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(54) **Title**: MOBILE MEDICAL IMAGING SYSTEM

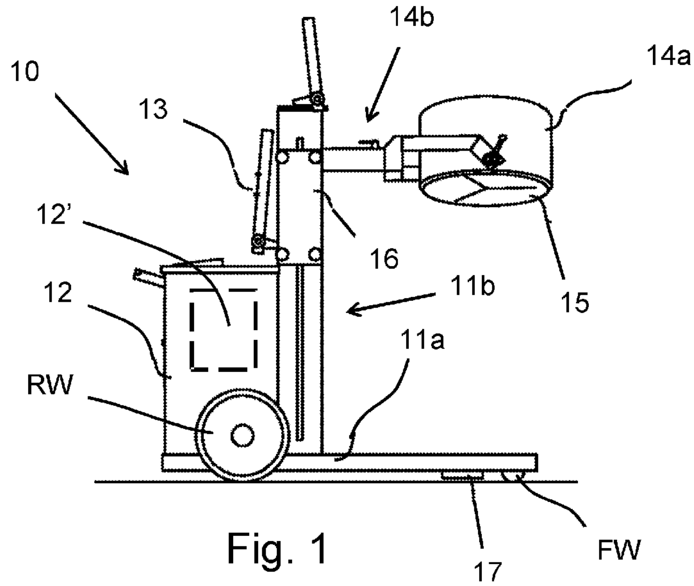


Fig. 1

(57) **Abstract**: The invention relates to a mobile imaging system (10), comprising a chassis (11a) having a front end and a rear end, the front end being configured to be insertable under a bed on which a patient is located, a detector (14a) with a collimator (15), attached to the chassis such that it can be positioned over the patient in the bed configured to register images of an object, such as the heart of the patient, control electronics (12'), and a display (13). There is also a detector position adjustment unit (17), mounted on the chassis at the front end thereof, comprising a top and a bottom slide block (20, 19) each comprising an upper (20", 19") and a lower part (20', 19') coupled to each other via a low friction interface. The system further comprises a rotary bearing arrangement (21) mounted between the upper part (19") of the bottom slide block (19) and the lower part (20') of the top slide block (20), thereby connecting the top and bottom slide blocks such that they are rotatable with respect to each other. There is also provided an actuator (10) coupled to the adjustment unit (17) and configured to provide a lifting action to lift the front end of the chassis (11a) to a predetermined height above the ground, whereby the front end will rest on the adjustment unit (17) only.

WO 2014/158079 A1

MOBILE MEDICAL IMAGING SYSTEM

The present invention relates to myocardial scintigraphy in general, and in particular to a mobile system for inter alia enabling imaging in acute situations without the need of moving a patient. It also relates to means for positioning the imaging system accurately.

Background of the Invention

Several studies have shown that myocardial scintigraphy is the most efficient method for the diagnosis and prognosis of ischemic heart disease. As an example this technique has exhibited a sensitivity of 96% for coronary stenosis compared to a 35% sensitivity using rest EKG in contrast to using biomarkers such as troponin I, myocardial scintigraphy can detect or exclude ischemic regions and infarctions in an earlier stage of the disease progression. This allows a considerably faster decision as to which intervention is to be carried out/performed.

Despite the advantages with myocardial scintigraphy the technique is used relatively infrequently in the diagnosing of acute ischemic heart disease, e.g. in an emergency care ward. One of the main reasons for this is thought to be the fact that an installed Single-photon emission computed tomography (SPECT) system is stationary and it is not always possible to move a patient to the location where such a system is placed.

In the 1980s it was demonstrated that it is possible to generate tomographic images from projections taken at an oblique angle. This new technique was referred to as ectomography. It differs from conventional SPECT imaging where the gamma camera, which is used as the detector, rotates at least 180° around the patient, by the provision of a collimator having slanted holes rotating around its own axis. The imaged layer will thus differ between the two techniques, resulting in SPECT being more useful to image organs located deeper inside the body, whereas ectomography is more useful for the imaging of smaller organs located closer to the body surface.

Summary of the Invention

In view of the drawback of the prior art SPECT systems, i.e. the stationary character thereof requiring patients to be moved to the location of the SPECT apparatus for investigation, the present inventors have now devised a novel imaging apparatus, based on the ectomography principle. The novel appartus is mobile, making it particularly useful for acute and emergency situations, and is optimized for three-dimensional heart investigations.

The novel system is defined in claim 1, and comprises a chassis 11a having a front end and a rear end, the front end being configured to be insertable under a bed on which a patient is located, a detector 14a with a collimator 15, attached to the chassis such that it can be positioned over the patient in the bed configured to register images of an object, such as the heart of the patient, control electronics 12', a display 13. The characterizing feature is a detector position adjustment unit 17, mounted on the chassis at the front end thereof, comprising a top and a bottom slide block 20, 19 each comprising an upper 20", 19" and a lower part 20', 19' coupled to each other via a low friction interface; a rotary bearing arrangement 21 mounted between the upper part 19" of the bottom slide block 19 and the lower part 20' of the top slide block 20, thereby connecting the top and bottom slide blocks such that they are rotatable with respect to each other. The system further comprises an actuator 10 coupled to the adjustment unit 17 and configured to provide a lifting action to lift the front end of the chassis 11a to a predetermined height above the ground, whereby the front end will rest on the adjustment unit 17 only.

An important aspect of the system is that it is provided with a positioning system making it very easy to quickly position the apparatus correctly in order to obtain good images.

The positioning system comprises several features that renders it advantageous, and these features are the subject of dependent claims.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter and the accompanying drawings which are given by way of illustration only, and thus not to be considered limiting on the present invention, and wherein

Fig. 1 shows a mobile imaging system;

Fig. 2 is a view of the mechanical positioning device;

Fig. 3a shows the positioning device in inoperative state;

Fig. 3b shows the positioning device in operative state;

Figs 4a-e illustrates a method of determining the necessary adjustment of the detector;

Fig. 5 illustrates means for operating the wheels of the system;

Fig. 6 is an example of a slant hole collimator; and

Fig. 7 illustrates a method schematically in a set-up with a patient.

Detailed Description of Preferred Embodiments

In order to provide optimal imaging it is required that the heart (or other imaged object) is located within the system field of view. However, to position the detector at an exact and correct position is difficult and readjustment of the apparatus some small distance such as one or a few millimetres is mostly necessary.

Therefore, the main object of the present invention is to provide accurate positioning of the imaging apparatus by fine-tuning/adjusting the position of the detector in order to optimize the imaging procedure. To meet this object there are provided novel features that each separately or together are usable to optimize the positioning.

One feature is a mechanical position adjustment unit designed as a means to substantially reduce the force required to move the rather heavy equipment in small increments for the adjustment of the position of the detector. This mechanical unit is disclosed in Figs. 1-2, and will be described in detail with reference to these Figs.

Another feature is a visual interface comprising at least two projections of the heart taken at different angles, and a control unit/calculation unit which enables the determination of the optimal detector position and subsequent accurate positioning of the detector.

A further feature, which is optional, is the provision of an automatic positioning of the detector when the optimal position has been determined by the control unit.

Fig. 1 shows schematically an embodiment of an entire mobile imaging system generally designated 10. It comprises a chassis 11a and an essentially vertically arranged frame 11b, a main cabinet 12 housing control electronics 12’, a display 13, a detector 14a, suitably a so called gamma camera (or scintillation camera also referred to as an Anger camera) mounted on an essentially horizontal beam 14b mounted to the frame 11b, a rotatable collimator 15, a height adjustment unit 16 and a mechanical position adjustment unit 17 for fine tuning of the detector position. The system also has a front wheel pair FW and a rear wheel pair RW.

The detector in Fig. 6 comprises a processor P, an amplifier AMP, photomultipliers PM, a scintillator crystal SC, a Slant Hole Collimator SHC made of lead, and schematically an organ is shown into which a substance emitting gamma radiation has been introduced.

For the purpose of this application “Y direction” refers to the longitudinal direction of the system, and “X direction” is a transverse direction with respect to the system, whereas “Z direction” is a vertical direction.

The system is generally used as follows. Since it is provided with wheels i.e. mobile and not too big, it is easily and quickly moved to a location where a patient is, instead of moving the patient. When the mobile system arrives at the patient the front of the chassis 11 is run in under the bed on which the patient lies. The detector 14a is provided at a nominal height such that it always goes clear of the patient in this operation. When it has been roughly positioned, the position adjustment system is activated. The detector 14a is then properly positioned within just a few minutes and images can be acquired.

Now the mechanical positioning unit 17 will be described in detail with reference to the schematic illustrations in Figs. 2 and 3a-3b.

As can be seen in Fig. 1 the mechanical positioning unit 17 is preferably located on the chassis 11a at the underside thereof, in the vicinity of the front part of the entire apparatus, i.e. at a position essentially vertically beneath the detector 14a and collimator 15. In operation the mechanical positioning unit 17, which functions like a jack, is activated such that a support member will be lowered using e.g. hydraulics to be brought in contact with the ground or floor. Continued activation will provide an upward force, thereby lifting the front part of the system. Thus the front wheels will no longer rest against the ground. This is illustrated in Figs 3a and 3b.

In Fig. 2 the details of the positioning unit 17 are shown.

The positioning unit 17 is essentially an “X/Y” table, which is a well known mechanism per se.

Here the unit comprises a pair of members referred to herein as slide blocks, a bottom slide block 19 and a top slide block 20. Each slide block comprises two parts. The bottom slide block 19 has a lower part 19’ resting on the floor in operative position, i.e. when the unit 17 has been lowered so as to lift the chassis 11, and an upper part 19” slideably coupled to the lower part. In the same manner the top slide block 20 comprises a lower part 20’ and an upper part 20” slideably coupled to each other. In one embodiment the coupling is a rail-like structure. However, any arrangement providing slideabililty is applicable. Thereby the respective upper and lower parts of each slide block exhibit a very low friction between them, which renders them easily movable without applying much force.

Between the upper part 19” of the lower slide block 19 and the lower part 20’ of the top slide block there is provided a bearing arrangement 21 (rotary bearing) enabling the two slide blocks to rotate with respect to each other. This bearing arrangement is essential to the function, since it will accommodate the angular displacement of the two slide blocks when the detector unit is moved laterally (X-direction). In this way it allows easy X-Y movement of the entire system such that it enables accurate positioning of the detector and collimator unit 14a, 15. When a correct position has been arrived at the system is locked in that position during image recording.

In operative position the upper part 20” of the top slide block 20 is rigidly connected to the chassis 11. The lower part 19’ of the bottom slide block 19 is resting against the ground or floor, and is thus stationary during position adjustment.

Preferably the slideblocks 19 and 20, respectively, are arranged perpendicularly with respect to each other if they have non-square geometry.

Thus, when the adjustment device 17 is in operative position, as shown in Fig. 3b, the low friction rotary bearing arrangement 21 will enable small movements with very little force applied, and the displacement of the entire system with respect to the ground will be accommodated by the slidable coupling between the parts of each slide block 19, 20.

There is also provided a mechanism for lowering the adjustment unit 17. This mechanism comprises in one embodiment a linear actuator 23, which can comprise a hydraulic, pneumatic or electric actuator coupled to an actuating bar 24 that is also coupled to the upper part 20” of the top slide block 20. The upper part 20” of the top slide block 20 is also coupled to the chassis 11 via link units 25 in the form of yokes pivotally connected to the upper part 20” and to the chassis 11, as can be clearly seen in Figs. 3a and 3b.

Thus, in non-operative position (Fig. 3a) the entire position adjustment unit 17 is retracted such that it rests essentially against the bottom of the chassis, or at least such that it goes clear of the ground or floor when the mobile imaging system is transported. When the linear actuator 23 is energized it will pull on the upper part 20” of the top slide block 20, whereby the entire unit 17 will swing downwards by virtue of the linking yokes 25 being pivotally connected as shown.

When the lower part 19’ of the bottom slide block 19 hits the ground, the continued pulling exerted by the linear actuator 23 will cause the front of the entire mobile imaging system to raise such that the wheels goes clear of the ground with about 5 mm (Fig. 3b), very much like the function of a common jack.

As already mentioned, in this elevated position it is very easy to adjust the detector using very little force.

In order to enable to make a final accurate position adjustment of the detector with respect to the heart there is provided a method and device which on the basis of at least two, preferably three, different projections of the heart acquired at different collimator rotation angles, enables very fine adjustment of the detector position to a correct position. This is herein referred to as a “sighting system” and will be described with reference to Figs. 4a-e.

By using only two or three projections instead of a complete image, the imaging during the position adjustment can be performed much more rapidly than the acquisition of a complete image thus simplifying and speeding up detector alignment.

For proper image acquisition it is important that the object to be imaged is within the system field of view. In limited view tomography the field of view is a cone, the frustum of a cone, a double cone or the frustum of a double cone with its axis coincident with the collimator axis of rotation.

The position of an object relative to the detector is uniquely determined by its positions in two different projections acquired with different collimator rotation angles. If the object is visible in and contained within three different projections acquired with three different collimator rotation angles it will, due to the circular symmetry of the field of view, be within the system field of view.

The preferred embodiment of the sighting system presents three different projections of the object in question, herein exemplified by the heart muscle, acquired with the three collimator rotation angles α1, α2 and α3, typically 0, 120 and 240 degrees, on a monitor screen. The display on the monitor for a sequence of operations is shown in Figs. 4a-e.

Furthermore three markers, here represented as rings 41, 42, 43, which is a preferred embodiment, are presented on the monitor screen. These rings can be moved like a cursor on the monitor screen using an input device such as a computer “mouse”. In particular they can be moved so as to be centred over the projection of the heart muscle shown on the monitor. It is not strictly necessary to use rings, any marker that can be positioned so as to be centred over the object in question, e.g. a heart, on the screen would do.

Thus, each ring is associated with one of the projections of the heart, the projections being designated P1, P2 and P3, respectively in the following. In Fig. 4a one projection 44 is shown. Also, the centre of gravity 45 of the triangle 46 formed by the three rings is shown, one bisector 47 being shown. The image boundary 48 is also shown.

The operator centres two of the rings over the projections of the imaged object with the aid of a mouse or other device. Two of the three rings can be positioned in this manner. Using the coordinates of the two rings manually positioned the system calculates a third position of a symmetric triangle, and thus the third ring is automatically placed on the third projection. The diameter of the rings can be adjustable so as to fit the object in question, or in the alternative be at least so large so that they can fully enclose the projection of the object to be imaged.

When the camera has been properly positioned and projections have been obtained, each ring will be centered over the corresponding projection of the object and each ring will be located in the center of the projection and contained within the corresponding projection.

When, in order to obtain a sequence of projections, the collimator rotates, the position of the rings could automatically be updated. It should be noted that in the above description three projections are foreseen. It is, however, sufficient with two. The third projection, which may be omitted, is used for increased operator confidence and convenience.

With P1 having the coordinates (x1, y1) and P2 having the coordinates (x2,y2), σ the slant angle of the collimator holes and R the radius of the detector the position (x,y,z) of the imaged object relative to the detector will be (the scale is here for simplicity assumed to be 1:1):

$$x = \frac{y1 - y2 - tg(\alpha 1)x1 + tg(\alpha 2)x2}{tg(\alpha 2) - tg(\alpha 1)}$$

$$y = \frac{tg(\alpha 2) \cdot y1 - tg(\alpha 1) \cdot y2 + tg(\alpha 1) \cdot tg(\alpha 2) \cdot (x2 - x1)}{tg(\alpha 2) - tg(\alpha 1)}$$

These x, y values represent the position in a plane, whereas, as indicated previously, also the height above the patient may be required to be adjusted. This height is represented by the z value:

$$z = (x1 - x) \cdot tg(\sigma)$$

Furthermore, the centre coordinates of P3 will be:

$$x3 = x + \cos(\alpha 3) \cdot \frac{z}{tg(\sigma)}$$

$$y3 = y + \sin(\alpha 3) \cdot \frac{z}{tg(\sigma)}$$

The necessary adjustments of the detector position will be:

$$dx = -x$$

$$dy = -y$$

$$dz = \frac{R \cdot tg(\sigma)}{2} - z$$

These values for the X-, Y- and Z-movements of the detector, respectively, will be displayed on the monitor. Thereby it is an easy matter to adjust the position.

The displacement in X and Y directions can be performed manually or by motors coupled top the rear wheels. The displacement in Z direction is performed suitably by moving the horizontal beam 14b, either manually but preferably using a motor.

Although it is convenient for many reasons to have operator control as described above, it is also within the inventive concept to have this process performed automatically. This can be achieved by using image recognition software to identify the position of the centre of gravity of the projections of the imaged object. In such case there is no need for operator intervention and strictly speaking not even a monitor screen for displaying the projections is required. However, for control purposes, it is nevertheless a preferred feature to display the projections for visual verification of correctness in position.

The sequence of operation when performing the method with operator intervention is as follows.

Fig. 4b shows the display on the monitor in an initial position before adjustment. Only one ring 42 is in correct position with respect to the heart. Now one of the other rings 43 is moved manually on the monitor screen such that it covers the heart, see Fig. 4c. The centre of gravity 45 of the triangle formed by the three rings is automatically moved to a new position. Then a third ring 44 is moved automatically to cover a third projection of the heart, Fig. 4d. Again, the centre of gravity 45 is changed, and now the deviation between current and optimal position is calculated. This deviation is displayed on the monitor and the adjustment can easily be performed, either manually or automatically as described below, and the display will than look like in Fig. 4e.

After the adjustment, optionally a new set of projections can be acquired so as to verify the correctness of the position.

In an automated mode, the control electronic suitably running an image recognition software would process the data of each image and provide the identification of the centre of gravity of the object in each projection, and calculate the triangle thus formed, i.e. spanned by the centres of gravity. Then the deviation between current and optimal position is calculated as above, and the adjustment performed like before.

Preferably the adjustment of the detector position in accordance with the calculated required displacement is effected automatically. This can be implemented, as shown in Fig. 5, by the provision of electric motors 51, 52 which are provided to drive the rear wheels RW of the mobile apparatus. Thus, when it is desired to move the detector in the Y-direction the motors will drive each wheel in the same direction, whereas when a movement in the X-direction is required the motors will drive the wheels in opposite directions.

In order to record the actual displacement during the adjustment operation there is in one embodiment provided a means for the detection of the position with respect to the ground or floor. The information regarding the position is synchronized with the data from the mechanical position adjustment unit 17, and this enables a determination of when the detector has reached an optimal position.

The position detection can be implemented by using the technology on which a so called optical mouse is based, see Fig. 3a. An image recorder (camera) C continuously records the ground or floor and by digital image processing changes in the image are recorded by sequentially comparing the recorded images, and hence the speed and direction of the displacement can be determined. Preferably a light source such as a LED is provided to enhance the image.

Of course any other type of position detection could be used as long as speed and direction of the displacement can be recorded and fed back to the system.

The method is illustrated in some further detail in Fig. 7. It comprises recording successive projections of e.g. a heart at different, preferably three different angles using the detector 60. The signals from the detector 60 representing each projection are stored in a memory 62 as pixels representing images that can be displayed on a display screen or monitor 64.

In one embodiment the control electronics 66 is programmed to execute an image recognition software. Thus, the data, i.e. the image pixels are retrieved form memory, and the control electronics, by executing the image recognition software, identifies the imaged objects and their respective centres of gravity and thus the coordinates of said centers of gravity.

The centre of gravity of each of the projections having been registered at different angles by means of the detector, each represent a corner of an equilateral triangle, which in its turn will have a centre of gravity directly given by the coordinates of the center of gravity of the projections, by simple geometric consideration.

Thus, since the field of view of the system is known in terms of coordinates in the reference frame of the apparatus itself, the deviation of the centre of gravity of the geometric figure spanned by said projections is calculated by the control electronics, and the deviation is presented as a required displacement of the detector in the X-, Y- and optionally Z-directions, in order that the detector be positioned properly for the investigation.

In one embodiment the data representing the displacements are fed as control signals to a couple of motors 68 individually driving the rear wheels 69 whereby an automatic adjustment of the detector is possible.

CLAIMS:

1. A mobile imaging system (10), comprising

a chassis (11a) having a front end and a rear end, the front end being configured to be insertable under a bed on which a patient is located,

a detector (14a) with a collimator (15), attached to the chassis such that it can be positioned over the patient in the bed configured to register images of an object, such as the heart of the patient,

control electronics (12’),

a display (13);

characterized by

a detector position adjustment unit (17), mounted on the chassis at the front end thereof, comprising

- a top and a bottom slide block (20, 19) each comprising an upper (20”, 19”) and a lower part (20’, 19’) coupled to each other via a low friction interface;
- a rotary bearing arrangement (21) mounted between the upper part (19”) of the bottom slide block (19) and the lower part (20’) of the top slide block (20), thereby connecting the top and bottom slide blocks such that they are rotatable with respect to each other; and

further comprising an actuator (10) coupled to the adjustment unit (17) and configured to provide a lifting action to lift the front end of the chassis (11a) to a predetermined height above the ground, whereby the front end will rest on the adjustment unit (17) only.

2. The system according to claim 1, wherein the parts (19’, 19”, 20’, 20”) of each slide block (19, 20) are connected by low friction skid rails, such that they are only linearly movable with respect to each other.

3. The system according to claim 1 or 2, wherein there is further provided an essentially vertically arranged frame (11b) attached to the chassis (11a), and wherein the detector is mounted on an essentially horizontal beam (14b) mounted to the frame (11b).

4. The system according to claim 1, 2 or 3, further comprising a detector height adjustment unit (16).

5. The system according to any preceding claim, wherein the detector is a gamma camera.

6. The system according to any preceding claim, further comprising means for moving the detector the required displacement.

7. The system according to claim 10, wherein the means for moving the detector comprises electric motors coupled to one rear wheel each, controlled by the control electronics to rotate the rear wheels in accordance with the required displacement, such that for movement in a longitudinal (X) direction both rear wheels are driven in the same direction, and for movement in a transverse (Y) direction the rear wheels are driven in opposite directions.

8. The system according to any preceding claim, wherein the chassis (11a) has a pair of front wheels (FW) and a pair of rear wheels (RW).

9. The system according to claim 8, comprising drive means (51, 52) configured to drive each rear wheel separately, in both directions, in response to the calculated displacements in X and Y directions.

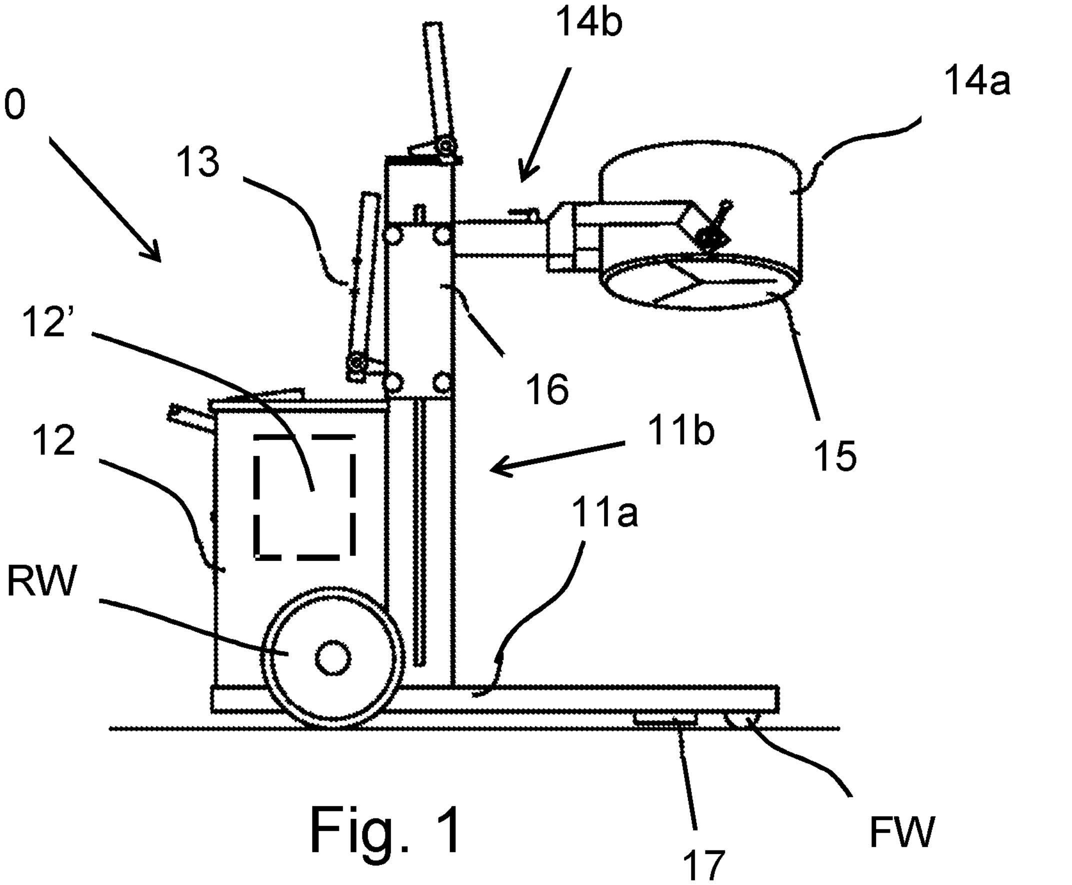

10
13
12'
12
RW
14b
14a
16
15
11b
11a
17
FW

Fig. 1

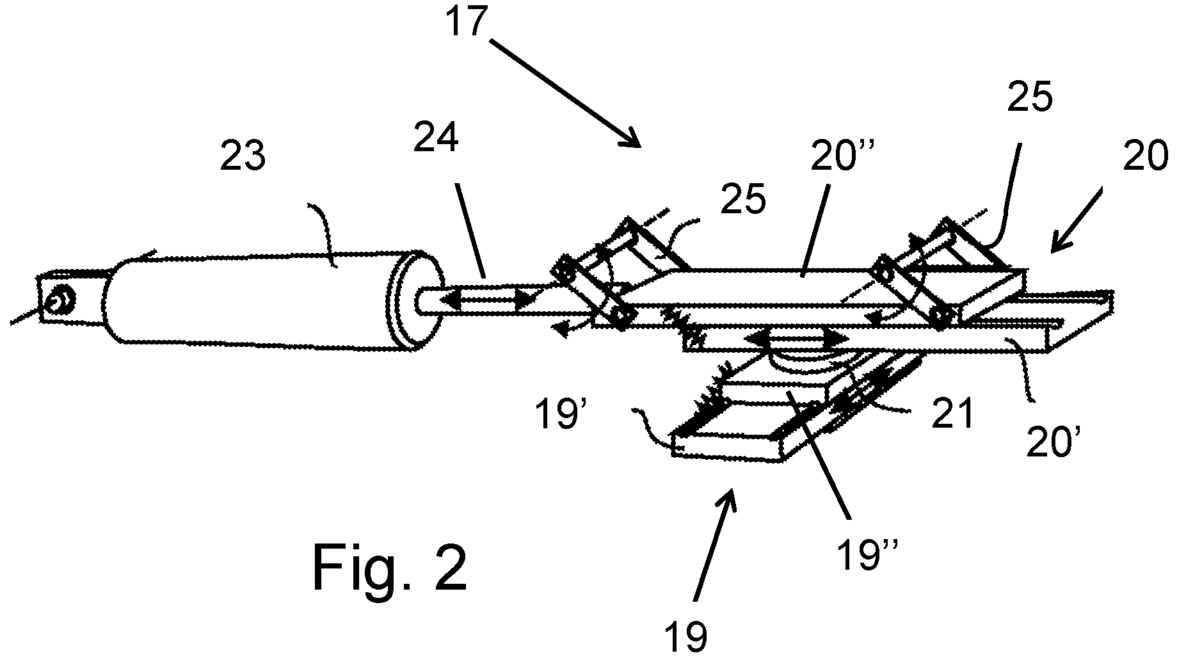

17
23
24
25
20''
25
20
19'
21
20'
19''
19

Fig. 2

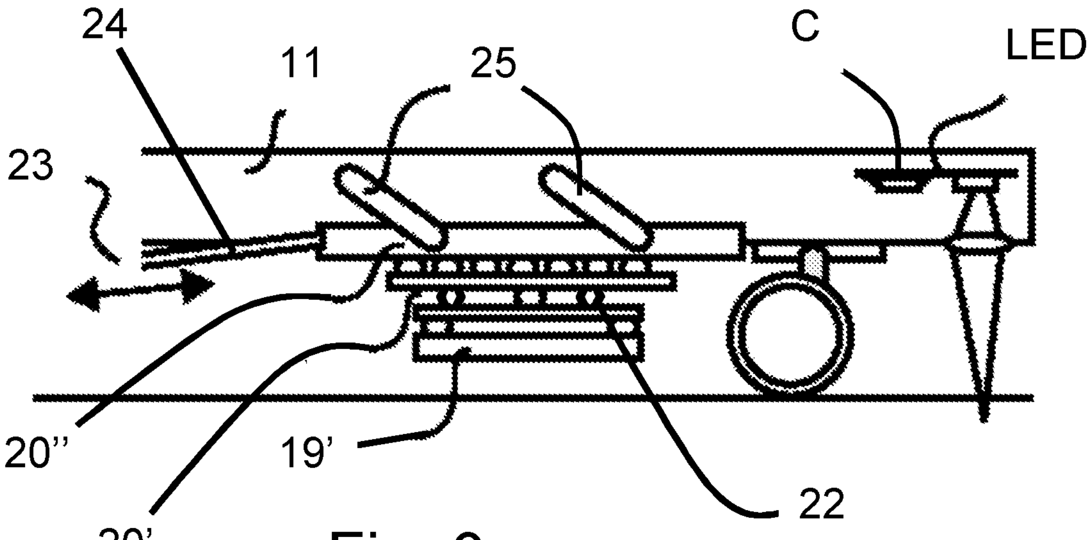


Fig. 3a

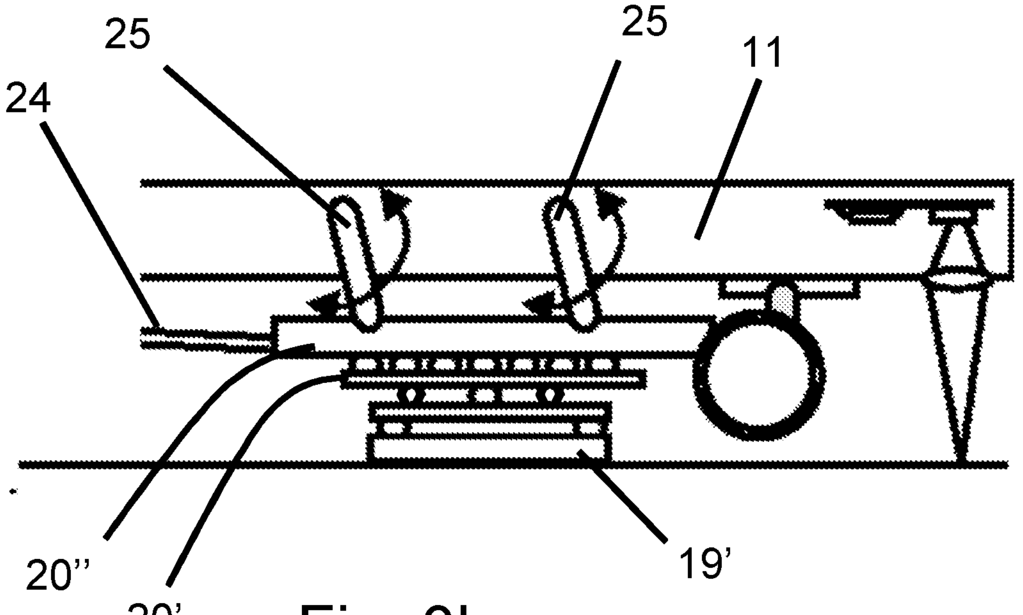


Fig. 3b

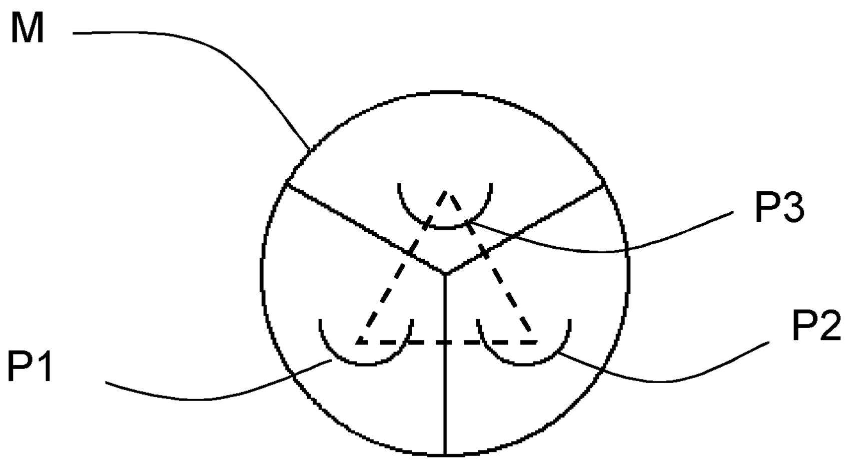
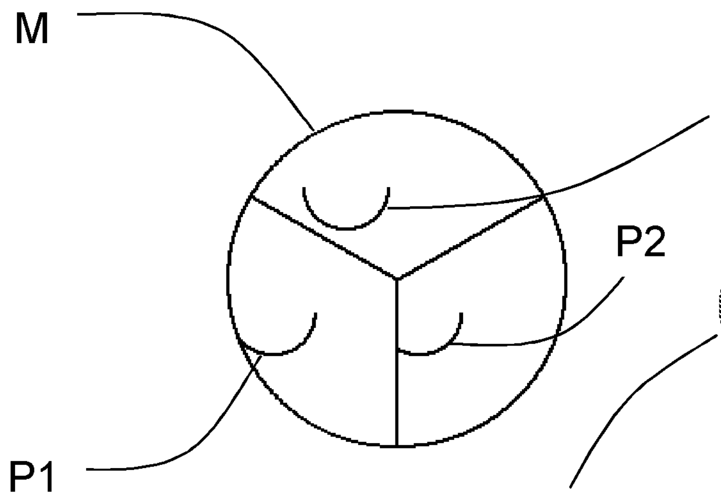


Fig. 4a



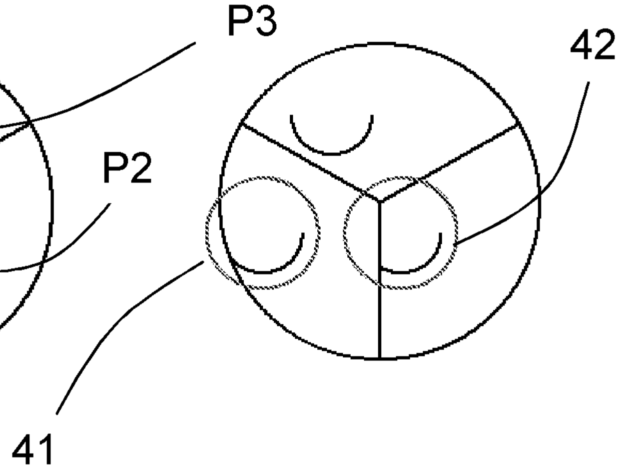


Fig. 4c

Fig. 4b

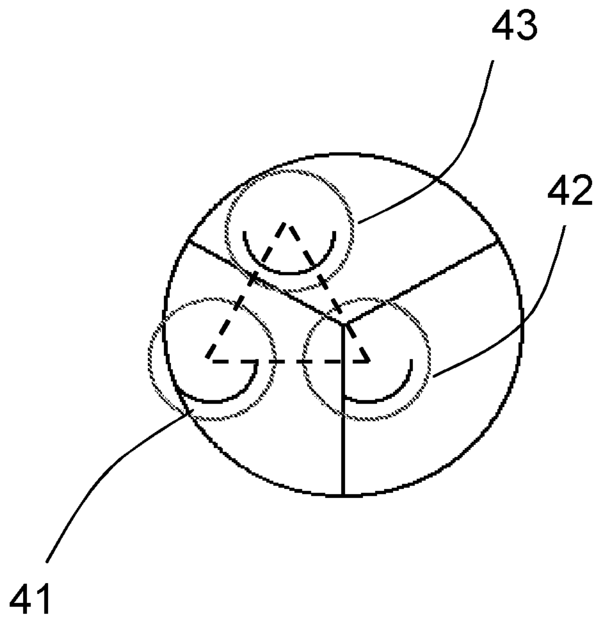


Fig. 4d

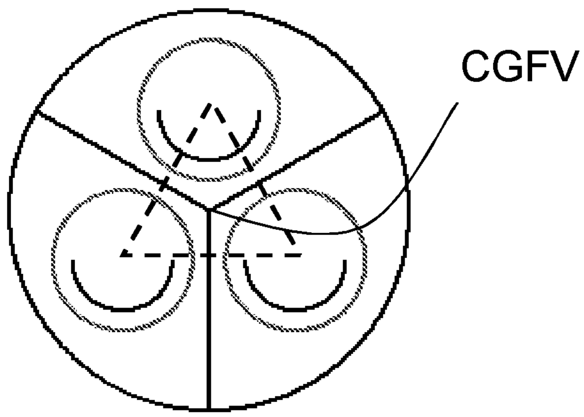


Fig. 4e

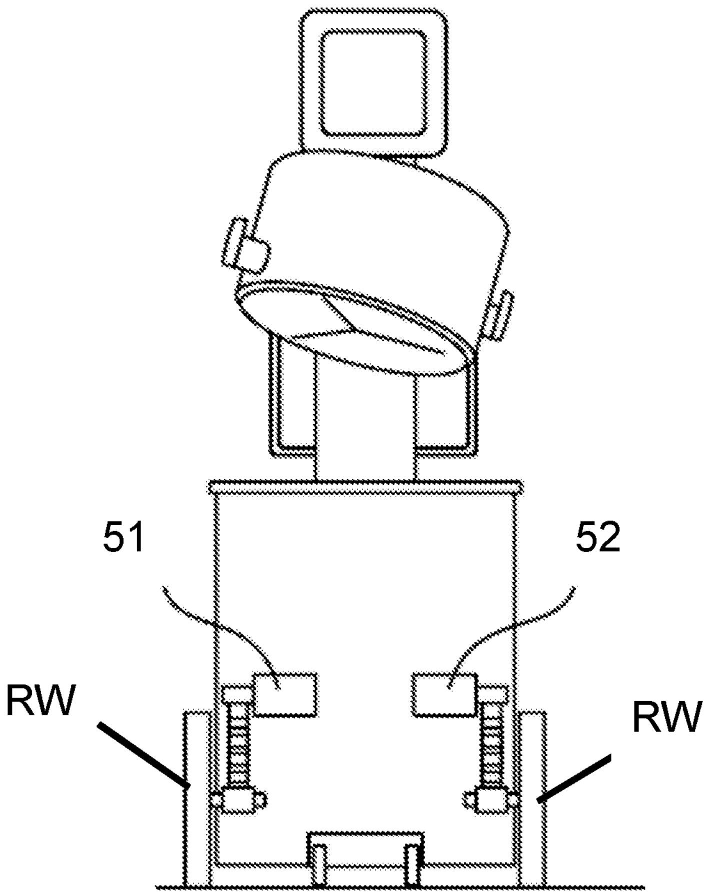


Fig. 5

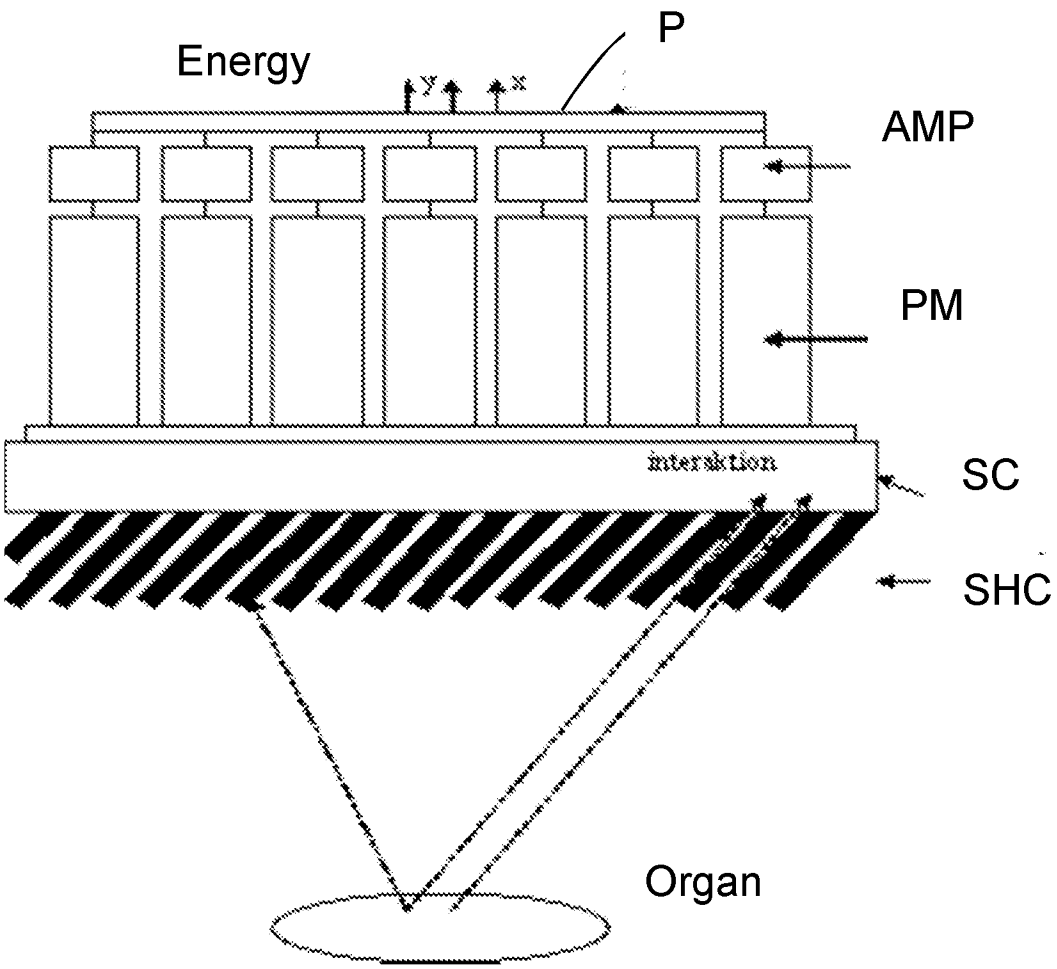


Fig. 6

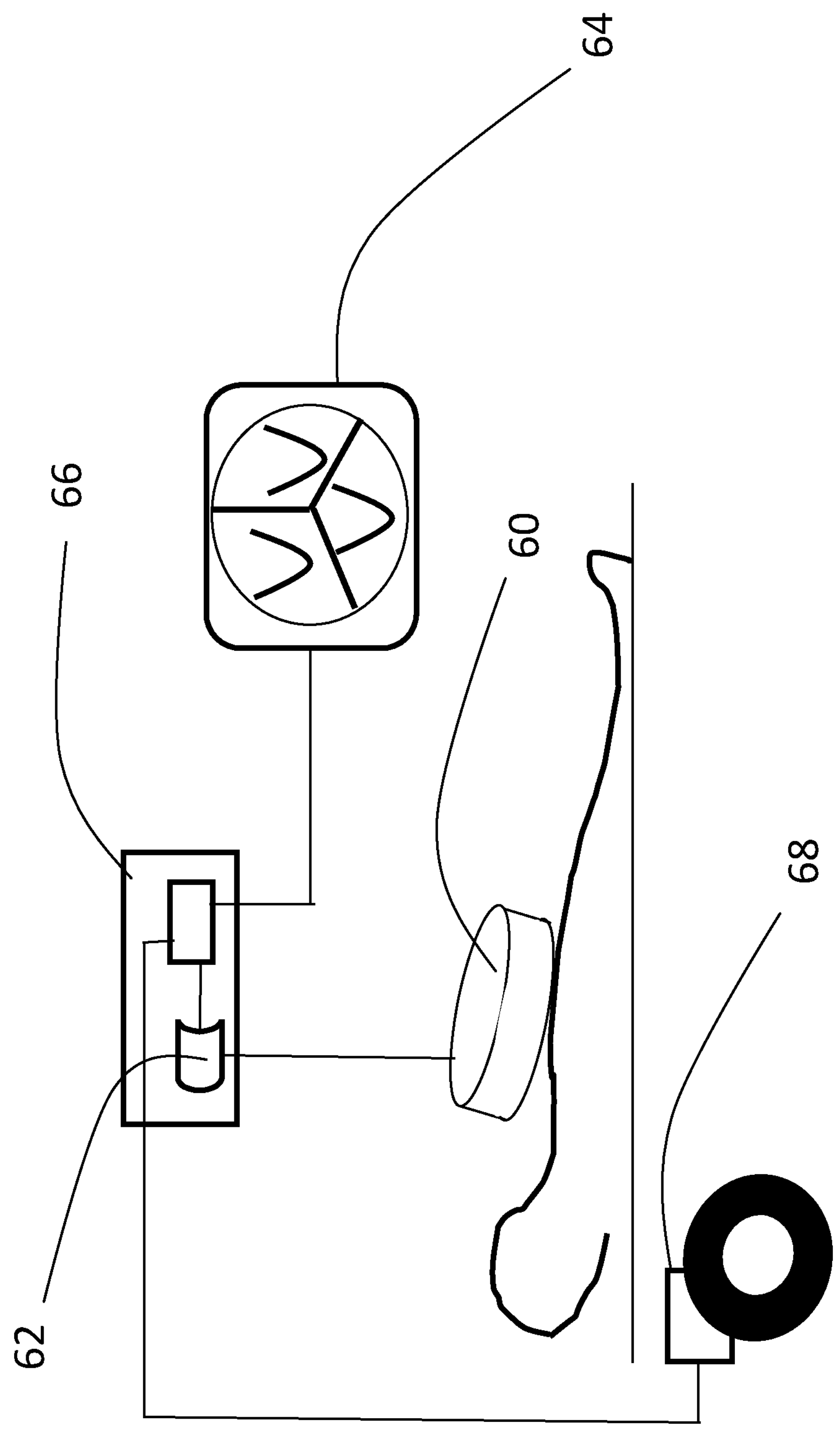


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2014/050343

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: A61B, A61G, F16M, G01T, H05G

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, BIOSIS, COMPENDEX, EMBASE, INSPEC, MEDLINE, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6374937 B1 (GALANDO JOHN ET AL), 23 April 2002 (2002-04-23); abstract; figures 1,6-13; claim 1 --	1-9
A	US 6131690 A1 (GALANDO JOHN ET AL), 17 October 2000 (2000-10-17); abstract; figures 1-10; claim 1 --	1-9
A	US 5503416 A1 (AOKI GARY ET AL), 2 April 1996 (1996-04-02); abstract; figures 1,5-7 --	1-9
A	US 5283823 A1 (MORRIS WILLIAM W), 1 February 1994 (1994-02-01); abstract; figures 4-12; claim 1 --	1-9

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"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
09-06-2014

Date of mailing of the international search report
11-06-2014

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5425069 A1 (PELLEGRINO ANTHONY J ET AL), 13 June 1995 (1995-06-13); abstract; figures 1,7a-7b; claim 1 --	1-9
A	US 20080095323 A1 (STAYMAN JOSEPH WEBSTER ET AL), 24 April 2008 (2008-04-24); abstract; figures 1,4,5; claim 1 --	1-9
A	US 20080123819 A1 (JENSEN VERNON THOMAS ET AL), 29 May 2008 (2008-05-29); abstract; figures 7-18; claim 1 --	1-9
A	US 20080123818 A1 (ALDER SAMUEL LEE ET AL), 29 May 2008 (2008-05-29); abstract; figures 5-15 --	1-9
A	US 4964152 A1 (KAUL KARLHEINZ ET AL), 16 October 1990 (1990-10-16); figure 1; claim 1 --	1-9
A	DE 102011078682 A1 (SIEMENS AG), 10 January 2013 (2013-01-10); abstract; figure 1 --	1-9
A	US 20120163543 A1 (FUSE MIYUKI ET AL), 28 June 2012 (2012-06-28); abstract; figures 1,2 --	1-9
A	DE 19701346 A1 (SIEMENS AG), 23 July 1998 (1998-07-23); abstract; figures 1-6 --	1-9
A	DE 10111798 A1 (SIEMENS AG), 2 October 2002 (2002-10-02); abstract; figures 1,7,8; claim 1 -- --------	1-9

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International Patent Classification (IPC)

A61B 6/00 (2006.01)
A61B 6/03 (2006.01)

US	6374937 B1	23/04/2002	AT	416117	T	15/12/2008
			AU	1105101	A	08/05/2001
			DE	60040988	D1	15/01/2009
			EP	1200300	A1	02/05/2002
			WO	0130635	A1	03/05/2001
US	6131690 A1	17/10/2000	NONE			
US	5503416 A1	02/04/1996	NONE			
US	5283823 A1	01/02/1994	NONE			
US	5425069 A1	13/06/1995	CA	2136708	C	08/06/1999
			FR	2780629	B1	10/10/2003
			FR	2712796	B1	17/03/2000
			GB	2284331	B	17/06/1998
			US	5499284	A	12/03/1996
US	20080095323 A1	24/04/2008	US	7422368	B2	09/09/2008
US	20080123819 A1	29/05/2008	US	7607832	B2	27/10/2009
US	20080123818 A1	29/05/2008	US	7686311	B2	30/03/2010
US	4964152 A1	16/10/1990	DE	3877759	D1	04/03/1993
			EP	0367836	A1	16/05/1990
			JP	2534895	Y2	07/05/1997
			JP	H0255919	U	23/04/1990
DE	102011078682 A1	10/01/2013	NONE			
US	20120163543 A1	28/06/2012	CN	102469970	B	12/03/2014
			EP	2471458	A1	04/07/2012
			WO	2011024608	A1	03/03/2011
DE	19701346 A1	23/07/1998	NONE			
DE	10111798 A1	02/10/2002	NONE			