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COMPOSITE PHOTOCONDUCTIVE LAYER

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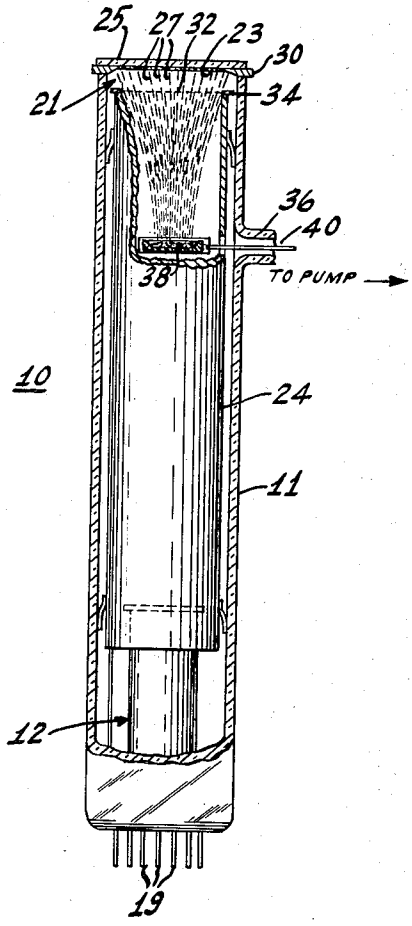


Fig. 1.

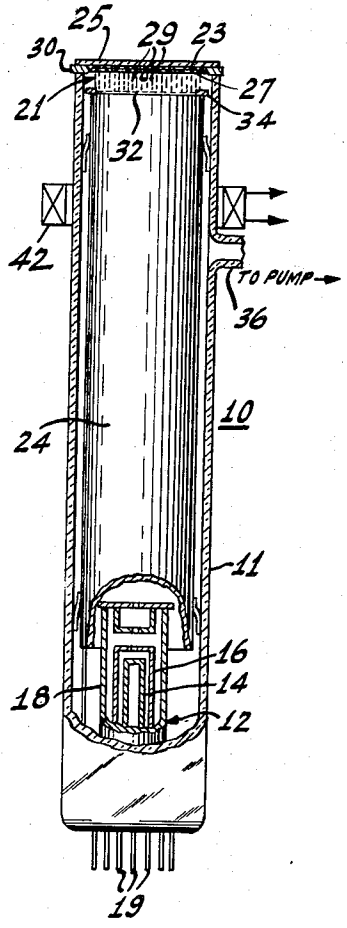


Fig. 2.

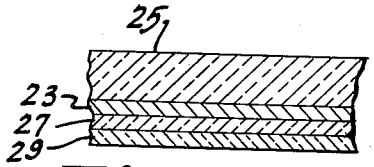


Fig. 3.

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COMPOSITE PHOTOCONDUCTIVE LAYER

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7 Claims. (Cl. 316—6)

This invention relates to photoconductive devices and particularly to a novel method of forming the photoconductive target in such devices.

Although the invention is applicable to various types of photoconductive devices it will be explained with particular reference to pickup tubes.

Pickup, or camera, tubes of the type considered in this invention include an elongated evacuated envelope having in one end an electron beam producing means. Within the other end of the envelope there is provided a target which normally includes a transparent conductive layer, or signal plate, and a photoconductive layer. The photoconductive layer, in the prior art targets, has taken two general forms. One of these forms is a photoconductive material which is porous in structure, i.e. one which has a dull or smoky appearance. Such a porous photoconductive layer normally has good lag characteristics, i.e. is capable of accurately reproducing pictures of fast moving objects, with fair sensitivity. The second general form of the prior art photoconductive layer is a layer of photoconductive material which is solid in form, i.e. one which has a smooth and shiny surface. A solid layer of photoconductive material normally has a high sensitivity but has a relatively poor lag characteristic. One specific material which has been utilized for both the porous and the solid type of target is antimony tri-sulphide.

It has been found that a target utilizing a composite photoconductive layer, i.e. one which includes both a solid and a porous layer of photoconductive material, provides a higher sensitivity than that found in the porous layer alone, with substantially the same lag characteristics as found in a porous layer. Furthermore, a target utilizing a composite photoconductive layer has greater resistance to image and raster burn and is also less subject to damage from loose particles within the envelope.

In the manufacture of composite photoconductive targets prior to this time, the practice has been to deposit a porous layer of photoconductive material by performing the evaporation of the material in an inert atmosphere such as argon. The solid layer of photoconductive material has normally been deposited by performing the evaporation of the photoconductive material in a good vacuum. In order to produce a composite target which includes both a layer of solid photoconductive material and a layer of porous photoconductive material by the prior art methods, two complete evaporation processes are required which is time consuming and expensive as compared to the evaporation of a single photoconductive layer.

It is therefore an object of this invention to provide a new and improved method of forming a composite photoconductive target.

Another object of this invention is to provide a novel method of forming a photoconductive target by depositing a porous layer of photoconductive material onto a signal electrode, and depositing a solid layer of photoconductive material onto the porous layer.

These and other objects are accomplished in accordance with this invention by first depositing, by evaporation, a porous layer of photoconductive material onto a transparent conductive signal electrode. This evaporation process is carried out within an envelope which is to be the envelope of the finished tube. The envelope is filled with an inert atmosphere and the evaporation is accomplished through a mesh electrode, which in the completed tube functions as a decelerator electrode. During this step some of the photoconductive material is deposited on the mesh electrode. After the porous layer of photoconductive material has been deposited, and the evaporator assembly removed from the envelope, the envelope is evacuated to form a good vacuum therewithin. After the envelope is evacuated the decelerator electrode is heated, such as by RF heating, to re-evaporate the photoconductive material that has been collected on the decelerator electrode. This re-evaporated photoconductive material is deposited onto the porous photoconductive layer, and due to the fact that the re-evaporation occurs in a high vacuum, the second layer of photoconductive material is solid in form.

The novel features which are believed to be characteristic of this invention are set forth in the appended claims.

The invention itself will be best understood by reference to the following specification when read in connection with the accompanying single sheet of drawings in which:

Figure 1 is a transverse sectional view of a camera tube in the process of having a first photoconductive layer deposited therein in accordance with this invention;

Figure 2 is a transverse sectional view of the camera tube shown in Figure 1 in the process of having a second photoconductive layer deposited therein in accordance with this invention; and,

Figure 3 is an enlarged fragmentary sectional view of a composite target formed in accordance with this invention.

Referring now to the drawings in detail, camera tube **10** comprises an evacuated envelope **11** having an electron gun **12** mounted in one end thereof. The electrodes of gun **12**, which are shown in more detail in Figure 2, comprise a conventional cathode **14**, control electrode **16**, and one or more accelerating electrodes **18** each of which is connected to lead-in pins **19** in the well known manner.

Supported within the other end of envelope **11** is a target **21**. The target, which is shown in its completed form in Figure 3, normally comprises a transparent conductive coating **23** which is deposited upon the end, or face plate **25**, of envelope **11**. Deposited on the transparent conductive coating **23** is a composite layer which includes a porous layer **27** of photoconductive material and a solid layer **29** of photoconductive material.

The transparent face plate **25** may be sealed to a conductive ring **30**. The conductive ring **30** is in turn sealed to the end of the envelope **11**. The seal between the face plate **25** and the conductive ring **30**, as well as the seal between conductive ring **30** and envelope **11**, may be any of the conventional glass-to-metal seals. The transparent conductive coating **23**, which may comprise a material such as tin chloride or tin oxide, is supported on face plate **25** and is electrically in contact with the conductive ring **30**. Spaced from, but adjacent to, the transparent conductive layer **23** is a flat mesh screen electrode **32** which is connected to a final tubular metallic electrode **24**, both of which form a decelerator electrode. The flat mesh electrode **32** may be bonded to an annular ring **34** which is in turn bonded to the metallic electrode **24**. In the alternative, the flat mesh **32** may be connected directly to the tubular metallic electrode **24**.

During the process of providing a porous photoconductive layer **27** on the transparent conductive coating **23** there is inserted through an appendage **36**, in the

envelope 11, an evaporator 38. The evaporator 38 may be any conventional evaporator which may be supported and energized within the envelope 11 by means of evaporator lead-ins 40. In accordance with this invention the porous photoconductive layer 27 is deposited by utilizing the evaporator 38 in an inert atmosphere at low pressure. One example of such an inert atmosphere and pressure is a filling of argon at a pressure of approximately 1 mm. of mercury. Other inert gases and pressures, examples of which will be described hereinafter, may also be utilized without departing from the scope of this invention. The porous photoconductive layer 27 may be a layer such as antimony tri-sulphide which may be evaporated by heating the evaporator 38 to a temperature of approximately 600° to 700° C. Evaporation and deposition is carried on until a layer of photoconductive material is deposited on the signal electrode 23 that is approximately 10 to 25 microns thick. This thickness of photoconductive material may be accomplished by evaporating within the temperature range specified above for a period of approximately 10 to 15 seconds.

The deposition of the continuous porous photoconductive layer 27 is done in a poor vacuum and in an inert atmosphere for the purpose of providing a porous layer of antimony tri-sulphide. This evaporation is done through the decelerator mesh screen 32 which is supported by means of the tubular metallic member 24. The tubular metallic member 24 functions as an evaporator shield during the process of evaporation that is shown in Figure 1. During the time the porous layer of photoconductive material 27 is being deposited on the signal output electrode 23, a certain amount of photoconductive material is deposited upon the inner walls of the hollow tubular electrode 24 and on the flat mesh electrode 32.

When the evaporation of the porous photoconductive layer 27 has been completed, the evaporator 38 is withdrawn from envelope 11. Referring now to Figure 2 for a description of the process of depositing a solid photoconductive layer 29 onto the porous layer 27, the envelope 11 is evacuated at this time by being connected to a pumping means (not shown) for providing a good vacuum within the envelope 11. In this step of the process, which is shown while the envelope is evacuated to a pressure of substantially 10^{-5} to 10^{-6} mm. of mercury, the solid layer 29 of photoconductive material is deposited upon the porous layer 29 of photoconductive material. The solid continuous layer of photoconductive material 29 is deposited by re-evaporating the material which was collected on the tubular member 24 and the mesh member 32 during the process shown in Figure 1. The solid layer is re-evaporated by heating the wall of the tubular member 24 which may be accomplished by means such as an RF coil 42. This heating of the tubular member 24 and mesh member 32 should be done by placing the RF coil approximately one inch away from the face plate 25, and heating the tubular member 24 to a temperature of approximately 700 to 800° C. When the tubular member 24 is so heated, heat is conducted to mesh member 32 and the photoconductive material which has been collected by these electrodes during the evaporation of the porous layer 27 is re-evaporated. The re-evaporated material 24 is deposited upon the nearest cold surface within the tube 10. Since the nearest cold surface is the porous photoconductive layer 27, substantially all of the re-evaporated photoconductive material is deposited upon photoconductive layer 27. The purpose of placing the RF coil in the position described above is to protect the seal between face plate 25 and conductive ring 30, as well as the seal between conductive ring 30 and envelope 11.

When the solid photoconductive layer 29 has been deposited the RF coil 42 is removed. At this time the tube is processed by a short reactivation of the cathode 14, and a tip-off of the tube from the vacuum system, as is well known. At this stage during the process of manufacturing, the pickup, or camera, tube 10 is completed and is substantially ready for use with deflection and alignment coils (not shown) as is well known in the art.

It has been found that when utilizing a camera tube of the type described having a target 21 constructed in accordance with this invention, i.e. a target including a porous photoconductive layer 27 and a solid photoconductive layer 29, the improved structure provides an output sensitivity of about two to one in comparison with prior art tubes, with approximately the same lag characteristics as that found in a porous layer alone. It is believed that the sensitivity increase which is gained by the method of depositing the composite photoconductive layer in accordance with this invention is due to the following mechanism:

The porous photoconductive layer 27, when evaporated onto the face plate 25, contains a relatively small percentage of excess antimony. This is true also when the photoconductive material condenses on the flat mesh electrode 32 and the electrode 24. However, with the re-evaporation, i.e. the evaporation of material from flat mesh electrode 32 and the tubular electrode 24, it is believed that some of the antimony tri-sulphide reacts with the Nichrome, or aluminized copper, mesh to release more free antimony, with the sulphur being taken up in the form of nickel sulphide, chromium sulphide, etc. This greater amount or excess of free antimony, when mixed with the antimony tri-sulphide, forms the solid layer of photoconductive material 29. The solid layer 24 when combined with the porous layer 27 results in a composite surface having greater sensitivity, and a lag characteristic comparable to the porous surface alone.

Other specific examples of photoconductors, as well as gas pressures for obtaining a porous layer 27 are: cadmium selenide which is porous when evaporated in an atmosphere of approximately 2×10^{-1} mm. of mercury; germanium sulphide which is porous when evaporated in an atmosphere of approximately 5×10^{-1} mm. of mercury; and antimony thiosulphide which is porous when evaporated in an atmosphere of approximately 5×10^{-1} mm. of mercury. These materials are solid when evaporated in higher vacuums, e.g. 10^{-6} mm. of mercury, than those specified above for the particular materials.

It should be understood that other gases may be utilized in accordance with this invention examples which are the rare gases. Also, other elements can be used within a particular enclosure to collect the photoconductive material for re-evaporation. Still further, it is within the contemplation of this invention to provide a porous layer of photoconductive material on a solid layer of photoconductive material by depositing the original layer in a good vacuum and the re-evaporated layer in a gaseous atmosphere.

What is claimed is:

1. The method of forming a light responsive element in an evacuated envelope having a conductive surface therein and a conductive member therein, said method comprising the steps of filling said envelope with an inert gas, depositing a first layer of photoconductive material on said conductive surface and on said conductive member by evaporating a photoconductive material within said envelope and condensing said evaporated photoconductive material on said conductive surface and on said conductive member in the presence of said gas, evacuating said envelope, heating said conductive member to evaporate the photoconductive material thereon while said envelope is evacuated, and depositing said last evaporated material on said first layer of photoconductive material while said envelope is evacuated.

2. The method as in claim 1 wherein said photoconductive material is antimony tri-sulphide.

3. The method of forming a light responsive element

in an evacuated envelope having a conducting surface therein and a conducting member therein comprising the steps of filling said envelope with an inert gas at approximately 10^{-1} mm. of mercury, depositing a layer of photoconductive material on said conducting surface and on said conducting member by evaporating a photoconductive material within said envelope while said envelope is filled with said inert gas and condensing said evaporated photoconductive material on said conducting surface while maintaining said surface at a temperature lower than that of other elements within said envelope, evacuating said envelope, and heating said conducting member to evaporate the photoconductive material condensed thereon while said envelope is evacuated and depositing said last evaporated material on said first layer of photoconductive material.

4. The method of forming a photoconductive target in a pickup tube having a signal electrode comprising the steps of filling said tube with an inert atmosphere, depositing a first photoconductive layer onto said signal electrode by evaporating photoconductive material through a mesh electrode within said tube in the presence of said inert atmosphere, evacuating said tube, and heating said mesh electrode to re-evaporate the photoconductive material collected by said mesh electrode while said tube is evacuated, and depositing said re-evaporated material on said first photoconductive layer.

5. The method of forming a photoconductive target in a pickup tube having a signal electrode comprising the steps of filling said tube with argon at a pressure of approximately 10^{-1} mm. of mercury, depositing a first continuous photoconductive layer on said signal electrode by evaporating photoconductive material onto said signal electrode through a mesh screen electrode in the presence of said filling of argon, evacuating said envelope to a pressure of approximately 10^{-5} mm. of mercury, and depositing a second continuous photoconductive layer by heating said mesh screen electrode to re-evaporate the photoconductive material collected thereupon while said pressure is approximately 10^{-5} mm. of mercury.

6. The method as in claim 5 wherein said photoconductive material is antimony tri-sulphide.

7. The method of forming a photoconductor on a signal electrode in an envelope, said signal electrode being characterized by the presence of a mesh screen adjacent to said signal electrode, said method comprising the steps of evaporating photoconductive material through said mesh screen and onto said signal electrode while the gas within said envelope is at a first pressure, evacuating said envelope to a second pressure which is lower than said first pressure, and re-evaporating the photoconductive material from said mesh screen and onto said signal electrode while the gas within said envelope is at said second pressure.

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