

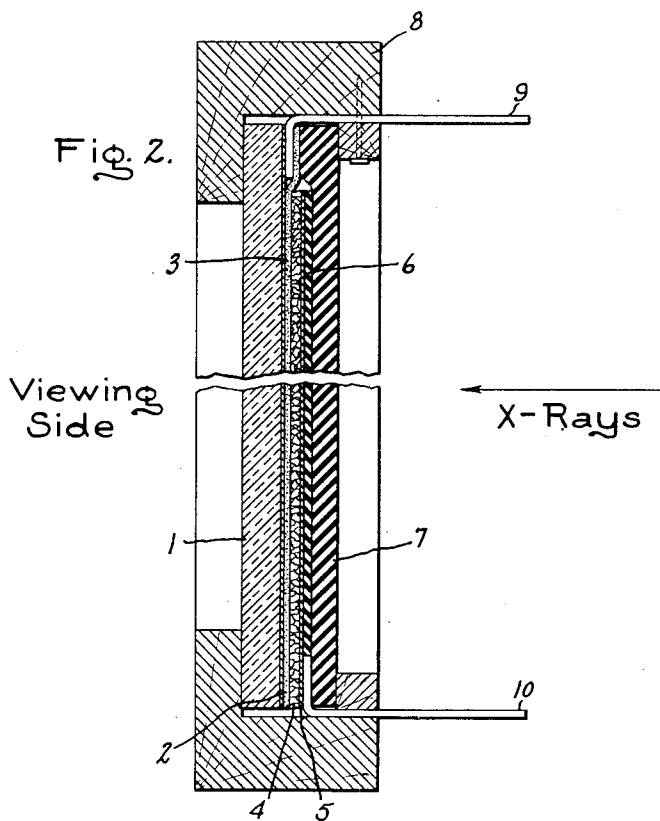
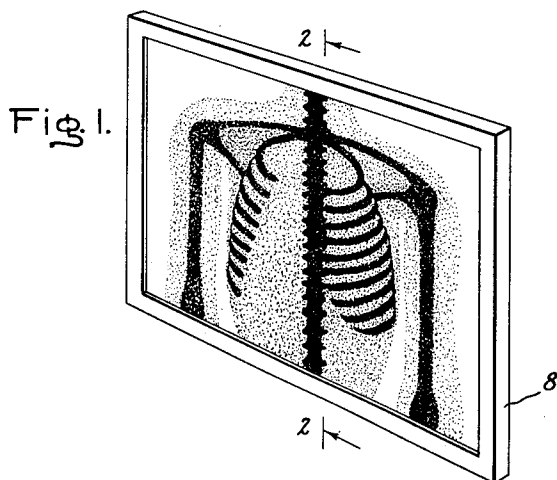
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X-RAY IMAGE INTENSIFICATION AND METHOD

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X-RAY IMAGE INTENSIFICATION AND METHOD

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The present invention relates to the visual intensification of images produced by X-rays. It has been desired for many years to produce brighter X-ray images without operating at higher X-ray intensity. The patient being examined, the examining doctor, the X-ray technician and others dealing with X-ray examinations would be endangered by X-ray exposure if brighter images were to be obtained by increase of X-ray intensity.

Heretofore visual images of an X-ray beam have been produced by the fluorescence of phosphors when bombarded by X-rays, for example, calcium tungstate.

It is the object of my invention to provide a method and means for producing X-ray images or greater luminosity than is possible by fluorescence of phosphors while at the same time keeping down the X-ray intensity to a level that is not dangerous to those exposed to X-ray radiation.

In accordance with my invention visual images corresponding to an invisible X-ray pattern are produced by an electroluminescent material through the intermediary effect of a medium, the electrical impedance of which is subject to variations by the passage of X-ray therethrough.

In the accompanying drawing Fig. 1 shows in perspective a framed X-ray intensifier and Fig. 2 is a cross-section taken on the lines 2—2 of Fig. 1 (in the direction of the arrows) and shows an assembly of elements for carrying out my invention.

Referring to Fig. 2, a plate 1 of a light-transparent material, such as glass, is provided with a light-transparent electrically conducting coating 2 on the inside surface of the glass. Glasses provided with a light-transparent conducting coating are commercially available utilizing, for example, of conducting tin oxide. On this conducting film 2 is deposited a thin layer or stratum 3 of electroluminescent phosphor material bonded by a resinous dielectric material, or otherwise applied as a thin layer over the surface of the conducting film 2. Electroluminescent phosphors are described in scientific literature and consist of a material which becomes luminescent in an electric field. For example, U. S. patent application, Serial No. 245,696, Jerome S. Prener, filed September 8, 1951, which is assigned to the same assignee as the present application, describes a phosphor of this type which consists of a fired mixture of about 60 parts zinc sulfide, 15 parts zinc selenide and about 0.5 part copper. If zinc oxide is present as an impurity in such

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mixture it should be dissolved from the product by treatment with acetic acid or other mild acid which may be followed by washing with a dilute solution of an alkali cyanide. The resulting powder is suspended in a dielectric material of high dielectric constant. An electroluminescent phosphor is described in Mager U. S. Patent 2,566,349.

Contiguous with the stratum of electroluminescent material is a material, the electric impedance of which is subject to change due to the X-rays passing therethrough, as exemplified by a stratum 4 of closely packed cadmium sulfide crystals. In the absence of X-ray excitation the impedance of the stratum is higher than the impedance of the electroluminescent stratum 3. Electric contact is made to the stratum 3 at the exposed side (opposite contact between strata 3 and 4) with a yielding material which conforms with surface inequalities of the exposed side of stratum 4. For example, desired contact may be made with a very thin sheet 5 of aluminum backed by a sheet 6 of soft elastomer, such as rubber, so that by a gentle application of pressure, contact will be made over the extent of the stratum 4 even though such stratum should have an uneven surface as will be the case if it consists of particles of varying size. The soft pressure-exerting sheet 6 is backed by a stiff sheet 7 of non-conducting material which is transparent to X-rays. It may consist of a suitable glass or a hard resin.

The described cooperating members are held in desired relation by a frame 8. Electrical contacts to the conducting coating 2 and to the backing sheet of aluminum 5 are made respectively by the conductors 9 and 10. To these conductors is connected a source of alternating current having a frequency and voltage suitable for the electroluminescent material that is employed. Assuming a source of alternating current of suitable frequency (as, for example, 1 to 5 kilocycles) to be connected to the conductors 9, 10 and X-rays impinging on the screen as indicated by the arrow, the impedance of the sulfide crystals is lowered to a degree depending on the intensity of the X-rays.

When X-rays (as indicated by an arrow) strike the stratum 4 of cadmium sulfide crystals the impedance of this material is lowered. The resulting variation of electric field will produce a corresponding variable pattern of the light generated by the electroluminescent material. For example, a spot of high X-ray intensity will result in a correspondingly bright spot of the elec-

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electroluminescence layer 3. Another spot of low X-ray intensity which may be due to interception of X-rays by a dense object (for example, a bullet imbedded in tissue) will result in little or no change of resistance in a corresponding adjacent spot of the layer 3. The result will be a shadow in the picture corresponding to the outline of the bullet.

By means of the arrangement described, a luminous image will be produced in the layer of electroluminescent material 3 and visible through the glass 1 looking from the left side of Fig. 2, as indicated. This image will be brighter than that obtained by the use of a well-known materials that fluoresce directly due to X-ray impingement. The crystals whose conductivity is sensitive to X-rays introduce an element of amplification. A brighter image thus results than could be obtained from any known X-ray-responsive phosphor because the power to supply this increase comes from an independent electrical source. This introduces a degree of intensification, the X-rays having what may be called a triggering effect on the electroluminescence of the material which is energized from the independent source.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of producing an intensified optically visible image corresponding to an optically invisible X-ray image comprising the following steps: (a) arranging particles of crystalline material which will change in electrical resistivity when irradiated with X-rays as a panel of desired spatial configuration and closely adjacent to one another (b) arranging a second panel of an electroluminescent phosphor substantially coextensive with and in close proximity to said first panel particles (c) setting up an electric field between said panels, and (d) subjecting said first-mentioned panel to X-ray radiation to be identified, whereby resulting changes in electric field distribution therein will produce an optically visible image in said second-mentioned panel.

2. The method of reproducing, a visual image, 45

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variations of an X-ray beam which consists in causing said variations to initiate corresponding variations of electric impedance in a body of cadmium sulfide crystals, impressing a high frequency electric field on said crystals, and exposing an electroluminescent material to the resulting pattern of electric field variations whereby a corresponding and intensified visual pattern is produced.

3. An X-ray image intensifier comprising the combination of a stratum of material, the electric impedance of which is subject to change by X-ray excitation, a stratum of electroluminescent material, means for supporting said respective strata in contiguous position, means for impressing an electric field on said strata.

4. An X-ray screen comprising the combination of a layer of cadmium sulfide, a contiguous layer of electroluminescent material, circuit means connecting said layers electrically in series, the impedance of said cadmium sulfide layer in the absence of X-ray excitation being higher than the impedance of said electroluminescent material, and means for impressing on said cadmium sulfide layer an X-ray beam having a contrasting pattern of intensity capable of being reproduced visually by said electroluminescent layer.

5. An X-ray image intensifier comprising a film of luminescent phosphor, a transparent support therefor, a layer of crystalline cadmium sulfide adjacent to and substantially coextensive with said phosphor, means for making electrical contact respectively with said phosphor film and said sulfide layer and means for impressing an electric field upon said electric contacts.

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Number	Name	Date
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2,555,545	Hunter et al.	June 5, 1951
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