

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
27 November 2008 (27.11.2008)

PCT

(10) International Publication Number  
WO 2008/142695 A1(51) International Patent Classification:  
A61B 6/03 (2006.01) A6IN 5/10 (2006.01)

KADIM, Azriel [IL/IL]; Hri Ha'Besamim 12, 44814 Elkana (IL).

(21) International Application Number:  
PCT/IL2008/000699

(74) Agent: KAHN, Simon; PYI Tech, Ltd., P.O. Box 34598, 91344 Jerusalem (IL).

(22) International Filing Date: 25 May 2008 (25.05.2008)

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(25) Filing Language: English

(26) Publication Language: English

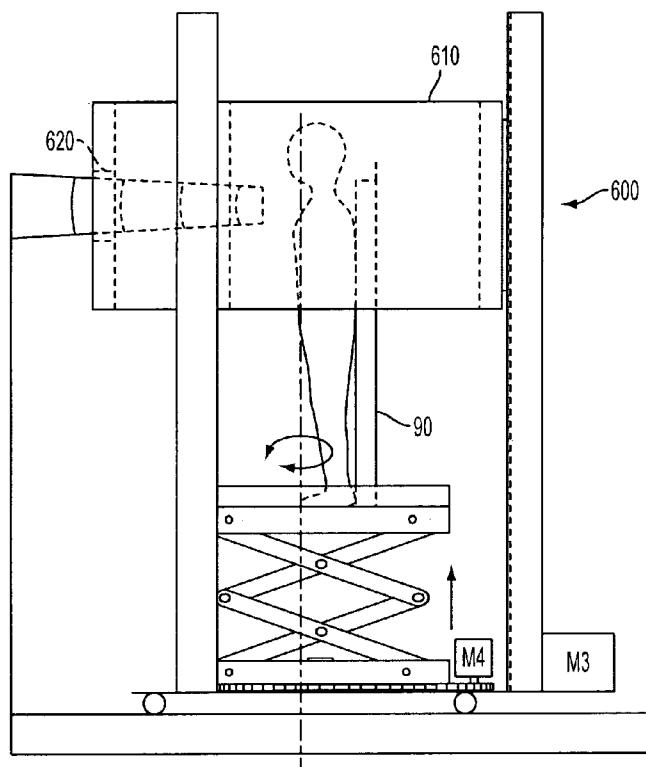
(30) Priority Data:  
60/939,923 24 May 2007 (24.05.2007) US  
60/028,519 14 February 2008 (14.02.2008) US

(71) Applicant (for all designated States except US): P-CURE LTD. [IL/IL]; 4 Hagavish St., 42101 Netanya (IL).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

*[Continued on next page]*

(54) Title: IRRADIATION TREATMENT APPARATUS AND METHOD



**(57) Abstract:** The present disclosure provides an irradiation treatment apparatus having a generally vertical patient support surface; a patient securing mechanism arranged to secure a patient in a fixed relation to the patient support surface; a rotation platform secured at one end of the patient support surface and arranged to rotate the patient support surface about a generally vertical axis and optionally translate the patient support surface at least partially about a plane generally orthogonal to the generally vertical axis; an imager exhibiting a first mode in which the imager occludes radiation from a fixed beam irradiation source and a second mode in which the imager enables irradiation from the fixed beam irradiation source; and a vertical translation mechanism in communication with the patient support surface and arranged to translate the patient support surface along the generally vertical axis from a loading position to an irradiation position.

FIG. 8



European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declaration under Rule 4.17:**

— *of inventorship (Rule 4.17(iv))*

**Published:**

- *with international search report*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

## IRRADIATION TREATMENT APPARATUS AND METHOD

5

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from U.S. Provisional Patent Application S/N 60/939,923 filed May 24, 2007, entitled "Teletherapy Positioning and Validation," and U.S. Provisional Patent Application S/N 61/028,519, bearing the 10 present title, filed February 14, 2008. Each of the above applications is incorporated herein by reference.

### TECHNICAL FIELD

[0002] The present disclosure relates generally to the field of teletherapy and 15 in particular to a system and method for positioning and validation of a patient before a fixed beam irradiation source.

### BACKGROUND

[0003] Teletherapy generally employs an irradiation source disposed at a 20 distance from the body to be treated. X-rays and electron beams have been used in teletherapy to treat various cancers. However, X-rays and electron beams exhibit an energy transfer characteristic approaching an exponential attenuation function and are therefore not optimal for treating deeply embedded growths or target areas. Recently, the use of heavy particles, particularly hadrons, in teletherapy has found increasing 25 acceptance, in part because of the ability of heavy particles to penetrate to a specific depth without appreciably harming intervening tissue. In particular, the energy transfer characteristic of hadrons exhibits an inverted depth profile with a Bragg peak at a location where the hadrons deposit most of their energy, which is approximately at the end of the hadrons' path. As a result of this hadron energy transfer 30 characteristic, increased energy can be directed at or deposited in an embedded growth as compared to X-rays and electron beams. Also, less damage to healthy intervening tissue results when hadron beams are used to treat deep-seated tumors or diseased target tissue.

[0004] It should be appreciated that the term "hadrons" can refer to a variety of particles, including protons and other ions that are used in therapy. While this document describes treatment as being accomplished with protons, this is not meant to be limiting in any way and other types of hadrons and ions can be included in such 5 discussion where appropriate.

[0005] Typically, in a therapy system, the charged protons or ions are focused into narrow, intensity-modulated, scanned pencil beams of variable penetration depth. In this way, the dose profile can be matched to the target volume. In order to ensure 10 complete irradiation of the target growth, a plurality of beams arriving at the embedded growth from several different directions can be used. The volume in which the plurality of beams intersects, whether the beams are provided sequentially or simultaneously, is often referred to as an isocenter. To improve the biological effectiveness of the treatment, the isocenter is collocated with the target growth to 15 deliver the maximum treatment dose to the target volume and to spare the surrounding tissue.

[0006] Present teletherapy systems use a gantry apparatus carrying a beam generating and delivery system. The gantry is a motorized or powered apparatus for moving the massive particle delivery system around a patient who is typically immobilized on a treatment table. Since the beam generating and delivery system is 20 large and extremely heavy, such gantry systems are prohibitively expensive, limiting the number of available proton therapy centers that can provide services to patients. Furthermore, the spatial range of such gantry-driven systems is limited due to mechanical constraints. Movement of the beam generating and delivery system from location to location in order to effect the delivery of the plurality of beams leads to an 25 offset in the isocenter which must be carefully adjusted prior to beam delivery. One example of the above-described treatment systems is illustrated in U.S. Patent No. 6,769,806 to Moyers.

[0007] For example, World Intellectual Property Organization Publication WO 2007/012649 published February 1, 2007 to Siemens Aktiengesellshaft, is 30 directed to a device for obtaining image data for planning a radiation therapy, comprising a computerized tomography (CT) gantry and a patient positioning unit. The CT gantry is arranged in a moveable fashion in such a way that imaging for the purposes of radiation therapy can be carried out in this body position of the patient.

The need for a freely moveable CT gantry adds to cost, as a CT of the quality necessary for preferred imaging can weigh 2 metric tons or more.

5 [0008] Imagers have been available for use in the context of patient treatment, for example as appear in U.S. Patent 6,949,941 issued September 6, 2005 to Gregerson et al., entitled "Breakable Gantry Apparatus for Multidimensional X-ray Based Imaging."

[0009] Additionally, the prior art requires separate arrangements for treatment planning and irradiation. Such a need for a plurality of arrangements further adds to the cost of the system and diminishes its practical availability.

10 [00010] There is thus a need for an improved teletherapy apparatus that overcomes some or all of the above limitations.

## SUMMARY

15 [00011] In view of the discussion provided above and other considerations, the present disclosure provides methods and apparatus to overcome some or all of the disadvantages of prior and present teletherapy systems and methods. Other new and useful advantages of the present methods and apparatus will also be described herein and can be appreciated by those skilled in the art.

20 [00012] In one embodiment, this is provided by an irradiation treatment apparatus comprising a patient securing means arranged to secure a patient in a generally vertical position to a patient support surface. The patient support surface is connected at one end to a rotatable platform, arranged to rotate the patient support surface about a generally vertical axis thereof, and to optionally translate the patient support surface along at least a portion of a plane perpendicular to the axis of rotation. 25 The patient support surface is further translatable vertically, generally along the axis of rotation and arranged generally before a fixed beam irradiation source.

30 [00013] In one embodiment, an imager, preferably a computerized tomography (CT) imager, exhibiting two modes of operation is provided. In a first mode, the imager occludes the fixed beam irradiation source, and in a second mode the imager enables irradiation from the fixed beam irradiation source.

[00014] In one particular embodiment, the imager is translatable vertically between the first and second modes. In another particular embodiment the imager exhibits a radially shiftable section, with the first mode representative of the imager

being a substantially closed ring and the second mode representative of the imager with section radially shifted.

5 [00015] In yet another particular embodiment the imager is provided with a window for passage of the treatment irradiation beam, with the first mode representative of the window being closed and the second mode representative of the window being open.

[00016] Preferably, the imager in the first mode provides fine resolution images sufficient for treatment planning. In certain embodiments the second mode provides sufficient definition for inter-treatment verification and intra-treatment verification.

10 [00017] In one embodiment the patient is loaded onto the patient support surface, platform, or generally, member, in a loading position, and the patient support member is translated vertically to approximately align a target tissue with a fixed beam irradiation source. The patient support surface is further translated horizontally and/or rotated so as to approximately align the target tissue with the ultimate path of a 15 fixed beam of irradiation at the desired angle to treat a target volume of diseased tissue.

20 [00018] It is to be understood that the term fixed beam irradiation source, as used in this document, does not exclude scanning and scattering technologies, which are sourced from a fixed location charged hadron source with post beam generation scanning or scattering functionality. It is also to be understood that the term fixed beam irradiation source, as used in this document, is not limited to a single fixed beam irradiation source, and multiple fixed beams, which are independently controlled or joint controlled, may be supplied without exceeding the scope of the invention.

25 [00019] In one embodiment the invention provides for an irradiation treatment apparatus comprising: a patient support surface; a rotation mechanism; a patient securing mechanism arranged to secure a patient in a fixed relation to the patient support surface; a platform in communication with the patient support surface and the rotation mechanism and arranged to rotate the patient support surface about a 30 generally vertical axis; an imager exhibiting a first mode in which the imager occludes radiation from a fixed beam irradiation source and a second mode in which the imager enables irradiation from the fixed beam irradiation source; and a vertical translation mechanism in communication with the patient support surface and arranged to

translate the patient support surface along the generally vertical axis from a loading position to an irradiation position.

[00020] In one further embodiment, the imager is translatable vertically between an imaging position being the first mode and a neutral position being the 5 second mode. In another further embodiment, the imager exhibits a window, the first mode being when the window is closed and the second mode being when the window is open. In one yet further embodiment, the irradiation treatment apparatus further comprises a control unit in communication with the imager, the control unit operative to: set the imager to the first mode; translate the patient support surface vertically 10 through the imager via the vertical translation mechanism, and operate the imager to thereby image a section of the patient.

[00021] In one further embodiment, the imager exhibits a radially shiftable section, the first mode being when the radially shiftable section is shifted to enable a 360 degree x-ray image, and the second mode being when the radially shiftable 15 section is shifted to enable a less than 360 degree x-ray image. In one yet further embodiment the irradiation treatment apparatus further comprises a control unit in communication with the imager, the control unit operative to: set the imager to the first mode; translate the patient support surface vertically through the imager via the vertical translation mechanism, and operate the imager to thereby image a section of 20 the patient. In one yet further embodiment, the imager in the second mode is operative to perform intra-treatment imaging.

[00022] In one further embodiment, the imager is arranged to perform computerized tomography. In another further embodiment, the vertical translation mechanism is coupled to the platform thereby in the communication with the patient 25 support surface.

[00023] In one further embodiment, the irradiation treatment apparatus further comprises a horizontal translation mechanism coupled to the platform, the horizontal translation mechanism operative to translate the patient support surface along a pair of orthogonal axes perpendicular to the generally vertical axis. In another further 30 embodiment, the irradiation position aligns a target tissue of the secured patient with a beam of radiation ultimately exiting a fixed beam irradiation source.

[00024] In one further embodiment, the irradiation treatment apparatus further comprises an imager translation mechanism coupled to the imager and operative to position the imager vertically over a continuous range of positions in relation to the

- patient support surface loading position. In another further embodiment the irradiation treatment apparatus further comprises an imager translation mechanism in communication with the imager operative to position the imager vertically at an imaging position being the first mode and a neutral position being the second mode,
- 5 the imaging position arranged to image tissue intersecting an treatment irradiation beam ultimately exiting a fixed beam irradiation source. In one yet further embodiment the irradiation treatment apparatus further comprises a control unit in communication with the imager translation mechanism, the imager and the vertical translation mechanism, the control unit operative to: translate the imager vertically via the imager translation mechanism to the first mode; translate the patient support surface vertically through the imager via the vertical translation mechanism, and operate the imager to thereby image a section of the patient. In one even further embodiment the imaging of the section at least partially provides for treatment planning.
- 10 [00025] In one further embodiment the irradiation treatment apparatus further comprises a fixed beam radiation source. In another further embodiment, the patient support surface is generally vertical. In one yet further embodiment, the generally vertical patient support surface exhibits a chair mode in which the spine of the patient is generally secured vertically by the generally vertical patient support surface.
- 15 [00026] In one embodiment, the invention provides for a method comprising: securing a patient to a patient support surface; vertically translating the secured patient so as to approximately align a target tissue of the secured patient with an treatment irradiation beam ultimately exiting a fixed beam irradiation source; rotating the secured patient about a generally vertical axis so as to approximately present the target tissue to the treatment irradiation beam ultimately exiting the fixed beam irradiation source at a first desired angle; setting an imager to a first of two modes in which the imager occludes radiation from a fixed beam irradiation source; imaging, via the imager in the first mode, the target tissue aligned with the treatment irradiation beam ultimately exiting the fixed beam irradiation source; setting the imager to a second of two modes in which the imager does not occlude radiation from the fixed beam irradiation source; and irradiating the target tissue from the fixed beam irradiation source at the first desired angle.
- 20 [00027] In one further embodiment, the method further comprises subsequent to the imaging the target tissue, at least one of: finely vertically translating, responsive

to the imaging, the secured patient so as to align the target tissue of the secured patient with the treatment irradiation beam ultimately exiting a fixed beam irradiation source at the first desired angle; and finely rotating the secured patient about the generally vertical axis, responsive to the imaging, so as to present the target tissue to the treatment irradiation beam ultimately exiting the fixed beam irradiation source at the first desired angle. In another further embodiment, the method further comprises prior to the irradiating, translating a source of irradiation along a longitudinal axis of the ultimate radiation beam, so as to achieve a desired distance between the fixed beam irradiation source and the target tissue.

10 [00028] In one further embodiment, the imager is arranged to perform computerized tomography. In another further embodiment, the imager is translatable over a range of positions, the first mode being an imaging position.

15 [00029] In one further embodiment, the imager is translatable between the neutral position and the imaging position. In another further embodiment, the method further comprises imaging the target tissue during the irradiating with the imager in the second mode.

20 [00030] In one further embodiment, securing the patient to a patient support surface is in one of a standing and a sitting position. In another further embodiment, the method further comprises subsequent to the irradiating at the first desired angle: rotating about a generally vertical axis, and translating about a plane orthogonal to the generally vertical axis, the secured patient so as to approximately present the target tissue to the treatment irradiation beam ultimately exiting the fixed beam irradiation source at a second desired angle; setting the imager to the first mode; imaging, via the imager, the target tissue aligned with the treatment irradiation beam ultimately exiting the fixed beam irradiation source; setting the imager to the second mode; and irradiating the target tissue from the fixed beam irradiation source at the second desired angle.

25 [00031] Additional features and advantages of the invention will become apparent from the following drawings and description.

## BRIEF DESCRIPTION OF THE DRAWINGS

- [00032] For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings in which numerals designate corresponding elements or sections throughout.
- 5 [00033] With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice. In the accompanying 10 drawings:
- 15 [00034] Fig. 1 illustrates an exemplary embodiment of an irradiation treatment apparatus and treatment;
- [00035] Fig. 2A illustrates an exemplary embodiment of a first base rail platform of the irradiation treatment apparatus of Fig. 1;
- 20 [00036] Fig. 2B illustrates an exemplary cut 2B of the first base rail platform of Fig. 2A;
- [00037] Fig. 3A illustrates an exemplary embodiment of a translatable second base rail platform of the irradiation treatment apparatus of Fig. 1;
- 25 [00038] Fig. 3B illustrates an exemplary cut 3B of the translatable second base rail platform of Fig. 3A;
- [00039] Fig. 3C illustrates an exemplary cut 3C of the translatable second base rail platform of Fig. 3A;
- 30 [00040] Fig. 4A illustrates an exemplary, partially cut away, top view of a base support for the patient platform of Fig. 1, including a mechanism for translating an imager and a mechanism for rotating a patient support surface;
- [00041] Fig. 4B illustrates an exemplary cut 4B of the base support of Fig. 4A;
- [00042] Fig. 4C illustrates an exemplary cut 4C of the base support of Fig. 4A;

- [00043] Fig. 5A illustrates an exemplary, partially cut away, top view of a patient platform, including a scissor mechanism in the closed position, for translating the patient platform vertically;
- [00044] Fig. 5B illustrates an exemplary side view of scissor mechanism 420, 5 in a partially opened position, with patient platform 70 at a top end thereof;
- [00045] Fig. 5C illustrates an exemplary high level perspective bottom view drawing of patient platform 70, including a scissor mechanism in a closed position;
- [00046] Fig. 6 illustrates an exemplary high level side view of the irradiation treatment apparatus and treatment arrangement of Fig. 1 with a seated patient secured 10 in a generally vertical position against a patient support surface, with the imager in a neutral position;
- [00047] Fig. 7 illustrates an exemplary high level side view of the irradiation treatment apparatus and treatment arrangement of Fig. 1 with a standing patient secured in a generally vertical position against a patient support surface, with the 15 imager in a an imaging position;
- [00048] Fig. 8 illustrates an exemplary high level side view of an irradiation treatment apparatus and treatment arrangement in which the imager exhibits a window which when open allows for entry of the fixed beam irradiation source;
- [00049] Fig. 9A illustrates an exemplary high level top view of an imager 20 exhibiting a radially shiftable section;
- [00050] Fig. 9B illustrates an exemplary high level side view of an irradiation treatment apparatus and treatment arrangement in which the imager the imager of Fig. 9A has shifted the radially shiftable section to allow for entry of the fixed beam irradiation source;
- 25 [00051] Fig. 10 illustrates an exemplary perspective drawing of an embodiment of a patient support surface;
- [00052] Fig. 11 illustrates an exemplary high level flow chart of an embodiment of a method of irradiation;
- [00053] Fig. 12 illustrates an exemplary high level flow chart of an 30 embodiment of a method of treatment planning; and
- [00054] Fig. 13 illustrates an exemplary high level frontal view drawing of a second embodiment of an irradiation treatment apparatus and treatment arrangement.

## DETAILED DESCRIPTION

[00055] Some or all of the present embodiments provide and enable an irradiation treatment apparatus which preferably further provides treatment planning.

5 [00056] Where a patient is referred to, the patient is preferably a live human, but can also be an animal, other suitable organs, or target for application of the present teletherapy thereto.

10 [00057] The target tissue is delineated from adjacent non-target tissue; a planned target volume (PTV) is determined; and a plurality of beam angles and the preferred distance of the delineated target tissue from the treatment irradiation beam source for each of the plurality of angles is determined.

15 [00058] It is also to be understood that fixed beam irradiation may include scanning and scattering technologies, which are sourced from a fixed location charged hadron source with post beam generation scanning or scattering functionality. In addition, fixed beam irradiation is not limited to that from a single fixed beam irradiation source, but can include multiple fixed beams which are independently controlled or jointly controlled.

20 [00059] In one embodiment, the irradiation treatment apparatus comprises a patient securing means arranged to secure a patient in a generally vertical position to a patient support surface. The patient support surface is connected at one end to a rotatable and translatable platform, arranged to rotate the patient support surface about a generally vertical axis thereof, and to translate the patient support surface along a plane perpendicular to the axis of rotation. The patient support surface is further translatable vertically, generally along the axis of rotation. An imager, preferably a 25 computerized tomography imager exhibiting fine resolution, is provided and arranged to be translatable vertically. In one further embodiment, the imager is translatable between a first neutral position and a second imaging position. In another embodiment the imager is translatable over a range of positions. In yet another embodiment the imager is fixed, and is arranged to change from a mode in which the treatment irradiation beam is occluded from the patient and a mode in which the treatment irradiation beam is arranged to impact the patient.

30 [00060] The patient is loaded onto the patient support surface in a loading position, and the patient support surface is translated vertically to approximately align a target tissue with a fixed beam irradiation source. The patient support surface is

further rotated, and optionally translated horizontally, so as to approximately align the target tissue with the ultimate beam of irradiation at the desired angle.

5 [00061] Optionally, and advantageously, the irradiation treatment apparatus can in one embodiment be further utilized for treatment planning, particularly in an embodiment in which the imager is of sufficiently fine resolution.

[00062] In the event that multiple treatment angles are prescribed the above is repeated for each treatment angle, preferably with imaging after each translation or rotation of the patient support surface.

10 [00063] In order to accomplish teletherapy in accordance with an embodiment of the subject invention, a fixed beam irradiation source is supplied in a treatment room. In one embodiment the fixed beam irradiation source is arranged to controllably output a generally horizontal beam, and in another embodiment the fixed beam irradiation source is arranged to controllably output a generally angled beam up to 45° from horizontal. It is understood that unless specifically limited by the 15 particular instance, where angles and orientations are referred to herein, such are only provided by way of example, and other angles or orientations can be included within the scope of the present discussion.

20 [00064] In yet another embodiment multiple fixed beams, which are independently controlled or joint controlled, may be supplied without exceeding the scope of the invention. The fixed beam irradiation source may further exhibit post scanning or scattering functionality without exceeding the scope of the invention. Preferably, the fixed beam irradiation source exhibits an exit nozzle, which may be telescoped or otherwise translated to a prescribed distance from the target tissue.

25 [00065] As stated earlier and elsewhere, it is to be appreciated that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention also comprehends other embodiments and can be practiced or carried out in various ways.

30 [00066] Fig. 1 illustrates an exemplary high level frontal view of a first embodiment of an irradiation treatment apparatus and treatment arrangement. The apparatus includes a fixed beam irradiation source 10 and an irradiation treatment apparatus 5 and a control unit 15. Irradiation treatment apparatus 5 includes a first base rail platform 20, a translatable second base rail platform 30, a translatable platform 40 and an imager 50. Translatable platform 40 comprises: a base support 55,

an imager vertical translation mechanism 60, a platform vertical translation mechanism 65, a patient platform 70 and a patient support surface or member 90. Patient platform 70 is rotatable around an axis 80 and is vertically translatable by vertical translation mechanism 65 in relation to base support 55. Patient support 5 surface 90 is arranged to secure a patient in a generally vertical position, and is secured at one end to patient platform 70. Imager 50 is vertically translatable by imager vertical translation mechanism 60. The translation mechanisms of translatable second base rail platform 30, translatable platform 40 and patient support surface 70 will be described further in relation to Fig. 2, 3 and 5, respectively. Platform vertical 10 translation mechanism 60 will be described further relation to Fig. 4.

[00067] Imager 50 is illustrated as a circular CT imager, however this is not meant to be limiting in any way. In another embodiment imager 50 is selected from among an ultrasound imager, a CT imager, a magnet resonance imager, an x-ray imager, a fluoroscope, a positron emission tomography imager and a single photon 15 emission computed tomography imager, and may comprise a combination of imagers without exceeding the scope of the invention.

[00068] In operation, patient platform 70 is placed in a loading position by platform vertical translation mechanism 65, and the patient is loaded and secured to patient support surface 90. Patient platform 70 is then translated by platform vertical 20 translation mechanism 65, in relation to base support 55, to approximately align a target tissue with fixed beam irradiation source 10. Patient platform 70 is further translated horizontally, if required, by translatable second base rail platform 30 and translatable platform 40, and rotated around axis 80 so as to approximately align the target tissue of the patient secured to patient support surface 90 with the ultimate 25 target tissue of the patient secured to patient support surface 90 with the ultimate beam of irradiation exiting fixed beam irradiation source 10 at the desired angle.

[00069] Imager 50 is translated vertically to the imaging position by imager vertical translation mechanism 60, and the target tissue is imaged. Again it is pointed out that when referring to vertical direction or orientation, it is intended to include substantially vertical direction or orientation. The same generalization applies to 30 discussion of horizontal, or other, directions and orientations.

[00070] In the imaging position, imager 50 occludes the ultimate beam from fixed beam irradiation source 10. Responsive to the image, fine tuning of the vertical translation, rotation and horizontal translation of patient platform 70, if required, is performed. Imager 50 is then translated vertically by imager vertical translation

mechanism 60 to a neutral position in which imager 50 does not occlude the ultimate beam from fixed beam irradiation source 10. Optionally, a nozzle or aperture of fixed beam irradiation source 10 is translated generally along the ultimate irradiation beam axis, so that the nozzle or aperture is at a predetermined distance from the target tissue, and irradiation from the fixed beam irradiation source is performed without further movement of the patient.

5 [00071] In the event that multiple treatment angles are prescribed the above is optionally repeated for each treatment angle, further optionally with imaging after each rotation, or optional translation, of patient platform 70.

10 [00072] Irradiation treatment apparatus 5 is being described in an embodiment in which patient platform 70 may be translated along a plane, however this is not meant to be limiting in any way. In another embodiment, patient platform 70 is only partially translatable about a plane, with the balance of the translation effective supplied by the articulation of fixed beam irradiation source 10 along the axis of 15 irradiation.

[00073] In a preferred embodiment imager 50 and all translation and rotation mechanisms are responsive to control unit 15.

20 [00074] Fig. 2A illustrates an exemplary high level top view of first base rail platform 20 of the irradiation treatment apparatus 5 of Fig. 1, including a plurality of rails 110, a plurality of extended screws 120, a tooth gear 125, a pair of chains 130, a tooth gear 135 and a motor 140. Motor 140 is arranged to move chains 130 horizontally by engaging with tooth gear 135 connected to the shaft of motor 140. Each of extended screws 120 are arranged to engage a respective chain 130 by the 25 respective tooth gear 125 arranged at an end of the respective extended screw 120. Fig. 2B illustrates cut 2B of first base rail platform 20 of Fig. 2A.

[00075] In operation, motor 140 turns tooth gear 135 which interacts with chains 130, thereby moving chains 130. Chains 130 interact with a respective tooth gear 125, thereby turning the respective extended screw 120. Extended screws 120 represent the translation mechanism of translatable second base rail platform 30, as 30 will be described further in Fig. 3B.

[00076] Fig. 3A illustrates an exemplary high level top view drawing of translatable second base rail platform 30 of irradiation treatment apparatus 5 of Fig. 1, including a plurality of strengthening members 205, a plurality of wheels 210, a plurality of rails 230, a plurality of extended screws 240 each exhibiting a tooth gear

245, a pair of chains 250, and a motor 260 exhibiting a tooth gear 255 connected to the shaft thereof. Tooth gear 255 and tooth gears 245 each engage chain 250 at respective locations.

5 [00077] In operation, motor 260 turns tooth gears 255 which interacts with chain 250, thereby moving chain 250. Moving chain 250 interacts with each tooth gear 245, thereby turning extended screws 240. Extended screws 240 represent the translation mechanism of translatable platform 40, as will be described further in relation to Fig. 3C. Wheels 210 run along rails 110 of first base rail platform 20 of Fig. 2.

10 [00078] Fig. 3B illustrates an exemplary cut 3B of translatable second base rail platform 30 of Fig. 3A. Extended screws 120 of Fig. 2 are placed through a respective nut 220. In operation, extended screws 120 are rotated as described above in relation to Fig. 2, thereby translating translatable second base rail platform 30 along rails 110 of first base rail platform 20 of Fig. 2, with wheels 210 engaging rails 110.

15 [00079] Fig. 3C illustrates an exemplary cut 3C of translatable second base rail platform 30 of Fig. 3A. Residing on rails 230 are wheels 210 of translatable platform 40 of Fig. 1, as will be described further in Figs. 4A, 4B. Extended screws 240 of Fig. 3A are placed through a respective nut 270 of platform 40, as will be further in Figs. 4A, 4B. In operation, extended screws 240 are rotated as described above, thereby 20 translating translatable platform 40 of Fig. 1 along the rails of second base rail platform 200 of Fig. 3A, with wheels of translatable platform 40 running along rails 230.

25 [00080] In some embodiments, the longitudinal axis of rails 230 are arranged to be orthogonal to the longitudinal axis of rails 110 thereby enabling translation of patient platform 70 about a horizontal plane.

[00081] Fig. 4A illustrates an exemplary high level, partially cut away, top view of base support 55 of irradiation treatment apparatus 5 of Fig. 1, including a hole 305, a plurality of wheels 310, a plurality of channels 320 each enclosing a respective extended screw 325, a chain 340; a plurality of pulleys 345, a motor 350, a 30 strengthening ring 360, a plurality of tooth gears 365 and a motor 370. A centering pin of a base for patient support surface 70 of Fig. 1, as will be described further in Fig. 5A, is placed in hole 305. Wheels 310 run along rails 230 of translatable second base rail platform 30 of Fig. 3A, as described above in relation to Fig. 3C. Extended screws 325 of respective channels 320 each exhibit a tooth gear 330, as will be

described further in relation to Fig. 4B, which are arranged to engage chain 340. Chain 340 is arranged to run substantially around the perimeter of base support 55 by pulleys 345, and engages a tooth gear (not shown) connected to the shaft of motor 350.

- 5 [00082] In operation, motor 350 interacts with chain 340 thereby moving chain 340, and moving chain 340 interacts with tooth gears 330 connected to extended screws 325, as described further in relation to Fig. 4B, thereby turning extended screws 325. Extended screws 325 interact with one of fixed slots on imager 50 (not shown), or nuts attached thereto, thereby translating imager 50 vertically.
- 10 [00083] Motor 370, which exhibits a tooth gear 365 attached to the shaft thereof, turns a large tooth gear 470, which will be explained further in relation to Fig. 5A, by meshing through an intermediary tooth gear 365. Patient platform 70 of Fig. 1 is connected to large tooth gear 360, as will be described further in relation to Fig. 5A. Thus, in operation motor 370 rotates patient platform 70 by turning large tooth gear 15 360.

- [00084] Fig. 4B illustrates an exemplary cut 4B of base support 55 showing tooth gears 330 of extended screws 325 and Fig. 4C illustrates cut 4C of base support 55. Extended screws 240 of Fig. 3A are arranged to pass through a respective nut 380. In operation, as described above in relation to Fig. 3C, extended screws 240 are 20 rotated as described in Fig. 3A, thereby translating platform base 55 along the rails of second base rail platform 30 of Fig. 3A, with wheels 310 running along rails 230 of second base rail platform 30.

- [00085] Fig. 5A illustrates an exemplary high level, partially cut away, top view of patient platform 70, including a scissor mechanism in the closed position, for 25 translating patient platform 70 vertically. In some embodiments, patient platform 70 includes a plurality of connecting members 410, a scissor mechanism 420, a pair of beams 430, a plurality of runners 435, a pair of channels 440, a pair of toothed linear members 450, a tooth gear 455, a motor 460 and a large tooth gear 470. Connecting members 410 are arranged to connect patient platform 70 to large tooth gear 360 of base support 55 of Fig. 4A and a centering pin 490 of base 400 (shown in Fig. 5B) is placed in hole 305 of base support 55, thereby enabling rotation of patient platform 70 of Fig. 1 when large tooth gear 470 is turned, as described above in relation to Fig. 4A. Scissor mechanism 420 is connected at and thereof to beams 430, beams 430 being connected at their ends to runners 435, which are placed in channels 440. Each

beam 430 is also connected to a toothed linear member 450. Toothed linear members 450 are arranged to mesh with tooth gear 455. Motor 460 exhibits a tooth gear (not shown) arranged to mesh with a tooth gear on the shaft of tooth gear 455. Tooth gear 455 is arranged to mesh with toothed linear member 450.

5 [00086] In operation, motor 460 rotates tooth gear 455 which translates toothed linear members 450 in unison. As toothed linear members 450 are translated, beams 430 are also translated, thereby opening or closing scissor mechanisms 420. Opening scissor mechanisms 420 causes patient platform 70 of Fig. 1 to translate vertically towards imager 50; closing scissor mechanisms 420 causes patient platform 70 to 10 translate vertically towards imager 50 translatable platform 40. Runners 435 are arranged inside channels 440 to keep beams 430 straight.

15 [00087] Fig. 5B illustrates an exemplary side view of scissor mechanism 420, in a partially opened position, with patient platform 70 at a top end thereof. The cut away sections of Fig. 5A and 5B are illustrated as well as a centering pin 490 described above.

20 [00088] Fig. 5C illustrates an exemplary bottom view drawing of patient platform 70 in accordance with a principle of the invention, including scissor mechanism 420, beams 430, runners 435, tubes 440, toothed linear members 450 and a tooth gear 455. Scissor mechanism 420 are connected at the ends thereof to beams 430, and beams 430 are connected at their ends to runners 435, which are placed in channels 440. Beams 430 are also connected to a toothed linear member 450. Toothed linear members 450 each mesh with tooth gear 455.

25 [00089] The above has been illustrated in an embodiment in which a pair of independent substantially orthogonal translation mechanisms is provided, however this is not meant to be limiting in any way. In another embodiment a rotation and extension mechanism is provided, enabling translation to achieve a particular positioning along the plane.

30 [00090] Vertical translation mechanism 60 has been described in relation to a scissors mechanism, however this is not meant to be limiting in any way. In particular, in another embodiment a hydraulic mechanism is provided without exceeding the scope of the invention.

[00091] Fig. 6 illustrates an exemplary high level side view of the irradiation treatment apparatus and treatment arrangement of Fig. 1 with a seated patient secured

in a generally vertical position against patient support surface 90, with imager 50 in a neutral position, in which the ultimate beam of irradiation is not occluded.

5 [00092] Fig. 7 illustrates an exemplary high level side view of the irradiation treatment apparatus and treatment arrangement of Fig. 1 with a standing patient secured in a generally vertical position against patient support surface 90, with imager 50 in an imaging position in accordance with a principle of the invention, in which the ultimate beam of irradiation is occluded.

10 [00093] Fig. 8 illustrates an exemplary high level side view of an irradiation treatment apparatus and treatment arrangement 600 in which imager 610 exhibits a window 620 which when open allows for entry of the fixed beam irradiation source. Imager 610 need not be translated vertically. In one embodiment imager 601 is in a fixed position. When window 620 is closed, imager 610 performs 360 degrees of imaging suitable for treatment planning and inter-treatment verification. Preferably, when window 620 is open, imager 610 is capable of performing lower resolution imaging sufficient for intra-treatment verification.

15 [00094] Fig. 9A illustrates an exemplary high level top view of an imager 700 exhibiting a radially shiftable section 710. When radially shiftable section 710 is closed, imager 700 performs 360 degrees of imaging suitable for treatment planning and inter-treatment verification. Preferably, when radially shiftable section 710 is open, imager 700 is capable of performing lower resolution imaging sufficient for intra-treatment verification

[00095] Fig. 9B illustrates an exemplary high level side view of an irradiation treatment apparatus and treatment arrangement in which imager 700 has shifted the radially shiftable section to allow for entry of fixed beam irradiation source 10.

20 [00096] Fig. 10 illustrates an exemplary perspective drawing of an embodiment of a patient support surface 90, exhibiting a knee support surface 800; movable armpit and/or shoulder supports 810; frontal securing mechanism 820; and foot support 830. Advantageously, knee support surface 800 is foldable into a seat, thereby enabling a sitting or standing presentation with a single patient support surface 90.

25 [00097] Fig. 11 illustrates an exemplary high level flow chart of an embodiment of a method of irradiation. In stage 1000, a patient is secured in a generally vertical position to a patient support surface. Optionally, the patient is secured in one of a standing and a sitting position.

[00098] In one or more embodiments, stage 1010, the secured patient is vertically translated to approximately align a target tissue with the ultimate beam of a fixed beam irradiation source. In stage 1020, the secured patient is rotated, and optionally translated along a horizontal plane, to a desired first irradiation angle and 5 presentation. It is to be understood that stage 1010 may be accomplished intermingled with stage 1020, or after stage 1020, without exceeding the scope of the invention.

[00099] In stage 1030, the imager, preferably a CT imager, is set to a first mode occluding the treatment irradiation beam. In one embodiment, the imager exhibits a 10 fine resolution. In one embodiment, the imager is translatable between two fixed positions, and in another embodiment the imager is translatable over a range of positions. The imager is thus substantially in-line with, and intersects, the ultimate beam from the fixed beam irradiation source.

[000100] In another embodiment, as described above in relation to Fig. 8, a 15 window is closed. In yet another embodiment, as described above in relation to Figs. 9A – 9B, a radially shiftable section is closed.

[000101] In stage 1040, the patient target tissue is imaged at the first irradiation angle presentation of stages 1010, 1020. In stage 1050, responsive to the imaging of 20 1050, the target tissue image is viewed to determine if adjustment of the presentation is required. This may be due to changes in the target tissue, or patient registration misalignment.

[000102] In the event that adjustment is required, in stage 1060, the secured patient is finely vertically translated, horizontally translated along a horizontal plane and rotated to the desired first irradiation angle and presentation responsive to the 25 imaging of stage 1050. Optionally, in stage 1070 imaging as described above in relation to stage 1040 is again performed to confirm proper presentation, and any further fine adjustment is further performed.

[000103] In the event that in stage 1050 no adjustment was required, or after stage 1070, in stage 1080 the imager is set to the second mode in which the fixed 30 beam irradiation source is not occluded. In an embodiment in which the imager is translatable vertically, the imager is translated to a neutral position. In the embodiment, as described above in relation to Fig. 8, the window is opened. In yet another embodiment, as described above in relation to Figs. 9A – 9B a radially shiftable section is shifted to be open, i.e. no longer presenting a closed ring.

[000104] In stage 1090, optionally the source of the fixed beam irradiation is translated along the longitudinal axis of the ultimate beam so as to exhibit the desired distance from the target tissue. In another embodiment a nominal position is utilized and the energy level of irradiation is instead modified.

5 [000105] In stage 1100, the patient is irradiated from the fixed beam irradiation source at the first irradiation angle. Optionally, if allowed by the imager in the second mode, such as imager 610 of Fig. 8 and imager 700 of Figs. 9A, 9B, intra-treatment imaging is accomplished, typically at a lower resolution than the imaging of stage 1040. It is to be understood that preferably the patient position and presentation 10 remains unchanged between the confirming imaging of stages 1040, 1070 and the irradiation of stage 1100.

[000106] In the event that multiple irradiation angles and presentations have been prescribed, in stage 1110, the secured patient is rotated about the z-axis as shown in Fig. 1, and optionally translated at least partially along a horizontal plane to a 15 desired second irradiation angle and presentation. Optionally, the secured patient may be further vertically translated as required. In stage 1120, the imager of stage 1030 is set to the first mode. The imager is thus substantially in-line with, and generally occludes, the ultimate beam from the fixed beam irradiation source.

[000107] In stage 1130, the patient target tissue is imaged at the second 20 irradiation angle presentation of stage 1110. Adjustment responsive to the imaging, as described above in relation to stages 1050 – 1070, may be accomplished if required.

[000108] In stage 1140 the imager is set to the second mode in which the beam 25 is not occluded, i.e. no longer in-line with the fixed beam irradiation source. In stage 1150, optionally the source of the fixed beam irradiation is translated along the longitudinal axis of the ultimate beam so as to exhibit the desired distance from the target tissue.

[000109] In stage 1160, the patient is irradiated from the fixed beam irradiation source at the second irradiation angle. It is to be understood that preferably the 30 patient position and presentation remains substantially unchanged between the confirming imaging of stage 1130 and the irradiation of stage 1160.

[000110] The above has been described in an embodiment in which 1 or 2 irradiation angles and presentations are prescribed, however this is not meant to be limiting in any way. In another embodiment, 3 or more irradiation angles and

presentations are prescribed by repeating stages 1110 – 1160 for each additional angle and presentation.

[000111] Fig. 12 illustrates an exemplary high level flow chart of an embodiment of a method of treatment planning. In stage 2000, a patient is secured in 5 a generally vertical position to a patient support surface. Optionally, the patient is secured in one of a standing and a sitting position.

[000112] In stage 2010, the imager, preferably a CT imager, is set to a first mode. Preferably, the imager exhibits a fine resolution. In one embodiment the imager is translatable between two fixed positions, and in another embodiment the 10 imager is translatable over a range of positions.

[000113] In another embodiment, as described above in relation to Fig. 8, a window is closed. In yet another embodiment, as described above in relation to Figs. 9A – 9B a radially shiftable section is closed.

[000114] In stage 2020, the secured patient of stage 2000 is translated vertically 15 through the imager of stage 2010 so as to image a slice of the patient. In stage 2030, the image of stage 2020 is used as part of a treatment planning process to determine irradiation angle, power and distance.

[000115] Fig. 13 illustrates an exemplary high level frontal view drawing of a second embodiment of an irradiation treatment apparatus and treatment arrangement. 20 In some instances, the embodiment of Fig. 13 differs from irradiation treatment apparatus 5 of Fig. 1, primarily in the order of the translation and rotation mechanism. Fig. 13 includes a translation and rotation mechanism 900 constituted of a rotation mechanism 910, a first translation mechanism 920, a second translation mechanism 930 and a platform 935; a patient support surface 90; a vertical translation mechanism 25 940; and a fixed beam irradiation source 10. Rotation mechanism 910 is in communication with a horizontal base, such as a floor or a platform, first translation mechanism 920 is in communication with rotation mechanism 910, and second translation mechanism 930 is in communication with first translation mechanism 920. Platform 935 is in communication with second translation mechanism 930, and via 30 vertical translation mechanism 940 with patient support surface 90. First translation mechanism 920 is arranged to translate along a direction denoted Y, orthogonal to the direction of translation of second translation mechanism 930, whose direction is denoted X. Directions X and Y generally define a plane orthogonal to the axis of

rotation of rotation mechanism 910, illustrated as rotation  $Z_i$ . The direction of motion of vertical translation mechanism 940 is denoted  $Z$ .

5 [000116] Advantageously, the arrangement of Fig. 13 allows for setting the isocenter of a target tissue to be aligned with the output beam from fixed beam irradiation source 10, and to be rotated about an axis  $Z$  generally along the isocenter of the target tissue.

10 [000117] The above has been described in an embodiment in which patient support surface 90 is generally vertical, however this is not meant to be limiting in any way. Patient support surface 90 may in one embodiment enable a tilt of up to 15° from vertical without exceeding the scope of the invention. In another embodiment, patient support surface 90 is generally vertical; however a separate tilting head support is provided allowing for tilting of the head while maintaining the patient body 15 in a generally upright position.

15 [000118] Thus, the present embodiments enable an irradiation treatment apparatus comprising a patient securing means arranged to secure a patient in generally vertical position to a patient support surface. The patient support surface is connected at one end to a rotation and translation platform, arranged to rotate the patient support surface about a generally vertical axis thereof, and to translate the patient support surface along a plane perpendicular to the axis of rotation. The patient support surface is further translatable vertically, generally along the axis of rotation. An imager, preferably a computerized tomography imager exhibiting fine resolution and a large scan width, is provided and arranged to exhibit two modes: a first mode in which the beam of irradiation is occluded and a second mode in which the beam of irradiation is not occluded.

20 [000119] It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

25 [000120] Unless otherwise defined, all technical and scientific terms used herein have the same meanings as are commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods are described herein.

**[000121]** All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the patent specification, including definitions, will prevail. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

5 **[000122]** The terms “include”, “comprise” and “have” and their conjugates as used herein mean “including but not necessarily limited to”.

10 **[000123]** It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined by the appended claims and includes both combinations and sub-combinations of the various features described hereinabove as well as variations and modifications thereof, which would occur to persons skilled in the art upon reading the foregoing description.

We claim:

1. An irradiation treatment apparatus comprising:
  - a patient support surface;
  - 5 a rotation mechanism;
  - a patient securing mechanism arranged to secure a patient in a fixed relation to said patient support surface;
  - 10 a platform in communication with said patient support surface and said rotation mechanism and arranged to rotate said patient support surface about a generally vertical axis;
  - an imager exhibiting a first mode in which the imager occludes radiation from a fixed beam irradiation source and a second mode in which the imager enables irradiation from the fixed beam irradiation source; and
  - 15 a vertical translation mechanism in communication with said patient support surface and arranged to translate said patient support surface along said generally vertical axis from a loading position to an irradiation position.
2. An irradiation treatment apparatus according to claim 1, wherein said imager is translatable vertically between an imaging position being said first mode and a neutral position being said second mode.
3. An irradiation treatment apparatus according to claim 1, wherein said imager exhibits a window, said first mode being when said window is closed and said second mode being when said window is open.
- 25 4. An irradiation treatment apparatus according to claim 3, further comprising a control unit in communication with said imager, said control unit operative to:
  - set said imager to said first mode;
  - translate said patient support surface vertically through said imager via said vertical translation mechanism, and
  - 30 operate said imager to thereby image a section of the patient.

5. An irradiation treatment apparatus according to claim 1, wherein said imager exhibits a radially shiftable section, said first mode being when said radially shiftable section is shifted to enable a 360 degree x-ray image, and said second mode being when said radially shiftable section is shifted to enable a less than 360 degree x-ray image.
10. An irradiation treatment apparatus according to claim 5, further comprising a control unit in communication with said imager, said control unit operative to:
  - set said imager to said first mode;
  - translate said patient support surface vertically through said imager via said vertical translation mechanism, and
  - operate said imager to thereby image a section of the patient.
15. An irradiation treatment apparatus according to any of claims 3 - 6, wherein said imager in said second mode is operative to perform intra-treatment imaging.
20. An irradiation treatment apparatus according to any of claims 1 - 7, wherein said imager is arranged to perform computerized tomography.
25. An irradiation treatment apparatus according to any of claims 1 - 8, wherein said vertical translation mechanism is coupled to said platform thereby in said communication with said patient support surface.
10. An irradiation treatment apparatus according to any of claims 1 - 9, further comprising a horizontal translation mechanism coupled to said platform, said horizontal translation mechanism operative to translate said patient support surface along a pair of orthogonal axes perpendicular to said generally vertical axis.
30. An irradiation treatment apparatus according to any of claims 1 - 10, wherein said irradiation position aligns a target tissue of the secured patient with a beam of radiation ultimately exiting a fixed beam irradiation source.
12. An irradiation treatment apparatus according to claim 1, further comprising an imager translation mechanism coupled to said imager and operative to position said

imager vertically over a continuous range of positions in relation to said patient support surface loading position.

13. An irradiation treatment apparatus according to claim 1, further comprising an imager translation mechanism in communication with said imager operative to position said imager vertically at an imaging position being said first mode and a neutral position being said second mode, said imaging position arranged to image tissue intersecting an treatment irradiation beam ultimately exiting a fixed beam irradiation source.

10

14. An irradiation treatment apparatus according to claim 13, further comprising a control unit in communication with said imager translation mechanism, said imager and said vertical translation mechanism, said control unit operative to:

translate said imager vertically via said imager translation mechanism to said first mode;

translate said patient support surface vertically through said imager via said vertical translation mechanism, and

operate said imager to thereby image a section of the patient.

20 15. An irradiation treatment apparatus according to claim 14, wherein said imaging of said section at least partially provides for treatment planning.

16. An irradiation treatment apparatus according to any of claims 1 - 15, further comprising a fixed beam radiation source.

25

17. An irradiation treatment apparatus according to any of claims 1 - 16, wherein said patient support surface is generally vertical.

18. An irradiation treatment apparatus according to claim 17, wherein said generally vertical patient support surface exhibits a chair mode in which the spine of the patient is generally secured vertically by said generally vertical patient support surface.

19. A method comprising:
  - securing a patient to a patient support surface;
  - vertically translating the secured patient so as to approximately align a target tissue of the secured patient with an treatment irradiation beam ultimately exiting a fixed beam irradiation source;
  - rotating the secured patient about a generally vertical axis so as to approximately present the target tissue to the treatment irradiation beam ultimately exiting the fixed beam irradiation source at a first desired angle;
  - setting an imager to a first of two modes in which the imager occludes radiation from a fixed beam irradiation source;
  - imaging, via said imager in said first mode, said target tissue aligned with the treatment irradiation beam ultimately exiting the fixed beam irradiation source;
  - setting said imager to a second of two modes in which the imager does not occlude radiation from the fixed beam irradiation source; and
  - irradiating the target tissue from said fixed beam irradiation source at said first desired angle.
20. A method according to claim 19, further comprising subsequent to said imaging said target tissue, at least one of:
  - finely vertically translating, responsive to said imaging, the secured patient so as to align the target tissue of the secured patient with the treatment irradiation beam ultimately exiting a fixed beam irradiation source at said first desired angle; and
  - finely rotating the secured patient about the generally vertical axis, responsive to said imaging, so as to present the target tissue to the treatment irradiation beam ultimately exiting the fixed beam irradiation source at said first desired angle.
21. A method according to either claim 19 or claim 20, further comprising prior to said irradiating, translating a source of irradiation along a longitudinal axis of the ultimate radiation beam, so as to achieve a desired distance between the fixed beam irradiation source and said target tissue.
22. A method according to any of claims 19 - 21, wherein the imager is arranged to perform computerized tomography.

23. A method according to any of claims 19 - 22, wherein the imager is translatable over a range of positions, said first mode being an imaging position.
24. A method according to any of claims 19 - 22, wherein said imager is 5 translatable between said neutral position and said imaging position.
25. A method according to any of claims 19 - 23, further comprising imaging said target tissue during said irradiating with said imager in said second mode.
- 10 26. A method according any of claims 19 - 25, wherein said securing the patient to a patient support surface is in one of a standing and a sitting position.
27. A method according to any of claims 19 - 26, further comprising subsequent to said irradiating at said first desired angle:
- 15       rotating about a generally vertical axis, and translating about a plane orthogonal to said generally vertical axis, the secured patient so as to approximately present the target tissue to the treatment irradiation beam ultimately exiting the fixed beam irradiation source at a second desired angle;
- setting the imager to said first mode;
- 20       imaging, via said imager, said target tissue aligned with the treatment irradiation beam ultimately exiting the fixed beam irradiation source;
- setting said imager to said second mode; and
- irradiating the target tissue from said fixed beam irradiation source at said second desired angle.

1/14

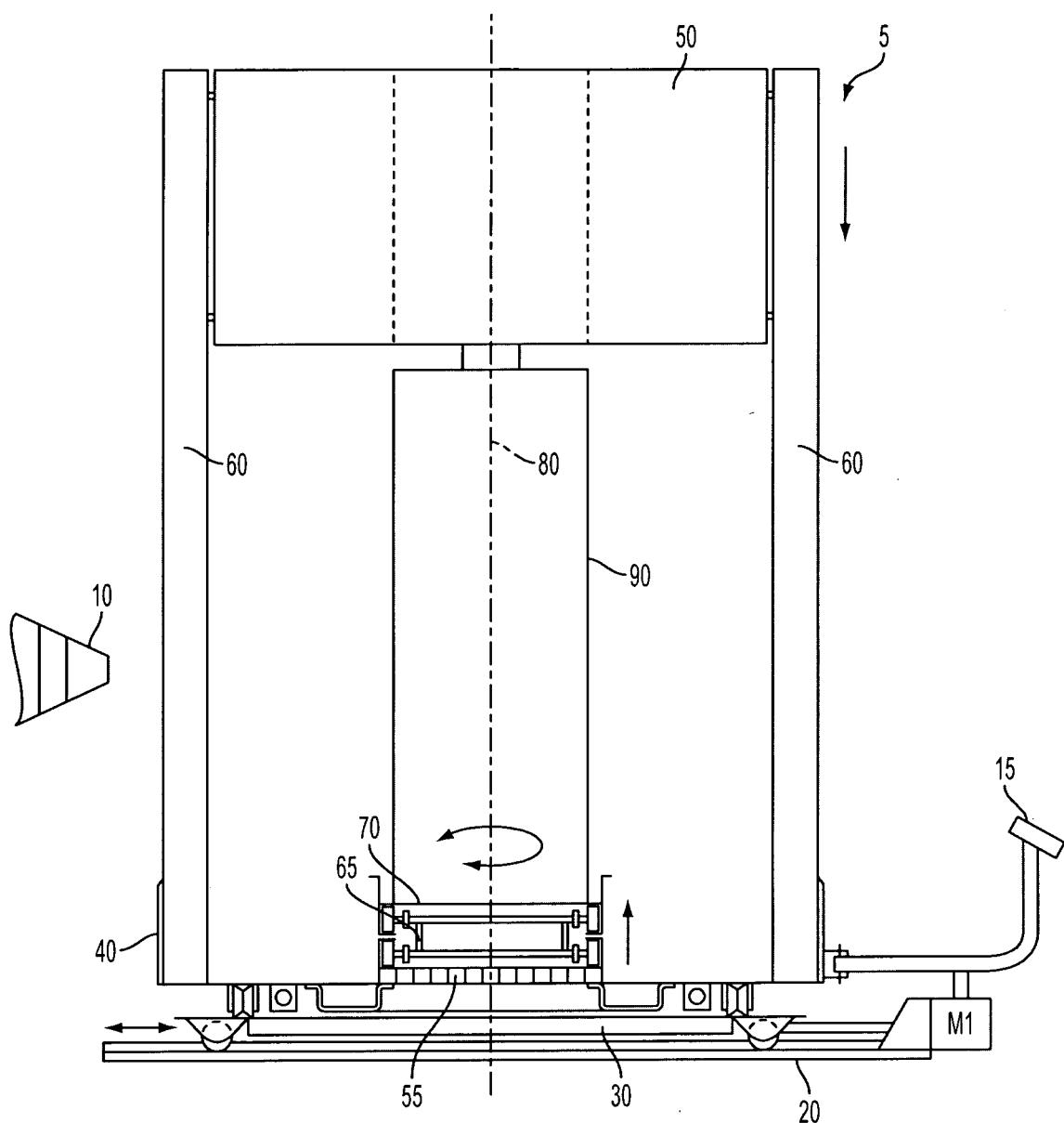


FIG. 1

2/14

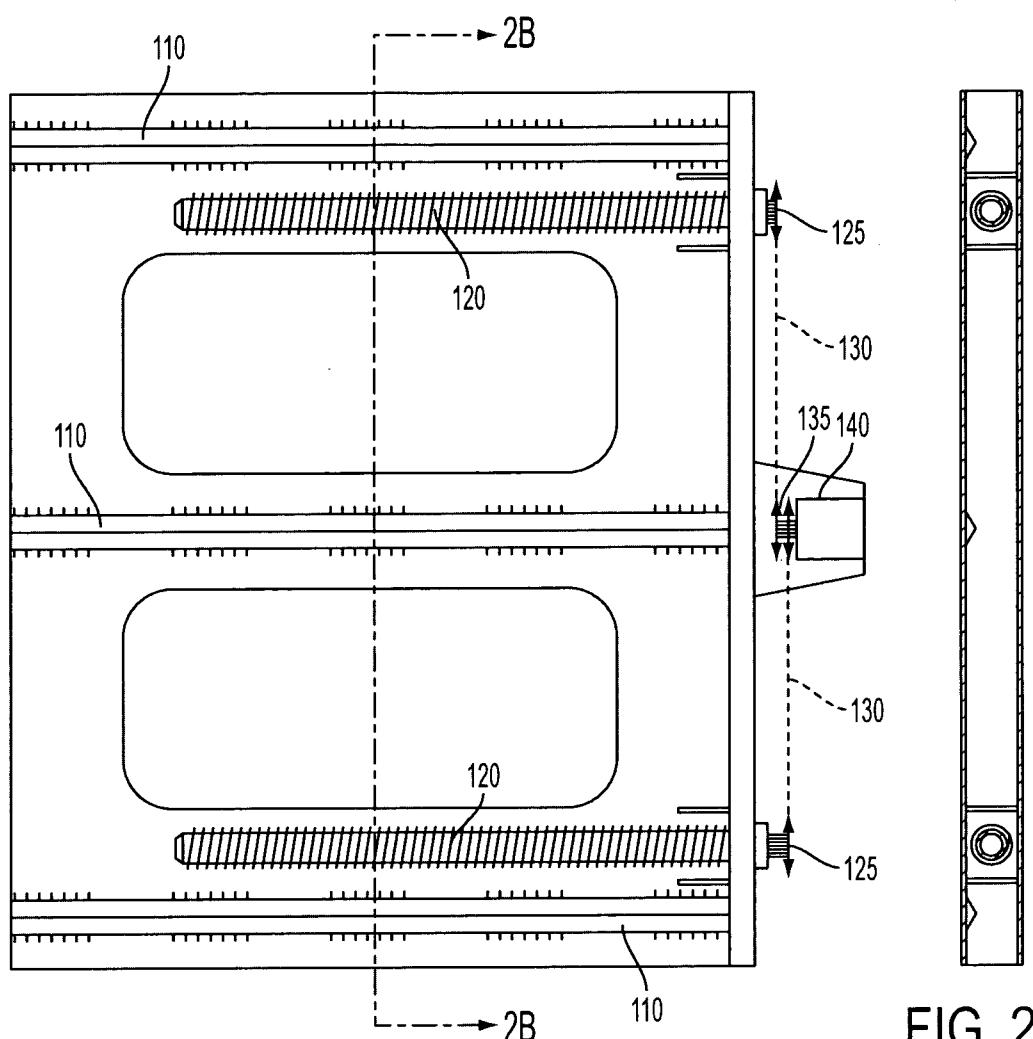


FIG. 2B

FIG. 2A

3/14

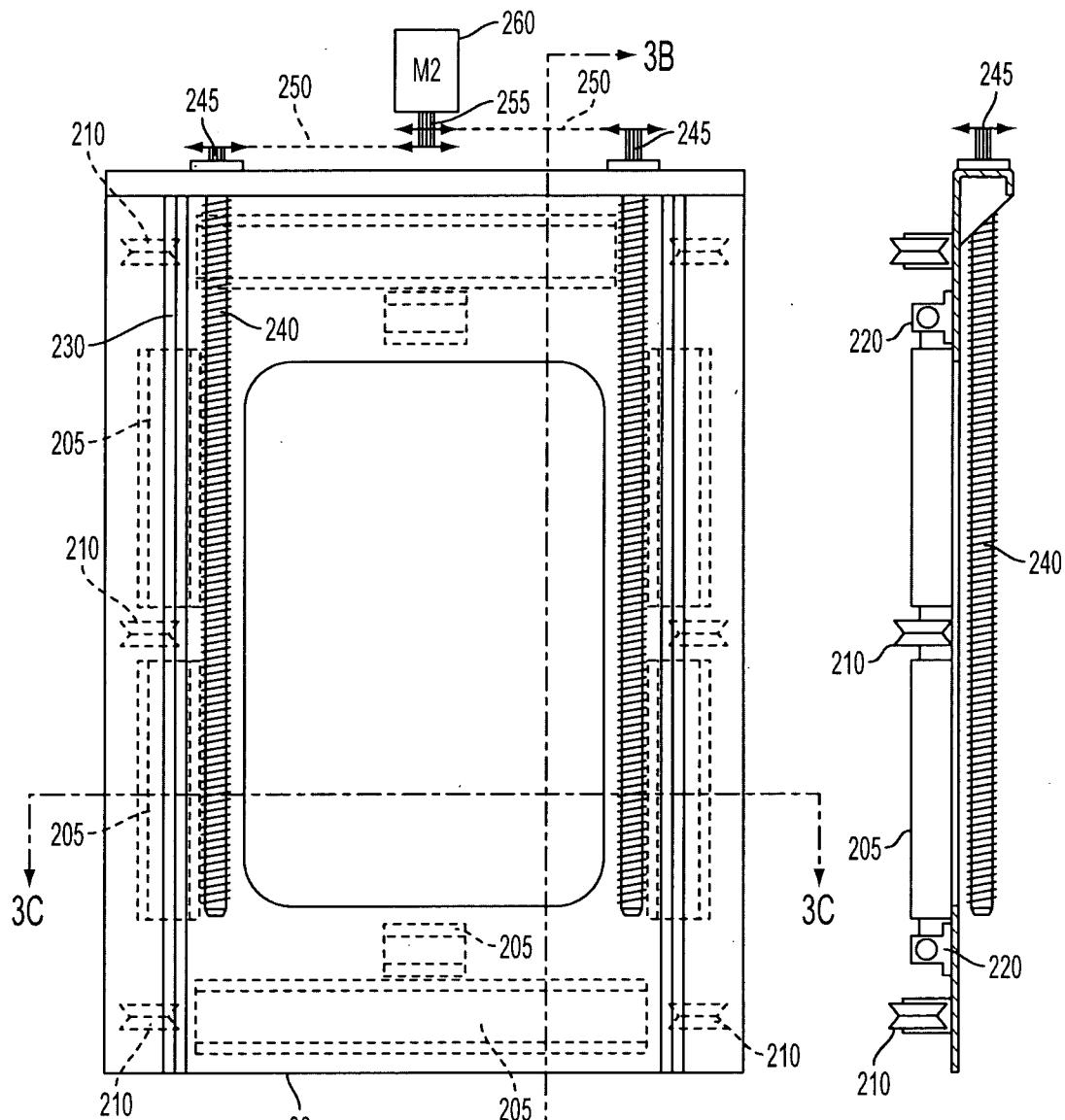


FIG. 3A

FIG. 3B

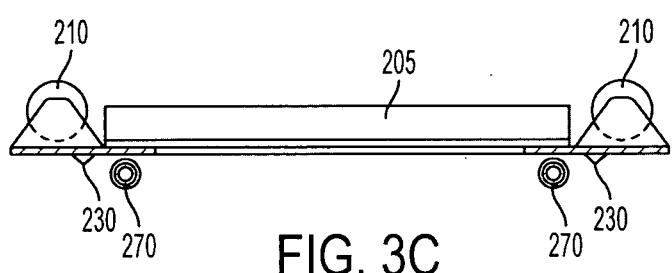


FIG. 3C

4/14

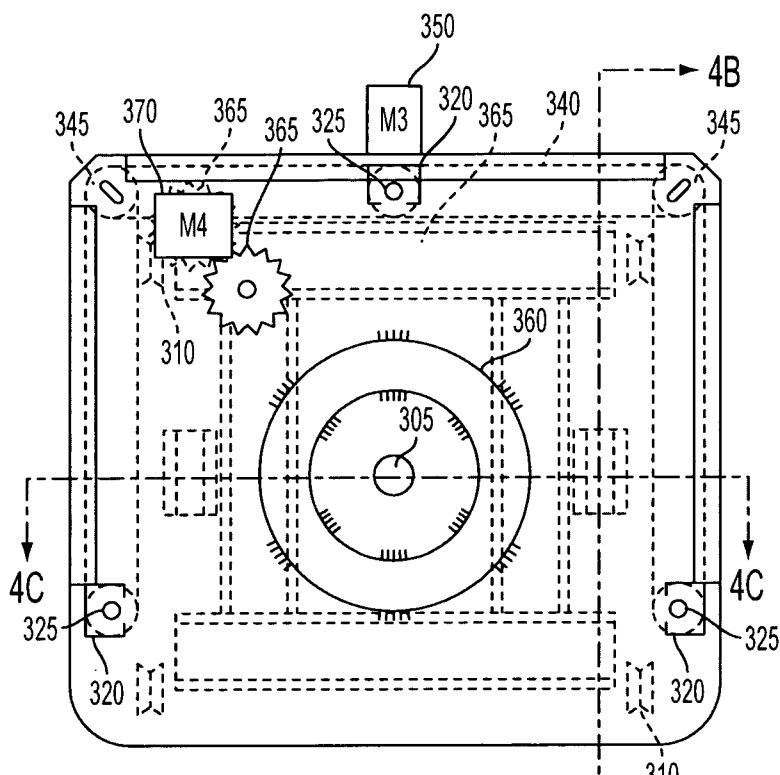


FIG. 4A

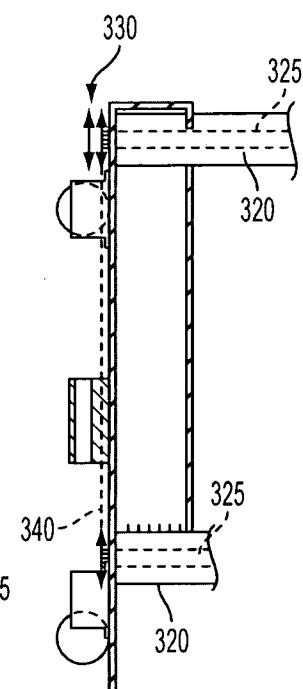


FIG. 4B

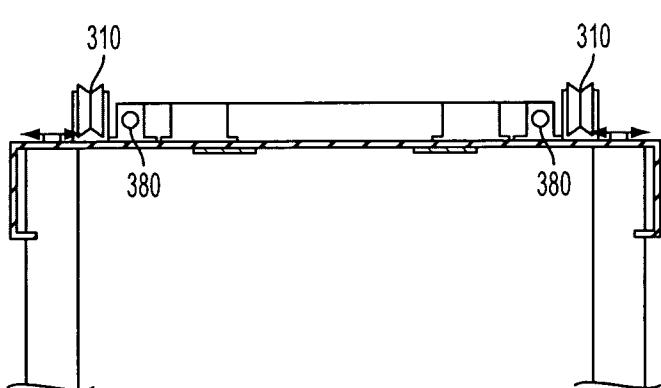


FIG. 4C

5/14

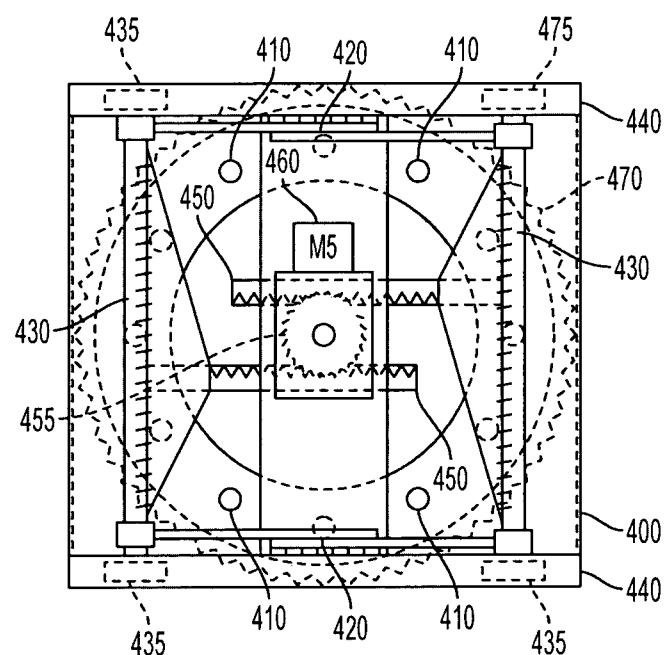


FIG. 5A

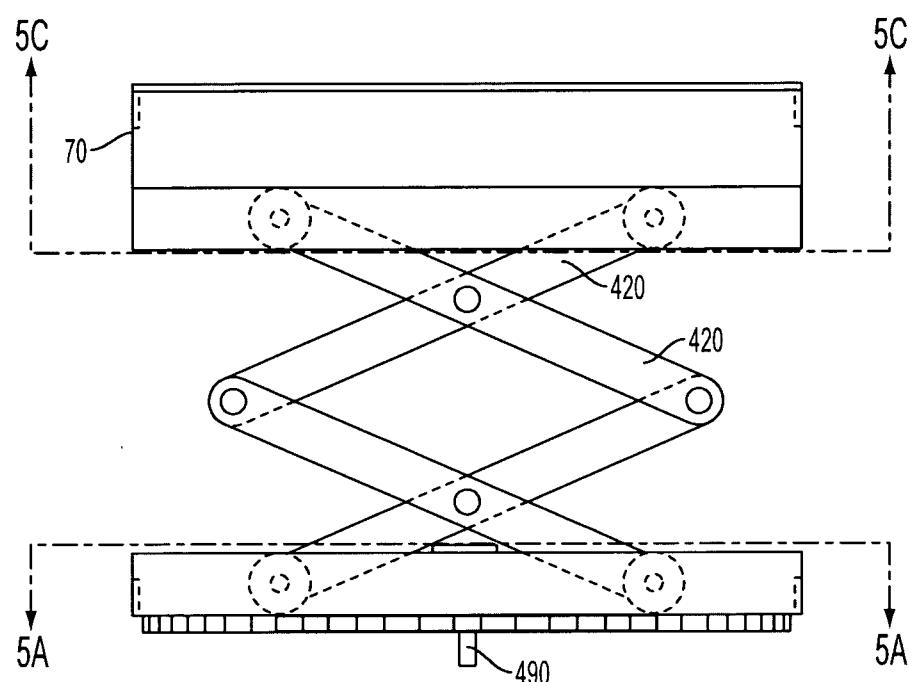


FIG. 5B

7/14

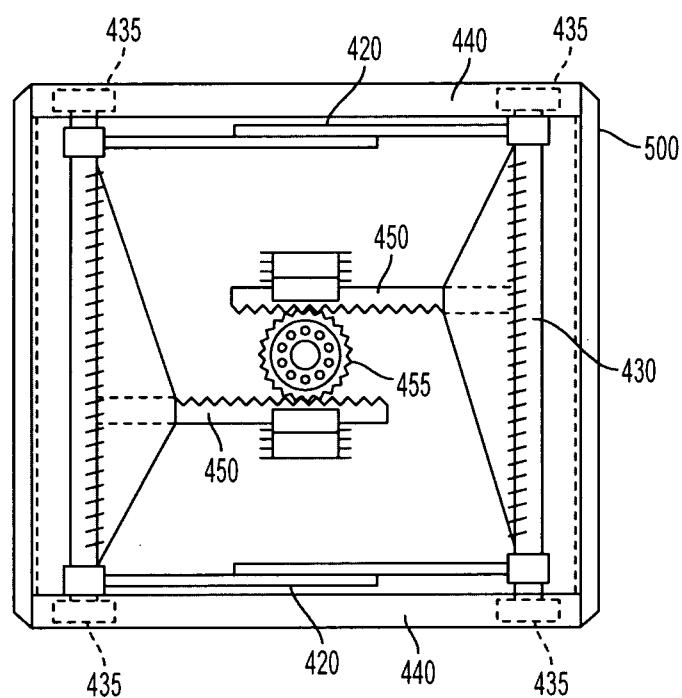


FIG. 5C

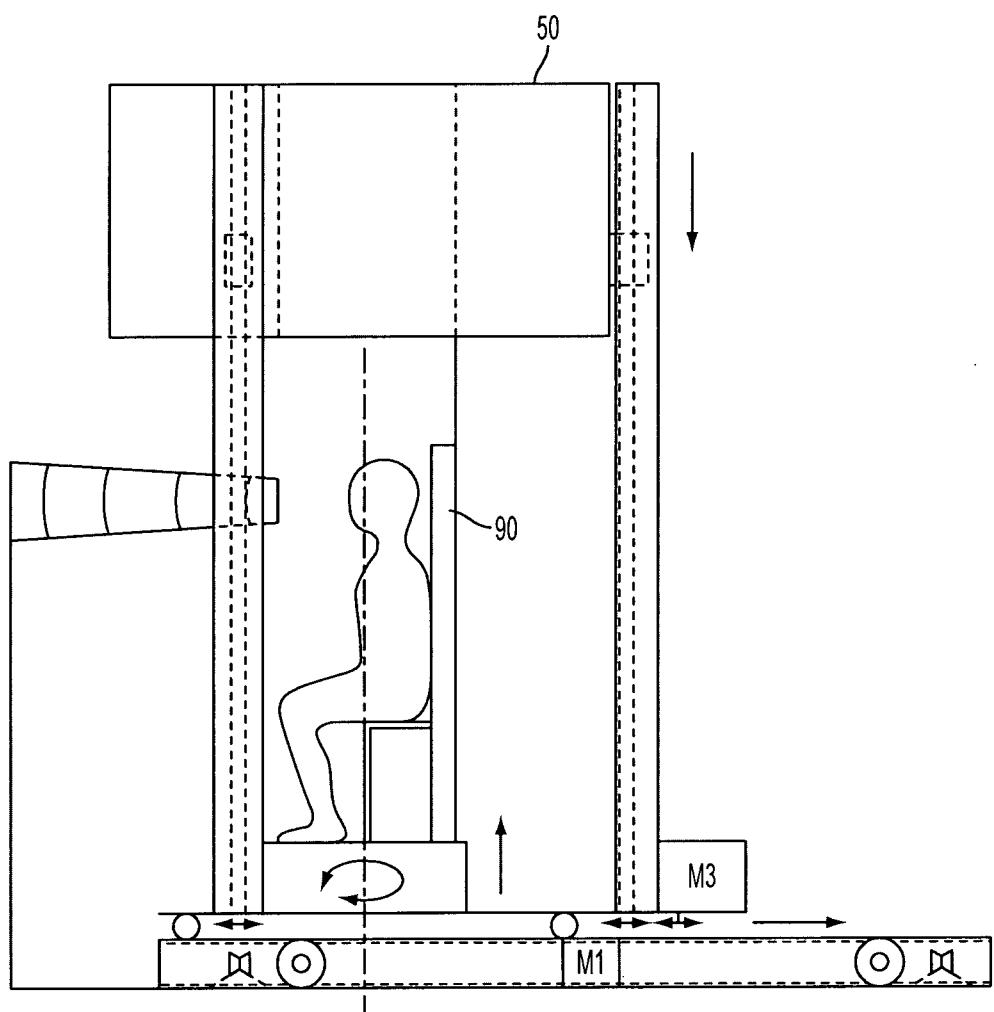


FIG. 6

9/14

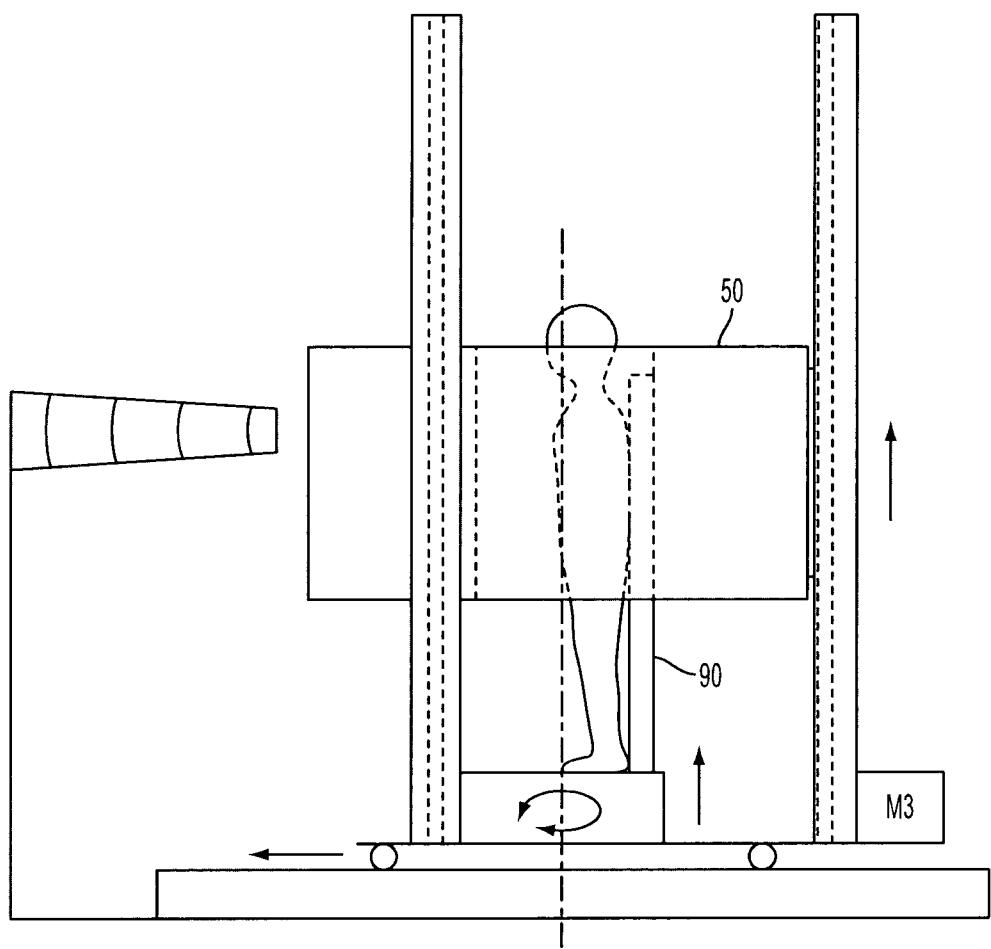


FIG. 7

10/14

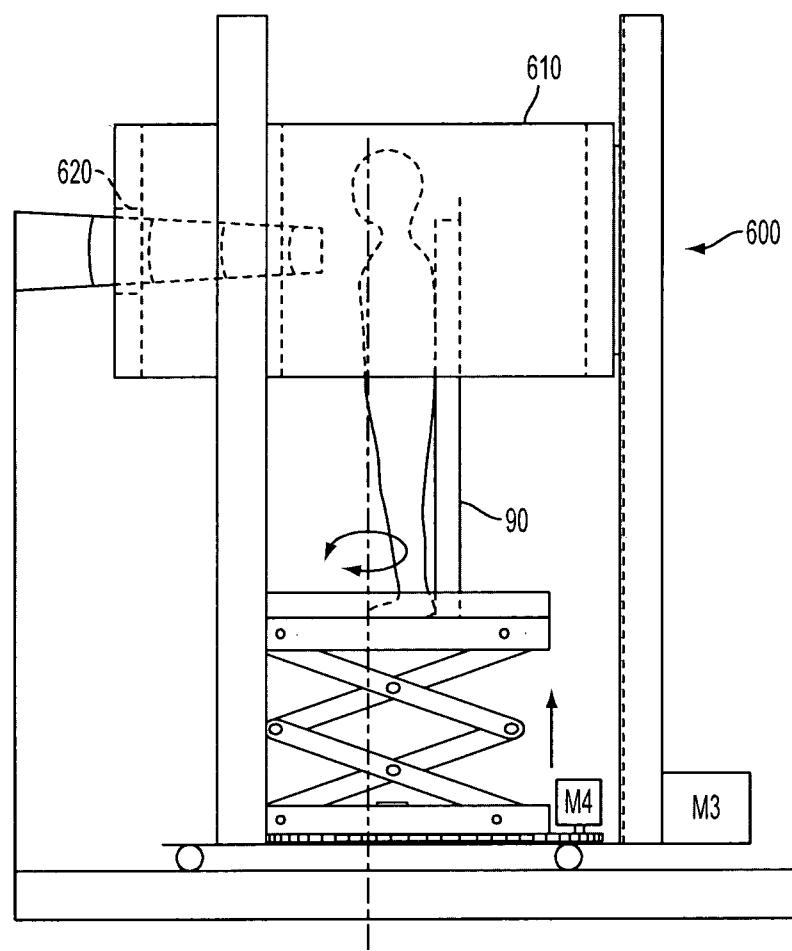


FIG. 8

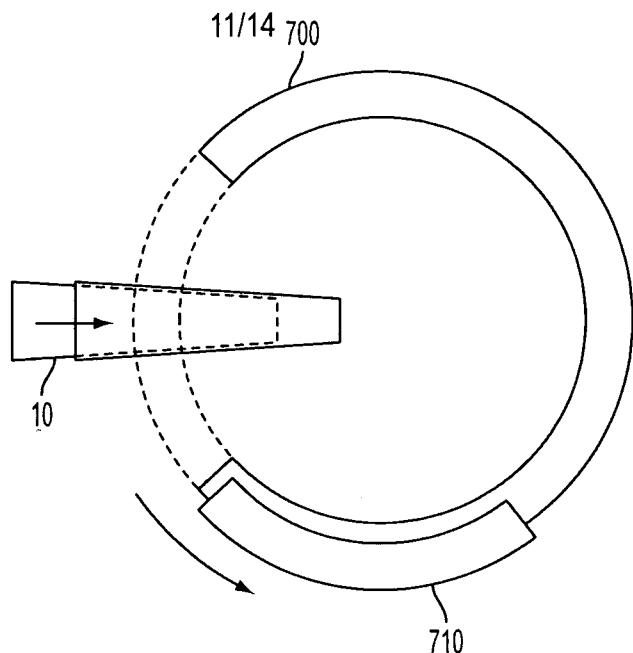


FIG. 9A

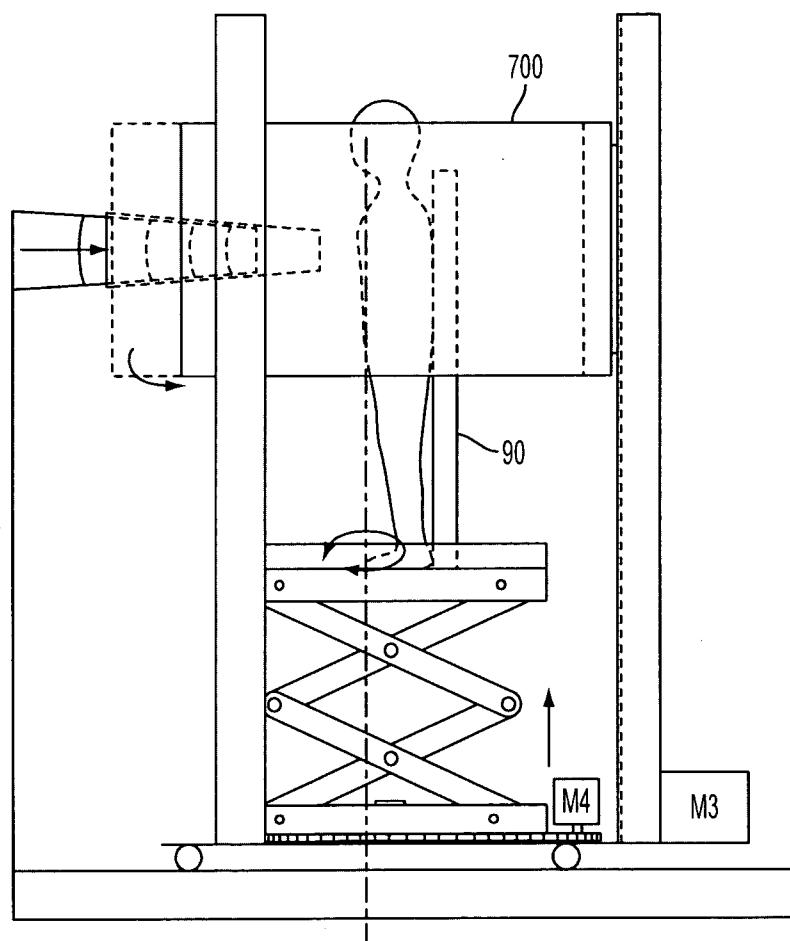


FIG. 9B

12/14

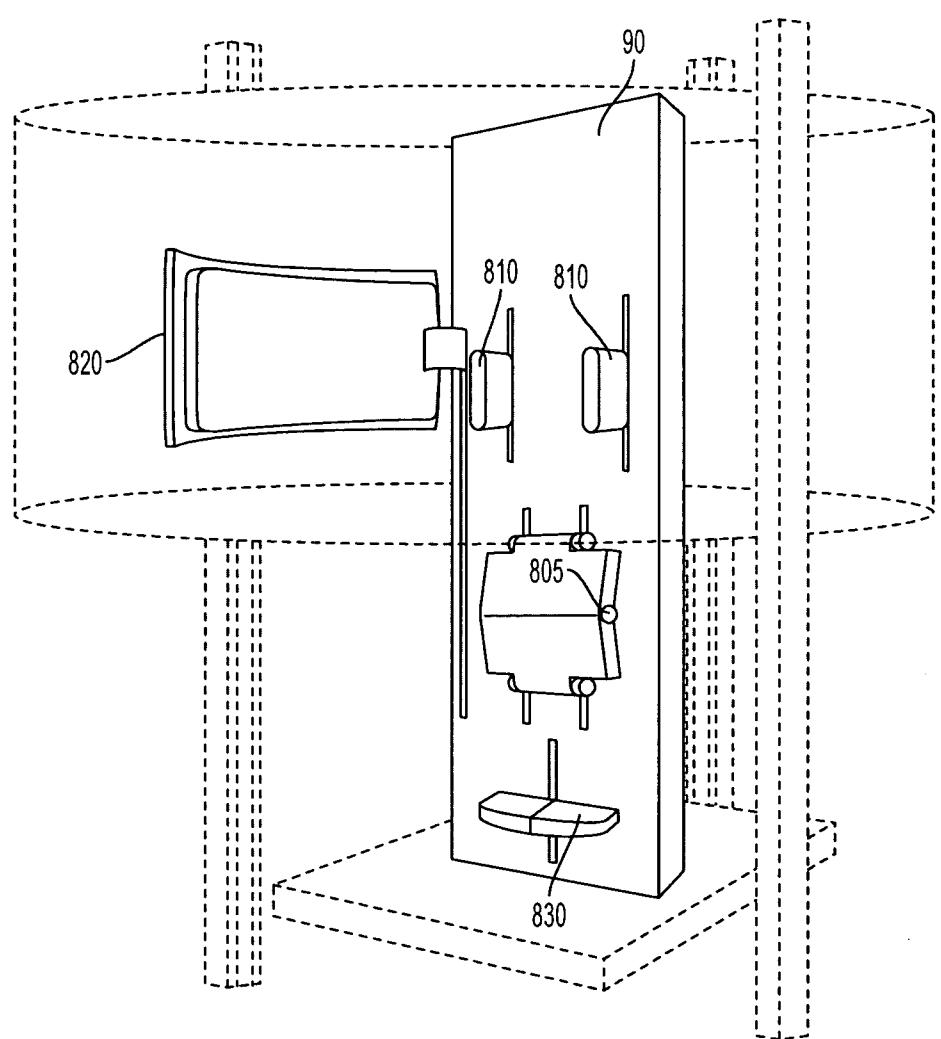


FIG. 10

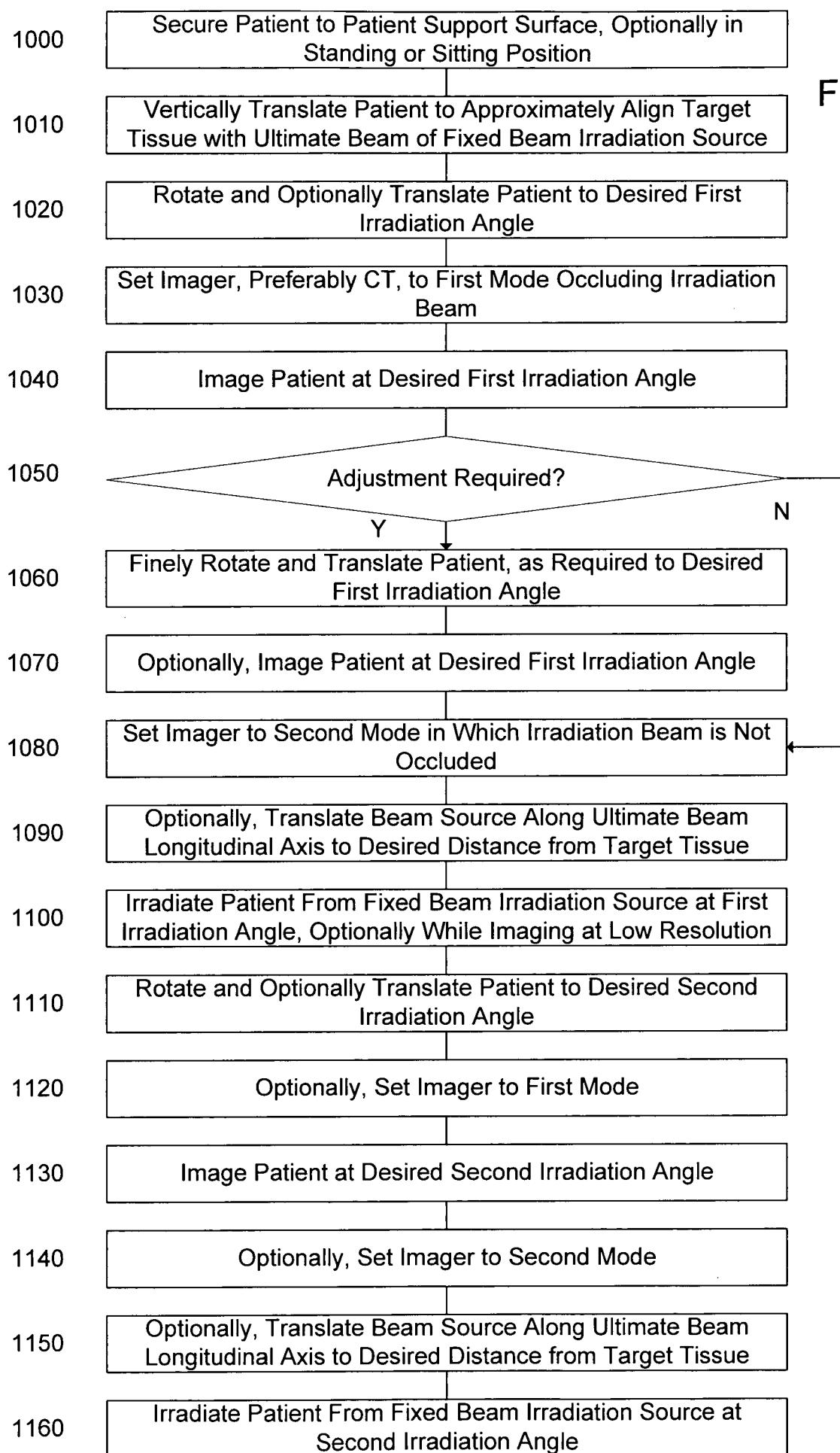


Fig. 11

14/14

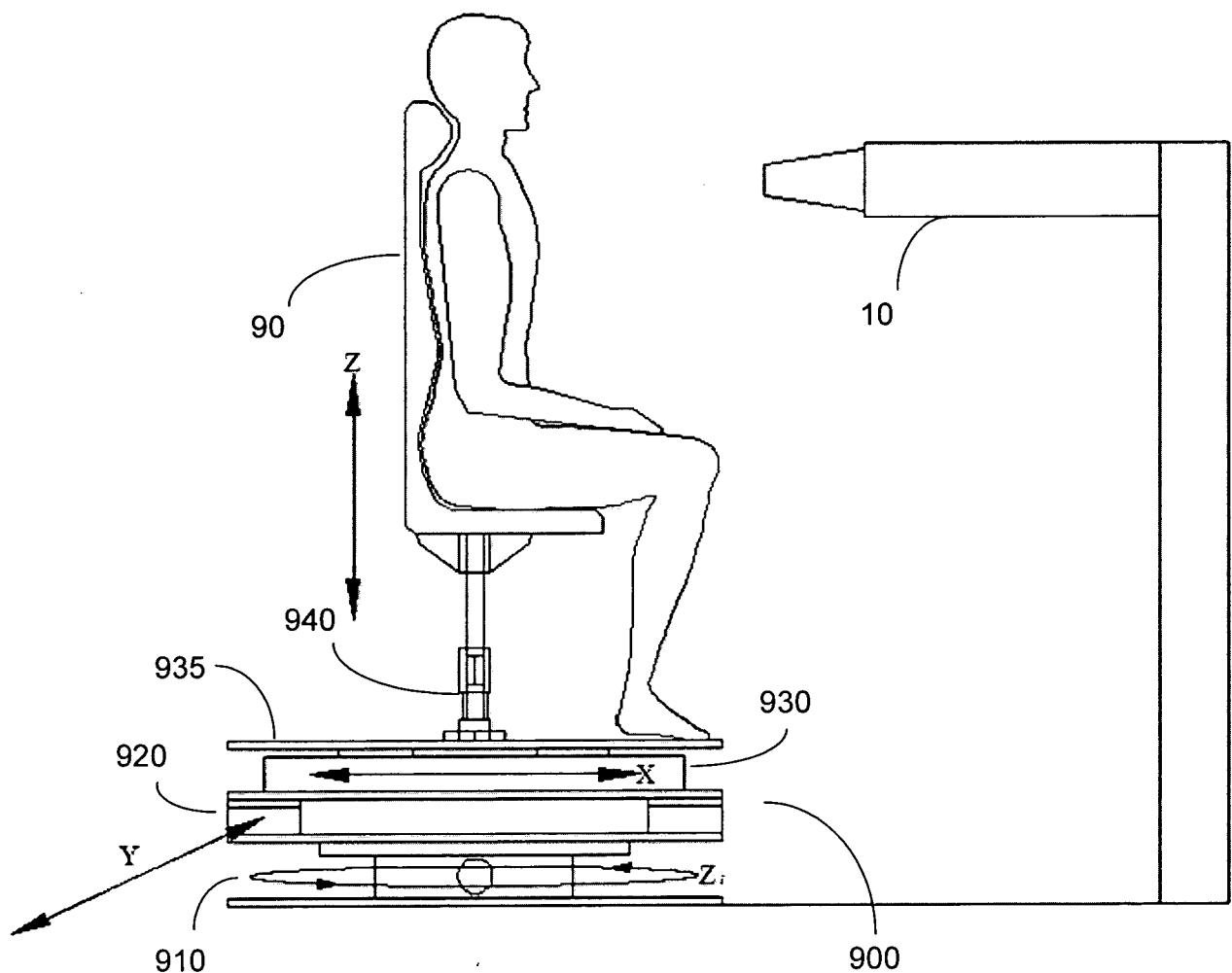
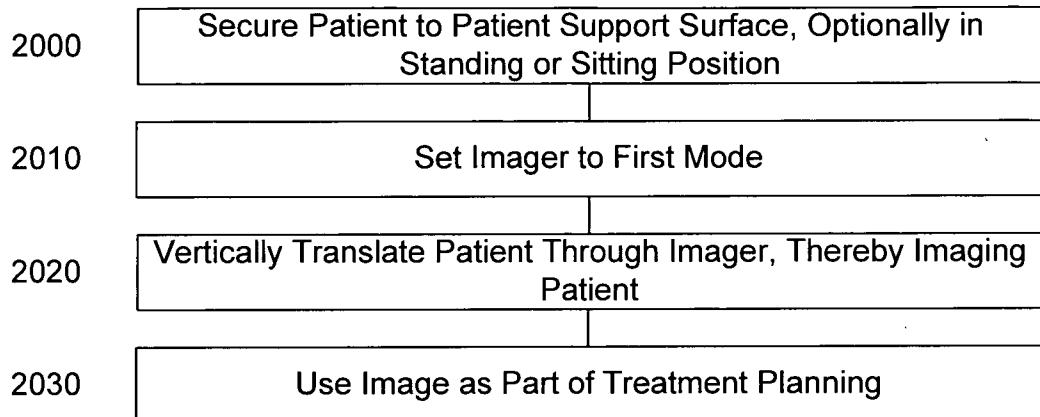


Fig. 13

## INTERNATIONAL SEARCH REPORT

International application No

PCT/IL2008/000699

**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. A61B6/03 A61N5/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A61N A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KAMADA T ET AL: "A horizontal CT system dedicated to heavy-ion beam treatment" RADIOTHERAPY AND ONCOLOGY, ELSEVIER, vol. 50, no. 2, 1 February 1999 (1999-02-01), pages 235-237, XP002359765 ISSN: 0167-8140 the whole document	1,2,8-18
Y	-----	5,6
X	EP 1 454 653 A (HITACHI LTD [JP]) 8 September 2004 (2004-09-08)	1,3, 8-11,15, 16
Y	paragraphs [0021] - [0026]; figures 4,5	7
Y	JP 2001 161839 A (MITSUBISHI ELECTRIC CORP) 19 June 2001 (2001-06-19) paragraphs [0002], [0010], [0023], [0031]; claim 6; figure 11	7
	-----	
	-/-	

Further documents are listed in the continuation of Box C.

See patent family annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*&\* document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

6 October 2008

24/10/2008

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040.  
Fax: (+31-70) 340-3016

Authorized officer

Link, Tatiana

## INTERNATIONAL SEARCH REPORT

 International application No  
 PCT/IL2008/000699

## C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 039 867 A (NISHIHARA SUSUMU [JP] ET AL) 13 August 1991 (1991-08-13) column 8, lines 10-27 column 9, lines 44-62 column 13, lines 4-28 -----	1, 9-11, 16
Y	US 2003/072416 A1 (RASCHE VOLKER [DE] ET AL) 17 April 2003 (2003-04-17) paragraphs [0034] - [0046]; figures 2-5 -----	7 5, 6
Y	WO 03/070101 A (BREAKAWAY IMAGING LLC [US]) 28 August 2003 (2003-08-28) the whole document -----	5, 6
X	WO 98/18523 A (UNIV LOMA LINDA MED [US]) 7 May 1998 (1998-05-07) page 6, lines 13-28; figures 2,3 -----	1, 3
A	EP 1 121 957 A (UNIV ST LOUIS [US]) 8 August 2001 (2001-08-08) the whole document -----	1-18
A	DE 41 03 588 C1 (SIEMENS AG, 8000 MUENCHEN, DE) 27 May 1992 (1992-05-27) the whole document -----	1, 2, 4-8, 12-15

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IL2008/000699

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.: 19-27 because they relate to subject matter not required to be searched by this Authority, namely:  
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by therapy
2.  Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3.  Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1.  As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No  
PCT/IL2008/000699

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
EP 1454653	A 08-09-2004	AU 2004200350 A1 DE 602004009122 T2 JP 3748433 B2 JP 2004267250 A KR 20040079835 A US 2006203958 A1 US 2004184583 A1			23-09-2004 10-01-2008 22-02-2006 30-09-2004 16-09-2004 14-09-2006 23-09-2004
JP 2001161839	A 19-06-2001	NONE			
US 5039867	A 13-08-1991	NONE			
US 2003072416	A1 17-04-2003	AT 317666 T CN 1571648 A DE 60209247 T2 EP 1439784 A2 WO 03032835 A2 JP 2005505375 T			15-03-2006 26-01-2005 09-11-2006 28-07-2004 24-04-2003 24-02-2005
WO 03070101	A 28-08-2003	AT 376389 T AU 2002359712 A1 CN 1617688 A DE 60223179 T2 EP 1474040 A1 EP 1875866 A2 HK 1068090 A1 JP 2005517486 T US 2004022350 A1			15-11-2007 09-09-2003 18-05-2005 14-08-2008 10-11-2004 09-01-2008 23-05-2008 16-06-2005 05-02-2004
WO 9818523	A 07-05-1998	AU 721460 B2 AU 4997297 A CA 2269597 A1 CN 1238707 A DE 69737264 T2 EP 0946228 A1 ES 2281097 T3 JP 2000510023 T KR 20000052789 A US 5825845 A			06-07-2000 22-05-1998 07-05-1998 15-12-1999 08-11-2007 06-10-1999 16-09-2007 08-08-2000 25-08-2000 20-10-1998
EP 1121957	A 08-08-2001	US 2001049475 A1 US 2004199068 A1			06-12-2001 07-10-2004
DE 4103588	C1 27-05-1992	JP 3279617 B2 JP 4312450 A US 5247556 A			30-04-2002 04-11-1992 21-09-1993