United States Patent

Palermo et al.

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[54] ADJUSTABLE COLLIMATOR

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[52] **U.S. Cl.** ..... **250/105,** 250/108 FS

[51] **Int. Cl.** **G03b 41/16**

[58] **Field of Search** 250/105, 62, 63

[56] **References Cited**

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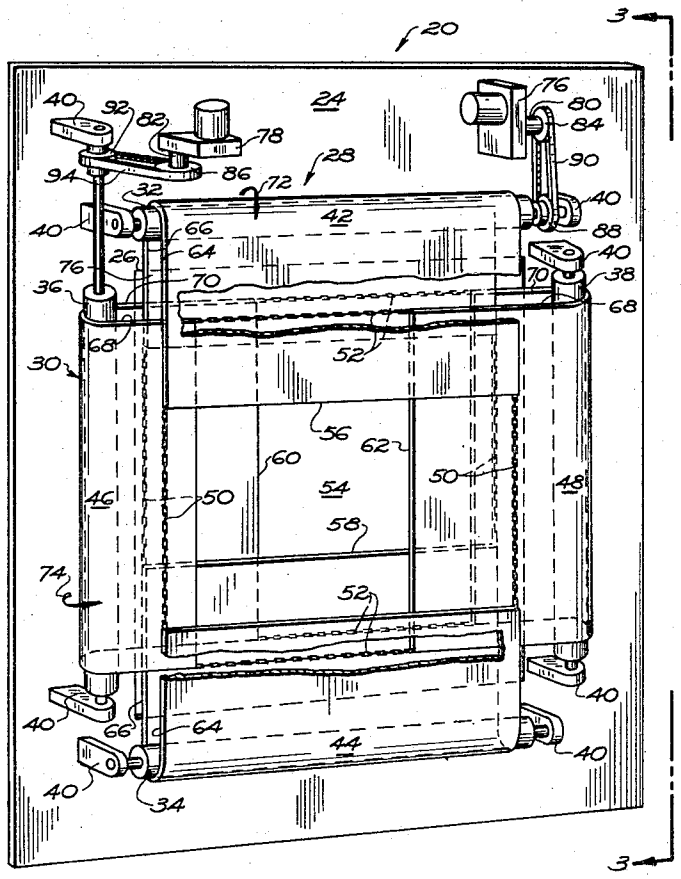
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[57] **ABSTRACT**

An adjustable X-ray collimator is disclosed which has two web assemblies. Each web assembly has a pair of spaced and connected webs which form a continuous loop reaved over a pair of rollers. The assemblies are positioned near and parallel with one another with the axes of the rollers on one assembly being perpendicular to the other so that one assembly defines the sides and the other assembly the ends of a rectangular X-ray beam opening. The size of the opening is adjusted by rotating the rollers so as to move the interconnected webs to adjust the amount of space between ends of the webs.

9 Claims, 3 Drawing Figures



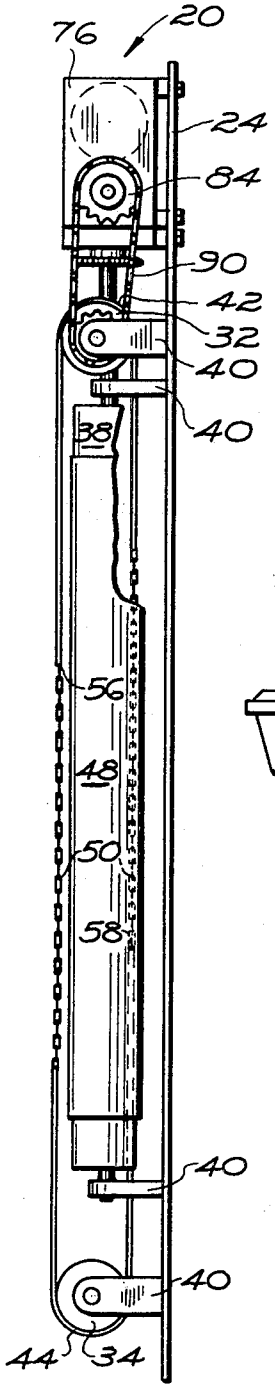


Fig. 3

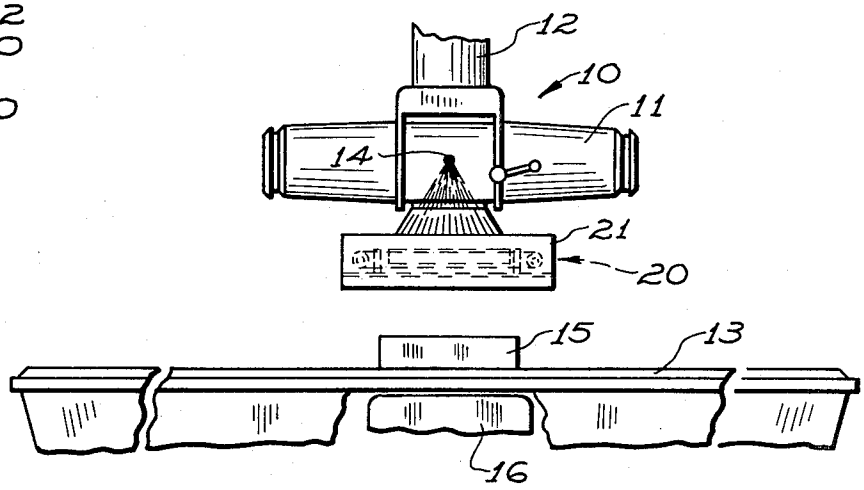


Fig. 1

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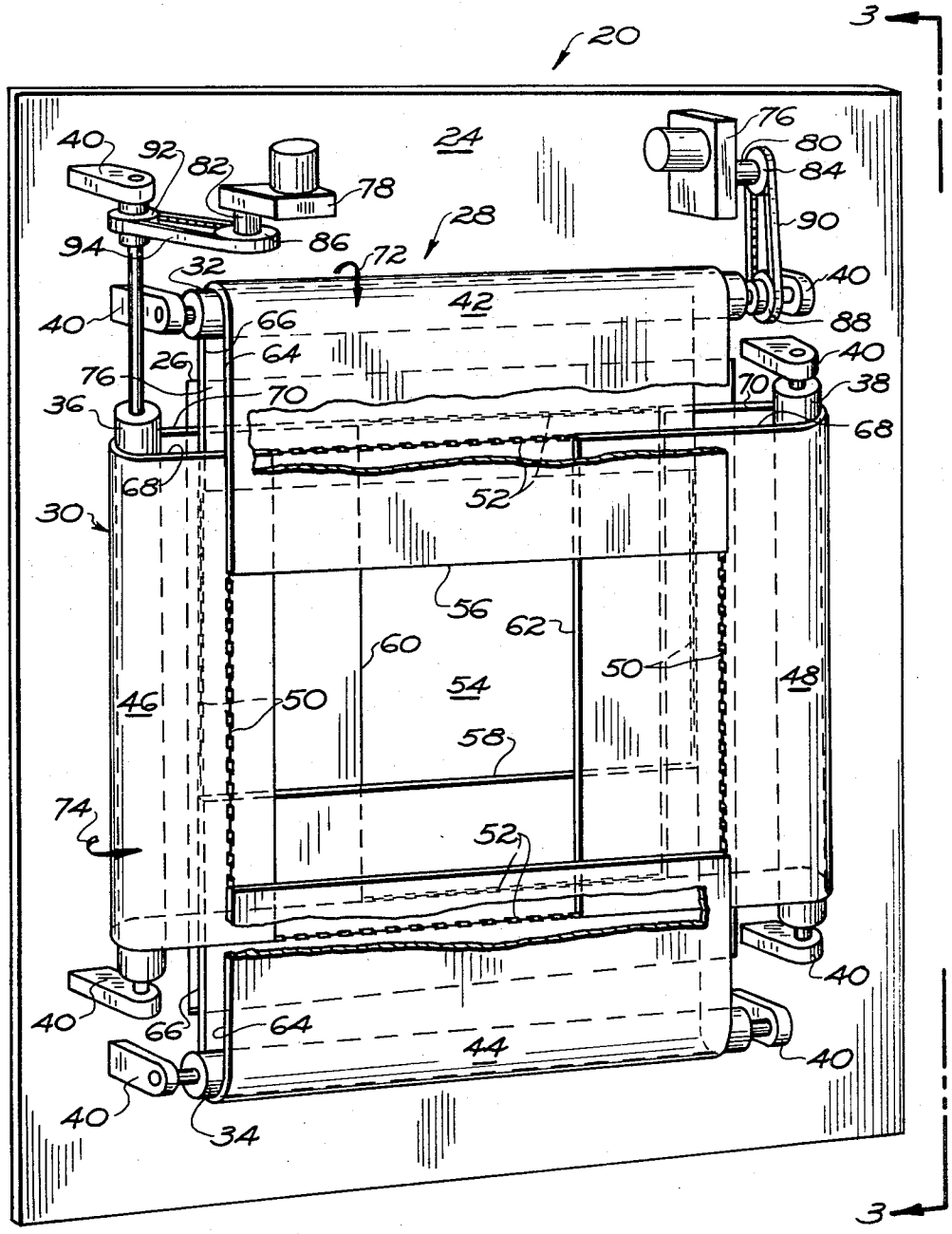


Fig. 2

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ADJUSTABLE COLLIMATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to X-ray apparatus and more particularly to an improved adjustable collimator apparatus for delineating the size of an X-ray beam to be impinged on a subject.

2. Prior Art

In a typical X-ray tube, X-rays are emitted in a cone from a locus on the anode of an X-ray tube known as the focal spot. The cone has a transverse dimension in the plane of an object to be investigated or an X-ray sensitive imaging device which is normally larger than that required. Mechanisms known as collimators are used to block off that part of the cone which is not desired or required for a given study.

There are a number of reasons to limit the size of the X-ray beam. These include: (a) protecting the operator from being struck by the primary beam of rays in regions around the X-ray imaging device; (b) if the subject under investigation is a patient, avoiding subjection to the patient to excessive radiation which can be injurious to health; and, (c) preventing the emanation of scatter radiation from regions around the area actually under investigation. This scatter radiation can blur or fog an image. The result is a shadow image produced by the imaging device which is of poorer quality than that which can be obtained if the beam is limited to the area actually under investigation.

The desired X-ray beam field size varies according to: (a) the tube to image device distance; (b) the desired size of the image to be produced; and (c) the size of the subject under investigation. Accordingly it is desirable to limit this field by means of an adjustable diaphragm apparatus which delineates the perimeter of a beam of X-rays to desired size whereby X-rays other than those in the beam are absorbed by the collimator.

In order to carry out these objectives, a wide variety of adjustable collimators have been developed, most of which employ diaphragms which are rigid plates of lead or other X-ray impermeable substance. Due to the size and weight of such movable rigid plates, the collimators known in the prior art have comprised relatively large bulky structures with relatively heavy, often complex, mechanisms for moving the plates.

In adjusting the diaphragms of rectangular X-ray collimators, it is desirable to close in on the axis of the beam substantially equally from opposite sides and ends whereby the object and the imaging device, once positioned, remain aligned with the field of radiation. For this reason, commonly at least four movable rigid plates have been provided to define a rectangular aperture. Adjustment of such collimators has therefore involved the movement of all four rigid shutter plates such that opposed plates are spaced an equal distance from the axis of the X-ray beam.

As will be readily apparent, when the aperture in use is quite large, the four rigid plates extend outwardly from the axis of the X-ray beam a substantial distance in all directions. Thus, a further disadvantage of prior art collimators has been their requirement for a substantial amount of side clearance for the outward travel of the plates.

SUMMARY OF THE PRESENT INVENTION

The present invention is directed toward a highly compact adjustable collimator requiring minimal side clearance and employing two movable shutter assemblies. Each assembly has a pair of spaced connected webs forming a continuous loop which is reaved over a pair of rollers.

By rotating the rollers, the spacing between ends of the webs is varied to adjust the effective cross-sectional area of the X-ray beam. Unlike prior art rigid-plate collimators which require large side clearance for the outward movement of the shutter plates, the present invention disposes unused shutter portions about the rollers and in overlapping relation with the used portions. The transverse size of the shutter assemblies thereby remains constant as the beam size is adjusted.

Another advantage of the present invention is the simplicity of the mechanism with which the shutter assemblies are adjusted. Whereas prior art collimators commonly employed four adjustable plates which were interconnected in pair by relatively complex adjustment arrangements, the present invention has only two simple mechanism for rotating the rollers of each shutter assembly. The present invention thereby provides an adjustable collimator which is much simpler to operate than prior art devices.

A still further advantage is the relative thin collimator construction obtained by the present invention. Whereas prior art devices were quite thick, as measured along the axis of the X-ray beam, to accommodate bulky diaphragm adjustment structures, devices made in accordance with the present invention may be constructed with a minimum of thickness to provide a maximum of working room for the object to be X-rayed.

Accordingly, the object of this invention is to provide a novel and improved X-ray collimator of simplified construction and which requires reduced space.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of the improved X-ray apparatus of the present invention with the improved collimator shown mounted on the housing of an X-ray tube, a subject support, and a fragmentary portion of an imaging device in the form of an X-ray image intensification tube;

FIG. 2 is a partially schematic perspective view of the collimator of the invention; and,

FIG. 3 is an end view with parts broken away and removed as seen from the plane indicated by the line 3—3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and initially to FIG. 1, an X-ray apparatus is shown generally at **10**. The apparatus includes an X-ray tube, not shown, mounted within a protective tube housing **11**. The tube and its housing **11** are supported in an operative position by a suitable supporting structure **12**. The tube housing **11** is shown above an object support **13**. The tube emits X-rays in a beam emanating from a focal spot shown schematically at **14** and directed toward an object **15** positioned on the support **13**. X-rays passing through the object are intercepted by an X-ray stimulated device such as an image intensification tube, an input portion of which is indicated schematically at **16**.

In order to limit the field of radiation directed toward the object **15**, a collimator mechanism **20** is provided. The collimator **20** has an outer protective housing **22** supported beneath the tube housing **11**. In FIGS. **2** and **3** the details of the collimator construction are shown. The housing **22** has an apertured base plate **24** which extends in a plane substantially perpendicular to the direction of the X-ray beam. A relatively large rectangular aperture **26** is formed within the plate **24** for passage of the X-ray beam therethrough.

A pair of web structures **28, 30** are positioned above and parallel to the plate **24**. Since the web structure **28** is the closest to the X-ray source and the web structure **30** is closest to the subject, they will, for clarity, be referred to as the source and subject web structures. These web structures are supported by source and subject rollers **32, 34** and **36, 38** respectively. The rollers are disposed outwardly from the aperture **26** and with their axes parallel to the plate **24**. The source rollers **32, 34** comprise a first set of rollers adapted to support the source web structure **28**. The subject rollers **36, 38** comprise a second set of rollers adapted to support the subject web structure **30**. Brackets **40** are fixed to the base **24**. The brackets **40** journal and support the rollers in spaced but parallel relationship with the plate **24**.

The web structures **28, 30** each includes a pair of spaced and connected webs **42, 44** and **46, 48** respectively. The

source web structure 28 comprises a continuous loop formed of the pair of source webs 42, 44 connected together by chains 50. This loop is reaved over the source rollers 32, 34. The subject web structure 30 comprises a continuous loop formed of the pair of subject webs 46, 48 connected together by chains 52. This loop is reaved over the subject rollers 36, 38. Each of the webs 42, 44, 46, 48 comprise flexible sheets of X-ray impermeable material. A suitable X-ray opaque material is that sold commercially under the Trademark Lead X by Bar-Ray Products, Inc. Brooklyn, New York. The Lead X material is vinyl sheeting impregnated with lead particles such that for example, a sheet having a nominal thickness of one-eighth inch is equivalent to a lead sheet of 1.00 mm thickness.

In use, the webs are disposed across perimetral portions of the X-ray beam such that X-rays in the perimentral portions are absorbed thereby. Hence by controlling the extent to which the webs are disposed within the X-ray beam, the desired cross-sectional area of the effective beam is delineated. Thus the webs delineate an effective beam opening 54 as best seen in FIG. 2. The ends of the opening 54 are defined by the source web structure 28, and particularly by ends 56, 58 of the source webs 42, 44. The sides of the opening 54 are defined by the subject web structure 30, and particularly by ends 60, 62 of the subject webs 46, 48.

Each of the web structure loops is reaved over the rollers in such manner that each web is always in contact with an associated one of the rollers. Thus the web 42 is associated with and contacts the roller 32, the web 44, the roller 34, and the webs 46, 48, the rollers 36, 38 respectively.

Each loop has a pair of reaches spanning the space between its associated rollers comprised of portions of each of its webs and the associated chains. Thus the loop of the source web structure 28 includes a source side web reach 64 and a subject side web reach 66. The subject side web reach 66, as is best seen in FIG. 3, passes through the loop of the subject web structure 30. Similarly, the subject web structure 30 includes a source side reach 68 and a subject side reach 70.

The side of the opening 54 may be adjusted by rotating the rollers. By way of illustration, rotation of the roller 32 in the direction of arrow 70 will cause concurrent movement of the source webs 42, 44 such that the ends 56, 58 move toward each other to reduce the size of the opening 54. Similarly, rotation of the roller 36 in the direction of arrow 74 will cause concurrent movement of the subject webs 46, 48 such that the ends 60, 62 move toward each other to reduce the size of the opening 54. In a similar fashion, rotation of either of the rollers 32, 36 in directions reverse to those shown by arrows 72, 74 will serve to enlarge the opening 54.

One outstanding feature of the present invention, is that the portion of webs which are not being used as beam delineating diaphragms are either disposed about the rollers or are held in overlapping relation with beam delineating portions. Thus the subject sides of webs 42, 48 and the source sides of webs 44, 46 comprise substantially unused web portions which are respectively disposed in overlapping relation with beam delineating portions which include the source sides of webs 42, 48 and the subject sides of webs 44, 46. Hence, the transverse dimension of the web structures 28, 30 is constant as the size of the opening 54 is adjusted.

For the purpose of controlling the rotary position of the rollers 32, 36 an appropriate rotary drive in the form of motors 76, 78 are fixed to the base plate 24. The motors 76, 78 have drive shafts 80, 82 which respectively carry drive gears 84, 86. The roller 32 carries a gear 88 which is coupled to the drive gear 84 by a drive chain 90. The roller 36 carries a gear 92 which is coupled to the drive gear 86 by a drive chain 94. Suitable motor controls, not shown, may be provided to precisely control the rotation of the rollers 32, 36 whereby the size of the opening 54 may be adjusted.

As will be apparent to those skilled in the art, various modifications and adaptations may be made in the arrangement of the flexible shutter webs to provide additional X-ray shielding as may be required when high intensity X-rays are employed. By way of example, one or more additional pairs of shutter web structures of the type previously described may be used in series and provided with drive means interconnected for concurrent operation. Or, in the alternative, continuous belts of X-ray impermeable material having a plurality of shutter openings may be looped back and forth through the beam of X-rays whereby movement of one such belt would simultaneously operate all of its shutter openings. It is therefore intended that the appended claims shall cover such modifications and adaptations as are within the true spirit and scope of the invention.

What is claimed as new and desired to secure by Letters Patent of the United States is:

1. In an X-ray device having a source of X-rays positioned to direct a beam of X-rays along a path toward a subject and an X-ray stimulated device having a target area positioned to intercept X-rays passing through the subject, the improvement of an adjustable collimator disposed within the path of X-rays passing between the source and the object, the collimator comprising:

a plurality of web structures disposed across the path of the beam of X-rays, each of said web structures including upper and lower apertured web reaches which extend transversely across the X-ray beam path;

each of said upper and lower web reaches including material substantially opaque to X-rays with the material adjacent the aperture of each reach in part delineating the perimeter of an opening therebetween for the passage of X-rays; and,

web structure support means for supporting said web reaches for movement such that translation of one reach of one of said web structures in one direction is accompanied by translation of the other reach of said one web structure in the opposite direction;

whereby the perimeter delineating material in said reaches may be selectively moved relatively to adjust the perimeter of the opening and thereby to adjust the transverse dimension of the beam of X-rays transmitted to the object.

2. The X-ray device of claim 1 wherein said plurality of shutter web structures comprises first and second web structures each comprising an endless apertured loop, the loop of said first web structure being interleaved with the loop of said second web structure.

3. The X-ray device of claim 2 wherein said means for supporting said web reaches comprises:

A first set of elongate rollers adapted to support said upper and lower web reaches of said first web structures;

a second set of elongate rollers adapted to support said upper and lower web reaches of said second web structure;

each of said sets of rollers including a pair of rollers disposed on opposite sides of the X-ray beam;

said first set of rollers having parallel axes of rotation which extend in a plane substantially perpendicular to the X-ray beam; and,

said second set of rollers having parallel axes of rotation which extend in a plane substantially perpendicular to the X-ray beam and substantially perpendicular to said axes of rotation of said first set of rollers.

4. The X-ray device of claim 3 wherein each of said first and second web structures comprises a pair of spaced connected webs forming a loop reaved respectively around said first and second sets of support rollers.

5. The device of claim 1 wherein each of said web structures comprises a pair of spaced webs of X-ray opaque material and connecting elements connecting said webs together to form a loop.

6. The device of claim 5 wherein each of said webs is comprised of a sheet of vinyl material impregnated with lead particles in sufficient density to make said vinyl material opaque to X-radiation.

7. The device of claim 5 wherein there are four such connecting elements each connecting one corner of a web to one corner of the other web, whereby said loop is comprised of two webs connected together by said chains with the chains disposed substantially along edges of said loop and whereby said webs have ends which provide said perimeter delineating of said opening.

8. The device of claim 1 wherein one reach of said web structure is disposed between the reaches of the other web structure whereby the web structures are interleaved.

9. In an X-ray device having a source of X-rays positioned to direct a beam of X-rays toward a subject, and an X-ray stimulated device having a target area positioned to intercept X-rays passing through the subject, the improvement of an adjustable collimator disposed within the path of X-rays passing between the source and the subject, the collimator comprising:

a first pair of elongate rollers disposed on opposite sides of the beam of X-rays and having parallel axes of rotation which extend in a plane substantially perpendicular to the direction of said beam of X-rays;

a second pair of elongate rollers disposed on opposite sides of the beam of X-rays and having parallel axes of rotation which extend in a plane substantially perpendicular to the direction of the beam of X-rays and substantially perpendicular to said axes of said first pair of rollers;

a first flexible web structure reaved around said first pair of rollers so as to dispose upper and lower web reaches within the path of the beam of X-rays in planes which are substantially perpendicular to the direction of the beam of X-ray, said upper and lower web reaches having a space therebetween for passage of X-rays;

a second continuous flexible web structure reaved around said second pair of rollers so as to dispose upper and lower web reaches within the path of the beam of X-rays in planes which are substantially perpendicular to the direction of the beam of X-rays, said upper and lower web reaches having a space therebetween for passage of X-rays;

each of said upper and lower web reaches comprising a material which is substantially impermeable to X-rays;

said upper and lower reaches of each of said web structures being movable toward and away from each other to selectively vary the space therebetween to control the cross-sectional size of the X-ray beam transmitted to the subject.

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