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3,304,427

X-RAY BEAM DEFINING APPARATUS HAVING ADJUSTABLE COLLIMATOR
PLATES DISPOSED IN THREE PARALLEL PLANES

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FIG. 1

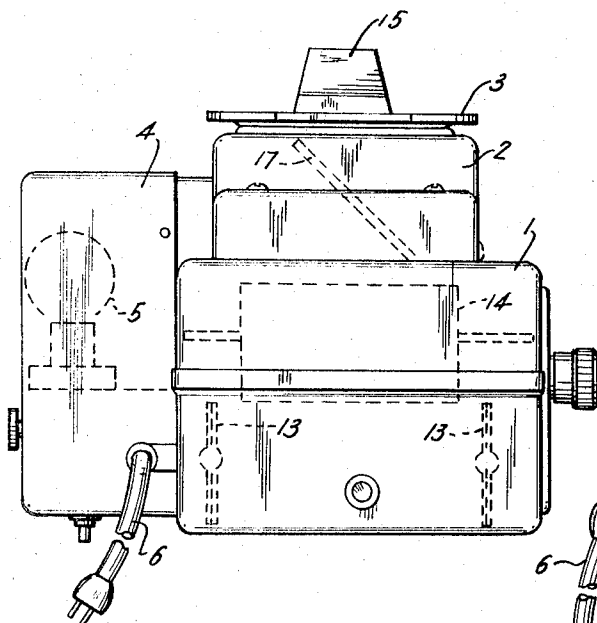


FIG. 2

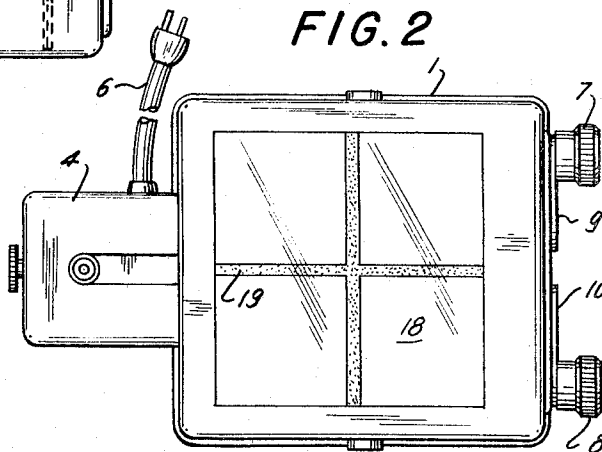
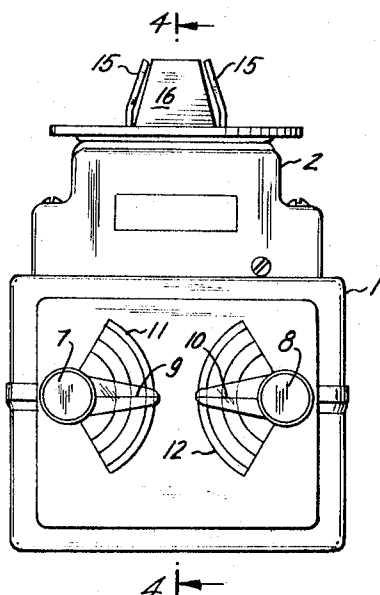


FIG. 3



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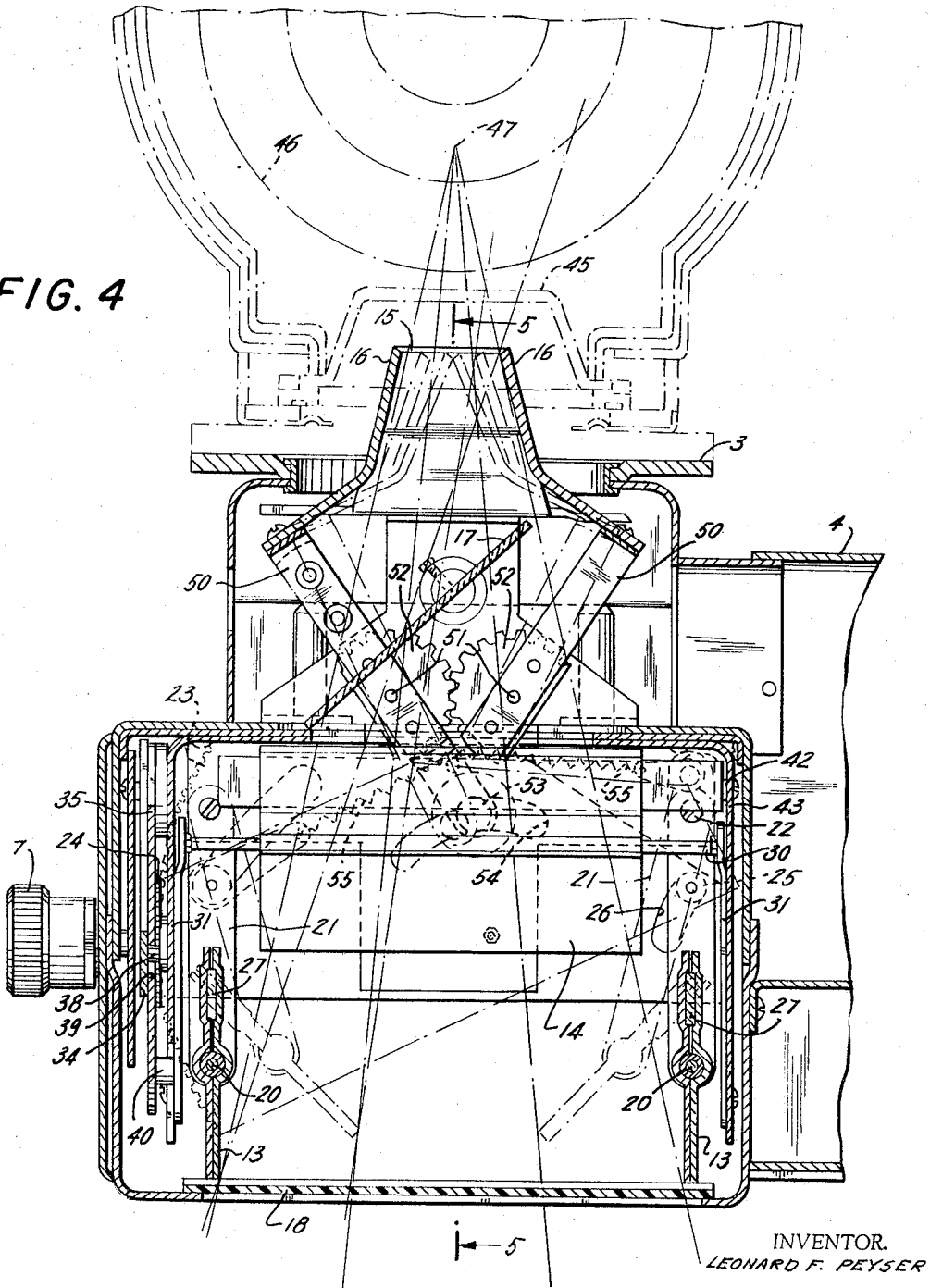
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FIG. 4



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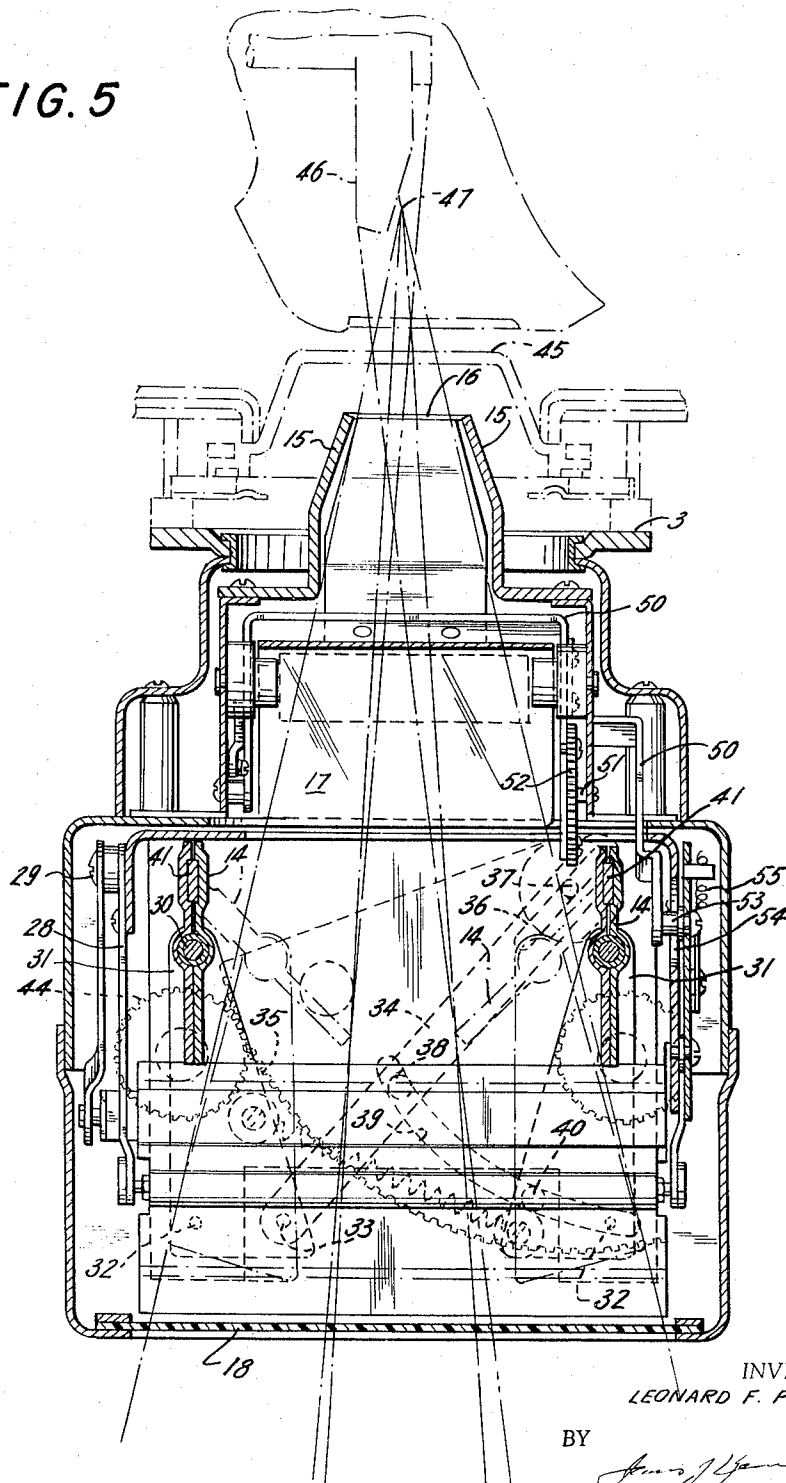
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FIG. 5



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X-RAY BEAM DEFINING APPARATUS HAVING ADJUSTABLE COLLIMATOR PLATES DISPOSED IN THREE PARALLEL PLANES

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This invention relates to X-ray collimators.

More particularly, the invention is concerned with collimators having aperture plates defining a rectangular beam. A collimator of this type is shown in United States Patent No. 3,163,762. The present invention is an improvement thereon.

In such devices, it is desirable that the size of the collimator be kept to a minimum, so as to permit full use in any of various positions, and also not only to collimate the beam from the theoretical focal point on the X-ray tube anode, but also to eliminate secondary radiation to the greatest extent possible. Attainment of this latter objective requires the use of elements set as close as possible to the X-ray tube itself and the provision of such elements, together with the operating mechanism therefor, has resulted heretofore in unduly bulky and expensive equipment.

It is an object of the present invention to provide an improved means for eliminating secondary radiation while keeping the collimator dimensions as compact as possible.

With this object as well as others which will appear in the following description in mind, the invention consists in the combinations and arrangements of parts and details of construction which will now first be fully described in the following specification with reference to the accompanying drawing and then be more particularly pointed out in the appended claims.

In the drawing:

FIG. 1 is a side elevation of a collimator embodying the invention in a preferred form;

FIG. 2 is a bottom elevation;

FIG. 3 is a front elevation;

FIG. 4 is a section on the line 4—4 of FIG. 3, on an enlarged scale and showing the relation of the collimator to the X-ray tube; and

FIG. 5 is a section on the line 5—5 of FIG. 4.

Referring first to FIGS. 1—3, the collimator there shown may be of a very compact construction, the width of the instrument (FIG. 3) being only about five inches, with other dimensions in proportion, and the weight of the unit being about six and a half pounds. Comparable equipment as heretofore used is considerably larger, by approximately sixty percent or so and more than twice as heavy.

The collimator is enclosed in a generally rectangular housing 1 having an upper portion 2 of reduced length and width, which is surmounted by a circular flange 3 which attaches to the X-ray tube unit. To the rear of the housing (left in FIGS. 1 and 2) is a light housing 4 containing a bulb 5 for visually indicating the field, this bulb being supplied with current by means of the electric cord or cable 6. On the front of the collimator (FIG. 3) are positioned two knobs 7 and 8 equipped with pointers 9 and 10 which read on the scales 11, 12 for indicating a width of beam along the two directions of the rectangle. Lower aperture plates 13 and upper aperture plates 14 (FIG. 1) serve to define the X-ray beam and further collimating elements 15 and 16 (FIGS. 1 and 3) serve to eliminate the major part of secondary radiation, as described more particularly below.

The visual light system involves the bulb 5 and mirror 17 (FIG. 1) and a bottom window 18 provided with cross lines 19 (FIG. 2), the visual illuminating system being substantially as shown in the prior application, above mentioned.

Referring now to FIGS. 4 and 5, showing the relevant details of the construction, the lower collimating elements or aperture plates 13 are carried on shafts 20 which, in turn, are supported on arms 21 pivoted to the inner frame structure of the unit at 22. The arms 21 are adjustably swung above their pivot 22 (as between the full line and dot-dash lines of FIG. 4), by means of a gear sector 23 engaged by the gear 24 rotatable by the knob 7, the arms 21 being coupled to this sector by means of rollers 25 received in arcuate slots 26 therein. The aperture plates 13 also comprise bars 27 pivotally connected to further links 28 swingable about pivots 29, so that the aperture plates have a combined bodily swinging movement of rotation about their shafts 20, as described in the above mentioned patent.

The adjustment in the other plane of collimation is similar, the upper plates 14 being carried on shafts 30 which are swingingly supported on the triangular plates or arms 31 pivoted to the frame at 32. One of the arms 31 is pivotally connected at 33 FIG. 5 to a link 34 maintained in radial position with reference to gear sector 35 by a slot 36 in the link and pin 37 coaxial with the sector axis. The link 34 carries a roller 38 engaging in arcuate slot 39 in the gear sector 35, while the other arm 31 (to the right in FIG. 5) carries a roller 40 also engaging in this slot. In consequence as the gear sector 35 is rotatably adjusted, the plates 14 are swung (as between full and dot-dash line positions in the figure) about the pivot points 32. Plates 14 include bars 41 which carry studs 42 riding in slots in plates 43, so as to give these upper elements a combined swinging and turning movement as in the case of the lower elements 13. A gear 44 carried by the knob 8 serves to adjust the position of the gear sector 35 and hence, of the upper aperture plates.

There are further provided upper fixed elements 15 and movable elements 16 extending up beyond the mounting ring 3 and as close to the window 45 of the X-ray tube housing as is considered safe. The X-ray tube contains a rotating anode disc 46, the focal spot of which is indicated at 47 and it will be noted that the fixed elements 15 (FIG. 5) are located so as to cut off secondary radiation in a plane containing the axis of rotation of the anode disc 46. The upper edges of elements 15 are set as close together as conveniently possible without interfering with the edges of the beam as defined by the collimating elements 13 and 14 when set to their widest open position in use.

In the other plane of collimation (FIG. 4), the adjustable elements 16 are utilized, these being carried on arms 50 pivotally supported on pins 51 and coupled together for rotation in unison but in opposite directions by the gear bar 52. One of the arms 50 (to the left in FIG. 4) extends down below its pivot 51 and carries a roller 53, which engages in an arcuate slot 54 in the gear sector 23, the slot 54 being curved and located so that the elements 16 are adjusted along with the elements 13, and in such a way that their upper edges are close but slightly spaced from the focal spot 47 as defined by the element 13. Takeup springs 55 attached to the arms 50 and to the casing take up backlash in the movement of the arms 50 and elements supported thereby.

It will be noted that the mirror 17 for the visual system is positioned within the space between the arms 50,

this being possible in a compact device of the type shown because the elements 15 (FIG. 5) are fixed and do not require adjusting mechanism.

In the collimator described herein, full advantage has been taken for the first time of the characteristics of the rotating anode X-ray tube with respect to "off-focus" radiation, and with very striking results. The "off-focus" radiation sometimes referred to, though inaccurately, as "secondary" radiation, is composed of radiation from portions of the anode surface outside the desired focal spot, such radiation being the result of imperfect collimation of the electron beam and of the anode rotation. In the absence of tube port shutters, the off-focus radiation in the plane of rotation of the anode disc tends to be several times as great as that along the stem of the tube (in a plane containing the anode disc rotary axis). It has been found possible, by using fixed elements in the axial plane, to improve the action of the elements in the more important plane (plane of rotation of the anode) by a factor ranging from thirty to sixty percent over the distance range mentioned, thus effecting a very great improvement in reduction of off-focus radiation, while simplifying the construction.

As will be apparent from a consideration of FIGS. 4 and 5, if it is attempted to adjust the elements 16 for the tube axis plane (FIG. 5), it becomes necessary either to narrow the elements for the other plane (FIG. 4) or to make these elements of a T-shaped configuration while dropping the elements in the other plane to a lower level. It has been discovered that any such effort to improve the operation by using adjustable elements in both planes necessarily reduces efficiency in the other and more important plane due to off-focus radiation leakage underneath the T-shaped barrier in the anode disc plane which offsets any gain obtained from having the elements for the tube axis plane movable.

The device of the present invention provides a degree of limitation of beam equal or superior to previous devices approximately three times its weight and double its width. The reduction in counterweighting and inertia of the moveable X-ray carriage and the reduction in interference with other parts of X-ray apparatus, notably the edge of the X-ray table when the unit is used in the horizontal position, increase the over-all flexibility of the X-ray machine. When used in conjunction with an X-ray tube under the table in fluoroscopic examination procedures, the significantly reduced size increases the available cross-table traverse.

What is claimed is:

1. An X-ray collimator for rotating anode tubes com-

prising first and second pairs of collimating elements movable in planes at right angles to each other for defining a rectangular beam of adjustable dimensions, a mounting plate at one end for attachment to an X-ray tube housing, two pairs of opposing off-focus radiation shielding plates extending beyond said mounting plate so as to position their edges close to the window of an X-ray tube when the mounting plate is fastened to the housing thereof, one pair of opposed shielding plates being stationary, parallel to the planes of said first pair of collimating elements and to the plane of anode rotation, and subtending an angle about the tube focal spot slightly greater than the maximum angle of the opening defined by said first pair of collimating elements with respect to said focal spot, said second pair of shielding elements being adjustable, means mounting the second pair of said shielding plates for adjustment toward and away from each other in parallelism to the planes of said second pair of collimating elements and to the tube axis, and means coupling the said second pair of radiation shielding elements to said second pair of collimating elements for movement therewith with their edges subtending an angle slightly greater than the angle of the opening defined by the said second pair of collimating elements with respect to said focal spot.

2. An X-ray collimator according to claim 1, comprising also a visual light field indicating system including a mirror disposed in the X-ray beam between the collimating elements and the shielding plates, the means mounting the said second pair of shielding plates being located at opposite ends of the said mirror and having a space between them in their position of closest adjustment, and means located in the said space for mounting the mirror.

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