

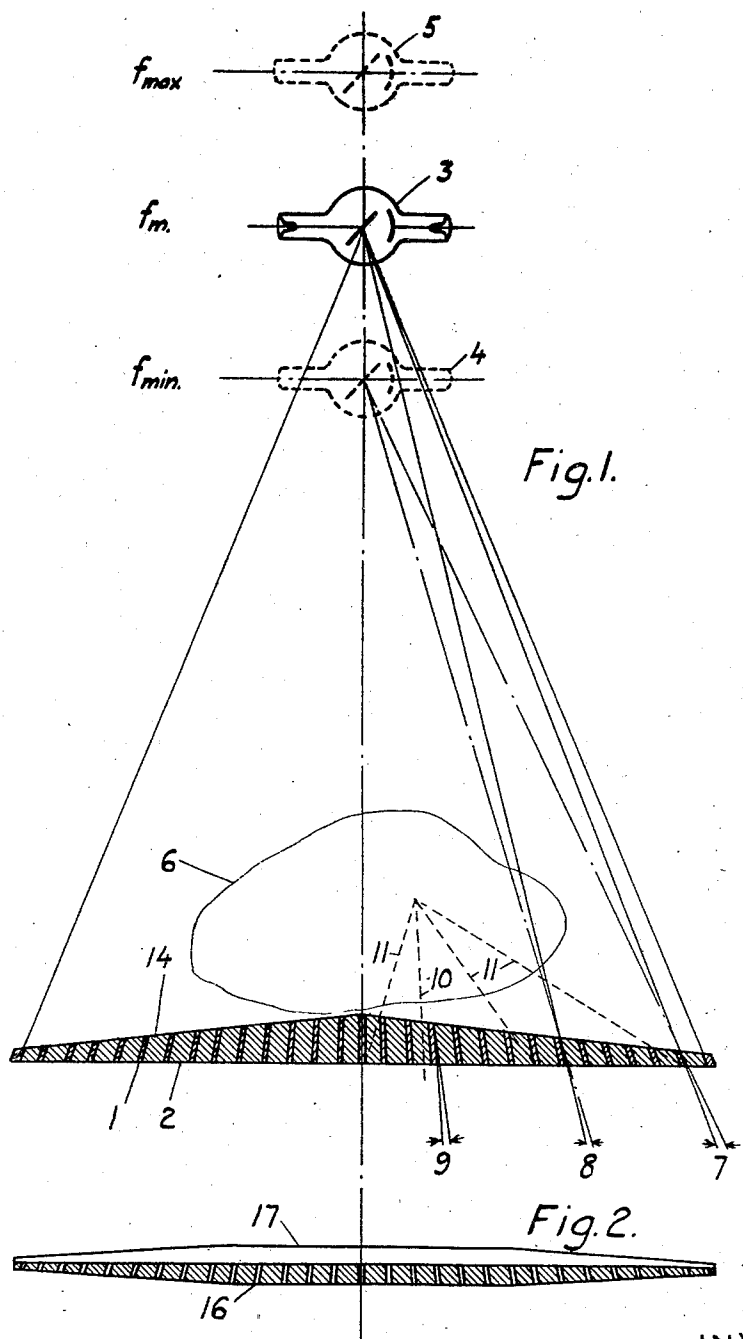
Sept. 17, 1946.

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X-RAY SCREENING APPARATUS

2,407,938

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2 Sheets-Sheet 1



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FIG. 3.



FIG. 4.

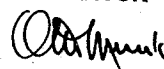


FIG. 5.



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X-RAY SCREENING APPARATUS

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7 Claims. (Cl. 250-62)

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The present invention relates to X-ray apparatus for screening or shutting out undesirable secondary radiation, when for example X-ray radiographs or photographs are being taken.

When a body is being penetrated by X-rays, secondary X-rays are generated in the body and which secondary X-rays scatter in all directions, thus causing an impairment of the contrast of the picture to be obtained by the primary X-rays. Said impairing action of the secondary X-rays can be lessened by introducing between the object to be X-rayed and the photographic plate or film or the fluoroscopic plate a screen consisting of ribs, strips or leaves of a material substantially impervious to X-rays, for example lead, which ribs, strips or leaves are placed on edge, and thus to a great extent absorb the secondary rays, while the primary rays can pass through spaces or material transparent to said rays between the said ribs, strips or leaves.

Such screening devices in their simplest form are provided with plane leaves standing on edge at right angles to the base of the screen. This device, however, causes the disadvantage that the primary rays will considerably be shut out at the edges of the screen, due to the fact that the direction of the rays there forms an angle to the surface of the leaves. In order to lessen this disadvantage several remedies have been proposed. Thus somebody has proposed to bend the entire screen in concave shape, for example in the form of a spherical surface, whereby the X-ray focus is located in the center of the sphere.

These devices, however, have several disadvantages. Thus the sharpness of the picture is successively lessened towards the edges due to the broader shadows of the leaves at said edges. Furthermore the shape of the screen is impracticable, as the object table for practical purposes should be plane. They are besides expensive to make.

It has furthermore been proposed, while keeping the screen plane, to let the planes of the individual leaves pass through the X-ray focus.

It has previously been proposed by myself to use the simplest type of screen using thin plane or curved leaves at right angles to the plane of the screen, whereby the thickness of the screen was decreased towards the edge of the screen, parting from a place, where the primary rays are parallel to the plane or to the generatrix of the surface of the leaves. The advantage of this arrangement is clear, because due to the fact that the height of the leaves decreases when the angle of the primary rays to the leaves increases, the screening effect of the leaves to the primary rays

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will be less. The carrying principle of such a construction was such that the shadow of each leaf of said screen should be the same throughout the screen. However, the disadvantage of such a screen only solves the problem, when the X-rays' focus is located at a relatively large distance from the screen. If said X-ray focus is moved nearer to the screen, the shadows of the leaves towards the edges will be greater than the shadows near to the center. In other words the picture will be lighter or less distinct towards the edges.

The present invention aims to create an improved screening device eliminating the disadvantage of all known screening devices.

The present invention thus relates to an X-ray apparatus comprising an X-ray tube, a screen for reducing secondary X-ray radiation on X-ray fluoroscopic or photographic plates or films and interposed between the object to be X-rayed and the said plate or film, said screen comprising on edge standing leaves of material substantially impervious to X-rays, said leaves being alternately interspaced with material substantially transparent to X-rays, and means for moving the X-ray tube to vary the distance between the focus of said tube and the said screen, plate or film, and the invention is principally characterised by this, that the leaves are convergently directed towards a point located about half way between the extreme positions of said variable focus, whereby the height of said on edge standing leaves have been lowered towards the edges of said screen, in order thus to obtain substantially the same width of leaf-shadows and sharpness of picture over the entire surface of said plate or film at varying distances between the said X-ray focus and the said screen, plate or film.

The invention is thus characterised by the two facts that the leaves are inclined to serve an X-ray focus at a medium distance, for example 90 cm., said medium distance being located between a maximum and a minimum distance of, for example, 120 and 60 cm. respectively, and that the heights of the leaves decrease towards the edges of the screen, in order to obtain substantially the same width of shadow and sharpness of picture over the entire surface of the screen, even if the distance of the X-ray focus to the screen should considerably vary.

Due to the fact that the leaves are inclined, and that their height decrease when the angle of the primary rays to the respective planes increase, the screening effect of the leaves for the primary rays will lessen, even if the X-ray focus

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varies within considerable limits. On the same time the screening effect of the secondary rays will, of course, lessen, but said effect will be insignificant due to the fact that a translucent object, for example, a human body, the thickness of which decreases towards the edges, emits less secondary rays towards the edges. Besides the secondary rays emitted from the leaves themselves decrease in proportion to the height of said leaves.

A plurality of embodiments of the invention are possible within the scope of the same. In the following description it is supposed that the screening device is symmetrically located with respect to the source of rays and that it is symmetrical itself. The invention, however, comprises also unsymmetrical screens.

It is not necessary gradually to decrease the height over the entire width of the screen. As the primary rays can be permitted a certain angle of entry towards the leaves before the shadowing effect of the screen is noticeable, a certain part at the center of the screen can be retained plane and only one or more of the side surfaces be inclined towards the edge over a plane, concave or a convex surface, depending upon the mean distance of the focus, for which the screen should function.

The invention will be further understood in connection with the accompanying drawings, of which:

Fig. 1 illustrates diagrammatically the principle of the invention, one embodiment of the screen being shown in cross-section.

Fig. 2 shows in cross-section another embodiment of the invention with two combined screening devices.

Figs. 3, 4 and 5 are cross-sections of three further screen modifications, respectively.

The leaves 1 are made of metal of preferably high specific gravity, for example lead, and located at from each other equal distances 2. The spaces 2 between the leaves can consist of strips or laminae of light metal, paper, Bakelite or similar material that will allow X-rays to pass through same.

The leaves 1 are substantially directed towards a focus situated at an average from the screen, plate or film, and they can consist of straight leaves located in planes that pass through said average focus or they can be curved and form part or parts of concentric or spirally shaped surfaces converging towards said focus.

The X-ray tube 3 with its focus is located at the average distance f_m from the back part of the screen, while the dotted positions 4 and 5 indicate the maximum and minimum distances for the same tube. The translucent body 6 is located between the X-ray focus and the screen.

Upon moving the X-ray tube to the position 4, the shadow of the lead leaves will be of about the same size 7, 8, 9 over the entire surface of the screen. The secondary rays 11 from the body 6 will entirely be prevented by the leaves to pass, while the spaces in front of the place of secondary emission will allow only a small part 10 of the entire secondary emission to pass.

Being known that 80 to 90% of the blacking of a film originates from secondary emission of the irradiated or translucent body at, for example a voltage of 80 kv. impressed on the X-ray tube, and that this secondary emission will rapidly increase at increased voltage, the importance of an efficient screening device, that will simultaneously shut out the greater part of the secondary

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emission, and on the same time will permit a variable X-ray focus distance, is easily understood. A variable X-ray focus is an indispensable requirement to enable an operator efficiently to scrutinize objects of varying size and form, in order to obtain the best results.

One surface of the screen is preferably plane, while the opposite surface may be shaped in various different ways. For instance, the second surface 14 may rise from its peripheral edge to the center of the screen at a constant rate to give to the screen the shape of a prism of substantially triangular cross-section (Fig. 1). If desired, the central part of this second screen surface 13 may be made plane parallel to the first surface, so that the screen assumes the shape of a prism of regular parallel trapezium cross-section (Fig. 3), the top surface parallel to the bottom surface in the embodiment shown comprising about $\frac{1}{3}$ of the whole surface of the prism. Alternatively, the second screen surface 15 may be made convex to give to the screen the shape of a planoconvex lens (Fig. 4), or the height of the second surface 12 may rise from its peripheral edge towards the center of the screen at a gradually increasing rate (Fig. 5). These alternatives could lead to a great number of embodiments in the form of lens—respectively prism-shaped bodies, which all have the advantage of the nearly complete elimination of the bad effects of the secondary ray emission. At the same time the invention offers a simple way of manufacturing and of mounting, due to the substantially plane shape of the screen, which permits a variable X-ray focus for practical purposes within ample limits.

At a high voltage impressed on the X-ray tube two screens with straight leaves placed one on the top of the other can be used, whereby the leaves of one screen are located at substantially right angles to those of the other.

In this way a double screen is obtained, which has the advantage that the effect of the increased secondary emission on the film in the direction of the straight leaves is considerably limited, and that a fine screen with mesh similar to that of prints on paper is obtained.

When double screens are used the spaces between the leaves can be made somewhat greater than in single screens in order to let through a greater amount of primary rays on the same time that the effects of the secondary emission is limited in all directions. In making the spaces between the lead leaves greater, the cost of production of each of the two screens will also be cheaper.

Fig. 2 shows an embodiment of the invention, in which two prisms or conically shaped screens 16 and 17 are shown. In the shown embodiment the truncated prisms or cones are placed with their bases facing each other, whereby the leaves of the screen 16 consist of straight surfaces, the prolonged planes of which would pass through the average X-ray focus, while similar leaves of the screen 17 preferably and substantially are located at right angles to the leaves of the screen 16, and also so directed that their prolonged planes would pass through the same X-ray focus.

Instead of the screening truncated prisms having been placed with their bases facing each other, as shown on the drawings, they of course can be placed one on top of the other, their truncated tops facing the same way, whereby the leaves of one screen should be placed at a certain angle to the leaves of the other screen, so that both the screening units together will form a fine

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square, rectangular, rhombic, rhomboidal or trapezoidal mesh.

By making a screen according to this invention with a relatively fine mesh the screen or screens can with advantage be stationary.

I claim:

1. An X-ray apparatus comprising an X-ray tube, a screen for reducing secondary X-ray radiation on X-ray fluoroscopic or photographic plates or films and interposed between the object to be X-rayed and the said plate or film, said screen comprising on edge standing leaves of material substantially impervious to X-rays, said leaves being alternately interspaced with material substantially transparent to X-rays, and means for moving the X-ray tube to vary the distance between the focus of said tube and the said screen, plate or film, in which the leaves are convergently directed towards a point located about half way between the extreme positions of said variable focus in which the height of said leaves are lower near the edges of said screen than near the center of the same, in order thus to obtain substantially the same width of shadows and sharpness of picture over the entire surface of said plate or film at varying distances between the said X-ray focus and the said screen, plate or film.

2. The X-ray apparatus as claimed in claim 1, in which the screen has the shape of a prism of regular parallel trapezium-formed cross section.

3. The X-ray apparatus as claimed in claim 1, in which the screen has the shape of substantially a prism of triangular-formed cross section.

4. The X-ray apparatus as claimed in claim 1, in which the screen has the shape of a prism of

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regular parallel trapezium cross section, the top surface parallel to the bottom surface comprising about $\frac{1}{3}$ of the whole surface of the prism.

5. In combination with an X-ray apparatus comprising an X-ray tube, two screens for reducing secondary X-ray radiation on X-ray fluoroscopic or photographic plates or films and interposed between the object to be X-rayed and the said plate or film, each screen comprising on edge standing leaves of a material substantially impervious to X-rays, said leaves being alternately interspaced with a material substantially transparent to X-rays, and means for moving the X-ray tube to vary the distance between the focus of said tube and the said screen, plate or film, said leaves being convergently directed towards a point located about half way between the extreme positions of said variable focus and the heights of said leaves being lower near the edges of said screen than near the center of same, the leaves of one screen being placed at an angle to those of the other screen.

6. The combination as claimed in claim 5, in which the surface of each screen is flat on one side and sloping on the other side, the flat surfaces of both screens being adjacent each other and the leaves of one screen being located at about right angles to those of the other screen.

7. The X-ray apparatus, as claimed in claim 1, in which the screen has a plane surface and, opposite said plane surface, a surface the height of which rises from its peripheral edge to the center of the screen at a gradually increasing rate.

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