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PHOTOCONDUCTIVE PICK-UP TUBE AND METHOD OF MANUFACTURE

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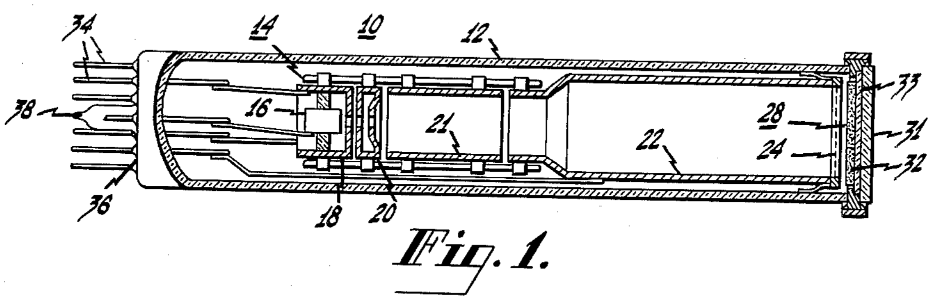

Fig. 1.

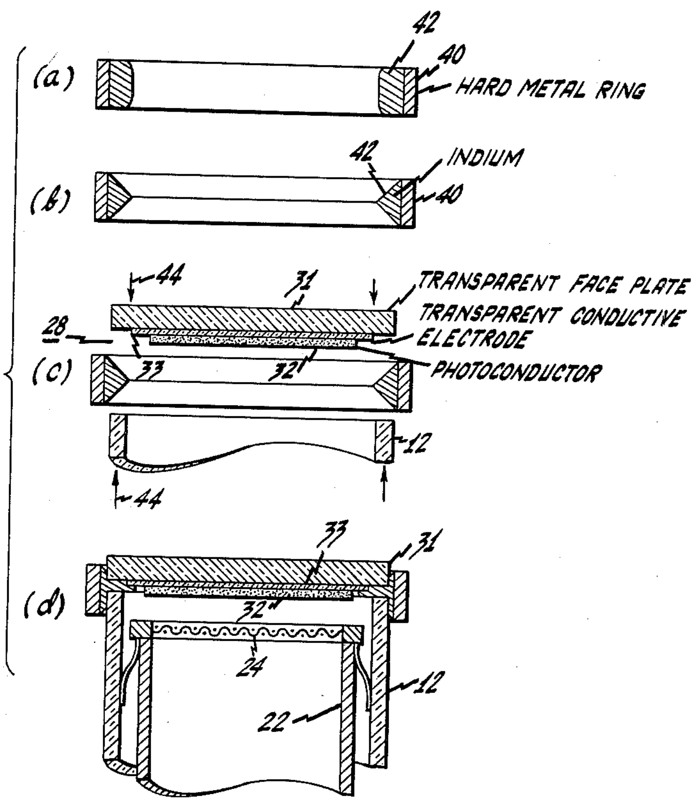

Fig. 2.

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PHOTOCONDUCTIVE PICK-UP TUBE AND METHOD OF MANUFACTURE

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This invention relates to pickup or camera tubes of the type using a photoconductive material as the photosensitive element. In particular, this invention relates to an improved method of, and means for, manufacturing an improved photoconductive type of pickup tube.

One of the several known types of pickup tubes generally comprises an evacuated tubular envelope enclosing an electron gun and a photoconductive target electrode. The target electrode comprises a transparent support member, which normally is the optically clear transparent face plate sealed to the end of the envelope and facing the electron gun. The face plate normally has a transparent conductive coating, or signal electrode, on the gun side thereof. On the transparent conductive coating there is provided a layer of photoconductive material. Photoconductive materials are materials which change in electrical conductivity in response to light. These materials have a relatively high electrical resistance when in the dark and a relatively high electrical conductivity when exposed to the light.

One of the problems that has made it difficult to mass produce high quality tubes of this type is the problem of depositing the photoconductive material as a layer, or layers, having a uniform thickness. Variations in thickness of the photoconductive material results in differences in the current through the photoconductor, and thus variations in the sensitivity of the tube, from point to point across the target, in addition to variations in conductivity caused by the input light.

In the past, when the photoconductor was deposited on the face plate prior to the sealing of face plate to the tubular envelope, the uniformity of the photoconductive film of the target electrode was destroyed by the high temperatures required to form the face plate seal. Also in the past, if the face plate was sealed to the tubular envelope prior to the deposition of the photoconductor, the uniformity of the photoconductive film of the target could not be obtained because of the restricted area within the envelope in which the deposition of the photoconductor must be preformed.

It is therefore, an object of this invention to provide an improved method of and means for manufacturing a photoconductive type pickup tube.

It is another object of this invention to provide an improved photoconductive type pickup tube characterized in that the photoconductive target is of a uniform thickness.

These and other objects are accomplished in accordance with this invention by depositing the transparent signal electrode onto the transparent support plate, and then forming a uniform deposit of the photoconductor on the transparent signal electrode. The transparent support plate is then sealed to one end of the envelope as the tube face plate. The method of manufacturing the pickup tube may comprise either inserting the electron gun and appropriate electrodes into the envelope prior to the sealing of the coated faceplate to the tube, or sealing the coated face plate to the envelope prior to the insertion of the electron gun. The order of the steps that are necessary for completing the tube, such as baking and degassing, will vary depending upon which method of manufacturing is chosen. In accordance with the invention, the sealing of the faceplate and the tube envelope is by a novel technique using pressure and indium metal resulting in a highly efficient seal which makes good electrical contact with the transparent signal electrode and which extends outwardly from the envelope for making electrical connection thereto.

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

Fig. 1 is a transverse sectional view of a photoconductive type of pickup tube in accordance with this invention; and,

Figs. 2A through 2D are enlarged sectional views of tube portions to illustrate steps in the novel method of manufacturing the pickup tube shown in Fig. 1 and in accordance with this invention.

Referring now to Fig. 1 in detail, there is shown a photoconductive type pickup tube **10** which is a conventional type of tube except for the improvements in accordance with this invention which will be pointed out hereinafter. The tube **10** comprises an elongated evacuated envelope **12** having an electron gun **14**, for producing an electron beam, in one end thereof. The electron gun **14** is conventional and includes a cathode electrode **16**, a cup-shaped control electrode **18**, a first accelerating electrode **20**, a second accelerating electrode **21**, and a final accelerating electrode **22**. The end of the accelerating electrode **22** remote from the gun is terminated by an apertured fine mesh screen electrode **24**. The electrodes are supported by lead-in pins **34** that extend through a stem **36** that forms an end of the envelope **12**. The stem **36** also includes an exhaust tubulation **38**.

The electron beam is accelerated by the accelerating electrodes **20** and **22** to pass through the mesh screen **24** and to strike a photoconductive target electrode **28**. The photoconductive target electrode **28** is supported on a transparent support member **31** which normally is the other end or face plate of the envelope **12**. The photoconductive target electrode **28** comprises a transparent conductive coating, or signal electrode **33** on the inner surface of the face plate **31**. The transparent conductive coating may be of a material such as tin-oxide or tin chloride. On the signal electrode **33** there is formed a photoconductive film **32** that may be of a material such as porous antimony tri-sulphide. The photoconductive film **32** may be deposited in a porous layer by evaporating antimony tri-sulphide onto the signal electrode **33** in the presence of an inert atmosphere, e.g. argon, at a pressure of approximately one millimeter of mercury.

In accordance with this invention the photoconductive film of the target electrode is formed under accurately controlled conditions before the faceplate **31** is sealed to the envelope **12**. The first provision for accurate deposition of the photoconductive film **32** is that the transparent support be an optically flat, clean, polished face plate. The face plate **31** may be of any known optically transparent glass, or even other polished ceramic materials if desired, and may pass any desired portions of the light spectrum. An optical flat face plate **31** is produced by any of the well known lens grinding and polishing techniques. The polishing and grinding should be done until a good spectacle lens quality is achieved. The face plate is cleaned with chromic acid and a distilled water rinse, and then air baked at 350° C. to remove any grease from the glass.

The face plate **31** is first coated in any appropriate manner on one side with the film **33** of tin oxide to form the signal electrode of the photoconductive target 28. In accordance with the invention, the film 33 is accurately centered on the face plate 31 and spaced from the periphery of the plate 31, as indicated in Fig. 2C, so as not to interfere with the formation of a good seal between the face plate 31 and tube 12. The location of the transparent conductive coating 33 is controlled, by an apertured mask (not shown), that exposes only the center area of the face plate. In a one inch diameter tube the face plate 31 has a diameter of 1.022 inch and the transparent signal electrode 33 is concentric with the face plate and has a diameter of 0.940 inch. When the face plate 31 is coated before sealing the face plate to the tube 12, the thickness of the transparent conductor 33 can be accurately controlled since the face plate may be easily handled for the processing steps involved.

Another requisite in providing a photoconductive target 28 having optimum characteristics is to deposit, e.g. by evaporation, the photoconductive film 32 as a layer having a very uniform thickness. Since the deposition of the photoconductor is done while the face plate 31 is separate from the envelope 12, it is possible to more easily set up optimum conditions for the evaporation of the photoconductive material onto the electrode 33, so that a film 32 is obtained with greater uniformity in thickness and density. Also, the position of the photoconductive layer 32 can be accurately controlled by an apertured mask (not shown), so that it is formed only on the signal electrode film 33, leaving the peripheral edge of plate 31 uncoated. For example, the photoconductive film 32 in a one inch diameter tube is concentric with the face plate and has a diameter of 0.830 inch.

The seal between the face plate 31 and envelope 12, which will be explained in detail in connection with Fig. 2, is a glass-to-metal-to-glass seal. In accordance with this invention, a metal pressure sealing ring 42 is used. The metal ring is of a material that will form a vacuum tight seal to glass without heating the metal to its melting point. The seal between the face plate 31 and the envelope 12 is formed solely by the application of pressure to the glass and metal parts to be joined together and below the melting temperature of the metal sealing member, the glasses, or any combination thereof.

The novel method of forming the pressure seal is described in detail by referring now to Figs. 2A through 2D, which show various sectional views of the tube parts involved in the steps of forming the seal between the face plate 31 and the balance of the envelope 12. Fig. 2A is an enlarged sectional view of a pressure sealing ring assembly comprising a hard metal ring 40, which may be of a material such as stainless steel or brass. Within the hard metal ring 40 there is provided a soft metal ring 42, which has the property of forming a vacuum tight seal, between glass parts by means of pressure and without the application of heat. In accordance with this invention the soft metal ring 42 is made of substantially pure (99.97%) indium bonded to the hard metal ring 40.

One method of bonding the indium ring 42 to the hard metal ring 40, when a stainless steel ring 40 is used, is to copper plate the inside surface of the hard metal ring 40, and centrifugally cast molten indium, e.g. at 7000 r.p.m., on the inner copper plated surface of the hard metal ring 40. When brass is used for ring 40, copper plating is not necessary.

In the particular example of a one inch diameter tube described above, the hard metal ring has an outside diameter of 1.125 inch; an inside diameter of 1.056 inch; and a length of 0.125 inch. The indium is coated onto the hard metal ring 40 to form a ring 42 having an inside diameter of 0.860 inch. The next step in the formation of the seal is to trim the indium ring 42 to produce a top and bottom bevel each equal to approximately 45° with respect to the plane of the ring as shown in Fig. 2B. The trimming may be done by any appropriate means.

In the particular example the inside diameter of the indium ring is now 0.940 inch.

Fig. 2C is a sectional view of the face plate 31 and the photoconductive target 28, the indium sealing ring 42, and the envelope 12 to which the face plate is to be sealed. As shown, the elements are supported in a holding fixture (not shown), so as to be in accurate alignment with each other. Also, before being placed in this position, the open end of the envelope 12 is ground, polished and cleaned by known techniques. This provides a matching flat polished surface to support and be sealed to the clean polished face plate 31.

The several tube parts are positioned in the relationship shown in Fig. 2C. While in this position axial pressure is applied to the glass elements 31 and 12, as indicated by arrows 44. The axial pressure is applied around the periphery to prevent glass breakage and until the indium of ring 42 flows, by plastic deformation, inwardly to cover the surfaces of the end of the envelope 12 as well as a substantial peripheral area of the lower surface of plate 31, to form the seal. Also, the indium flows farther inwardly to overlap the transparent conductor 33, to form an electrical connection to signal electrode 33. It has been found that a pressure of approximately 600 lbs. per square inch plastically deforms the indium metal of ring 42. For the particular example of the tube described above, the area of the end of tube 12 is a fraction of a square inch and 170 lbs. total force is sufficient to form a successful seal. While forming the seal, no heat is applied. However, it should be understood that it is within the contemplation of this invention to form the seal at any ambient temperatures that are below the critical temperature which would harmfully change the characteristics of the photoconductor 32. For example, it has been found that temperatures above 150° C. reduce the sensitivity of an antimony tri-sulphide photoconductor. During the sealing process, no melting of the face plate, envelope or indium ring occurs. Furthermore, no eutectic temperature is reached, and the seal is formed solely by the pressure 44 which plastically deforms the indium ring 42.

After the seal has been formed between the face plate 31 and the envelope 12, the electron gun 14 may be sealed into the envelope, the tube baked, the electrodes degassed, the cathode activated, the tube sealed off and the getters flashed, in any conventional method as long as the temperature of the photoconductor is maintained below the critical temperature that would harm the photoconductor and as long as the temperature of the seal is maintained below the melting point of indium (155° C.). During these processing steps the temperature of the photoconductor 32 may be artifically controlled, e.g. by blowing a stream of air on the face plate 31, when the processing tends to raise the temperature of the photoconductor above the critical temperature.

In the alternative, the electron gun 14 may be sealed into the envelope 12 prior to the time when the seal between the face plate 31 and the envelope 12 is formed. If this sequence is used the processing of the tube prior to forming the indium seal can be performed at temperatures above the critical temperature without concern of harming the photoconductor or the seal.

During operation of the tube shown in Fig. 1, and made in accordance with this invention, the focus coils and deflection yoke can be positioned closely adjacent to the walls of envelope 12 since no side tip off of the envelope is required. Furthermore, the magnetic fields produced by these magnets are not distorted as the face plate seal, in accordance with this invention, may be made with non-magnetic materials, e.g. brass and indium.

Also, the indium seal in accordance with this invention makes good electrical contact with the transparent conductive electrode by slightly overlapping the periphery thereof. When using this type of seal the optically flat face plate is not deformed by the pressure seal as was true at times when using the high temperature seals of the prior art.

It should be noted that when using the indium metal seal in accordance with this invention, it is not necessary that the coefficients of thermal expansion of the face plate **31** and the envelope **12** be matched. The reason for this is that the indium metal will absorb differences in these coefficients.

This invention should not be limited to the use of indium, or indium alloys, but is equally applicable to other materials as long as these materials have the property of forming a vacuum tight seal with glass, when the materials are plastically deformed and "smeared" over the glass, by the application of pressure and at temperatures below the melting point of the materials. As was previously pointed out, these temperatures must be below the temperatures which would harm the photoconductor.

What is claimed is:

1. An electron discharge device comprising an envelope, said envelope including a vacuum tight hermetic seal, said seal comprising a first glass member, indium metal sealed to said first glass member, a second glass member sealed to said indium metal, said seal being made solely by pressure, and means to retain said indium in a position between said glass members while said pressure is being applied.

2. A photoconductive pickup tube comprising an evacuated glass envelope having a transparent glass face plate closing one end of said envelope, a photoconductive target electrode supported on said face plate and in a position such that said target electrode would be damaged if said face plate were heated to a temperature greater than 150° C., said photoconductive target electrode comprising a transparent conductive electrode on said face plate and a photoconductor on said transparent conductive electrode, and a glass-to-glass seal between said face plate and said envelope, said seal including indium, and said seal being made solely by pressure and without any application of heat, said indium being forced into electrical contact with said transparent conductive electrode by said pressure.

3. In a photoconductive type pickup tube comprising an evacuated envelope having an electron gun in one end thereof for producing an electron beam, a transparent face plate closing the other end of said envelope and in the path of said beam, a photoconductive target electrode supported on said face plate, said photoconductive target electrode comprising a transparent conductive electrode on said face plate and a photoconductor on said transparent conductive electrode, the improvement in said tube comprising a hermetic seal including indium between said face plate and said envelope, and said seal being made solely by pressure and without any application of heat whereby said indium is pressed inwardly within said envelope and into contact with said transparent conductive electrode.

4. A photoconductive type pickup tube comprising an evacuated envelope having an electron gun in one end thereof for producing an electron beam, a transparent face plate closing the other end of said envelope and in the path of said beam, a photoconductive target electrode supported on said face plate, said target comprising a

transparent conductor on said face plate and a photoconductor on said transparent conductor, an electrical connection of indium between said transparent conductor and the exterior of said envelope, said connection forming the hermetic seal between said face plate and said envelope, and said seal being formed solely by the application of pressure and without the application of heat.

5. The pickup tube of claim 4 further including a ring of stainless steel in contact with the outer periphery of said electrical connection of indium.

6. A photoconductive type pickup tube comprising an elongated envelope having an electron gun in one end thereof for producing an electron beam, a transparent face plate closing the other end of said envelope and in the path of said beam, a hermetic seal including indium metal between said face plate and said envelope, said hermetic seal being of the type produced by pressure and at temperatures substantially below the melting point of said indium, a transparent conductor on the inner surface of said face plate and extending close to but spaced from the periphery of said face plate, said indium metal extending into electrical contact with the outer periphery of said transparent conductor, a layer of photoconductive material on said transparent conductor and extending close to but spaced from the inner periphery of said indium metal.

7. A photoconductive pickup tube comprising an elongated envelope having a face plate on one end thereof, a photoconductive target electrode on the inner surface of said face plate, a hermetic seal between said face plate and said envelope, said seal including a plastically deformable metal comprising indium and having the property of adhering to said face plate and said envelope under the application of pressure at temperatures below 150° C., said seal being made by pressing said plastically deformable metal at said temperatures, and means around the outer periphery of said plastically deformable metal to retain said metal between said face plate and said envelope while pressing said plastically deformable metal.

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