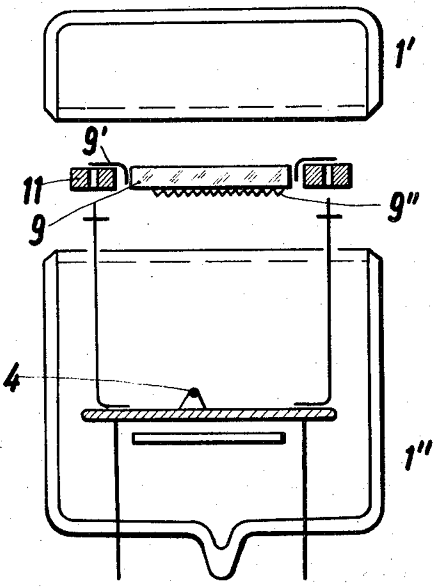


Fig.3

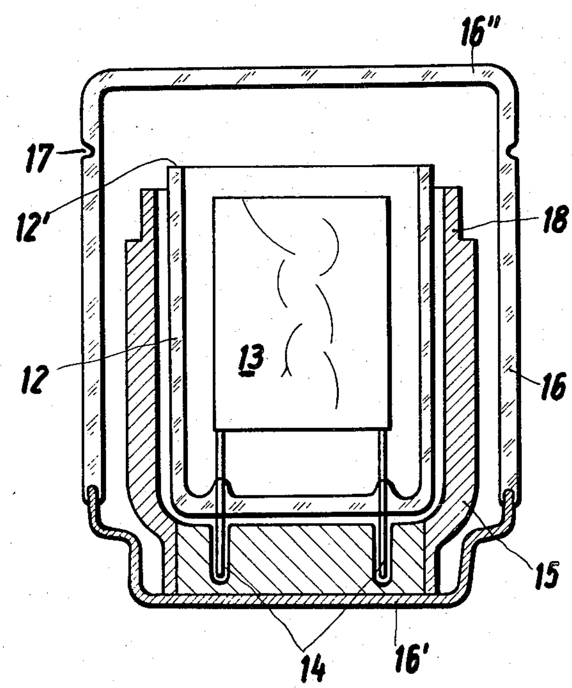
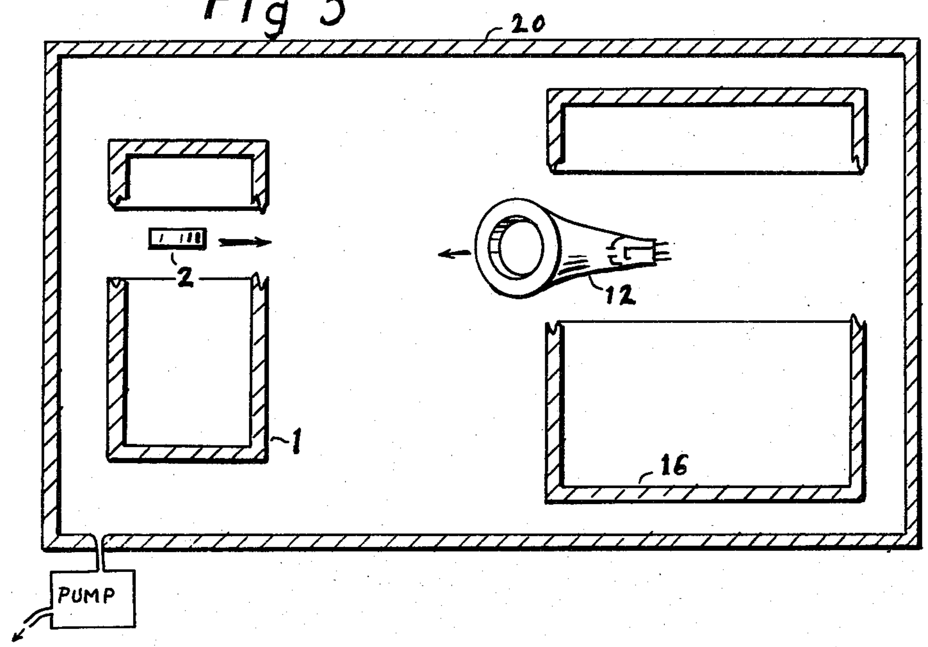


Fig.4

Fig 5



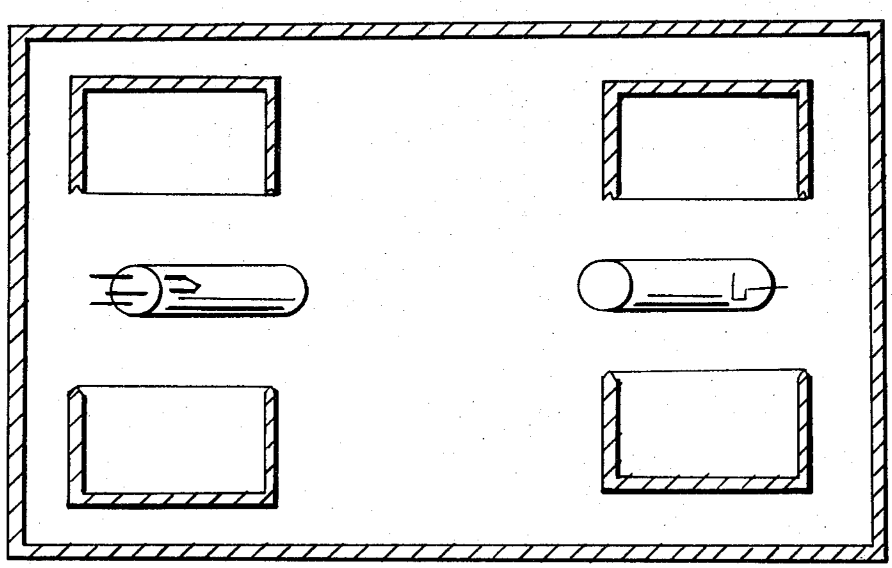


Fig 6

METHOD FOR THE MANUFACTURE OF PHOTOELECTRON MULTIPLIERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a method for manufacturing electron tubes provided with a photosensitive layer which is applied to a flat disc, particularly to a method for manufacturing photoelectron multiplier tubes.

2. Description of the Prior Art

In the manufacture of photoelectron multipliers, it is difficult to reconcile the requirement of great homogenity and high quality of the photocathode with that of low manufacturing cost. The usual photocathode consists of a multi-component layer in which antimony or bismuth and one or more alkalis are present. The photocathode support usually is a flat disc. The photosensitive surface is very sensitive to extraneous gases and to overheating, e.g., in the sealing-in process, so that in the conventional manufacture of photocells, first the tube bulb and the flat disc were fused together, and subsequently the dynode structure was mounted on a glass stem, introduced into the bulb and the stem fused to the bulb. Then a metal layer was precipitated upon the front plate and an alkali-containing gas was introduced or developed which combined with the metal layer applied to the front plate so as to form an alloy. This procedure is relatively complicated and is ill-suited to conveyer-line production. The quality of the cathode is adversely affected by gasses, released when the exhaust tube is tipped off.

However, a method has also become known in which the bulb and photocathode are joined and the bulb is sealed without glass fusion. In this case the photocathode is placed in a secondary chamber of a common vacuum vessel which can be divided by diaphragms. The multiplier with its tube casing is placed in another section of the vacuum casing. For the purpose of the subsequent joining of the photocathode support or the front plate with the tube bulb, the bulb is provided, at its open edge, with a layer of indium. To carry out this process, alkali vapor is developed in the secondary chamber of the vacuum vessel and thereby the photocathode is shaped. Thereafter, the photocathode is brought, by means of a manipulator, into the main chamber wherein the bulb section with the multiplier electrodes has been placed. This bulb section is heated to such an extent that the metallic indium edge melts. Then the photocathode support with the photocathode is placed upon the tube edge and the liquid indium produces the hermetic joint of the two parts.

In practice, considerable difficulties result from the fact that, during the heating of the multiplier bulb, the liquid indium layer combines with the residual gases in the vacuum chamber, so that the capacity of the layer to adhere to the edge of the photocathode support decreases. If alkali metal was absorbed, the indium alloy formed recrystallizes later and produces leaks.

SUMMARY OF THE INVENTION

The described disadvantages of the aforementioned methods are overcome in a method for manufacturing electron tubes that contain a photocathode by crack-off groove, according to the invention, on the one hand, the photocathode with its support, and on the other hand the other electrodes of the tube (e.g., hot cathodes, shielding electrodes, multiplier dynodes) with the tube bulb section holding them, each in a closed vessel, each of the two vessels being provided with a crack-off groove; then opening both vessels in a common evacuated vessel by blasting, placing the photocathode support and the bulb section opposite each other by movable gripping devices, and sealing them hermetically to each other by pressure effect, e.g., by pressing an indium ring between the seam of the two tube sections. Preferably, only the tube section that supports the photocathode is moved by means of a gripping device and placed opposite the tube bulb section and finally closely thereto.

This method results in the following advantages: The photocathode, as well as the other electrodes of the tube, can be processed under optimum conditions in separate vessels and be manufactured on a large scale, e.g., by mechanical means. The vessels can be tested and stored. They are cracked open only at the proper time in the vacuum vessel unjoining the two vessels. From the photocell vessel, the front plate with the photocathode is removed and finally hermetically sealed to an edge of the other vessel by means of a cold-pressing process. This requires that the manufacture of the finished tube can in each case be carried out upon order, and furthermore, that the photocathode and the other electrodes are joined without the effect of heat or extraneous gases, so that optimum properties are achieved.

Since the photocathode support, as well as the bulb section that contains the other electrodes, is preheated, the vacuum no longer deteriorates when the two sections are joined, and long life of the tube are assured. The element to be connected to the photocathode may be, e.g., an electron multiplier, an electron-beam tube or an image converter. When the method is being employed, it is useful to fill the vacuum vessel joining the two vessels, before the cracking open, with alkali gases of low vapor pressure, so that the photocathode, when its vessel is opened, is exposed to an atmosphere changed as little as possible. A further advantage of this method consists in that only such photocathodes are used for manufacturing the tubes which present a sufficient sensitivity.

It has already been proposed to produce the required photocathode in a separate bulb in the manufacture of proxicon tubes which contain a porous KCl layer for multiplying photoelectrons. In this case, however, the photocathode would be arranged directly on the wall of the auxiliary vessel. This presents disadvantages since the cracked edge formed in the cracking off is not always of the same shape and it may be difficult to join to the opposite cracked edge of the bulb that contains the proxicon sections.

In the invention, on the other hand, the two sections to be joined may be rough-ground at the edges provided for the connection, so that hermetic sealing can be accomplished by the pressing process.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, an embodiment of the method of the invention is explained in greater detail by means of the attached drawings. In this case, the joining of a photocathode support to a secondary amplifier is involved.

FIG. 1 is a schematic cross-sectional view of the auxiliary vessel for processing the photosensitive layer.

FIG. 2 is a schematic cross-sectional view of the apparatus during the step of receiving the photocathode from the vessel of FIG. 1.

FIG. 3 is a schematic cross-sectional view of an auxiliary device for removal of the photocathode.

FIG. 4 is a schematic cross-sectional view of an auxiliary vessel with the bulb section that contains the multiplier electrodes, after the blasting-open.

FIG. 5 is a schematic view of two evacuated vessels being opened in a third evacuated vessel to allow assembly of contents.

FIG. 6 is a schematic view of two evacuated vessels being opened in a third evacuated vessel to allow assembly of a multipart tube.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1**, an auxilary vessel **1** contains a flat disc **2** for holding the photcathode and the necessary evaporation devices **4, 5** for producing precipitations upon the flat disc. An antimony evaporator **4** and alkali channels **5** are fastened to support element **3** and are provided with connections to sealing wires **6, 7**, etc. which supply current for heating the evaporation elements. Further pins (not shown) may serve to measure the photoelectric current during and after the processing. The vessel is also provided with a crack-off groove in which a heating wire may be inserted whose electric heating opens bulb **1** at groove **8.** The cell of FIG. **1** is, after the usual complete processing first stored to observe possible aging processes. The best of the stored cells may be selected for bulbs of top quality. In other vessels, which contain a portion of the later tube cover casing, the other electrodes are mounted and properly processed. When a multiplier cell with such a photocathode is to be manufactured, the cell according to FIG. **1** is introduced into a bell jar **20** (FIG. **5**) together with the auxiliary vessel **16** containing the multiplier electrodes of FIG. **4.** After a good vacuum has been achieved in the bell jar, which may, in addition, be gettered by the introduction of alkali vapor, cells **1** and **16** are cracked open at the cracking grooves **8** and **17.** The process for the removal of the photocathode from auxiliary vessel **1** is explained by means of FIGS. **2** and **3.** After the opening, the lower section **1''** of bulb **1** drops downward, so that the photocathode which is supported by supports **10** is released to be seized by a gripping device. FIG. **3** shows the gripping device **11** which abuts below a clamping ring **9'** fastened to the photocahtode support.

In the meantime, as shown in FIG. **4,** a multiplier cell **12** with multiplier electrodes **13** has been opened by blasting open auxiliary vessel **16** at a cracking groove **17,** in which process a suitable gripping device remove the upper section **16''**. A multiplier vessel **12** is located in a support vessel **15,** which is provided with holes for holding socket pins **14.** Furthermore, this support vessel contains strong edges **18** which serve as abutment surfaces in the subsequent sealing of the vessel by pressing an indium ring. In order to increase the stability of the auxiliary vessel in this pressing process, the bottom portion **16'** thereof is made of kovar. For completing the multiplier cell, a photocathode **9** is then mounted, by means of gripping device **11,** opposite to the edge **12'** of multiplier **12,** and an indium ring is inserted between edges **17** of vessel **12** and the edge **9''** of the photocathode **9.** Finally, by means of a punch, photocathode **9** is pressed against vessel **12** and abutment surface **17, 18.** Edge **12'** of the multiplier bulb **12** may be surface-ground for the purpose of safe connection to the front plate by means of indium.

Material capable of cold pressing other than indium, may also be employed for the sealing. Furthermore, the invention is not restricted to the employment of a front plate of glass. Materials with a coefficient of expansion very different from that of glass can also be employed.

Then the bell jar can be opened and the finished tube can be removed from the bell jar. According to another technique, the finished tube may also be removed from the bell jar through a gate and at the same time a new pair of auxiliary vessels **1** or **16** may be introduced into the bell jar through another gate, whereupon the manufacture of the next specimen begins.

The method described above can be modified in various ways without deviating from the essence of the invention. It is suitable for the manufacture of various types of electron tubes from individual elements, the manufacturing process of each or one of which would impair the optimum manufacture of the other elements.

In a plumbicon tube, the sensitivity of the photoactive layer is substantially damaged by residual gases of oxygen or hydrogen which impair the oxidation state of the lead oxide. In the conventional method in which the photosensitive layer is produced in a container and is transferred by a transfer process to the tube bulb likwise ready in the container, the residual gases produced in all vaporization or evaporation processes are harmful to the photosensitive layer. According to the method of the invention, the photosensitive layer is produced on a window in a closed auxilary vessl. The beam system of the plumbicon with the anode and other electrodes is likwise; during preparatory operation, degassed in a closed auxiliary vessel and the thermal cathode is processed. In the final joining of the window and the tube bulb in the container, no harmful gas is developed in the bell jar. By present-day means the vacuum can be readily held to 10^{-8} torr (mm Hg pressure) so that during the transfer process, which lasts only a few seconds, no impairment whatsoever of the two tube sections by residual gases can occur. It is also possible to getter previously the electrodes of the tube vessel in such a way that the photosensitive layer cannot absorb any residual gases from the electrodes after the joining of the two sections.

In conventional manufacture of image converters with so-called proximity focus, i.e., with very small distance between opposite photocathodes and luminous screens, the processing of the photocathodes presents very great difficulty since the gases necessary for activation can be introduced into the tube only through a pump connection so that the distribution of the precipitated metals can be controlled at best only by a differentiated heating or cooling of the vessel. When a high-grade photocathode, e.g., of the type of multialkali cathodes, is involved, a faultless manufacture of the image converted by the conventional method is impossible. In the invention, the material is precipitated in one of the auxiliary vessels upon the window according to a well controlled process of evaporation for various metals, e.g., antimony, potassium, sodium, and cesium, in which process the cell can be conveniently controlled with respect to maximum photosensitivity. The other section of the image converter, consisting of a luminescent screen coated with an aluminum layer and a receiving vessel with insulated sections at the cylindrical tube wall is likewise located in a auxiliary vessel. In this auxiliary vessel it is degassed by preheating to such an extent that it later yields no vapors or other gases at all and presents optimum insulation. Then it is only necessary to crack open the two auxiliary vessels in a well evacuated container, to transfer the window with the photocathode to the aperture of the image converter vessel where, with insertion of an indium ring, it is pressed together therewith in such a manner that a hermetic seal is achieved. Again such hermetic seal can be readily assured by a polishing pretreatment of the surfaces to be joined.

Under certain circumstances, pholomultipliers with photocathodes which are sensitive within a wide range of the infrared spectrum are necessary. The manufacture of such cells is rendered difficult, in the first place, by the fact that the multiplier joined to the photocathode becomes insensitive or undergoes insulation damages by the gases produced in the preparation of the cathode. In the second place, the measurement in the infrared range requires the use of a window of quartz which can be connected with glass only by the insertion of multistage transistion glasses. In this case too, the problems of such cells can be overcome by means of the invention. The photocathode for infrared can be manufactured without hesitation under optimum conditions in the auxiliary vessel where vapor of the required materials is applied to the quartz window. The remaining section of the multiplier is treated in the second auxiliary vessel in the conventional manner. Finally, however, the two sections are joined in the container at room temperature, after the auxiliary vessels are cracked open as described above.

It may happen that a tube has to be constructed whose target is very sensitive to the conditions of the manufacture of the photocathode as well as of the thermal cathode and requires for manufacture thereof a vacuum practically free of residual gas. In this case not only two but three auxiliary vessels are used, the photocathode, possibly with a special window, being provided in the first, and the bulb or the cathode ray tube with all electrodes, but without the target, being provided in the second, and the target itself in the third. Each of the three system can be manufactured only under optimum conditions. Their joining takes place in the container, after the auxiliary vessels are cracked open by means of two rings of ductile metal, e.g., indium.

The method also has the advantage of being readily adaptable to the most varied tasks, since entirely different tube parts can be joined in the same container after the exchange of inserts.

Generally, in a transplantation in a container of a layer sensitive to residual gases the damage done to parts is the smaller *a*) the shorter the duration of staying in the container, and *b*) the better vacuum. The two values are mutually exchanageable, i.e., the poorer the vacuum, the less time must pass between the opening of the auxiliary vessels (removal of the window, transfer to the tube bulb) and closure of the tube bulb. The most detrimental water vapor can be removed by a cooling finger which extends into the container and is filled with liquid air.

We claim:

1. Method for manufacturing an electron discharge tube comprising a bulb which includes a photosensitive layer for detecting radiation in a certain band, which radiation enters the tube through a window, which window is permeable to radiation of that band, and which bulb further includes other electrode structure functioning in cooperation with the photosensitive layer for operation as an electron discharge tube, comprising the steps of:

A. assembling said other electron structure in the bulb, leaving a prepared opening,
B. placing the bulb and the electrode structure contained therein in a first evacuated vessel provided with a crack-off groove,
C. performing a polishing pretreatment on the edge surface of the window and on the edge surface of the bulb which surrounds the prepared opening,
D. constructing the photosensitive layer in connection with the window within a second evacuated vessel provided with a crack-off groove,
E. preheating the photosensitive layer and the electrode structure to degas the preheated elements for vacuum preservation,
F. placing the first and second vessels and their respective contents inside a third evacuated vessel,
G. opening the first and second vessels inside the third vessel by cracking open their respective crack-off grooves,
H. operating a mechanical gripping device which removes the photosensitive layer from the second vessel and places it close to the bulb,
I. inserting the photosensitive layer and the window in the prepared opening while inside the third vessel,
J. sealing the window to the bulb to preserve a vacuum within the bulb, while inside the third vessel, and
K. removing the bulb and contents, forming the discharge tube, from the third vessel.

2. A method according to claim **1** wherein the sealing step comprises pressing a ductile, conductive material into a gap left between the window and the prepared opening.

3. A method according to claim **1** wherein the first vessel is constructed of glass with a metal base and the second vessel is constructed of glass.

4. A method according to claim **1,** wherein the window consists of a crystalline material and the bulb consists of glass.

5. A method according to claim **2,** wherein the ductile, conductive material is metal.

6. A method according to claim **5,** wherein the metal is a ring of indium.

7. A method according to claim **1** wherein, during the constructing step, the window is held in the second evacuated vessel with a clamping ring on supports and wherein the inserting step is conducted by lifting the window from the supports with a gripping device and placing the window adjacent to the prepared opening.

8. A method according to claim **1,** wherein gettered surfaces are prepared in the container along the paths covered in the transfer of the window, which surfaces shield the photosensitive layer from residual gas during the transfer.

9. A method according to claim **1,** wherein at least two tube components are prepared in an optimum manner in separate auxiliary vessels and then are placed opposite each other in a common container and are enclosed in a multipart tube bulb by pressing the sections together.

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