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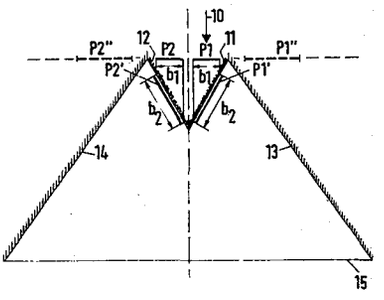
(54) X-ray screen device and its use for tomography.

(57) An X-ray screen device comprising a substrate (11, 12) that is transparent to light and is coated with a scintillating material adapted to generate light in response to X-radiation (10) incident thereon. The X-ray screen includes a plurality of sections having surfaces extending at a grazing angle relative to the incident X-radiation.



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TITLE MODIFIED
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Title: X-ray screen device.

The invention relates to an X-ray screen device comprising a substrate that is transparent to light and is coated with a scintillating material adapted to generate light in response to X-radiation incident thereon. The invention particularly relates to an X-ray screen device suited especially for converting X-ray shadow images, the information contents of which vary in only one direction, into light images. Such X-ray shadow images will hereinafter be called one-dimensional X-ray images, although in practice such images will never be one-dimensional in the mathematical sense of the word.

When designing and manufacturing an X-ray screen for converting X-ray shadow images into light images, which is also known by the name X-ray scintillator, always a compromise should be found between, on the one hand, the absorption properties in respect of X-radiation and, on the other hand, the absorption properties in respect of light. In order to achieve an X-ray screen absorbing as much X-radiation as possible, the screen should be provided with a thick layer of scintillating material. A drawback inherent in such a thick layer of scintillating material is that in this thick layer a large portion of the light generated by the scintillation is lost, so that the resultant light image will be of poor luminosity. Moreover, due to lateral dispersion of the light in the screen material, the light image will become blurred. The thicker the layer, the greater the lateral dispersion and the poorer the modulation transfer. Consequently, in order to achieve as good a light image as possible, the X-ray screen should be as thin as possible.

It is an object of the invention to provide such a screen that the two above conflicting requirements are satisfied both at the same time. To achieve this object, in accordance with the invention an X-ray screen device of the above type is characterized in that the X-ray screen com-

prises a plurality of sections having surfaces extending at a grazing angle relative to the incident X-radiation.

The invention will be described in greater detail hereinafter with reference to the accompanying drawing showing a number of embodiments of the invention. In this drawing:

Fig. 1 is a schematic illustration of the inventive idea underlying the present invention;

Fig. 2 shows a cross-sectional view of an embodiment of an X-ray scintillator according to the invention;

Fig. 3 and Fig. 4 show variants of the X-ray scintillator shown in Fig. 2;

Fig. 5 shows a cross-sectional view of another embodiment of the X-ray scintillator according to the invention; and

Fig. 6 shows a variant of Fig. 5.

Fig. 1 shows an X-ray screen or X-ray scintillator comprising a substrate 1 that is transparent to light, on which substrate a layer of scintillating material 2 is provided. The layer 2 is a granular layer having an average thickness d. Consequently, X-radiation incident in the direction of arrows 3 is confronted with an absorbing layer of a thickness d. In dependence upon the energy of the incident radiation and upon the point of incidence, this radiation penetrates the layer 2 to a greater or lesser depth before being absorbed and converted into light. The deeper the X-radiation penetrates layer 2, the brighter the light image obtained at the substrate side of the screen will be, as less light is being absorbed. The deeper the penetration, however, the greater the chances of a portion of the X-radiation passing through the screen without being absorbed, which is undesirable.

It is possible to increase the thickness of the screen with which the X-rays are confronted by causing the X-rays to be incident at an angle relative to the screen, for example as indicated by arrows 4. As the real thickness of the screen remains the same, the degree of light absorption likewise remains the same. Consequently, it is possible in principle to obtain an X-ray screen that is thick for incident X-radiation and thin for light, by simply positioning the screen at a grazing angle relative to the incident X-radiation. This simple solution, however, has the practical drawback that an image is obtained that is deformed in one direction, which is the x-direction in the drawing, as the image is extended in this direction.

This drawback is not relevant if the information contained in the

X-ray shadow image image does not vary in the x-direction. Such a situation occurs, for example, when constructing a tomogram, in which procedure an image of a cross-section of a body is formed from a plurality of profiles by means of back-projection. Details of this technique have been described in German Offenlegungsschrift 2,017,441 and in Dutch patent application 76,05254, open to public inspection. In this connection, a profile is an X-ray shadow image that is linear in theory but strip-like in actual practice and whose intensity varies in only one direction, i.e. the direction of the line or strip.

When constructing a tomogram from a plurality of profiles, a breadthwise extension of the strip-like profiles due to the manner of projecting constitutes no problem at all as such an extension is imperative indeed in constructing the tomogram. Consequently, if in the situation shown in Fig. 1 the profile extends normal to the plane of the drawing and is projected at an angle onto the screen, for example in the direction of arrows 4, the width of the profile is increased indeed (i.e. the width is greater that it would be in the event of a conventional projection normal to the screen as indicated by arrows 3) but no deformation in the longitudinal direction of the profile occurs.

Fig. 2 shows a cross-sectional view of an example of a practical embodiment of an X-ray scintillator suitable for tomography and based on the principles described above. The direction of the X-rays incident on a V-shaped X-ray screen is indicated by arrow 10. The V-shaped X-ray screen extends normal to the plane of the drawing and consists of two surfaces 11 and 12. Assuming that the incident X-radiation represents one or more profiles, the information contents of the profiles will vary only in a direction normal to the plane of the drawing. The included angle of the V-shaped screen and the width of the profiles can be selected so that the two surfaces 11 and 12 jointly receive the X-rays associated with a single profile. However, the X-ray scintillator is preferably dimensioned so that one or more profiles are projected onto each surface 11, 12. In practice, these different profiles are associated with different tomograms to be constructed.

Fig. 2 shows the situation in which a first profile P1 is projected onto screen section 11 and a second profile P2 is projected onto screen section 12. The profiles P1 and P2 have a width b1 determined by the thickness of the X-ray beam. The X-ray scintillator surfaces 11 and 12 convert the profiles P1 and P2 into light images P1' and P2' having a greater width b2.

In connection with the further processing of the profiles, it is often, but not always, desirable to project the profiles converted into light images P1' and P2' onto one and the same planar surface. To this end, the X-ray scintillator device is provided with reflective surfaces 13 and 14. In the embodiment shown, these surfaces are planar but, if desired, surfaces 13 and 14 may have a certain curvature in the plane of the drawing, for example if it is desired to anamorphotically project the profiles P1' and P2'.

The reflective surfaces 13 and 14 are mounted at an angle to each other and to screen sections 11 and 12. The angles are selected so that the reflected images P1" and P2" are in one plane. These images P1" and P2" can be projected in known per se manner by means of an optical projection system onto the entrance window of a television camera tube.

Preferably, screen sections 11 and 12 and reflective surfaces 13 and 14 are formed on surfaces of a prism-shaped piece of glass having a cross-sectional shape as shown in Fig. 2 with a bottom face or exit face 15. If desired, the exit face may be of cylindrical shape in order to achieve, if necessary in combination with other cylindric optical elements, an anamorphotic projection of high luminosity. Examples of such exit faces are shown in Fig. 3 and Fig. 4.

Fig. 5 shows another embodiment of an X-ray scintillator according to the invention. This embodiment is particularly suited for concurrently forming light images of a large number of juxtaposed X-ray shadow images, for example a plurality of profiles associated with different tomograms to be constructed.

The X-ray scintillator shown in Fig. 5 comprises a plurality of screen sections 50 through 57 mounted at an angle to the direction of X-ray incidence indicated by arrow 10, which screen sections extend normal to the plane of the drawing. In this embodiment, the profiles converted by the screen sections into light images are not projected onto a planar surface by means of reflective surfaces but by means of suitably shaped fibre optics elements 60 through 67. In cross-section, these fibre optics elements have the shape of a right-angled triangle, the hypotenuse of which is placed against a screen section. All profiles are projected onto an exit face 68 that may be planar as well as curved. It will be clear that two juxtaposed elements, such as 60 and 61, may be formed integrally or that even all the elements may be formed from a single fibre optics plate, as shown in Fig. 6. The embodiment illustrated by Fig. 5 as well as the embodiments illustrated by Figs. 6 and

7 may be combined with one or more anamorphotic lenses in a manner similar to that shown in Fig. 3 and Fig. 4. Each screen section can form a light image of one or more profiles or even of a part of a profile.

Fig. 6 shows a cross-sectional view of a variant of the embodiment shown in Fig. 5. This embodiment comprises a plurality of parallel screen sections 70 through 74 having their sides remote from the sides on which X-radiation is incident disposed against the oblique sides of projections of a fibre optics plate 75, which projections have the shape of a right-angled triangle in cross-section. All profiles are projected onto an exit face 76 of the fibre optics plate, which face may be a curved or a planar surface.

It is observed that only a few embodiments of the inventive idea have been described above. Various modifications of the embodiments described are obvious to the worker in the art. For example, in the embodiments shown in Figs. 2-4 the inwardly directed screen sections may just as well be directed outwardly, resulting in a screen of inverted V-shape. This modification and similar obvious modifications are considered to fall within the scope of the invention.

It is further observed that in the above the invention has been described with reference to the application of the inventive idea to a device for tomography. The invention, however, is equally applicable to other situations in which one-dimensional X-ray shadow images are to be processed and even to situations involving two-dimensional X-ray shadow images if a certain deformation of the image is either acceptable or can be readily eliminated during the further processing of the images.

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1. An X-ray screen device comprising a substrate that is transparent to light and is coated with a scintillating material adapted to generate light in response to X-radiation incident thereon, characterized in that the X-ray screen comprises a plurality of sections having surfaces extending at a grazing angle relative to the incident X-radiation.

2. An X-ray screen device according to claim 1, characterized in that the X-ray screen comprises means adapted to transmit the light images formed by the sections extending at an angle relative to the incident X-radiation to a single surface.

3. An X-ray screen device according to claim 2, characterized by two planar sections each constituting, in cross-section, one of the legs of a V-shape having its inside coated with the scintillating material; and by two reflecting surfaces located outside the V-shape, which reflecting surfaces each enclose an acute angle with one of the legs of the V-shape so as to reflect the light images formed by the sections so that said images are brought to a single surface.

4. An X-ray screen device according to claim 3, characterized by a prismatic glass body having its side faces provided with an internally reflecting layer and having its top face provided with a V-shaped groove having its walls coated with scintillating material.

5. An X-ray screen device according to claim 4, characterized in that the bottom face is curved so as to cause an anamorphotic projection of the images reflected by the reflecting layers.

6. An X-ray screen device according to claim 2, characterized by a substrate consisting of a flat fibre optics plate having its optical fibres extending normal to its top and bottom surfaces, a plurality of juxtaposed and laterally adjoining grooves of equal shape being formed in the top surface of said plate, the walls of which grooves are always parallel with the corresponding walls of adjacent grooves and are coated with scintillating material.

7. An X-ray screen device according to claim 6, characterized in that the grooves of equal shape each have one wall extending parallel with the direction of the optical fibres.

8. An X-ray screen device according to claim 6, characterized in that the grooves are of V-shaped cross-section and that both walls of each groove are coated with scintillating material.

9. An X-ray screen device according to any one of claims 6-8, characterized in that the substrate includes anamorphotic lens means on its side remote from the side in which the grooves are formed.

10. An X-ray device for forming and displaying X-ray shadow images, characterized by an X-ray screen device according to any one of claims 1-9.

11. A device for tomography for constructing a tomogram from profiles, characterized by an X-ray screen device according to any one of claims 1-9, in which the sections placed at an angle extend parallel with the longitudinal direction of the profiles.

FIG. 1

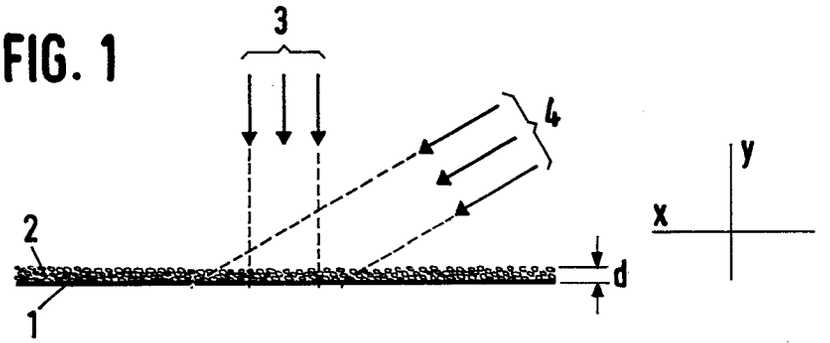

FIG. 2

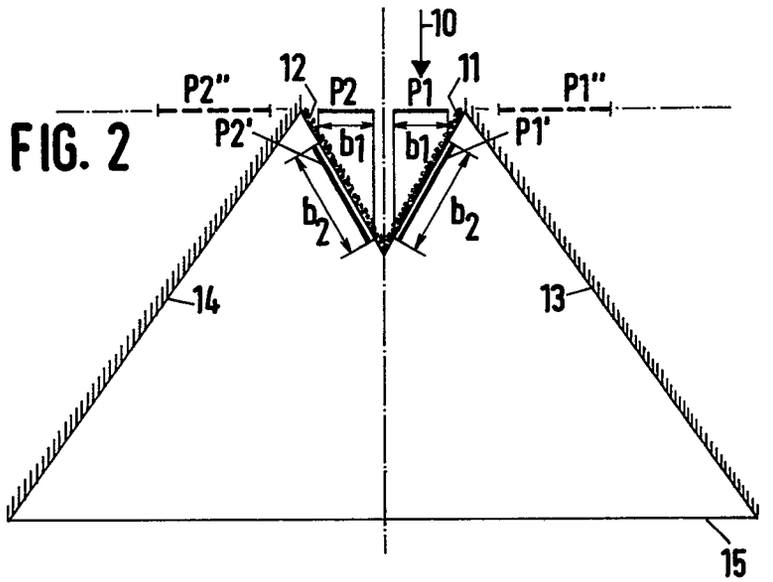

FIG. 3

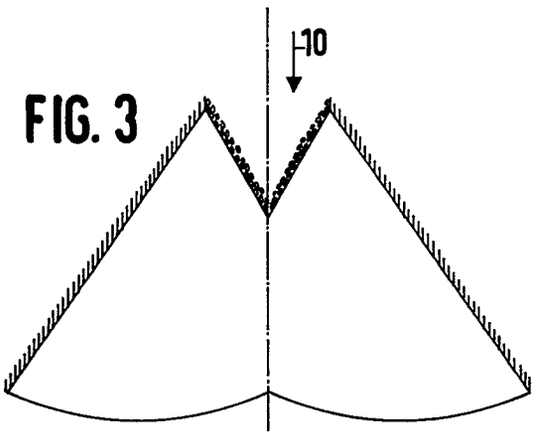

FIG. 4

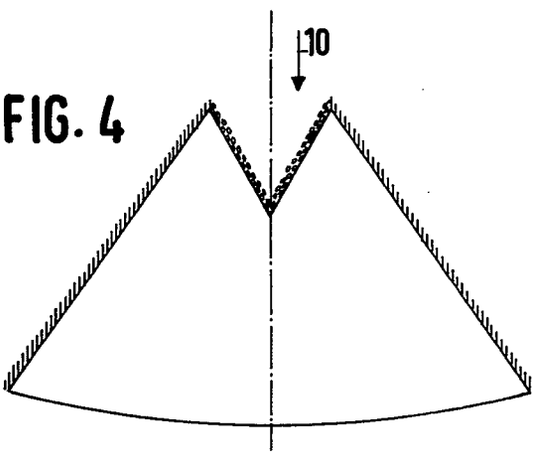

FIG. 5

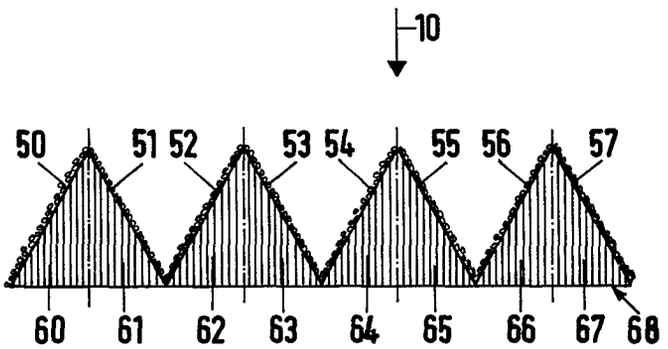
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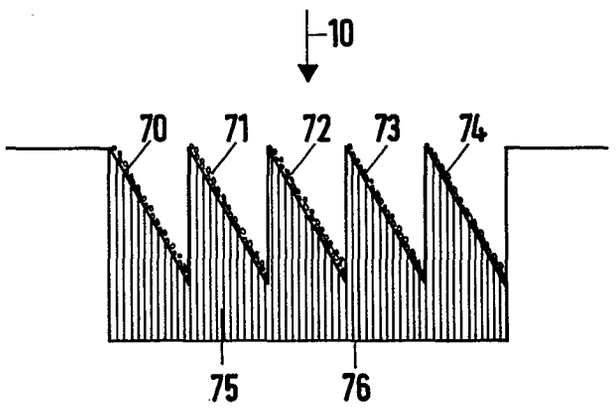
FIG. 6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European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 79 20 0734

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - A - 2 004 622 (VARIAN ASSOCIATES) * Page 6, last paragraph - page 8, first paragraph; figures 4,5 *	1,6,10
	US - A - 3 378 388 (A. NAWIJN) * Column 1, line 62 - column 2, line 12; column 2, lines 25-66; figure 2 *	1,10
	US - A - 3 584 216 (J.F. TINNEY) * Claims 1,3-5; column 2, line 66 - column 3, line 8; figure 3 *	1,10

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

G 21 K 4/00
G 03 C 5/17

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

G 21 K 4/00
G 03 C 5/17
G 01 T 1/20
G 01 T 1/16

CATEGORY OF CITED DOCUMENTS

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	19-02-1980	DECANNIERE

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