

April 13, 1954

D. T. GREEN ET AL

2,675,486

BEAM THERAPY COLLIMATING UNIT

Filed Feb. 5, 1952

4 Sheets-Sheet 1

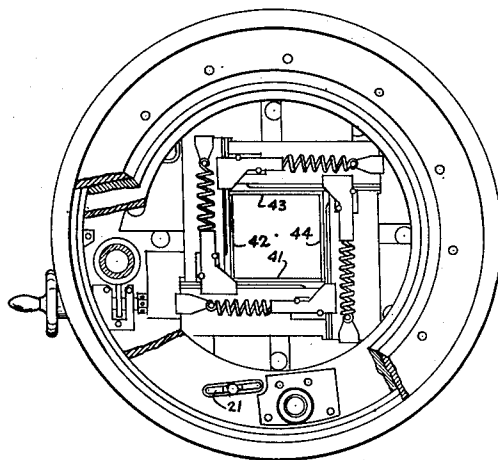
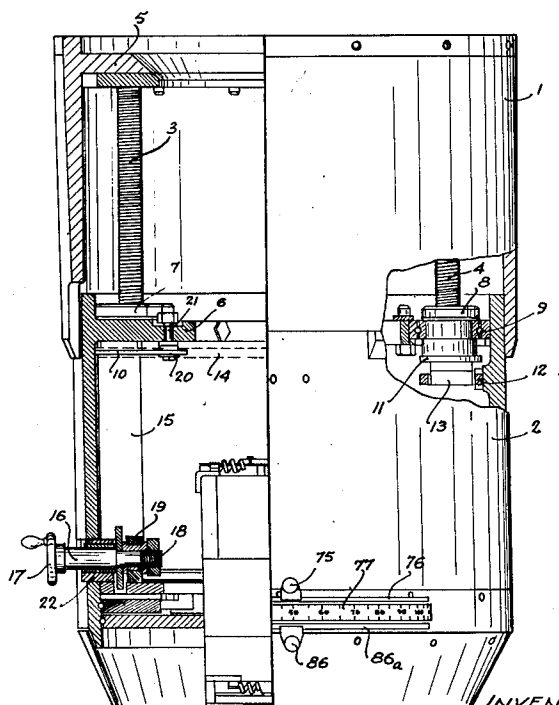


FIG. 2.



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FIG. 1.

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4 Sheets-Sheet 2

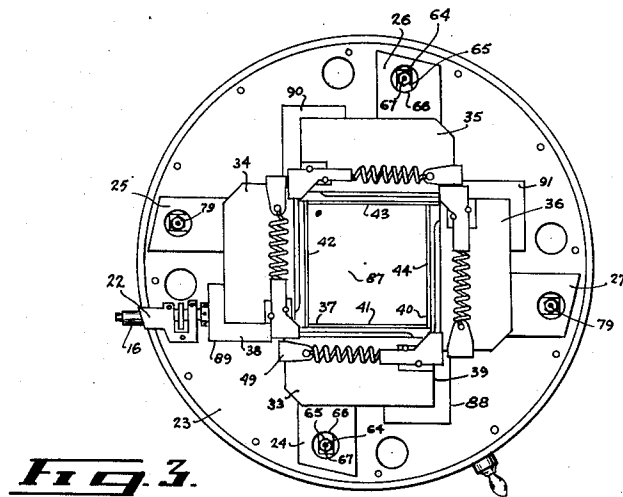


Fig. 3.

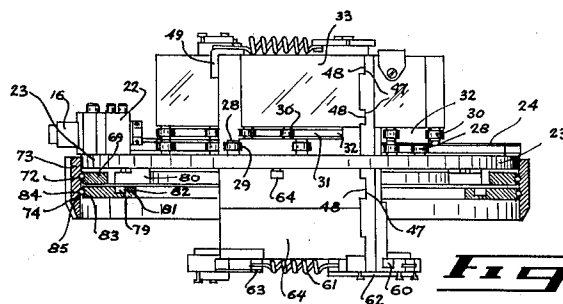


Fig. 4.

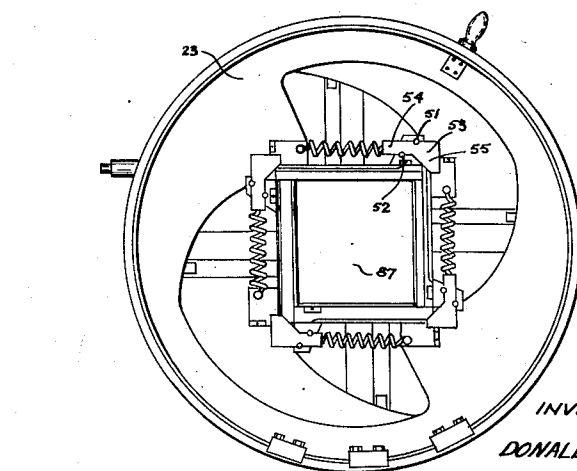


Fig. 5.

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4 Sheets-Sheet 3

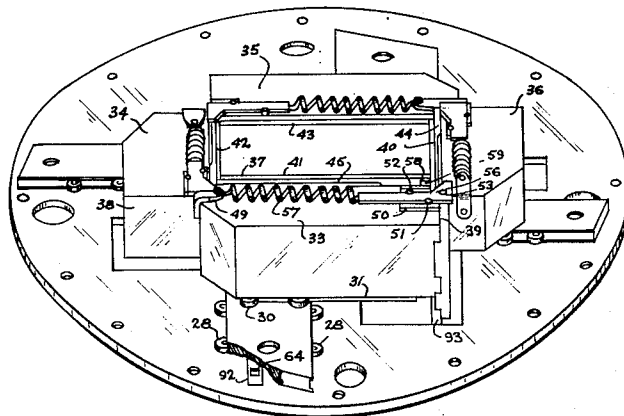


Fig. 6.

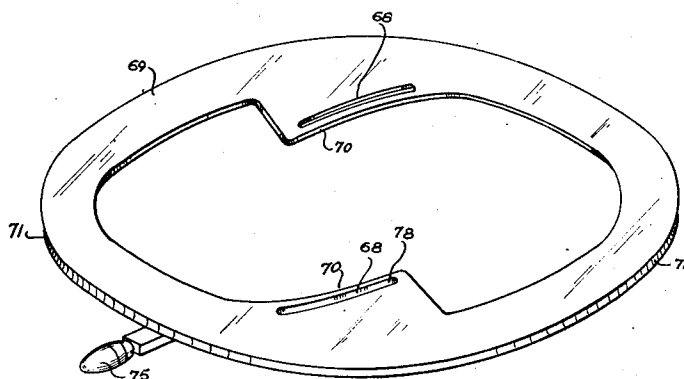


Fig. 7.

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4 Sheets-Sheet 4

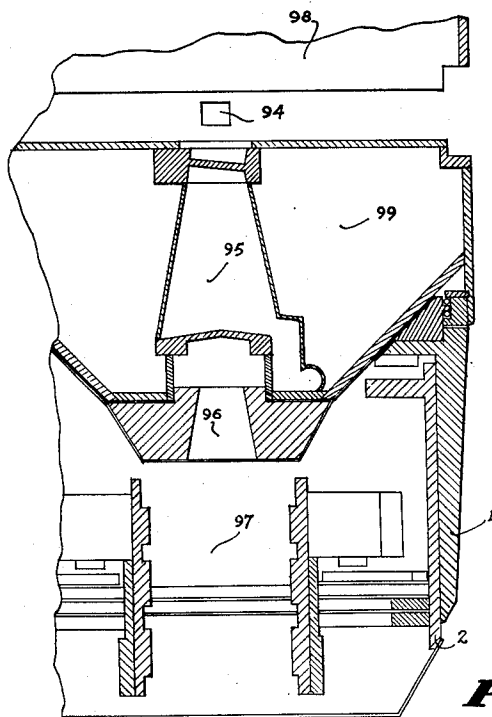


Fig. 8.

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UNITED STATES PATENT OFFICE

2,675,486

BEAM THERAPY COLLIMATING UNIT

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Application February 5, 1952, Serial No. 270,054

Claims priority, application Canada
December 8, 1951

13 Claims. (Cl. 250-105)

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This invention is concerned with a collimator to define a beam of radiation.

The primary application of this device is to the collimation of the radiation from a radio active source of Co^{60} to be used for therapeutic purposes but it could be used for other isotopes emitting high energy gamma radiation or for high voltage X radiation. The same principles could also be applied to collimators for low energy gamma or X radiation in which case the thickness of material necessary to define a beam of high energy radiation could be considerably reduced.

An object of the present invention is to provide a collimator, for radiation, the aperture of which can be infinitely varied through a wide range of square and rectangular shapes.

A further object is to provide a collimator in which the aperture is defined by blocks disposed in a single plane and movable only in one plane.

Another object is to provide a convenient means for varying the distance between the source of radiation and the blocks which define the aperture of the collimator, thereby enabling a constant distance from aperture to skin to be maintained for a range of treatment distances (source to skin distances). This is of importance as it is undesirable for the skin to be too close to the blocks as the skin may then be subject to secondary radiation emitted by the blocks, and on the other hand too great a distance will result in a blurred and poorly defined beam.

In accordance with this invention the distance between the source of radiation and the blocks is varied by providing a cylindrical upper shell telescoping with a cylindrical lower shell within which are disposed the blocks which define the aperture for the emission of the beam. The upper and lower shells are telescoped by means of a series of screws parallel to the axis of the shells and spaced about the periphery of one shell and secured thereto in a manner which prevents axial rotation and movement in a direction parallel to these axes. A series of nuts co-operating with these screws are rotatably supported by the other shell so that the nuts may be turned in one direction to extend the shell and may be rotated in the other direction to close up the shell. A series of sprockets corresponding to said nuts are operably connected thereto so that the rotation of each sprocket causes rotation of the corresponding nut. A continuous sprocket chain is carried by the sprockets so that all of the sprockets will rotate simultaneously. Means are provided for rotating one of the sprockets whereby all of the nuts will be rotated.

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The beam of radiation is defined by blocks movable in a unitary plane which is substantially perpendicular to the axis of the beam of radiation. These blocks comprise two pairs of opposed parallel blocks, the blocks of one pair being at right angles to the blocks of the other pair. The inner face of each block is in abutment with and slidable along the end of one of the blocks in the other pair and its end is in abutment with and slidable along the inner face of the other of the blocks in the other pair. Means are provided for maintaining the blocks in abutment as aforesaid and mounting means is provided for the blocks which permit the movement of each of the blocks within the unitary plane in a direction parallel to the ends of the block and also in a direction perpendicular thereto. Means are also provided for increasing or decreasing the distance between one of said pairs of blocks and means for increasing or decreasing the distance between the other of said pairs of blocks. As the distance between one of the pairs of blocks is increased or decreased the other blocks will be moved in opposite directions along parallel paths. Hence a square or rectangular aperture will at all times be defined by the two pairs of blocks.

Confining the blocks to a unitary plane is considered to be of great importance. If two or more planes were used the total thickness of the defining portion would be twice as great as in accordance with the present invention and the total weight would also be somewhat greater. In addition the distance to the skin from one pair of defining blocks would be different than for the other pair, thus losing some definition of the beam for any given distance. Further, the centre of gravity of the defining system would be further from the source for a system capable of a certain minimum placement from the source, and thus the entire device would be more difficult to rotate about a horizontal axis.

In the drawings which illustrate the preferred embodiment of this invention:

Fig. 1 is an elevation view partly in section of the collimator.

Fig. 2 is a plan view partly broken away of the collimator shown in Fig. 1.

Fig. 3 is a plan view showing a different position of the blocks from that illustrated in Fig. 2.

Fig. 4 is an elevation view partly in section corresponding to Fig. 3.

Fig. 5 is a sectional view illustrating the base plate assembly.

Fig. 6 is a perspective view showing the blocks mounted on the base plate.

Fig. 7 is a detailed view of the lower cam plate. Fig. 8 is a view illustrating the general assembly of the collimator and the source of radiation.

In the drawings in which the same numerals indicate similar parts a cylindrical upper shell 1 slidably engages a cylindrical lower shell 2 so that the lower shell 2 will telescope within upper shell 1. Four screws of which 3 and 4 are illustrated are symmetrically disposed around the periphery of shell 1, the screws being parallel to the axis of shell 1 and being within the shell. The screws are anchored to an inwardly directed flange 5 at the top of shell 1 in a manner which prevents axial rotation and movement in a direction parallel to these axes. At the upper portion of shell 2 there is an inwardly directed flange 6 within which is journaled a series of nuts corresponding to each of the four screws, nuts 7 and 8 being illustrated. Ball bearings 9 facilitate the rotation of these nuts. A series of sprockets corresponding to the nuts, of which 10 and 11 are illustrated, are rigidly connected with or integral with the nuts so that rotation of the sprockets rotates their corresponding nuts. An additional needle bearing 12 engaging a shaft 13 which downwardly depends from the sprocket can be provided to give additional support to the nut sprocket assembly. Shaft 13 is preferably hollow. A sprocket chain 14 encircles the four sprockets so that rotation of one sprocket causes all four sprockets to rotate simultaneously in the same direction. Idler sprocket 20, adjustable in groove 21, provides for the adjustment of chain 14. A vertical scale may be provided on the lower shell 2 which is read off from the lower edge of the upper shell 1. This scale will show the correct relative position of the shells for any treatment distance within the useful range.

A cylindrical tube 15 replaces bearing 12 and shaft 13 in one of the nut sprocket assemblies. Tube 15 is rigidly secured to sprocket 10 so that rotation of tube 15 causes rotation of sprocket 10 and nut 7. A shaft 16 is inwardly directed with respect to shell 2 perpendicular to the axis of tube 15. A handle 17 exterior to shell 2 turns shaft 16. A helical gear 18 mounted on shaft 16 meshes with a corresponding gear piece 19 at the bottom end of shaft 15 so that shaft 15 will rotate when the handle 17 is turned. Shaft 16 is journaled in a bearing 22 which is mounted on base plate 23. The screws are permitted slight, angular and lateral displacement to prevent binding when the nuts are close to the heads of the screws.

Plates 24, 25, 26 and 27 are mounted on base plate 23 between rollers 28 which engage grooves 29 in the side edges of plates 24, 25, 26 and 27. These rollers permit plates 24, 25, 26 and 27 to move inwardly or outwardly with respect to base plate 23 but prevent lateral movement. Additional rollers 30 are mounted on plates 24, 25, 26 and 27. Rollers 30 engage grooves 31 in the side edges of plate 32. There are four plates 32 corresponding to each of plates 24, 25, 26 and 27, and plates 32 are mounted between rollers 30 so that each of plates 32 is capable of movement relative to its corresponding plate 24, 25, 26 or 27 in a direction perpendicular to the direction of movement of its corresponding plate. It will be evident that the combined effect of mounting plates 24, 25, 26 and 27 between rollers 29, and plates 32 between rollers 30 is to enable plates 32 to assume a variety of position in a unitary plane parallel to base plate 23.

Blocks 33, 34, 35 and 36 are rigidly mounted on

each of plates 32 and are movable with plates 32. The blocks are arranged with their longest dimension in the direction of movement of plate 32 with respect to plates 24, 25, 26 or 27. The inner surface 37 of block 33 is partly in abutment with the end 38 of block 34 adjacent to one end of block 33 and the other end of block 33, namely 39, is partly or completely in abutment with the inner face 40 of block 36. Similarly one end of block 34 is in abutment with the inner face 37 of block 33, and at the other end of block 34 there is an abutment between the inner face of block 34 and the end of block 35. One end of block 35 is in abutment with the inner face of block 34 and at the other end of block 35 there is abutment with the end of block 36. One end of block 36 is in abutment with inner face of block 35 and at the other end of block 36 there is abutment between the inner face 39 of block 36 and the end of block 33.

It will be appreciated from the foregoing that if a pair of parallel opposed blocks 33 and 35 are moved inwardly towards each other from an initial position adjacent to the periphery of base plate 23, the inward movement of block 33 will cause block 34 to move in the same direction as block 33, the plate 32 upon which block 34 is mounted sliding between its rollers 30. Similarly the inward movement of blocks 35 will cause block 36 to move in the same direction as block 35 the inner face 40 of block 36 sliding with respect to the abutting end 39 of block 33 and the plate 32 upon which block 36 is mounted moving between its rollers 30. A rectangular space will thereby be defined by blocks 33, 34, 35 and 36. Similarly if blocks 34 and 36 which are parallel and in opposed position with respect to each other are moved inwardly, blocks 33 and 35 will move in opposite parallel directions, block 33 moving in the same direction as block 36 and block 35 moving in the same direction as block 34. If blocks 33 and 35 are brought together to the same extent as blocks 34 and 36 a square space will be enclosed by the blocks.

Plates 41, 42, 43 and 44 are mounted on the inner faces of blocks 33, 34, 35 and 36 respectively. These plates extend the full length of their corresponding blocks and have portions such as 45 which extend slightly above the upper surfaces of the corresponding blocks. Facing plates 41, 42, 43 and 44 also have downwardly extending portions 46 which extend beneath the lower surfaces of the corresponding blocks a distance which is approximately equal to the height of the blocks. These downward extensions enable suitable definition for the beam to be provided whilst keeping the heavy mass of the block as close as possible to the source and as far as possible from the patient. This means that the treatment unit is easier to tilt, due to their being a lower moment about the horizontal axis, the heavy blocks can be smaller in size, and there is less scattered radiation delivered to the patient's skin. The inner surfaces of plates 41, 42, 43 and 44 have longitudinally extending grooves 47, which correspond to raised portions 48 in the abutting end of the block and the facing plate in contact with that inner face, in order that there may be no direct downward path between abutting blocks for the escape of radiation. This construction prevents the escape of radiation and enables rollers to be included which give rolling rather than sliding friction between the blocks.

A strap 49 is mounted on each of blocks 33, 34, 35 and 36 at the end of the block which is not

in abutment with the inner face of another block. At the abutting end of the block a plate 50 is located on the upper surface of the block adjacent to the end of the block. Spaced upwardly extending studs 51 and 52 are diagonally disposed on block 50. A clamping piece 53 is placed with its shank portion 54 between studs 51 and 52, and its head portion 55 extending over the facing plate 41, 42, 43 or 44 of the adjacent block. A roller 56 is mounted on the lower surface of head portion 55 and moves along the outer surface of extension 45. A tension spring 57 is connected between strap 49 and the end of shank 54 and this urges roller 56 against the outer surface of extension 45 thereby tending to keep the end of one block in close abutment with the inner face of a second block while permitting the inner face of the second block to slide relatively to the abutting end of the first block. A roller 58 mounted in an indentation 59 in the end of extension 45 bears against the inner face of extension 45 in the adjacent block and reduces the friction when the inner face of one block slides with respect to the abutting end of another block. Similarly at the bottom of downward extension 46 a roller 60 is urged against the outer surface of the downward extension 46 of an adjacent block by a spring 61 connected between clamp 62 and a strap 63.

Cam followers 64 are mounted beneath each of plates 24 and 26 on supports 65 which are secured to plates 24 or 26. Apertures 66 in plates 24 or 26 provide access to bolts 67 which secure cam followers 64. Cam followers 64 engage arcuate oppositely disposed cam grooves 68 in cam plate 69. Cam plate 69 is in the form of an annular ring with inwardly directed fins 70 in the upper surfaces of which are cam grooves 68. A groove 71 runs around the outer edge of cam plate 69 to provide a race for balls 72 which are retained in an annular groove 73 in a cylindrical flange 74 which downwardly depends from the edges of plate 23. A handle 75 is attached to cam plate 69 and this moves through a slot 76 in flange 74. A scale 77 mounted on flange 74 enables the extent to which handle 75 has been moved to be measured. It will be appreciated that movement of handle 75 in a clockwise direction causes cam followers 64 to ride up to the inner end 78 of cam groove 68, this moves plates 24 and 26 inwardly and consequently moves blocks 33 and 35 towards each other. Similarly movement of handle 75 in an anti-clockwise direction increases the distance between blocks 33 and 35.

Cam followers 79 are mounted beneath plates 25 and 27 in a similar manner on supports 18 which bring cam followers 79 into a position beneath cam plates 69 and radially inwardly from the annular edge of cam plate 69 so that there will be no interference between cam followers 79 and upper cam plate 69, cam followers 79 engage cam grooves 81 in a cam plate 82. The annular edge of cam plate 82 is wider than the annular edge of cam plate 69 and the fins and cam grooves in cam plate 82 are inwardly disposed with respect to the corresponding members in cam plate 69. The edge of cam plate 82 is grooved as at 83 to provide a face for balls 84 which are carried by an annular groove 85 in cylindrical flange 74. A handle 86 is secured to cam plate 82 and this moves in a slot 86a in flange 74 to enable the inward and outward movement of blocks 34 and 36 to be controlled in the same manner as that described for blocks 33 and 35.

Base plate 23 has a square central aperture 87

to permit free movement of the downwardly extending portion 46 of the facing plates and to provide an opening for the emission of the beam of radiation. A rectangular indentation 88 in base plate 23 permits lateral movement of the downward extension 46 of facing plate 44 and indentations 89, 90 and 91 are provided for a similar purpose with respect to the downward extensions of facing plates 41, 42, and 43 respectively. An inwardly directed slot 92 in base plate 23 permits inward and outward movement of cam followers 64 and similarly slots are provided to allow inward and outward movement of the other cam followers. The downwardly extending portion 46 of the facing plates may require slotting as at 93 to prevent interference with the cam plates.

Figure 8 illustrates the general arrangement of the collimator and the source of radiation. It will be seen that source of radiation 94 outlet port 95, beam limiting aperture 96 and the collimator indicated generally at 97 are in alignment. The source may be positioned by means of a sliding tray between absorptive lead housings 98 and 99. A conical shaped outlet port 95 in lead housing 99 defines a beam of radiation which is restricted by beam limiting aperture 96. Outlet port 95 may be closed off by the insertion of mercury.

Source 94, outlet port 95, aperture 96, housing 99, are mounted upon upper shell 1. The collimator 97 is mounted in lower housing 2 which telescopes with upper housing 1 in the manner described.

It will be appreciated from the foregoing that a device in accordance with the present invention will enable a fixed distance to be preserved between the defining blocks and the patient for different distances from the source to the patient and will achieve the various other objects of this invention.

We claim:

1. In a collimator for defining a beam of radiation a lower shell telescoping with an upper shell, means for defining the beam disposed within the lower shell, means for telescoping the upper and lower shells comprising a series of screws attached to one shell and parallel to the direction of telescoping, a series of nuts engaging said screws said nuts being journaled in bearings in the other shell and means for simultaneously rotating all of said nuts whereby the shells will be telescoped together.

2. In a collimator for defining a beam of radiation an upper shell telescoping with a lower shell, means for defining the beam disposed within the lower shell, means for telescoping the upper and lower shells comprising a series of screws parallel to the direction of telescoping spaced about the periphery of one shell and secured to that shell a series of nuts engaging said screws said nuts being journaled in bearings in the other shell and means for rotating all of said nuts simultaneously whereby the upper and lower shells will be telescoped together.

3. A device as in claim 2, in which the means for rotating the nuts simultaneously comprises a series of sprockets corresponding to the nuts and operably connected thereto, a continuous sprocket chain carried by said sprockets and means for rotating one of said sprockets.

4. In a collimator for defining a beam of radiation a cylindrical upper shell telescoping with a cylindrical lower shell, means disposed within the lower shell to define a beam of radiation,

means for telescoping the upper and lower shells comprising a series of screws parallel to the axis of said shells spaced about the periphery of one shell and secured to that shell, a series of nuts co-operating with said screws and rotatably supported by the other shell, a series of sprockets corresponding to said nuts and operably connected thereto, a continuous sprocket chain carried by said sprockets and means for rotating one of said sprockets.

5. In a collimator for defining a beam of radiation a cylindrical upper shell telescoping with a coaxial cylindrical lower shell, blocks disposed within the lower shell and movable in a plane transverse to the axis of the shell to define an aperture for the emission of the beam of radiation, means for telescoping the upper and lower shells comprising a series of screws parallel to the axis of the shells spaced about the periphery of one shell and secured to that shell a series of nuts co-operating with said screws and rotatably supported by the other shells, a series of sprockets corresponding to said nuts, and operably connected thereto, a continuous sprocket chain carried by said sprockets and means for rotating one of said sprockets.

6. In a collimator for defining a beam of radiation a cylindrical upper shell telescoping with a coaxial cylindrical lower shell, blocks movable in a unitary plane substantially perpendicular to the axis of the beam of radiation to define an aperture for the emission of the beam, said blocks comprising two pairs of opposed parallel blocks, the blocks of one pair being at right angles to the blocks of the other pair, each block having its inner face in abutment with and slidable along the end of one of the blocks in the other pair and having its end in abutment with and slidable along the inner face of the other of the blocks in the other pair, means for maintaining the blocks in abutment as aforesaid, supporting means for the blocks permitting movement of each block within said unitary plane in a direction parallel to the axis of said block and in a direction perpendicular thereto, means for increasing or decreasing the distance between one of said pairs of blocks and means for increasing or decreasing the distance between the other of said pairs of blocks, means for telescoping the upper and lower shells comprising a series of screws parallel to the axis of the shells spaced about the periphery of one shell and secured to that shell, a series of nuts co-operating with said screws and rotatably supported by the other shell, a series of sprockets corresponding to said nuts and operably connected thereto, a continuous sprocket chain carried by said sprockets and means for rotating one of said sprockets.

7. In a collimator for defining a beam of radiation, blocks movable in a unitary plane substantially perpendicular to the axis of the beam of radiation to define an aperture for the emission of the beam, said blocks comprising two pairs of blocks, the blocks of each pair being parallel to each other and at right angles to the blocks of the other pair, each block having its inner face in abutment with and slidable along the end of one of the blocks in the other pair and having its end in abutment with and slidable along the inner face of the other of the blocks in the other

pair, means for maintaining the blocks in abutment as aforesaid, mounting means for said blocks permitting movement of each of said blocks within said unitary plane in a direction parallel to the axis of said blocks and in a direction perpendicular thereto, means for increasing or decreasing the distance between one of the said pairs of blocks and means for increasing or decreasing the distance between the other of said pairs of blocks.

8. A device as in claim 7 in which the mounting means for said blocks to permit movement of said blocks within said unitary plane in a direction parallel to the axis of said blocks and in a direction perpendicular thereto comprises for a plate on each of which one of said blocks is mounted in a manner which permits relative movement between said block and said plate only in a direction parallel to the axis of the block, each of said plates being mounted on a base in a manner which permits movement only in a direction perpendicular to the axis of said block.

9. A device as in claim 8 in which the means for increasing or decreasing the distance between said pairs of blocks comprises cam followers mounted beneath the plates, a cam plate for moving the cam followers associated with one pair of blocks inwardly or outwardly to decrease or increase the distance between that pair of blocks, and a second cam plate for moving the pair of cam followers associated with the other pair of blocks inwardly or outwardly to decrease or increase the distance between the other of said pairs of blocks.

10. A device as in claim 9 in which the cam plates are in the form of an annular ring having diametrically opposite inwardly directed fins and arcuate cam grooves in said fins.

11. A device as in claim 7 in which each of the means for maintaining the blocks in abutment comprises a clamp extending beyond the end of a block which is in abutment with the inner face of another block and engaging an upward extension along the inner face of said other block, said clamp having a shank portion slidable between upwardly extending studs mounted on the first mentioned block and the clamp being connected to a tension spring longitudinally disposed with respect to the first mentioned block.

12. A device as in claim 7 in which the inner face of each of said blocks comprises a facing plate having a portion extending downwardly below the block.

13. A device as in claim 7 in which each of the inner faces of the blocks have longitudinally extending grooves which correspond with raised portions at the end of the block which co-operates with said face.

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