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Description

The present invention relates to a TV pick-up tube which is far higher in resolution than conventional ones.

In order to get a picture image with high resolution by a television camera, the number of scanning lines for producing a television signal has hitherto been increased. The pick-up tube is usually made up of a photoconductive target for converting an optical image into an electric signal, an electron gun for emitting a scanning electron beam to detect the electric signal, and an electron beam control section for focusing and deflecting the electron beam.

In order to improve the resolution of a pick-up tube by increasing the number of scanning lines, various methods have been used, that is, the scanning electron beam has been made thin, or a photoconductive film having a high resolving power has been used for forming the photoconductive target. A pick-up tube having such a construction will be hereinafter referred to as "image pick-up tube for high definition television."

For example, a 1 in.(2,54 cm) image pick-up tube for high definition television using 1125 scanning lines and including a photo-conductive film which has a thickness of 4 to 6 μm and is made of an amorphous photo-conductive material containing selenium as main component, can produce an amplitude response of about 45 % at 800 TV lines (cf. the Journal of the Institute of Television Engineers of Japan, Vol. 39, No. 8, August 1985, pages 663 to 674).

The conventional image pick-up tube for high definition television has high resolution as mentioned above, but the resolution of the image pick-up tube is much less than that of a 35 mm or 75 mm video film. Accordingly, it is ardently desired to further improve the resolution of the image pick-up tube for high definition television.

When a scanning electron beam of large diameter is used in the above pick-up tube, the improvement in resolution is limited by the beam diameter. Accordingly, it is preferable to use a scanning electron beam having a small diameter. According to the prior art, however, there arises a problem that even when the beam diameter of the scanning electron beam is made small, the pick-up tube cannot have the desired high resolution.

NHK Laboratories Note, No. 309, December 1984, pages 3-11, NHK, Tokyo, JP, T. Kawamura et al., "A new high-resolution pick-up tube for live X-ray topography" relates to a high definition pick-up tube for X-ray topography provided for replacing nuclear plates. The pick-up tube comprises an amorphous Se-As alloy layer for X-ray sensing. It is disclosed in this document to achieve a very high resolution by making the scanning electron beam as narrow as 10 to 12 μm in diameter. Furthermore, it is mentioned in

this document that the capacitance of an ordinary 2/3 inch Saticon, i.e. of a thickness of 4 μm , is 1600 pF, corresponding to a specific capacitance of 7.1 $\mu\text{F}/\text{m}^2$. This document, however, is silent about the interdependence or the electron beam diameter and the film thickness or capacity of the photoconductive layer.

The present invention is based on the finding that when a conventional image pick-up tube for high definition television is operated, the variation in the surface potential at the surface of the photoconductive film due to incident light is great, which makes it impossible for the image pick-up tube to have the desired high resolution. In more detail, when the scanning electron beam is made thin to attain high resolution, it is deflected due to the above-mentioned great variation in the surface potential. This effect is remarkable in the vicinity of the edge of an optical image, and thus a reconstructed pattern will become fuzzy.

It is the object of the present invention to provide a TV pick-up tube, in which the variation in the surface potential at the surface of the photoconductive film is only small, and the resolution of the pick-up tube is markedly improved.

Furthermore, the pick-up tube shall be small-sized and include a photoconductive film which is low in manufacturing costs, particularly concerning a reduction of the deposition time of the photoconductive film, to enhance the manufacturing productivity.

This object is achieved according to claim 1. The dependent claims relate to preferred embodiments.

According to the concept of the invention, the variation in the surface potential at the surface of the photoconductive film is made small by increasing the capacity of the photoconductive film.

The TV pick-up tube according to the present invention comprises

a photoconductive film for converting an optical image into electric signals, the film being made of amorphous semiconductor material at least a portion of which contains selenium as its main component, and having a capacity of 15 to 150 $\mu\text{F}/\text{m}^2$, a mesh electrode disposed so as to confront the photoconductive film, and

a diode type electron gun for emitting a scanning electron beam which is provided with a beam limiting aperture limiting the diameter of the emitted electron beam and having a diameter of 5 to 25 μm .

The capacity of the photoconductive film of 15 to 150 $\mu\text{F}/\text{m}^2$ leads to a marked reduction of the surface potential variation.

For further improving the resolution, the thickness of the photoconductive film is made small which further reduces the variation of the surface potential of the photoconductive film.

In the following, the pick-up tube according to the present invention will be explained in more details with reference to examples and the accompanying

drawings. It is to be noted that operation, shape, size and structural details of the pick-up tube can be modified within the scope of the claims.

Fig. 1 shows a schematic cross-section of a pick-up tube, to which the present invention is applied.

Fig. 2 is a diagram showing the relation between the capacity per unit area of the photoconductive film and the amplitude response for a 2/3 in. (1.7 cm) pick-up tube having a small beam limiting aperture and using 1125 scanning lines.

Fig. 3 is a diagram showing the relation between the distance between the mesh electrode and the photoconductive film, and the amplitude response for a 2/3 in. (1.7 cm) pick-up tube having a small beam limiting aperture and increased capacity of the photoconductive film.

Figs. 4a and 4b are schematic representations showing examples of the cross-sectional structure of the beam limiting aperture according to the invention.

Prior to the explanation of the present invention, the structure and operation of a pick-up tube will be explained.

Fig. 1 shows a schematic cross-section of a pick-up tube, to which the present invention is applied. It comprises a cathode 1, a scanning electron beam 2, an electrode 3 for controlling the electron beam 2, a beam limiting aperture 4, a photoconductive film 5, a mesh electrode 6, a transparent electrode 7, a face plate 8 made of glass, and a glass bulb 9. When an external power source 10 is connected between the cathode 1 and the transparent electrode 7 as shown in Fig. 1, and further the photoconductive film 5 is scanned with the focused electron beam 2, the surface of the photoconductive film 5 on the scanning side is negatively charged, and the potential of this surface becomes nearly equal to the cathode potential. That is, the photoconductive film 5 is charged up to a level substantially equal to the output level of the external power source 10. When light is incident upon the photoconductive film 5, the resistance thereof decreases, and thus the negative charges on the surface of the photoconductive film 5 are decreased by discharge. Accordingly, a charge pattern corresponding to the intensity distribution of the incident light is formed on the surface of the photoconductive film 5 on the scanning side, that is, a variation in the surface potential is caused by the intensity distribution of the incident light. When the photoconductive film 5 is scanned with the electron beam 2, the electron beam 2 lands on the photoconductive film 5 in accordance with the above variation in the surface potential, and hence a charging current corresponding to the discharged electric quantity flows through an ammeter 11. Thus, the optical image formed on the photoconductive layer 5 is time-sequentially converted into a signal current.

In connection with the invention the relation between the resolution of such a pick-up tube and the

capacity of the photoconductive film has been investigated in detail, and it has been found that the resolution can be markedly improved by making the diameter of the beam limiting aperture 4 small and by increasing the capacity of the photoconductive film 5.

Fig. 2 shows an example of the relation between the capacity per unit area of the photoconductive film and the amplitude response for a 2/3 in. (1.7 cm) photoconductive pick-up tube provided with a beam limiting aperture having a diameter of 10 μm which is operated with 1125 scanning lines. Fig. 2 shows that the amplitude response, that is, the resolution of the pick-up tube, is greatly improved by making the capacity per unit area (hereinafter referred to as "normalized capacity") of the photoconductive film $\geq 15 \mu\text{F}/\text{m}^2$. The resolution becomes higher the larger the normalized capacity is made. However, when the normalized capacity is made too large, the lag, namely, the delay of the photo-response, becomes remarkable. Accordingly, the normalized capacity of the photoconductive film is made $\leq 150 \mu\text{F}/\text{m}^2$; the upper limit of the normalized capacity should be determined in accordance with the specific purpose, for which the pickup tube is used.

In a case where the photoconductive film is made of an amorphous photoconductive material which contains selenium having a high resolving power as a main component, by making the thickness of the photoconductive film $\leq 3.5 \mu\text{m}$, the normalized capacity of the film can be made greater than $15 \mu\text{F}/\text{m}^2$, and the resolution of the pick-up tube can be markedly improved thereby.

The improvement in resolution by increasing the normalized capacity of the photoconductive film is remarkable in a case where the diameter of the beam limiting aperture 4 is made small, and a large number of scanning lines is used. When the diameter of the beam limiting aperture is large, it is impossible to greatly improve the resolution by increasing the normalized capacity of the photoconductive film, since the resolution is restricted by the beam diameter determined by the beam limiting aperture 4.

Accordingly, it is desirable that the diameter of the beam limiting aperture 4 is made smaller than 15 μm for a 2/3 in. (1.7 cm) pick-up tube, and smaller than 25 μm for a 1 in. (2.54 cm) pick-up tube. However, the electric charge quantity carried by the electron beam 2 decreases as the diameter of the beam limiting aperture 4 is smaller. Accordingly, the lower limit of the diameter of the beam limiting aperture 4 is 5 μm .

Further, it is desirable to taper the beam limiting aperture 4 in the direction from its exit toward its entrance, thereby enhancing the transmissivity for the electron beam 2. Figs. 4a and 4b show examples of the beam limiting aperture 4. Preferably, the cross-section profile of the (enlarged) portion of the beam limiting aperture 4 which is parallel to its center axis,

is defined by a polygon-like plurality of straight lines or a curved line on each side of the center axis, as shown in Figs. 4a or 4b, respectively.

Fig. 3 shows an example of the relation between the resolution of a 2/3 in. (1.7 cm) photoconductive pick-up tube having the above-mentioned construction, and the distance between the mesh electrode and the photoconductive film. As can be seen from Fig. 3, in order to improve the resolution of the pick-up tube to a great extent, the distance between the mesh electrode 6 and the photoconductive film 5 must be in the range from 1 to 3 mm, and preferably in the range from 1 to 2 mm.

In the above description, a 2/3 in. (1.7 cm) pick-up tube has been explained, by way of example. Of course, according to the invention, the resolution of other pick-up tubes, such as 1 in. (2.54 cm) pick-up tubes, can also be improved analogously.

For example, a 1 in. (2.54 cm) pick-up tube and a 2/3 in. (1.7 cm) pick-up tube according to the present invention were operated so as to have 1125 scanning lines, and produced an amplitude response of more than 80 % and of about 40 %, respectively, at 800 TV lines, while conventional pick-up tubes of the same size gave an amplitude response of about 45 % and of about 30 %, respectively. As is evident from the above, the resolution of pick-up tubes can be markedly improved on the basis of the present invention.

Now embodiments of pick-up tubes according to the present invention will be explained.

Embodiment I

A transparent electrode containing SnO_2 as its main component is deposited on a 1 in. (2.54 cm) diameter glass substrate by a chemical vapor deposition method, and an amorphous photoconductive film made of selenium, arsenic and tellurium and containing more than 50 % by mass of selenium is deposited on the transparent electrode by a vacuum deposition method in a vacuum of less than 1.3 mPa (10^{-5} Torr). The thickness of the photoconductive film is made such to be in the range of from 0.35 to 3.5 μm . Next, a porous Sb_2S_3 film is deposited on the photoconductive film in an atmosphere of argon kept at a pressure of 1.3 Pa (10^{-2} Torr) so that the thickness of the Sb_2S_3 film lies in the range of from 40 to 100 nm (400 to 1000 Å), to be used as an electron beam landing layer. Thus, a photoconductive target having a normalized capacity of more than 15 $\mu\text{F}/\text{m}^2$ is formed.

The above photoconductive target, an electron gun, a mesh electrode and an electrode structure for focusing and deflecting the electron beam are mounted in a glass bulb, which is then evacuated. In this pick-up tube, the diameter of the beam limiting aperture is made equal to 15 μm .

Embodiment II

A transparent electrode containing SnO_2 or In_2O_3 as its main component is deposited on a 2/3 in. (1.7 cm) diameter glass substrate by a chemical vapor deposition method or by sputtering, and a CeO_2 film is deposited on the transparent electrode to a thickness of 15 nm (150 Å) by a vacuum deposition method, to be used as a hole blocking layer. Next, first, second and third photoconductive layers are successively deposited by a vacuum deposition method so that a photoconductive film having a thickness of 0.35 to 3.5 μm is formed on the CeO_2 film. The first photoconductive layer is an amorphous Se-As layer which has a thickness of 10 to 100 nm (100 to 1000 Å), and in which the mean arsenic content is less than 15 % by mass. The second photoconductive layer serves as a sensitizing layer and is an amorphous Se-Te-As layer which has a thickness of 20 to 150 nm (200 to 1500 Å), and in which the mean tellurium content lies within the range of from 20 to 50 % by mass, and the mean arsenic content is less than 5 % by mass. The third photoconductive layer is an amorphous Se-As layer, in which the mean arsenic content is less than 15 % by mass. Finally, a porous Sb_2S_3 film is deposited on the photoconductive film to a thickness of 40 to 100 nm (400 to 1000 Å) in an inert atmosphere kept at a pressure of 1.3 Pa (10^{-2} Torr), to be used as an electron beam landing layer. Thus, a photoconductive target having a normalized capacity of more than 15 $\mu\text{F}/\text{m}^2$ is obtained. In the above-mentioned photoconductive film most of incident light is absorbed by the first and second photoconductive layers. Accordingly, even when the third photoconductive layer is made thin to increase the normalized capacity thereof, the sensitivity of the photoconductive film is not decreased.

The above photoconductive target, an electron gun, a mesh electrode and an electrode structure for focusing and deflecting the electron beam are mounted within a glass bulb, which is then evacuated. In this pick-up tube, the electron gun is of a diode type, the beam limiting aperture has a cross-section such as (enlarged) shown in Fig. 4a, that is, the cross-section profile of the portion of the aperture which is parallel to its center axis, is shaped polygon-like and defined by two straight lines on both sides of the center axis, the minimum diameter of the beam limiting aperture being 10 μm ; the mesh electrode is formed of a 1500 to 2000-mesh copper screen, and the distance between the mesh electrode and the photoconductive target lies in the range of from 1 to 2 mm.

The pick-up tubes explained in the embodiments I and II are preferred embodiments of the present invention. However, these embodiments have been described for explaining the technical concept of the present invention. Accordingly, it is to be understood that the present invention is not limited to the specific

embodiments described above.

Claims

1. A TV pick-up tube comprising:
a photoconductive film (5) for converting an optical image into electric signals, the film being made of amorphous semiconductor material at least a portion of which contains selenium as its main component, and having a capacity of 15 to 150 $\mu\text{F}/\text{m}^2$,
a mesh electrode (6) disposed so as to confront the photoconductive film (5), and
a diode type electron gun (1, 3) for emitting a scanning electron beam (2) which is provided with a beam limiting aperture (4) limiting the diameter of the emitted electron beam and having a diameter of 5 to 25 μm .
2. The pick-up tube according to claim 1, wherein the thickness of the amorphous photoconductive film (5) is 0,35 to 3,5 μm .
3. The pick-up tube according to claim 1 or 2 wherein the beam limiting aperture (4) is tapered in the direction opposite to the propagation direction of the electron beam (2).
4. The pick-up tube according to one of claims 1 to 3, wherein the cross-section profile of the portion of the beam limiting aperture (4) which is parallel to its center axis, is defined by a polygon-like plurality of straight lines on both sides of the center axis (Fig. 4a).
5. The pick-up tube according to one of claims 1 to 3, wherein the cross-section profile of the portion of the beam limiting aperture (4) which is parallel to its center axis, is defined by a curved line on both sides of the center axis (Fig. 4b).
6. The pick-up tube according to one of claims 1 to 3, wherein the cross-section of the enlarged portion of the beam limiting aperture (4) which is parallel to its center axis, is defined by two straight lines, on one side of the center axis (Fig. 4a).
7. The pick-up tube according to one of claims 1 to 6, wherein the distance between the photoconductive film (5) and the mesh electrode (6) is 1 to 3 mm.
8. The pick-up tube according to one of claims 1 to 7, wherein the diameter of the beam limiting aperture (4) is $\leq 15 \mu\text{m}$ for a 2/3 in. (1,7 cm) pick-up tube and is $\leq 25 \mu\text{m}$ for a 1 in. (2,54 cm) pick-up tube, and is $\geq 5 \mu\text{m}$ in all cases.

Patentansprüche

1. Fernsehaufnahmeröhre, umfassend
einen photoleitenden Film (5) zur Umwandlung eines optischen Bildes in elektrische Signale, wobei der Film aus einem amorphen Halbleitermaterial, das zumindest teilweise Selen als seinen Hauptbestandteil enthält, besteht und eine Kapazität von 15 bis 150 $\mu\text{F}/\text{m}^2$ aufweist,
eine Maschenelektrode (6), die so angeordnet ist, daß sie dem photoleitenden Film (5) gegenüberliegt, und
eine Elektronenkanone (1, 3) vom Diodentyp zur Emission eines Abtastelektronenstrahls (2), die mit einer den Strahl begrenzenden Öffnung (4), die den Durchmesser des Strahls der emittierten Elektronen begrenzt und einen Durchmesser von 5 bis 25 μm aufweist, ausgerüstet ist.
2. Aufnahmeröhre nach Anspruch 1, wobei die Dicke des amorphen photoleitenden Films (5) 0,35 bis 3,5 μm beträgt.
3. Aufnahmeröhre nach Anspruch 1 oder 2, wobei sich die den Strahl begrenzende Öffnung (4) in der der Ausbreitungsrichtung des Elektronenstrahls (2) entgegengesetzten Richtung verjüngt.
4. Aufnahmeröhre nach einem der Ansprüche 1 bis 3, wobei das Querschnittsprofil des Teils der den Strahl begrenzenden Öffnung (4), der parallel zu seiner Mittelachse verläuft, durch eine polygonartige Mehrzahl von Geraden auf beiden Seiten der Mittelachse definiert ist (Fig. 4a).
5. Aufnahmeröhre nach einem der Ansprüche 1 bis 3, wobei das Querschnittsprofil des Teils der den Strahl begrenzenden Öffnung (4), der parallel zu seiner Mittelachse verläuft, durch eine gekrümmte Linie auf beiden Seiten der Mittelachse definiert ist (Fig. 4b).
6. Aufnahmeröhre nach einem der Ansprüche 1 bis 3, wobei der Querschnitt des vergrößerten Teils der den Strahl begrenzenden Öffnung (4), der parallel zu seiner Mittelachse verläuft, durch zwei Geraden auf einer Seite der Mittelachse definiert ist (Fig. 4a).
7. Aufnahmeröhre nach einem der Ansprüche 1 bis 6, wobei der Abstand zwischen dem photoleitenden Film (5) und der Maschenelektrode (6) 1 bis 3 mm beträgt.
8. Aufnahmeröhre nach einem der Ansprüche 1 bis 7, wobei der Durchmesser der den Strahl begrenzenden Öffnung (4) bei einer 2/3 in. (1,7 cm) Aufnahmeröhre $\leq 15 \mu\text{m}$, bei einer 1 in. (2,54 cm)

Aufnahmeröhre $\leq 25 \mu\text{m}$ und in allen Fällen $\geq 5 \mu\text{m}$ ist.

Revendications

1. Tube de prise de vues de télévision comprenant :
une pellicule photoconductrice (5) pour convertir
une image optique en des signaux électriques, la
pellicule étant formée d'un matériau semiconduc-
teur amorphe, dont au moins une partie contient
du sélénium comme constituant principal, et pos-
sédant une capacité de 15 à 150 $\mu\text{F}/\text{m}^2$,
une électrode à mailles (6) disposée en vis-à-vis
de la pellicule photoconductrice (5), et
un canon à électrons du type diode (1, 3) pour
émettre un faisceau d'électrons de balayage (2),
qui comporte une ouverture (4) de limitation du
faisceau, qui limite le diamètre du faisceau
d'électrons émis et possède un diamètre de 5 à
25 μm . 5 10 15 20
2. Tube de prise de vues selon la revendication 1,
dans lequel l'épaisseur de la pellicule photocon-
ductrice amorphe (5) est comprise entre 0,35 et
3,5 μm . 25
3. Tube de prise de vues selon la revendication 1 ou
2, dans lequel l'ouverture (4) de limitation du fais-
ceau se rétrécit dans la direction opposée à la di-
rection de propagation du faisceau d'électrons
(2). 30
4. Tube de prise de vues selon l'une des revendica-
tions 1 à 3, dans lequel le profil en coupe trans-
versale de la partie de l'ouverture (4) de limitation
du faisceau, qui est parallèle à son axe central,
est défini par une pluralité de droites disposées
selon un polygone, des deux côtés de l'axe cen-
tral (figure 4a). 35 40
5. Tube de prise de vues selon l'une des revendica-
tions 1 à 3, dans lequel le profil en coupe trans-
versale de la partie de l'ouverture (4) de limitation
du faisceau, qui est parallèle à son axe central,
est défini par une ligne courbe des deux côtés de
l'axe central (figure 4b). 45
6. Tube de prise de vues selon l'une des revendica-
tions 1 à 3, dans lequel la section transversale de
la partie élargie de l'ouverture (4) de limitation du
faisceau, qui est parallèle à son axe central, est
définie par deux droites, d'un côté de l'axe central
(figure 4a). 50 55
7. Tube de prise de vues selon l'une des revendica-
tions 1 à 6, dans lequel la distance entre la pelli-
cule photoconductrice (5) et l'électrode à mailles

(6) est comprise entre 1 et 3 mm.

8. Tube de prise de vues selon l'une des revendica-
tions 1 à 7, dans lequel le diamètre de l'ouverture
(4) de limitation du faisceau est $\leq 15 \mu\text{m}$ pour un
tube de prise de vues de 2/3 pouce (1,7 cm) et est
 $\leq 25 \mu\text{m}$ pour un tube de prise de vues de 1 pouce
(2,54 cm) et est $\geq 5 \mu\text{m}$ dans tous les cas.

FIG. 1

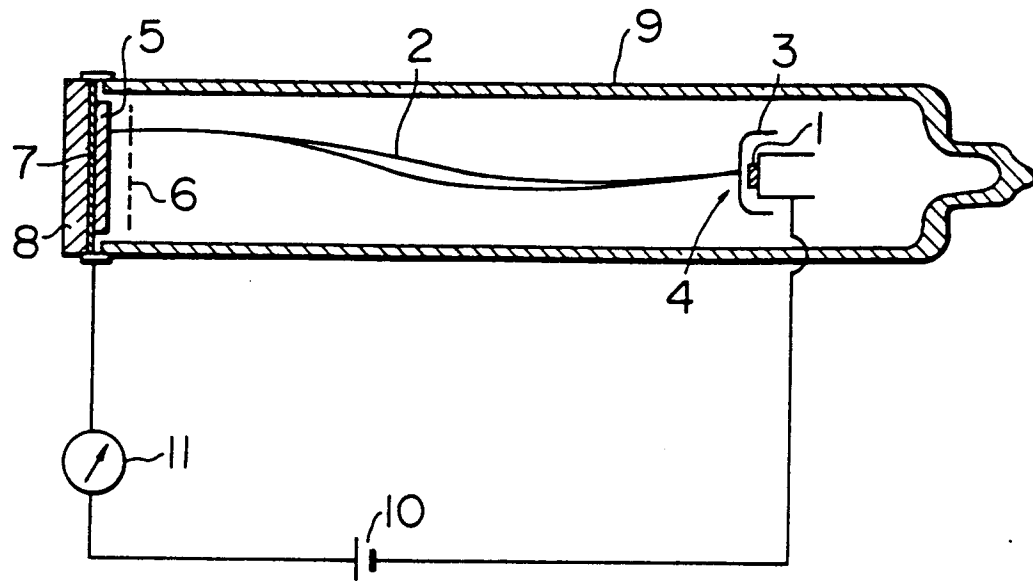


FIG. 2

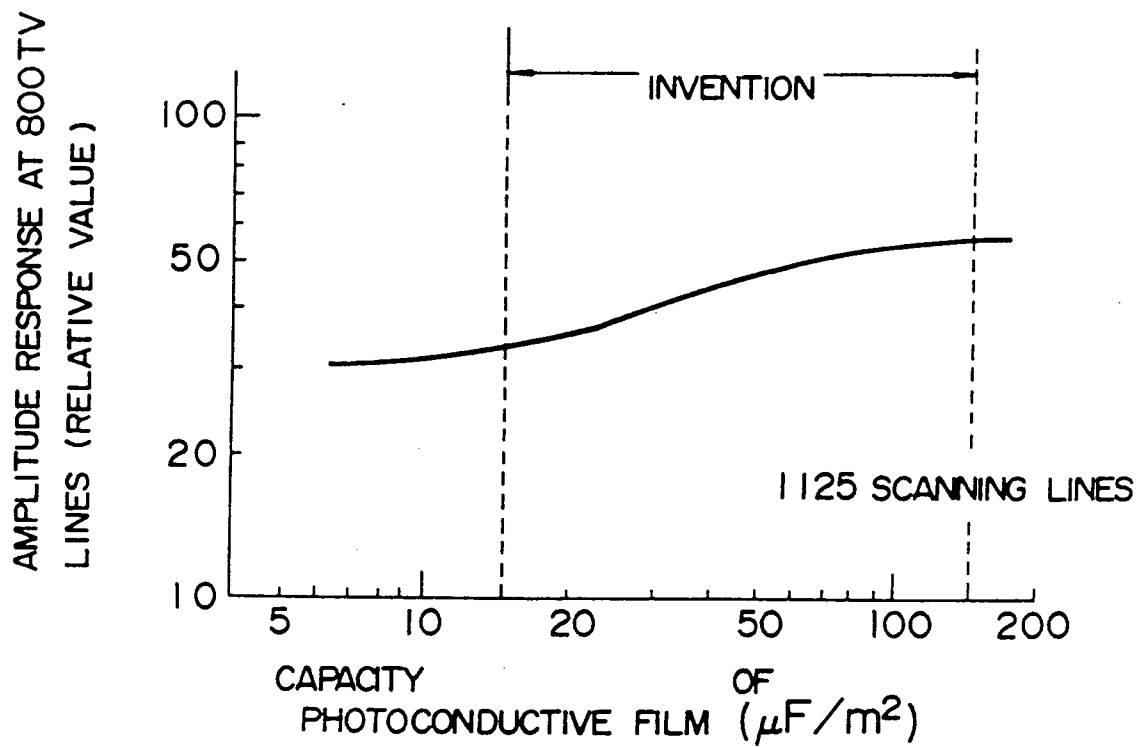


FIG. 3

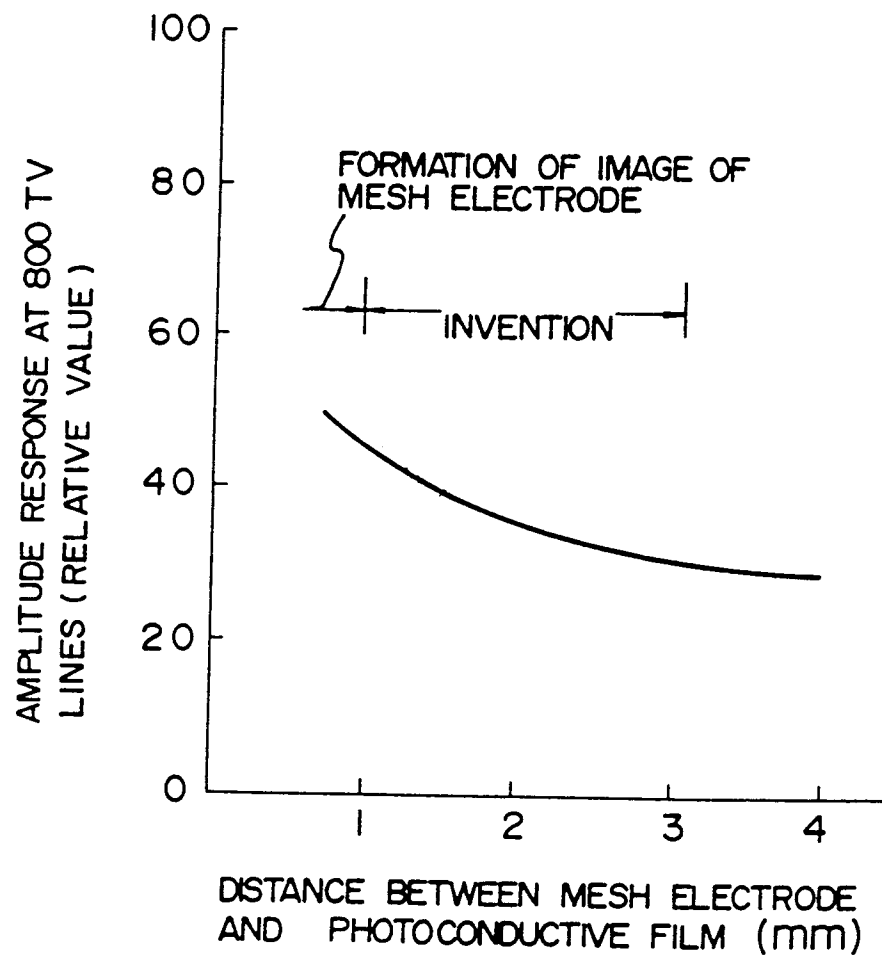


FIG. 4a

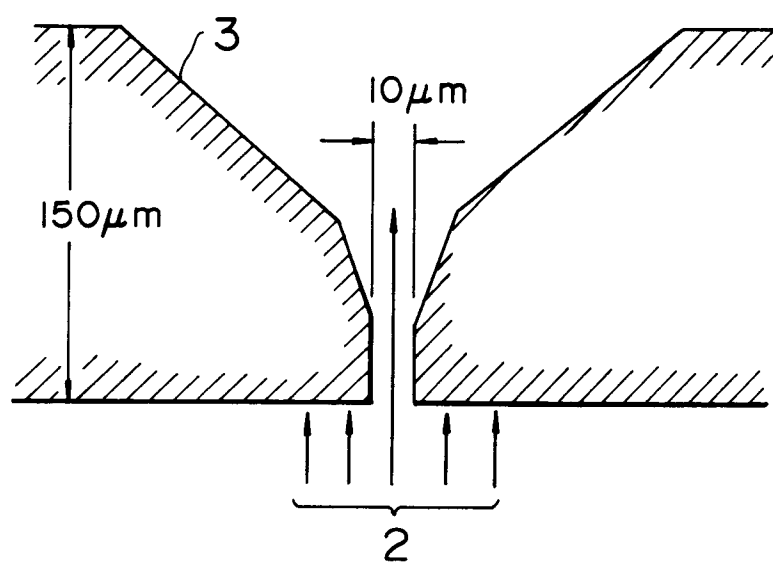


FIG. 4b

