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(54) **Magnetic resonance and ultrasound imaging apparatus**

Magnetresonanz- und Ultraschallbildgebungsgerät

Appareil d'imagerie par résonance magnétique et ultrasons

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- **PATENT ABSTRACTS OF JAPAN vol. 1997, no. 08, 29 August 1997 (1997-08-29) & JP 09 094233 A (OLYMPUS OPTICAL CO LTD), 8 April 1997 (1997-04-08)**
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EP 1 286 172 B1

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## Description

**[0001]** The invention relates to an imaging apparatus according to the preamble of claim 1.

**[0002]** As is known, MRI examinations are often combined with the use of various tools, which may consist of diagnostic assistance instruments or of therapeutic instruments. This may be the case, for instance, of shoulder dedicated MRI apparatuses, wherein contrast agents are often to be injected in the region under examination. The perfusion of said contrast agents shall be as accurate as possible and requires a critical time selection, which may not be easy, especially due to the anatomic peculiarities of the shoulder which, as is known, is a very complex anatomic region, especially when said operations are carried out in a wholly manual manner. In this case, the success of these operations only depends on the skills and expertise of the operator. Any error in the selection of the injection point and/or of the needle orientation, or a poor synchronization with MRI operations may lead to less than optimal images and require a new injection. In particular cases, this may even cause damages to tissues. Similar or even more serious difficulties may be encountered when the MRI apparatus is used in combination with other types of diagnostic and/or therapeutic tools, to be further mentioned hereafter in the description.

**[0003]** Document EP 1090 594 and US 5,706,812 discloses an MRI apparatus having an RF receiving coil comprising means for supporting a therapeutic tool such as a syringe or a needle.

**[0004]** The supporting means helps in correctly aiming the tool against the zone to be treated while the imaging apparatus helps in viewing the tool and the part where the tool acts for better controlling the position, the orientation and the effect of the tool.

**[0005]** Document WO01/01845 discloses systems and methods for medical diagnostic and for medical guided interventions using medical imaging systems. These systems and methods enable to combine information available from two or more medical imaging apparatus in medical diagnosis and in image guided surgery and therapy. Particularly these methods enable to minimize mechanical constraints involved in a cooperative operation of several medical scanning devices. The apparatus and methods are based on using localizing devices comprising attachable position measuring components thus enabling to perform image guided medical interventions by calculating the position of a medical tool with respect to the image produced by the medical imaging device and/or with respect to the patient. These localizing devices enable to perform frameless stereotactic procedures anywhere in the body assisted by images produced by CT, MRI, X-Ray or other medical imaging devices. The methods and apparatus enable to position a second medical imaging device over a desired area/volume according to information received from the image produced by the first medical imaging device. Additionally the apparatus and methods facilitate image fusing when images of the same plane/volume are available from different medical imaging systems.

**[0006]** Document JP-A-09-094233 discloses a treatment apparatus capable of bringing an MR signal detecting coil as closely as possible to a region of human body to be MR photogragh-examined and simplifying the whole operation system including MRI apparatus. The apparatus comprises an MRI apparatus for obtaining a magnetic resonance tomographic image in the body of a patient and is provided with a fixing member capable of closely approaching and fixing to a region of the body and a receiving coil for receiving the magnetic resonance signal from the body is disposed on the fixing member.

**[0007]** Document EP1090594 discloses a puncture needle support tool comprising a base member attached to an RF coil of an MRI apparatus, a slider attached to the base member movably in parallel to the axis of the RF coil, and a puncture needle guide having a puncture needle through hole and an MR marker disposed in parallel to the through hole, capable of linearly moving in a direction perpendicular to the sliding direction on the slider and of rotatively moving in a plane perpendicular to the axis of the RF coil.

**[0008]** Document WO 01/43640 discloses a magnetic resonance imaging system which comprises a receiver antenna for picking-up magnetic resonance signals and an ultrasound probe for receiving ultrasound echoes. A reconstruction unit is arranged to reconstruct a diagnostic image from the magnetic resonance signals and the ultrasound echoes. The magnetic resonance image and ultrasound images are registered in a common reference frame and geometric distortions in the ultrasound image are corrected on the basis of the magnetic resonance image. Information contained in the magnetic resonance signals can be displayed in combination with information contained in the ultrasound echoes.

**[0009]** Although the known devices according to the above mentioned documents works, there are some tools and some tissue which depending on the kind of material or of tissue and form the shape of the tool or the structure of the tissue are not well imaged by the MRI apparatus.

**[0010]** Therefore, this invention has the object of improving the imaging capability of the imaging apparatus for better viewing the part of the body to be treated and the tool which is used, by collecting more or better information thus improving the performances of the imaging apparatus and the precision of positioning and orienting the tool. Particularly, there is the need to define in a reliable manner the position and the orientation of the diagnostic and/or therapeutic instrument, whose use is provided in combination with MRI, in relation to the particular anatomy of the region under examination and to the anatomy of the individual patient, and to obtain an optimized synchronization between the various diagnostic and/or therapeutic times, or anyway a better synchronization than is currently possible.

**[0011]** The invention achieves the above purposes by providing an apparatus according to the combination of

the features of the preamble and of the characterizing part of claim 1.

**[0012]** The supporting and/or guiding means for the ultrasound probe and for the tool may be integrated in a unique element or may be separate and independent one form the other.

**[0013]** The apparatus may include a receiving coil case made of a material which does not interfere with Magnetic Resonance signals, generally plastic, whereon the probe and the tool supporting and guiding means are supported. This arrangement allows to reduce the total size of the apparatus and provides a considerable construction simplification. This also allows an easier location of the probe and of the diagnostic or therapeutic instrument at least partly inside the MRI volume.

**[0014]** Said supporting and guiding means may be provided in an external or internal position relative to the case of the receiving coil.

**[0015]** The supporting and guiding means may have for the probe and/or for the tool one, two but preferably at least three degrees of freedom with respect to the case of the receiving coil, in such a manner as to allow to accurately aim at the region of interest.

**[0016]** The tool and the probe may be independent or they may be movable together at least for some of the degrees of freedom provided.

**[0017]** The supporting and guiding means may be of such a type as to allow the probe and the diagnostic or therapeutic tool to be displaced in their axial direction independently one from the other or together.

**[0018]** According to an improvement, the supporting and guiding means may be of such a type as to allow the probe and the tool to be displaced independently one from the other or together in one or more directions transverse to each other and to the axial direction, particularly in three perpendicular directions, i.e. oriented in space along three Cartesian axes.

**[0019]** In accordance with a further improvement, these supporting and guiding means may be of such a type as to allow the probe and the tool to be swung/tilted independently one from the other or together in at least one plane containing the axis of the tool and/or of the probe, but may be further improved in such a manner as to allow the probe and the tool to be swung/tilted independently or together in at least two non parallel, i.e. transverse planes, which contain the axis of the tool and/or of the probe.

**[0020]** A preferred arrangement provides that these supporting and guiding means are of such of type as to allow the probe and/or the tool to be tilted in all directions independently one from the other or together.

**[0021]** According to a highly advantageous improvement, this housing hole may accommodate an interchangeable element allowing adaptation to the type of probe and/or of tool in use from time to time.

**[0022]** This adapter element may consist of a sleeve, wherein the probe and/or the tool, particularly an injection syringe, is introduced, the sleeve having such an internal size as to allow the probe and/or the tool to slide in its axial direction.

**[0023]** According to yet another improvement, the probe and/or the tool may have one or more slides for axial slidable engagement in corresponding guides provided on the inner surface of the probe and/or the tool housing hole or sleeve, or vice versa.

**[0024]** Advantageously, the probe and/or the tool housing hole or the probe and/or the tool-holding sleeve may be formed in a supporting member which is displaceable in one, two, but preferably three directions transverse, particularly perpendicular to each other, i.e. oriented in space along three cartesian axes, one of which corresponding to the axial direction of the probe and/or the tool. The displacements of the probe and of the tool according to only some or all of the direction provided may be carried out independently for the probe and for the tool or the two parts execute at least some of the said displacements together.

**[0025]** The probe and/or the tool supporting members may be fastened on a first carriage for axial slidable engagement of the probe and/or of the tool on at least one first guide.

**[0026]** This first guide may be carried by a second carriage which is slidably engaged in a direction perpendicular to the probe and/or to the tool axis on at least one second guide, which in turn may be carried by a third carriage which is slidably engaged on at least one third guide, the latter being fastened to the coil case, in another direction, perpendicular both to the first direction and to the probe and/or to the tool axis.

**[0027]** A highly advantageous improvement provides that the probe and/or the tool supporting member has means for swinging or tilting the probe and/or the tool axis relative to a predetermined direction, particularly a substantially vertical direction relative to the body part under examination.

**[0028]** These tilting means may consist of a swinging suspension element, particularly a spherical element, wherein a probe or a tool housing hole is formed, which element is housed in a corresponding spherical seat provided inside the supporting member.

**[0029]** The probe and/or the tool may be displaced manually, or alternatively motor driven, manually controlled displacing means may be provided for one or more displacements, which means may be of the mechanical, electrical, electromechanical, pneumatic and/or hydraulic type.

**[0030]** These motor driven means may consist of at least one combination, for each type of displacement, of a motor driven pinion and of a corresponding rack, or of any other means being suitable for the purpose.

**[0031]** The diagnostic or therapeutic functions of the tool and/or the functions of the probe may be operated manually, or automatic, manually controlled operation means may be provided.

**[0032]** Automatic control means may be also provided for displacing and/or operating the probe and/or the tool.

**[0033]** These control means may consist of one or more software programs loaded in a control unit which, after displaying and interpreting an acquired image, controls in a predetermined manner the tilt and/or displacement of the probe and/or of the tool and/or the operation of the diagnostic or therapeutic functions thereof.

**[0034]** The diagnostic or therapeutic tool may consist of a syringe or a needle for injecting contrast agents.

**[0035]** Advantageously, automatic means for pushing the syringe plunger or for automatically supplying the needle with an appropriate dose of a diagnostic or therapeutic substance drawn from an external tank through an appropriate tube.

**[0036]** An additional diagnostic or therapeutic tool may consist of a biopsy needle, and/or a microwave and/or RF antenna and/or a cryotherapy probe and/or an infrared probe, and/or a surgical tool, particularly a curet or suction tool and/or any other diagnostic and/or therapeutic tool whose action may be required in combination with the MRI apparatus.

**[0037]** A particular kind of additional therapeutic tool may consist of an additional ultrasound (US) probe for irradiating anatomic parts with sound. As is known, a type of ultrasounds may be used for a therapeutic purposes, for instance by using the potential destructive action thereof on neoplastic tissues or the like.

**[0038]** A particular advantage of the combination of an MRI imaging apparatus with an ultrasound imaging apparatus results from the following. MRI sequences may be very long, whereby advantages may be obtained from using ultrasound imaging to orient the tool, particularly an injection needle. Once the latter is in the proper position, the ultrasound probe may be disabled, the contrast agent may be injected, and the MRI excitation sequences may be initiated, followed by tissue transmitted sequences.

**[0039]** The ultrasound probe may be displaced and/or operated manually, or there may be provided, wholly or partly, displacing and/or operating means like those described above, which may assist the operator in aiming operations even for the ultrasound probe.

**[0040]** The apparatus according to the invention is a so-called combined apparatus, i.e. used for Magnetic Resonance imaging and ultrasound imaging, particularly operating in a time-sharing mode, which allows to optimize the functions of electronic image processing means.

**[0041]** According to an advantageous improvement, the ultrasound probe may include means for detecting the position of the probe by MRI, so that the position of the individual ultrasound scan sections may be defined relative to MRI images and that the desired relations between the two image types may be established.

**[0042]** Moreover, the means for supporting and/or displacing the ultrasound probe and/or the probe itself may have analog or digital, mechanical, electromechanical, electronic or optoelectronic means for detecting the position of the ultrasound probe relative to the anatomic part under examination and/or to the Magnetic Resonance imaging volume.

**[0043]** The advantages of this invention are self-evident from the above, and consist in that a stable structure is provided for supporting a diagnostic or therapeutic tool, viz. a syringe or a needle, and a ultrasound probe, which may assume and maintain more easily a defined position relative to the part of the body under examination. By this arrangement, the injection may be performed in a much more accurate manner and with no risk for the patient, especially when compared to manual displacement of the syringe or needle. Thanks to the inventive apparatus, both the anatomy of the region under examination and the image of the needle may be simultaneously displayed, whereby it is possible to get closer to the region of interest, and to avoid a repeated injection or even damages. The possibility of integrating mechanical instrument displacement and/or orientation mechanisms further simplifies the operator's task, whereas a wholly automatic control of the orientation and introduction of the needle may be provided, with specific injection times to improve the synchronization between contrast agent perfusion in the region under examination and imaging. It is also possible to evaluate very accurately not only the position but also the intensity of perfusion. The possibility of also integrating an ultrasound probe considerably increases the versatility of the apparatus.

**[0044]** Further characteristics and improvements form the subject of the dependent claims.

**[0045]** Further characteristics and advantages of the invention will appear more clearly from the following detailed description of the annexed figures, in which:

Figure 1 shows a sectional view of an apparatus of this invention having a first type of receiving coil, with the patient in the MRI examination position.

Figures 2 and 3 are two different perspective views of a second type of receiving coil according to the invention and being associated to a supporting member for an ultrasound probe and for a diagnostic or therapeutic tool.

Fig. 4 is a sectional view of the area of the receiving coil as shown in Fig. 1 and having means for supporting an injection syringe.

Fig. 5 shows an enlarged detail of the syringe supporting portion according to the embodiment of Fig. 4.

Fig. 6 shows a receiving coil having a double support for a needle and an ultrasound probe for a combined MRI/US apparatus according to this invention.

Fig. 7 is a sectional enlarged view of the needle supporting housings for the needle and the ultrasound probe according to the coil of Fig. 6.

Fig. 8 is a sectional view of the syringe supporting portion, having a slide for translating the syringe and means for tilting the syringe.

Fig. 9 is the same view as Fig. 8, the syringe being oriented with a different tilt angle with respect to Fig. 8.

Fig. 10 is the same view as Figs. 7 and 8, the coil having syringe tilting and translating means and dosing means for directly and automatically supplying the syringe.

Figs. 11 and 12 show top plan views of further embodiments of a receiving coil, with two types of translating guides for the support member for the ultrasound probe and for the diagnostic or therapeutic tool.

Fig. 13 is the same view as Fig. 10, motor driven means being provided for displacing and orienting the syringe.

**[0046]** Referring to Fig. 1, a dedicated combined MRI imaging and ultrasound imaging apparatus of this invention is shown. The example illustrated and described is particularly related to the examination of the shoulder. As is known, the above mentioned dedicated type of apparatus has the advantage of a relatively low cost and of a considerable comfort, versatility and ease of use and installation, particularly when compared with larger apparatuses. This apparatus for imaging a part of a body C under examination comprises a magnetic structure 1 having at least two opposite poles which define an intermediate cavity, between which a static magnetic field is generated in a predetermined imaging volume of said cavity. The cavity may be accessed from one or more openings of the magnetic structure 1. The body part under examination is inserted in the cavity with the region to be examined passing through the imaging volume. The apparatus further includes at least one transmitting coil, having the purpose of sending a sequence of Radio Frequency nuclear spin exciting electromagnetic pulses in a predetermined order, and at least one receiving coil 2 which records the nuclear emissions relative to the transmitted electromagnetic pulses.

**[0047]** As is known, due to the low intensity of the MRI signals transmitted by nuclei, the receiving coil 2 must have such a size and a shape as to be as close as possible to the body part under examination. The receiving coil 2 includes an external covering and finishing case. This case is made of a material which does not interfere with MRI, generally plastic. The coil 2 may be further provided with a bearing and supporting pedestal 402.

**[0048]** In Figs. 1 to 6 and 11, 12 variously shaped receiving coils 2 designed for the shoulder are shown. In Figs. 1 and 4, the receiving coil 2 is arranged to have a C shape, i.e. open on one side for an easy introduction of the shoulder under examination, whereas in Figs. 2, 3 to 6 and 11, 12 the coil 2 is made of a strap-shaped element having an essentially annular section, which requires the arm to be inserted therein to allow the coil 2 to reach the shoulder. In Fig. 2, the coil 2 is a substantially annular strap-shape element, which is additionally curved according to an axis perpendicular to the axis of the annular element. The coil 2 is applied on the shoulder in the same manner as the coil 2 of Fig. 1.

**[0049]** As widely described in the introduction, this invention provides that the coil 2 is provided with means for supporting a diagnostic or therapeutic tool and an ultrasound probe 22 of an ultrasound imaging apparatus combined with the MRI apparatus. Ultrasound imaging systems, send ultrasound pulses in a region under examination and collects the reflected ultrasound pulse. This reflected pulses carry information about the reflectors which are retrieved form the reflected pulses and transformed in image data that are printable on a monitor screen.

**[0050]** A wide variety of instrument types to be associated to the receiving coil 2 has been mentioned above. In the drawings, this instrument consists of an injection syringe 3, particularly for injecting contrast agents, which shall be only intended as a nonlimiting example.

**[0051]** In the drawings may examples and embodiments of the supporting means having different features are shown with reference to the therapeutic tool, i.e. to the syringe. The invention is to be understood that for sake of simplicity the same means may be used in combination with the ultrasound probe also if this means have not been illustrated separately in combination with the probe, since this would consist in an unnecessary repetition of the features already disclosed in combination with the syringe.

**[0052]** In accordance with the invention, the supporting means for the probe 22 and for the tool consist of a through hole 4 formed in the case of the coil 2 or in an external extension 302 thereof, and designed to accommodate each one respectively the syringe and the probe 22. These holes 4 may be formed in any position, particularly in an end portion, in the case of the C-shaped coil 2 and a median portion, in the case of the two annular coils 2. These through holes 4 have such an internal size as to allow the syringe 3 and the probe 22 to be inserted in the corresponding hole 4 and to slide in the axial direction. Relating to the syringe the axial displacement allows the needle 5 to penetrate the body C under examination. Relating to the probe the axial displacement allows the probe to be brought in contact with the surface to be investigated also by ultrasound waves. In practice, in most cases, the holes will have a circular section with a slightly greater diameter than the diameter of the syringe body 3 and of the probe 22. Anyway, these holes 4 are an effective means for supporting and guiding the syringe 3 and the probe 22 and a good help for the operator. When the needle 5 of the syringe 3 is inside the imaging volume of the receiving coil 2, the aiming operations will be further facilitated by the possibility of simultaneously viewing the MRI images and the ecographic images of the tissues and of the needle 5.

**[0053]** According to an improvement, these through holes 4 may accommodate an interchangeable element for adaptation to the tool type and to the probe type which are to be used from time to time. The interchangeable elements may be a sleeve 6 wherein the syringe 3 and the probe 22 are introduced (Figs. 6, 7). Obviously, the sleeves 6 have such an internal size and shape as to fit

to the syringe 3 and to the probe 22. Furthermore the internal size and shape of the sleeves 6 is such as to allow the syringe 3 and/or the probe 22 to slide in their axial direction. The syringe 3 may slide freely inside the hole formed in the case or in the sleeve 6, or with the help, for instance, of a combination of slides and guides provided on the outer surface of the syringe body 3 and on the inner surface of the hole 4 respectively, or vice versa. Alternatively or in combination, this construction may be provided also for the probe 22.

**[0054]** In the embodiment as shown in Fig. 7, means are provided for tilting the syringe 3 and the probe 22 substantially in all directions turned toward the body part under examination and in a substantially vertical direction relative to the latter, for the purpose of improving the possibilities to aim the needle 5 and the probe 22. These means consist of a spherical element 7, 7' which acts as a swinging suspension element housed in a corresponding spherical seat 108 formed inside the thickness of the case, but preferably inside a support element 8 which is in turn attached as an extension to the case of the receiving coil 2. This spherical elements 7, 7' have a through hole 4 for the syringe 3 and for the probe 22 to be introduced and slide therein. Alternatively, any other swinging suspension element may be provided, for instance a gimbal which, as is known, is a joint with two perpendicular oscillation axes, allowing motion in all directions. According to an improvement, members may be provided to restrict the rotation of the elements 7, 7' inside the seat 108, e.g. small pads having such a construction as to generate a variable friction or one or more locking elements, or the like.

**[0055]** Motor driven means may be further provided allowing the syringe 3 and/or the probe 22 both to slide and be tilted (Fig. 13). This means are illustrated only with respect to the syringe 3 but may be provided alternatively or at the same time also for the probe 22, the construction of the above mentioned means being essentially identical also for the probe 22. In the first case of the said motor drive means, there is provided a combination of at least one motor driven pinion 9 and at least one corresponding rack-like linear set of teeth, arranged axially on the outer surface of the syringe 3 or possibly of the sleeve 6 in which the syringe 3 and/or the probe 22 is held. In the latter case, an advantageous arrangement consists in that the syringe 3 and/or the probe 22 are secured in the sleeve 6, e.g. by means which prevent it from projecting on the side toward the patient C, which may consist, for instance, of a suitable annular flange 106, which causes the diameter of the sleeve 6 to narrow at its end turned toward the patient C. Regarding the displacement of the spherical elements 7, 7' two rubber tracks may be provided on the surface thereof, each following half-meridians corresponding to perpendicular planes, whereon a small wheel splined on a driving motor or a gear 11 for engagement of a rack 107' shaped like a sector of a sphere 7, 7' rotates. Obviously, several other mechanical displacement arrangements, widely known per se, may be provided as an alternative thereto or in combination therewith.

**[0056]** With reference to Fig. 13, the supporting element 8 is provided with means allowing displacement in two directions which are substantially perpendicular to each other and to the axis of the syringe 3 when the latter is not in the tilted condition. The displacement in the first direction, which is substantially radial with respect to the peripheral edge of the case is obtained by fitting the supporting element 8 at the external end of a carriage 12, particularly having a tubular shape, which is slidably engaged on guides 13. This movement may be motorized by providing a worm 14 which acts on an internally threaded bush 15, integral with the carriage 12. This bush 15 may be linked to a driving motor which causes the worm 14 to rotate and the carriage 12 to translate. The movement in the second direction which, as shown in Figs. 11 and 12, may be a substantially coincident or parallel direction with respect to the peripheral edge of the case or in a direction corresponding to a line secant or tangent to said edge, is obtained by arranging the guides 13 to be in turn carried by an additional carriage 16 slidably engaged on an additional pair of guides 17 provided within a supporting element 18 attached to the peripheral edge. It shall be understood that all the above mechanical displacement arrangements are only provided by way of example, any other prior art arrangement being allowed.

**[0057]** All the guides illustrated herein, and particularly the translation guides 17 may be integrated in a hidden manner within the structure of the case of the receiving coil 2, as shown by the coils of Figs. 2 and 3. Here, a slit allows the passage of a stirrup for connection with the carriage or the slide, sliding on the guide which follows the edge of the receiving coil.

**[0058]** In Figs. 10 and 13, the diagnostic tool is an injection needle 23, particularly for injecting contrast agents. At the upper end, this has an element 19 for connection to a tube 20 linked to automatic dosing means 21 for supplying with a predetermined pressure the desired dose of contrast agent.

**[0059]** In Fig. 6, the guiding principle is shown as applied to a combined apparatus for simultaneous Magnetic Resonance and Ultrasound imaging. Each of the above diagnostic techniques has its own peculiar characteristics and is particularly suitable for imaging certain specific anatomic structures. The combined apparatuses tend to integrate both technologies, while trying to obtain as great an advantage as possible from each of them, for the purpose of obtaining as good a diagnostic image as possible, thanks to a good integration of the two images. Moreover, they generally allow to precisely detect the position of the ultrasound probe 22 with respect to the MRI volume, both to obtain the desired appropriate integration of the two images and to focus with a high accuracy the transmission of ultrasounds.

**[0060]** There may also be a further ultrasound probe used as an ultrasound source for emitting ultrasound energy having surgical or therapeutic action, for instance

for the destructive action they can exert on neoplastic tissues or the like.

**[0061]** In figures 6 and 7 a syringe 3 for injecting contrast agents and an ultrasound probe 22, particularly for irradiating a shoulder with sound, are provided in an support element 8 which is appropriately oversized as compared with the one described above. Obviously the seat for the probe 22 shall be adapted to the conformation thereof. The ultrasound probe 22 itself is provided with means 7' which allow it to be tilted, whereas translation is performed by means shared by the two instruments and like those described above. Obviously, the probe may be arranged to be either of the manual operation and displacement type, or provided with its own separate means for displacement thereof towards the part C under examination, distinct from those of the syringe 3. The signals from the ultrasound probe 22 and the receiving coil 2 may be advantageously processed with the well-known time sharing procedure which, as is known, provides that the electronic means for processing the received signals and for constructing a digital image formed by an array of pixels are at least partly the same for Magnetic Resonance signals and Ultrasound signals, particularly as regards equal imaging functions. These programs are executed alternately based on the type of corresponding received signal being processed from time to time.

**[0062]** It shall be noted that the means 8 for supporting the probe 22 may be such that the latter is at least partly located inside the MRI volume. This allows to integrate means for detecting the position of the probe 22 which may consist, for instance of one or more marking elements provided on the probe and recognizable by MRI.

**[0063]** It shall be also noted that the needle and the ultrasound probe may be supported in a simultaneous and substantially identical manner by one or more of the arrangements provided in this description as regards the needle only and in any combination or subcombination thereof.

**[0064]** The ultrasound probe and the needle may be simultaneously supported in such a manner as to allow said two devices to be displaced with independent degrees of freedom or to only allow them to be displaced together with no possibility to change their relative position. To this end, the embodiment of Figs. 6 and 7 only allows the needle and the probe to be tilted in different manners. An additional example may consist in providing a construction as shown in Figs. 2, 3 and 11 and 12, wherein the same supporting member may be arranged to carry the needle and the probe, the needle and the probe being only allowed to be displaced along the guide together and not independently from each other. Alternatively as shown by the dotted line indicated by the number 602 at least one additional movable probe supporting member is provided, which is displaced, for instance, along the same translation guide for the needle support, but is wholly independent and unlinked from the needle supporting member.

## Claims

**1.** An imaging apparatus for combined magnetic resonance imaging and ultrasound imaging, the apparatus comprising:

a magnetic resonance imaging apparatus with at least one transmitting coil having the purpose of sending a sequence of radio frequency nuclear spin exciting electromagnetic pulses in a predetermined order for exciting the matter of a body (C) under examination and at least one coil (2) for receiving the signals transmitted by the said body under examination caused by the said radio frequency nuclear spin exciting electromagnetic pulses;
electronic means for processing said received signals to create a diagnostic image;
wherein the receiving coil is a freestanding annular or C-shaped coil designed to surround a human body part like, for instance, the shoulder; and wherein
the receiving coil (2) is provided with a case having a peripheral edge;
an ultrasound imaging apparatus having
an ultrasound transmitting and receiving probe (22) for sending ultrasound pulses and collecting the reflected ultrasound pulses;
electronic means for driving the probe and for reconstructing an image from the received ultrasound pulses;
means for supporting and guiding the said probe (22) for allowing the probe to be brought in contact with the surface of the said body under examination;
the probe having a cylindrical shape and the means for supporting and guiding the said probe (22) consisting of a through hole (4) formed in the case of the receiving coil (2) or in an extension (302) at the peripheral edge of the said case;
the said through hole (4) having a diameter slightly greater than the diameter of the probe (22) for inserting the probe (22) in it and for sliding the probe (22) in the said hole (4) in the axial direction of the probe (22);
at least one further diagnostic or therapeutic tool (3, 23) which consists of a syringe having cylindrical shape or of a needle; and
means for supporting and guiding the said at least one further diagnostic or therapeutic tool which consist of a through hole (4) formed in the case of the receiving coil (2) or in an extension (302) at the peripheral edge of the said case;
the said through hole (4) having a diameter slightly greater than the diameter of the said syringe or needle (3, 23) for inserting the syringe or the needle (3, 23) in it and for sliding the sy-

ringe or needle (23) in the said hole (4) in the axial direction of the said syringe or needle (3, 23);
the said holes (4) for supporting and guiding respectively the said probe (22) and the said syringe or needle (3, 23) being oriented with their axis against the body under examination within the receiving coil (2).

**2.** An apparatus as claimed in claim 1, wherein the ultrasound probe and the diagnostic or therapeutic tool are supported in such a manner as to allow said two devices to be displaced with independent degrees of freedom or to only allow them to be displaced together with no possibility to change their relative position.

**3.** An apparatus as claimed in claim 1 or 2 in which an interchangeable adapter sleeve (6) is provided into which said syringe (3) and said probe (22), respectively, are introduced, the said sleeve (6) being accommodated in the corresponding through hole (4) and having such an internal size and such an internal shape as to fit to the said syringe (3) and to the said probe (22), respectively, and to allow the syringe (3) and the probe (22), respectively, to slide in the axial direction.

**4.** An apparatus as claimed in one of the preceding claims, in which the said therapeutic or diagnostic tool (3, 23) and/or the probe (22) has one or more slides for axial slidable engagement in corresponding guides provided on the inner surface of the through hole (4) or of the sleeve (6).

**5.** An apparatus as claimed in one of the preceding claims, in which the extensions (302) at the peripheral edge of the said case of the receiving coil (2) in which extensions the through holes (4) for housing the tool (3, 23) and the probe (22), respectively, are provided comprise a supporting member which is displaceable relatively to the case of the receiving coil (2) in one, two, or three directions perpendicular to each other, i.e. oriented in space along three cartesian axes, one of which corresponding to the respective axial direction of the tool (3, 23) and of the probe (22).

**6.** An apparatus as claimed in claim 5, in which the supporting member for supporting the tool (3, 23) and the supporting member for the probe (22) are fastened to a respective first carriage for axial slidable engagement of the tool and the probe, respectively, on at least one first guide.

**7.** An apparatus as claimed in claim 6, wherein said first guide is carried by a second carriage (12) which is slidably engaged in a first direction perpendicular to the axis of the tool (3, 23) or of the probe (22) on at least one second guide (13).

**8.** An apparatus as claimed in claim 7, wherein the second guide (13) is carried by a third carriage (16) which is slidably engaged on at least one third guide (17), fastened to the case of the coil (2), in another direction, perpendicular both to the first direction and to the axis of the tool (3, 23) or of the probe (22).

**9.** An apparatus as claimed in one of the preceding claims, in which the means for supporting the tool (3, 23) or the probe (22) has means (7, 7', 108) for swinging or tilting the axis of the tool (3, 23) or of the probe (22) relative to a vertical direction relative to the body part under examination.

**10.** An apparatus as claimed in claim 9, **characterized in that** said tilting means consist of a swinging suspension element, particularly a spherical element (7, 7'), wherein the said through hole (4) for housing the tool (3, 23) or the probe (22) is formed, which swinging suspension element (7, 7') is housed in a corresponding spherical seat (108) provided inside the supporting means.

**11.** An apparatus as claimed in one of the preceding claims, **characterized in that** the tool (3, 23) and/or the probe (22) are displaced by motor driven, manually controlled displacing means (9, 10, 11), which means may be of the mechanical, electrical, electromechanical, pneumatic and/or hydraulic type.

**12.** An apparatus as claimed in claim 11, **characterized in that** said motor driven means consist of at least one combination, of a motor driven pinion (9) and of a corresponding rack (10).

**Patentansprüche**

**1.** Bildgebungsvorrichtung für kombinierte Magnetresonanz-Bildgebung und Ultraschall-Bildgebung, wobei die Bildgebungsvorrichtung aufweist:

eine Magnetresonanz-Bildgebungsvorrichtung mit mindestens einer Sendespule zum Senden einer Sequenz hochfrequenter elektromagnetischer Kernspinerregungs-Impulse in vorbestimmter Reihenfolge zwecks Erregung der Materie eines zu untersuchenden Körpers (C), und mindestens einer Spule (2) zum Empfangen der von dem untersuchenden Körper ausgesendeten Signale, die durch die hochfrequenten elektromagnetischen Kernspinerregungs-Impulse verursacht werden;
eine elektronische Vorrichtung zum Verarbeiten der empfangenen Signale, um ein diagnosti-

sches Bild zu erzeugen;
wobei die empfangende Spule eine freistehende ringförmige oder C-förmige Spule ist, die zum Umgeben eines menschlichen Körperteils wie z.B. der Schulter ausgebildet ist; und wobei
die empfangende Spule (2) mit einem Gehäuse versehen ist, das einen Umfangsrand aufweist,
eine Ultraschall-Bildgebungsvorrichtung mit
einer Ultraschall-Sende- und Empfangssonde (22) zum Senden von Ultraschall-Impulsen und zum Aufnehmen der reflektierten Ultraschall-Impulse;
einer elektronischen Vorrichtung zum Steuern der Sonde und zum Rekonstruieren eines Bilds aus den empfangenen Ultraschall-Impulsen;
einer Vorrichtung zum Halten und Führen der Sonde (22), so dass die Sonde in Kontakt mit der Oberfläche des zu untersuchenden Körpers gebracht werden kann;
wobei die Sonde eine zylindrische Form hat und die Vorrichtung zum Halten und Führen der Sonde (22) aus einer Durchgangsöffnung (4), die in dem Gehäuse der empfangende Spule (2) ausgebildet ist, oder aus einem Vorsprung (302) am Umfangsrand des Gehäuses besteht;
wobei die Durchgangsöffnung (4) einen Durchmesser hat, der etwas größer ist als der Durchmesser der Sonde (22), damit die Sonde (22) in sie eingeführt werden kann und die Sonde (22) in Axialrichtung der Sonde (22) in der Öffnung (4) verschoben werden kann;
mindestens einem weiteren diagnostischen oder therapeutischen Instrument (3, 23), das aus einer zylinderförmigen Spritze oder aus einer Nadel besteht; und
einer zum Halten und Führen des mindestens einen weiteren diagnostischen oder therapeutischen Instruments vorgesehenen Vorrichtung, die aus einer Durchgangsöffnung (4), welche in dem Gehäuse der empfangende Spule (2) ausgebildet ist, oder aus einem Vorsprung (302) am Umfangsrand des Gehäuses besteht;
wobei die Durchgangsöffnung (4) einen Durchmesser hat, der etwas größer ist als der Durchmesser der Spritze oder Nadel (3, 23), damit die Spritze oder Nadel (3, 23) in sie eingeführt werden kann und die Spritze oder Nadel (23) in Axialrichtung der Spritze oder Nadel (3, 23) in der Öffnung (4) verschoben werden kann;
wobei die Öffnungen (4) zum Halten und Führen der Sonde (22) bzw. der Spritze oder Nadel (3, 23) mit ihren Achsen gegen den in der empfangende Spule (2) angeordneten, zu untersuchenden Körper ausgerichtet sind.

**2.** Vorrichtung nach Anspruch 1, bei der die Ultraschallsonde und das diagnostische oder therapeutische Instrument derart gehalten sind, dass die beiden Vorrichtungen entweder mit unabhängigen Freiheitsgraden versetzt werden können oder nur zusammen ohne Möglichkeit einer Änderung ihrer Relativposition versetzt werden können.

**3.** Vorrichtung nach Anspruch 1 oder 2, bei der eine austauschbare Adapterbuchse (6) vorgesehen ist, in welche die Spritze (3) bzw. die Sonde (22) eingeführt werden, wobei die Buchse (6) in der entsprechenden Durchgangsöffnung (4) aufgenommen ist und eine derartige Innenbemessung und eine derartige Innenform hat, dass sie an die Spritze (3) bzw. die Sonde (22) angepasst ist und ein Gleiten der Spritze (3) bzw. der Sonde (22) in axialer Richtung erlaubt.

**4.** Vorrichtung nach einem der vorhergehenden Ansprüche, bei der das therapeutische oder diagnostische Instrument (3, 23) und/oder die Sonde (22) ein oder mehrere Gleitteile zum axialen Gleiteingriff in entsprechenden Führungen aufweist, die an der Innenfläche der Durchgangsöffnung (4) oder der Buchse (6) vorgesehen sind.

**5.** Vorrichtung nach einem der vorhergehenden Ansprüche, bei der die am Umfangsrand des Gehäuses der empfangenden Spule (2) ausgebildeten Vorsprünge (302), in denen die Durchgangsöffnungen (4) zur Aufnahme des Instruments (3, 23) bzw. der Sonde (22) vorgesehen sind, ein Halteteil aufweisen, das relativ zu dem Gehäuse der empfangenden Spule (2) in einer, zwei oder drei zueinander rechtwinkligen Richtungen versetzbar ist, d.h. in einem Raum entlang dreier kartesischer Achsen ausgerichtet ist, von denen eine der jeweiligen Axialrichtung des Instruments (3, 23) bzw. der Sonde (22) entspricht.

**6.** Vorrichtung nach Anspruch 5, bei der das Halteteil zum Halten des Instruments (3, 23) und das Halteteil für die Sonde (22) an einem jeweiligen ersten Träger zum axialen Gleiteingriff des Instruments bzw. der Sonde an mindestens einer ersten Führung angeordnet ist.

**7.** Vorrichtung nach Anspruch 6, bei der die erste Führung von einem zweiten Schlitten (12) getragen ist, der in einer rechtwinklig zur Achse des Instruments (3, 23) oder der Sonde (22) verlaufenden ersten Richtung in Gleiteingriff an mindestens einer zweiten Führung (13) angeordnet ist.

**8.** Vorrichtung nach Anspruch 7, bei der die zweite Führung (13) von einen dritten Schlitten (16) getragen ist, der in einer weiteren Richtung, die rechtwinklig sowohl zu der ersten Richtung als auch zu der Achse des Instruments (3, 23) oder der Sonde (22) verläuft, in Gleiteingriff an mindestens einer am Gehäuse der

Spule (2) befestigten dritten Führung (17) angeordnet ist,

**9.** Vorrichtung nach einem der vorhergehenden Ansprüche, bei der die Vorrichtung zum Halten des Instruments (3, 23) oder der Sonde (22) eine Vorrichtung (7, 7', 108) zum Schwenken oder Kippen der Achse des Instruments (3, 23) oder der Sonde (22) relativ zu einer Richtung aufweist, die vertikal zu dem zu untersuchenden Körperteil verläuft.

**10.** Vorrichtung nach Anspruch 9, **dadurch gekennzeichnet, dass** die Kippvorrichtung aus einem Schwenkaufhängungselement, insbesondere einem Kugelelement (7, 7') besteht, in dem die Durchgangsöffnung (4) zur Aufnahme des Instruments (3, 23) bzw. der Sonde (22) ausgebildet ist, wobei das Schwenkaufhängungselement (7, 7') in einem entsprechenden Kugelsitz (108) untergebracht ist, der in der Haltevorrichtung vorgesehen ist.

**11.** Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Instrument (3, 23) bzw. die Sonde (22) mittels einer motorgetriebenen, handgesteuerten Versetzungsvorrichtung (9, 10, 11) versetzt wird, die vom mechanischen, elektrischen, elektromechanischen, pneumatischen und/oder hydraulischen Typ sein kann.

**12.** Vorrichtung nach Anspruch 11, **dadurch gekennzeichnet, dass** die motorgetriebene Vorrichtung aus mindestens einer Kombination eines motorgetriebenen Ritzels (9) und einer entsprechenden Zahnstange (10) besteht.

**Revendications**

**1.** Appareil d'imagerie pour imagerie par résonance magnétique et imagerie par ultrasons combinées, l'appareil comprenant :

un appareil d'imagerie par résonance magnétique comportant au moins une bobine émettrice ayant pour fonction d'envoyer dans un ordre préfixé une séquence d'impulsions électromagnétiques d'excitation de spin nucléaire en radiofréquence pour exciter la matière d'un corps (C) soumis à examen et au moins une bobine (2) destinée à recevoir les signaux transmis par ledit corps soumis à examen provoqués par lesdites impulsions électromagnétiques d'excitation de spin nucléaire en radiofréquence ;
des moyens électroniques destinés à traiter lesdits signaux reçus afin de créer une image de diagnostic ;
dans lequel la bobine réceptrice est une bobine de forme annulaire ou en C, tenant librement, conçue pour entourer une partie de corps humain comme, par exemple, l'épaule ; et dans lequel
la bobine réceptrice (2) est pourvue d'un boîtier présentant un bord périphérique ;
un appareil d'imagerie par ultrasons comportant une sonde (22) émettrice et réceptrice d'ultrasons, destinée à envoyer des impulsions ultrasonores et à recueillir les impulsions ultrasonores réfléchies ;
des moyens électroniques destinés à diriger la sonde et à reconstruire une image à partir des impulsions ultrasonores reçues ;
des moyens destinés à porter et à guider ladite sonde (22) pour permettre à la sonde d'être amenée en contact avec la surface dudit corps soumis à examen ;
la sonde ayant une forme cylindrique et les moyens destinés à porter et à guider ladite sonde (22) consistant en un trou traversant (4) ménagé dans le boîtier de la bobine réceptrice (2) ou dans un prolongement (302) situé à l'endroit du bord périphérique dudit boîtier ;
ledit trou traversant (4) ayant un diamètre légèrement plus grand que le diamètre de la sonde (22) afin de permettre l'introduction de la sonde (22) dans celui-ci et de permettre le glissement de la sonde (22) dans ledit trou (4) suivant la direction axiale de la sonde (22) ;
au moins un autre instrument de diagnostic ou thérapeutique (3, 23) qui consiste en une seringue ayant une forme cylindrique ou en une aiguille ; et
des moyens destinés à porter à et guider ledit ou lesdits autres instruments de diagnostic ou thérapeutique qui consistent en un trou traversant (4) ménagé dans le boîtier de la bobine réceptrice (2) ou dans un prolongement (302) situé à l'endroit du bord périphérique dudit boîtier ;
ledit trou traversant (4) ayant un diamètre légèrement plus grand que le diamètre de ladite seringue ou aiguille (3, 23) afin de permettre l'introduction de la seringue ou aiguille (3, 23) dans celui-ci et de permettre un glissement de la seringue ou aiguille (3, 23) dans ledit trou (4) suivant la direction axiale de ladite seringue ou aiguille (3, 23) ;
lesdits trous (4) destinés à porter et à guider respectivement ladite sonde (22) et ladite seringue ou aiguille (3, 23) étant orientés avec leurs axes dirigés vers le corps soumis à examen à l'intérieur de la bobine réceptrice (2).

**2.** Appareil tel que revendiqué à la revendication 1, dans lequel la sonde à ultrasons et l'instrument de diagnostic ou thérapeutique sont portés d'une manière permettant auxdits deux dispositifs d'être dé-

placés avec des degrés de liberté indépendants ou ne leur permettant d'être déplacés qu'ensemble sans possibilité de changement de leur position relative.

**3.** Appareil tel que revendiqué à la revendication 1 ou 2, dans lequel il est prévu un manchon adaptateur (6) interchangeable dans lequel ladite seringue (3) et ladite sonde (22), respectivement, sont introduites, ledit manchon (6) étant logé dans le trou traversant (4) correspondant et ayant une telle taille intérieure et une telle forme intérieure qu'il peut s'adapter à ladite seringue (3) et à ladite sonde (22), respectivement, et qu'il permet à la seringue (3) et la sonde (22), respectivement, de glisser suivant la direction axiale.

**4.** Appareil tel que revendiqué dans l'une des revendications précédentes, dans lequel ledit instrument de diagnostic ou thérapeutique (3, 23) et/ou la sonde (22) présentent un ou plusieurs éléments de glissement en vue d'une venue en contact glissant axial dans des guides correspondants ménagés sur la surface intérieure du trou traversant (4) ou du manchon (6)

**5.** Appareil tel que revendiqué dans l'une des revendications précédentes, dans lequel les prolongements (302) situés à l'endroit du bord périphérique dudit boîtier de la bobine réceptrice (2), prolongements dans lesquels sont prévus les trous traversants (4) destinés à loger l'instrument (3, 23) et la sonde (22), respectivement, comprennent un élément de support qui est déplaçable par rapport au boîtier de la bobine réceptrice (2) suivant une, deux ou trois directions perpendiculaires l'une à l'autre, c'est-à-dire orientées dans l'espace suivant trois axes cartésiens, dont l'une correspond à la direction axiale respective de l'instrument (3, 23) et de la sonde (22).

**6.** Appareil tel que revendiqué à la revendication 5, dans lequel l'élément de support destiné à porter l'instrument (3, 23) et l'élément de support destiné à la sonde (22) sont fixés à un premier chariot respectif en vue d'une venue en contact glissant axial de l'instrument et de la sonde, respectivement, sur au moins un premier guide.

**7.** Appareil tel que revendiqué à la revendication 6, dans lequel ledit premier guide est porté par un deuxième chariot (12) qui vient en contact glissant suivant une première direction perpendiculaire à l'axe de l'instrument (3, 23) ou de la sonde (22) sur au moins un deuxième guide (13).

**8.** Appareil tel que revendiqué à la revendication 7, dans lequel le deuxième guide (13) est porté par un troisième chariot (16) qui vient en contact glissant sur au moins un troisième guide (17), fixé au boîtier de la bobine (2), suivant une autre direction, perpendiculaire à la fois à la première direction et à l'axe de l'instrument (3, 23) ou de la sonde (22) .

**9.** Appareil tel que revendiqué dans l'une des revendications précédentes, dans lequel les moyens destinés à porter l'instrument (3, 23) ou la sonde (22) comportent des moyens (7, 7', 108) destinés à permettre un basculement ou une inclinaison de l'axe de l'instrument (3, 23) ou de la sonde (22) par rapport à une direction verticale vis-à-vis de la partie de corps soumise à examen.

**10.** Appareil tel que revendiqué à la revendication 9, **caractérisé en ce que** lesdits moyens d'inclinaison consistent en un élément de suspension basculant, en particulier un élément sphérique (7, 7'), dans lequel est ménagé ledit trou traversant (4) destiné à loger l'instrument (3, 23) ou la sonde (22), lequel élément de suspension basculant (7, 7') est logé dans un siège sphérique (108) correspondant ménagé à l'intérieur des moyens de support.

**11.** Appareil tel que revendiqué dans l'une des revendications précédentes, **caractérisé en ce que** l'instrument (3, 23) et/ou la sonde (22) sont déplacés par des moyens de déplacement (9, 10, 11) entraînés par moteur et commandés manuellement, lesquels moyens peuvent être du type mécanique, électrique, électromécanique, pneumatique et/ou hydraulique.

**12.** Appareil tel que revendiqué à la revendication 11, **caractérisé en ce que** lesdits moyens entraînés par moteur consistent en au moins une combinaison d'un pignon (9) entraîné par moteur et d'une crémaillère (10) correspondante.

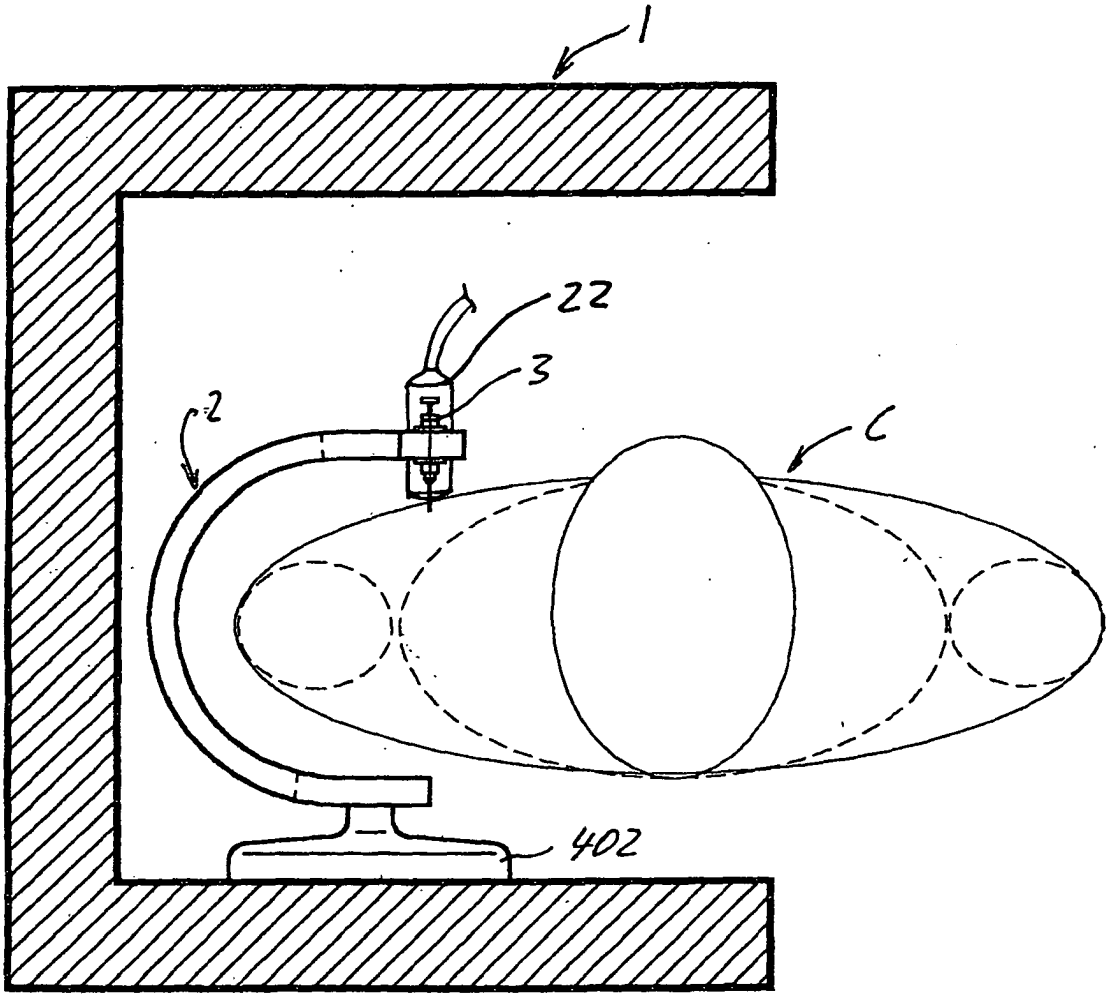


Fig. 1

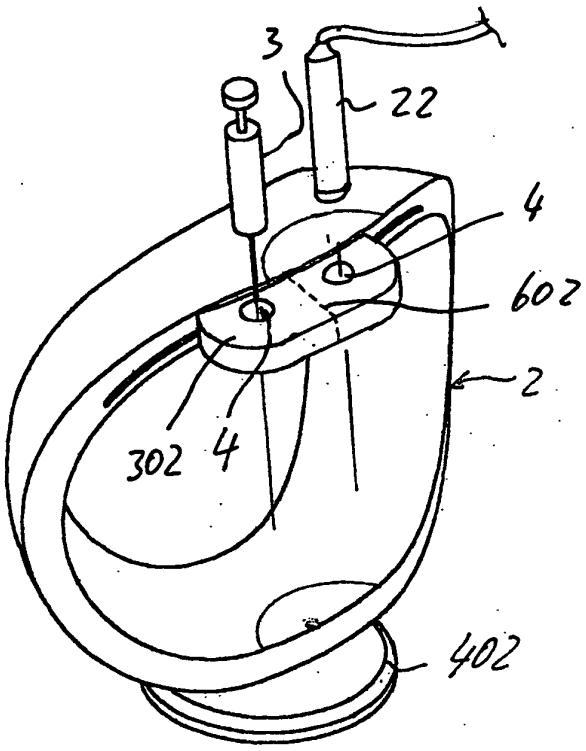


Fig 2

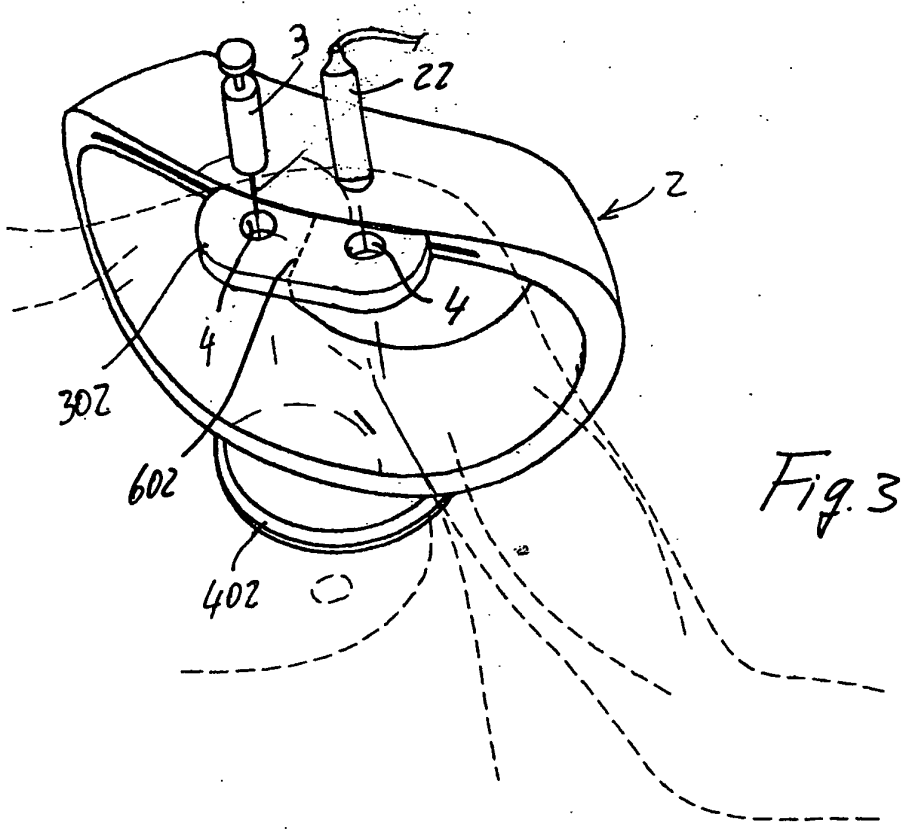


Fig 3

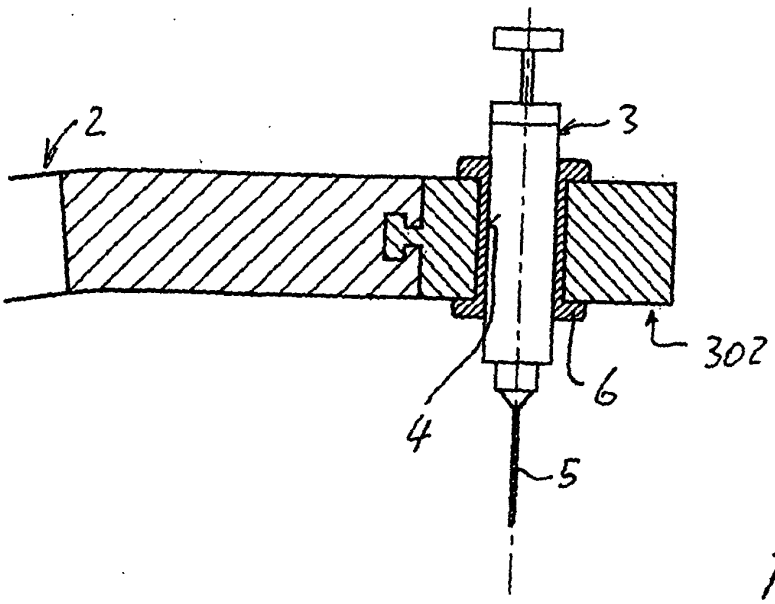


Fig.5

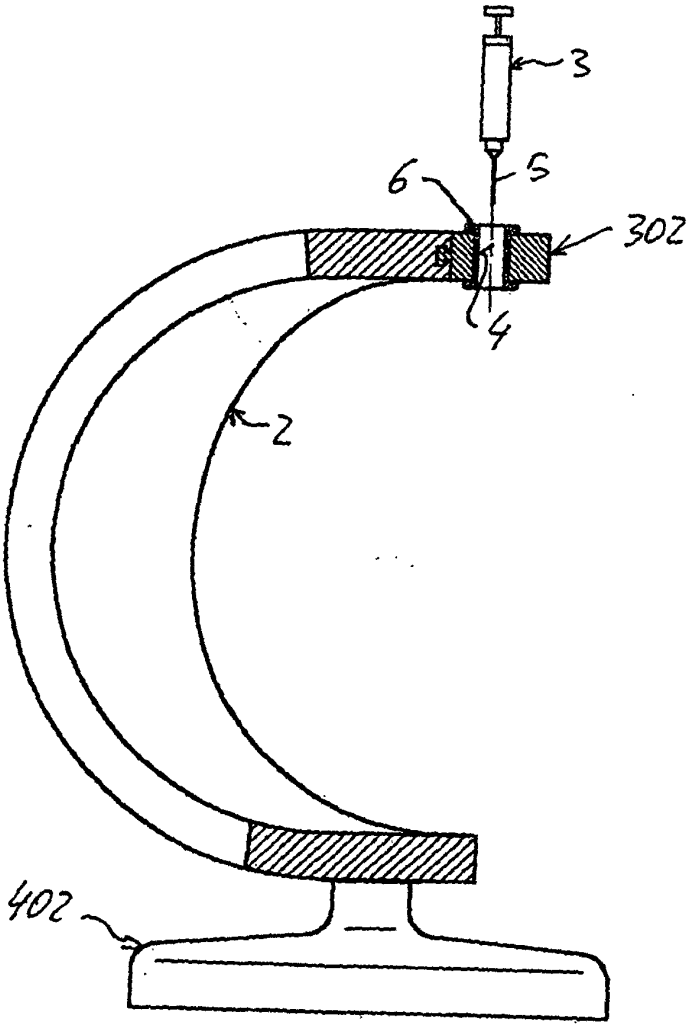


Fig.4

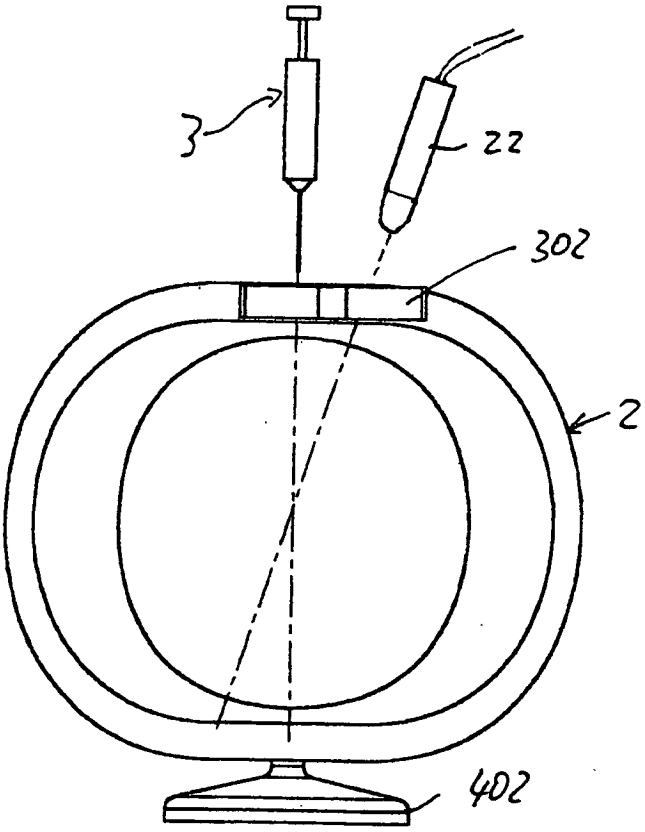


Fig. 6

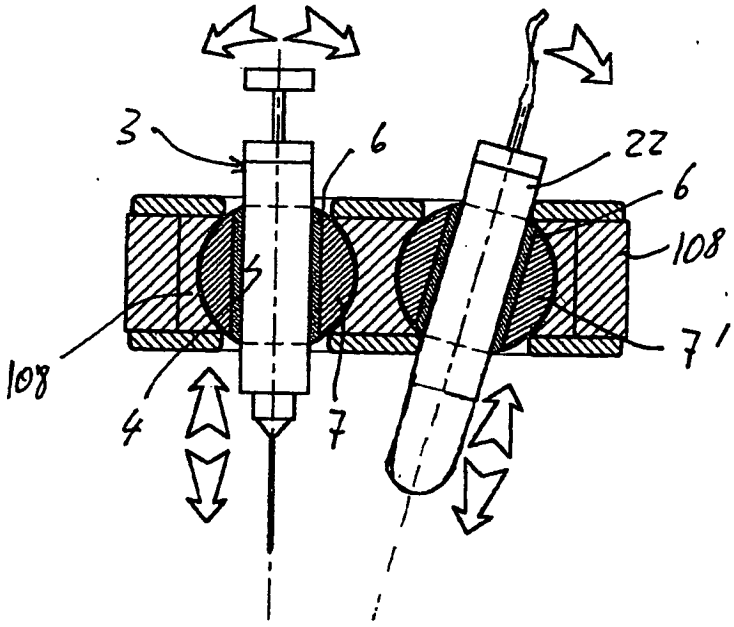


Fig. 7

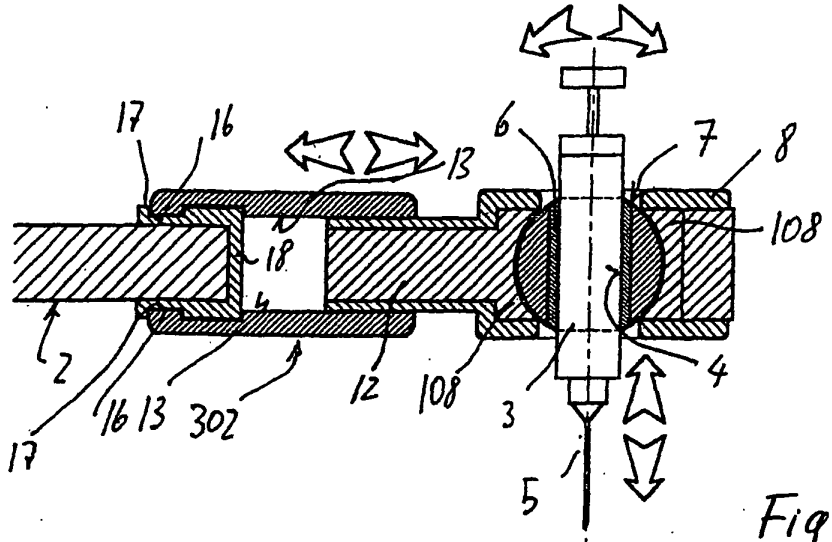


Fig 8

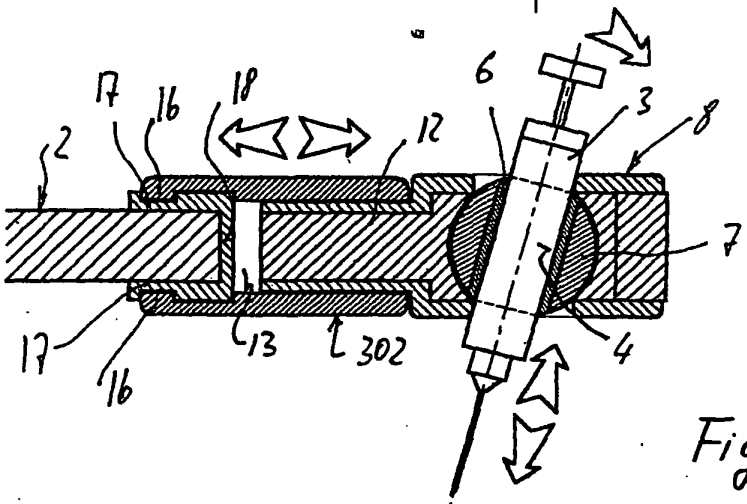


Fig. 9

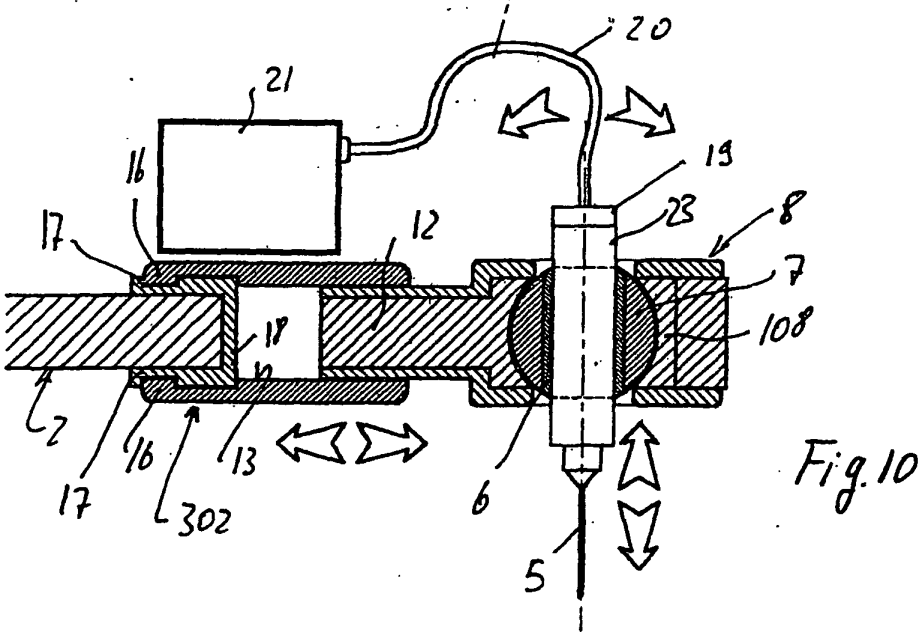


Fig. 10

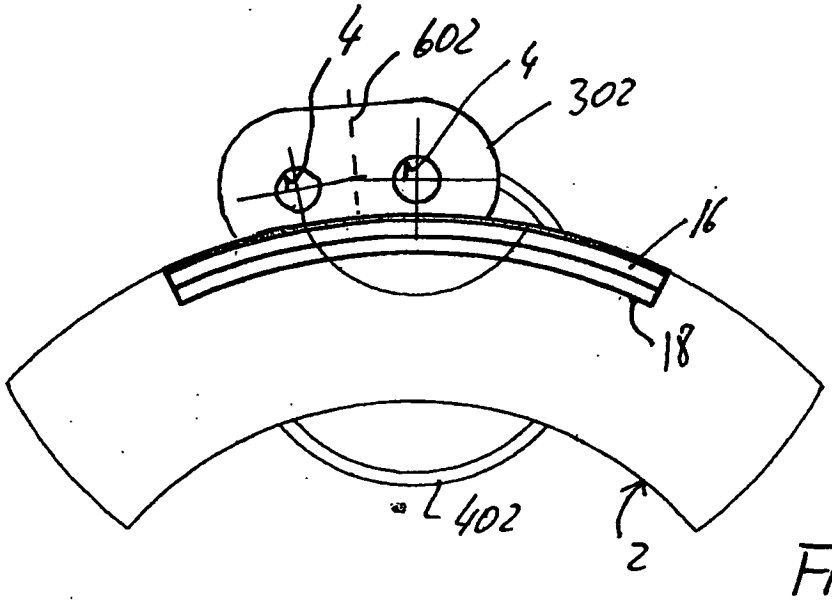


Fig. 11

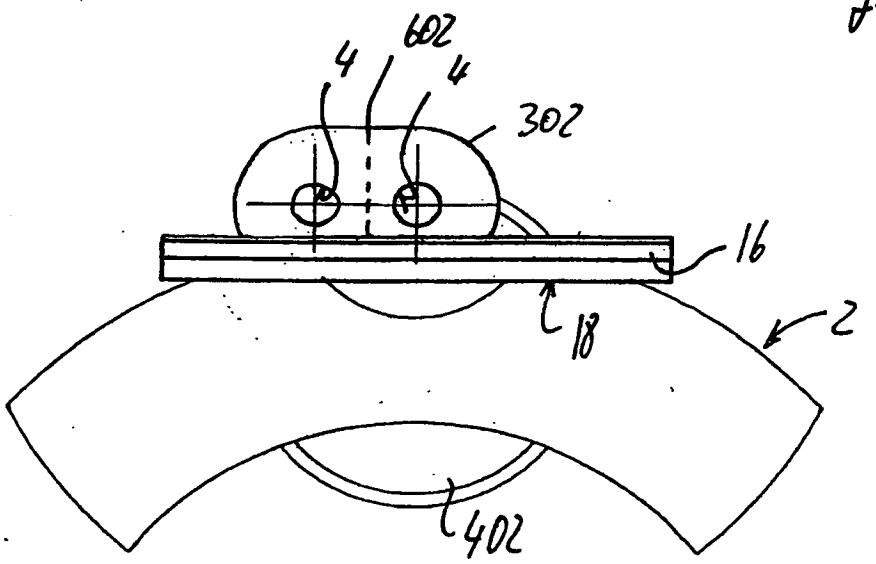


Fig. 12

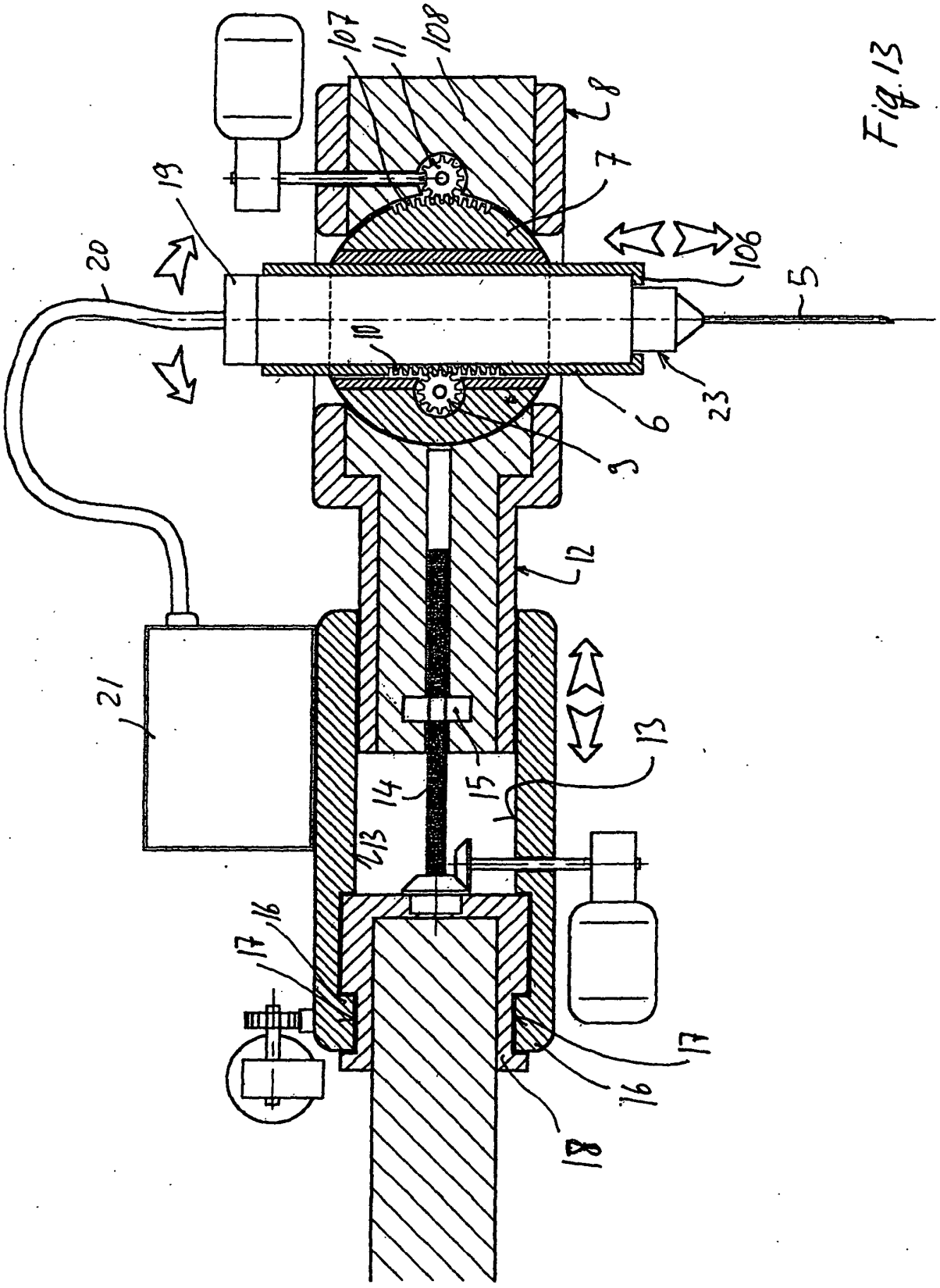


Fig. 13

## REFERENCES CITED IN THE DESCRIPTION

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- WO 0143640 A **[0008]**

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|---|---|---|---|
| 专利名称(译) | 磁共振和超声成像设备 | | |
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| 申请号 | EP2002018005 | 申请日 | 2002-08-12 |
| [标]申请(专利权)人(译) | 百胜集团 | | |
| 申请(专利权)人(译) | ESAOTE S.P.A. | | |
| 当前申请(专利权)人(译) | ESAOTE S.P.A. | | |
| [标]发明人 | SATRAGNO LUIGI<br>BIGLIERI EUGENIO | | |
| 发明人 | SATRAGNO, LUIGI<br>BIGLIERI, EUGENIO | | |
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| CPC分类号 | G01R33/28 A61B5/0035 A61B5/055 A61B5/4528 A61B8/00 A61B8/4416 | | |
| 优先权 | 102001900951138 2001-08-14 IT | | |
| 其他公开文献 | EP1286172A2<br>EP1286172A3 | | |
| 外部链接 | Espacenet | | |


摘要(译)

1。一种成像设备，包括具有至少一个发射线圈的磁共振成像设备，所述发射线圈用于激励所检查的身体（C）或其一部分的物质，以及至少一个线圈（2），用于接收由所述身体检查或其一部分，以及用于处理所述接收的信号以创建诊断图像的电子装置，并且包括用于检测所述诊断图像的装置（4,6,7,8,108,9,10,11,12,13,14,15,16 ，17,18），用于支撑和/或引导至少一个诊断和/或治疗工具（3,23），所述至少一个诊断和/或治疗工具特别地具有基本上细长的形状，并且特别地以适当的方式插入所述主体并且具有精确取向，其特征在于，其还包括具有超声发射和接收探头（22）的超声成像设备以及用于驱动所述探头并且用于从所接收的超声脉冲重建图像的装置，用于支持和/或移动和/或操作所述探针（22）。


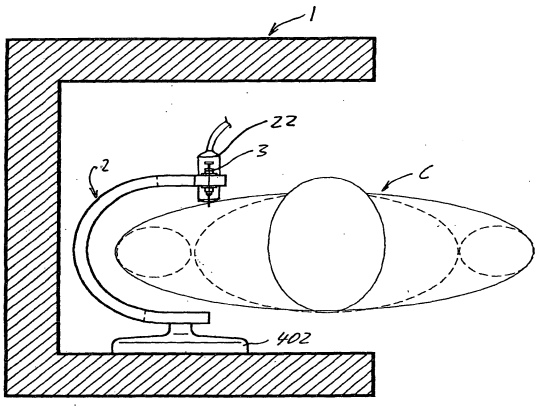


Fig.1