Feb. 23, 1954 J. C. PENNOCK ET AL 2,670,443

RADIATION BEAM FORMING UNIT

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Fig. 2.

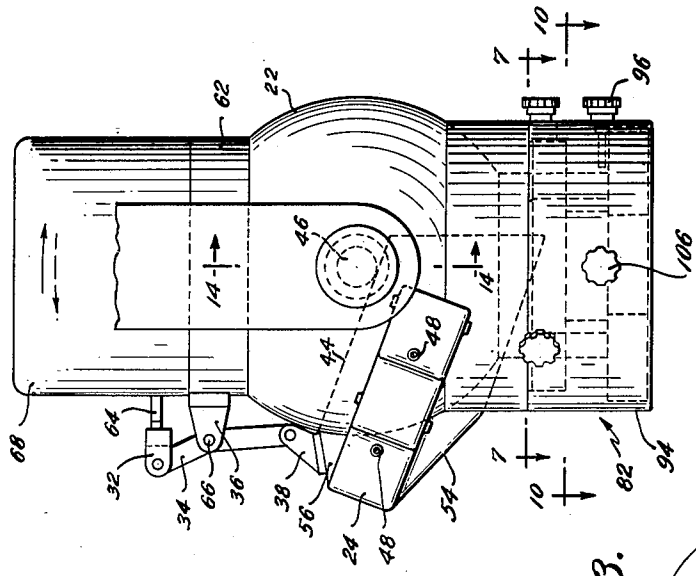


Fig. 3.

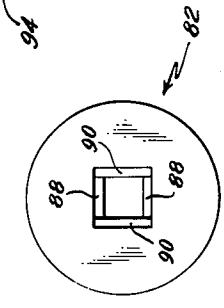
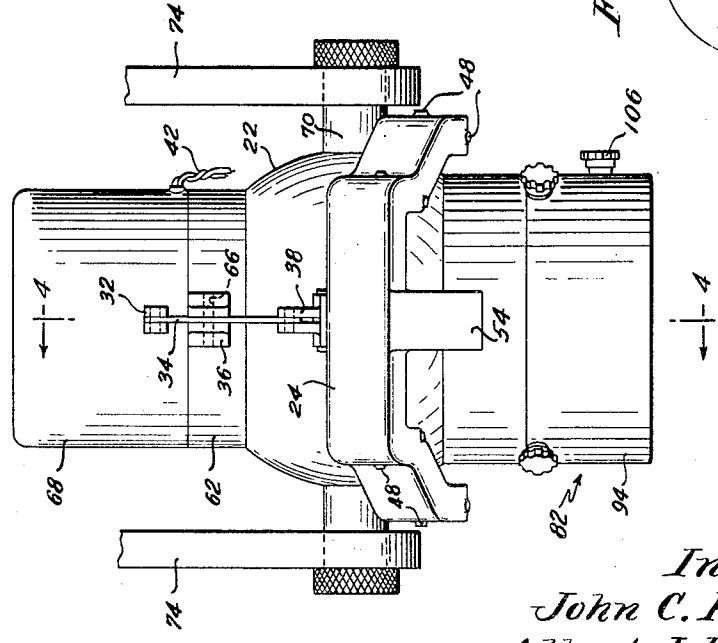


Fig. 1.



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Fig. 4.

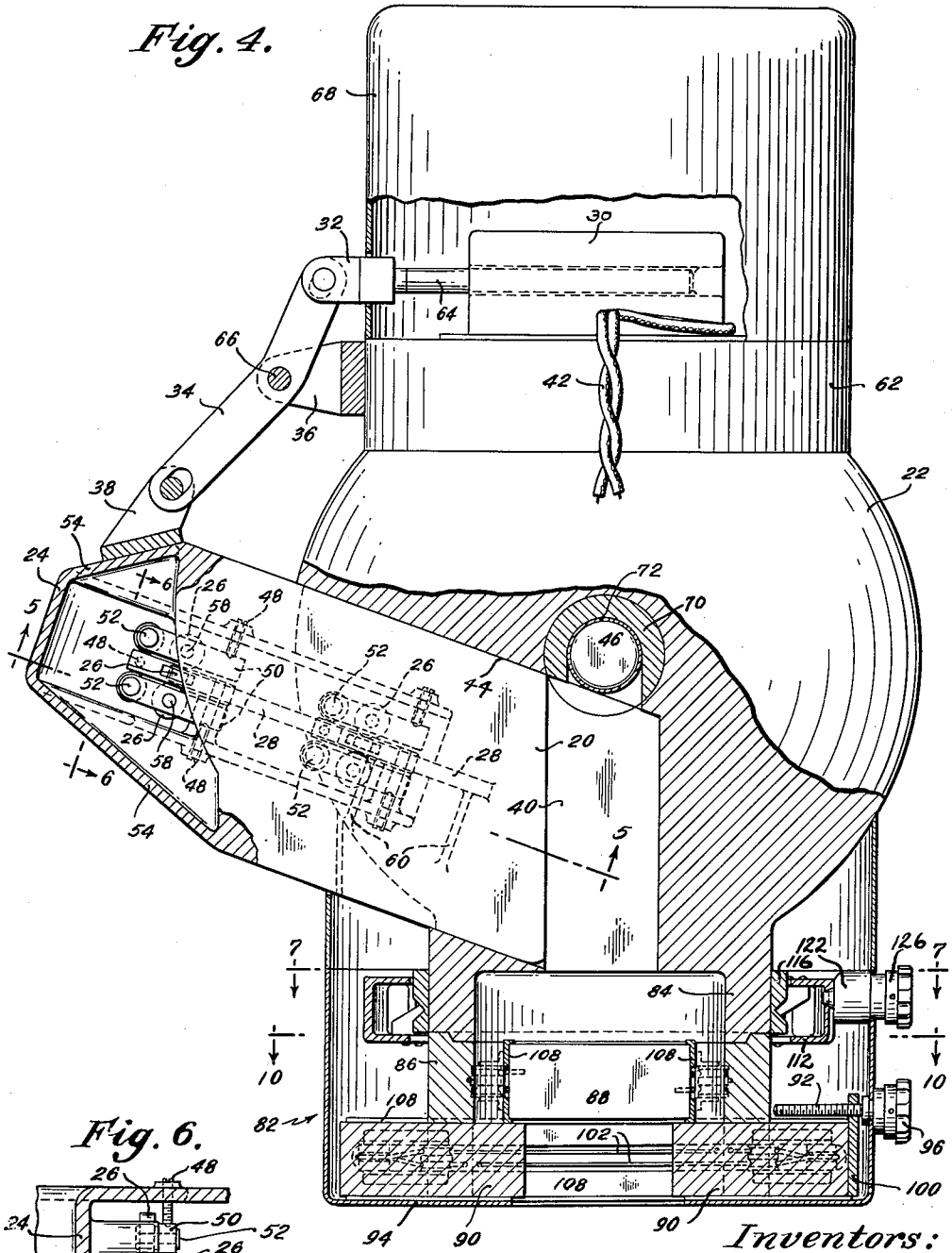
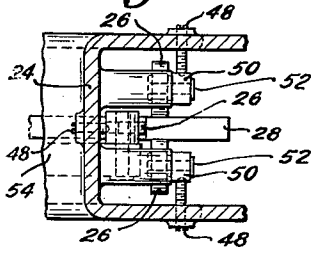


Fig. 6.



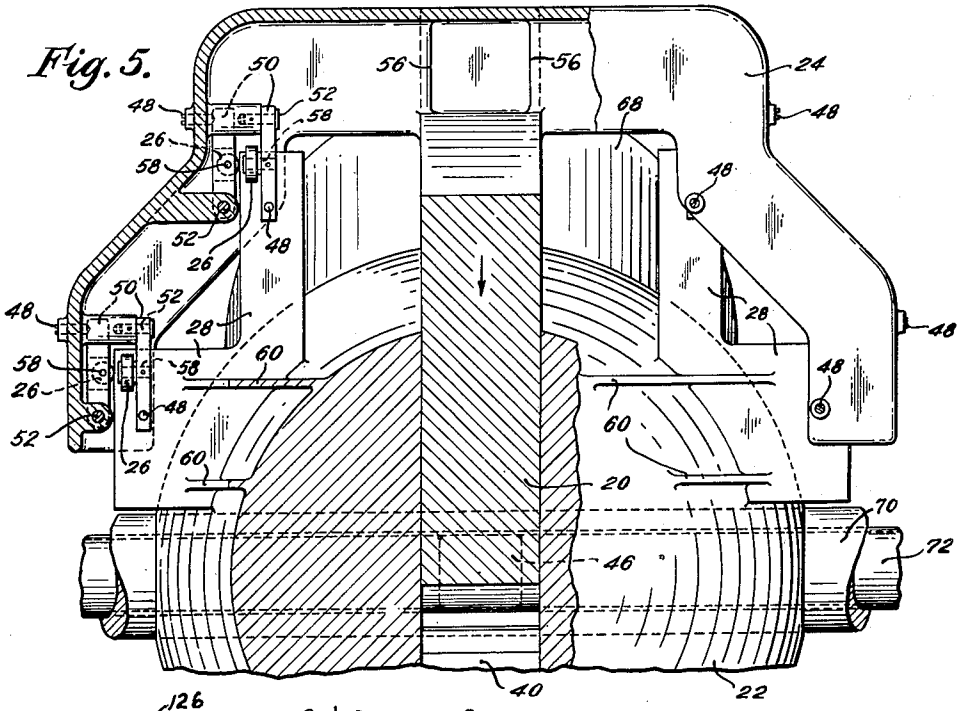
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RADIATION BEAM FORMING UNIT

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Fig. 5.



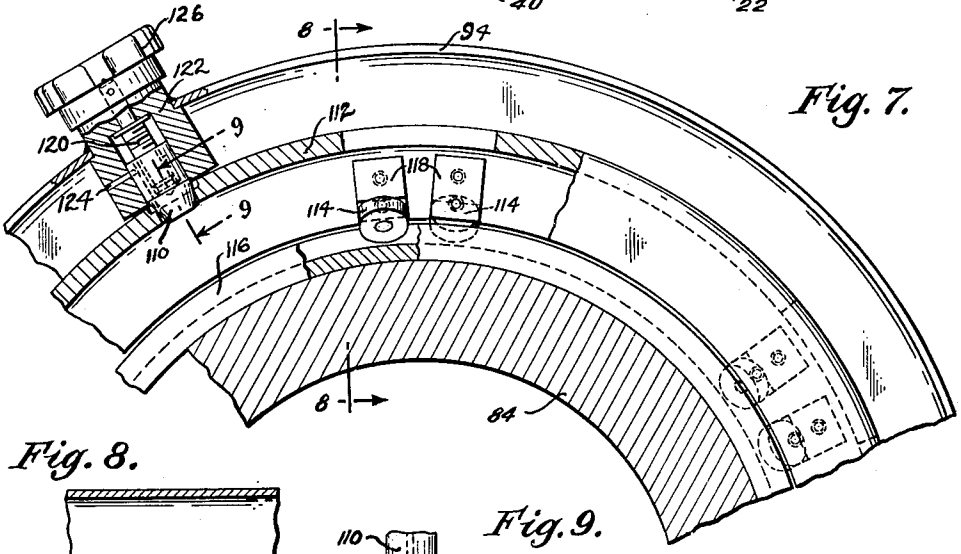


Fig. 7.

Fig. 8.

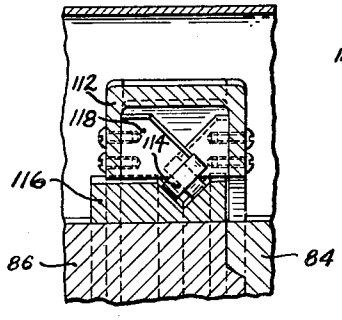
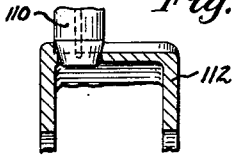


Fig. 9.



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Fig. 10.

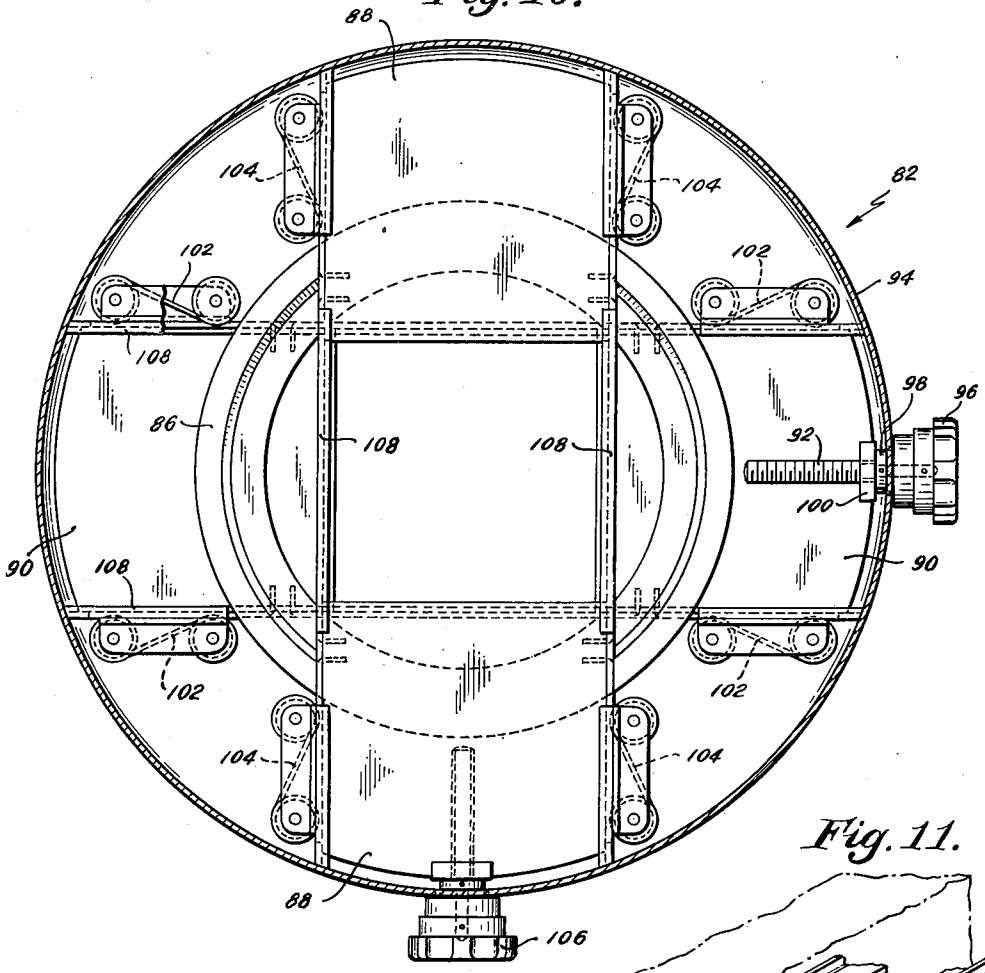


Fig. 11.

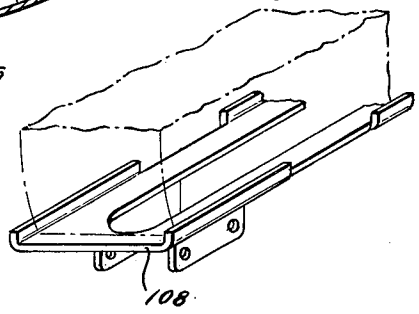
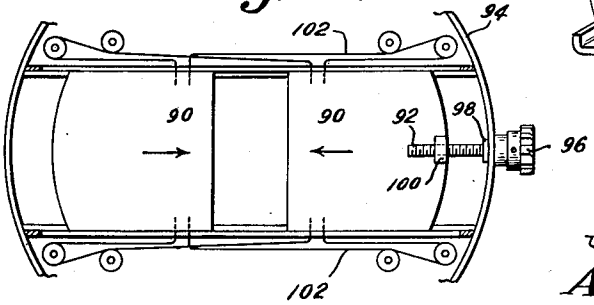


Fig. 12.



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RADIATION BEAM FORMING UNIT

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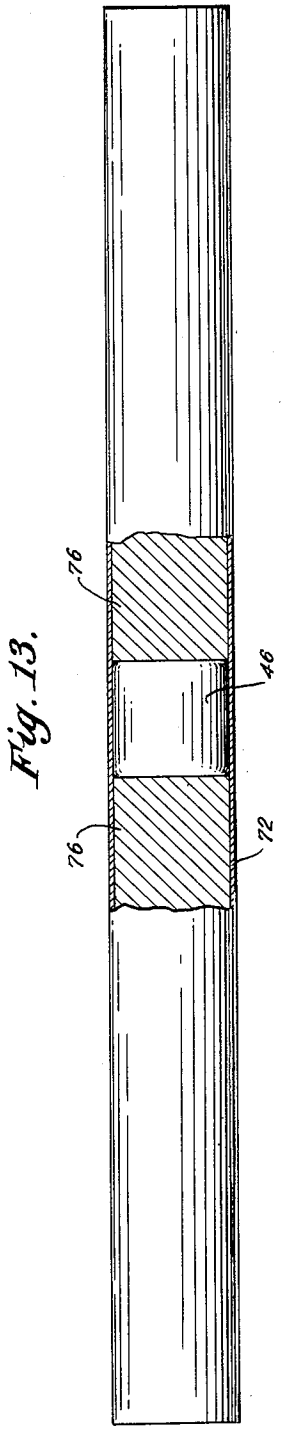


Fig. 13.

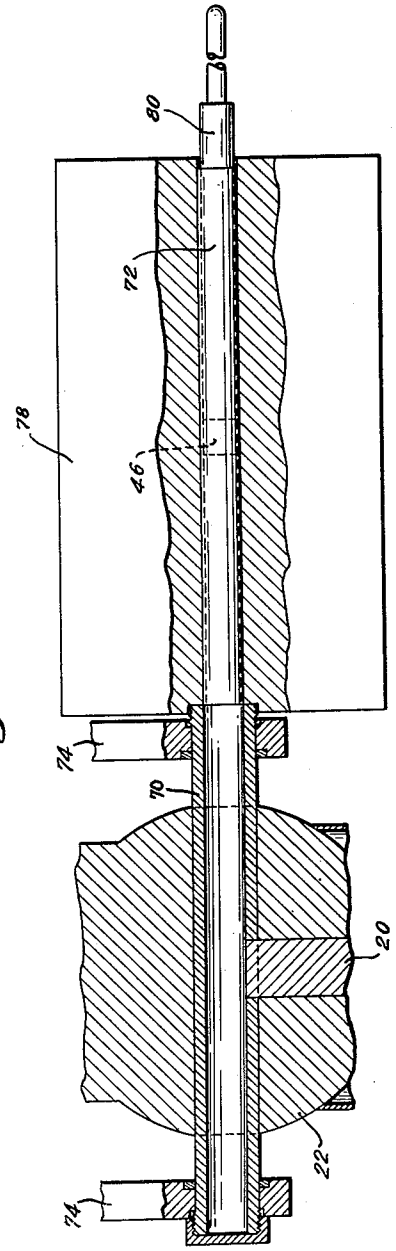


Fig. 14.

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UNITED STATES PATENT OFFICE

2,670,443

RADIATION BEAM FORMING UNIT

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Application February 28, 1951, Serial No. 213,174

11 Claims. (Cl. 250—105)

1

This invention relates to devices for forming a beam of radiant energy which may be used for the treatment of disease or the radiography of structural materials or the like. More particularly the invention is concerned with a new and improved radiant energy beam-forming device in which a radioactive source is removably mounted in a shield of radiation absorbing material with provision for producing an opening in the absorbing material to form a collimated beam of radiations and embodying new and improved means permitting the simple and safe loading into the shield and unloading therefrom of the radioactive source, together with a novel "fail safe" arrangement to keep the source shielded in the event of power failure to the device.

Devices for the purpose stated above have been used for a number of years with radium as the source of radiation. Because of the great cost of such material and the inherent limitation on the amount of radiation which can be obtained from a naturally radioactive source of given size (volume specific activity), such devices have never been built to handle more than about 50 grams of radium.

Beam forming devices using radium sources of 1 to 20 grams have usually consisted of a pneumatic device for transporting the radium source from a shielded storage container, which protects the attendant personnel from irradiation, to a collimating device and then back to the shielded storage container. While such a pneumatic transport system is satisfactory for handling radiation sources of limited strength, the possibility of sticking of the radiation source in the transport tube in a position in which there is no protection for the attendant personnel makes such a device extremely hazardous for use with very high intensity gamma-ray sources.

In order to arrive at some estimate of the potential danger inherent in the use of very high intensity gamma-ray sources, a comparison is given of the time required to receive a mean-lethal-dose (assumed to be 250 roentgens over the whole body) of gamma-radiation from a 50 gram radium source and from a 1000 curie and a 10,000 curie cobalt-60 source if the entire body is exposed at a distance of one meter from the source.

Lethal exposure table

Source	Time Required
50 Gram Radium	Approximately 6 hours.
1,000 Curie Cobalt-60	Approximately 11 minutes.
10,000 Curie Cobalt-60	Approximately 1.1 minutes.

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It becomes obvious from the above that the degree to which the device in which the source will be used must be made fail-proof increases very rapidly with the intensity of the source to be used.

Very high intensity gamma-ray sources are now available and will become increasingly available in the form of materials which have been made artificially radioactive by exposure to neutrons in a nuclear reactor. Such materials can be made with a much higher rate of emission of radiant energy per unit volume of source (higher specific activity) than is possible with radium or other naturally radioactive materials and at a much lower cost per unit of radiant energy. It is, therefore, now possible and economically practical to produce and use radiation sources with gamma-ray emission equivalent to thousands of grams of radium.

Several mechanisms which may be used to form collimated beams of radiations by moving a radioactive source into position in line with a hole in surrounding radiation absorbing material have been suggested. All of the devices which have been suggested have three major disadvantages: First, they require power of some sort to move the source from the beam-forming to the completely surrounded position and the hazard of having the source in the beam-forming position for longer than is safe if the power supply fails is always present; second, it is extremely difficult to produce a mechanism which will always position the source in exactly the same location for forming the beam and any location difference will change the shape of the gamma ray beam emerging from the device; and third, the problems of protection of personnel during the loading of the radioactive source into a device which requires that the radioactive source must subsequently move during the operation of the device are much more difficult of solution than the similar problems with a device in which the source remains fixed after it has been loaded into the device.

The invention has for its primary object the overcoming of the foregoing difficulties by providing a device for forming a collimated beam of penetrative radiations which will close off the beam automatically in case of failure of the supply of power to the device and which makes provision for the easy loading into and unloading from the surrounding absorption material of the radioactive source.

A further object of the invention is to provide a device of the foregoing class in which the radioactive source is stationary during operation.

With the foregoing objects in mind, the in-

vention is featured by the provision of a shielded container adapted to be loaded with and thereafter to hold an extremely intense radioactive source in a fixed position generally at its center, the shield being composed of radiation absorbing material of sufficient thickness to reduce the radiation intensity at or near its surface to a tolerable level and having a collimating slot extending from the location of said source to its surface for forming a beam of radiations, the shield also having a slot intersecting the collimating slot and adapted to receive a shutter of radiation absorbing material, the shutter being so mounted and arranged that, in the event of power failure, it will be moved by the force of gravity alone to its closed position, blocking said collimating slot, even in a wide variety of different positions of the container, the collimating slot also being preferably provided with an iris for adjusting the cross-sectional area of the beam of radiations.

The novel radioactive source holder, shielding carrying container therefor and the special arrangement for loading of the source into the radiography container have been made the subject matter of a separate divisional application co-pending herewith.

Still another object of the invention is to provide a radiation beam-forming unit having a gravity operated shutter for closing off the beam and which will permit the proper functioning of such shutter in a variety of different positions of the device.

Still a further object of the invention is to provide a device of the character described which may be loaded with a radioactive source or unloaded without danger to the operating personnel.

With the foregoing objects, features and advantages in view, the invention consists of the novel features, combinations and arrangement of parts as disclosed in the following detailed description taken in connection with the accompanying drawings which disclose a preferred embodiment thereof and in which like numerals refer to like parts in the several views.

Fig. 1 is a front view of the outside of the beam forming unit;

Fig. 2 is a side view of the same;

Fig. 3 is a bottom view of the unit which shows only the face of the iris;

Fig. 4 is a section with portions cut-away on line 4—4 of Fig. 1 showing the shielding sphere shutter, shutter supports, shutter operating mechanism, and the iris;

Fig. 5 is a section with portions cut-away on line 5—5 of Fig. 4 showing further details of the shutter, shutter supports, shielding sphere, and source cylinder;

Fig. 6 is a fragmentary sectional view on line 6—6 of Fig. 4 showing the details of the movable mounting for the shutter supports on the shielding sphere;

Fig. 7 is a fragmentary section on line 7—7 of Figs. 2 and 4 showing the movable mounting of the iris on the shielding sphere;

Fig. 8 is a fragmentary sectional view taken on line 8—8 of Fig. 7 showing further details of the mounting of the iris;

Fig. 9 is a sectional view on line 9—9 of Fig. 7 showing further detail of the movable mounting of the iris;

Fig. 10 is a view taken on line 10—10 of Figs. 2 and 4 showing the iris;

Fig. 11 is a partially diagrammatic view of one

of the block guides of the iris, including the supports for the cable rollers;

Fig. 12 is a schematic diagram showing the arrangement of the cables used to move the absorbing blocks in the iris;

Fig. 13 is an elevation with portions cut-away of the source holder; and

Fig. 14 is a fragmentary representation illustrating the manner of loading the source cylinder into the shielding sphere.

In the preferred embodiment here disclosed, the device consists of a shielding sphere 22 in which is mounted a shutter 20 which is movably connected to the shielding sphere 22 through the shutter support arm 24, the shutter support bearings 26, and the shutter support tracks 28. Said shutter 20 may be made to move linearly between the closed position in which it is shown in Fig. 2 and the open position in which it is shown in Figs. 4 and 5 by means of a solenoid 30 or other device for producing linear motion. The solenoid 30 acts through the solenoid core fork 32, shutter lever 34, fulcrum fork 36, and shutter support fork 38 to move the shutter 20. The motion of the shutter 20 to open position is just sufficient that the collimating opening 40 is square in cross-section in a plane perpendicular to the vertical center line of the device. When the solenoid is not activated, the shutter 20 moves to closed position automatically; when the solenoid 30 is activated by passing an electric current from a power source (not shown) through the wires 42 and thence through the solenoid 30, the shutter 20 is drawn into the open position. The shutter 20 is so mounted that the force of gravity always acts in the direction of moving the shutter 20 to the closed position as will be described below in the description of the shutter mounting. Thus the shutter 20 is always in the closed position except when power is applied to the solenoid 30.

The shielding sphere 22 is constructed of a strong material which also has the property of strongly absorbing radiations emanating from the source used, in this case gamma rays. Such a material as tungsten or an alloy containing a high percentage of tungsten is suitable. The shielding sphere 22 may also be constructed of a sturdy shell which need not have the additional property of strongly absorbing gamma rays but which is filled with another material which has the property of strongly absorbing gamma rays. Such a combination of material as a steel shell filled with lead is suitable.

A slot 44 formed in the shielding sphere 22 provides room for the insertion of the shutter 20 and also forms three of the walls of the collimating opening 40 which is produced when the shutter 20 is in the open position. The side of the slot 44 which is at the top in Fig. 4 is formed at an angle to a line perpendicular to the vertical center line of the device. This angle is approximately 20 degrees in the preferred form of the invention but may be slightly more or less without affecting proper functioning. The slot 44 extends beyond the vertical center for a distance equal to one-half its own width.

The shutter 20, like the shielding sphere 22, is constructed of a strong material which also has the property of strongly absorbing gamma rays. Again like the shielding sphere 22, the shutter 20 may be constructed of a shell of a strong material which need not have the additional property of strongly absorbing gamma rays but which is filled with another material having

good absorption characteristics. It is not necessary to the invention that the same material or combination of materials be used in the shutter 20 as is used in the shielding sphere 22.

The shutter 20 is so shaped that it fits closely into the slot 44 in the shielding sphere 22 with only sufficient clearance between the walls of the shutter 20 and the slot 44 to allow linear motion of the shutter 20 with respect to the slot 44 in a direction parallel to the side of the slot 44 which is at the top in Fig. 4. Further, the shutter 20 is of sufficient height and length that when it is in the closed position as shown in Fig. 2, it mates with the slot 44 at both the top and bottom in such a way that the radioactive source 46 is shielded on all sides by sufficient thickness of gamma ray absorbing material to reduce the radiation intensity at or near the surface of the shutter 20 to a tolerable level. Further, the shutter 20 is so shaped that when it is in the open position as shown in Fig. 4 the vertical inside wall of the shutter 20 extends sufficiently far along a line parallel to the vertical center line of the device so that the bottom of all of the four vertical walls of the collimating opening 40 are in the same plane, said plane being taken perpendicular to vertical center line of the device.

The shutter 20 is movably mounted on the shielding sphere 22 through the shutter support arm 24, the shutter adjustment screws 48, the shutter adjustment pivots 52, the shutter adjustment arms 50, the shutter support bearings 26, and the shutter support tracks 28. The shutter support arm 24 is a rigid member which a firmly fastened to the shutter 20 through the shutter support plates 54 and shutter support ribs 56 which are, of course, firmly fastened to both the shutter 20 and the shutter support arm 24. The shutter support arm 24 extends around the outside of the shielding sphere 22. The shutter adjustment arms 50 are mounted on the shutter support arm 24 by the shutter adjustment pivots 52 around which said shutter adjustment arms 50 are free to rotate. The shutter support bearings 26 are mounted on the shutter adjustment arms 50 by the shutter support bearing pins 58 around which said shutter support bearings 26 are free to rotate. Eight of the shutter support bearings 26 have their axes of rotation on a line perpendicular to the plane indicated by line 4—4 and four of the shutter support bearings 26 have their axis of rotation on a line perpendicular to the plane indicated by line 5—5. The shutter support bearings 26 roll on the surfaces of the shutter support tracks 28. The shutter adjustment screws 48 pass through internally threaded apertures in the shutter support arm 24 and the ends of said shutter adjustment screws 48 bear on the end of the shutter adjustment arms 50 opposite to the end where the shutter adjustment pivots 52 are located. The shutter adjustment screws 48 may be moved linearly along their axes in the normal fashion of a screw and will then bear down on the shutter adjustment arms 50 causing the shutter support bearings 26 to press against the shutter support tracks 28. By repeated successive adjustments of the shutter adjustment screws 48 the shutter may be raised or lowered, moved from side to side, and turned slightly about both a vertical and a horizontal axis to permit the exact positioning of the shutter 20 within the slot 44 so that said shutter 20 will be free to move linearly within said slot 44 and parallel to the walls of said slot 44.

The shutter support tracks 28 are made of a strong hard material such as steel. They are firmly attached to the outside of the shielding sphere 22 and are given support by shutter support tracks ribs 60 such as are shown in Figs. 4, 5. The horizontal surfaces of the shutter support tracks 28 are smooth and are made parallel to the side of the slot 44 which is at the top in Fig. 4. The outer vertical surfaces of the shutter support tracks 28 are smooth and are made to be parallel to the plane indicated by line 4—4 for at least a distance equal to the length of travel of the shutter 20. The shutter support tracks 28 thus form surfaces on which the shutter support bearings 26 ride to support the shutter 20 and to define the direction of travel of the shutter 20 so that it moves freely and without binding within the confines of the slot 44.

The shutter support fork 38 is firmly attached to the shutter support plate 54; the fulcrum fork 36 is firmly attached to the solenoid base 62; the solenoid core fork 32 is firmly attached to the solenoid core 64. The shutter lever 34 is a strong, rigid member which is rotatably attached to the fulcrum fork 36 by the fulcrum fork pin 66 which passes through round holes in the fulcrum fork 36 and the shutter lever 34. The shutter lever 34 is attached in a similar manner to the solenoid core fork 32 and the shutter support fork 38 except that at these places a slot is provided in the shutter lever 34 in place of the round hole in order to permit the required motion when the shutter 20 is moved from the open to the closed position or from the closed to the open position.

The solenoid base 62 is a cylindrical section which is firmly attached to the shielding sphere 22. At least enough of the solenoid base 62 is made of a gamma ray absorbing material in such a shape that the gamma rays from the radioactive source must pass through sufficient thickness of absorbing material to reduce the radiation intensity at or near the surface of the solenoid cover 68 to a tolerable level. In the embodiment shown in the accompanying drawings, the solenoid base 62 is a cylinder of the same material or combination of materials as the shielding sphere 22. The invention is not changed, however, if the solenoid base is a hollow cylindrical section in the nature of a cover and containing only sufficient absorbing material that the gamma rays from the radioactive source 46 must pass through at least as much absorbing material before reaching the surface in this direction as they would if they passed through the shielding sphere 22 in any other direction and containing further such solid pieces as may be required to permit the fastening of the solenoid 30 or equivalent firmly onto the shielding sphere 22.

The solenoid cover 68 is a hollow piece which is removably mounted onto the solenoid base 62 and covers the solenoid 30 and which contains an opening through which the solenoid core 64 and the solenoid core fork 32 pass. Said solenoid cover 68 serves the usual functions of a cover such as protection from dust and damage by knocking and may be made of any suitable material.

The axle 70 is a hollow shaft passing through and firmly attached to the shielding sphere 22 and protruding from the sides of said shielding sphere 22 to form trunnions by which the entire device may be supported. The axle 70 is partially cut away at and near the center of the shielding sphere 22 where the axle 70 passes through the slot 44 in order to permit the shutter

20 to slide into the slot 44 and in order to eliminate partial absorption of the gamma radiation from the radioactive source 46 which would occur if the rays were required to pass through the full wall of the axle 70. The axle 70 performs the dual function of providing a means of supporting the entire device and of providing an opening for the insertion of the radioactive source 44 contained in the source cylinder 72.

The hangers 74 which support the device may be of any type which will not permit lateral motion of the device with respect to the hangers 74 but which will permit rotational motion of the device about the axle 70. The hangers 74 may be attached to any solid foundation such as the ceiling, walls, or floor of a room. These hangers may be so arranged that translational motion of the device can be produced in any direction.

Since the device may be rotated about the axle 70, it is necessary to indicate how the shutter 20 will operate when the device is at any angular position other than the vertical position shown in the drawings. The device may be operated with gravity closure of the shutter 20 between the two positions at which the component of the force of gravity which acts in the direction of closing the shutter 20 is just sufficient to overcome the opposing frictional forces and cause the shutter 20 to close. Thus, one extreme position is with the gamma ray beam pointing in a generally downward direction with the shutter support tracks 28 in a nearly horizontal position but sloping downward slightly to the right as seen in a view taken on line 4—4; the other extreme position is with the gamma ray beam pointing in a generally upward direction with the shutter support tracks 28 in a nearly horizontal position but sloping slightly downward to the left as seen in a view taken on line 4—4; and all positions produced by rotation of the device from position one clockwise to position two are permissible. It may be seen by examination of the drawings (particularly Fig. 4) that a component of gravitational force is acting in the direction of closing the shutter 20 in any of the above-defined permissible positions.

Referring to Fig. 13, the source cylinder 72 is a thin-walled cylinder with an outside diameter nearly equal to the inside diameter of the axle 70 but sufficiently smaller to permit the source cylinder 72 to slide freely within the axle 70. Said source cylinder 72 is made of a material of sufficient strength and hardness to support its contents and to permit it to slide within the axle 70 without binding. The radioactive source 46 is a capsule which fits inside the source cylinder 72 and which contains the radioactive material which is used as a source of the gamma rays which form the gamma ray beam. Said radioactive source 46 is positioned in the center of the source cylinder 72 between the two source cylinder plugs 76. The source cylinder plugs 76 are made of a material which has the property of strongly absorbing gamma rays, are fitted closely to the inside diameter of the source cylinder 72, and serve the purpose of preventing unwanted beams of gamma rays from coming out of the ends of the axle 70.

The manner of loading the radioactive source 46 into the shielding sphere 22 is indicated in Fig. 14. The radioactive source 46 and the source cylinder plugs 76 have previously been loaded into the source cylinder 72 in a working area provided with the necessary safeguards and equipment. The source cylinder 72 is then transported to the beam forming unit in the auxiliary shielding container 78. The auxiliary shielding container 78 is made of a material which has the property of strongly absorbing gamma rays or of a shell of a strong material such as steel which is filled with another material which has the property of strongly absorbing gamma rays.

Said auxiliary shielding container 78 may have any convenient shape provided only that it provide sufficient thickness of absorbing material to reduce the intensity of radiation outside it to a tolerably low level and that it contain a cylindrical hole of the same dimension as the inside dimension of the axle 70, said hole to contain the source cylinder 72 during transport. In order to load the radioactive source 46 into the beam forming unit, the hole in the axle 40 is aligned with the hole in the auxiliary shielding container 78 which contains the source cylinder 72 and the latter is pushed out of the hole in the auxiliary shielding container 78 and into the hole in the axle 70 using a ram 80. Thus, the radioactive source 46 is always surrounded by sufficient absorbing material to reduce the radiation intensity to a level which is tolerable to the people near it except for the moment when it is actually being loaded into the beam forming unit. If desired, it is possible to provide additional gamma ray absorbing material surrounding the space between the beam forming unit and the auxiliary shielding container 78 to reduce the radiation intensity in the surrounding area during the moment of loading. Even if no such additional protection is provided, however, the persons who are doing the loading are to a great extent protected by interposing the auxiliary shielding container 78 between their persons and the radioactive source 46 during the moment of loading. If it is desired to remove the radioactive source 46 for replacement or to make the maintenance of the beam forming unit easier, the above procedure is reversed and the radioactive source 46 is pushed from the beam forming unit into the hole in the auxiliary shielding container 78.

The iris 82 and the manner of its attachment to the shielding sphere 22 will now be described.

On the bottom of the shielding sphere 22 and firmly attached to or forming a continuous part of the same is a cylindrical annulus which will be designated as the scatter shield upper section 84. This section 84 is constructed of a strong material which also has the property of strongly absorbing gamma rays. It may be constructed of a shell of a strong material which need not have the added property of strongly absorbing gamma rays but which is filled with another material which has the property of strongly absorbing gamma rays. In conjunction with the iris scatter shield 86 and the upper absorbing blocks 88 and lower absorbing blocks 90, the scatter shield upper section 84 surrounds the path of the gamma ray beam between the bottom end of collimating opening 40 and the bottom end of the iris 82 and reduces the amount of gamma radiation which passes out of the iris in any direction other than the direction of the original beam.

The iris 82 is best described by referring to Figs. 3, 4, 10, 11 and 12 and its movable attachment to the shielding sphere 22 is best described by referring to Figs. 4, 7, 8 and 9. The iris 82 consists of the upper absorbing blocks 88, the lower absorbing blocks 90, and guides for the same, and means for moving the blocks of each pair toward and away from each other. The

function of the iris 82 is to collimate the gamma ray beam further after it passes out of the collimating opening 40 and to vary the size and cross-sectional shape of the beam by positioning absorbing blocks in such a way that they absorb part of the radiations, and to reduce the amount of gamma radiation which passes out of the iris in any direction other than the direction of the original beam.

Referring now to Figs. 4 and 10, it may be seen that the two sets of absorbing blocks 88 and 90 are movably mounted in the iris one set above the other and with the direction of motion of the two sets of blocks mutually perpendicular as seen in Fig. 10 and perpendicular to the vertical center line of the device. The blocks are composed of material having the desired radiation absorption characteristics. In addition, the blocks may have a piece inserted along their edges nearest the vertical center line of the device, said piece being made of a material which has the property of absorbing gamma rays exceptionally strong. This inserted piece would serve the function of absorbing very strongly the edge of the gamma ray beam as it passes through the iris and thus of producing a gamma ray beam with very sharply defined edges.

The means for moving the two sets of absorbing blocks 88 and 90 will now be described. Fig. 12 shows a schematic diagram of the arrangement for producing motion of one set of absorbing blocks, that of the other set being identical except for direction of motion.

In order to produce a gamma ray beam the center of which is always coincident with the vertical center line of the device, it is desirable to use a means of adjusting the distance of separation of the two absorbing blocks in each pair of blocks, such that both blocks in each pair are not only moved by the adjustment of a single control, but that they will be moved toward or away from each other the same distance by adjustment of that control.

For convenience in describing the means of producing the motion of the blocks, Fig. 12 will be taken to represent the lower absorbing blocks 90, but in actuality it could be taken to represent the upper absorbing blocks 88 as well.

An iris control screw 92 is rotatably mounted in the iris cover 94. Motion of the iris control screw 92 along its own axis is prevented in one direction by the iris control knob 96 and in the other direction by the iris control collar 98. The iris control screw 92 is threaded into the iris control drive bracket 100 which is firmly attached to one of the pair of absorbing blocks and which is inset into the edge of the absorbing block. Rotation of the iris control knob and screw moves the bracket 100 and block 90 in a direction along the axis of the iris control screw. The blocks 90 are interconnected by a pair of cables 102 which make the absorbing block which is not attached to the iris control drive bracket perform the desired motion. Referring to Fig. 12, it will be seen that when the iris control knob 96 is turned to move the bracket 100 inwardly or outwardly the two blocks will move toward or away from each other, an equal distance.

A similar cable system 104 operates the other set of blocks 88 under the control of the knob 106.

The absorbing blocks are mounted between block guides 108 of the type indicated in the schematic view of Fig. 11 so that only linear motion in the desired direction is produced by the action of the iris control knob and the associated motion producing equipment.

The iris 82 is rotatably and removably mounted on the shielding sphere 22 through the iris support 110, the outer iris ring 112, the iris support wheels 114, and the iris support track 116. The iris support track 116 is firmly attached to the scatter shield upper section 84. The iris support wheels 114 ride on the surfaces of a V-shaped notch cut in the outer surface of the iris support track 116. Said iris support wheels 114 are arranged in pairs about the circumference of the iris support track 116 with one of each pair riding on one surface of the notch and the other of each pair riding on the other surface of the notch. The outer iris ring 112 is attached to the iris support wheels 114 through the iris support wheel mounts 118 which are adjustable in position to permit the iris support wheels 114 to be so located that they will ride accurately on the surfaces of the notch in the iris support track 116. It may be seen that the outer iris ring 112 is thus rotatably attached to the scatter shield upper section 84 regardless of the position of the device.

The iris support 110 is attached to the iris cover 94 through iris support screw 120 and iris support mount 122. Said iris support 110 is prevented from rotating within the iris support mount 122 by a pin 124 which rides within a slot in the iris support 110. Rotation of the iris support knob 126 causes the iris support 110 to move in and out of the iris support mount 122. Three iris supports 110 and their associated mountings are arranged equidistant around the circumference of the iris 82 and may be aligned with three equally spaced apertures in the outer iris ring 112. When so arranged, the iris supports 110 may be moved into the apertures in the outer iris ring 112 by turning the iris support knobs 126 and the iris 82 thus be attached to the outer iris ring 112. The iris 82 may be removed by reversing the above process. A slot is provided in the outer iris ring 112 as indicated in Figs. 7 and 9 to facilitate the alignment of the iris supports 110 and the apertures in the outer iris ring 112.

The device of the invention has been illustrated as adapted for use with a strong emitter of gamma rays, such as cobalt–60, since for therapeutic and radiographical purposes such radiation, at present, appears to have the greatest practical value. It will be understood, however, that modifications and changes, primarily as to the nature of the absorbing material employed in the shielding members, will be readily apparent to those skilled in the art to adapt the unit for use with other radioactive sources emitting predominantly other types of penetrative radiations. For example, sources of neutrons might be employed necessitating the employment of paraffin or other material of like characteristics in the shield.

Still other modifications and changes may occur to those skilled in the art within the spirit and scope of the appended claims.

Having described our invention, we claim:

1. A radiation beam forming unit which comprises a shield having an internal chamber for holding a radioactive source, said shield having a collimating slot extending from an external wall into said chamber for forming radiations from said source into a beam and a second slot transversely intersecting said collimating slot, and a shutter movably mounted in said second

slot, said shutter being shiftable from a closed position shielding said collimating slot and interrupting said beam to another position leaving said slot clear for the passage of said beam, said shield and shutter being composed of radiation absorbing material of sufficient thickness to reduce the intensity of radiation at the outer surface of said unit to a tolerable level and said second slot being so positioned that in normal use of said unit said shutter will be urged to its closed position by the force of gravity.

2. A radiation beam forming unit capable of being readily loaded and unloaded with a radioactive source without endangering operative personnel which comprises a shielding member having a central bore therein, an elongated source holder insertable in said bore directly from a shielding container thereof, said holder being composed of radiation absorbing material and having a source holding portion intermediate its length for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall into said bore at the location of said source holding portion of said holder when said holder is in place in said bore, said member also having a second slot intersecting said collimating slot at an angle thereto, and a shutter composed of radiation absorbing material movably mounted in said second slot and shiftable from an open position to a position effectively blocking the escape of radiations through said collimating slot, said second slot being directed at such an angle that in the normal use of the unit said shutter will be gravity operated to its closed position.

3. A radiation beam forming unit capable of being readily loaded and unloaded with a radioactive source without endangering operative personnel which comprises a shielding member having a central bore therein, an elongated source holder insertable in said bore, said holder being composed of radiation absorbing material and having a source holding portion intermediate its length for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall into said bore at the location of said source holding portion of said holder when said holder is in place in said bore, said member also having a second slot intersecting said collimatinng slot at an angle thereto, a shutter composed of radiation absorbing material movably mounted in said second slot and shiftable from an open position to a position effectively blocking the escape of radiations through said collimating slot, said second slot being directed at such an angle that in the normal use of the unit said shutter will be gravity operated to its closed position, and an iris associated with said collimating slot to control the cross-sectional area of said beam.

4. A unit for forming a beam of penetrative radiations from a radioactive source which comprises a generally spherical shield of radiation absorbing material, a mounting for said shield permitting rotation thereof about an axis, said shield having an opening along said axis for the reception of said source and a collimating slot extending radially from said opening for the passage of a beam of radiations from said source, said shield also having a second slot intersecting said collimating slot at an angle which is directed downwardly in normal positions of said unit, a shutter of radiation absorbing material movably held in said second slot and operable by the force of gravity to closed position across said collimating slot to block off said beam and means for opening said shutter against said force.

5. A device in accordance with claim 4 in which said means comprises a solenoid connected to said shutter by a lever system.

6. A unit for forming a beam of penetrative radiations from a radioactive source which comprises a generally spherical shield of radiation absorbing material, a hollow axle extending through said shield with the ends thereof protruding on either side of said shield to form trunnions for rotatably mounting the same, the opening in said axle being adapted to receive a radioactive source, said shield and axle having adjoining slots forming a single collimating slot extending radially outwardly from the position of said source when inserted in said axle to an external wall of said shield, said shield also having a second slot intersecting said collimating slot at an angle which is tilted downwardly in normal positions of said unit, a shutter movably held in said second slot and operable by the force of gravity to closed position across said collimating slot to block off said beam and means for opening said shutter against said force.

7. A radiation beam forming unit comprising a shielding member having a central bore therein, an elongated source holder insertable in said bore, said holder being formed of radiation absorbing material and having a source holding portion intermediate its length for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall perpendicularly into said bore at the location of said source holding portion when said holder is in place in said bore, said shielding member also having a second slot formed therein and intersecting said collimating slot at an angle thereto, a shutter formed of radiation absorbing material slidably mounted in said second slot and movable from an open position to a position effectively blocking the escape of radiation through said collimating slot, said second slot being directed at such an angle that in the normal use of the unit said shutter will be gravity operated to its closed position, and means for moving said shutter to said open position against the force of gravity.

8. A radiation beam forming unit comprising a shielding member having a central bore therein, an elongated source holder insertable in said bore, said holder being formed of radiation absorbing material and having a source holding portion intermediate its length for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall perpendicularly into said bore at the location of said source holding portion when said holder is in place in said bore, said shielding member also having a second slot formed therein and intersecting said collimating slot at an angle thereto, supporting tracks secured to said shielding member and disposed parallel to the axis of said second slot, a shutter formed of radiation absorbing material provided with supporting bearings arranged to ride on said supporting tracks and slidable in said slot from an open position to a position effectively blocking the escape of radiation through said collimating slot, said second slot being directed at such an angle that in the normal use of the unit said shutter will be moved to its closed position by the force of gravity, a solenoid connected to said shutter through a lever system for moving said shutter to said open position against the force of gravity, and an adjustable iris

surrounding said collimating slot to control the cross-sectional area of said beam.

9. A radiation beam forming unit comprising a shielding member having a central chamber therein for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall into said central chamber, said shielding member also having a second slot formed therein and intersecting said collimating slot at an angle thereto, a shutter formed of radiation absorbing material slidably mounted in said second slot and movable from an open position to a position effectively blocking the escape of radiation through said collimating slot, said second slot being directed at such an angle that in the normal use of the unit said shutter will be gravity operated to its closed position, means connected to said shutter for moving said shutter to said open position against the force of gravity, and an adjustable iris surrounding said collimating slot to control the cross-sectional area of said beam.

10. A radiation beam forming unit comprising a shielding member having a central bore therein, a mounting for said shielding member permitting rotation thereof about the axis of said bore, an elongated source holder insertable in said bore and having a source holding portion intermediate its ends for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall into said bore at the location of said source holding portion when said holder is in place in said bore, said shielding member also having a second slot formed therein intersecting said collimating slot at an angle thereto, a shutter formed of radiation absorbing material slidably mounted in said second slot and movable from an open position to a position effectively blocking the escape of radiation through said collimating slot, said second slot being so directed that in the normal rotation of said unit about the axis of said bore said shutter will be gravity operated to its closed position, means for moving said shutter to said open position against the force of gravity, and an iris surrounding said collimating slot to control the cross-sectional area of said beam.

11. A radiation beam forming unit comprising a shielding member having a central bore therein, mounting trunnions secured to said shielding member coaxially with said bore permitting rotation of said member about the axis of said bore, an elongated source holder coextensive with said bore insertable in said bore and having a source holding portion intermediate its ends for holding a radioactive source, said shielding member having a collimating slot extending from an exterior wall into said bore at the location of said source holding portion when said holder is in place in said bore, said shielding member also having a second slot formed therein disposed perpendicular to said bore and intersecting said collimating slot at an angle thereto, a shutter formed of radiation absorbing material slidably mounted in said second slot and movable from an open position to a position effectively blocking the escape of radiations through said collimating slot, said second slot being directed at such an angle that for the rotation of said unit about the axis of said bore encountered in normal use said shutter will be gravity operated to its closed position, electromechanical means for moving said shutter to said open position against the force of gravity, and an iris including a plurality of blocks of radiation absorbing material adjustable in position relative to the axis of said collimating slot to control the cross-sectional area of said beam.

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