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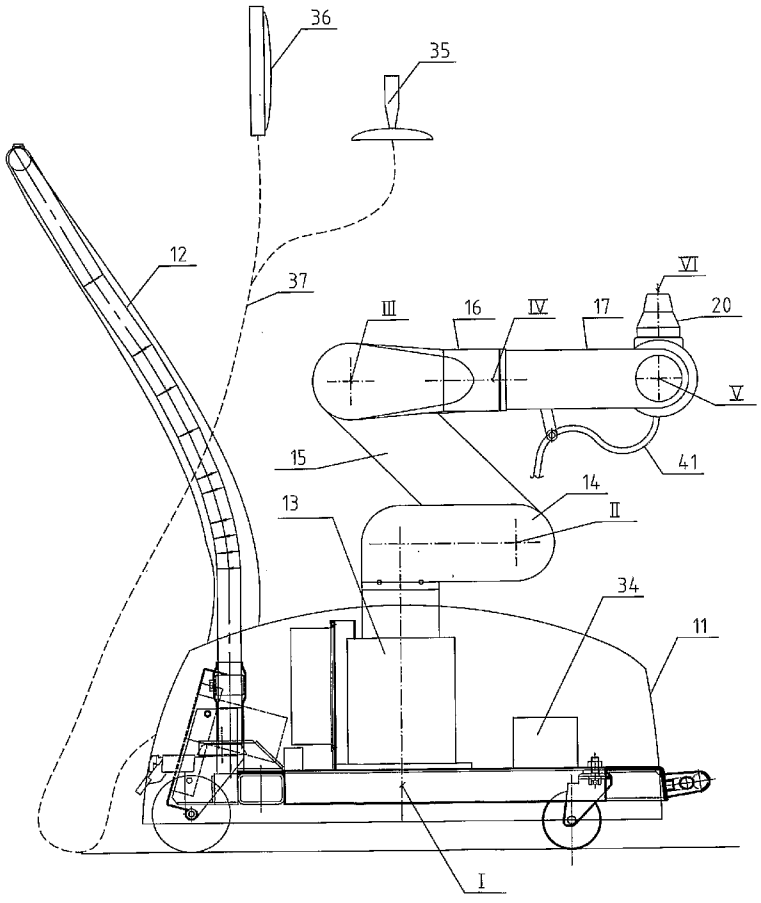
(54) Title: ROBOT FOR ULTRASONIC EXAMINATION



(57) Abstract: A robot for medical ultrasonic examination comprises an articulated robot arm with a plurality of arm units (14-16) successively mounted one on the other to be pivotable, and a computerised system for controlling the movements of the arm, the outermost arm unit (16) being arranged to carry a probe (40). The outermost arm unit (16) has a carrying member (17) that is turnable about its longitudinal axis (IV) and carries a probe holder (20) that is pivotable about a transverse axis (V) perpendicular to said longitudinal axis. The probe holder (20) includes a housing (21) pivotable about said transverse axis and a holder sleeve (25) turnable about its longitudinal axis (VI) and all three axes (IV, V, IV) intersect. The probe holder (20) has a lateral opening through which a cable (41) from the rear end of the probe (40) extends when the probe is mounted, and the carrying member permits for the probe to be inserted through the lateral hole and into the probe holder from the back of the probe holder.

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Robot for ultrasonic examination

Technical field

This invention relates to a robot for medical ultrasonic examination comprising an articulated robot arm with a plurality of arm units successively mounted one on the other to be movable thereon, and a computerised system for controlling the movements of the arm, the outermost arm unit being arranged to carry a probe.

Background of the invention

Ultrasonic examination is a common method. Usually, the transducer probe is held by hand. It is possible to transmit ultrasonic images over internet to an expert, telemedicine. It is desirable that the expert himself controls the positioning of the probe in real time, which calls for a robot that is convenient to control. Also when the expert is at hand, it is desirable to have such a robot instead of having a hand-held probe.

Object of invention and brief description of the invention

It is an object of the invention to permit for a convenient control of the movement of the probe during an examination procedure. It is also an object to make the replacement of the probe simple and fast. According to the invention, the outermost arm unit has a carrying member that is turnable about its longitudinal axis and carries a probe holder that is pivotable on the carrying member about a transverse axis perpendicular to said longitudinal axis. Preferably, the probe holder should include a housing pivotable about said transverse axis and a holder sleeve turnable about its longitudinal axis and said three axes should intersect. The probe holder should preferably have a lateral opening through which a cable from the rear end of the probe can extend, and the probe holder should preferably permit for the probe to be inserted from the back of the probe holder.
The invention is defined by the claims.

Short description of the drawings

Figure 1 shows in a side view a robot as an example of the invention.

Figure 2 is a top view of the robot shown in figure 1.

Figure 3 shows in a longitudinal section and enlarged a detail of the robot.

Detailed description of the illustrated and preferred embodiment

As shown in figure 1, the robot has a base 11 on wheels and it has a handle 12. The base is shown cut up so that its interior is shown. The wheels can be locked to make the base stand stably. The base has a vertical mount 13 for a first unit 14 of an articulated arm comprising arm units 14-16 and a probe holder 20. The mount 13 and thereby the arm unit 14 is turnable about the vertical axis I and the arm units 15 and 16 are pivotable about the respective axes II and III which are parallel with each other and perpendicular to axis I. The arm unit 16 has an outer portion 17 that is turnable about the longitudinal axis IV of the arm. This portion 17 is bifurcated and between its two extensions 18,19, figure 2, it carries the probe holder 20 which is pivotable about a transverse axis V perpendicular to the longitudinal axis IV. The arm 14-16 is not shown in the same position in figures 1 and 2.

The probe holder 20 with its probe 40 is shown in figure 3. It comprises a housing 21 with a steel tube 22 rotatable in bearings 23,24 in the housing about the axis VI of the probe but axially fixed. Another steel tube 25 inside tube 22 is locked to rotate together with the tube 22 by means of a bearing 27 that is fixed to the tube 25 and slideable in an axial groove 38 in the tube 22 so that the inner tube 25 will be axially slideable a limited length of one or a few mm in the outer tube 22. The bearing 27 ensures that there will be no friction that hinders axial movement of the inner tube 25 if there is a tangential force between the two tubes 22,25. Inside the inner tube 25 is a longitudinally split insert 26 of plastic that is adapted to the form of the probe and holds the probe fixed in it. An annular cap 28 is screwed to the outer tube 22 and engages with an annular shoulder 29 on the insert 26 to prevent the insert from falling out. The inner tube 25 has an axial groove for an axial ridge 43 on the insert 26 so that the insert cannot turn in the inner tube.

When there is an axial force on the probe 40, the shoulder 29 on the insert 26 transmits the axial force to the tube 25 which transmits the force to a pin 30 that exerts the force onto a force sensor 31 that provides an electric signal via a non-illustrated line to an electronic unit 34 in the base 11.

There are different probes for different ultrasonic medical examinations and the probes are easily interchangeable. For replacing a probe for the one mounted, one removes the cap 28, and pushes out the tube 25 forwards. Then, the insert 26 with the probe is pushed out of the tube 25 and the split insert 26 is separated from the probe and the probe is pulled backwardly in its cable 41 out of the tube 22 and out of the housing 21. The opening 42 at the back of the housing 21 and the tube 22 are

dimensioned to permit for this withdrawal of the probe. The cable extends sideways out through one of the lateral openings 32 that are provided between the two extensions 18,19 of the bifurcated portion 17, and the probe can be pulled through the opening 32.

Now another probe can be moved through the outer tube 22 and mounted in the inner tube 25 with inserts adapted for this particular probe. Then, the inner tube 25 with inserts and probe are inserted in the outer tube 22 and the cap 28 is screwed on. The probe is thus moved through the point where the three axes IV, V, and VI intersect and the distance between the axis V and the point of the probe, when the probe is in place, is small. The probes are normally elliptical and, therefore, such probes need not be held against rotation in the inserts solely by friction.

The robot includes built-in motors, electric motors, for carrying out the pivoting or rotation about the axes I-VI. The motors and their transmissions are not illustrated. The two motors for pivoting about the axes V and VI are placed inside the portion 17 of arm 16 and they transmit movement via transmission belts, one belt in each extension 18,19. The transmission belt for rotating the outer tube 22 rotates a non-illustrated gear that engages with a ring gear 33 on the tube. Thus, in order for maintaining the outer tube fixed in the housing 21, the motor for rotating the outer tube must be actuated when the housing 21 is pivoted about the axis IV by the other motor in order to counteract the rotation of the tube 22 that otherwise would occur.

The computerised system for controlling the movements of the arm and probe includes the computerised electronic unit 34 in the base 11 coupled to a control unit for example in the form of a joystick 35 and some buttons or a joystick and a keyboard. The force sensed by the force sensor will appear on a display (monitor) 36. The ultrasonic image from the probe will also appear on the same display or on a separate display. The line between the electronic unit and the operator's panel is indicated with dashed lines 37. The operator, that is, the medical expert can be in the room or he can remote control the robot via internet or other communication means (telemedicine examination).

The computerised system includes two control systems:

The first programmed control system controls the probe in cartesian coordinates which means that the probe is moved in X, Y and Z coordinates in response to movement of the joystick, that is the joystick controls the movements about all the axes and the direction of the probe is maintained constant during its movement.

The second programmed control system controls the probe in an Euler angle system, which means that the direction of the probe is controlled by the joystick but the point of the probe is not moving sideways.

In both control systems, the medical expert need not control the individual movements about the axes I-VI but he simply uses the joystick to move the probe.

The programming is not described since it can be carried out in various ways by any skilled programmer.

Description of the operation of the illustrated robot in a telemedicine examination.

Step 1:

The assistant on site helps the patient to right position for the examination and moves the robot to position and locks the wheels of the robot. The medical expert may have real time video contact so that he/she can instruct the assistant.

Step 2:

The medical expert remote controls the robot and chooses the pre-programmed start position suitable for the examination to be carried out.

Step 3:

The expert chooses the cartesian control system and moves the robot arm by means of the joystick and chooses a suitable force applied by the probe to the patient. When the point of the probe is at the right place, the expert switches to the Euler angle control system and adjusts the direction of the probe with the probe point not moving sideways. The expert may also alternate between the two control systems several times for carrying out an examination in order to get the best possible positioning and to get the desired images. The distance between the axis V and the point of the probe is small, which facilitates its positioning. He may also switch to another pre-programmed start position and start over again with the probe at another position on the patient.

Claims

1. A robot for medical ultrasonic examination comprising an articulated robot arm with a plurality of arm units (14-16) successively mounted one on the other to be movable thereon, and a computerised system (34) for controlling the movements of the arm, the outermost arm unit (16) being arranged to carry a probe (40),
characterised in that
the outermost arm unit (16) has a carrying member (17,18,19) that is turnable about its longitudinal axis (IV) and carries a probe holder (20) that is pivotable on the carrying member about a transverse axis (V) perpendicular to said longitudinal axis.

2. A robot according to claim 1, **characterised in** that the probe holder (20) comprises a housing (21) pivotable about said transverse axis (V), a holder sleeve (25) for the probe (40) and a locking device (27,28) for locking the holder sleeve axially in the housing.

3. A robot according to claim 1 or 2, **characterised in** that the probe holder (20) has a through opening (42) through which the probe (41) can be inserted from the back and be locked in position.

4. A robot according to claim 2 or 3, **characterised in** that the holder sleeve (25) is turnable about its longitudinal axis (VI).

5. A robot according to claim 4, **characterised in** that said three axes (IV, V, VI) intersect.

6. A robot according to anyone of the preceding claims, **characterised in** that said carrying member (17,18,19) has a lateral opening (32) through which a cable (41) from the rear end of the probe (40) extends when the probe is mounted.

7. A robot according to any one of the preceding claims, **characterised by** a force sensor (31) in the housing (21) arranged to sense the axial force on the probe (40).

8. A robot according to any one of claims 2-5, **characterised in** that the holder sleeve (25) is axially movable in the housing (21) and a force sensor (31) is coupled between the holder

sleeve and the housing.

9. A robot according to claim 7 or 8, **characterised in** that the computerised system (34) is arranged to permit for an adjustment of the maximum allowed forced to be sensed by the force sensor (31) when the probe (40) is in contact with the patient.

10. A robot according to any one of claims 4-7, **characterised in** that the holder sleeve (25) comprises a replaceable insert (26) adapted to the form of the actual probe (40) in use.

11. A robot according to claim 10; characterised in that the replaceable insert (26) is longitudinally split.

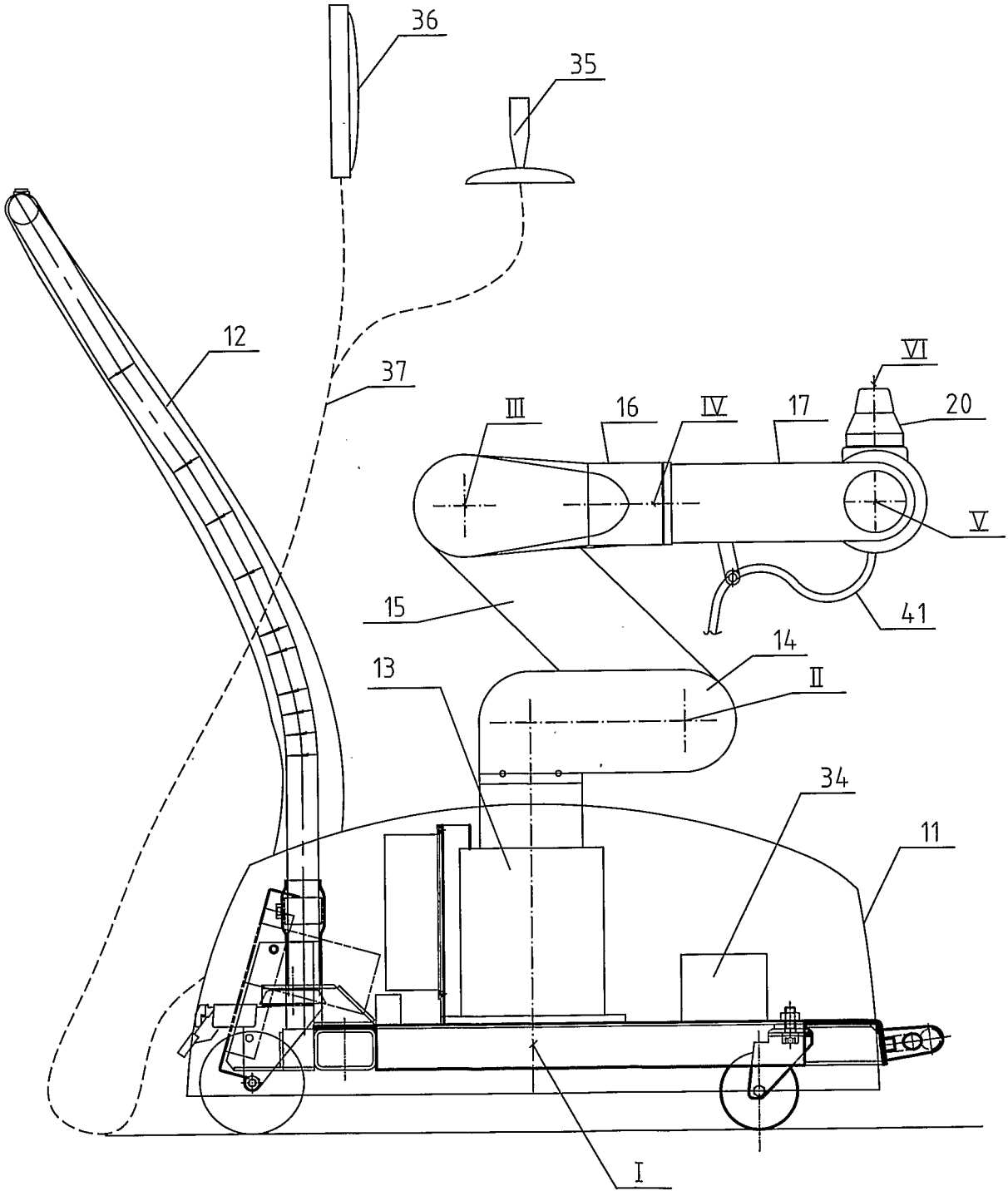

Fig.1

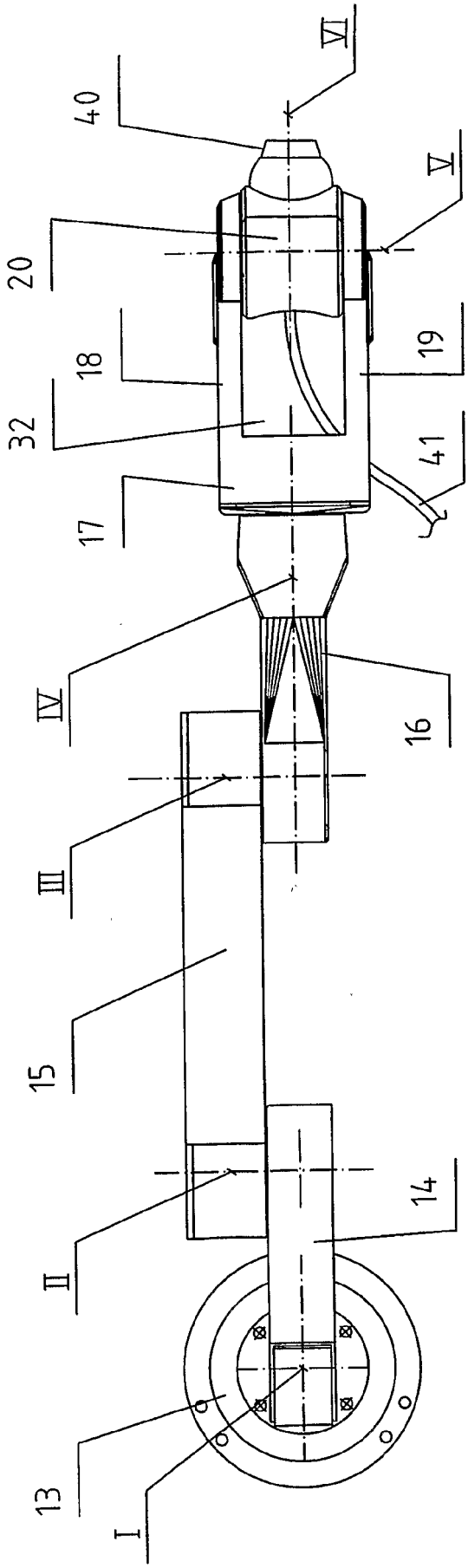

Fig. 2

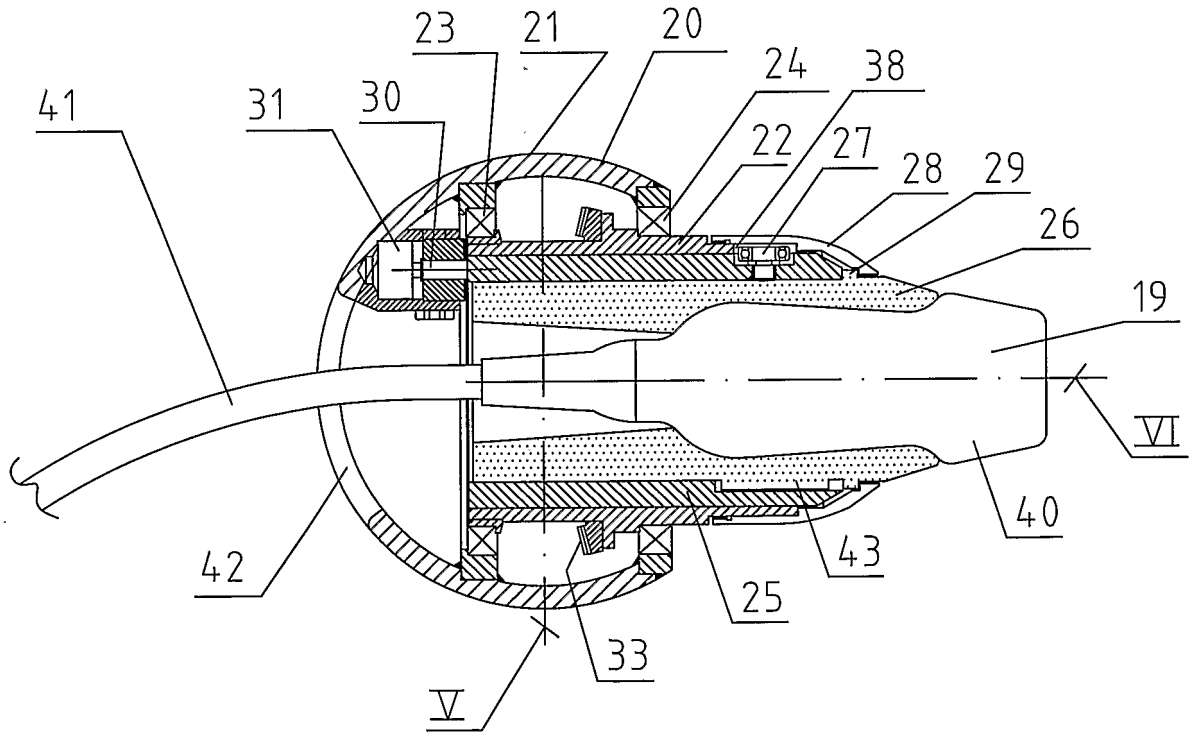

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/001492

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A61B 8/00, B25J 19/04
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)

IPC7: A61B, B25J

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-INTERNA, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y		2-11
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Y	WO 9747441 A1 (ASEA BROWN BOVERI AB), 18 December 1997 (18.12.1997), figure 1	1-11
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Y	WO 2004016401 A1 (ABB AB), 26 February 2004 (26.02.2004), figures 1,2	1-11
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Y	US 6325760 B1 (S. TAKANORI ET AL), 4 December 2001 (04.12.2001), figure 5	1,2-4,6,10, 11
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[X] Further documents are listed in the continuation of Box C. [X] 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 application or patent but published on or after the international filing date
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"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
24 May 2005	24 -05- 2005
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Lars Jakobsson / MRo Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/001492

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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专利名称(译)	超声波检查机器人		
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其他公开文献	EP1804668B1		
外部链接	Espacenet		

摘要(译)

一种用于医学超声波检查的机器人包括：多关节机器人臂，其具有多个臂单元（14-16），所述臂单元一个接一个地安装在另一个上以便可枢转，以及用于控制臂的运动的计算机化系统，最外面的臂单元（16）被安排来携带探针（40）。最外面的臂单元（16）具有可绕其纵向轴线（IV）转动的承载构件（17），并且承载探针保持器（20），该探针保持器（20）可绕垂直于所述纵向轴线的横向轴线（V）枢转。探针支架（20）包括可绕所述横向轴线枢转的壳体（21）和可绕其纵向轴线（VI）转动的保持器套筒（25），并且所有三个轴线（IV，V，IV）相交。探头支架（20）具有侧向开口，当探头安装时，来自探头（40）后端的电缆（41）延伸穿过该侧向开口，并且承载构件允许探头插入穿过侧孔并且从探头支架的后部进入探头支架。