

Aug. 13, 1957

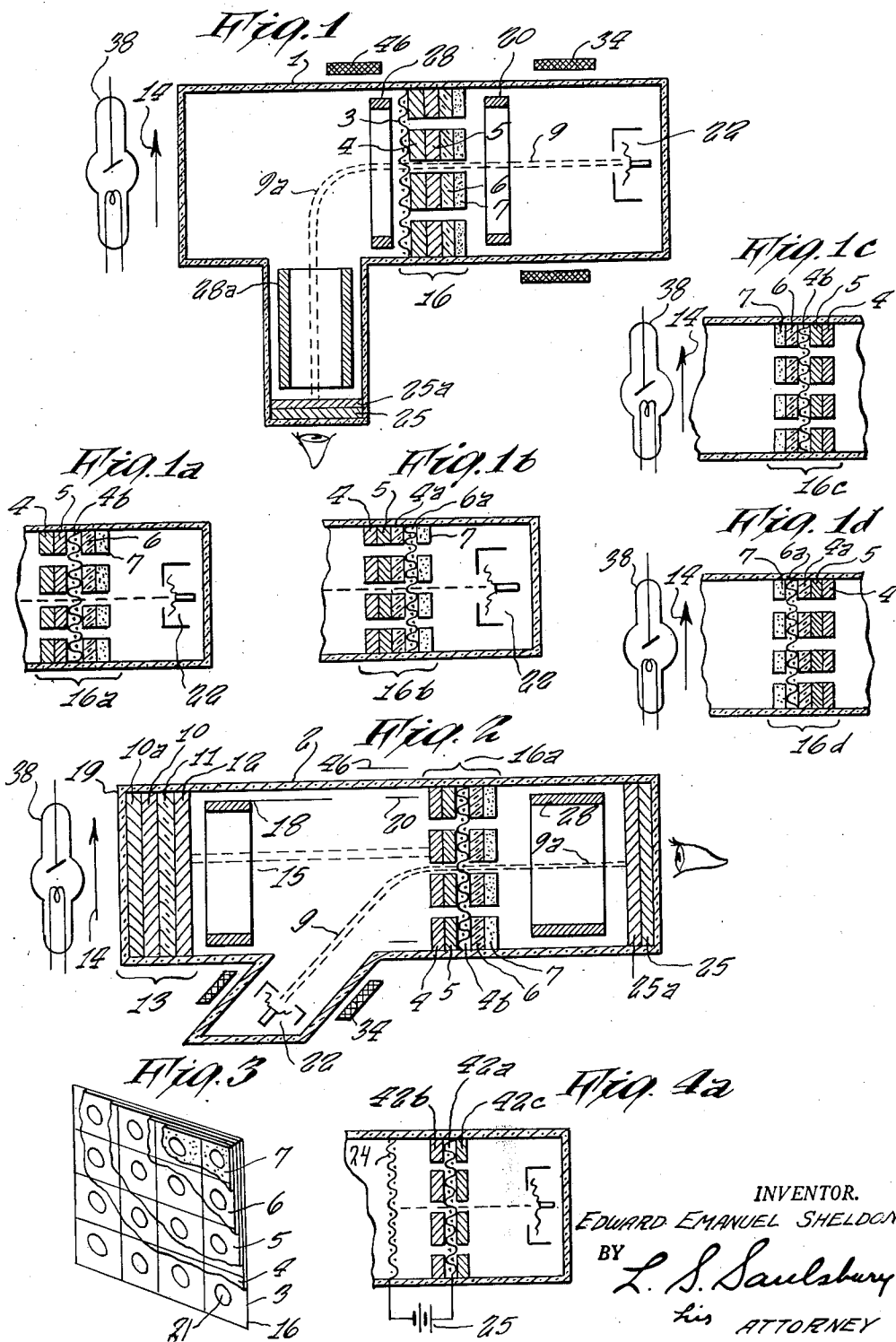
E. E. SHELDON

2,802,963

TUBE FOR REPRODUCING INVISIBLE IMAGES

Filed Feb. 28, 1952

2 Sheets-Sheet 1



INVENTOR.
EDWARD EMANUEL SHELDON
BY *L. S. Saulsbury*
his ATTORNEY

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2 Sheets-Sheet 2

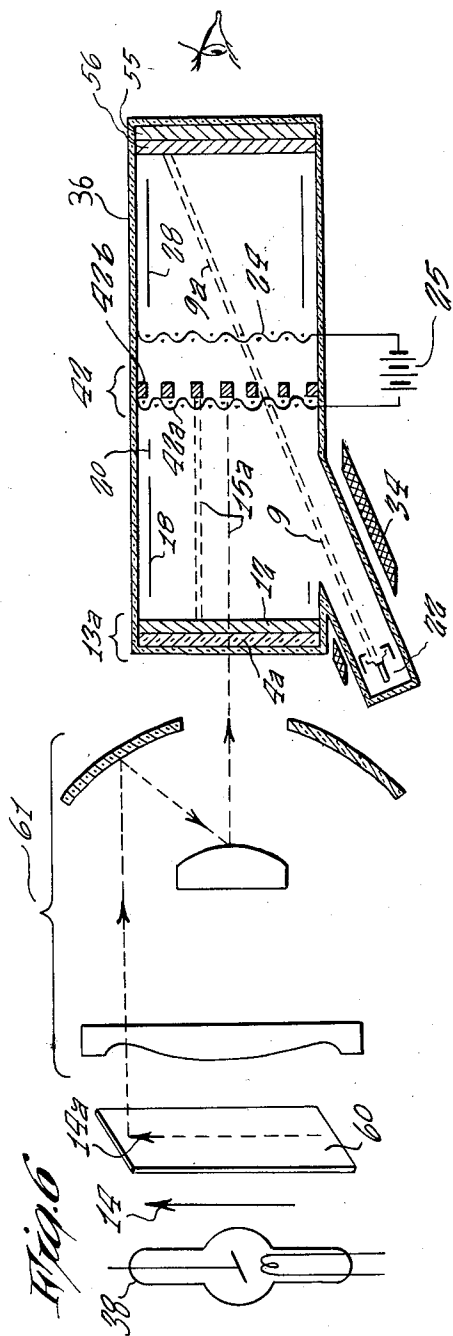


Fig. 4

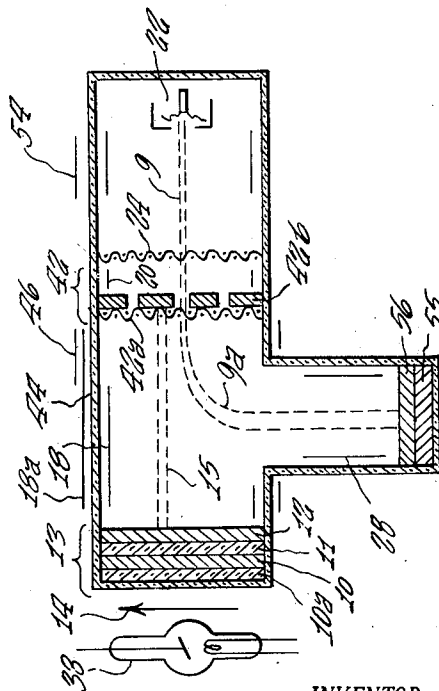
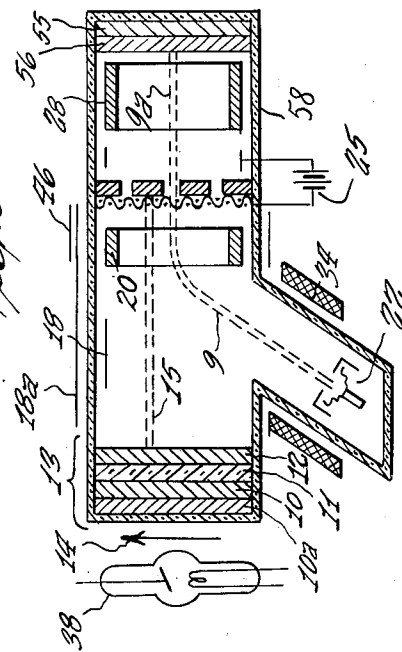


Fig. 5



INVENTOR.
EDWARD EMANUEL SHELDON
BY
L. S. Saulsbury
his ATTORNEY

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TUBE FOR REPRODUCING INVISIBLE IMAGES

Edward Emanuel Sheldon, New York, N. Y.

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14 Claims. (Cl. 313—65)

This invention relates to a method and device for intensifying and storing images of invisible radiations, and refers more particularly to a method and device for intensifying and storing invisible radiations images, which term is meant to include X-rays and other invisible radiations, such as gamma rays and the like, and also for images formed by irradiation by beams of atom particles, such as electrons or neutrons, and represents a continuation in part of my co-pending application Serial No. 84,326, filed March 30, 1949 which is now U. S. Patent 2,717,971, issued September 13, 1955 and has subject matter common with my U. S. Patent No. 2,555,423.

One primary objective of this invention is to provide a method and device to produce intensified images for examination. This intensification will make it possible to overcome the inefficiency of the present fluoroscopic examination. At present, illumination of the X-ray fluoroscopic image is of the order of 0.001–0.01 millilambert. At this level the human eye has to rely exclusively on scotopic (dark adaptation) vision which is characterized by tremendous loss of normal visual acuity in reference both to the detail and contrast.

Another object of this invention is to make it possible to prolong the fluoroscopic examination, since it will reduce markedly the strength of radiation affecting the patient's body. Conversely, the exposure time or energy necessary for examination using an invisible radiation may be considerably reduced.

Another object of this invention is to provide a method and device to produce sharper and more contrasting images of invisible radiations than was possible heretofore.

Another purpose of this invention is to provide the possibility of storing the invisible images and inspecting them for a desired length of time when wanted.

The present intensifying devices concerned with reproduction of X-ray images are completely unsatisfactory, because at low levels of fluorescent illumination, such as we are dealing with, there is not enough of X-ray photons to be absorbed by fluorescent or photoelectric screens used in such devices. Therefore the original X-ray image can be reproduced by them only with a considerable loss of information. It is well known that the lack of sufficient number of X-ray quanta cannot be remedied by the increase of intensity of X-ray radiation, as it will result in damage to the patient's body. This basic deficiency of the X-ray examination was overcome in my invention by using an X-ray exposure of a strong intensity but of a short duration, and storing the invisible X-ray image for subsequent inspection for the desired length of time without any need of maintaining the X-ray irradiation. The X-ray or neutron beam, therefore, can be shut off while reading the stored X-ray image and in this way the total X-ray exposure received by the patient is not increased, in spite of using bursts of a great X-ray intensity. The storage of radar signals is well known in the art as evidenced by U. S. Patent No. 2,451,005 to P. K. Weimer. The novelty of my inven-

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tion consists of storing the images of invisible radiation and not only signals, and what is even more important, of storing simultaneously the total images instead of breaking them up into minute point images by scanning, in order to be able to store them. Further deficiency of the present storage systems, is that the stored image can be reproduced with a good definition only if they are not intensified in the process of reproduction. In my invention, intensification of stored images is accomplished without sacrificing detail and contrast of the stored image. This feature is of a great importance especially in X-ray examinations in which, without intensification of the order of 1000 the eye is confined to so-called scotopic vision, at which it is not able to perceive definition and contrast of the fluorescent X-ray image.

The purposes of my invention were accomplished by converting the invisible radiation images into photoelectron images by using the composite photo-cathode suitable for the particular kind of radiation applied. In case of dealing with X-ray radiation, said composite photocathode consists of light-reflecting layer, fluorescent layer, separating layer and photo-emissive layer. In case infra red radiation is used, such a composite photocathode has infra red transmitting visible light reflecting layer, such as of gold, and infra red sensitive fluorescent layer, separating layer and photoemissive layer. Instead of composite photo-cathode in some instances a simple photo-cathode consisting of a layer emitting electrons under the influence of radiation applied and of a backing plate, may be used.

The photoelectron image emitted from the photo-emissive layer, and having the pattern of invisible radiation image is intensified by acceleration, demagnification and if necessary by secondary emission, and is focused by means of magnetic or electrostatic fields on the image storage target of perforated type. A strong broad beam of electrons from another electron source disposed in the same vacuum tube is projected on that target covering simultaneously all points of the target. The photoelectron image deposited on the target controls the passage of said strong broad electron beam through the perforated target acting in a similar way to a grid in electronic tube. The transmitted electron beam is therefore modulated according to the pattern of the photo-electron image and is focused on the viewing fluorescent or other electron-reactive screen positioned in the same vacuum tube. The transmitted electron beam will reproduce the total image simultaneously and the reproduced image will be obviously greatly intensified as compared with the original image which was the primary objective of my invention. In view of the fact that the photoelectron image is deposited on the image storage target which is of dielectric or semi-conductor type, it will persist there for a long time. During all this time it will be able to control the strong broad electron beam which produces the intensified final image. In this way the image of invisible radiation can be stored and read when it is desired, which was another purpose of this invention.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings which show by way of example only preferred embodiments of the inventive idea.

In the drawings:

Figure 1 represents a sectional diagrammatic view of the invisible radiation sensitive image storage tube.

Figures 1a, b, c and d represent diagrammatic cross-sectional views of modifications of the storage target.

Figure 2 represents a sectional view of a modification of the image storage tube.

Figure 3 represents a plan view of the storage target.

Figure 4 represents a sectional diagrammatic view

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of a modification of the image storage tube having a simplified perforated storage target.

Figure 4a represents a diagrammatic sectional view of the storage target used in the embodiment of invention illustrated in Fig. 4.

Figure 5 represents a sectional view of a modification of the storage image tube shown in Fig. 4.

Figure 6 represents a sectional view of a modification of the image storage tube having an optical system.

Reference will now be made to Fig. 1, which represents invisible radiation image sensitive storage tube 1. In case the X-ray radiation 38 is used, the composite perforated photocathode 16 consists of a light reflecting slow electron impervious layer 4, a fluorescent layer 5, a very thin transparent dielectric layer 6 and a photoemissive mosaic layer 7. All said layers are in close apposition to each other and are deposited on a supporting mesh screen 3, which has a high percentage of openings therein, in such a manner as not to obstruct openings in said screen. The light reflecting layer 4 may be a very thin layer of aluminum or other metals transparent to invisible radiation used in examination, and is connected to the outside source of potential. It is obvious that the conducting layer may be used also between the fluorescent layer 5 and dielectric layer 6, in which case said conducting layer 4a must be light transparent and very thin, such as less than 0.25 millimeter thick, in order to preserve sharpness of X-ray image. Such layer may be of mica, glass, quartz, silicates or plastics coated with a conductive substance known under the name of "Nesa," manufactured by Pittsburgh Glass Co.

The fluorescent layer 5 may be of silicates, sulphides, ZnO, BaPbSO₄ or of organic phosphors, such as anthracene or naphthalene. The dielectric layer 6 has to be light transparent, very thin, such as less than 0.25 millimeter thick, in order to preserve sharpness of image, and to cause no chemical interference with fluorescent or photoemissive layers. Mica, glass, quartz, silicates or plastics of poor electric conductivity are best suitable for this purpose. The storage of the X-ray image depends on the electrical conductivity of said dielectric layer. 30-60 seconds are sufficient for inspection of one X-ray image. This means that the X-ray image has to be stored without deterioration for a period of time which is equivalent to a minute or a fraction thereof. The photoemissive mosaic layer 7 has to be correlated with the emission of the fluorescent layer. Caesium, potassium, rubidium or lithium on antimony, bismuth or arsenic are suitable materials for photoemissive layer.

The apertures in the screen 3 remain open because the layer 4, being evaporated on said screen can fuse only with the solid parts of the screen. Some apertures may become accidentally clogged during evaporation by a thin film but it is a rare occurrence. In such a case after evaporation of layer 4, a strong jet of air is directed against the screen and will cause rupture of any occluding membrane. The air will not dislodge the layer 4 from the solid parts of screen 3, as it becomes fused with the mesh of the screen during evaporation. The same procedure is followed in deposition of subsequent layers 5, 6 and 7. The fluorescent layer 5, may instead be deposited by evaporation, also sprayed with a suitable binder on the mesh screen 3, and afterwards fired.

In case infra-red radiation is used as a depicting radiation, the layer 4 has to be transparent to infra-red rays. A thin layer of gold is very suitable for this purpose. The fluorescent layer 5 may be, in such case, of alkaline earth selenides or sulphides activated with cerium, samarium or europium, of ZnSO₄ Pb or of CaSPb or of lanthanum oxysulphides with activators. The dielectric layer 6 may be of mica, glass, quartz or of plastic of poor electric conductivity. The photoemissive mosaic should be of CsOAg, which is the most sensitive in this region of spectrum.

In case neutrons are used as a depicting radiation, the

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fluorescent layer should be activated with elements which have a large cross-section for neutrons, such as boron, lithium, gadolinium or an additional neutron sensitive layer, such as of boron, lithium or gadolinium, should be disposed adjacent to fluorescent layer 5.

Better definition will be obtained by the use of evaporated phosphors, which have no grain structure and, therefore, are suitable for reproducing images of high definition. Such phosphors were described in the article published in the Journal of the Optical Society, August, 1951, page 589.

The light reflecting layer 4, the fluorescent layer 5, the dielectric light transparent layer 6 and the photoemissive layer 7 are deposited on the mesh screen 3, so that the openings 21 of said screen 3 remain unobstructed, as shown also in Fig. 3. The conducting mesh screen 3 serves here as a support for the other layers of the composite photocathode 16. In some applications, the conducting layer 4a may be used preferably as a supporting layer. In such a case, it is made of a fine mesh screen 4b or of perforated light transparent sheet, or of a perforated glass coated with "Nesa," which can be attached to the walls of the tube by means of metal rings. The perforations in said layer must be of a size of 25-50 microns and must be equal and spaced uniformly throughout the whole surface of said layer in order to be able to reproduce images without distortion. The best method of producing such perforated screen is by using photoengraving method. By stippling process photography the surface of said layer is covered with plurality of minute dots. Next, the dots are etched through the plate under electronic control. Another preferred method of producing perforated screens is to place a thin dielectric or conducting plate in the evacuated cathode-ray tube and to scan its surface with a sharply focused thin electron beam. By proper selection of the length of time, the electron beam remains in contact with each point of the plate, and of energy of said scanning electron beam, small holes may be burned through the plate in a uniform, symmetrical pattern, because of combined chemical and electrical etching action. The construction of this type of perforated photocathode 16a is illustrated in Fig. 1a, which shows the supporting layer in this embodiment of my invention to be the layer 4b. Also, the dielectric layer 6 may be used as a supporting member, as shown in Fig. 1b. In this embodiment, the layer 6a is of a dielectric perforated sheet, such as glass or of mesh screen coated with a transparent insulator such as quartz, glass or transparent plastic. The photocathode 16, 16a and 16b may be disposed in the image tube 1, so that they face the electron gun 22 with the photoemissive mosaic layer 7, as shown in Figs. 1, 1a and 1b.

Fig. 1a shows the photocathode 16a in which the photoemissive mosaic layer 7 faces the electron gun 22. Next to it, there are dielectric perforated layer 6, the conducting supporting mesh screen 4b, the fluorescent layer 5 and the light reflecting layer 4. Also, the reverse arrangement, in which the photoemissive mosaic 7 faces the invisible radiation image, may be used for the purposes of this invention, as illustrated in Figs. 1c and 1d. This type of the perforated photocathode can be well used for X-ray or neutron images, which can easily penetrate through the thin photoemissive layer 7 to reach the fluorescent layer 5, but it is not suitable for less penetrating radiation, such as infra-red images.

The invisible X-ray or neutron image of the object 14 is converted by the fluorescent layer 5 into a fluorescent image. The fluorescent image directly and by reflection from the light reflecting layer 4 passes through the transparent layers 4a and 6 and is converted in the photoemissive layer 7 into photoelectron image and then into a charge image. The charge image has the pattern of the original X-ray image and, being insulated by the dielectric layer 6, can be stored for a desired period of

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time. The stored X-ray image is irradiated by a slow electron beam 9 emitted from the cathode-ray gun 22. The electron gun is well known in the art and, therefore, does not have to be described in detail, in order not to complicate the drawings. The electron beam 9 is focused by the magnetic or electrostatic fields 34 on the composite photocathode 16. In front of the photocathode, it is decelerated by decelerating ring or mesh electrode 20, so that the electron beam approaches the mosaic 7 with a low velocity. The mosaic has a positive charge image on its surface, as explained above. The passage of the electron beam 9 through the openings 21 in the perforated photocathode 16 is controlled by the potentials present around said openings, which are due to the action of the invisible radiation image. In particular, the more positive the potentials around the openings 21, the more electrons of beam 9 will be transmitted. In this way, the potential image in the photocathode 16, which corresponds to the invisible radiation image, modulates the electron beam 9. The transmitted electron beam 9a will have, therefore, the pattern of the original invisible image. The transmitted electron beam 9a is bent by suitable magnetic fields 46 and is focused on fluorescent screen 25. It is of a much greater intensity than the original X-ray image, therefore, by converting said transmitted electron beam 9a into a visible image in the fluorescent screen 25, a marked intensification of the original X-ray image is obtained. The fluorescent screen 25 has an electron transparent, light reflecting layer 25a such as of aluminum, to prevent destructive back-scattering of light. Instead of fluorescent screen other electron reactive surfaces may be used, such as photographic films, electrolytic papers or electrographic plates. The transmitted electron beam 9a before its reproduction into visible image may be intensified by acceleration by fields 28 and 28a and by electron-optical demagnification. The final X-ray image can be examined for a desired length of time, as it is available as long as the charge image is present on the mosaic.

After the examination of the X-ray image has been concluded, the composite photocathode 16 has to be restored to its original condition before the next X-ray image can be stored. The mosaic layer 7 at the end of the reading has remaining positive charges thereon. In order to neutralize these charges, I spray the mosaic with a broad electron beam from the gun 22 with velocity, at which secondary electron emission ratio of the mosaic is below unity. This requires only change in potentials of fields 34 and 20, so that a broad beam of electrons is produced, and so that the electrons have the necessary velocity when striking the mosaic. In this way, the mosaic can be restored to the original condition rapidly.

In case the mosaic 7 is not facing electron gun 22, as illustrated in Figs. 1c and 1d, another electron gun which faces mosaic 7 may be provided for this purpose.

In order to increase sensitivity of this novel invisible radiation image storage tube, I made a modification shown in Fig. 2. The face 19 of the image tube 2 must be of material transparent to the type of the depicting radiation to be used. Inside of the face of the tube, there is a composite screen 13 comprising a very thin depicting radiation transparent and visible light reflecting layer 10a, which prevents the loss of the light from the adjacent fluorescent layer 10, very thin transparent layer 11 and photoemissive layer 12. The reflecting layer 10a may be of aluminum or silver. The fluorescent and photoemissive layers should be correlated so that under the influence of the depicting radiation, there is obtained a maximum output of photoemission. More particularly, the fluorescent layer should be composed of a material having its greatest sensitivity to the type of radiation to be used and the photoemissive material, likewise should have its maximum sensitivity to the wave-length emitted by the fluorescent layer. Fluorescent substances to be used are zinc silicates, zinc sulphides,

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zinc oxide, BaPbSO₄ or organic phosphors, such as anthracene or naphthalene with or without activators. The satisfactory photoemissive material will be in case of depicting radiation of infra red wave-length, caesium oxide activated by silver. In case of depicting radiation of short wave-length, such as X-rays 38 or gamma rays, the best photoemissive surface would be of caesium, potassium or lithium on antimony, arsenic or bismuth. The very thin transparent separating layer 11 may be of mica, silicates, quartz, or of a suitable transparent plastic, or glass coated with a conducting material, "Nesa." The separating layer must not exceed 0.25 millimeter in thickness in order to preserve the sharpness of image. The invisible X-ray image of the examined body 14 is converted into a fluorescent image in the fluorescent layer 10 and then into photoelectron image in the photoemissive layer 12. The photoelectron image 15 is accelerated and focused by the magnetic or electrostatic fields 18 on the composite target 16a. The focusing and accelerating fields are not indicated in detail as they are well known in the art and will only serve to complicate the drawings. Sometimes it is better to demagnify the photoelectron image electron-optically before projecting it on said target. This can be done by the use of electron lenses. The intensified photoelectron image is focused on the perforated target 16, 16a or 16b described above. The photoelectron image 15 strikes the storage target 16 with velocity, at which it can penetrate the layer 4 and excite the fluorescent layer 5. The fluorescent light from the layer 5 acts on the photoemissive mosaic 7. As a result, a positive charge image having the pattern of the original invisible radiation image, is stored in the layer 7, as was explained above.

It is obvious that the electron gun 22 and the storage target 16 may be disposed in many different ways, and it is to be understood that all such modifications come within the scope of this invention. In the invisible image storage tube 2, the electron gun 22 is shown to be at the angle to the long axis of the tube. This necessitates the use of magnetic fields 46 for bending the broad electron beam 9 and projecting it on the storage target 16a. The rest of the operation of the storage tube 2 is the same as described above for the storage tube 1.

The action of accelerating and focusing fields 18, 20, 34 and 28 and of electron gun 22 is of sequential character. At the time of the X-ray exposure, the fields 18 are simultaneously activated. At the time of reading the stored X-ray image, when electron gun 22 is in operation, the fields 20, 34, 46 and 28 are simultaneously activated, whereas fields 18 remain inactive.

The best contrast of the stored X-ray image is realized in the image pick-up storage tube 44, shown in Fig. 4. In this modification of my invention, the invisible X-ray image of the examined object 14 is converted by the composite screen 13, which has been described above, into a photoelectron image. The photoelectron image is accelerated by the electrode 18 and is focused by the electrostatic or magnetic fields on the perforated target 42, of poor electrical conductivity, such as of mica, glass, quartz, diamond, halides, ZnS, CdS or of a suitable plastic. The storage target 42 should be as thin as possible. For this purpose, the following target construction is adopted. The storage target in this modification consists of a supporting mesh screen 42a, on which a very thin layer of dielectric 42b, such as of diamond, halides, ZnS, CdS, quartz or glass, is deposited in such a manner that the openings in the mesh screen and in the dielectric layer remain unobstructed. With such a target, which may be 1 micron thin, the photoelectrons from the photocathode 13, when given a proper velocity, may pass to the opposite side of the target and form a charge image on the side facing the electron beam 9. This charge image has the pattern of the X-ray or neutron image, and is intensified markedly by the electron induced conduc-

tivity observed in thin dielectric layers subject to bombardment by an electron beam.

In some applications, a mesh screen 24, connected to the source of the electrical potential, may be used to improve electrical field across the target 42 during the writing, i. e., storing phase of the operation. In some cases, the decelerating electrode of mesh type 20 may serve for this purpose. In many cases, better results are obtained by using a pulsating electrical field. In particular, applying a square wave voltage of a low frequency, such as 15-30 cycles per second to the dielectric layer 42b, will improve the sensitivity of the storage target and will prevent "fatigue" effects. One terminal of said electric potential source is always applied to screen 42a; the other one may be connected also to conducting coating inside of wall of the tube.

The target 42 is irradiated by a slow electron beam 9 from the electron gun 22. The electron beam 9 is focused by magnetic or electrostatic fields 54, and is decelerated by the ring or mesh electrode 20, so that it arrives to the target with a very low velocity. A part of the scanning electron beam passes through the perforations in the target 42. The charge image on the target 42 controls the passage of the scanning electron beam acting in the similar manner to a grid in the electron tube. The transmitted electron beam 9a is modulated by the X-ray image stored as a charge image in the target 42. The transmitted electron beam 9a is bent by suitable magnetic fields 46 and is focused on fluorescent screen 55, it is of a much greater intensity than the original X-ray image; therefore, by converting said transmitted electron beam 9a into a visible image in the fluorescent screen 55, a marked intensification of the original X-ray image is obtained. The fluorescent screen 55 has an electron transparent, light reflecting layer 56, such as of aluminum, to prevent destructive back-scattering of light. Instead of fluorescent screen, other electron reactive surfaces may be used, such as photographic films, electrolytic papers or electrographic plates. The transmitted electron beam 9a before its reproduction into visible image may be intensified by acceleration by fields 28 and by electron-optical demagnification.

The operation of the image storage tube 44 is conducted in two stages. In the first stage, the X-ray image is converted into a photoelectron image, and said photoelectron image is stored as a charge image. In this phase, the electron gun 22, the magnetic field 46, as well as the decelerating electrode 20, are inactive. After the invisible radiation image has been stored, the electrode 24 and the focusing and accelerating fields 18 and 18a are inactivated and instead, the electron gun 22, as well as decelerating electrode 20, magnetic fields 46 and focusing fields 54 and 28 are activated now.

After the stored image has been read, the composite storage target 42 has to be restored to its original condition before the next X-ray image can be stored. The dielectric layer 42b, at the end of the reading, has some charges remaining thereon. If the remaining charges on the storage target are negative, which is the preferable way of storing the invisible radiation image, the velocity of electrons of the broad electron beam from the gun 22, must be such that they will cause secondary electron emission from the storage target higher than unity, and will thereby neutralize the remaining negative charges. If the X-ray image has been stored as a positive charge image, then the broad electron beam must have velocity at which the secondary emission ratio is below unity. This can be accomplished by proper adjustment of potentials of the electron gun 22 and of the electrode 20.

It is obvious that the perforated target 42 may be constructed in many different ways, and it is to be understood that all of them come within the scope of this invention. One of such modifications is shown in Fig. 4a, in which the dielectric layer 42b is deposited on the side of supporting mesh screen 42a closer to the source of in-

visible radiation 38. In such a case, it may be advisable to evaporate a thin layer 42c of metal or other protective material on the side of the dielectric layer 42b closer to the electron gun 22. In this arrangement, the mesh screen 24, if it is used, must be disposed between the dielectric layer 42b and the photocathode 13 in close proximity to said layer 42b. Also, the electron gun 22 may be disposed in many different ways, well known to those versed in this art, and it is to be understood that all such modifications are within the scope of my invention. In the embodiment of the invention shown in Fig. 5, the electron gun is at the angle in relation to the long axis of the pick-up-storage tube 58, whereas the fluorescent screen 55 is disposed in the long axis of said X-ray pick-up-storage tube.

My invention can also be used for intensification of images of invisible radiations, without storing them prior to their reading. In such a case, composite perforated target 16 or its modifications, as well as the dielectric target 42 have to have the conductivity allowing the stored charge to dissipate completely within a desired period of time. In this case, operation of the storage tube and of X-ray source, have to be continuous, instead of being intermittent, as was described above.

The sensitivity of invisible radiation pick-up-storage tube can be increased markedly by the use of a storage phosphor for the fluorescent layers 5 and 10 in the composite photocathodes 16 and 13 respectively. The invisible X-ray image is stored in said phosphor and is released therefrom in the form of fluorescent image, only after irradiation with an additional source of radiation such as infra-red. In this case, the visible light reflecting layer 4 or 10a obviously must be transparent to infra-red radiation. A thin layer of gold will be suitable for this purpose. Satisfactory phosphors for the storage of images are alkaline earth sulphides and selenides activated with cerium, samarium or europium, sulphides activated with lead or with copper or lanthanum oxysulphides with activators. In case image storage tube should serve for storage and detection of infra-red images, the photocathode should be irradiated with ultra-violet radiation from an extraneous source after the exposure to infra-red image. In such case, the visible light reflecting layer obviously has to be transparent to ultra-violet light. The phosphor of the fluorescent layer may be the same as described above, that is, such as of alkaline earth sulphides activated with lead or with copper.

The invisible radiation image may also be projected first on the fluorescent screen 60 outside of the image storage tube, so that the invisible radiation image is converted into a fluorescent image 14a. In such a case, the photocathode 13 has to be modified and will consist in this embodiment of my invention of a fluorescent light transparent, conducting layer 4a and of a photoemissive layer 12. The fluorescent X-ray image 14a is projected onto said photocathode 13a by an optical system 61 and is converted thereby into a photoelectron image 15a. The photoelectron image 15a is accelerated and projected onto perforated target. The rest of the operation of the image storage tube 36 is the same as described above and illustrated in Figs. 4 and 5. The photoelectron image 15a may be projected also on a perforated storage target 16a or its modifications.

It will thus be seen that there is provided a device, in which the several objects of this invention are achieved, and which is well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention, and as various changes might be made in the embodiment above set forth, it is to be understood that all matter herein set forth or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A device for the reproduction of invisible images comprising in combination perforated means comprising perforated fluorescent means for converting an invisible image into a fluorescent image and perforated photoelectric means for receiving said fluorescent image, means for forming an electron beam, means for irradiating with said electron beam said perforated photoelectric means to modulate the passage of said electron beam through said perforated means, and means for receiving electrons of said modulated beam.

2. In a device, as defined in claim 1, said perforated means comprising a perforated fluorescent layer, a perforated light transparent separating layer and a perforated photoelectric layer.

3. A perforated composite target comprising, a perforated fluorescent layer, a perforated light transparent dielectric layer and a perforated photoelectric layer.

4. In a device as defined in claim 1, said perforated means comprising a perforated fluorescent layer, a perforated light transparent conducting layer, a perforated light transparent dielectric layer and a perforated photoelectric layer.

5. In a device, as defined in claim 1, said perforated means comprising a perforated light reflecting layer, a perforated fluorescent layer, a perforated light transparent conducting layer, a perforated light transparent dielectric layer and a perforated photoemissive layer.

6. In a device, as defined in claim 1, said perforated means comprising a perforated conducting layer, perforated dielectric layer and perforated photoemissive mosaic layer.

7. A device for the reproduction of invisible images comprising in combination a screen for converting an invisible radiation image into a photoelectron image, a perforated composite target comprising perforated photoelectric means, means for focusing said photoelectron image on said target for converting said photoelectron image into a charge image and for storing said charge image in said target, means for forming an electron beam, means for irradiating with said electron beam said target to modulate the passage of said electron beam with said

stored charge image and means for receiving electrons of said modulated transmitted beam.

8. In a device as defined in claim 7, said composite image target comprising a perforated fluorescent layer, a perforated light transparent separating layer and a perforated photoemissive layer.

9. In a device as defined in claim 7, said composite image target comprising a perforated light reflecting layer, a perforated fluorescent layer, a perforated light transparent dielectric layer and a perforated photoemissive layer.

10. In a device, as defined in claim 7, said composite image target comprising a perforated fluorescent layer, a perforated light transparent conducting layer, a perforated light transparent dielectric layer and a perforated photoemissive layer.

11. In a device as defined in claim 7, said composite image target comprising a perforated light reflecting layer, a perforated fluorescent layer, a perforated light transparent conducting layer, a perforated light transparent dielectric layer and a perforated photoemissive layer.

12. In tubes, a composite target comprising a perforated fluorescent layer, a perforated light transparent separating layer and a perforated photoemissive layer.

13. In tubes a composite perforated screen comprising a perforated fluorescent layer and a perforated photoelectric layer.

14. In tubes a composite perforated screen comprising a perforated fluorescent layer and a perforated photoelectric layer having one surface thereof exposed.

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