Dec. 13, 1938. M. A. LOEBELL 2,139,966

X-RAY APPARATUS

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Fig. 1.

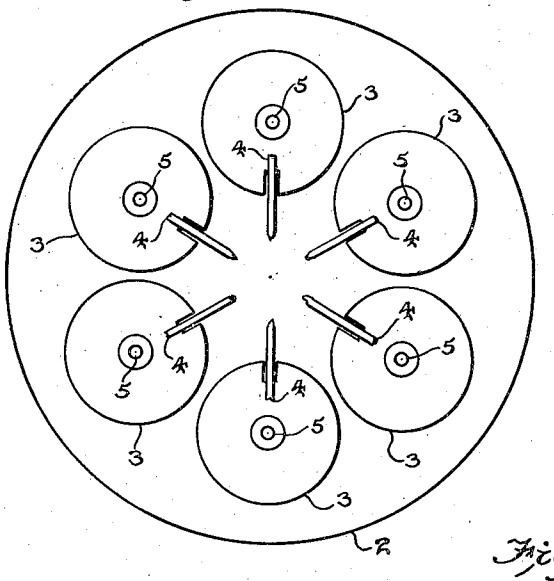


Fig. 4.

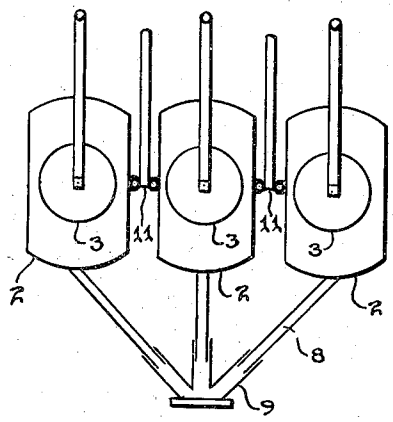


Fig. 3.

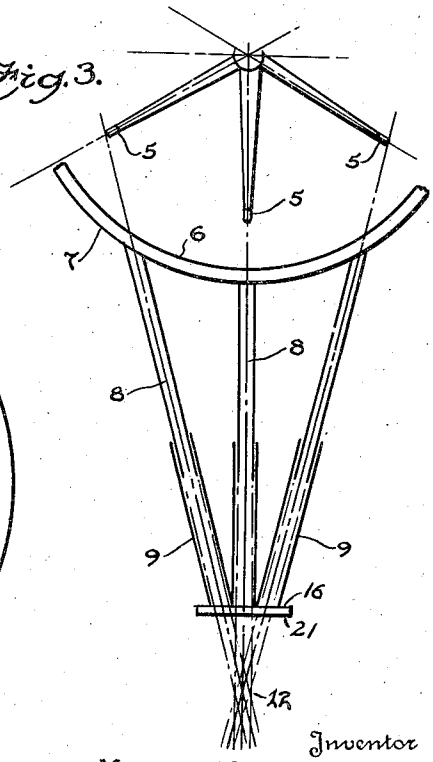
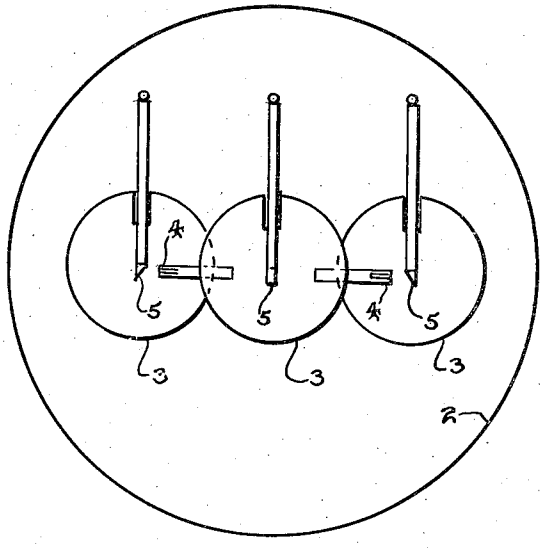


Fig. 2.



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X-RAY APPARATUS

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Fig. 13.

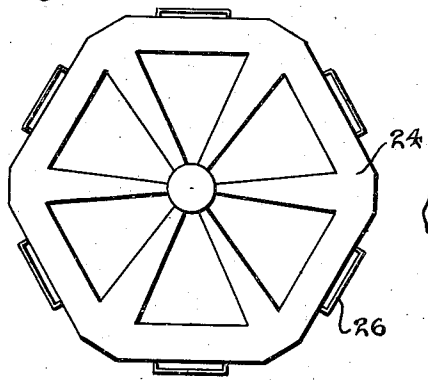


Fig. 5.

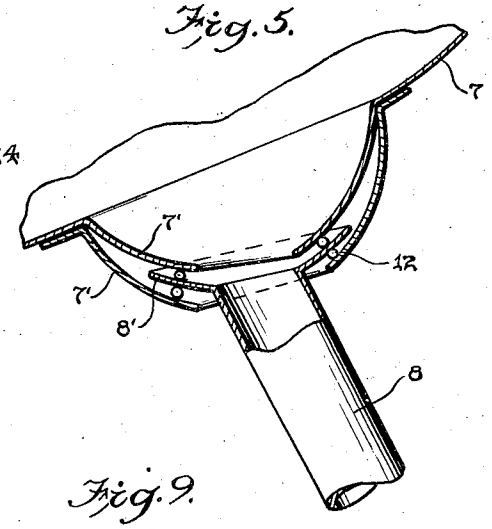


Fig. 10.

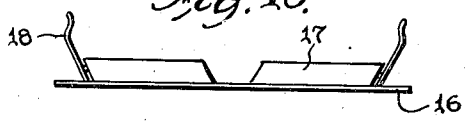


Fig. 9.

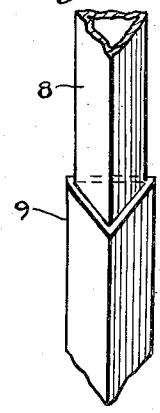


Fig. 12.

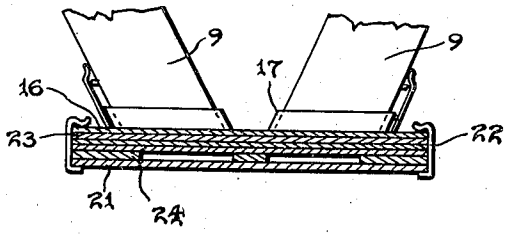


Fig. 8.

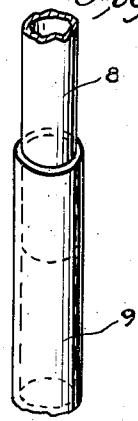


Fig. 11.

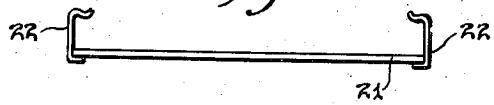


Fig. 7.

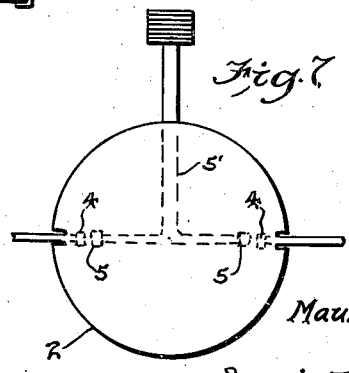
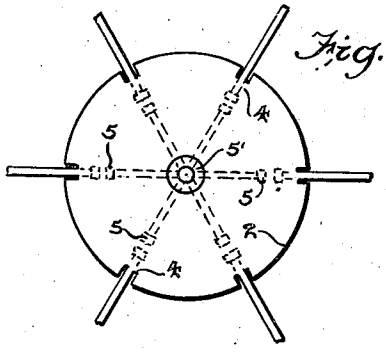


Fig. 6.



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X-RAY APPARATUS

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Fig. 14.

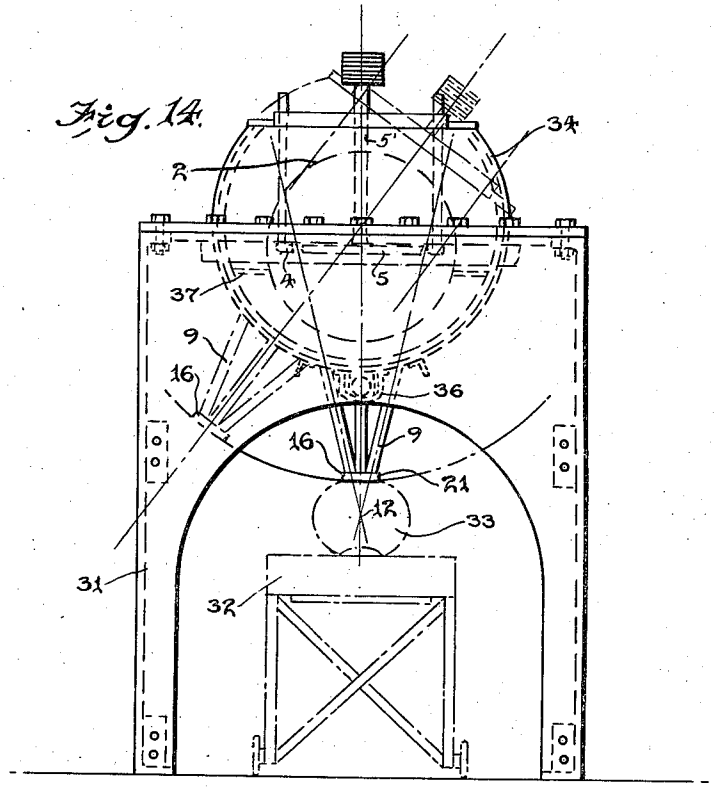
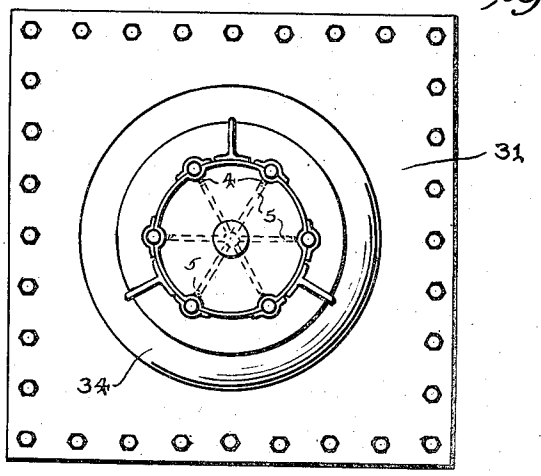


Fig. 15.



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X-RAY APPARATUS

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Fig. 16.

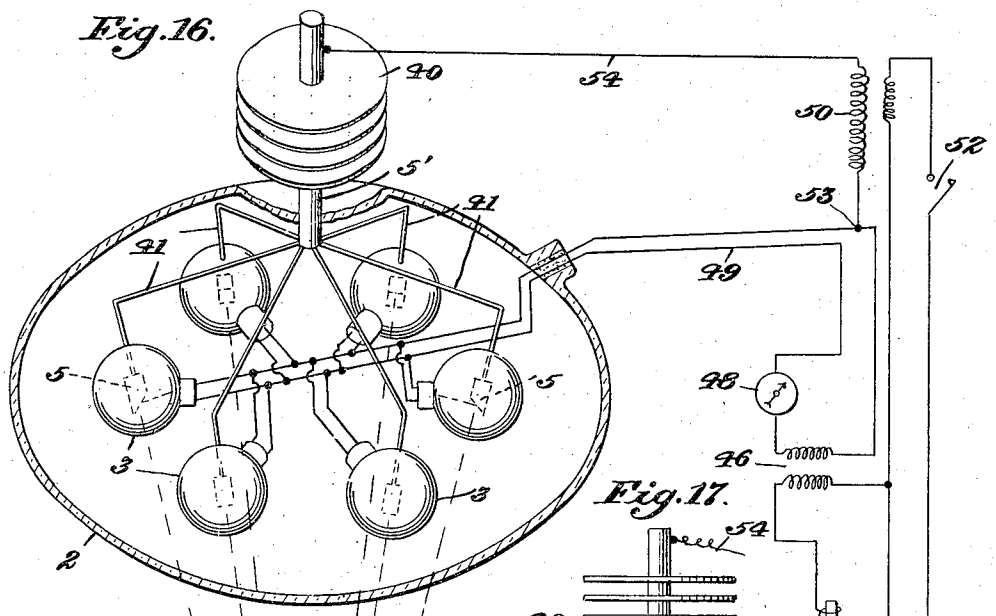
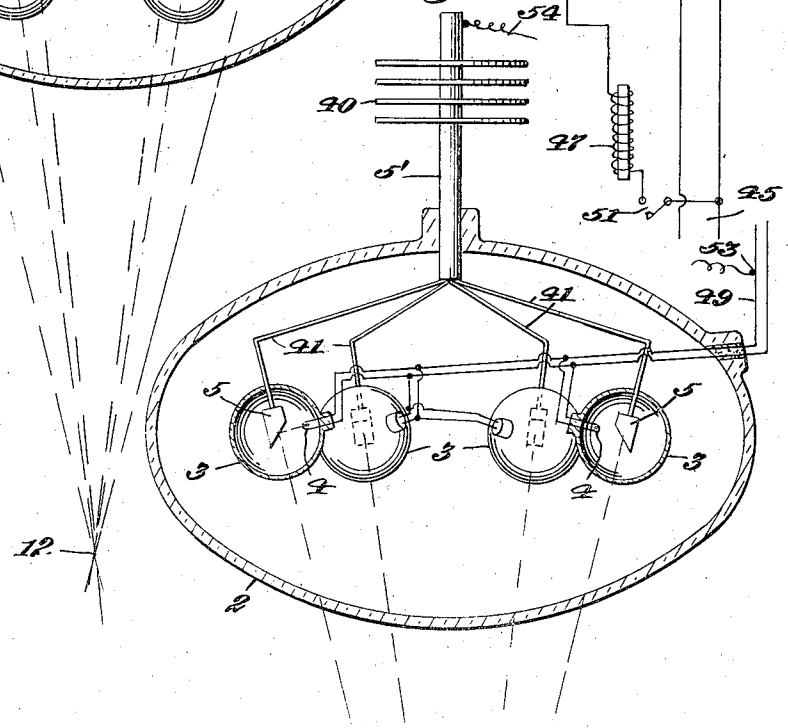


Fig. 17.



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X-RAY APPARATUS

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Fig. 18.

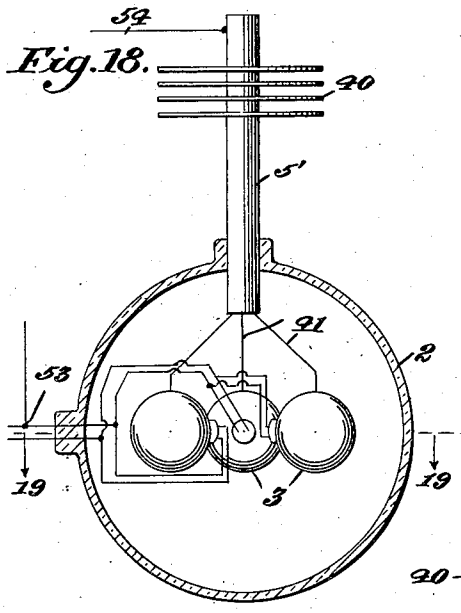


Fig. 19.

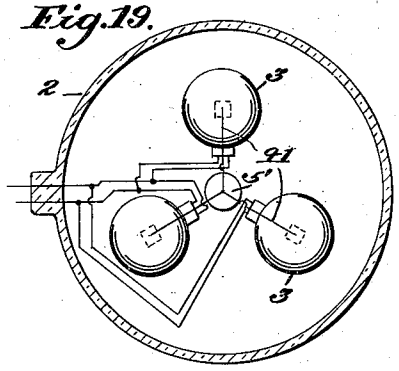
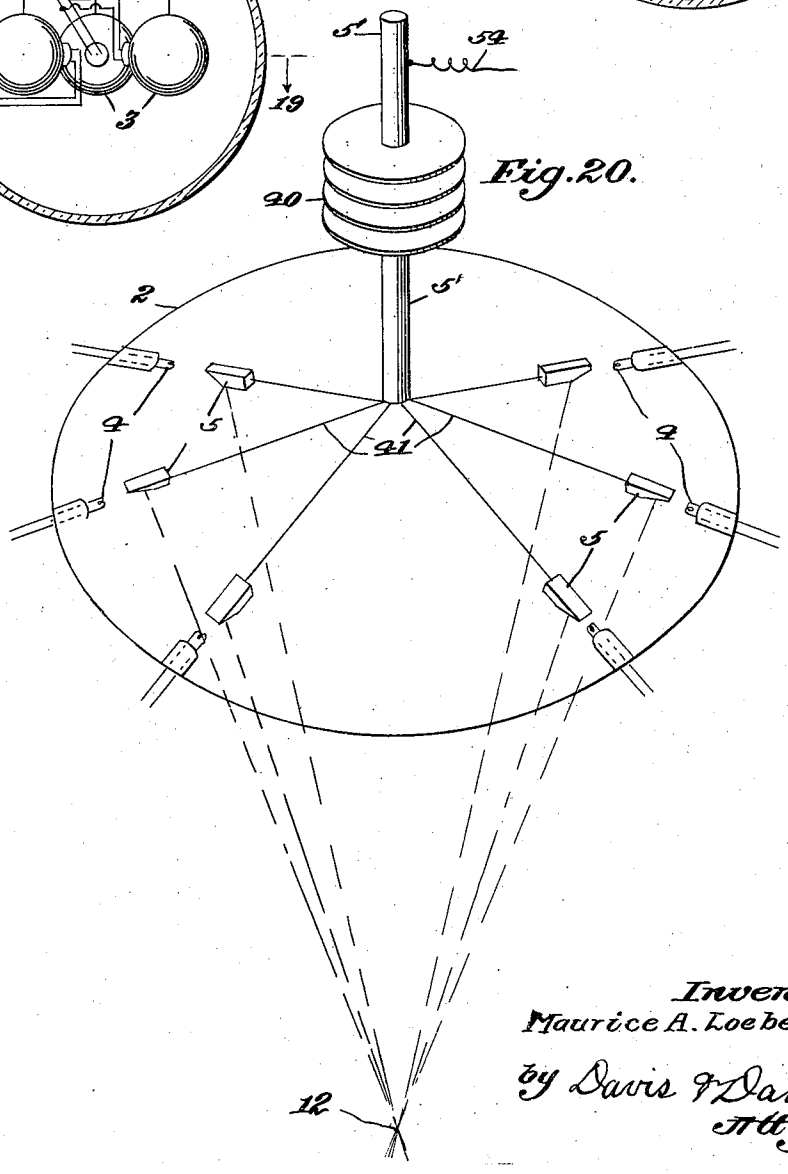


Fig. 20.



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Patented Dec. 13, 1938

2,139,966

UNITED STATES PATENT OFFICE

2,139,966

X-RAY APPARATUS

Maurice A. Loebell, Zanesville, Ohio

Application March 25, 1935, Serial No. 12,933

14 Claims. (Cl. 250—94)

My invention relates to Röntgen or X-rays, and more particularly to apparatus for and method of directing and concentrating such rays at any desired point or area within the human body or other living matter to be treated.

Heretofore, Röntgen rays have been easily applied to superficial areas without difficulty. Obviously it has been recognized that these rays can have beneficial results on internal organs and tissues, like glands, bones, and others. Attempts have been made to treat these parts by directing the rays through the outside of the body, but this has inevitably subjected the skin and contiguous tissues to the rays, with danger of burning or other harm.

Some operatives achieve a slight measure of success by directing the rays to the part to be treated, the liver for example, at a certain angle. Thereafter, the tube or the patient is rotated or otherwise moved so that the rays impinge on the liver at another angle. This avoids burning the skin, but the interval between successive exposures is several days or weeks, with consequent loss of effect of previous radiation. Of course, the amount of rotation of the patient or the tube cannot be predetermined with great exactitude, so that in effect this method has serious limitations.

My method and apparatus are simple and efficacious to an unusual degree. I employ several tubes, or one tube with several anodes or targets, and arrange the targets so that the rays produced thereon are directed outside the tube at angles which cause all the rays to focus or converge at a predetermined point, or area, or space outside the tube. It is then a simple matter to move the table on which the patient lies, to bring the affected part within the area of greatest density of rays. This will permit treatment of internal parts, yet the superficial tissues will not be subjected to great doses. This method and apparatus may be used to treat plants and animals, as well as human beings, and it may be modified for electron emissions or other forms of radiant energy.

The procedure of this invention is not intended to locate cancers, tumors or the like, but to treat them after being located. Its object is to destroy such growths by intense concentration of X radiation without destroying adjacent tissue or causing much burning of surface tissue at "portals" as places at which the rays enter are technically known. The invention is also intended to eliminate burning of skin areas where the rays leave the body, because in this case so much divergence occurs blow the locus to be treated that the rays are substantially all absorbed by the tissue.

A still further object of the invention is to provide such joints and extensions for X-ray carrying conduits attached to my apparatus so that X radiation may be safely carried to the spot desired, focused as desired and this done with no substantial leakage of ray.

The invention will be more readily understood by reference to the accompanying drawings. It is understood, of course, that the illustrated embodiments of my invention are merely examples, and that they do not limit the forms which the invention may take, except as defined by the claims.

Fig. 1 shows schematically a vessel containing a plurality of X-ray tubes, each tube comprising a cathode and an anode.

Fig. 2 is another view of the vessel shown in Fig. 1.

Fig. 3 represents diagrammatically the principle of invention as applied to three targets or anodes.

Fig. 4 is a schematic view of another form of my invention, wherein several distinct X-ray tubes are hingedly mounted to cooperate with one one another.

Fig. 5 shows how the telescoping protecting tubes may be attached to the X-ray devices.

Fig. 6 is a schematic plan view of another form of my invention, wherein one envelope contains a plurality of cathodes and anodes.

Fig. 7 is a side elevation of the apparatus of Fig. 6.

Fig. 8 and Fig. 9 show details of the telescoping protecting tubes through which the rays are projected.

Figs. 10 to 13, inclusive, show details of the protective or filtering elements which regulate the amount and kind of exposure to the rays.

Fig. 14 represents schematically an elevation of a form of my apparatus as it is to be used on a person.

Fig. 15 is a plan of the apparatus of Fig. 14.

Figure 16 is a view of the device shown in Figure 1, with the outer casing in section, and the separate tubes and supporting conductors in perspective, with the electrical connections and a standard system of electrical supply, and showing X-ray beams converging to a focal point below;

Figure 17 is a vertical section of the device shown in Figure 1, with the outer casing in section, and a portion of the tubes shown in section and others in elevation, and with electrical con-

nections, and with X-ray beams shown converging toward a focal point below;

Figure 18 is a vertical section of a three-tube device, with the outer casing shown in section, and the tubes in elevation, and showing electrical connections;

Figure 19 is a horizontal section on the line 19—19 of Figure 18, looking from above; and

Figure 20 is a diagrammatic view, in perspective, resembling in principle the device shown in Figures 6 and 7, with the cathodes and targets supported within the casing, instead of individual bulbs or tubes, and showing the X-rays converging to a focal point below.

In any form of my invention, whether employing a multiple X-ray tube, such as shown in Figs. 6 and 7, wherein a single envelope contains several anodes or cathodes, or whether employing a plurality of distinct tubes, such as shown in Figs. 1, 2 and 4, the principle remains the same. The idea is best illustrated in Fig. 3, where three anodes are shown by way of example, although two or more may be used. No matter how many anodes 5 are used, or how they are relatively located, they are so shaped and angularly positioned that the X-rays generated on the anodes are all directed to a common meeting point or area 12 outside the apparatus.

As is well-known, the cathode 4, which is of the filamentary type, emits cathode rays, which are electrons or negatively charged particles (and not waves in the ether). These cathode rays are focused so that they impinge on the anode or target 5; this focus is the point at which the X-rays are generated. The X-rays are not streams of particles, like cathode rays, but are waves in the ether, similar to light rays, but very much shorter and incapable of being reflected.

The cathode 4 and anode 5 may be arranged in any practical or convenient manner consistent with the principles of my invention. Thus, Figs. 1 and 2 show a spherical vessel 2 containing six spherical X-ray tubes 3, of which the centers, if Fig. 1 is taken to be a plan view, are arranged in a circle. The anodes 5 are vertical, and the cathodes 4 are radial.

Fig. 6 is the plan view of a spherical multiple tube 2, in which the six cathodes 4 are horizontal and emerge at the equator of the tube 2. It is understood, of course, that this form may be varied so that the cathodes 4 extend vertically. In either of these cases, the anodes 5 have a common stem 5', which extends vertically and emerges through the top of the tube 2.

In Figures 16 to 20, a common stem 5' which carries cooling or radiating discs 40, supports a plurality X-ray tubes 3 and targets 5 by stout conductors 41, all enclosed in outer bulbs or casings 2. In Figures 16 to 19, each target 5 and its cooperating ray-emitting filament 4 is enclosed in a separate bulb or tube 3, and the entire assembly of separate bulbs or tubes 3, with filaments 4 and targets 5 being supported and held firmly in position by conductors 41. The separate bulbs or tubes 3 are placed at the proper angle to project the X-ray beams toward a common focal point 12 below, as illustrated in Figure 3. In Figure 20, which is another view of the device illustrated in Figures 6 and 7, the filaments 4 and targets 5 are enclosed within the outer glass bulb 2, instead of mounting cooperating pairs of said filaments and targets in individual bulbs 3, as shown in Figures 1, 2, and 16 to 19.

A standard system of electrical supply is shown in Figure 16, consisting of the usual alternating current supply circuit 45, a filament circuit transformer 46, current regulator 47, meter 48, filament circuit conductors 49, high tension transformer 50, and switches 51 and 52. One end of the high tension transformer secondary is connected to the filament circuit 49 at 53, and the other end of said high tension secondary is connected to the target or anode stem 5' by the wire 54.

The shape and position of the anodes 5 being properly determined, the focus or area or space 12 of intensity of the rays will thereafter be at a known distance and direction from the vessel 2. This distance and direction are so chosen that any organ or tissue in a human body may be brought within its range without interfering with the vessel 2.

If, however, it is desired to change this distance or direction, the angle of the anodes 5 must be accordingly adjusted, and means may be provided for this end. The anodes 5 may themselves be moved, as in a multiple tube, or, if several X-ray tubes are in cooperative arrangement, these tubes may be moved. Thus, in Fig. 4, each vessel 2 contains a complete X-ray tube 3. Each vessel 2 is pivotally mounted with respect to its adjoining vessel or vessels by means of a ball-and-socket joint 11, which permits the vessels 2 to be rotated to vary the angle of the emitted rays because movement of the vessel 2 also moves the contained tube 3 correspondingly. This allows adjustment in the direction and distance of the area of intensity 12.

Of course, the tube 3 is suitably evacuated. The envelope of the tube 3 is of glass or similar material. If, as in Figs. 2, 3 and 4, there is an outer vessel 2 surrounding the tube 3, the vessel 2 has a double wall of glass 6 and metal 7 (Fig. 3). Where the rays traverse the vessel 2, the wall 7 has connected to it appropriate telescoped metal protecting tubes 8, 9. These tubes may be circular as shown in Fig. 8, triangular as shown in Fig. 9, or of other suitable shape. The tubes 8, 9 surround the paths of the rays to protect the operative and patient, and allow the rays to reach only the desired parts of the body.

When the angle of the anodes 5 has been changed to vary the direction and distance of the area of intensity 12, the angles of the beams will also vary. When the change in angle is slight, the tubes 8, 9 need not be moved. Otherwise, the tubes 8, 9 will have to be moved, and for this purpose, the upper tube 8 may be attached to the metal wall 7 by means of the sliding joint shown in Fig. 5. The flange 8' of the upper tube 8 slides between the flanges 7' of the metal wall 7 on ball or roller bearings 12. This joint is leak-proof for X-rays, and at the same time allows free motion for rotating the tube 8 or for lengthening or shortening it.

Means is provided at the lower end of the tube 9 for filtering or regulating the amount or kind of rays to be thrown on the patient. A clip 16 has spring-pressed arms 18 for gripping the ends of the tubes 9, and the sleeves 17 fit snugly around the tubes 9. A lower clip 21 also has spring-pressed arms 22 which are adapted to clamp onto the upper clip 16. Between the clips 16 and 21 may be inserted one or several filters 23 or regulators 24. The filters 23 may be of copper, zinc, aluminum, or other material for filtering undesirable rays. At least one regulator 24 has several apertures, to correspond with the number of targets 5, and the size of these aper-

tures may be adjusted, either centrally or laterally, to govern the size of space to be irradiated, and indirectly, the depth. The closer the apertures to the center, the more superficial will be the areas treated; conversely, the farther from the center, the deeper will be the space where the rays meet. The openings may be narrow and movable, so that the rays may be administered through alternating areas.

One regulator 24 is shown in Fig. 13; this is designed to be used for an apparatus having up to six anodes. If desired, the regulator 24 may have loops 26, to which adhesive tape may be connected to fasten the regulator directly to the surface of the body, instead of holding it between the clips 16 and 21. Of course, several such regulators may be used, one or more on the body, and one or more between the clips.

One form of my complete apparatus is shown schematically in Figs. 14 and 15. The support 31 is open on all four sides to permit the operating table or chair 32 to be slid thereunder from any direction. The support 31 is of such height as to allow sufficient space between the filter clips 16, 21 and the operating table 32 for comfortable position of a large body 33. This space is adjustable by raising or lowering the operating table 32, so that any part of the body 33 may be subject to the focus of irradiation 12. Both the support 31 and the table 32 are suitably lined with lead for safety. If desired, the support 31 may also be vertically adjustable.

The top of the support 31 has a circular opening in which is seated a spherical tank 34, made of metal and lined with thick lead. Rows of ball or roller bearings allow universal spherical motion of the tank 34 in all directions, so that the rays may be sent to any desired point or area. Suitable stops may limit extreme movement, to avoid injury to the telescoping tubes 8, 9. If desired, the tank 34 may have attached on the exterior thereof a fan 36 to cool the tank and the enclosed X-ray tube or tubes; the targets may also be cooled by circulating fluid.

Within the tank 34, a Bakelite ring 37 supports either a multiple tube of the type shown in Figs. 1, 2 and 3, or a battery of single tubes of the type shown in Figs. 6 and 7. On the underside of the tank 34 are apertures to which are attached the telescoping tubes 8, 9, previously described.

This apparatus permits efficient, safe, and facile treatment of any part of the body, internal as well as external.

Not only does my apparatus control the degree of intensity of irradiation of any part of the body, but the risk of radiation-burns is minimized, if not prevented, and the exact location, volume, and depth of the radiation are under rigid control. The intensity depends not only on the distance, but on the number of sources of radiation, and it is apparent that some of the cathodes may be energized and the others not, as desired.

It will be apparent from the foregoing description of the several embodiments of my invention that the rays emitted from the anodes and passing through the protective telescopic tubes 8 and 9 will emerge as converging, sharply defined beams having a common point of convergence at 12. Substantially all of the rays composing the several beams thus intersect within a common plane including the common point of convergence 12 and the pattern—that is, the cross-sectional area—of each of the beams at their intersection with the common plane will substantially coincide with each other to form an area of substantially uniform X-ray concentration without any substantial number of stray rays lying outside this area. In this way the dosage is concentrated within a circumscribed area upon the affected part of a patient without danger of injury to the surrounding tissue resulting from secondary radiation. Other variations will appear to those skilled in the art, and are contemplated to be within the scope of the appended claims.

I claim:

1. An X-ray apparatus comprising a closed envelope or casing, a series of independent sources of rays arranged within said envelope concentrically about a common axis and in a common plane, means for supporting the ray emitting targets in position to converge the paths of emitted rays at a point co-axial with the central point about which the ray emitting sources are concentrically arranged to produce an area of rays of comparatively high intensity, said point of convergence being outside of the tube and at a predetermined distance from the sources of the rays, whereby the paths of the rays from the targets to the point of convergence will all be at a predetermined degree of inclination with respect to an axial line passing through the point of convergence and the central point about which the ray emitting sources are concentrically arranged, and means for adjustably changing the direction of the rays to cause them to converge at different distances from the envelope.

2. An X-ray apparatus comprising a closed envelope or casing, a series of independent sources of rays comprising targets arranged within said envelope, means for supporting the ray emitting targets in position to converge the paths of emitted rays at a point to produce an area of rays of comparatively high intensity, said point of convergence being outside of the tube and at a predetermined distance from the sources of the rays, a shielding tube of material impervious to X-rays for the rays from each of the independent sources, and adjustable means at the ends of said tubes to control rays passing from said tubes to vary the length and breadth of the rays permitted to pass the adjustable means, and to thereby vary the point of convergence of the rays passing through the said adjustable means.

3. An X-ray apparatus comprising a substantially spherical tank or casing, means supporting said tank or casing to permit of its rotation in any direction and within its own dimensions, a plurality of individual sources of X-rays in the tank and movable with it, and means within the tank to direct the rays from the individual sources of rays in paths to converge at a point outside the tank and a predetermined distance from the sources of rays.

4. An X-ray apparatus comprising a substantially spherical tank or casing, means supporting said tank or casing to permit of its rotation in any direction and within its own dimensions, a plurality of individual sources of X-rays in the tank and movable with it, means within the tank to direct the rays from the individual sources of rays in paths to converge at a point outside of the tank and a predetermined distance from the sources of rays, and shielding tubes of material impervious to X-rays carried by the tank and extending from the tank to a point adjacent the point of convergence of the paths of the rays,

said tubes shielding the independently generated rays along their individual paths.

5. In an X-ray apparatus, a shielding tube impermeable to the X-rays surrounding the path of the rays, removable means at the distal end for regulating the rays, said device comprising a spring-pressed clip adapted to clamp on the distal end of the tube, an outer clip adapted to clamp on the first clip, a regulating or filtering element between the two clips and means for retaining same in said location.

6. An X-ray apparatus comprising a substantially spherical tank or casing, a plurality of cathodes and targets in said casing in operative relation to one another, said tank or casing enclosing said cathodes and targets entirely, one telescopic tube for each target adapted to conduct X radiation from one of said targets, an X-ray proof joint for said tube allowing the latter to be swiveled, said tubes being made of X-ray impermeable material and adapted to be pointed to a variable locus of convergence of said X radiation.

7. An X-ray apparatus according to claim 6 in which the face of each target is inclined to cast X radiation to a common focal point lying outside of the tube.

8. An X-ray apparatus according to claim 6 in which each of the telescopic tubes is turned toward a common point, a filter holder above said point and attached to said tubes and an X-ray filter in said holder.

9. In an X-ray apparatus for therapeutic treatment, a plurality of independent sources of X-ray beams, said sources being positioned to direct the beams in converging relation so that all of the rays composing the beams intersect within a common plane, the pattern of each of the beams at their intersection with the common plane substantially coinciding with each other to form an area of substantially uniform X-ray concentration, whereby a suitably concentrated dosage of rays may be applied to a subsurface part of a patient without injury to the surrounding tissue.

10. In an X-ray apparatus for therapeutic treatment, a plurality of independent sources of X-ray beams, said sources being positioned to direct the beams in converging relation so that substantially all of the rays composing the beams intersect to define within a common plane an area of substantially uniform maximum X-ray concentration through which pass substantially all of the rays, the size, shape and location of said area coinciding substantially to the size, shape and location of the area defined by the intersection of each of the beams with said common plane, whereby a suitably concentrated dosage of rays may be applied to a subsurface part of a patient without injury to the surrounding tissue.

11. In an X-ray apparatus for therapeutic treatment, a plurality of independent sources of X-rays, said sources being positioned to direct the rays from the sources in converging relation, means for masking out a portion of said rays but permitting the passage of other of said rays as sharply defined beams, substantially all of the rays composing the beams intersecting within a common plane and the pattern of each of the beams at their intersection with the common plane substantially coinciding with each other to form an area of substantially uniform X-ray concentration, whereby a suitably concentrated dosage of rays may be applied to a subsurface part of a patient without injury to the surrounding tissue.

12. In an X-ray apparatus for therapeutic treatment, a series of independent sources of X-rays, said sources being arranged in equidistantly spaced-apart relation in a common plane and positioned to direct the rays in converging relation, means for masking out a portion of said rays but permitting the passage of other of said rays as sharply defined beams, substantially all of the rays composing the beams intersecting within a common plane and the pattern of each of the beams at their intersection with the common plane substantially coinciding with each other to form an area of substantially uniform X-ray concentration, whereby a suitably concentrated dosage of rays may be applied to a subsurface part of a patient without injury to the surrounding tissue.

13. In an X-ray apparatus for therapeutic treatment, a plurality of independent sources of X-rays, said sources being located within a closed envelope and positioned so as to direct the rays from the sources in converging relation, means for masking out a portion of said rays but permitting the passage of other of said rays as sharply defined beams, substantially all of the rays composing the beams intersecting within a common plane and the pattern of each of the beams at their intersection with the common plane substantially coinciding with each other to form an area of substantially uniform X-ray concentration, whereby a suitably concentrated dosage of rays may be applied to a subsurface part of a patient without injury to the surrounding tissue.

14. In an X-ray apparatus for therapeutic treatment, a plurality of independent sources of X-ray beams, X-ray impervious tubes surrounding the beams throughout a portion of their length and serving to prevent the escape of stray rays therefrom, said sources being positioned to direct the beams in converging relation so that all of the rays composing the beams intersect within a common plane, the pattern of each of the beams at their intersection with the common plane substantially coinciding with each other to form an area of substantially uniform X-ray concentration, whereby a suitably concentrated dosage of rays may be applied to a subsurface part of a patient without injury to the surrounding tissue.

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