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APPARATUS FOR FORMING CATHODES

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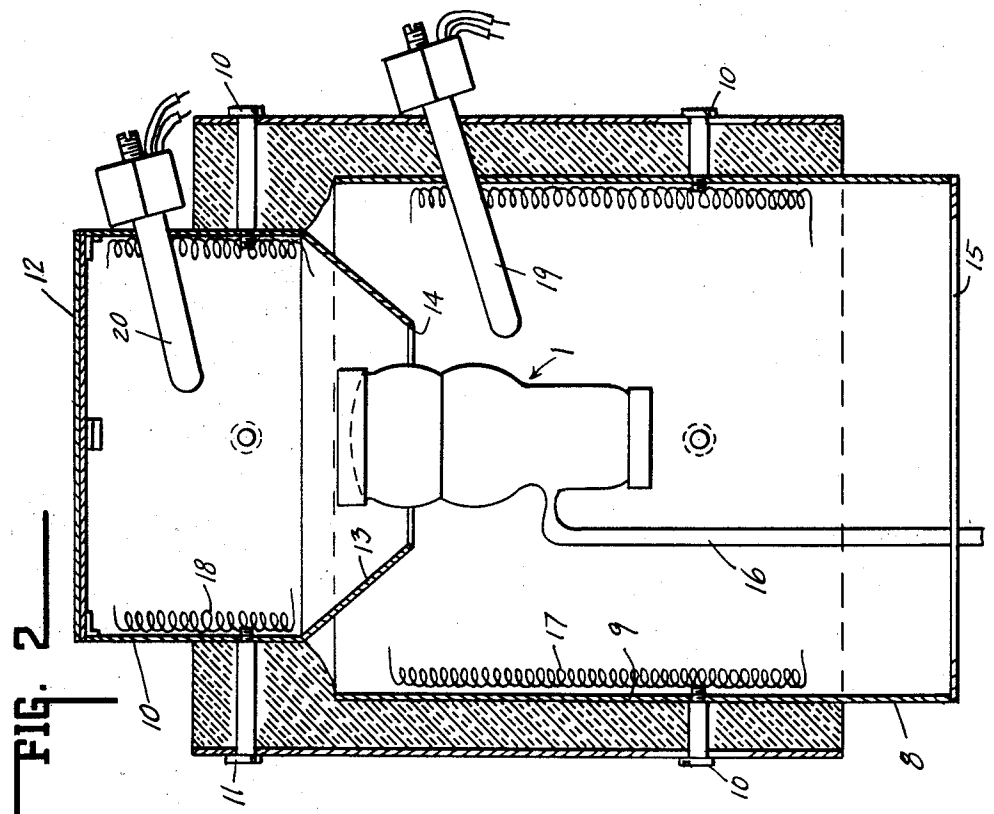



FIG. 2

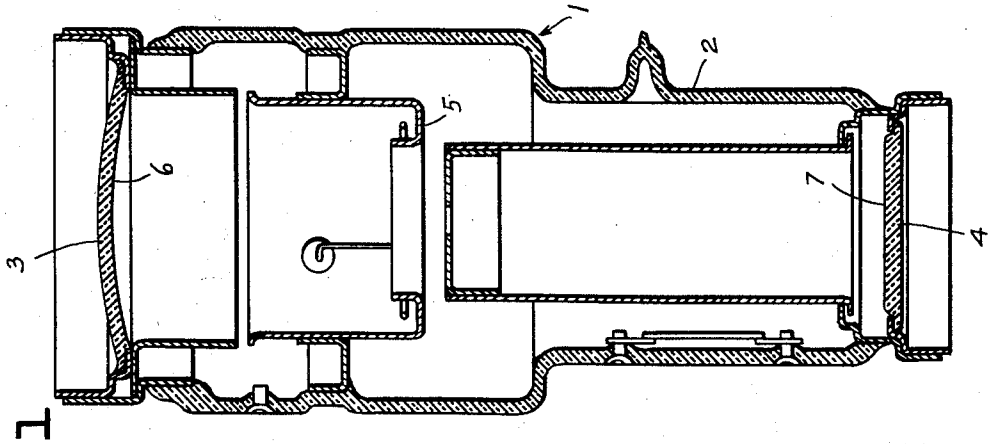



FIG. 1

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# APPARATUS FOR FORMING CATHODES

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1 Claim. (Cl. 219—35)

The present invention relates to a method and apparatus for forming radiant energy cathodes, and more particularly to a method and apparatus for forming a cathode on the face plate of an evacuated, cylindrically shaped glass envelope.

In the formation of silver-oxide-caesium cathodes which emit electrons in response to radiant energy projected thereon, the usual process incorporates the step of releasing pure caesium inside an evacuated bulb or envelope which is provided with a base or support upon which the cathode is formed. In the process of liberating the pure caesium, the caesium vapor tends to distribute itself throughout the bulb and to react with various portions thereof as temperature and other conditions may allow. By the use of certain materials, such as silver oxide, as a base for the cathode, the caesium may be caused to condense thereon and to react therewith to provide a film which is sensitive to radiant energy. In order to control the reaction of the caesium with the silver-oxide, the entire tube is maintained within critical temperature limits, whereupon the major portion of the released caesium may be caused to deposit in the desired area only constituting the cathode surface. However, since the caesium has a great affinity for oxygen and furthermore is a highly reactive metal, it will tend to deposit and react with the remaining portions of the tube envelope and with the metallic electrodes contained in the envelope. This caesium reaction with the other portions of the tube is undesired since these portions become sensitive to radiant energy and liberate electrons which interfere with the operating characteristics of the tube.

Therefore, it is an object of this invention, to provide a method and apparatus for forming radiant energy cathodes, which will tend to prevent the reaction of the caesium material with portions of the tube other than the cathode surface.

It is another object of this invention to provide a method and apparatus for confining the deposition of caesium to a limited area on the inside wall of an evacuated tube.

It is a still further object of this invention to provide an apparatus for forming silver-oxide-caesium cathodes on the face plate only of a cylindrically shaped evacuated tube containing metallic electrodes by the use of at least two separate heat sources which maintain the face plate of the tube at a different temperature from that of the remaining portions of the tube which include the envelope and the metallic electrodes.

It is yet another object of this invention to provide an apparatus for forming radiant energy-sensitive cathodes on the face plate of a completely assembled vacuum tube which comprises two separate heating sources which are so controlled as to maintain the temperature of the face plate constant and at a level which differs from the temperature of the remaining portions of the tube assembly.



Other objects will become apparent as the description proceeds.

In accordance with the present invention there is provided an oven having two heating chambers which are equipped respectively with radiant heat-generating elements and which are fully enclosed with the exception of a tube-receiving opening in a baffle separating the two chambers. The chambers and the heating elements are so arranged that with a tube positioned inside the opening, the opposite ends of the tube will be maintained at different respective temperatures. By means of this differential heating of the tube, deposition of the caesium on the tube face plate is facilitated and unwanted deposition on other parts of the tube assembly is substantially reduced.

For a better understanding of this invention, reference is made to the following description, taken in connection with the accompanying drawings, with the scope being pointed out in the appended claims.

In the accompanying drawings:

Figure 1 is a longitudinal section of a radiant energy-sensitive vacuum tube which may be provided with a cathode by following the teachings of this invention; and

Figure 2 is a longitudinal section of an embodiment of the apparatus of this invention with a tube being shown in position during the cathode processing step.

Referring to the drawings, and more particularly to Figure 1, an evacuated image tube generally indicated by the reference numeral **1** is comprised of a cylindrically shaped glass envelope **2** and opposite transparent end plates **3** and **4** which serve as bases upon which the cathode and anode elements, respectively are formed. Metallic focusing, accelerating and the like electrodes generally indicated by the reference number **5**, which are secured in suitable positions inside the envelope **2**, are arranged between the end plates **3** and **4** for directing an electron image emitted by the cathode surface **6** formed on the end plate **3** through the length of the tube onto the luminescent anode **7** formed on the end plate **4**. The construction of this and similar image tubes and the operation thereof are well known to the art and need not be explained, further here. The invention is directed primarily to the formation of the radiant energy-sensitive cathode **6** on the inner surface of the tube face plate **3** as will now be more fully explained.

With reference to Figure 2, the apparatus constituting an embodiment of this invention is comprised of an outer support casing **8** of annular cross section and two coaxially arranged cylindrical enclosures **9** and **10** supported inside the casing **8**. Suitable mounting screws **21** serve to mount securely the enclosure **9** with respect to the casing **8**, and similar fastenings **11** serve in mounting the enclosure **10** in the upper end of the casing **8**. The enclosure of chamber **10** is sealed on its topside by means of a plate or the like **12** while the lower end thereof is provided with a tapered baffle **13** which extends a short distance downwardly into the interior of the lower enclosure or chamber **9** and which is further provided with a tube-receiving opening **14**. The space between the two chambers **9** and **10** and the casing **8** is filled with suitable heat-resistant packing or insulation, such as glass wool or the like. The lower end of the chamber **9** is closed by means of a removable plate **15** which is slotted to accommodate an exhaust tube or tubulation **16** which serves a purpose to be more fully explained hereafter.

The arrangement thus far described is substantially completely enclosed, thereby reducing the tendency of air currents being developed inside or between the two chambers **9** and **10**.

The chamber 9 is provided with electrical radiant heating elements 17 of suitable design which are arranged around the periphery thereof and which in the preferred embodiment extend axially of the chamber. Similarly, suitable heating elements 18 are mounted on the inside walls of the chamber 10. For maintaining the temperatures of the respective heating elements 17 and 18 at the proper level, thermostats or temperature-controlling devices 19 and 20, respectively, are operatively coupled thereto. In general, the thermostat 19 is set to provide a higher temperature within the chamber 9 than is produced in the chamber 10 under the control of the thermostat 20.

In operation, a tube completely assembled as illustrated in Figure 1 is supported in an upright position by means of the stiff evacuating conduit 16, and the tube is completely evacuated by the use of suitable vacuum or exhausting pumping mechanism (not shown) operatively connected to the conduit. At this stage of processing, the face plate 3 of the tube is completely transparent and free of dirt and other foreign material. As the first step in forming the cathode on the inner surface of this face plate 3, a silver film of minute substantially transparent thickness is evaporated on the face plate from a bead of silver exposed to the face plate and supported by suitable heater wires in accordance with common practice. Next, a measured quantity of pure oxygen is admitted to the interior of the tube through the conduit 16 for oxiding the silver thus far deposited. In accordance with conventional practice, this oxidation is expedited and made more complete by producing a glow discharge in the oxygen by means of, for example, a radio frequency field positioned adjacent the face plate. Upon completion of this oxidation step, the excess oxygen is pumped out of the tube through the conduit 16. Another layer of silver is now evaporated onto the silver oxide film which may, if desired, be oxidized in the same manner as explained in the foregoing.

At this state of processing the tube is now ready for applying the caesium onto the silver oxide base film. In the present instance, a capsule containing caesium chromate and pure silicon is permanently mounted inside the tube and is heated by passing an electrical current therethrough. As a result of this heating, pure caesium is released and the silicon is chemically combined with the chromate to provide a stable composition which does not interfere with the operating characteristics of the tube.

Before releasing the caesium, the oven of Figure 2 is dropped over the tube 1 to such a position as will place the face plate end of the tube inside the chamber 10 and the remaining portion of the tube in chamber 9. It should be mentioned at this point, that it is desirable to keep the size of the tube-receiving opening 14 as small as possible to prevent the exchange of convection currents between the two chambers 9 and 10 during the heating cycle.

With the oven so positioned, the thermostat 19 is adjusted to provide a temperature within the chamber 9 which is of sufficient magnitude to heat the envelope 2 to a temperature somewhat in excess of 200 degrees C. Radiant heat from the heating element 17 serves in heating the metal electrodes inside the tube to a suitable high temperature also in excess of 200 degrees C. At the same time, thermostat 20 is adjusted so that the heating elements 18 will radiate heat in sufficient quantity to maintain the temperature of the face plate 3 between 180 degrees C. and 200 degrees C.

With the differential in temperatures, the caesium released inside the tube will tend to deposit or condense on the cooler tube portions, and further will be driven from the hotter portions of the tube and thereby be prevented from depositing or reacting therewith. Also, the caesium by reason of its affinity for oxygen tends to flow toward the silver oxide film on the face place and upon contact therewith tends to react with the oxygen molecules in the silver oxide. The resulting chemical reaction produces a film having a composition of silver-oxide-caesium, the exact constituency of the composition being common and not important to this invention. Silver-oxide-caesium cathodes have been known for many years and vary in the constituency thereof depending upon design requirements.



Since the two chambers, 9 and 10, are completely enclosed, with the exception of the communicating opening 14, convection air currents are kept at a minimum, thereby facilitating the control of the face plate temperature within the critical limits explained previously. A differential heating of the tube is further made possible through the use of the radiant heat elements, 17 and 18, which are directly exposed to the tube. All sides and portions of the tube exposed to the respective heating elements are maintained at the proper temperatures for causing the caesium vapor to flow toward the face plate 3.

Thermionic electron emission from the cathode during this differential heating and the release of caesium is continuously measured in accordance with conventional practice to determine photoelectric sensitivity. The release of caesium is halted at or near the point of peak emission, at which time the temperature in the cathode oven is suddenly increased to approximately 200° C. for not more than one minute as determined by a second peak in emission. The heating cycle is now completed and the tube is allowed to cool.

This sudden increase in cathode temperature has been found to speed up the cathode material reaction and to improve infra-red sensitivity. Also, more uniform sensitivity results in a production run of tubes.

The operating characteristics of the tube fabricated in accordance with the teachings of this invention are superior to those constructed in accordance with previous arrangements, since the operation of the prior tubes was obstructed in some degree by spurious electron emission from the caesium which reacted with the metallic electrodes and the internal surfaces of the tube envelope. In following the present invention, undesired sensitization of the tube walls and the metallic electrodes is kept at a minimum, thereby providing for improved tube operation.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

Apparatus for use in forming a photosensitive cathode on an end face plate of a tube, said apparatus comprising: an upper heating chamber having a closed upper end and having radiant heat generating elements disposed therein arranged to heat said upper chamber to a first elevated temperature; a lower heating chamber having its upper end joined to the lower end of said upper heating chamber and having an opening formed in its lower end for admitting said tube to the interior of said upper and lower chambers, said lower chamber having radiant heat generating elements disposed therein arranged to heat said lower chamber to a second elevated temperature higher than said first elevated temperature in said upper chamber; and a baffle member separating said upper and lower chambers and having a central opening formed therethrough communicating with said upper and lower chambers and arranged to support said tube therein with said face plate disposed in said upper chamber and the remainder thereof disposed in said lower chamber.

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