May 18, 1954 E. D. HALL 2,679,008

X-RAY GRID

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FIG. 1.

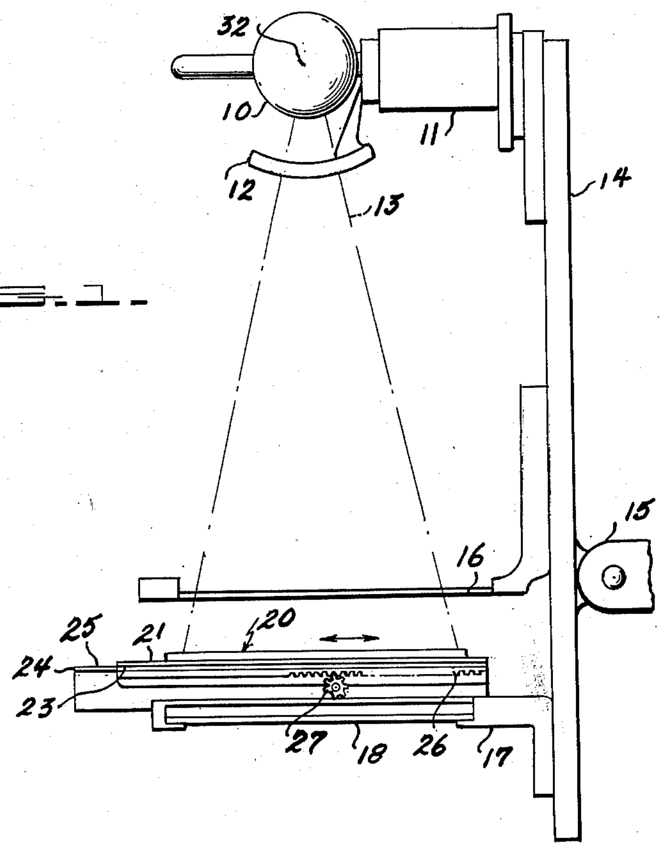


FIG. 2.

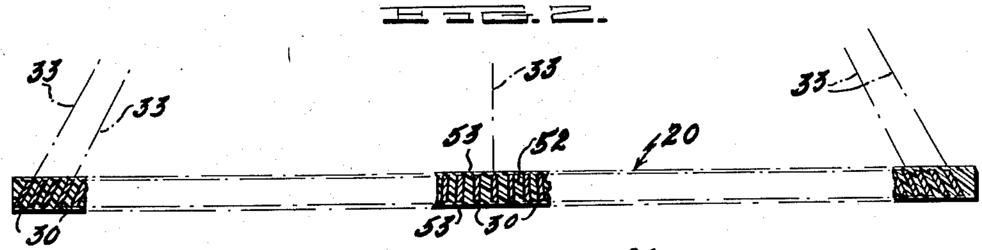
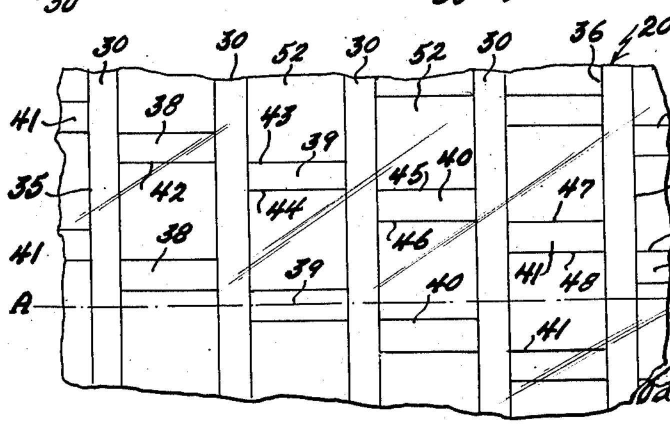


FIG. 3.



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X-RAY GRID

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8 Claims. (Cl. 250—63)

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This invention relates to an X-ray grid, and more particularly to a grid structure which greatly improves the images cast by X-ray tubes.

As is well known, so-called X-ray tubes directly radiate rays of many wave lengths. These rays pass through different materials in accordance with the densities thereof, and in passing through an organic substance of less atomic weight than aluminum, there are resultant secondary radiations sent out in all directions, such rays being similar in nature to the direct rays which generate them.

These secondary rays result in blurred images which are disadvantageous, particularly when the apparatus is used for diagnostic purposes. In order to provide sharper images, it is highly desirable to eliminate as much of the secondary radiation as possible, and many types of devices have been developed with this idea in mind. The means employed in an effort to eliminate or reduce secondary radiation usually is in the form of a grid made of X-ray opaque material such as lead formed in thin walls to divide the grid into cells. The purpose of this arrangement is to permit the free passage through the cells of direct radiation from the source while the lead separator strips intercept secondary radiation which attempts to pass through the grid at many different angles relative to lines radiating from the source. Many such previous devices have been effective to a limited extent, but so far as I am aware, all such prior devices either eliminate secondary radiation in the direction of movement of the grid while permitting the free passage of secondary radiation at other angles, or they are of such structure as to streak the light-sensitive materials exposed to the rays.

An important object of the present invention is to provide a radiographic grid of such character as to intercept secondary radiation in all directions at angles to lines radiating from the source while at the same time preventing the highly undesirable streaking of the light-sensitive element such as the photographic film or plate.

A further object is to provide such a grid which is made up of cells divided by strips of X-ray opaque material so arranged that movement of the grid over the light-sensitive element in a predetermined direction provides for the uniform exposure of the light-sensitive element to direct rays emanating from the source, thus providing images which are highly improved as to sharpness and diagnostic value, and wherein lining or streaking of the light-sensitive element is eliminated.

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A further object is to provide a grid of the character referred to wherein the grid strips which extend in the direction of movement of the grid are so offset with respect to each other that a section taken through the grid parallel to the direction of movement and in the plane of direct rays from the source will intersect the same cross-sectional area of the lead of the strips no matter where such section is taken, thus providing throughout the area of the grid a uniform interception of rays by the lead strips to eliminate any streaking of the light-sensitive film or plate.

Other objects and advantages of the present invention will become apparent during the course of the following description.

In the drawing, I have shown one embodiment of the invention. In this showing,

Figure 1 is a side elevation of the essential parts of an X-ray apparatus,

Figure 2 is a somewhat enlarged sectional view through the grid taken in a plane extending longitudinally of the direction of movement of the grid and passing through the center of the source of X-ray emanations, and

Figure 3 is an enlarged fragmentary plan view of a portion of the grid.

Referring to Figure 1, the numeral 10 designates a conventional X-ray tube mounted in a tube support 11 to which may be connected a conventional lead screen 12 apertured for the passage therethrough of the X-ray emanations 13. The tube support 11 is fixed to a standard 14 which may be suitably supported by conventional means such as a pivot clamp 15 to permit the standard 14 to be swung to and fixed in any desired position. The standard 14 carries a conventional table 16 to support the subject to be X-rayed, and spaced beneath such table is arranged a holder 17 for a light-sensitive film or plate 18. The parts described are all conventional and form no part per se of the present invention.

The device forming the subject matter of the present invention comprises a grid indicated as a whole by the numeral 20. This grid is mounted on a supporting frame 21 supported for reciprocation in a horizontal plane from left to right as viewed in Figure 1. The frame 21 may have opposite sides grooved as at 23 to receive ribs 24 of side bars 25 to support the frame 21 for the reciprocation of the grid in the usual manner. The frame 21 may be provided with any suitable means for effecting such reciprocation. For example, rack teeth 26 formed on the frame 21 may mesh with a pinion 27 suitably supported and rotated in any desired manner to move the frame 21 in the manner described.

The grid comprises a grid body formed of lead to divide the grid into cells. For this purpose, the grid body comprises relatively thin lead strips 30 extending parallel to each other and perpendicular to the direction of movement of the grid, which direction is indicated by the arrow 31 in Figure 3. The grid strips 30 are all arranged in planes passing through the center of emanation of the rays, for example the point 32 in Figure 1. Thus direct rays, as indicated by the broken lines 33 in Figure 2, are adapted to pass freely between the grid strips 30, these strips interfering with the passage of the rays only to the extent of their own thickness because of their arrangement in planes passing through the center 32.

The grid body further comprises strips extending longitudinally of the direction of movement of the grid. Such strips repeat themselves after the manner of a pattern as will become more apparent below. In the embodiment of the invention shown in Figure 3, one pattern may be considered to extend from one edge 35 of one of the strips 30 to the corresponding edge 36 of the fourth strip 30 therefrom. The strips extending longitudinally of the direction of movement of the grid under such conditions are made up of strip sections 38, 39, 40 and 41 extending across successive spaces between successive pairs of strips 30 from the line 35 to the line 36. Thus these strip sections are in sets, each corresponding in number to the number of spaces between the strips 30 included within the limits of each pattern, for example the lines 35 and 36. In the present embodiment of the invention, the strip sections are in sets of four and they are preferably relatively arranged as described below. The strip sections 38 to 41 are precisely offset from each other so that what may be termed the lower edge 42 of the strip 38 lies in a plane coincident with what may be termed the upper edge 43 of the strip 39. Similarly, the lower edge 44 of the strip 39 lies in a plane coincident with the upper edge 45 of the strip 40; the lower edge 46 of the strip 40 is in a plane coincident with the upper edge 47 of the strip 41; the lower edge 48 of the strip 41 is in a plane coincident with the upper edge 49 of the strip 38 of the next pattern to the right as viewed in Figure 3, and so on across the entire width of the grid 20. Under such conditions, a section taken through any plane coincident with the center 32 and extending in the direction of movement of the grid as indicated by the arrow 31, in the embodiment of the invention illustrated, will pass transversely through four strips 30 and longitudinally through one of the strips 38, 39, 40 or 41 for each pattern of the grid. Therefore, the same amount of direct rays from the source will be intercepted by the lead grid elements during the reciprocation of the grid perpendicular to the elements 30.

The grid body is the essential element of the present invention, and the grid as a whole may be completed as a unit to fix the parts thereof relative to each other in any suitable manner. For example, the cells outlined by the grid strips may be filled with any ray permeable material, such as a suitable plastic, as indicated by the numeral 52 in Figure 3. Integral with such fillers may be formed plastic sheets 53 covering and protecting the top and bottom of the grid, as shown in Figure 2.

Operation

The grid 20 is supported on the frame 21 and suitable power means (not shown) rotates the pinion 27 to effect movement of the grid 20 in the direction of the arrows in Figures 1 and 3. In accordance with prior means used for this purpose and forming no part of the present invention, energization of the tube 10 may be made dependent upon the starting of the power source used for driving the pinion 27, or dependent upon movement of the grid 20 or frame 21, together with means for opening the circuit to the tube 10 after the grid has been moved a predetermined distance. This distance of movement should be at least equal to one pattern width of the grid, that is, the distance between the lines 35 and 36 or any reasonable multiple of such distance.

All of the grid elements 30, 38, 39, 40 and 41 are flat and are arranged in planes coincident with the light center 32, as suggested by the inclination of the grid strips in Figure 2. The plane of section in Figure 2 may be either parallel to the direction of movement of the grid or perpendicular thereto, and accordingly the grid strips appearing in Figure 2 may be any of the grid strips described. This inclination of all of the grid strips permits direct rays from the source to pass through the cells of the grid, interfered with only to the extent of the thickness of the grid strips.

As indicated above, it is highly important that streaking of the light-sensitive film or plate be eliminated while at the same time preventing all secondary radiation from each light-sensitive element. All secondary emanations, unless coincident with direct emanations such as suggested by the lines 33 in Figure 2, will be intercepted and stopped by the lead of the strips of the grid body. In this connection, it is pointed out that the present grid body includes strips extending both longitudinally and transversely of the direction of movement of the grid, and this is necessary in order to intercept all secondary emanations. With prior grid structures, however, it has been impossible through any given area of the light-sensitive element 18 to interfere with the passage of direct emanations from the source uniformly by the lead of the grid strips. Perfect uniformity is provided for with the present construction.

It will be apparent that if the grid elements 38, 39, 40 and 41 were arranged in alignment, parallel to the direction of movement of the grid, blank lines would appear on the light-sensitive element 18 corresponding to the position of such grid strips parallel to the direction of movement of the grid. This condition can be materially improved by forming all of the grid strips forty-five degrees to the direction of movement. Under such conditions, however, the total cross-sectional area of the lead of the strips which interfere with the passage of direct emanations will not be uniform at the intersections of the strips, and light streaks will appear where such intersections occur. As previously stated, any section taken through the present grid with the plane of section coincident with the light center 32 and extending in the direction of movement of the grid will pass through the same amount of lead in the grid strips. One such plane might be as indicated by the plane A—A in Figure 3, and such plane will pass transversely through four grid strips 30 and longitudinally through one of the strips perpendicular thereto, in this case, one of the strips 39. The total cross-sectional area of the lead in such plane will be identical with the cross-sectional area of the lead in any plane parallel thereto. Thus the passage of direct emanations will be interfered with uniformly throughout the area of the light-sensitive element 18, and no streaks will appear on such element when developed.

It might appear that the cross-sectional area of the lead would not be as described above if a plane of section were taken through the bottom edge of one of the strips 38 to 41 inclusive and the top edge of the next adjacent strip, for example, along a plane coincident with the lines 42 and 43. Such a plane would intersect only four thicknesses of strips 30 through each grid pattern, but it must be remembered that a plane is of zero thickness, and this would involve a purely theoretical plane which would not affect the practical results of the present construction. In actual practice, there is a uniformity in the exposure of the light-sensitive element as perfect as it is possible to attain.

The present construction accordingly provides for perfect uniformity in the exposure of the light-sensitive element 18 while at the same time intercepting all secondary emanations which, in accordance with present practice, cause a blurred image, for example, of the bones of the human body. The present construction provides for the making of much sharper images than heretofore has been possible, and the invention greatly increases the diagnostic value of an X-ray apparatus.

Obviously, the proportions, etc., of the grid body may be designed in accordance with the particular uses to which the X-ray apparatus is to be put. The inclination of the grid strips may be designed in accordance with the focal distances, and the size of the cell openings in relation to lead strip thicknesses will be subject to the method or methods of manufacture.

I claim:

1. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined relation to an X-ray tube, said grid body being formed of X-ray opaque strips crossing each other to form cells therebetween, certain of said strips extending at a substantial angle to the direction of movement of the grid body and being parallel to each other, the remaining strips extending parallel to the line of movement of said grid body and the portions of such strips between each adjacent pair of said first-named strips being offset from the portions of such strips between the next adjacent pairs of said first-named strips a distance such that any sections taken in planes coincident with the center of the source of X-ray emanations and extending parallel to the direction of movement of the grid body will pass through equal areas of the X-ray opaque material.

2. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined relation to an X-ray tube, said grid body being formed of X-ray opaque strips crossing each other to form cells therebetween, certain of said strips extending at a substantial angle to the direction of movement of the grid body and being parallel to each other, the remaining strips extending parallel to the line of movement of said grid body and the portions of

such strips between each adjacent pair of said first-named strips being offset from the portions of such strips between the next adjacent pairs of said first-named strips a distance equal to the individual thicknesses of said remaining strips whereby any sections taken in planes coincident with the center of the source of X-ray emanations and extending parallel to the line of movement of said grid body will cut through equal areas of the X-ray opaque material.

3. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined relation to an X-ray tube, said grid body being formed of X-ray opaque strips crossing each other to form cells therebetween, certain of said strips extending transversely of the line of movement of said grid body and being parallel to each other and equidistantly spaced apart and of uniform width and depth, all of the remaining strips extending parallel to the line of movement of said grid body and the portions of such strips between each adjacent pair of said first-named strips being offset from the portions of such strips between the next adjacent pairs of said first-named strips a distance equal to the individual thicknesses of said remaining strips whereby any sections taken in planes coincident with the center of the source of X-ray emanations and extending parallel to the line of movement of said grid body will cut through equal areas of the X-ray opaque material.

4. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined relation to an X-ray tube, said grid body being formed of X-ray opaque strips crossing each other to form cells therebetween, certain of said strips extending transversely of the line of movement of said grid body and being parallel to each other and equidistantly spaced apart and of uniform width and depth, all of the remaining strips extending parallel to the line of movement of said grid body and the portions of such strips between each adjacent pair of said first-named strips being offset from the portions of such strips between the next adjacent pairs of said first-named strips a distance equal to the individual thicknesses of said remaining strips whereby any sections taken in planes coincident with the center of the source of X-ray emanations and extending parallel to the line of movement of said grid body will cut through equal areas of the X-ray opaque material, and a body of moldable material filling all of said cells and extending over opposite faces of said grid to form protective layers for all of said grid strips.

5. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined spaced relation to an X-ray tube, said grid body comprising transverse strips arranged perpendicular to the line of movement of said grid body, said strips being flat and of uniform thickness and each lying in a plane coincident with the center of the source of X-ray emanations from said tube, and strip sections extending between adjacent pairs of said transverse strips parallel to said line of movement and lying in planes coincident with the center of the source of X-ray emanations, corresponding edges of certain of said transverse strips, having a number of intervening transverse strips therebetween, defining limits of a particular grid pattern, said grid sections being of uniform thickness and the grid sections starting from one of said corresponding edges being offset from the

strip sections between successive pairs of said transverse strips throughout the width of the grid pattern a distance equal to the thickness of said grid sections whereby one face of each grid section lies in a plane coincident with the opposite face of the grid section of the next successive space between adjacent pairs of said transverse strips.

6. In combination with an X-ray tube, a light sensitive element spaced therefrom, a frame mounted for reciprocation in a plane adjacent and parallel to said light sensitive element, a radiographic grid carried by said frame and comprising a grid body formed of X-ray opaque strips crossing each other to form cells therebetween, certain of said strips being of uniform thickness and equidistantly spaced from each other and extending perpendicular to the line of reciprocation of said frame, all of the remaining strips being in sections extending between adjacent pairs of said first-named strips, all of said sections being of the same thickness and those lying in the space between each adjacent pair of first-named strips being offset from the sections in the space between another pair of said first-named strips a distance equal to the thickness of said sections.

7. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined relation to an X-ray tube, said body comprising a plurality of X-ray opaque strips extending at a substantial angle to the direction of movement of the grid body and strip sections extending parallel to the direction of movement of the grid body and each connected to the strips of an adjacent pair, said strip sections being arranged in sets and one edge of a strip section of each set being in a plane coincident with the relatively opposite edge of another strip section of such set whereby any section through said grid body coincident with the center of the source of X-ray emanations and

extending parallel to said direction of movement will, in passing through a number of said strips corresponding to the number of said strip sections in a set, always pass through equal areas of the X-ray opaque material.

8. A radiographic grid comprising a grid body adapted to be mounted for linear movement in predetermined relation to an X-ray tube, said body comprising a plurality of X-ray opaque strips extending at a substantial angle to the direction of movement of the grid body and strip sections extending parallel to the direction of movement of the grid body and each connected to the strips of an adjacent pair, said strip sections being arranged in sets and one edge of a strip section of each set being in a plane coincident with the relatively opposite edge of another strip section of such set whereby any section through said grid body coincident with the center of the source of X-ray emanations and extending parallel to said direction of movement will, in passing through a number of said strips corresponding to the number of said strip sections in a set, always pass through equal areas of the X-ray opaque material, the spaces between said strips and said strip sections being filled with X-ray permeable material.

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