May 1, 1962 R. V. WOLF 3,032,661

TELETHERAPY HEAD HAVING SHIELDING CARRIER FOR RADIOACTIVE SOURCE

Filed March 4, 1957 2 Sheets-Sheet 1

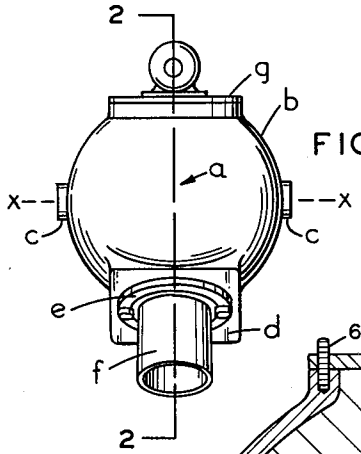


FIG. 1

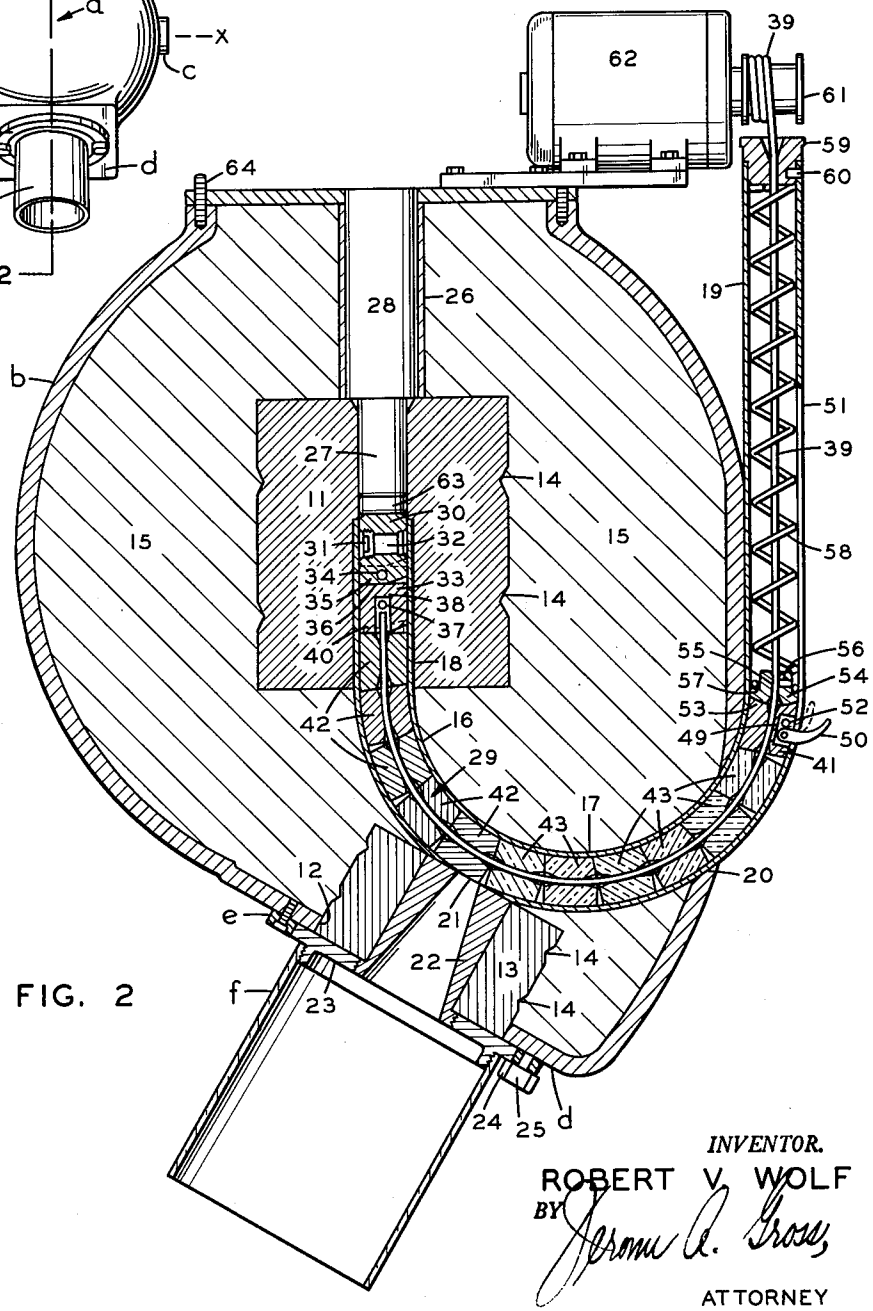


FIG. 2

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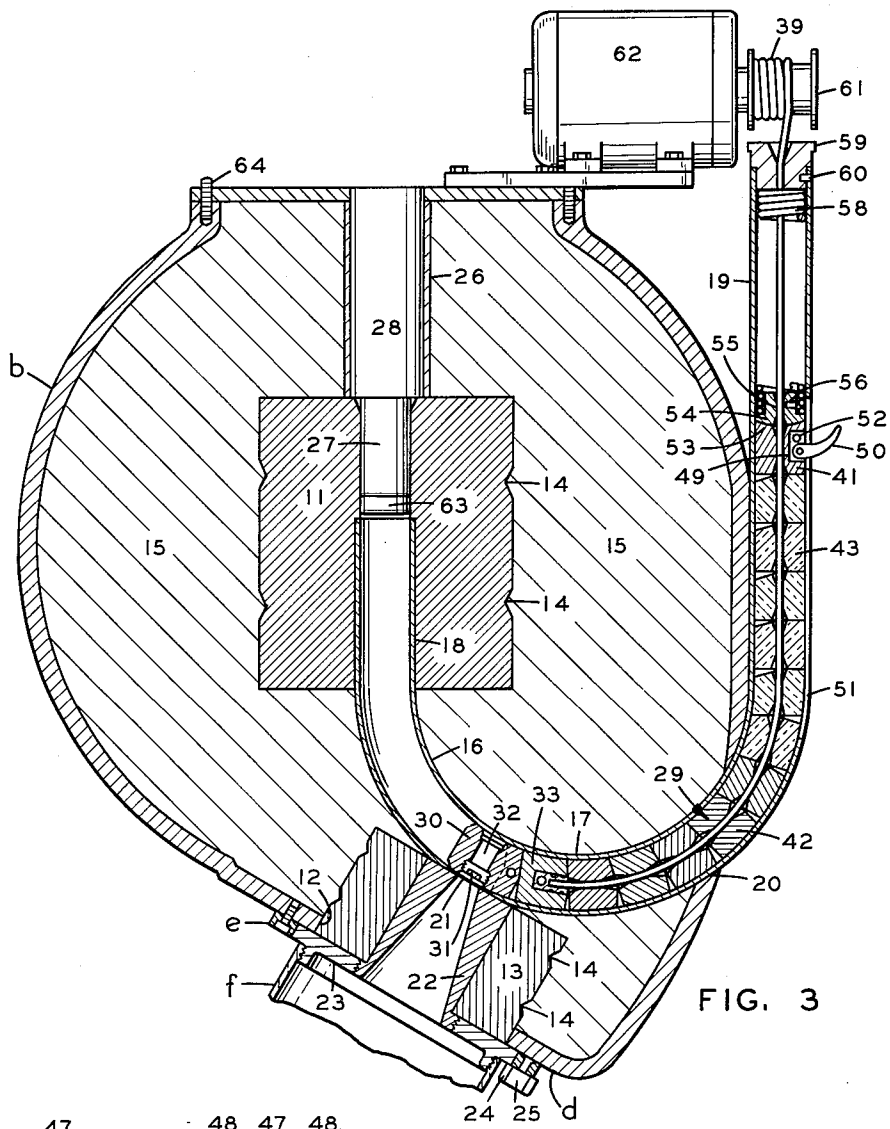


FIG. 3

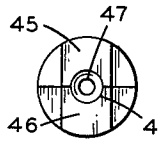


FIG. 6

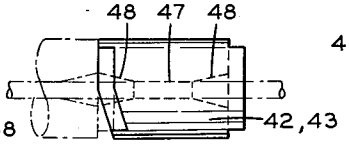


FIG. 4

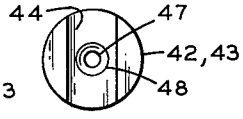


FIG. 7

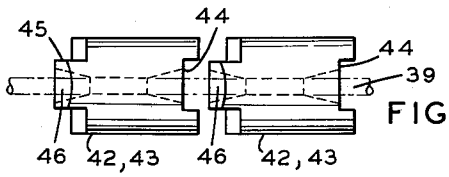


FIG. 5

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TELETHERAPY HEAD HAVING SHIELDING CARRIER FOR RADIOACTIVE SOURCE

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14 Claims. (Cl. 250—108)

This invention relates to radiation instruments and particularly to teletherapy heads wherein a radioactive source, such as cobalt 60, which is dangerous when exposed, must be moved from a safety position deep within the shielding of the head to a radiation position adjacent an aperture, to permit the emanation of radiation for a limited time only; and must then promptly and securely be restored to the safety position.

The purposes of the present invention include: providing such a radiation instrument, and particularly a teletherapy head, with an easily moved source-carrier of minimum mass, nevertheless assuring the maximum of shielding whether the source is in safety position or in radiation position or being moved therebetween; assuring accurate registration of the radioactive source with the radiation aperture; providing a fail-safe control means for positioning the source and for emergency return of the source to the safety position; providing an articulated carrier having a minimum of mechanical connector parts and articulated in such manner as to achieve close fit of the parts within the head; using the articulated carrier to furnish shielding.

I attain these purposes, and others which will be apparent from this specification, in the manner set forth hereinafter and as shown in the drawings, in which:

FIGURE 1 is a front elevation, somewhat schematic, of a teletherapy head embodying the present invention;

FIGURE 2 is an enlarged sectional view taken along line 2—2 of FIGURE 1, with the radioactive source in safety position;

FIGURE 3 is a sectional view similar to FIGURE 2, showing the source moved to radiation position in registration with the radiation aperture;

FIGURE 4 is a side elevation of a typical link of the articulated carrier, with part of an adjacent link shown in phantom lines;

FIGURE 5 is an exploded view of two adjacent links, taken from the inner side of the curve of the head passage;

FIGURE 6 is a left end view of the link of FIGURE 4; and

FIGURE 7 is a right end view of the link of FIGURE 4.

The teletherapy head generally designated *a* in FIGURE 1 comprises a housing *b* which is nearly spherical in general contour, and is mounted on a lateral axis *x* for rotation on trunnion-like side extensions *c*. Projecting from the housing *b* near its lower and forward portion is a collimator face *d* mounting a shield-holding ring *e* by which any one of a variety of spacers may be held to a collimator face. Such spacers (as the plastic hollow cylindrical spacer *f*) fix the distance from the patient's body at which the source of radiation is to be used. At its upper end the housing *b* has a planar face *g* which is utilized as hereinafter more fully set forth.

Within the housing *b* I locate at substantially its center a thick-walled, hollow cylindrical safety-position shield **11**. Within a collimator face aperture **12** of the housing *b* I locate a somewhat similar, though smaller, hollow cylindrical collimator face shield **13** with its cylinder axis substantially perpendicular to the housing face *d*. The shields **11**, **13** are preferably machined of a material having exceptionally high shielding qualities, i.e., resistance to the passage of the emanations from radioactive sources.

Tungsten alloys have proved well-suited for this purpose. A plurality of tapered depressions **14** formed in the outer cylidrical surfaces of the shields **11**, **13** are filled when a mass of lead shielding **15** is cast within the housing *b*, holding these shields permanently in place.

Before casting the lead shielding in place, however, a tubular track **16**, preferably circular in cross-section and having a 180° bend portion **17** whose bend radius is roughly half the diameter of the head *a*, is affixed with its inner end **18** inside the safety position shield **11**, with the axis of this cylindrical shield **11** directed perpendicular to the face *g*. The tube axis of the track **16** lies entirely within a plane corresponding to that shown in the sectional views FIGURES 2, 3.

The outer end of the tubular track **16** consists of a straight outer track portion **19** parallel to the axis of the safety position shield **11**, and where it joins the 180° bend portion it enters the head *a* through a casting outlet **20**. Adjacent the inner end of the central opening in the collimator face shield **13**, the tubular track has, on the outer side of its 180° bend portion **17**, a radiation opening **21**. Radiations emitted through this opening are controlled by the use of a collimator plug having a suitable inner contour. One of such plugs, numbered **22** and having a truncated conical aperture, is shown fitted within the cylindrical collimator face shield **13**. Such plugs all employ a similar radially enlarged outer retention portion **23**, into which the plastic spacer *f* is engaged. Both are held within the shield-holding ring *e* under the overhanging projecting ends **24** of twistable knobs **25**, or by other suitable retention means.

A tubular insert **26**, of slightly greater diameter than the inner diameter of the safety shield **11**, connects its bore to the face *g*.

The safety position for the radioactive source is at the center of the cylindrical shield **11**. A tungsten alloy inner shielding plug **27** is removably positioned and retained therein under a larger diameter lead plug **28** which removably fills the extension tube **26**.

One of the principal problems met by the present invention is to move the radioactive source from the safety position to the radiation position in precise registration with the radiation opening **21** in the track **16** and the central aperture of the collimator plug **22**; nevertheless, to provide adequate shielding between the safety position and the radiation position when the source is removed from the radiation position, and also to provide shielding between such source and the casting outlet **20**.

I utilize an articulated source-carrier generally designated **29**, which bears the radioactive source at its inner end, rides easily within the track **16**, and is manipulated from its outer end by means outside of the housing *b* and with complete safety to the operator. This articulated source-carrier is essentially a train of source-positioning links, hereinafter more fully described, the inner links of which serve as additional shielding material for the source.

This train includes a radiation source link **30**, located at the inner end of the carrier train and shown in FIGURE 2 in the safety position and in FIGURE 3 in the radiation position. A radio-active source **31**, such as cobalt **60**, is loaded within a lateral, threaded bore **32** in the source link **30**. The link **30** is substantially cylindrical in shape, its outer diameter being sufficiently less than the inner diameter of the tubular track **16** to slide readily within the 180° bend portion **17**. Angular registration within the plane shown in cross-section, FIGURES 2 and 3, is obtained by connecting the successive links to each other in a manner as will avoid twisting. As between the source link **30** and the outwardly adjacent link to which it is coupled (hereinafter referred to as the "coupling link" **33**) this result is obtained by means of a removable coupling pin **34**, arranged perpendicular to the plane of

the 180° bend in the track 16, through a tongue portion 35 of the source link 30 and a mating groove portion 36 at the adjacent end of the coupling link 33. These tongue-and-groove portions serve to continue the shielding material with minimum interruption.

Articulation of the links, despite their tongue-and-groove end portions, is achieved as follows: Within the plane shown in FIGURES 2 and 3 the link portions on the inward side of the curved track 16 are considered the inner portions. Outward of the centerline of the links, the tongue-and-groove portions described are formed perpendicularly to the axes of the links; but inwardly of their centerlines one or the other of them (here the tongue portion 35 of the source link 30) is cut away at a relief angle sufficient to permit relative slant of adjacent links, so the articulated carrier may pass around the 180° bend. Inasmuch as this bend is formed to a circular arc, the relief angle to be provided may be readily computed by dividing 180° by the number of links necessary to fill the path within the bend. For instance, if ten links are necessary to fill this path, the minimum relief angle to be cut away at each juncture of adjacent links would be 18°. In practice a slightly greater angle should be provided.

Firmly secured by an end pin 37 within a blind centerline bore 38 within the coupling link 33, is the inner end of a control cable 39, upon which all the remaining articulated links are "strung" as hereinafter described. The centerline bore 38 in the coupling link is at its end opposite the attachment to the source link; this end includes a tongue portion 40, shown in section in the drawings, for mating with a groove portion of the next adjacent link, hereinafter to be described, but they are not pinned together.

Intermediate the coupling link 33 and the outermost "trigger link" 41, all the intermediate links are identical in size and shape to those shown in FIGURES 4, 5, 6 and 7, inclusive, but are of two different materials. The five links starting adjacent the coupling link 33 and extending outwardly therefrom are referred to as the shielding links 42; these are formed of a tungsten alloy having high shielding qualities. The six links next adjacent are identified as the low mass links 43; these are formed of any substantially rigid light-weight material, such as nylon plastic, which may be held to sufficiently close tolerance to avoid any twisting in the mating tongue-and-groove connecting portions.

Referring to FIGURES 4 to 7, inclusive, each of the shielding links 42 and low mass links 43 is generally cylindrical and has at one end a square-cut groove 44, formed perpendicular to the cylinder axis, and at the other end a projecting tongue including a tongue portion 45 formed to mate within such a square-cut groove and having at the inner side of the curve an angularly cut-back tongue portion 46, together with faces which flank the tongue base, formed at the relief angle or bevel—say 18°. The grooves 44 receive the tongue portions 45, 46 with close tolerance, so that the links need not be pinned as long as they are not permitted to spread apart from each other. When the source is in safety position, shielding material is provided by the shielding links 42 between the safety position and the radiation position; similarly, when the source is in radiation position, they provide shielding between the radiation position and the casting outlet. The low mass links are, in either case, positioned where no additional shielding is necessary; therefore, their light-weight construction minimizes the mass to be moved.

Each of the shielding links 42 and low mass links 43 has a centerline bore 47 including taperingly enlarged end portions 48 of sufficient depth and taper to permit the control cable 39 to assume either curved or straight alignment without loosening or otherwise affecting the spacing between adjacent links. Thus the links have a snakelike freedom to bend in the plane which is defined by the mating tongue-and-groove portions 44, 45, 46, to coincide with the plane of the track 16 and to assure positioning

of the source in perfect registration with the radiation opening 21.

The trigger link 41 is the outermost link of the articulated source-carrier. Its innermost end is grooved at 44, to mate with the tongue of the adjacent low mass link. It has a similar flared-end centerline bore 47, and its outer diameter is the same as the other links which make up the carrier. Pin-pointed within a recess 49 in the outer side of the link is a trigger-shaped finger grip projection 50 which extends outwardly through an elongated slot 51 in the outer side of the outer track portion 19. This finger grip projection 50 is free to deflect upward and inward as shown in the dashed lines of FIGURE 1, against a stop pin 52; thus chance contact with the projection will not tend to move the radioactive source out of the safety position shown in FIGURE 2. However, the projection 50 is readily grasped for moving the source from the radiation position of FIGURE 3 toward the safety position and when pressed in this direction will not deflect out of the way. Thus while the link 41 is referred to as a trigger link, the term is descriptive of its appearance; other finger grip projections would serve the same function.

The outermost end of the trigger link 41 has a concave face 53 against which seats a convex-ended plug 54 having a centerline bore 55 through which the control cable 39 passes, and an assembly set-screw 56 extending inward from the outer side and adapted to be tightened against the control cable. This assembly set-screw 56 is used only during assembly, installation and dis-assembly of the articulated source-carrier 29, not during normal use. Once installation is complete, the assembly set-screw 56 is backed off, so that the mating tongue-and-groove portions of the links of the source-carrier 29 may be continuously held pressed together, as herein set out, and the cable 39 held continuously in tension.

Opposite the convex end of the plug 54, its diameter is reduced to provide an annular seating flange 54 for the inner end of a coiled compression spring 58, whose outer end bears against a similar seating flange formed on a centrally bored closing plug 59 retained by a set-screw 60 in the outer end of the tubular track 16. The control cable passes freely through the centerbore of the closing plug 59 and is secured around a rotatable drum 61 on the shaft of an electric torque motor 62 mounted to the face plate *g*. The compression spring 58, acting against the closing plug 59, holds the cable 39 under continuous tension (and the links strung thereon aligned under continuous compression) exerted all the way to the coupling link 33.

The motor 62 preferably includes a preset torque clutch or other means to permit the drum 61 to stop when subjected to a preselected amount of torque exerted in the control cable 39 when the radioactive source is in the radiation position heretofore described. Such torque may be brought about in a variety of ways. In the drawing, FIGURE 3, it is shown as being induced by compressing the spring 58 to its flat height; but other ways may be preferred.

When the motor 62 is energized by a power source, not shown, to exert tension on the control cable, the radioactive source 31 will be drawn from the safety position shown in FIGURE 2 to the radiation position shown in FIGURE 3, that is, opposite the radiation aperture. When the motor is turned off, or should the power source fail, the torque exerted by the motor will cease, and the compression spring will cause an immediate return of the radioactive source 31 to within the safety position cylindrical shield 11. To avoid any abrupt force, the shielding plug 27 is provided with a nylon or other plastic bumper 63.

The articulated source-carrier herein described thus permits the safe positioning, from the remote outer end of the carrier, of a radioactive source which would be dangerous were there any gap in the shielding. Although the source-carrier possesses snake-like flexibility in the

plane of its mating tongue-and-groove juncture portions, which corresponds to the plane of the 180° bend in the tubular track **16**, its precisely controlled length and inability to twist achieve precise registration at the radiation aperture, so that there will be no question as to the strength of the radiations emanating through the collimator plug **22**. Thus the source-carrier is readily manipulated from its end remote in distance from the source and removed from it by a substantial angular bend.

A plurality of studs **64** projecting from the face plate *g* of the head *a* may be used to mount a "safe" for changing the radioactive source from time to time. This is done by disconnecting the cable **39** from the drum **61**, and removing the pin which mounts the finger grip projection **50**, thus permitting the articulated source-carrier to be moved further inward when the shielding plug **27** and its associated lead plug are withdrawn outwardly through an opening in the face plate *g*. These plugs may be safely removed in a variety of ways, which are known in the art, as for example, into one aperture of an indexable turret in a safe. The coupling pin **34** may then be removed by conventional means, such as a remote-controlled screwdriver, to permit the source link **30** to be disconnected and received in another aperture of such a rotating turret, and a substitute source link may be indexed in place and secured by re-engaging the coupling pin **34**.

In contrast to teletherapy heads now in use, the head shown and herein described provides a minimum mass source-carrier with a maximum of shielding. The minimmum mass permits the operation and control by a relatively small motor **62**. Such motor may be fitted with a variety of limit switches or other means by which the positioning of the source may be controlled.

Extensive changes of details may be made without departing from the scope of this invention. For example, the links might be enlarged to a somewhat barrel-shaped contour at their centers if this were necessary for easier movement within the tubular track and even more complete shielding. Other cross-sections of track might be used, with the cross-sectional shape of the links modified for easy sliding fit therein.

The tongue-and-groove link-joining means shown, including the holding of the links together by the compression spring **58**, provides the maximum shielding with a minimum of mechanical complexity, easy manufacture, and freedom from a plurality of mechanical connectors which conceivably might become disengaged and jam within the track **16**. The tension-held cable cannot kink out of its path; the compression spring which supplies the tension also assures fail-safe operation. Other articulated link-joining details might be substituted, relative angular movement in the plane of curvature of the path being provided and twist out of such plane being restrained.

Many such modifications and others will occur to those skilled in the art. Accordingly, this invention is not to be construed narrowly, but instead as fully coextensive with the scope of the claims which follow.

I claim:

1. A teletherapy head comprising a mass of shielding material of generally spherical configuration and a curved hollow tubular track embedded therein, the track having a safety position located substantially at the center of the mass, an outlet to the outer side of the head, and a radioactive radiation position intermediate the safety position and the outlet, the head having a radioactive radiation aperture adjacent the radiation position of the track, together with an articulated source-carrier having at its inner end a source link, and having links outwardly thereadjacent formed of shielding material and substantially filling the inner cross-sectional area of the tubular track, together further with position-control means at the outlet including a tension connector, a motor operatively connected therewith to apply tension thereto, whereby to move the source from the safety position to the radiation position, and an opposing compression spring urging the source-carrier toward the safety position.

2. In a radiation instrument having an innermost storage position for a radioactive source and a radiation position somewhat outward therefrom, the combination comprising a shielded head having a walled passage curved in a plane and connecting the storage position, the radiation position, and a positioning control point outside the head, together with articulated rigid source-positioning links movable within said passage and carrying the source at their inner end, at least some of the inner links being of radioactive shielding material, a tension connector connecting said source-positioning links to said positioning control point and a compression spring urging the source-positioning links toward storage position, together further with means for exerting tension on said tension connector at said positioning control point in opposition to said spring whereby to draw the source-positioning links to said radiation position.

3. The combination as defined in claim 2, the walled passage having a longitudinal slot whose length at least equals the distance of movement within said passage of said articulated source-positioning links, one of said links located remote from the source having a finger grip projection extending through said slot.

4. For use within a teletherapy head having within it a curved tubular track including a shielded safety position, a radiation aperture position, and an outlet from the head, an articulated radiation-shielding carrier for a radioactive source including a source link remote from the outlet, a plurality of links formed of radioactive radiation-shielding material and having a cross-sectional shape smaller than and conforming substantially to the inner cross-section of the tubular track, whereby to fit slidingly therein, together with manipulative means at the carrier end remote from the source link whereby to position the source link along the track selectively in the radiation position and to return it to safety position.

5. A shielded teletherapy head for containing a source of radioactive radiation and having within it a storage position for the source, a radiation position therefor, a radiation aperture adjacent said radiation position, and a tunnel-like passage extending from the storage position to and beyond the radiation position, together with a source-holding member and a train of links secured thereto and accommodated and movable within said passage, the links having such cross-section as to fit slidingly within and substantially to fill the passage thereof, said links adjacent said source-holding member and extending for a length substantially as great as that from the storage position to the radiation position, being formed of radiation-shielding material, together with means for moving said train of links withn said passage whereby to postion the source selectively in radiation position and in storage position.

6. The combination comprising a shielded head having a storage position for a radioactive source, a radiation position therefor, a radiation aperture thereadjacent, and a curved tunnel-like passage extending from the storage position beyond the radiation position, and having an outlet from the head, together with a source-positioning train movable within said passage and including an articulated carrier having a source-holding member and a plurality of articulated shielding links adjacent said member and extending therefrom outwardly along said passage a distance substantially as great as the distance from the storage position to the radiation position, said carrier further having additional articulated links extending along the passage a distance as great as that from the outlet to the outermost shielding link, measured when the source-holding member is in the storage position.

7. The combination defined in claim 6, said additional articulated links being formed of light-weight non-shielding material whereby to lessen the mass of the carrier.

8. In a shielded teletherapy head having a tunnel-like

source-track curved in a plane, said track including a storage position near the center of the head and a radiation position outward therefrom, source-positioning means comprising a plurality of links including an innermost source-holding link within such tunnel-like track and articulated link-joining means permitting said links relative angular movement in the plane of said curved path and restraining them against relative twist, at least some of the links near said source-holding link being of radioactive shielding material.

9. Source-positioning means as defined in claim 8, the link-joining mechanism including mating tongue-and-groove portions formed in the plane of curvature of the passage and cut away inward of the center of the path.

10. Articulated source-positioning means for a teletherapy head having a planar source passage including a curved portion extending from inside to outside the head, comprising a plurality of unpinned links each having a centerline bore and having mating tongue-and-groove end portions, the parts of said tongue-and-groove portions on the outer side of the curve being formed perpendicular to the centerline bore, one part thereof at each tongue-and-groove junction including an angle less than 90°, together with a flexible cable extending from the innermost unpinned link through the centerline bores of said links to and through the outermost link, and retention means secured to the cable outward of the outermost link for retaining said tongue-and-groove portions of adjacent links in registration with each other, a plurality of said links being formed of radioactive shielding material.

11. For use in a radiation instrument having a curved passage for moving a source of radioactive radiation from a safety position to a radiation aperture, an articulated radiation-shielding source-carrier including a source-holding link substantially at one end thereof, a plurality of articulated links formed of radiation-shielding material and of such cross-sectional area and shape as to substantially fill and fit slidingly within such curved passage, together with manipulative means at the other end whereby to move the source-carrying link along the passage from the safety position to the radiation aperture and back.

12. For moving a source of radioactive radiation within a curved tunnel-like passage of a teletherapy head from storage position to a radiation position and back, a lightweight shielding carrier for a radioactive source comprising a source-holding member and a plurality of articulated links operatively connected thereto and to each other, said carrier being such length as to extend from the storage position beyond the radiation position to the outer side of the head, the links adjacent the source-holding member being formed of radiation-shielding material, the links remote from the source-holding member being formed of lightweight material whereby the total mass of the carrier is lessened.

13. Means for moving a source of radioactive radiation within a teletherapy head along a tunnel-like path having a curved path portion, comprising a flexible cable secured at its inner end to such radiation source and at its outer end to a tension-applying control means, a plurality of shielding links riding within such tunnel-like path at least the length of the curved portion thereof and strung bead-like along said cable outward of said source, and a spring yieldably exerting compression inwardly against said links whereby to hold the cable continuously in tension around the curved portion of such path.

14. Fail-safe means for moving a source of radioactive radiation within a teletherapy head along a tunnel-like path having a curved portion, comprising the mechanism defined in claim 13, the spring being helical and surrounding a portion of the cable adjacent the outer end of said links so strung, the outer end of the spring bearing against a fixed member having an aperture through which the outer cable end passes, whereby to move the source inwardly away from the fixed member toward a safety position in case of failure of the tension-applying control means.

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