

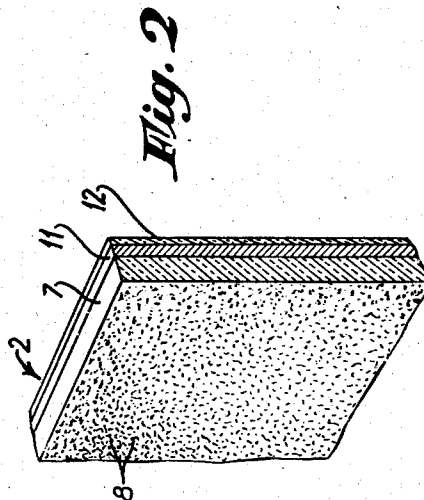
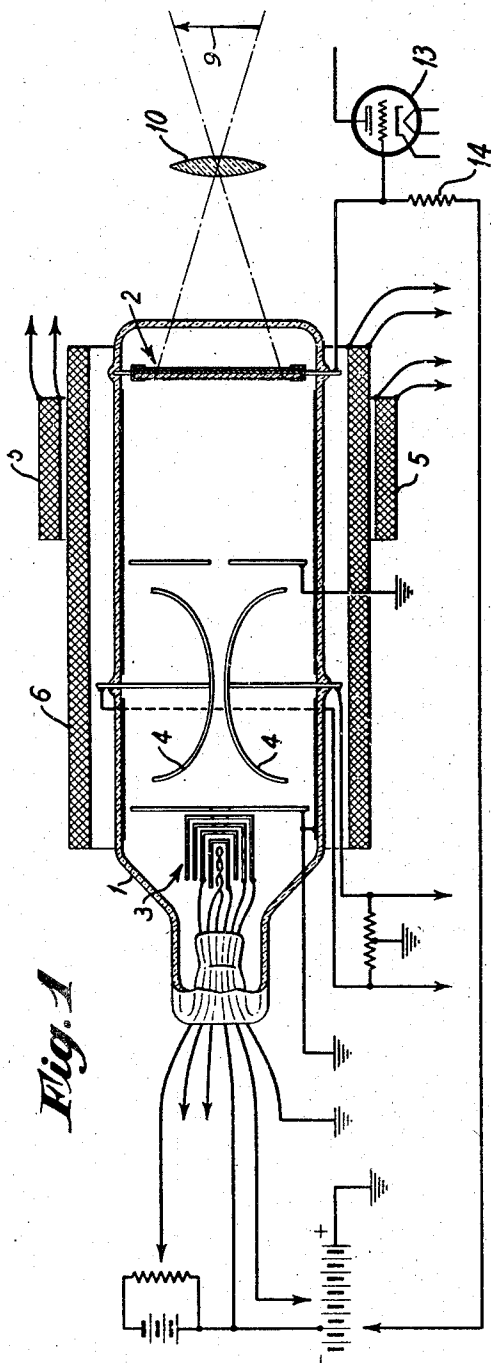
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**2,252,770**

# LIGHT SENSITIVE ELECTRODE AND METHOD OF MANUFACTURE

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LIGHT SENSITIVE ELECTRODE AND  
METHOD OF MANUFACTURERobert B. Janes, Verona, N. J., assignor to Radio  
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My invention relates to electrode assemblies including semi-transparent metal films and in particular to the manufacture and application of such assemblies and films to television transmitting devices.

In conventional television transmitting tubes of the type described by Iams and Rose, Serial No. 276,106, filed May 27, 1939, light is focused through a thin semi-transparent electrically conducting electrode which serves as the signal electrode for the tube, and upon a photosensitive mosaic of mutually insulated particles. I have found that the transmission of light through such a semi-transparent conductor is considerably less than that which might normally be expected by reason of the absorption of the semi-transparent film.

It is an object of my invention to provide a semi-transparent metal film and method of manufacturing such a film and associated structure which has a higher light transmission factor than heretofore obtainable. It is a further object to provide an improved light sensitive electrode structure of the semi-transparent type in which the light incident upon the structure is more efficiently utilized. It is a still further object of my invention to provide a television transmitting tube having a higher signal-to-noise ratio than conventional tubes by reason of the more efficient use of the available light for signal generation.

In accordance with my invention, I provide a semi-transparent metal film with a transparent layer which effectively increases the light transmitting properties of the metallic film. More specifically, I provide a layer of material contacting and covering one side of a semi-transparent metallic film and so correlate the index of refraction of the layer with that of the film that increased light transmission is obtained. These and other objects, features and advantages of my invention will become apparent when considered in view of the following description and the accompanying drawing in which:

Figure 1 is a longitudinal sectional view of a television transmitting tube incorporating an electrode made in accordance with my invention and

Figure 2 is a greatly enlarged cross-sectional view of a portion of the metal film and associated electrode structure as used in the tube of Figure 1.

Referring to Figure 1 which shows a tube of the type described by Iams and Rose in the above-mentioned co-pending application and in-

corporating my novel electrode structure, the tube comprises an evacuated envelope 1 enclosing at one end a target or mosaic electrode 2 and at the opposite end an electron gun assembly 3 adapted to project electrons toward the mosaic electrode. While I will describe my improved electrode assembly in connection with a photo-electrically sensitive mosaic structure, it is to be understood that my invention is equally applicable to semitransparent electrodes utilizing light sensitive structure other than the mosaic type. My invention is thus equally applicable to electrodes utilizing semi-conductive and voltaic-type light sensitive structures.

The electron gun assembly 3 is of the conventional type comprising an electron source such as an indirectly heated cathode, a control electrode and one or more electron beam forming anodes. The electrons from the cathode are directed as an electron beam toward the mosaic electrode 2 and controlled in their passage to the mosaic electrode by a pair of deflection plates 4, a pair of magnetic deflection coils 5 operating to deflect the beam in a uniform magnetic field such as produced by the elongated magnetic coil 6.

The mosaic electrode 2 which faces the electron gun preferably includes a transparent sheet of insulation such as the mica sheet 7 having on its surface facing the electron gun 3 a great number of mutually separated and insulated photosensitive particles 8. In operation, an optical image such as represented by the arrow 9 is focused by a conventional lens system 10 through the mica sheet 7 and upon the photosensitive particles 8 which are exposed to and scanned by the electron beam from the electron gun 3.

In accordance with my invention, and as best shown in Figure 2, the mica sheet 7 is provided with a metal film 11 which is thin enough to be semi-transparent to light by vaporizing a quantity of metal in a highly rarefied atmosphere with respect to oxidizing gases and corresponding to a pressure of less than  $10^{-6}$  mm. Hg and condensing the metal on the mica sheet 7. While I refer to these vaporizing and condensing steps as being performed in a rarefied oxidizing atmosphere, the film 11 may be deposited such as by sputtering, which is a form of evaporation and condensation, in a non-oxidizing atmosphere such as highly purified hydrogen. Therefore, when I refer to evaporation of metal in a high vacuum, I am referring to a highly rarefied atmosphere with respect to oxidizing gases. Following the formation of the metal film 11, I vaporize and condense a quantity of transparent

material to form a transparent layer 12 on the exposed surface of the film 11. This latter evaporation and condensation is preferably performed in the absence of any gas whatsoever at a vacuum corresponding to a pressure of  $10^{-6}$  mm. Hg, but this pressure may be increased depending on the index of refraction of the material of the layer, as appears later.

The metal to form the film 11 may be of metal such as platinum or palladium and is vaporized and deposited on the insulating foundation or mica sheet 7 in a chamber or bell jar having a greatly rarefied oxidizing atmosphere, in fact, the vacuum with respect to oxidizing gases such as air should be as high as obtainable. Films of a metal such as platinum or palladium having a thickness between 75 and 125 Å. units with a normal light transmission of 50% may be formed in such a high vacuum. I have found, however, that under poor vacuum conditions with respect to an oxidizing atmosphere the film of metal has low electrical conductivity and is more opaque to light than when deposited in a high vacuum.

Following the formation of the film 11, I evaporate material to form the layer 12 without removing the foundation or mica sheet 7 from the vacuum chamber or bell jar. Provided the film 11 was deposited in a high vacuum with respect to all gases, the layer 12 material may be evaporated immediately, while maintaining the high vacuum. However, if a sputtering process was used, all non-oxidizing gas is removed from the chamber or bell jar by evacuating to a pressure of  $10^{-6}$  mm. Hg or less. I have found that, if the metal film 11 and layer 12 are not deposited in this manner, the results obtained are not as satisfactory in that the metal film tends to change color and becomes more opaque and that the layer 12 is not firmly adherent to the metal film 11. However, if the film 11 and layer 12 are successively deposited without admitting air or an oxidizing gas to the vacuum enclosure, the layer 12 is in molecular contact with the film 11 and the best results are obtained.

I choose a material for the layer 12 having an index of refraction between 1.7 and 2.2, the exact index being determined by the particular metal of which the film 11 is composed. For platinum or palladium this index of refraction may be from 1.75 to 2.0, whereas the index of refraction may be from 2.0 to 2.2 for a film 11 of a metal such as silver. These indices of refraction have been found suitable for metal film thicknesses having a normal white light transmission of 50%. By "normal white light transmission" I mean the proportion of incident light which is transmitted through the film prior to the deposition of the transparent layer 12. A normal white light transmission factor of approximately 50% corresponds to a film thickness of between 75 and 125 Å. units. The index of refraction of the material of the layer 12 is on the high side of the above limits for thicker metal films and on the low side of the above limits for thinner metal films. I have found materials such as aluminum oxide, magnesium oxide and bismuth oxide to be particularly advantageous for such films because their indices of refraction lie within the above limits for use with platinum or palladium films when the layer 12 is deposited by vaporization in a high vacuum. I have found, however, that materials having a higher index of refraction normally suitable for use in conjunction with metals such as silver may be used to form the

layer 12 over a platinum or palladium film, provided the material of the layer 12 is vaporized and deposited in a vacuum somewhat poorer than the best vacuum obtainable. Thus materials such as titanium oxide or zirconium oxide and having a higher index of refraction than 2.0 may be deposited as a layer having an index of refraction within the range of 1.75 to 2.0 when deposited by condensation in vacuum corresponding to a pressure of approximately 1 micron Hg. Thus between the steps of depositing the film 11 and layer 12, a slight amount of air or other gas may be admitted to the vacuum chamber or bell jar to a pressure of approximately 1 micron Hg, although I prefer to introduce a non-oxidizing gas in this step. This pressure may be further increased to decrease the index of refraction of the material when materials for the layer 12 having higher indices of refraction are used. Determinations of the indices of refraction of materials suitable for the layer 12 from bulk materials and from condensed layers indicate that the index of refraction of a condensed layer is substantially the same as that of the bulk material, provided the layer is formed in a high vacuum. These determinations for materials having an index of refraction up to 1.85 may be made by using a conventional refractometer, although the "International Critical Tables," McGraw-Hill, New York city, gives reliable data on the index of refraction of such materials.

By the use of the layers of transparent material referred to above I have obtained an increase in the normal white light transmission of greater than 20% when the layer is deposited to an optical thickness of approximately 1500 angstroms. The optical thickness of the layer 12 may be defined as the product of the actual thickness and the index of refraction of the layer 12, and I will use the term "optical thickness" to define the layer 12 in terms of its actual thickness and index of refraction. Thus if the desired transmission is to be a maximum for white light whose average wave length is 6000 angstroms, the optical thickness should be

$$\frac{6000}{4}$$

or 1500 angstroms, and the actual thickness of the layer 12 for an index of refraction of 2.0 should be

$$\frac{1500}{2}$$

or 750 angstroms. This relation between actual thickness and optical thickness is discussed at considerable length by Jenkins and White in their book entitled "Fundamentals of Physical Optics," 1937, McGraw Hill, New York city. With a normal transparency of 50%, the use of the layer 12 increases the transmission to approximately 60% of the incident light. Thus the light transmitting property of the film 11 increases beyond the normal transmission with increased thickness of the layer 12, but if the layer 12 is made too thick, the light transmitting property of the film 11 decreases to a value below the normal transmission. Therefore, in depositing the layer 12 I continuously observe the transmission of light through the film by using a standard light source with a calibrated photocell on opposite sides of the mica sheet and discontinue the vaporization when the light transmission has reached a maximum. While I have found an optical thickness of 1500 angstroms to

be particularly suitable, and this thickness is equal to one quarter of the average wave length of white light, the optical thickness of the layer may be equal to any odd quarter wave length of the light for which maximum transmission is desired. The optical thickness of the film should be uniform within a fraction of a quarter wave length and such uniformity may be obtained by evaporating the material from a plurality of sources or from a single source at a distance such that the angle at the source made by lines drawn to opposite sides of the area to be coated with the metal film is 20 degrees or less. If a layer thickness greater than one-quarter wave length is inadvertently deposited upon the metal film 11, the vaporization and condensation may be continued until the desired thickness is obtained, although I prefer to limit the thickness to one-quarter wave length because additional deposition may accentuate irregularities of thickness. With an optical thickness of 1500 angstroms for white light transmission, I have found that the color of the light reflected by the film is purple and the optical thickness with this purple color is uniform over the area of the layer within 5% of a quarter wave length. This corresponds to an actual thickness uniformity of 2½% when using a layer material having an index of refraction of 2.0.

While I have indicated the preferred embodiments of my invention of which I am now aware and its application to light sensitive electrodes of the mosaic type and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed, such as its application to light sensitive electrodes of the continuous photosensitive type, without departing from the scope of my invention as set forth in the appended claims.

I claim:

1. An electrode for an electron discharge device comprising a semi-transparent metal film, a light sensitive coating adjacent and co-extensive with one side of said metal film and a transparent coating of material on the opposite side of said metal film having an optical thickness equal to an odd multiple of 1500 angstroms to increase the normal light transmitting properties of said metal film.

2. An electrode comprising a light sensitive member, a thin semi-transparent metal film having one side thereof adjacent said light sensitive member and a transparent closely adherent layer of transparent material in intimate contact with the other side of said metal film, said layer having an optical thickness equal to an odd multiple of 1500 angstroms and having a thickness uniform over the area of said layer to within a small fraction of 1500 angstroms.

3. An electrode having a white light transmission of approximately 60% of white light incident thereon comprising a metal film having a normal white light transmission of approximately 50% of white light incident thereon and a layer of transparent material having an optical thickness of substantially 1500 angstroms co-extensive with said metal film and in intimate contact with the entire surface of one side of said film whereby said normal transmission is increased to 60%.

4. An electrode comprising a light sensitive

member, a thin metal film having a white light transmission of at least 50% having one side thereof adjacent said light sensitive member, and a transparent closely adherent layer of transparent material having an index of refraction between the limits 1.7 to 2.2 on the other side of said metal film, said layer being of such thickness as to produce a purple color by reflected light when subjected to white light radiation.

5. An electrode including a light sensitive member, a metal film having a thickness between 75 and 125 angstroms co-extensive with said light sensitive member, and a layer of material having an index of refraction proportional to the thickness of said metal film between the limits of 1.7 for a film 75 angstroms thick, to 2.2 for a film 125 angstroms thick, said layer having the property of increasing the light transmission of said film for light projected through said layer.

6. An electrode including a light sensitive photo-emissive member, a metal film co-extensive with said member having a thickness insufficient to absorb more than 50% of light incident thereon, a transparent layer of material having an index of refraction between 1.7 and 2.2 when deposited on said film, said layer being in molecular contact with said film and having an optical thickness equal to odd quarter wave lengths of light for which said film is of insufficient thickness to absorb more than 50% of the light incident thereon.

7. An electrode as claimed in claim 6 wherein the optical thickness of said layer is equal to odd multiples of 1500 angstroms.

8. In combination, a thin metal film of insufficient thickness to absorb more than 50% of incident white light and a layer of transparent material of such thickness as to have a purple color when viewed by reflected white light on and in intimate contact with said film, said layer having an index of refraction between 1.7 and 2.2.

9. In combination, a thin metal film having a normal white light transmission of approximately 50%, and a layer of transparent material on and in molecular contact with said film, the material of said layer having an index of refraction lying between 1.7 and 2.2 and the optical thickness of said layer being approximately 1500 angstroms.

10. An electrode including a semi-transparent film of metal selected from the group consisting of platinum and palladium, and a transparent layer of metal oxide of a metal whose oxide has an index of refraction lying between 1.75 and 2.0 on and in intimate molecular contact with said film of metal.

11. The method of manufacturing a semi-transparent member including a metal film comprising the steps of vaporizing a metal in a high vacuum, condensing the vaporized metal on a substantially transparent foundation to form a semi-transparent metal film, vaporizing a material which when deposited as a film of 1500 angstroms thickness is transparent, said material having an index of refraction lying between 1.7 and 2.2, and depositing said vaporized material on said metal film to a predetermined transparent thickness while maintaining said vacuum substantially constant.

12. The method of increasing the light transmitting properties of a metal film which comprises depositing on a substantially transparent foundation by vaporization and condensation a semi-transparent metal film in a high vacuum, maintaining said high vacuum, depositing in

molecular contact with said film a metal oxide which when deposited as a film of 1500 angstroms thickness is transparent, said material having an index of refraction lying between 1.7 and 2.2 and discontinuing said deposition when the light transmitting property of said metal film has reached a maximum.

13. The method of manufacturing a semi-transparent assembly including a thin metal film comprising the steps of evacuating a chamber to provide a rarefied oxidizing gas pressure of less than  $10^{-6}$  mm. Hg, vaporizing and condensing a film of metal within said chamber to form a thin semi-transparent metal film on a substantially transparent foundation, retaining said metal film in said chamber and determining the light transmitting property of said film, providing an absolute gas pressure slightly above  $10^{-6}$  mm Hg, depositing by vaporization and condensation a layer of transparent material on said film and discontinuing the deposition of said material when the light transmitting property of said film has reached a maximum.

14. The method of manufacturing a semi-transparent member including a thin metal film comprising the steps of vaporizing and condens-

ing a quantity of metal on a supporting foundation in a rarefied atmosphere corresponding to a pressure of approximately  $10^{-6}$  mm. Hg to form a thin metal film, determining the light transmitting property of said metal film, slightly increasing the pressure of said rarefied atmosphere, depositing by vaporization and condensation a layer of transparent material on said film and discontinuing the deposition of said material when the light transmitting property of said film has reached a maximum.

15. The method of manufacturing a semi-transparent electrode including a thin metal film comprising the steps of vaporizing and condensing a quantity of metal in a high vacuum corresponding to a highly rarefied oxidizing atmosphere to form a thin metal film on a supporting foundation, determining the light transmitting properties of said film, evaporating and condensing a layer of material having a predetermined index of refraction on said film, and controlling the degree of vacuum during the condensation of said material to produce a layer on said film having an index of refraction lower than the index of refraction of said material prior to vaporizing.

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