

[54] **RADIATION COLLIMATOR**

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[52] **U.S. Cl.**..... **250/511, 250/513**

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

[58] **Field of Search**..... **250/511, 512, 513**

[56] **References Cited**

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*Primary Examiner*—James W. Lawrence

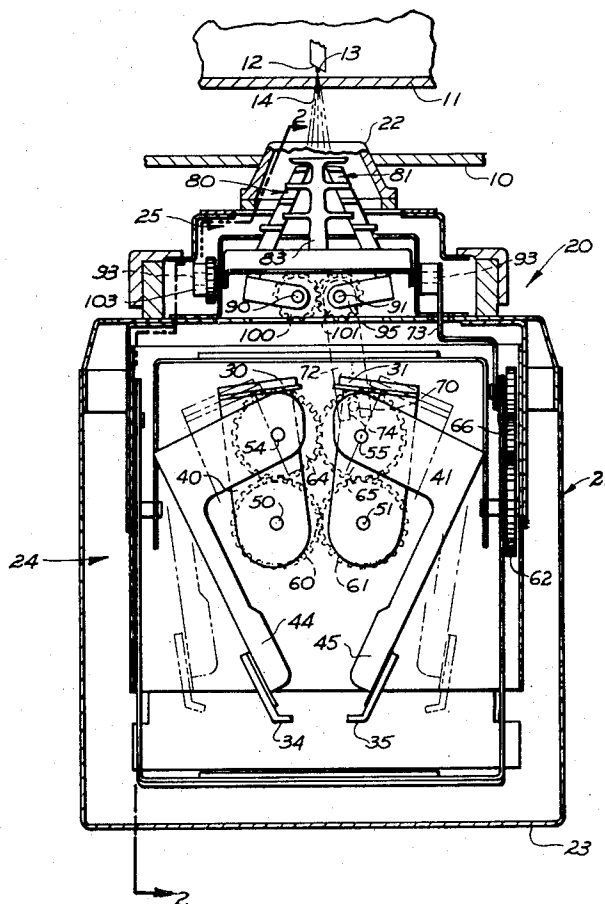
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[57] **ABSTRACT**

A radiation collimator including opposed pairs of movable off-focus radiation diaphragms comprising interleaved arrays of plates supported centrally on stems. The stems of each opposed pair of diaphragms are pivotally supported and coupled together for concurrent movement toward and away from each other. Each opposed pair of off-focus diaphragms is interconnected to corresponding on focus diaphragms movably mounted for rectangularly delineating the perimeter of the primary beam. The off-focus diaphragms extend to within very close proximity of the radiation source to block off-focus radiation.

**25 Claims, 9 Drawing Figures**



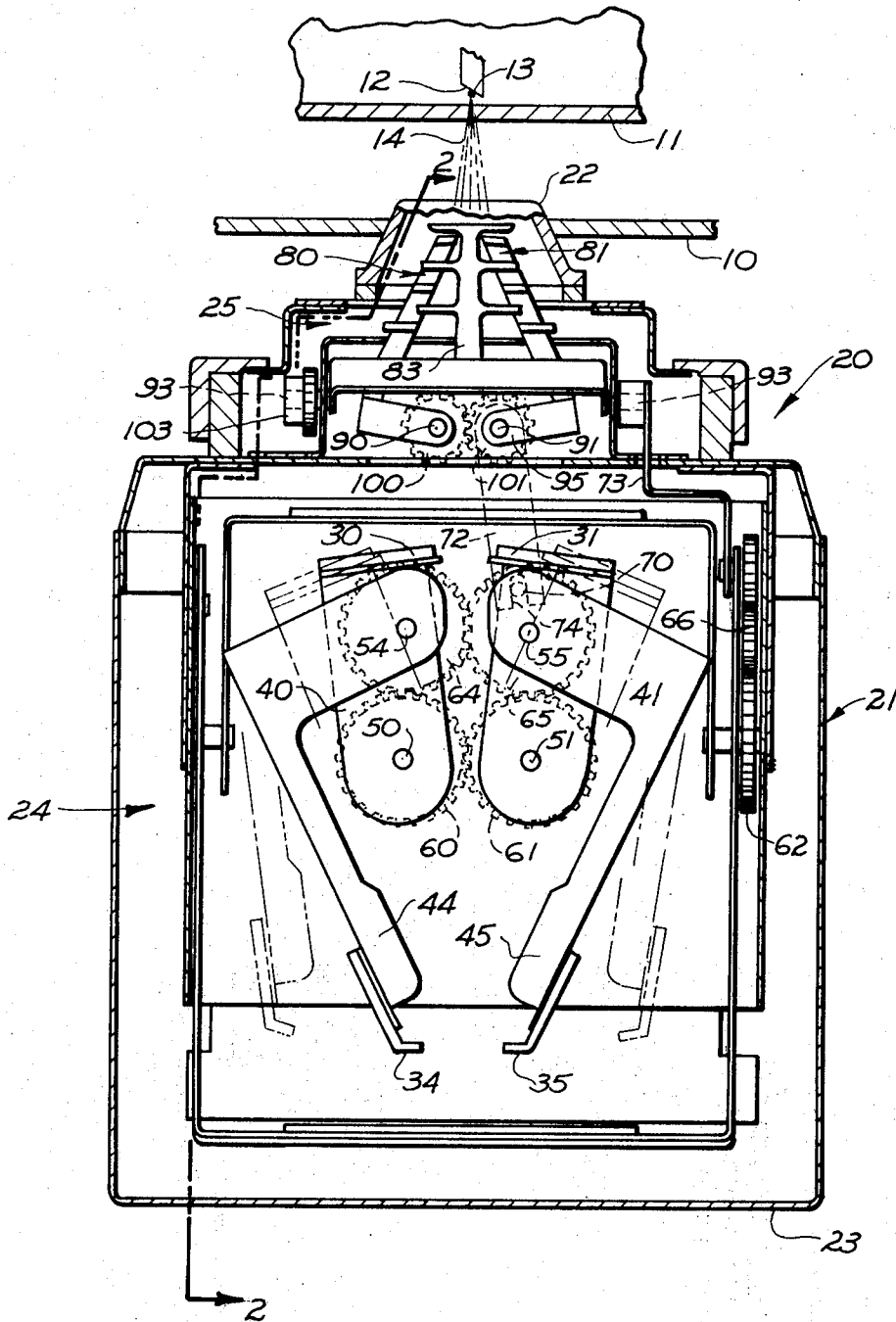
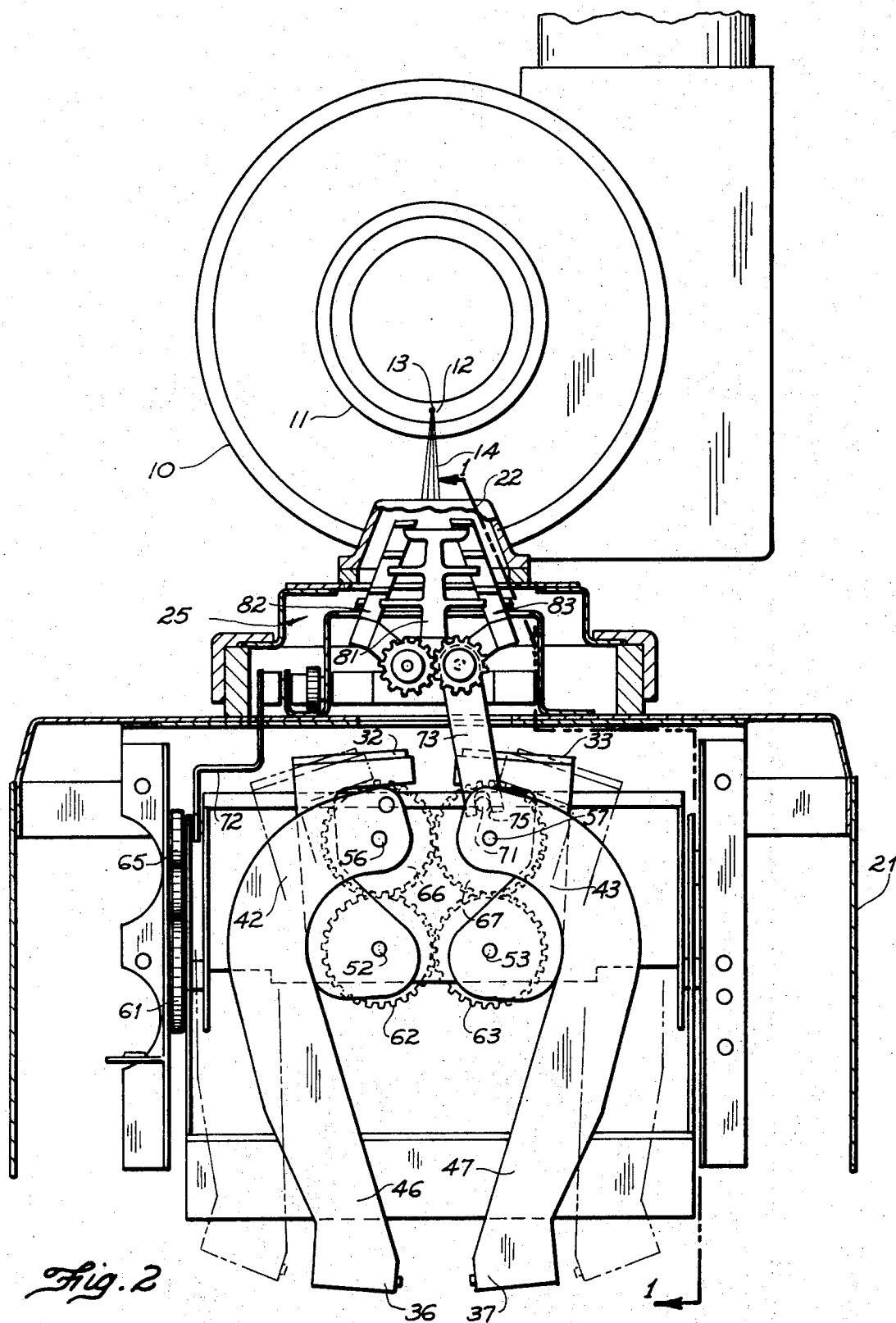
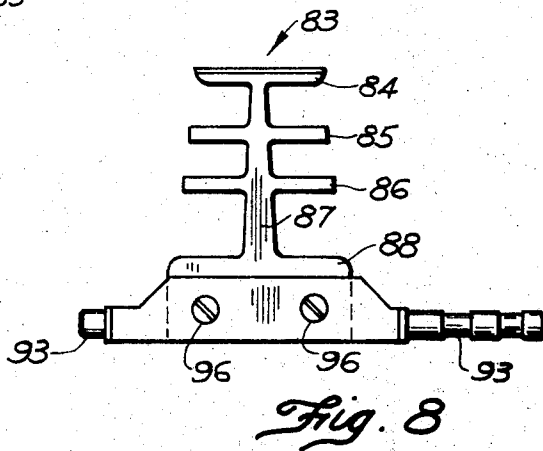
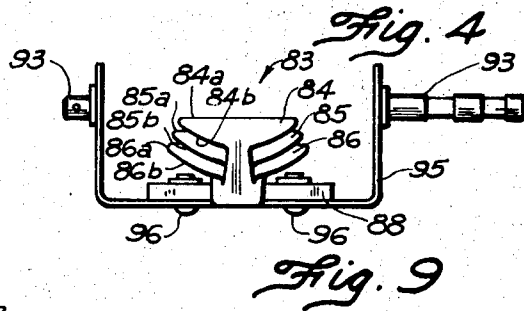
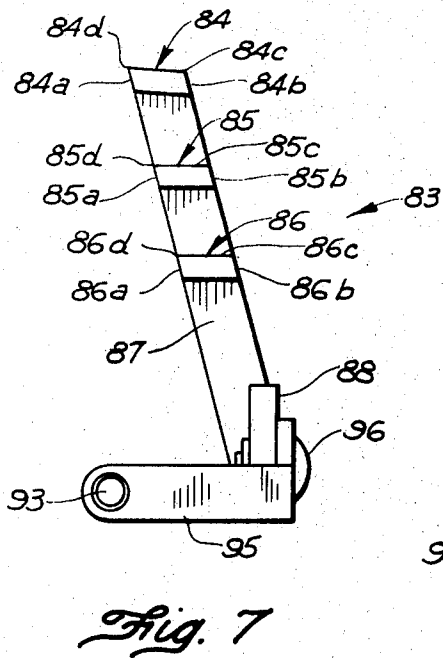
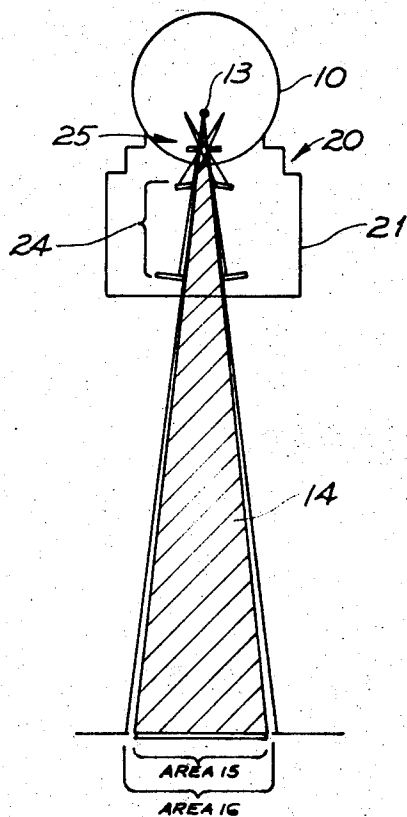
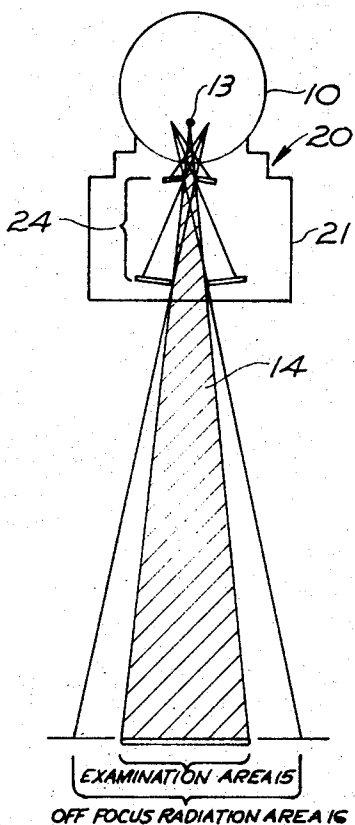
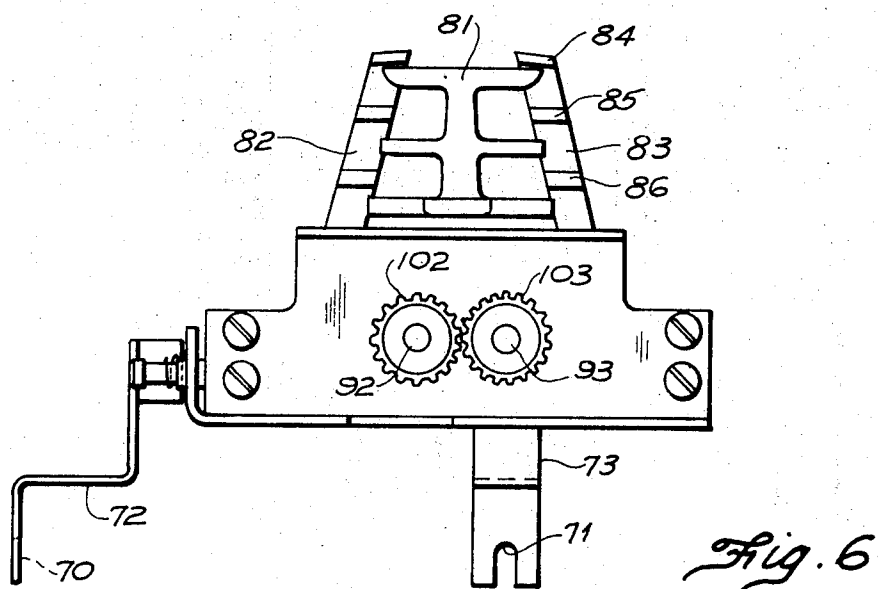
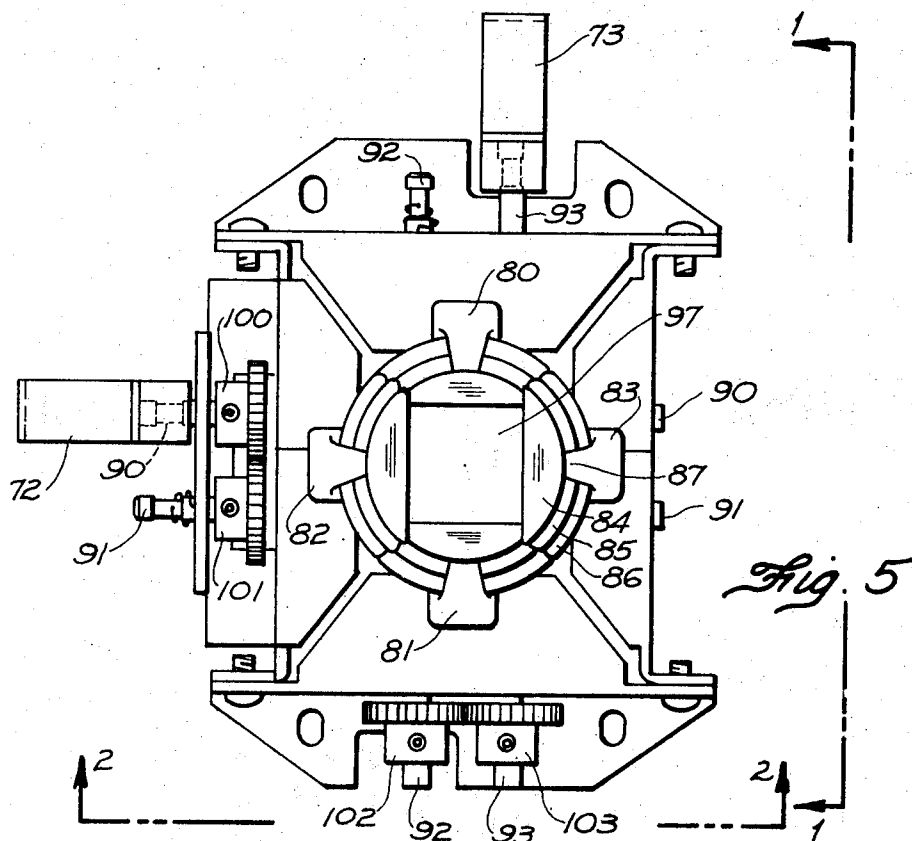


Fig. 1







## RADIATION COLLIMATOR

## CROSS REFERENCE TO RELATED PATENT

"X-Ray Apparatus," U.S. Pat. No. 3,023,314, issued Feb. 27, 1962 to Michael Hura.

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

The present invention relates generally to X-ray apparatus and more particularly to a collimator structure designed to block undesired off-focus radiation.

## 2. Prior Art

In radiographic studies, an X-ray film is exposed by radiation emanating from an X-ray tube. It is desirable to confine the X-radiation to the area of the subject under examination not only to minimize the exposure of the patient and attending persons to the primary beam, but also to minimize radiation scatter effects.

Radiation scatter is produced when the primary radiation beam strikes a patient or object and is diffracted. If the size of the X-ray beam is larger than required to accommodate a particular area under investigation, the X-radiation striking areas of the subject around the area of investigation will produce an unnecessary amount of radiation scatter which has the effect of fogging the radiograph thereby producing a poor image.

Mechanisms known as collimators are used to delineate an X-ray beam of the desired size. In radiographic examinations, these collimators generally include two pairs of relatively movable diaphragms which delineate an X-ray beam of rectangular cross section. These diaphragms, when properly adjusted, will minimize scatter, but by no means eliminate all causes of blurred radiographs. The X-ray beam is emitted from a very small area on an X-ray tube anode known as the focal spot. Theoretically, this spot can be so small and bombardment of it with electrons so precise that the beam is emitted in a precise and regular conical pattern of "on-focus" radiation. As a practical matter, the spot is a larger area than a theoretically optimized spot and an X-ray tube emits a penumbra or band of so-called "off-focus" radiation from areas around the spot. The collimator diaphragms are typically spaced from about four to about eleven inches from the X-ray tube focal spot. With this spacing, some off-focus radiation comes along with the on-focus radiation with a resultant blurring of the radiograph.

Mechanisms for adjusting the diaphragms are typically positioned, speaking transversely of the beam, between the diaphragms and the focal spot. The mechanisms are offset from the primary beam so that they do not interfere with it. The off-focus radiation, however, is not necessarily absorbed by the diaphragms provided to delineate the beam size, but rather may spread outwardly from the theoretical beam. To the extent that the off-focus radiation misses the diaphragms, it is said to "leak" from the collimator. Off-focus radiation can also strike the diaphragm-adjusting mechanisms and other parts of the collimator causing scatter.

Where the X-ray tube voltage is quite high, large quantities of off-focus radiation are given off. This added and undesired radiation has been found in tests to increase the on-focus radiation by as much as 25 percent where the X-ray tube is operated at a high potential such as 125 KVP. Thus, that part of the off-focus

radiation which comes along with the primary beam can cause serious degradation in radiographic quality.

Attempts have been made to control this off-focus radiation but none have been fully successful. The problems in properly controlling off-focus radiation are that:

1. The mechanism for controlling the off-focus radiation should not interfere with the desired on-focus radiation in the primary beam, but at the same time should absorb all radiation around the primary beam;
2. Since the area of the primary beam is adjustable both longitudinally and transversely, the off-focus device should desirably be adjustable with the on-focus diaphragms of the collimator;
3. With the limited space available, providing a rectangular off-focus device which is adjustable in both transverse and longitudinal directions and which does not leak radiation is an objective which has not been achieved in the prior art.

One proposal has been to provide a pair of diaphragms fixed in one direction and a second pair of diaphragms which are adjustable in another direction. The fixed diaphragms obviously must be positioned to correspond to the maximum opening of the on-focus diaphragms. Accordingly, at anything other than a maximum-size radiograph, the off-focus mechanism does not function to the desired level of effectiveness.

Attempts have been made at providing rectangular off-focus collimation with both longitudinal and transverse adjustment, but all such attempts have leaked radiation.

Other proposals have been to utilize an iris-type diaphragm which delineates a generally circular hole. Since the on-focus diaphragms delineate a rectangle, it will be apparent that there must be off-focus radiation around the rectangle or the full rectangular area of the film cannot be exposed when an iris is used.

## SUMMARY OF THE INVENTION

The present invention overcomes the foregoing drawbacks of the prior art and provides a novel and improved collimator for blocking off-focus radiation.

The improved collimator utilizes known on-focus beam delineating diaphragms of the type described in the referenced patent in combination with two pairs of opposed adjustable off-focus diaphragm structures which extend into close proximity with the X-ray source. The off-focus diaphragm structures are provided with linkages interconnecting them with the on-focus diaphragms to assure their concurrent movement with the on-focus diaphragms.

Each of the off-focus diaphragm structures includes an array of vanes supported by a stem at axially spaced positions along the X-ray beam path. The vanes of each diaphragm structure are interleaved on a one-to-one basis with the vanes of two adjacent diaphragm structures. The supporting stems are pivotally mounted such that the vanes of one pair of diaphragm structures are movable inwardly and outwardly of the vanes of the other pair of diaphragm structures.

The inner edges of the vanes are of straight-line configuration and positioned such that the diaphragm structures cooperate with the on-focus diaphragms to rectangularly collimate the beam. One vane of each of the diaphragm structures, hereinafter called the "upper vane," extends into very close proximity to the output

window of the X-ray tube. Others of the vanes, hereinafter called the "lower vanes," are spaced along the beam path and define progressively larger rectangular apertures.

In accordance with one feature of the invention, the sides of the vanes facing toward the X-ray beam, hereinafter called the "inner sides," are inclined relative to the beam path to prevent radiation scatter. The inner side inclination is such that the upper surface of each vane extends inwardly toward the beam path a greater distance than the lower surface. By this arrangement, the upper surface and the inner side of each vane define the beam delineating edge of the vane. Since radiation does not ordinarily strike the inner sides of the vanes, there is no resulting radiation scatter.

In accordance with another feature of the present invention, the upper vane of each off-focus diaphragm structure is cocked relative to its supporting stem in order to keep the inner, beam delineating vane edge at a relatively constant distance from the output window of the X-ray tube as the diaphragm pivots inwardly and outwardly. By this arrangement, a minimal clearance can be provided between the upper vanes and the X-ray tube output window, and the upper vanes will retain substantially the same clearance regardless of the position of the off-focus diaphragms.

The vanes have curved outer sides which give the assembled off-focus collimation system a generally circular cross section. The upper vanes are of smaller cross-sectional area than are the lower vanes. The lower vanes increase in cross-sectional area the farther removed they are from the X-ray source. Accordingly, the assembled off-focus system has a generally conical outer appearance and is of minimal size in regions adjacent the X-ray source.

The interleaved vanes have been shown to be effective to block off-focus radiation without substantial radiation leakage. The pivotal mounting of the supporting stems at positions removed from the X-ray source provides a construction wherein substantially only the effective area of the vanes themselves extend into regions adjacent the X-ray tube, while the linkages which connect with the on-focus diaphragms to effect concurrent movement of the on-focus and off-focus diaphragms are disposed in positions removed from the X-ray source where available operating space is less restricted.

Accordingly, it is a general object of the present invention to provide a novel and improved radiation collimator having an off-focus radiation collimation system which is effective to greatly reduce off-focus radiation.

Other objects and advantages of the present invention will become apparent from referring to the following description and claims taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially schematic cross-sectional view of a radiation collimator constructed in accordance with the present invention and mounted on an X-ray tube housing;

FIG. 2 is a partially schematic cross-sectional view as seen from the plane generally indicated by the broken line 2-2 in FIG. 1;

FIGS. 3 and 4 are schematic illustrations of the off-focus radiation problem and illustrating how the pres-

ent invention operates to greatly reduce off-focus radiation;

FIG. 5 is an enlarged top plan view of the off-focus collimation portion of the collimator of FIGS. 1 and 2;

FIG. 6 is a side-elevational view of the mechanism shown in FIG. 5 on the same scale as FIG. 5; and,

FIGS. 7, 8 and 9 are enlarged side, end and top plan views of one of the diaphragm structures incorporated in the mechanism of FIGS. 5 and 6, FIG. 7 being enlarged to a greater degree than are FIGS. 8 and 9.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2, an X-ray apparatus is shown including an X-ray tube housing 10 which supports and houses an X-ray tube 11. The X-ray tube 11 has an anode 12. In use, the anode 12 includes a small area known as a focal spot 13 which is bombarded with electrons to cause the emission of X-radiation along a conical beam path 14.

A collimator 20 is supported by the tube housing 10 around the beam path 14. The collimator 20 delineates the perimeter of the beam to a rectangular cross section. The collimator 20 includes a housing structure 21 defining spaced input and output ends 22, 23. Opposed pairs of diaphragm plates 24 are supported on pivotally mounted arms. The arms are mounted in the collimator housing 21 for delineating the perimeter of the X-ray beam. The diaphragm arrangement 24 is of the type disclosed in the referenced patent, and will be described in greater detail.

An off-focus collimation system 25 is interposed between the diaphragm arrangement 24 and the X-ray tube 11. As will be described in greater detail, the off-focus collimation system includes two pairs of movable diaphragm structures which interconnect with the diaphragm arrangement 24. The off-focus collimation system 25 cooperates with the diaphragm arrangement 24 to block off-focus radiation.

The diaphragm arrangement 24 comprises two pairs of upper diaphragm plates 30, 31 and 32, 33 and two pairs of lower diaphragm plates 34, 35 and 36, 37. The upper diaphragm plates 30, 31, 32, 33 are supported, respectively, by arms 40, 41, 42, 43. The lower diaphragm plates 34, 35, 36, 37 are supported, respectively, by arms 44, 45, 46, 47. The arms 40, 41, 42, 43, 44, 45, 46, 47 are pivotally mounted by stub shafts 50, 51, 52, 53, 54, 55, 56, 57 which in turn carry gears 60, 61, 62, 63, 64, 65, 66, 67. The gears 60, 61, 64, 65 are meshed as shown in FIG. 1 to provide for concurrent movement of the diaphragm plates 30, 31, 34, 35. The gears 62, 63, 66, 67 are meshed as shown in FIG. 3 to provide concurrent movement of the diaphragm plates 32, 33, 36, 37. The gear 65 rotates clockwise as seen in FIG. 1 when the diaphragm plates 30, 31, 34, 35 move toward each other, and counterclockwise as these diaphragm plates move apart. The gear 67 rotates clockwise as seen in FIG. 2 when the diaphragm plates 32, 33, 36, 37 move toward each other, and counterclockwise as these diaphragm plates move apart. Such a diaphragm arrangement is described in greater detail in the referenced patent.

The off-focus collimation system 25 makes connection with the gears 65, 67 in order to provide for concurrent movement of the off-focus diaphragms and the diaphragms 30-37. These connections include projec-

tions 70, 71 formed on the gears 65, 67 at locations spaced radially outwardly from their axes of rotation, and control levers 72, 73 having notches 74, 75 which receive the projections 70, 71. The control levers 72, 73 are pivotally mounted, as will be explained, so as to be pivotally moved in response to rotation of the gears 65, 67.

The off-focus collimation system 25 principally includes two pairs of diaphragm structures 80, 81 and 82, 83. The diaphragm structures 80, 81, 82, 83 are pivotally mounted on pairs of stub-shafts 90, 91, 92, 93 which also respectively mount gears 100, 101, 102, 103. The gears 100, 101 are meshed to effect concurrent movement of the diaphragm structures 80, 81 while the gears 102, 103 are meshed to effect concurrent movement of the diaphragm structures 82, 83.

As shown in FIG. 5, the control lever 72 connects respectively with one of the stub shafts 90 while the control lever 73 connects with one of the stub shafts 93. By this arrangement, the stub shafts 90, 93 pivotally mount the control levers 72, 73 to interconnect the off-focus diaphragm structures 80, 81 for concurrent movement with the diaphragms 30, 31, 34, 35, and the off-focus diaphragm structures 82, 83 for concurrent movement with the diaphragms 32, 33, 36, 37.

Each of the diaphragm structures 80, 81, 82, 83 comprises an array of vanes supported on a centrally located stem. Referring to FIGS. 7-9, the diaphragm structure 82 is shown in greater detail as including an array of three vanes 84, 85, 86 supported in cantilever fashion from an integrally formed, centrally located stem 87. The stem 87 is provided with a mounting flange 88. A U-shaped bracket 95 is rigidly secured near the distal ends of its legs to the stub shafts 93, and is fastened by means of threaded fasteners 96 to the mounting flange 88.

The vanes 84, 85, 86 are bounded by planar inner sides 84a, 85a, 86a and curved outer sides 84b, 85b, 86b. The inner sides 84a, 85a, 86a cooperate with the upper surfaces 84c, 85c, 86c of the vanes 84, 85, 86 to define beam delineating edges 84d, 85d, 86d. The inner sides 84a, 85a, 86a are inclined relative to the beam path to prevent their being struck by radiation in such fashion as would produce scatter. The beam delineating edges 84d, 85d, 86d cooperate with corresponding beam delineating edges on the diaphragm structures 80, 81, 82, 83 to delineate the beam perimeter to a rectangular cross-section, as best seen in the top view of FIG. 5. The curved outer sides 84b, 85b, 86b and the corresponding outer sides of the vanes of the diaphragm structures 80, 81, 82, 83 minimize the area occupied by the diaphragm structures to permit their extension into the X-ray tube housing 10 into close proximity to the X-ray tube 11.

The vanes on the opposed pairs of diaphragm structures 80, 81, and 82, 83 are arranged to interleave as shown in FIGS. 1, 2 and 6. Specifically, the vanes of the diaphragm structures 80, 81 underlie the corresponding vanes of the diaphragm structures 82, 83. By this arrangement, each pair of opposed diaphragm structures is movable independently of, and without disturbing the operation of, the other pair of opposed diaphragm structures.

The upper vanes of all of the diaphragm structures 80, 81, 82, 83 are cocked at an angle relative to their respective supporting stems in order to keep the inner beam delineating edges, e.g. edge 84d, at a substantially

constant, minimal distance from the output window of the X-ray tube. As the diaphragm structures are pivoted inwardly and outwardly, the cocked upper vanes keep their beam delineating inner edges in close proximity to the X-ray tube window.

Referring to the schematic illustrations of FIGS. 3 and 4, the diaphragm arrangement 24 principally serves to delineate the perimeter of the beam of on-focus radiation which emanates from the anode focal spot 13 confine the on-focus radiation to a selected examination area 15. Off-focus radiation emanating from anode locations spaced from the focal spot 13 can pass between the plates of the diaphragm arrangement 24 as shown in FIG. 3 so as to flood an area 16 which includes, but is substantially larger than, the examination area 15. The off-focus radiation which falls outside the examination area results in an undesirable and entirely useless exposure of the patient to radiation. The off-focus radiation which falls within the examination area 15 tends to overexpose radiographs and to blur the images thereon.

Referring to FIG. 4, in accordance with the present invention, the off-focus collimation system 25 is provided having movable interleaved vanes which, as described, extend within close proximity of the X-ray tube to block off-focus radiation. As will be apparent from an examination of FIG. 4, the vanes of the off-focus collimation system 25 confine the X-ray beam to one including on-focus radiation from the focal point 13, and a bare minimum of off-focus radiation. This arrangement not only substantially confines the off-focus radiation area 16 to that of the examination area 15, but also greatly reduces the amount of off-focus radiation which falls within the examination area 15. Accordingly, the patient is exposed to less radiation, and the resulting radiograph has a sharper and more readable image.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A radiation collimator comprising, in combination;

- a. an X-ray source for directing a beam of X-radiation along a beam path;
- b. on-focus diaphragm means for rectangularly delineating the beam;
- c. off-focus collimation means interposed between said source and said on-focus diaphragm means for blocking off-focus radiation, and including:
  - i. two pairs of opposed diaphragm structures interconnected with said on-focus diaphragm means for concurrent movement therewith to rectangularly delineate the X-ray beam;
  - ii. each of said diaphragm structures including a plurality of vanes supported at locations spaced longitudinally along the beam path and being movable as a unit toward and away from the beam path;
  - iii. the vanes of one pair of diaphragm structures being interleaved with the vanes of the other pair of diaphragm structures and being movable in-

wardly and outwardly thereof independently of the position of said other pair of diaphragm structures.

2. The radiation collimator of claim 1 wherein:

- a. each of said diaphragm structures further includes a supporting stem extending generally axially along the beam path and mounting said vanes;
- b. said stem being movable mounted for moving said vanes transversely of the beam path.

3. The radiation collimator of claim 2 wherein:

- a. said stems are pivotally mounted about axes spaced from said X-ray source; and,
- b. said vanes are mounted on said stems at locations intermediate said axes and said source.

4. The radiation collimator of claim 3 wherein such ones of said vanes as are positioned nearest to the radiation source are configured such that their inner beam delineating edges remain at a substantially constant distance from the X-ray source as said nearest vanes are pivoted inwardly and outwardly toward and away from the beam path.

5. The radiation collimator of claim 3 wherein all of said vanes have inner beam delineating edges defined by the inner sides of the vanes and the upper surfaces of the vanes, and the inner sides are inclined away from the beam path to prevent their being struck by radiation.

6. A radiation collimator for collimating a radiation beam emanating from the focal point of a radiation source and traversing a beam path, comprising:

- a. diaphragm means movably positioned along the beam path for delineating the perimeter of the beam to a first cross-sectional size and configuration;
- b. off-focus radiation collimation means positioned between said diaphragm means and the radiation source at a location near the radiation source and including movable means for blocking off-focus radiation emanating from points within said source other than said focal point, said movable means serving to delineate the beam perimeter to a second cross-sectional size and configuration which proportionally corresponds to said first cross-sectional size and configuration;
- c. said movable means including a plurality of movably mounted stems each rigidly supporting a plurality of vanes for movement as a unit toward and away from the beam path with the vanes supported by adjacent stems being interleaved; and,
- d. connection means operably interconnecting said diaphragm means and said movable means for concurrently moving said diaphragm means and said movable means toward and away from said beam axis whereby the beam perimeter delineated by said diaphragm means and said movable means proportionally decreases or increases in size, and the first and second cross-sectional configurations continue to proportionally correspond.

7. The radiation collimator of claim 6 wherein said vanes are supported centrally on their respective stems and said stems extend generally axially along the beam path and are movable to position said vanes transversely of the beam path.

8. The radiation collimator of claim 7 wherein the outer sides of said vanes are curved to give the assembled vane array a generally circular cross section.

9. The radiation collimator of claim 7 wherein said stems are pivotally mounted for pivoting said vanes through an arc to effect positioning of said vanes transversely of the beam path.

10. The radiation collimator of claim 9 wherein said stems are mounted for pivotal movement about axes extending generally parallel to the longitudinal dimension of said vanes, said axes being spaced from such ones of said vanes as are adapted to extend in closest proximity to the radiation source.

11. The radiation collimator of claim 10 wherein said ones of said vanes are smaller in cross-sectional area than others of said vanes.

12. The radiation collimator of claim 7 wherein such ones of said vanes as are adapted to be positioned nearest to the radiation source are configured such that the inner beam delineating edges remain at a substantially constant distance from the X-ray source as said nearest vanes are pivoted inwardly and outwardly toward and away from the beam path.

13. A radiation collimator a radiation beam emanating from a radiation source and along a beam path comprising:

- a. diaphragm means positioned along the beam path for delineating the perimeter of the beam;
- b. off-focus radiation collimation means positioned between said diaphragm means and the radiation source at a location near the radiation source comprising:
  - i. opposed pairs of diaphragm structures, the diaphragm structures of each pair being interconnected for concurrent movement toward and away from the beam path;
  - ii. each of said diaphragm structures including an array of vanes movable together as a unit toward and away from the beam path;
  - iii. the vanes of one pair of diaphragm structures being interleaved with the vanes of adjacent diaphragm structures; and,
- d. connection means interconnecting said diaphragm means and said opposed pairs of diaphragm structures for concurrent movement toward and away from the beam axis.

14. The radiation collimator of claim 13 comprising two pairs of opposed diaphragm structures, the vanes of one of said pairs of diaphragm structures being interleaved with the vanes of the other of said pairs of diaphragm structures.

15. The radiation collimator of claim 14 wherein the outer sides of said vanes are curved to give the assembled array of said diaphragm structures a generally circular cross section.

16. The radiation collimator of claim 13 wherein each diaphragm structure further includes a stem which supports each vane of said array of vanes at a location centrally of said vanes.

17. The radiation collimator of claim 16 wherein said stems are pivotally mounted.

18. The radiation collimator of claim 16 wherein the vanes supported on each stem are of increasing length and cross-sectional area the farther removed they are from the X-ray source.

19. The radiation collimator of claim 18 wherein the vanes nearest the X-ray source are configured such that their inner beam delineating edges remain at a substantially constant distance from the X-ray source as said

nearest vanes are pivoted inwardly and outwardly toward and away from the beam path.

20. The radiation collimator of claim 19 wherein all of said vanes have inner beam delineating edges defined by the inner sides of the vanes and the upper surfaces of the vanes, and the inner sides are inclined away from the beam path to prevent their being struck by radiation.

21. In an X-ray apparatus having a source of X-radiation positioned to direct a beam of X-rays emanating from a focal point along a path toward a subject, the improvement of a collimator disposed along the beam path for collimating the beam comprising:

- a. a housing structure;
- b. on-focus collimation means movable positioned within said housing structure at a position spaced from the source of X-radiation for adjustably delineating the perimeter of the X-ray beam at spaced locations along the beam path;
- c. off-focus collimation means movably carried by said housing structure at a position between said on-focus collimation means and the source of X-radiation and operably coupled to said on-focus collimation means for movement therewith;
- d. said off-focus collimation means comprising:
  - i. two pairs of opposed diaphragm structures;
  - ii. connection means interconnecting the diaphragm structures of each pair for concurrent movement toward and away from the beam path;

iii. each of said diaphragm structures carrying a plurality of diaphragm plate means movable together as a unit toward and away from the beam path;

iv. the plate means of one pair of diaphragm structures being interleaved with the plate means of the other pair of diaphragm structures at axially spaced positions along the beam path whereby either pair of diaphragm structures can be moved toward or away from the beam path independently of and without interfering with the operation of the other pair of diaphragm structures.

22. The X-ray apparatus of claim 21 wherein the diaphragm structures of at least one of said pairs each includes a supporting stem which extends transversely of the associated plate means, and said plate means comprise an array of plates supported on said stem.

23. The X-ray apparatus of claim 22 wherein said array of plates includes plates centrally mounted on said stem.

24. The X-ray apparatus of claim 21 wherein all of said diaphragm structures include a supporting stem extending transversely of said plate means, and said plate means comprises an array of plates supported on said stems.

25. The X-ray apparatus of claim 24 wherein said plates of one of said pairs of diaphragm structures is interleaved with the plates of said other pair of diaphragm structures on a one-to-one basis.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,829,701 Dated August 13, 1974

Inventor(s) Michael Hura

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 53, delete "3" and substitute - - 2 - -

Signed and sealed this 5th day of November 1974.

(SEAL)  
Attest:

McCOY M. GIBSON JR.  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents