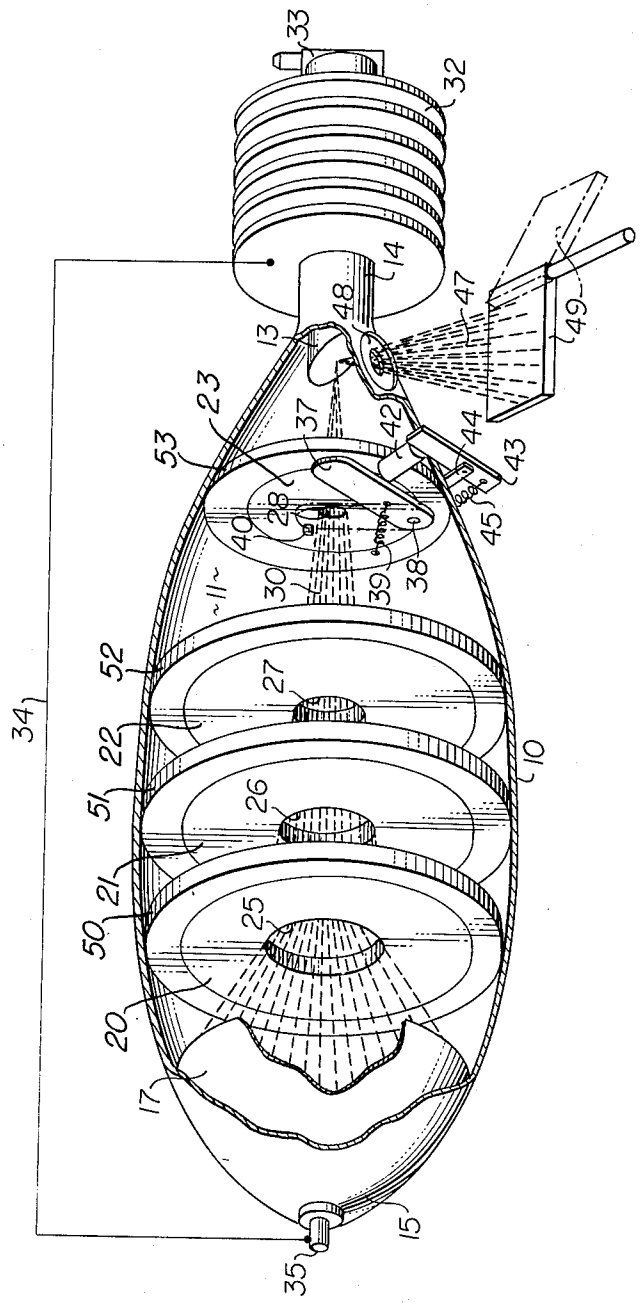
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ISOTOPE X-RAY

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ISOTOPE X-RAY

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This invention relates to X-ray apparatus and more particularly to that class of device known generally as "X-ray tubes."

In prior known X-ray tubes an external source of energy such as electricity has been required. For this reason prior known X-ray apparatus have only been used in locations where there is an available supply of electric energy. In many locations the X-ray apparatus is not dependable because the supply of electric energy is not dependable. Examples of this are some remote rural areas, army field hospitals, and medical installations in many foreign countries.

The present invention overcomes the previously outlined disadvantages by providing a self-energized X-ray tube. This self-energized tube contains, as its energy source, a quantity of beta particle emitting radioactive material. The tube also has a means to focus the beta particles into a beam against an X-ray emitting target.

Accordingly, one of the principal objects of the invention is to provide a self-energized X-ray tube, which tube is not dependent on an externally supplied source of electricity or other energy.

Another object of the invention is to provide a self-energized X-ray tube which is light, compact and portable, and which readily lends itself to use in such applications as army field hospitals and X-ray inspection at remote construction sites.

Conversely and negatively expressed, an object of the invention is to provide a self energized X-ray tube which requires no electric or other external source of energy when it is in use.

A further object of the invention is to provide an X-ray tube which utilizes a source of radioactive material as its energy source in which the energy source is fully shielded at all times except when the shutter control means is opened by the operator.

A related object of the invention is to provide a shutter control means which automatically assumes a closed and shieding position unless positively opened by the operator.

Another related object of the invention is to provide shutter control means which is mechanically actuated and thereby independent of an external source of power.

A similar object of the invention is to provide an X-ray tube having a beta particle emitting energy source and electrostatic focusing rings to focus such beta particles into a beam wherein the rings are charged by the beta particles.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a somethat schematic perspective view of a self-energized X-ray tube with parts broken away and removed for clarity of illustration.

Referring to the drawing, an elongated housing **10** is provided. The housing **10** is a relatively thin walled, relatively rigid and nonfrangible body which defines an internal evacuated chamber **11**.

The housing is preferably somewhat tear-drop shaped. This shape is preferred both because it gives the tube strength and rigidity and, as will be more apparent from the description below, because it is highly suitable for

housing the various components of the tube. To facilitate the provision of a rugged unit, the disclosed housing is metal.

An X-ray producing target **13** of tungsten, or other suitable material is carried at one end **14** of the housing **10**. An energy source is provided at opposite end **15** of the housing **10**. The energy source end **15** is of curved cross-section such as a segment of a sphere or other ellipsoid. The interior of a portion of the housing **10** adjacent the source end **15** is coated with a thin uniform layer **17** of a suitable radioactive material. The material is a beta particle emitting radiactive isotope of a relatively long half-life. It is also a material which is stable in a high vacuum. The sulfate and the chloride of strontium 90 ($Sr^{90}SO_4$, $Sr^{90}Cl_2$) are examples of suitable radio-active isotopes which have these described characteristics. The oxide of promethium ($Pm_2{}^{147}O_3$) is another satisfactory material.

A plurality of focusing rings **20**, **21**, **22**, **23** are provided. The focusing rings **20**, **21**, **22**, **23** are carried by insulating members such as rings **50**, **51**, **52**, **53**. The insulating rings are carried by the housing **10**. The rings are all substantially normal to the axis of the housing. The rings **20**, **21**, **22**, **23** are spaced from one another and have axially located central apertures **25**, **26**, **27**, **28** of progressively decreasing diameter.

The rings **20**, **21**, **22**, **23** are electrostatically charged focusing rings. The rings are charged by beta particles emitted by the source **17**. Once the rings have been charged, they will retain that charge and therefore tend to repel the beta particles. This causes the rings to focus the particles into and through their respective apertures and thus into a convergent beam which strikes the target **13**. The beta beam is indicated in dotted lines designated by the numeral **30**.

If desired, magnetic rings may be substituted for one or more of the electrostatic rings and the associated insulating ring or rings. Such magnetic rings are permanent magnets which create a magnetic field parallel to the axis of the beta beam **30**. Normally, if magnetic rings are substituted for some but not all of the electrostatic rings, the rings nearest the target end **14** of the housing will be the magnetic rings.

The electrostatically charged rings are formed of a material that is capable of receiving and holding an electrostatic charge. The material must be an electrically conductive material which is stable in a vacuum and which has secondary electron emission characteristics. Tungsten, nickel, molybdenum and copper are all examples of materials which will become charged by the beta particles, and once charged provided an electrostatic focusing field. Since the rings **20**, **21**, **22**, **23** are electrostatically charged focusing rings, it will be seen that they must be insulated from one another and from grounding. In the disclosed arrangement this is accomplished by the insulating rings **50**, **51**, **52**, **53** respectively, which insulate the electrostatically charged rings from the metal housing and one another. The insulating rings may be glass or quartz.

In the disclosed arrangement the housing is also a shield. To provide a rugged, unbreakable unit, a lead or tungsten housing, or an aluminum or stainless steel housing coated with lead or tungsten may, as examples, be used. A stainless housing is also suitable. Alternately, the insulating rings **50**, **51**, **52**, **53** may be eliminated and an insulating housing of such materials as leaded glass or quartz may be used. A leaded insulator serves the dual purpose of shielding from radioactivity and electric insulation.

A finned cooling jacket may be carried by the target end **14** of the housing. The cooling jacket **32** has a fitting **33** for connection to a suitable supply of cooling fluid.

The cooling jacket is provided to cool the target 13. The jacket is electrically connected to the target 13. A target grounding conductor 34 is then connected to the jacket 32 and to a source and terminal 35 to complete a circuit which includes the beta particle beam.

To protect the target 13 and to turn the beta beam 30 off and on, a beta particle shutter 37 is provided. The beta particle shutter 37 is preferably metal. The shutter 37 is opaque to electrons and in the disclosed arrangement it is also a magnetic material. The beta particle shutter 37 is carried on a pivot 38 which is connected to the ring 33. A spring 39 urges the shutter 37 against a stop pin 40 and into a closed position. The shutter 37 is normally in the closed position against the stop pin 40 closing the aperture 28. The closed position of the shutter 37 is shown in phantom in the drawing.

A permanent magnet 42 is connected to a pivot bar 43. The pivot bar is pivotally carried by a suitable bracket 44. A spring 45 urges the pivot bar 43 to an open position. In opening the beta particle shutter 37 an operator pivots the lever 43 against the action of the spring 45 until the magnet is close to or against the housing 10. In this position the magnet is sufficiently close to the beta particle shutter 37 to place it in the field of magnetic attraction. The magnetic field draws the beta particle shutter outwardly and against the action of the spring 39 to the open position shown in the drawing. When the beta particle shutter 37 is in the open position the beta particles 30 pass through the aperture 28 and strike the target 13.

When the beta particle beam 30 strikes the target 13, an X-ray beam is produced. The X-ray beam is shown by the dotted lines identified by the numeral 47. The X-ray beam 47 passes through a beam window 48 in the wall of the housing 10. A mechanically activated X-ray shutter 49 is provided. The shutter may be selectively positioned across the beam of X-rays 47 to intercept them, or pivoted away from the beam to permit an X-ray study to be conducted.

It will be recognized that any of the well known X-ray shutters may be employed in place of the mechanical shutter shown schematically at 49. It will also be recognized that other means may be employed to intercept or divert the beta particle beam 30 rather than the beta particle shutter 37. As an example, an electromagnet may be substituted for the permanent magnet 42 and the pivot linkage. However, in keeping with the concept of providing an X-ray tube which is totally independent of an outside source of power, the beta particle shutter 37 and activating mechanism have been devised. The mechanically activated X-ray shutter 49 has also been provided for the same purposes.

While the invention has been described with a great deal of clarity and detail, it is believed that it essentially comprises an X-ray tube which has a quantity of beta particle emitting radioactive material as the energy source, a target which emits X-rays when bombarded by the beta particles, and means to focus the beta particles emitted by the material into a beam directed against the target.

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

What is claimed is:

1. A self energized X-ray tube comprising a housing having an inner surface defining an evacuated chamber, a quantity of particle emitting radioactive material laminated on said inner surface, an X-ray emitting target carried by the housing and spaced from said material, means to prevent a substantial voltage differential between said target and said radioactive material, and focusing means carried in said chamber and interposed between the material and the target to focus material emitted particles against the target, said focusing means including a plurality of electrostatically charged rings, said focusing means being free of electrical connections.

2. A self energized X-ray tube comprising, an elongated housing having first and second ends, said housing defining an evacuated chamber, said housing having a first end portion, a thin layer of beta particle emitting radioactive material of substantially uniform thickness disposed in the housing chamber and covering the inside of said portion, an X-ray emitting target carried in said chamber adjacent the housing second end, electrical conductor means electrically connecting said target to said material, a plurality of electrostatically charged focusing rings carried by said housing and interposed between the material and the target to focus said emitted beta particles into a beam, each of said rings having a through focusing aperture, operator controlled target protection means operatively connected to the housing and selectively positionable to permit bombardment of the target by focused beta particles, and target cooling means carried by said housing at said second end.

3. A self energized X-ray tube comprising, an elongated housing having first and second ends, said housing definings an evacuated chamber, said housing having a first end portion, the first end portion having a contour generally in the shape of a segment of an ellipsoid, a thin layer of beta particle emitting radioactive material of substantially uniform thickness disposed in the housing chamber and covering the inside of said portion, an X-ray emitting target carried in said chamber adjacent the housing second end, electric conductor means electrically connecting said target to said source, a plurality of electrostatically charged focusing rings carried by said housing and interposed between the material and the target to focus said emitted beta particles into a beam, each of said rings having a through focusing aperture, the diameter of each ring aperture being of less diameter than the preceding ring aperture from the first to the second housing end, operator controlled target protection means operatively connected to the housing and selectively positionable to permit bombardment of the target by focused beta particles, and target cooling means carried by said housing at said second end.

4. A self energized X-ray tube comprising, an elongated housing having first and second ends, said housing defining an evacuated chamber, said housing having a first end portion, the first end portion having a contour generally in the shape of a segment of an ellipsoid, a thin layer of beta particle emitting radioactive material of substantially uniform thickness disposed in the housing chamber and covering the inside of said portion, an X-ray emitting target carried in said chamber adjacent the housing second end, electric conductor means electrically connecting said target to said material, a plurality of electrostatically charged focusing rings carried by said housing and interposed between the material and the target to focus said emitted beta particle into a beam, each of said rings being disposed substantially normal to the axis of said housing and having a through focusing aperture, the diameter of each ring aperture being of less diameter than the preceding ring aperture from the first to the second housing end, a shutter carried in the housing and selectively positionable across said path to permit selective bombardment of the target by said beta particle, and target cooling means carried by said housing at said second end.

5. A self-energized X-ray tube, comprising, a housing, a quantity of beta particle emitting material within said housing, means to prevent substantial voltage differential between said target and said material, and electrostatic ring means carried by said housing between said target and said material to form a beam of beta particles and focus the formed beam on the target.

6. A self energized X-ray tube comprising a housing, a quantity of particle emitting radioactive material disposed within the housing, an X-ray emitting target carried by the housing and spaced from said material, means to prevent electric potential build up between said target and said radioactive material, energy repelling focusing means connected to the housing between the material and the target and offset with respect to a path of beam travel to deflect a flow of energy emanating from said material and thereby focus such energy flow into a beam directed against said target, said focusing means being free of electrical connections.

7. A self-energized X-ray tube comprising a housing having an inner surface defining an evacuated chamber, a quantity of particle emitting radioactive material laminated on said inner surface, an X-ray emitting target carried by the housing and spaced from said material, means to prevent a substantial voltage differential between said target and said radioactive material, energy repelling focusing means connected to the housing between the material and the target and offset with respect to a path of beam travel to deflect a flow of energy emanating from said material and thereby focus such energy flow into a beam directed against said target, said focusing means being free of electrical connections.

8. A self-energized X-ray tube, comprising, a housing, a beta particle emitting material in the housing, an X-ray

emitting target connected to the housing and spaced from said material, means to prevent potential build-up between said material and said target, and energy repelling focusing means connected to the housing between the material and the target and offset with respect to a path of beam travel to deflect the flow of energy emanating from said material and thereby focus such energy flow into a beam directed against said target.

9. The device of claim 6 wherein an operator controlled means is connected to the housing between said material and said target and selectively positioned in the path of said beam to interrupt said beam.

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