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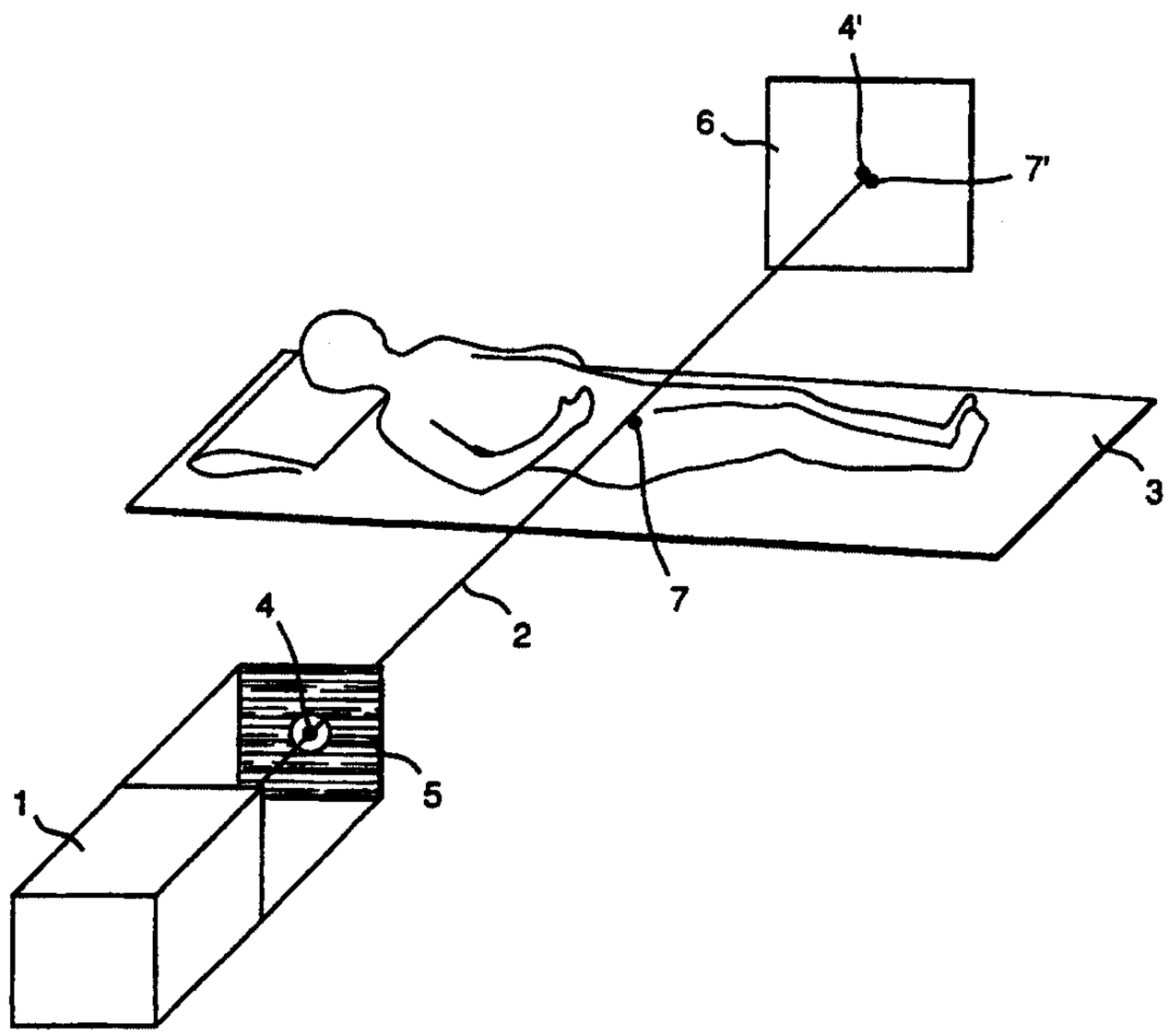
(54) **SYSTEME ET DISPOSITIF DE REFERENCE PERMETTANT DE DIRIGER UN FAISCEAU EN RADIOTHERAPIE**

(54) **ARRANGEMENT AND REFERENCE MEANS TO DIRECT A BEAM IN RADIATION THERAPY**



(57) La présente invention concerne un système et un procédé de référence utilisés pour pointer avec précision un faisceau de rayons au cours du traitement d'une tumeur cancéreuse interne affectant un patient. Ce procédé de traitement comprend au moins un marqueur de référence introduit dans le corps du patient dans une

(57) The present invention concerns an arrangement and a reference method for the precision aiming of a radiation beam for treating an internal cancer tumour in a patient. The method of treatment includes that least one reference marker introduced into the patient in a defined position in relation to the cancer tumour, whose

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position définie par rapport à la tumeur cancéreuse. On définit la géométrie de la tumeur et on planifie le traitement par rapport au marqueur de référence au moyen d'un tomodensitomètre ou par tomographie. Le patient, par un dispositif connu, est placé en position pour le traitement. Un point dans la section transversale du faisceau est défini par un viseur, et le patient, à l'aide d'au moins un marqueur de référence dans la position définie, est d'abord traité par rayons, les positions du ou des marqueurs de référence et du viseur étant lues à l'aide du faisceau qui irradie le patient, et les positions sont ajustées les unes par rapport aux autres de façon à s'assurer que le faisceau de traitement est dirigé avec précision sur la tumeur cancéreuse avant que les doses restantes de rayons soient administrées au patient. Le dispositif de cette invention comprend un équipement de traitement (1) connu qui émet un faisceau (2) de traitement d'une section transversale définie (5) et un dispositif (3) qui supporte le patient. Le dispositif de l'invention se distingue par au moins un marqueur de référence (7) qui est introduit dans le corps du patient par rapport auquel est déterminée la position de la tumeur cancéreuse; un viseur (4) placé dans la trajectoire du faisceau de façon à définir un point dans la section transversale du faisceau; un lecteur de faisceau (6) placé de façon à recevoir le faisceau qui a irradié le patient et visualiser la position d'au moins un marqueur de référence (7') et la position du viseur (4'). On détermine ainsi la position du faisceau par rapport à celle de la tumeur cancéreuse.

geometry is determined and the treatment planned in relation to the reference marker by means of computer tomography/tomography, that the patient is by known means brought into position for the treatment, that a defined point in the cross section of the beam is defined by a sight, that the patient with at least one said reference marker in the said defined position is initially treated with radiation, that the positions of the reference marker or the reference markers and the sight in relation to one another are read with the help of the beam that passes through the patient, and that the positions in relation to one another are adjusted to ensure that the treatment beam is directed precisely at the cancer tumour before the remaining doses of radiation are given to the patient. The device according to the invention includes known treatment equipment (1) for emitting a treatment beam (2) with a defined cross section (5) and a device (3) for supporting the patient, whereby the characteristics of the device include that at least one reference marker (7) is introduced into the patient in relation to which the position of the cancer tumour is determined, that a sight (4) is arranged in the path of the beam to define a point in the cross section of the beam, that a device to read the beam (6) is arranged to receive the beam that has passed through the patient and visualise the position of at least one said reference marker (7') and the position of the sight (4'), whereby the position of the beam in relation to the cancer tumour is determined.

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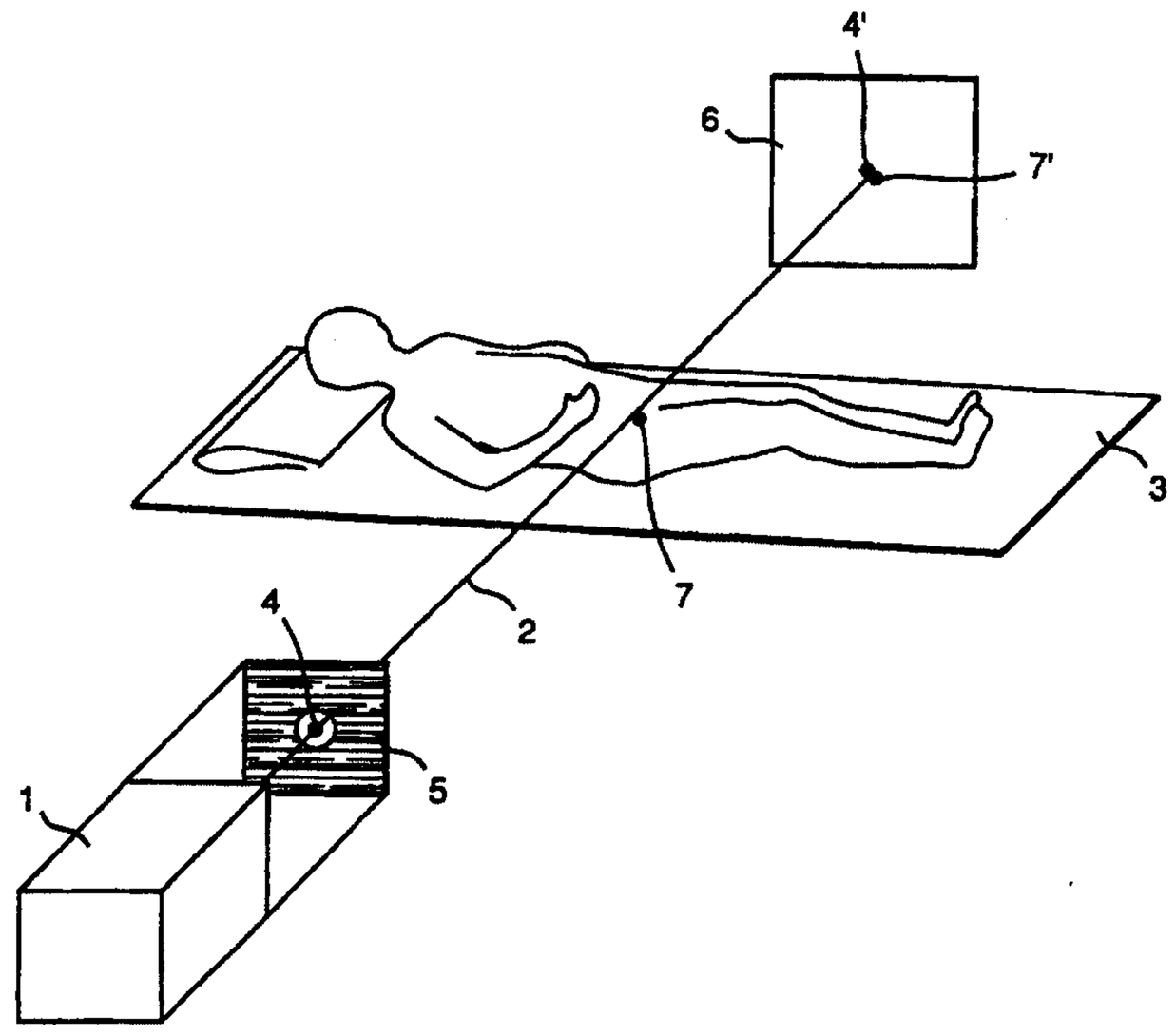
(54) Title: ARRANGEMENT AND REFERENCE MEANS TO DIRECT A BEAM IN RADIATION THERAPY

(57) Abstract

The present invention concerns an arrangement and a reference method for the precision aiming of a radiation beam for treating an internal cancer tumour in a patient. The method of treatment includes that least one reference marker introduced into the patient in a defined position in relation to the cancer tumour, whose geometry is determined and the treatment planned in relation to the reference marker by means of computer tomography/tomography, that the patient is by known means brought into position for the treatment, that a defined point in the cross section of the beam is defined by a sight, that the patient with at least one said reference marker in the said defined position is initially treated with radiation, that the positions of the reference marker or the reference markers and the sight in relation to one another are read with the help of the beam that passes through the patient, and that the positions in relation to one another are adjusted to ensure that the treatment beam is directed precisely at the cancer tumour before the remaining doses of radiation are given to the patient. The device according to the invention includes known treatment equipment (1) for emitting a treatment beam (2) with a defined cross section (5) and a device (3) for supporting the patient, whereby the characteristics of the device include that at least one reference marker (7) is introduced into the patient in relation to which the position of the cancer tumour is determined, that a sight (4) is arranged in the path of the beam to define a point in the cross section of the beam, that a device to read the beam (6) is arranged to receive the beam that has passed through the patient and visualise the position of at least one said reference marker (7') and the position of the sight (4'), whereby the position of the beam in relation to the cancer tumour is determined.



Arrangement and reference means to direct a beam in radiation therapy

The present invention concerns an arrangement and a reference means for the precision aiming of a radiation beam for treating an internal cancer tumour.

During the last 40 years, radiation therapy of localised prostate cancer has been used as one of a number of treatment methods. The levels of radiation considered suitable for treatment fall within the interval 65-70 Gy. However, the occurrence of viable cancer cells even after such a level of treatment has been demonstrated. One way of dealing with these remaining cells is to increase the level of treatment, known as scaling up the dose, initially to the interval of 76-80 Gy or more.

Because of the lack of precision of current techniques, radiation treatment also carries with it an increased risk of affecting organs adjacent to the tumour. In the area around the prostate, this means primarily an increased risk for side effects seen as damage to the rectum and the urinary bladder as these are normally found in the radiation field. The risk for damage is especially pronounced with high doses of radiation.

The preparations for the radiation treatment of prostate cancer can be described briefly in the following way. The patient undergoes computer tomography to determine the geometry and location of the prostate. The position of the prostate is shown by markings on the skin of the patient. These markings then constitute the directional points for the beams used in treatment.

Even if the geometry of the prostate is known, problems can arise during radiation treatment because the position of the prostate is not constant in relation to the pelvis or, for that matter, to the skin where the markings have been made. The patient's subcutaneous fat means that the markings can be displaced in relation to the pelvis, and different muscle contractions, such as those in the area around the prostate, can displace the prostate up to one centimetre in relation to the pelvis. Furthermore, variation in the contents of the intestine and the bladder can affect the position of the prostate. When added together, this has the effect that the field of radiation must have a margin of 1.5 - 2 cm around the determined position of the prostate, which means that the rectum and bladder can be subjected to radiation, thus limiting the possibility of giving very high doses of radiation.

Even though the problem has initially been described in connection with the treatment of prostate cancer, it should be emphasised that many aspects of the problem are common to the treatment of cancer tumours in other organs, which is why the invention also has applications

within these areas. This is especially true for tumours of the cervix, urinary bladder, stomach, intestinal tract, pancreas, mouth, throat, etc. Embodiments of the invention have further applications within general internal radiation treatment of cancer, as will be made evident below.

During radiation therapy, a treatment beam is emitted from equipment used for the treatment. Depending on the shape of the object to be treated, a cross-section of the treatment beam is chosen so that the treatment is restricted to a specified treatment area. If the treatment area is to be reduced to a size approximating the size of the object to be treated, it is of great importance that the beam strikes its target, the tumour, with great precision.

One objective of the present invention is to achieve the precise aiming of the direction of a treatment beam during the radiation treatment of internal cancer tumours so that the margins of the treatment beam can be reduced, thereby minimising the effect on adjacent organs and tissue.

This objective is achieved with an arrangement and a reference device first mentioned above and that have the features that are evident from the characteristics of the enclosed independent claims.

The advantages and features of the invention are evident from the non-independent claims and the following description.

By using the invention, it is possible to describe the geometry of an organ based on one or more reference points that always occupy the same position with reference to the organ. In addition, the possibility to repeatedly direct the treatment beam with precision in relation to at least one said reference point so that the beam always strikes the cancer tumour with precision, is also achieved. As such, the beam does not need as large a safety margin as has been required until now, but can be assigned a profile that is more or less exactly identical with that of the object to be treated.

Before each treatment occasion, it is thus possible to check, adjust and verify that the cancer tumour really is in the path of the treatment beam.

Additional features and advantages of the invention will be made evident by the following detailed description of one preferred embodiment of the invention, which constitutes one example and as such does not limit the area of protection of the invention. To simplify understanding, the text contains references to the enclosed drawings, in which equivalent or similar parts are assigned the same designation.

Fig. 1 shows schematically an arrangement according to one embodiment of the present invention.

Fig. 2 shows schematically a reference device according to one embodiment of the present invention.

The manner in which we intend to use the arrangement is as follows. For the precision aiming of the direction of a treatment beam 2 against an internal cancer tumour of a patient, at least one reference marker 7 is introduced into the patient at a defined position in relation to the cancer tumour and, if possible, into the tumour itself. The geometry of the tumour is determined and the treatment is planned with reference to the reference marker 7. For the geometrical determination of the tumour, computer tomography/tomography, magnetic X-rays, or other suitable radiological techniques can be used with advantage, and the reference marker(s) can, for example, be composed of a liquid contrast agent, lead, tantalum, tungsten or other material that is visible when computer tomography/tomography, magnetic X-rays, or other similar radiological techniques are used.

In addition, when the actual treatment is begun, the patient is brought into a treatment position and a set point in the cross-section of the beam is defined by a sight 4.

The geometrical determination and description of the cancer tumour is performed based on one or more reference markers 7 and, on the basis of that information, the cross-section of the treatment beam is built up and the position of the sight in the beam's cross-section is moved so that when the incidence of the beam corresponds with the cancer tumour, the positions of the sight and the reference markers coincide, even if they are located on separate elevations.

With at least one said reference marker in the defined position, the patient receives the first initial treatment, after which the relative positions of the reference marker or markers and the sight to one another are read with the help of, for example, the beam that passes through the patient. The relative positions can be adjusted later as needed to ensure the precision of the direction of the beam towards the cancer tumour before the remaining doses in the treatment are given to the patient. By allowing the beam to project the position of the sight 4′ and the position(s) of the marker(s) 7′ on a sensitive surface 6, their relative positions to one another can be visualised.

It is desirable to keep the initial radiation dose low as radiation that misses the target does more harm than good. Experiments have shown that a dose equivalent to 0.03 Gy has been

sufficient to visualise the reference marker and the sight on film. It is desirable to use a dose level that is less than 5% of the radiation dose used in treatment, preferably less than 2%.

When treating prostate cancer, the reference marker can be introduced through the urinary tract by means of a catheter 10, as shown in fig. 2. The reference markers need not be the same when determining the geometry of the cancer tumour and when treating it. The key factor is that the reference markers are located in known positions and in the same position in relation to the cancer tumour. To achieve this, the catheter 10 can be introduced through the urinary tract so that its free end enters the bladder 11 where an attachment arranged at the free end of the catheter, in this case a balloon device 12, is inflated inside the bladder to fix the position of the catheter in relation to the urinary tract, which is in turn essentially fixed in position relative to the prostate 13. The catheter is withdrawn slightly, which pulls the inflated balloon 12 against the floor of the bladder where it joins with the urinary tract. The actual reference marker 7 or reference markers 7 can be permanently positioned in the catheter or can be able to be introduced into the catheter in a defined position therein.

In addition to the said inflatable balloon, adjustable fold-out flaps that increase the local circumference, hooks or clips of different types or other similar locating devices suitable for reproducible location are also suggested as locating devices for the catheter or other carrier of the reference markers.

An arrangement according to the invention for performing the task includes what is, in fact, known treatment equipment 1 for emitting a treatment beam 2 and a device 3 for supporting the patient, whereby the patient has at least one reference marker 7 in relation to which the position of the cancer tumour is determined, a sight 4 arranged in the path of the beam to define a point in the cross-section of the beam, a device 6 to detect the beam arranged to receive the beam passing through the patient and visualise the position of at least one said reference marker 7′ and the position of the sight 4′, whereby the position of the beam in relation to the cancer tumour is determined.

The reading device 6 can be an X-ray film in a cassette suitable for high energy radiation.

The reading device 6 can even be one without film and instead include a receiving unit, a digital image processing system and a monitor for visualising the cross-section of the treatment beam. It can be advantageous if the reading device uses what is known as a portal imaging system.

When a deviation from the desired agreement between the beam and the cancer tumour is registered, the device for adjusting the relative positions of the patient and the treatment equipment to one another is activated, either manually or automatically. This can occur, for example, by a change in the elevation or position of the device supporting the patient or by adjustment of the treatment equipment.

It is advantageous if the reference marker 7 or reference markers 7 are included in a reference device. The reference device then has at least one reference marker 7 in a material with high density and a position fixing-device.

The reference device can include several reference markers arranged at defined distances from each other. A marker can, for example, take the form of a dot, a line, an arc, a cross, a circle, etc.

The position-fixing device results in the marker(s) taking up a defined position in relation to the cancer tumour, preferably a reproducible set-up of the reference markers in a defined position in relation to the cancer tumour.

In one embodiment, the reference device includes a catheter 10 that has at its free end a reproducibly inflatable balloon, plus markers in the form of spheres arranged at defined positions along the catheter. The spheres are produced from a material of high density to enable visualisation in a high energy beam, preferably lead, tantalum and/or tungsten.

The catheter shown in fig. 2 includes tubing 10 with several spheres 7 arranged in the internal channel of the tubing. The markers can naturally be arranged within the wall as spheres, rings, lines arcs, etc., to maintain an internal passage for, for example, urination. In this case, the use of several reference markers means that the catheter can be used by different patients with different anatomical measurements. For example, the third sphere can be used as a reference by one patient, whereas with another patient, the fourth sphere may be better placed to function as the reference point. A smaller channel passes through the tubing to the inflatable balloon 12 so that this can be expanded.

For certain treatments, it is not necessary to direct the beam at a point. Instead, a line can be judged to provide sufficient accuracy. For example, with a catheter with a wire or with several spheres arranged at a shorter distance from each other, the arc or line that the urinary tract forms through the prostate can be visualised and used to direct the beam.

Even if the text above to a large extent deals with the invention's application for the treatment of prostate cancer, it should be remembered that the invention also has uses with other types of cancer tumour.

In further applications of the invention, the reference marker can be introduced to, and kept in place by, surrounding body tissues, for example, in a cancer tumour.

For example, a marker provided with a clip or other attachment device can be arranged in a defined position in relation to a cancer tumour by means of, for example, surgery, peep-hole surgery or by the marker being introduced through one of the body's openings. The marker can then be kept in position throughout the whole cycle of treatment, from determining the position of the tumour to completed treatment, after which it can be removed by an appropriate means, such as the means by which it was introduced or, if made of material suitable for the purpose, be left in the body.

In those cases where a carrier is arranged to carry several reference markers with known positions relative to one another, it can be appropriate to arrange these in a pattern so that it is possible to determine where along the carrier the beam is directed. For example, the distance between the reference markers or their shape at a known position can deviate in a way that is easy to identify. The reference markers in a catheter can, for example, be arranged one cm apart, except for one position along the catheter where one marker is missing. In this way, the position of the beam along the carrier can be determined with increased certainty.

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Claims

1. Arrangement for the precision aiming of a treatment beam against an internal cancer tumour in a patient, including what is in fact known treatment equipment (1) for emitting a treatment beam (2) with a defined cross-section (5) and a device (3) for supporting the patient, c h a r a c t e r i s e d in that at least one reference marker (7) is introduced into the patient in relation to which the position of the cancer tumour is defined, that a sight (4) is arranged in the path of the beam (2) to define a point in the cross-section of the beam, that a device to read the beam (6) is arranged to receive the beam that has passed through the patient and to visualise the position of at least one said reference marker (7′) and the position of the sight (4′), whereby the position of the beam in relation to the cancer tumour is determined.

2. Arrangement according to claim 1 c h a r a c t e r i s e d in that the reading device (6) includes a surface for the incident beam that has passed through the patient, that the incident surface includes a layer sensitive to the incident beam, whereby a sight (4) arranged in the beam and a reference marker (7) of high density can be visualised by the projections (4′,7′).

3. Arrangement according to claims 1 or 2 c h a r a c t e r i s e d in that the reading device is an X-ray film.

4. Arrangement according to claims 1 or 2 c h a r a c t e r i s e d in that the reading device includes a receiving unit, a digital image processing system and a monitor for visualising the cross-section of the treatment beam and that the reading device preferably uses what is known as a portal imaging system.

5. Arrangement according to any of claims 1 to 4 c h a r a c t e r i s e d in that a device is arranged to adjust the positions of the patient and the treatment equipment relative to one another following an initial radiation dose, and that the adjustment device is preferably arranged in the device (3) that supports the patient.

6. Reference device carrying reference markers for use in the device according to claim 1, c h a r a c t e r i s e d in that the reference device includes several reference markers (7) in a material with high density, that the reference markers are arranged at defined distances from each other, that the reference device also includes a position fixing-device for the reproducible set-up of the reference markers in a defined position relative to the cancer tumour.

7. Reference device according to claim 6 c h a r a c t e r i s e d in that the reference device includes a catheter (10) having a position fixing-device at its free end, that the position fixing-

device is an inflatable balloon (12), and that at least one marker is arranged at a defined position along the catheter.

8. Reference device according to any of claims 6 or 7 c h a r a c t e r i s e d in that the reference markers are produced from a material of high density to enable visualisation in a high energy beam, and that the reference markers are preferably made of one or more materials from a group consisting of lead, tantalum and tungsten.

9. Reference device according to any of claims 7 or 8 c h a r a c t e r i s e d in that the catheter has a channel for manoeuvring the inflatable balloon (12), a channel to allow urination, and that the reference markers are arranged within the wall of the catheter.

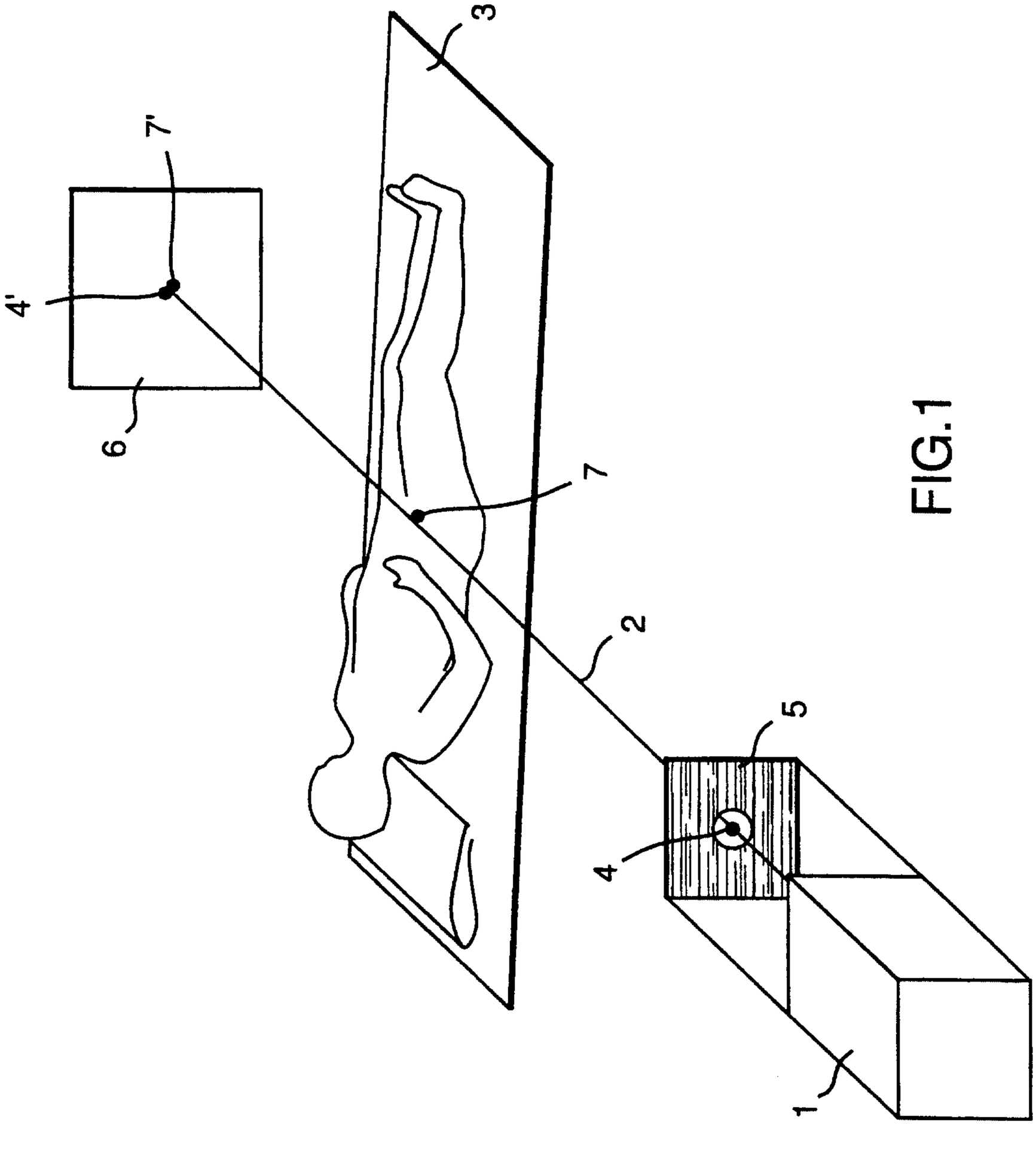

FIG.1

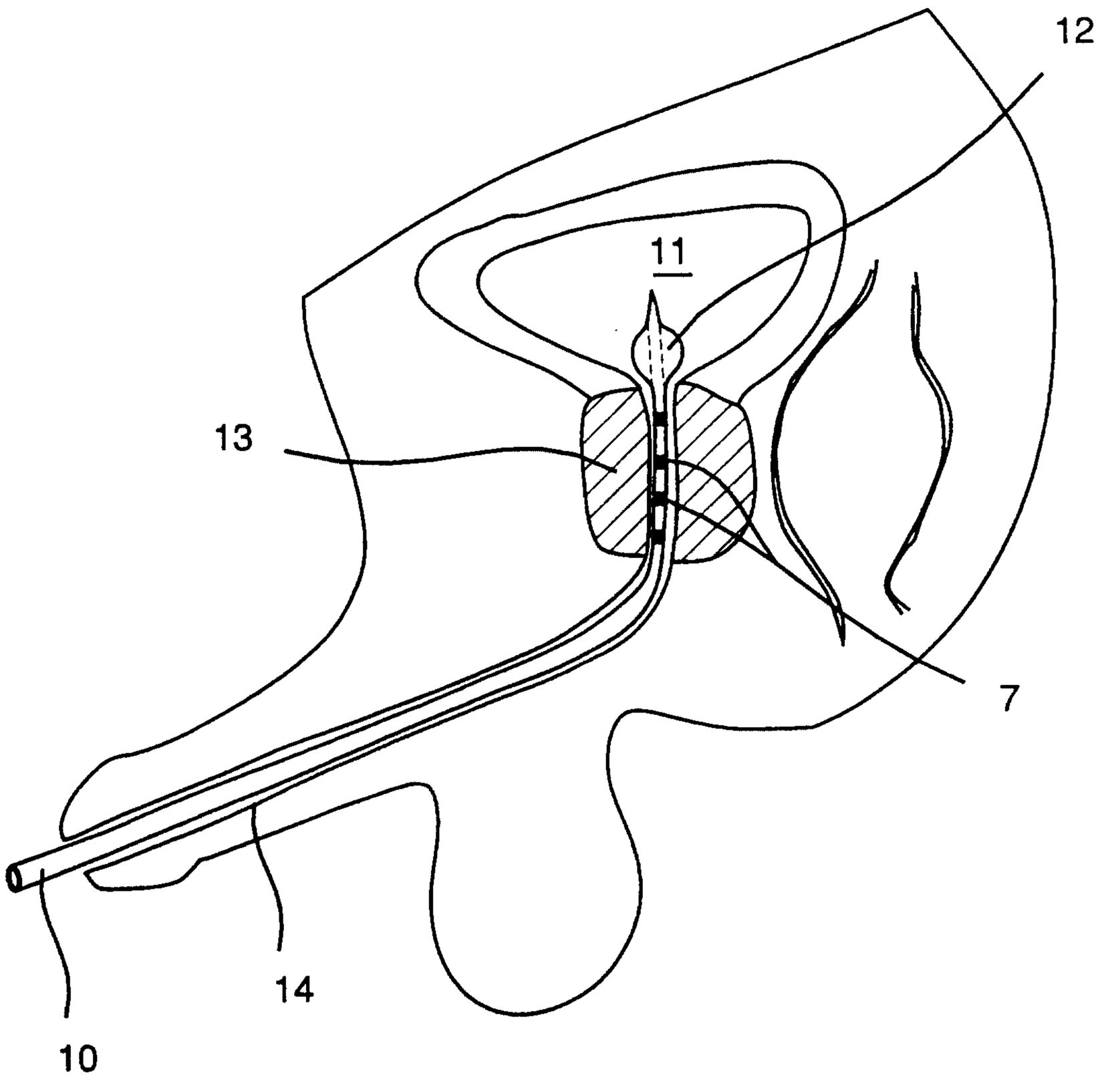

FIG.2