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SAFETY FLUOROSCOPE WITH AN ALERTING DEVICE OF CONTRASTING COLOR SURROUNDING THE SCREEN

Original Filed Jan. 15, 1960

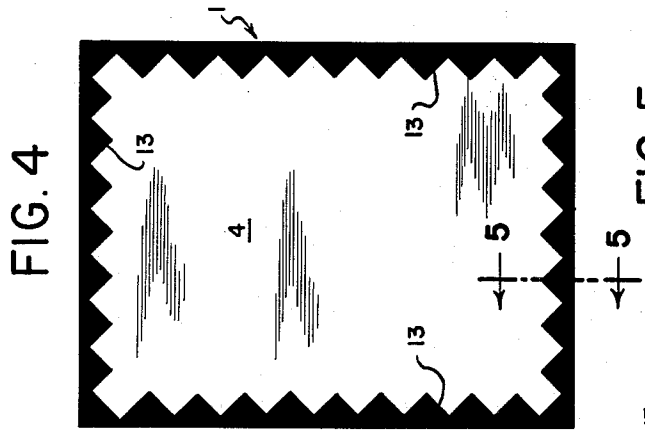

FIG. 4

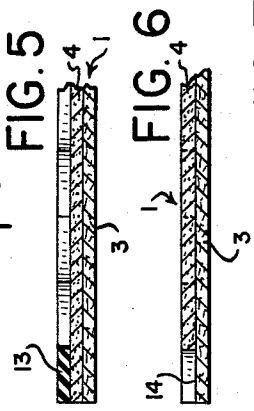

FIG. 5

FIG. 6

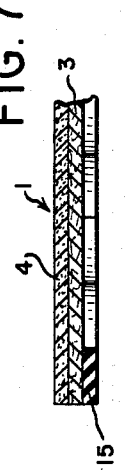

FIG. 7

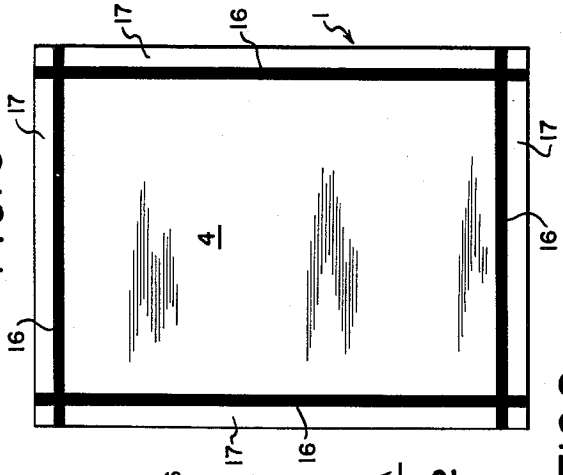

FIG. 8

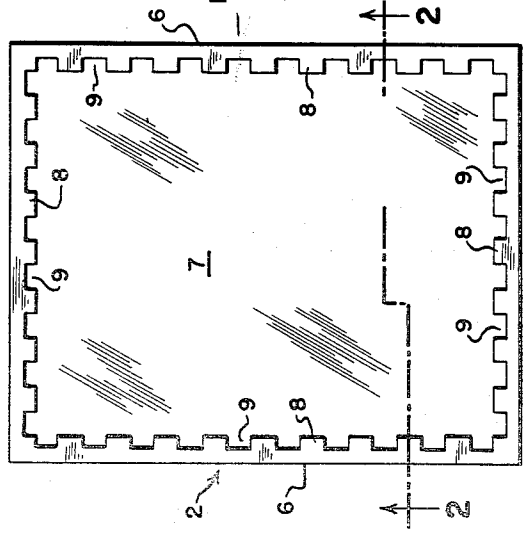

FIG. 1

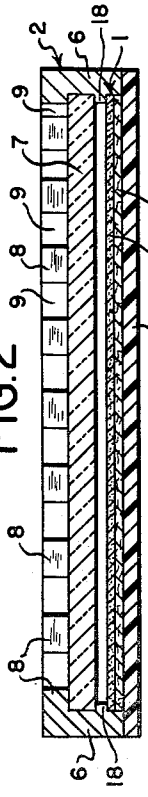

FIG. 2

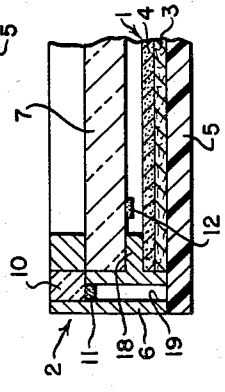

FIG. 3

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SAFETY FLUOROSCOPE WITH AN ALERTING DEVICE OF CONTRASTING COLOR SURROUNDING THE SCREEN

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Continuation of application Ser. No. 2,658, Jan. 15, 1960. This application Dec. 28, 1962, Ser. No. 248,848
4 Claims. (Cl. 250—80)

This invention relates to X-ray fluoroscopes, and is directed to means whereby to minimize exposure of the fluoroscopist to dangerous radiation.

This is a continuation of our application Ser. No. 2,658, filed January 15, 1960.

In the practice of fluoroscopy, it is customary to place the object or person being examined between the source of X-rays and a fluoroscope. The radiologist or fluoroscopist must then stand in front of the fluoroscope to examine the image thereon. In so doing, he may subject himself to the X-rays which pass beyond the peripheral edges of the fluoroscope. This is due to the fact that the X-ray beam which is emitted by X-ray tubes, especially with older equipment, may diverge considerably beyond the extreme edges of the fluoroscope. Usually, the portions of the X-ray beam which enter the fluoroscope do not pass through it because the face of the fluoroscope screen which is to be observed, is covered with a thick layer of glass containing sufficient lead to absorb most, if not all, of the X-rays at that point. Because of this shielding provided by the fluoroscope itself, it is obviously important to keep the X-ray beam confined to the area covered by the protective glass. However, with the ordinary fluoroscope assembly, this is often difficult to accomplish because, in practice, the X-ray tube or the fluoroscope, or both, must be moved about to accommodate objects of different sizes and thicknesses, and placed at different relative locations, as well as to permit examination in various directions through the object.

Heretofore, there has been no successful means, other than clumsy and expensive accessory apparatus, by which the fluoroscopist could determine whether the edge of the X-ray beam was confined within the edge of the protective fluoroscope, or was divergent beyond the fluoroscope, thereby exposing him to dangerous radiation.

In accordance with the present invention, the peripheral portion of the fluoroscope is provided with an indicating border which produces continuous visible warning to the fluoroscopist whenever the X-ray beam diverges beyond the working area of the fluoroscope screen, even at very low levels of radiation or screen brightness. This border can be incorporated in the screen itself or in the frame around the screen, or in both; and the cost thereof is negligible compared to the value of the safety it provides.

The nature of the invention and its several advantages will be understood from the following description considered in connection with the accompanying drawing in which

FIG. 1 is a plan view of the front of a fluoroscope assembly which includes the invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary view in cross-section of a fluoroscope which includes two similar embodiments of the invention;

FIG. 4 is a plan view of the front of a fluorescent screen including another embodiment of the invention;

FIG. 5 is a fragmentary view in cross-section taken along the line 5—5 of FIG. 4;

FIGS. 6 and 7 are fragmentary views in cross-section of fluoroscope screens of additional embodiments of the invention; and

FIG. 8 is a plan view of another modification of a fluoroscope screen which, because of its simplicity, may be preferred.

Referring first to FIGS. 1 and 2, the fluoroscope comprises, basically, a screen 1 and a screen holder or frame 2 in which the screen is mounted. The screen itself comprises, in accordance with general practice, a backing sheet 3 and a phosphor layer or coating layer 4 on the face of the sheet. Customarily, the backing sheets are of hard paper or cardboard but sometimes of suitable plastic. The phosphor coating is customarily of the silver-activated zinc cadmium sulphide type. When excited by X-rays of uniform intensity this type of phosphor emits a greenish light of uniform brightness. By changing the ingredients or the proportions of the ingredients, it is possible to change the color of the emitted light as well as the brightness of such light under given conditions of excitation, in well known manner.

The simple fluoroscope screen as above described, is customarily mounted for use in a holder or frame which comprises a bottom plate 5 of thin stiff material such as Bakelite or thin aluminum, but which in any case should be as nearly transparent as possible to X-rays. This bottom plate is suitably secured, as by screws, to the steel side pieces 6, four of which complete the rectangular enclosure. Supported in the side pieces and spaced slightly above the surface of the phosphor layer 4 is a thick transparent glass plate 7 which comprises a front cover for the fluoroscope. This plate not only protects the phosphor from dirt and abrasion, but it also protects the fluoroscopist from the X-rays because it is of lead glass ¼ inch or more in thickness.

In use, the fluoroscope is positioned with the bottom plate 5 toward the source of X-rays; viz., the object or person to be examined is interposed between the X-ray tube and the fluoroscope, usually with the plate 5 as close as possible to the object. When the X-rays penetrate the object, they impinge on the phosphor layer 4 and excite it to various degrees of brightness in inverse proportion to the absorption of the X-rays as they pass through the object. The resulting image is observed by the fluoroscopist when he looks at the phosphor through the glass cover 7. As above implied, the X-ray absorption characteristics of the glass 7 should be sufficient to absorb such X-rays as retain sufficient energy to emerge from the surface of the phosphor layer 4.

From the foregoing, it will be evident that if the beam of X-rays is restricted in its cross-section to an area which does not extend beyond that of the glass cover, the radiologist or fluoroscopist will not be subjected to dangerous X-ray radiation. However, if the X-ray beam diverges beyond the extreme periphery of the glass cover on any side, such unattenuated X-rays may be absorbed by the fluoroscopist without his being aware of the fact. Accordingly, the present invention provides a simple but

effective indicating means which warns the fluoroscopist whenever the beam of X-rays diverges to or beyond the frame portion which surrounds the fluoroscope screen. Since this visible warning exhibits brightness contrast at all degrees of brightness, it is effective even at very low brightness values.

Still referring to FIGS. 1 and 2, it will be seen that the side pieces **6** at their top portions overlap the peripheral edge of the glass cover **7**, and the screen **1** beneath it in a structurally irregular manner. In this embodiment, these irregularities comprise rectangular pieces or tabs **8** which extends inwardly of the edge of phosphor layer **4** thereby masking alternate small areas around the edge of the phosphor screen. Since these tabs **8** are opaque to light, the areas of the phosphor immediately beneath these tabs will be shielded from view, so that the intervening unshielded areas **9** will appear bright and the areas shielded by the tabs **8** will appear dark. The general effect of this construction is that when the X-ray beam is excessively and dangerously divergent, the illuminated periphery of the fluoroscope will have a scalloped appearance, and this will comprise a warning indication. Obviously, the form or shape of the irregularities in the frame can be varied as desired, so long as the contour is irregular or otherwise presents adjacent areas differing sufficiently in brightness.

A modification of the fluoroscope frame above described is illustrated in FIG. 3 in which corresponding components are indicated by the same reference characters. Here, however, the side pieces **6** are modified to a greater extent. In this embodiment, the side pieces are provided with a series of apertures **19** spaced at suitable intervals around the entire periphery of the frame. These apertures may be rectangular, round, or of other cross-sectional shape, but their purpose is to permit the passage therethrough of X-rays after they have penetrated the bottom plate **5**. At the top or front of each aperture is a plug **10** of transparent lead glass similar to that of cover **7** which is included for the same purposes. On the bottom of the glass plug **10**, is an auxiliary layer of phosphor **11** which will be excited to fluorescence when subjected to X-rays passing through aperture **19**. The resulting light will appear as a small bright area visible from in front of the glass plug **10**. If desired, the glass plug **10** may be tinted to cause the illumination thereof to be more significant, or a color phosphor may be used. Whether or not the glass **10** is tinted, it is usually preferable to employ for the coating **11** a high brightness phosphor.

A variation of the embodiment of the invention last above described is represented in FIG. 3 by the layer **12** which comprises a color filter, or equivalent, on the inside of glass cover **7**. This filter may comprise a continuous strip around the visible periphery of the cover plate **7** or preferably it may comprise a series of spaced or irregular areas around the same margin. If it is continuous it should be spaced away from the ledge **18**, as shown, to provide brightness contrast on both sides of the strip. Alternatively, strip **12** may be of a phosphor material or the like which will become luminous when subjected to the light from phosphor **4**; or this material may be directly on or in the phosphor **4**. Materials suitable for this purpose are the organic phosphors metadiethylaminophenolphthalein hydrochloride and metadiethylaminophenolsuccein hydrochloride. These organic materials may be applied in the form of spray or tape.

The interrupted form of strip configuration is often preferred for the reason already explained, namely, that a series of indicating areas which are adjacent to areas of contrasting brightness are much more clearly observable especially when the brightness of the brighter area is of a low degree. This is especially true in respect to color areas because it is well known that the human

eye loses color contrast sensitivity at a brightness of the order of 10 microlamberts. If the layer **12** is a color filter, the color thereof should be selected to be compatible with the color spectrum of the light emitted by the phosphor **4** as well as to be visible to a maximum degree at low brightness levels. From the foregoing description of the construction of the fluoroscope illustrated in FIG. 3, it will be clear that both embodiments of the invention there illustrated may be simultaneously employed if desired.

The objects of this invention can be achieved with equal success by incorporating the invention in the fluoroscope screen itself rather than in the screen holder or frame. Several alternative embodiments of such screens are illustrated in FIGS. 4–2 inclusive. FIGS. 4 and 5 illustrate a fluoroscope screen of which the central or "working" portion is of the same construction as the screen **1** of FIGS. 1, 2. Here, however, the periphery of the phosphor layer **4** is masked with a frame or border of light-opaque material **13** which is of irregular conformation. The irregularities are in the form of equilateral triangles instead of rectangles as in FIG. 1. Black plastic pressure-sensitive tape properly cut may be used for this purpose, although a large variety of other opaque materials are equally suitable. Some of these may be applied by spraying, painting or printing. A screen as shown in FIGS. 4 and 5 is suitable for use in a standard fluoroscope holder or frame in which it will provide warning indications as described in connection with the preceding embodiments. Any of the screens herein described may also be employed in combination with the holders of FIGS. 1–3, if desired. From FIG. 4 it is evident that when the fluoroscope screen is subjected to X-rays up to or beyond the peripheral frame, the portions thereof which appear alternately white and black in the drawing will appear bright and dark, respectively, on the fluorescent screen, thus providing the desired warning indications by brightness contrast. The light-opaque material **13** described in connection with FIGS. 4 and 5, may be replaced in any of the screens by a color filter material or by an inorganic or organic phosphor, or the like, as mentioned in connection with layer **12** of FIG. 3. This will provide warning indications equally as clear and of the same nature as those previously described.

An alternative embodiment of the screen of FIGS. 4 and 5 is represented in FIG. 6 wherein, instead of adding a structurally irregular masking or color border around the periphery of the screen, the phosphor layer itself is omitted in the same irregular pattern. Hence, a repetition of the surface area **14** of the backing sheet **3** where the phosphor layer has been omitted, if represented in plan view around the peripheral margin of the screen, would have the appearance of FIG. 4. In this case, the dark triangular areas **13** shown in FIG. 4 would also appear to be dark or non-illuminated in the structure of FIG. 6 because such portions carry no phosphor. As before, the pattern formed by these irregularities may be chosen from a wide variety of possible shapes although, in general, it is preferable for the present purpose that they comprise regularly repeated geometrical shapes and that the alternate light and dark areas be large enough to be clearly distinguishable at low brightness levels of the fluorescent areas.

The embodiment illustrated in FIG. 7 provides the same optical effect as previously described in connection with the preceding embodiments, especially those of FIGS. 1, 4, 5 and 6. However, here, instead of masking or shielding the light emitted by the phosphor, the mask is disposed on the bottom of the backing sheet of the screen and constitutes a shield against the penetration of X-rays. Accordingly, a suitable X-ray absorbing material **15**, which may contain lead or the equivalent, is affixed to the underside of the backing sheet **3**. The

phosphor layer **4** is the same as previously described. Likewise, the location and conformation of the X-ray-opaque material **15** may be assumed to be the same or equivalent to those of the materials **13** described in connection with FIGS. 4 and 5. Obviously, the effect of material **15** will be to prevent the X-rays from exciting the phosphor areas immediately above, so the latter areas will not fluoresce and will, therefore, appear to be dark with respect to the adjacent fluorescent areas. The material **15** may be disposed in or on the bottom plate **5** of the screen holder, or elsewhere in the X-ray path, to achieve the same result.

The embodiment of the invention illustrated in FIG. 8 is a variation of the embodiment of FIG. 4, the two being fundamentally the same. This embodiment, however, is the simplest of all those herein described and, for that reason, may be considered to be the preferable one. This screen comprises a phosphor layer **4** of uniform thickness supported on a backing sheet as previously described. The irregular peripheral areas are, in this instance, formed by applying a strip **16** of organic phosphor, opaque pigment, dye, masking tape, or the equivalent, as previously discussed, near each edge of the phosphor layer, but spaced inwardly thereof sufficiently to leave a clearly visible bright phosphor strip **17** between the strip **16** and the inside edge of the frame of the holder in which the screen is used. If this strip **16** is say, ¼ inch in width or slightly more, and the outside phosphor strips **17** are at least as wide, the divergent X-ray beam will be clearly indicated whenever it expands beyond the safe limit of the fluoroscope. If the strip **16** is applied in tape form, holes may be punched in it before it is applied, to accentuate the warning effect. Many variations and modifications of the invention, in addition to those previously described, will occur to those skilled in the art, all being within the scope of the appended claims.

We claim:

1. In a fluoroscope screen assembly having a frontside partly defined by a central working area in the whole of which is visible a primary phosphor coating excitable to luminescence of a given apparent color by an X-ray beam directed toward the opposite side of said screen assembly, and also partly defined by an edge area surrounding said working area and not excitable to luminescence by said X-ray beam; an alerting device for indicating visually on the frontside of said screen assembly when said X-ray beam is not confined to said working area comprising:

(a) a border portion defining a part of the screen assembly frontside circumscribing said working area and dividing it from said edge area, and

(b) at least one secondary X-ray excitable phosphor coating visible from the frontside of said assembly in at least part of said border portion and contrasting markedly from said primary coating in apparent color when excited by said X-ray beam.

2. A fluoroscope screen assembly according to claim **1** wherein one secondary phosphor coating is visible from the frontside of said assembly in the whole of said border portion and contrasts markedly from said primary coating in apparent color when excited by said X-ray beam.

3. A fluoroscope screen assembly according to claim **2** wherein the phosphors of the primary and secondary coatings differ from one another in the color characteristics of the light emitted thereby when both are excited to luminescence by said X-ray beam.

4. A fluoroscope screen assembly according to claim **2** wherein a strip of translucent color filter material is disposed over said secondary phosphor coating, said color filter material causing the light emitted by said secondary phosphor coating to contrast markedly in apparent color from that emitted by said primary phosphor coating when both are excited to luminescence by said X-ray beam.

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