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ULTRAVIOLET RADIATION DETECTOR

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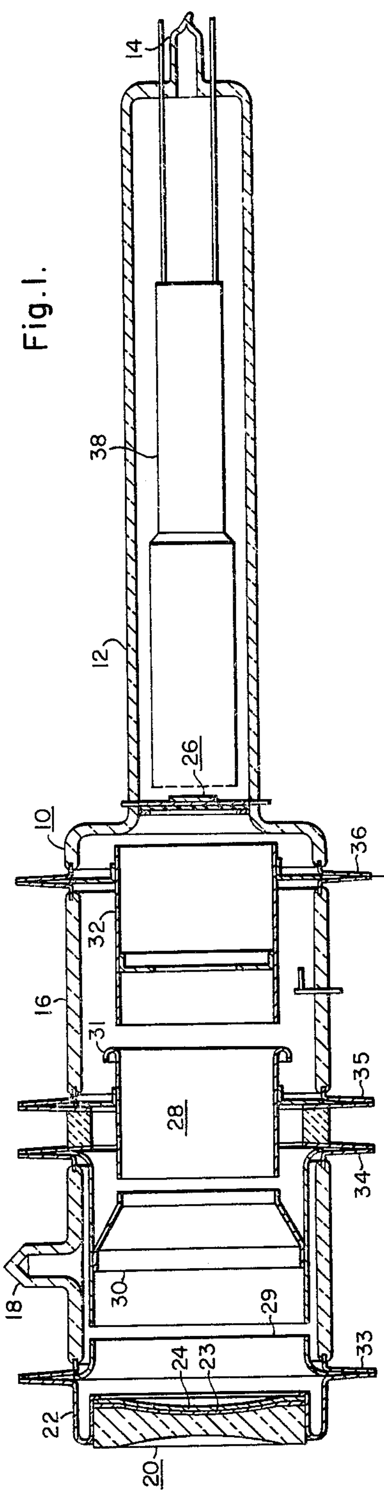

Fig. 1.

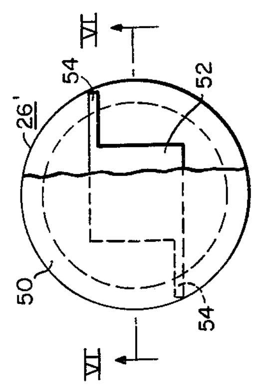

Fig. 5.

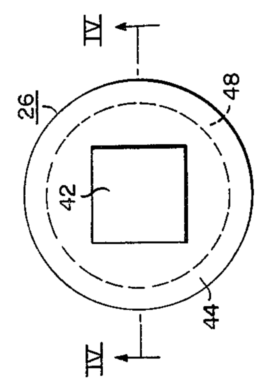

Fig. 3.

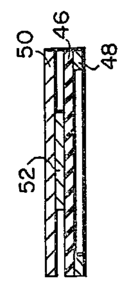

Fig. 6.

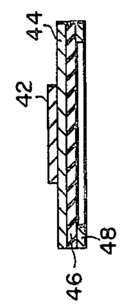

Fig. 4.

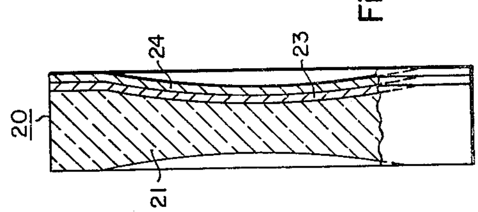

Fig. 2.

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ULTRAVIOLET RADIATION DETECTOR

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6 Claims. (Cl. 313—65)

The present invention relates generally to electron discharge devices and more particularly to devices which are responsive to radiation in the ultraviolet range.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of the national Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 426; 42 U.S.C. 2451), as amended.

In image tubes of this nature employing photocathodes, two elements which are very critical and which greatly affect the overall operation of the device are the photocathode and the target structure. With respect to the photocathode, it is known in the prior art to provide a window or support member of ultraviolet transmissive material such as lithium fluoride and to place a coating of electrically conductive material such as aluminum, nickel or platinum onto the window and then coat the conductive coating with an electron emissive material sensitive to ultraviolet radiation, such as cesium iodide. While these photocathodes have proved satisfactory to a certain extent they also suffer from certain limitations. Aluminum, which has a better ultraviolet transmission characteristic than that of the other conductive materials, reacts with silver chloride which is preferably used as a solder in vacuum sealing the window structure to the envelope. The use of silver chloride is advantageous because of its coefficient of thermal expansion and because of its ability to adhere to the components of the window and those of the envelope to effect a good vacuum seal. This reaction of the aluminum with the silver chloride results in the deterioration of the aluminum film and hence the elimination of the required electrical conductivity of the aluminum film.

Aluminum also suffers from the characteristic that the electrical resistance of the aluminum film increases when the tube is baked during processing. This increase in resistance causes the photocathode to charge up during the imaging operation of the tube and thus renders the tube useless, particularly at high signal levels.

As devices of the category with which the present invention is concerned require a target of high sensitivity, it has been found desirable to utilize targets of the electron bombardment induced conductivity (EBIC) type. In this type of target structure, a very undesirable charging effect is observed after the targets have been operated for a period of time, especially at high target voltages. This charge is due to secondary electrons from the unscanned area of the target which gradually creep in from the edges of the scanned area and render the tube inoperative. This charge may be eliminated by turning the tube off and letting the charge leak off or by focusing a light on the target to empty the electron traps in the semiconducting material. While these methods return the tube to operational status, they are unsatisfactory in that they necessitate a period of inoperability of the device.

It is therefore, an object of this invention to provide an improved electron discharge device.

Another object is to provide an improved image tube sensitive to radiation in the ultraviolet range.

Another object is to provide an improved radiation sensitive detector.

A further object is to provide an ultraviolet sensitive image tube having an improved photocathode with low electrical resistivity and high ultraviolet transmission qualities.

A still further object is to provide an ultraviolet sensitive image tube having an improved target structure.

Another object is to provide an electron discharge device of the image tube type responsive to ultraviolet radiation which possesses greater efficiency and longer life than those previously known in the art.

Stated briefly, the present invention provides an ultraviolet (wavelengths from approximately 1200–3000 angstrom units) responsive image tube utilizing a photocathode in which the electrical conducting layer is of palladium. This layer of palladium possesses the characteristic of non-reaction with the sliver chloride solder as well as being highly transparent to ultraviolet radiation and also possesses the unique quality of a decrease in resistivity upon baking. The efficiency and life of the image tube of the present invention is also increased by the utilization of a target whose structure provides that only those portions which are scanned are possessed of a co-extensive area of storage material and conducting substrate.

Further objects and advantages of the invention will become apparent as the following description proceeds and features of novelty which characterize the invention will be pointed out in particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIGURE 1 is a sectional view of an electron discharge device in accordance with the present invention;

FIG. 2 is an enlarged view of the image input screen of FIG. 1;

FIG. 3 is a front elevational view of the target structure of FIG. 1;

FIG. 4 is an end side view of the target shown in FIG. 3;

FIG. 5 is a modificatication of the target structure of FIGS. 3 and 4 in accordance with the present invention; and

FIG. 6 is a side view of the target structure shown in FIG. 5.

Referring now to FIG. 1 there is shown a discharge device in accordance with the present invention. The device comprises an envelope generally indicated as **10** which includes a neck portion **12** having a tipped off exhaust tubulation **14** located at one end thereof. The envelope **10** also includes an enlarged portion **16** having a tipped off exhaust tubulation **18** and having one end thereof connected to the neck portion **12** and the other end incorporating an input image screen **20**. The input image screen **20** is vacuum sealed to the portion **16** through a metallic member **22**, which may be of silver, by use of silver chloride which is disposed between the member **22** and the screen **20** and in a manner which is fully set forth in U.S. Patent No. 2,966,592 entitled, Vacuum-Tight Windows, by T. P. Vogel et al., issued December 27, 1960, and which is assigned to the assignee of the present invention. The full structure of the screen **20** will be more fully explained later, suffice to say at the present time that it incorporates a photoemissive surface **24** located on the vacuum side of the screen **20**. In the present instance, this photoemissive surface **24** is one which is responsive to ultraviolet radiation and emits electrons upon the incidence of ultraviolet radiation.

Located approximtaely at the jointure line of the enlarged portion **16** and the neck portion **12**, there is located a target structure **26** which receives electrons emitted from the emissive surface **24**. The structure of the target **26** will be explained in detail later.

Positioned intermediate the screen **20** and the target **26** is an electrostatic lens system **28** which serves to accelerate and focus the electrons emitted from the emissive surface **24**. The lens system **28** is comprised of a plurality of substantially cylindrically shaped electrically conducting members **29–32** which are provided with suitable sources of potential by means of lead members **33–36** which extend through the wall of the enlarged portion **16**.

An electron beam gun **38** is located within the neck portion **12**. The gun **38** is of any suitable design such as is commonly used in a vidicon pickup tube and serves to scan one side of the target structure **26** with an electron beam to read out information produced thereon by means of the electrons emitted from the emissive surface **24** which bombard the target **26**.

With reference to FIG. 2, there is shown in greater detail the input image screen **20** of FIG. 1. The screen **20** comprises a support member **21** which is shown to be of generally lenticular configuration. The support member **21** is of sufficient thickness and strength to withstand the pressure resulting from the vacuum within the tube and is made of a suitable material, for example lithium fluoride, which is transmissive to radiation in the ultraviolet range. A conducting layer **23**, which in the present invention is comprised of palladium, is disposed upon the vacuum side of the screen **20**. A layer of ultraviolet responsive electron emissive material **24**, for example cesium iodide is disposed upon the palladium layer **23**.

As has been stated, the conducting layer or substrate **23** in the present invention is of palladium. The use of palladium in photocathodes of this nature is particularly advantageous over the use of other conducting substrates such as aluminum which are known in the art for several reasons.

Palladium has slightly better ultraviolet transmissive characteristics than aluminum, particularly at the very short wave lengths ($\lambda \cong 1200$ angstrom units). In addition, it is necessary that a very good vacuum seal exists between the screen **20** and the envelope **10**. It has been found that this seal can best be effected through the use of silver chloride as a soldering material. This type of seal is fully set forth in U.S. Patent 2,966,592, which was previously cited. If aluminum is used as the conducting substrate, it has been found that the aluminum will be attacked by the silver chloride soldering material which results in the deterioration of the aluminum substrate and hence a loss of the necessary electrical conductivity in this member.

However, perhaps the most important reason for the use of palladium in the present device is its seemingly unique characteristic of a reduction in resistance upon baking. It has been found that when thin layers of such metals as aluminum, nickel, platinum or gold are baked, their resistivity increases. However, it has also been found that palladium, upon baking, has a decrease in resistivity. By way of comparison, it was observed that if thin films of nickel and palladium in the range of from 10 ohms per square to 1000 ohms per square (approximately 15 to 75% transmitting for white light) were baked for eight hours at 200° C., that the resistance of the nickel films always increased while that of the palladium films always decreased. As it is desirable that the conducting substrate be of low resistance, to prevent the cathode from charging up during imaging operation, it is readily apparent that the use of palladium is very desirable for this purpose.

One method of preparing an input image screen in accordance with the present invention may best be explained with reference to FIG. 2. A support member or window **21** of sufficient dimension to withstand the pressure occasioned by the vacuum to which it is to be subjected is provided. This support member **21** is of a suitable material such as lithium fluoride which is highly transmissive to ultraviolet radiation. A layer of palladium **23** is then vacuum evaporated onto one surface of the support member **21**. This layer **23** is preferably about 100 angstrom units in thickness; which thickness corresponds to a white light transmission of from 40 to 50 percent and to a resistivity of about 150 ohms per square before baking. A second layer **24** is then deposited onto the layer **23**. This layer **24** is comprised of an ultraviolet responsive, photoemissive material such as cesium iodide and is vacuum evaporated to a thickness of from 400 to 600 angstrom units in thickness. The structure is then baked at approximately 300° C. for a period of from 8 to 10 hours. After baking, the palladium substrate **23** will have a resistivity of approximately 50 ohms per square. Summarizing, palladium films as electrical substrates for ultraviolet cathodes offers at least four advantages over prior known cathodes:

(1) The resistivity of the substrate decreases rather than increases after bake out, thus eliminating the highly undesirable charging-up of the cathode during tube operation.

(2) The ultraviolet transmission of palladium is slightly better than that of aluminum at very short wave lengths ($\lambda \cong 1200$ angstrom units).

(3) The ultraviolet transmission of palladium improves by about a factor of 10 in the short wave length region upon baking in vacuum at 300° C.

(4) Palladium is not attacked by silver chloride as is aluminum. This permits the use of the preferable seal utilizing silver chloride solder.

Referring now to FIGS. 3 and 4, there is shown a target structure for use in an ultraviolet discharge device in accordance with the present invention. During the operation of electron bombardment induced conductivity targets, an undesirable charging effect is often observed after the targets have been operated for a period of time. This is especially at high target voltages. This charge is due to secondary electrons from the unscanned portion of the target which creep in from the edges of the scanned area and gradually render the tube inoperative.

The target **26** in accordance with the present invention includes a support ring **48** which may be of a suitable material such as stainless steel. A thin layer of insulating material **46**, such as aluminum oxide is then disposed onto the support ring **48** and serves to electrically insulate the support ring from the remaining elements. A thin layer **44**, which may be aluminum vacuum evaporated onto the aluminum oxide to a thickness of from 500 to 1000 angstrom units is then disposed onto one side of the insulating layer **46**. The conducting layer **44** serves to supply a suitable bias to a member **42** which is a semiconductor material exhibiting suitable electron bombardment induced conductivity (EBIC) properties such as arsenic trisulfide. The element **42** is shadow evaporated onto the conducting layer **44** to a thickness of approximately 1 to 2 microns through a mask which is the same size as the scanning raster. This structure does not permit the emission of secondary electrons except in the area where scanning takes place and hence does not allow the build up of any charge which would subsequently destroy the operation of the device.

As the element **42** is only the size of the scanning raster, image electrons which impinge onto the target structure at points at which there is no EBIC layer **42** are removed by the conducting layer **44** and hence are unable to build up a charge in these areas. This prevents a charge from building up outside of the scanned area which will gradually creep into the scanned area and cause the image on the scanned area to become fuzzy and indefinite.

Referring now to FIGS. 5 and 6 there is shown a modification of the target structure in accordance with the present invention. The embodiment as shown here includes a support ring **48** which may be of suitable material such as stainless steel onto which is disposed a layer **46** of insulating material, for example, aluminum oxide. A conducting layer **52** which may be of suitable material such as aluminum is then disposed on the layer **46**. This layer **52** is shadow evaporated onto the layer **46** through a mask which is of the same size as the scanning raster to form a conducting area which is the same size as the scanning raster. Layer **52** also is provided with one or more conducting tabs **54** extending from the area **52** to the support ring and connected thereto. A layer **50** of EBIC material such as arsenic trisulfide is then vacuum deposited onto the conducting layer **52**. This construction like that of the embodiment of FIGS. 3 and 4 prevents a charge from building up on the EBIC material outside of the scanned area and therefore does not permit the build up of a charge outside of the scanned area which could subsequently creep onto the scanned area and destroy the image thereon.

While there have been shown and described what are at present considered to be the preferred embodiments of the invention, modifications thereto will readily occur to those skilled in the art. It is not desired, therefore, that the invention be limited to the specific arrangement shown and described and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

I claim as my invention:

1. An image device responsive to ultraviolet radiation comprising an evacuated envelope having an input window of ultraviolet transmissive material disposed at one end of said envelope, a photocathode comprising a layer of palladium transmissives to ultraviolet radiation disposed on the vacuum side of said window, and a layer of photoemissive material sensitive to ultraviolet disposed on said palladium, target means within said envelope and spaced from said photocathode for receiving electrons emitted from said photocathode and means for forming and directing an electron beam onto said target means.

2. An image device responsive to ultraviolet radiation comprising an evacuated envelope having a input image screen disposed at one end thereof, said screen comprising a window of ultraviolet transmissive material and photocathode means comprising a layer of palladium transmissive to ultraviolet radiation disposed on the vacuum side of said window and a layer of photoemissive material sensitive to ultraviolet disposed upon said palladium, means including silver chloride for vacuum sealing said screen to said envelope, target means within said envelope spaced from said photocathode for receiving electrons emitted from said photocathode on one side of said target, and means for forming and directing an electron beam onto the other side of said target means.

3. An image device responsive to radiation in the ultraviolet range comprising an evacuated envelope having an ultraviolet transmissive window, a photocathode comprising a layer of palladium transmissive to ultraviolet and substantially 100 angstrom units in thickness deposited on the vacuum side of said window and a layer of cesium iodide of 400 angstrom units to 600 angstrom units in thickness deposited on said palladium, target means within said envelope spaced from said photocathode for receiving electrons emitted from said photocathode, and means for forming and directing an electron beam onto said target means.

4. An ultraviolet radiation detector comprising an evacuated envelope having a window transmissive to ultraviolet radiations within the range of 1200 to 3000 angstrom units, photocathode means comprising a layer of palladium, transmissive to ultraviolet radiations within the range of 1200 to 3000 angstrom units disposed upon the vacuum side of said window and a layer of photoemissive material sensitive to ultraviolet disposed upon said palladium layer and means for detecting electron emission from said photoemissive material.

5. An ultraviolet radiation detector comprising an evacuated envelope having an ultraviolet transmissive window, photocathode means comprising a layer of palladium substantially 100 angstrom units in thickness disposed upon the vacuum side of said window and a layer of cesium iodide of substantially 400 angstrom units in thickness disposed upon said palladium, and means for detecting electrons emitted from said layer of cesium iodide in response to ultraviolet radiation on said photocathode.

6. A radiation detector sensitive to ultraviolet radiation of substantially 1200 angstrom units comprising evacuated envelope having a window transmissive to ultraviolet radiations of substantially 1200 angstrom units, photocathode means comprising a layer of palladium of substantially 100 angstrom units in thickness to provide lateral electrical conductivity and transmission of ultraviolet radiations of substantially 1200 angstrom units and disposed upon the vacuum side of said window and a layer of photoemissive material sensitive to ultraviolet radiations of substantially 1200 angstrom units disposed upon said palladium layer and emitting electrons in response to ultraviolet radiations of substantially 1200 angstrom units.

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