US008453511B2

(12) **United States Patent**
Nakamura et al.

(10) **Patent No.: US 8,453,511 B2**
(45) **Date of Patent: Jun. 4, 2013**

(54) ULTRASONIC PROBE SUPPORT DEVICE

(75) Inventors: **Kozo Nakamura**, Tokyo (JP); **Isao Onishi**, Tokyo (JP); **Satoru Ohashi**, Tokyo (JP); **Eiichi Minagawa**, Mitaka (JP); **Koji Hirota**, Mitaka (JP); **Ryoichi Sakai**, Mitaka (JP); **Koji Ogawa**, Mitaka (JP); **Koichi Miyasaka**, Mitaka (JP); **Masaru Murashita**, Mitaka (JP)

(73) Assignees: **The University of Tokyo**, Tokyo (JP); **Hitachi Aloka Medical, Ltd.**, Mitaka-shi, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 327 days.

(21) Appl. No.: **13/055,376**

(22) PCT Filed: **Jul. 17, 2009**

(86) PCT No.: **PCT/JP2009/062982**
§ 371 (c)(1), (2), (4) Date: **Jan. 21, 2011**

(87) PCT Pub. No.: **WO2010/010853**
PCT Pub. Date: **Jan. 28, 2010**

(65) **Prior Publication Data**
US 2011/0132094 A1 Jun. 9, 2011

(30) **Foreign Application Priority Data**
Jul. 22, 2008 (JP) 2008-188709

(51) **Int. Cl.**
G01D 21/00 (2006.01)
A61B 8/13 (2006.01)

(52) **U.S. Cl.**
USPC **73/644**; 600/459

(58) **Field of Classification Search**
CPC A61B 8/0858; A61B 19/26
USPC 73/644, 632; 600/438, 459
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,457,311 A 7/1984 Sorenson et al.
6,117,080 A 9/2000 Schwartz

(Continued)

FOREIGN PATENT DOCUMENTS

DE 3925014 * 1/1991
JP 49-022431 B 6/1974

(Continued)

OTHER PUBLICATIONS

Tamai, Kazuya et al. "Sonographic Evaluation of Articular Cartilage of the Rheumatoid Knee," The Journal of the Japanese Society of Orthopedic Ultrasonics, Dec. 1, 1991, vol. 3, No. 1, pp. 13-16.

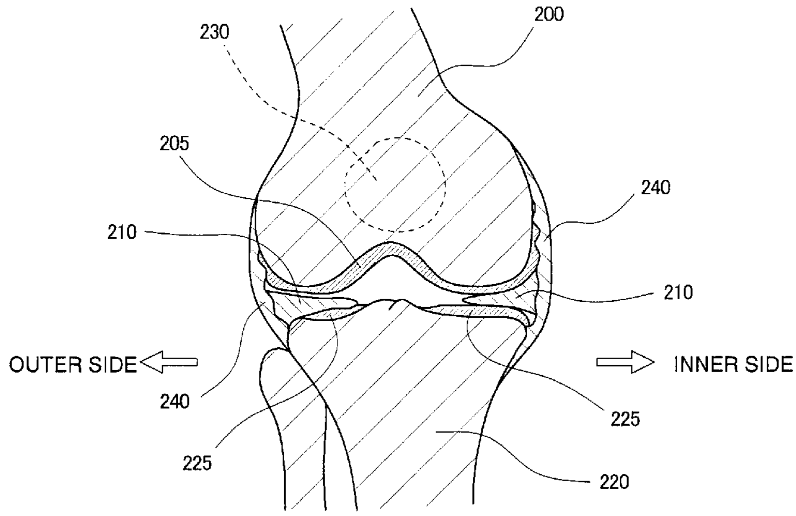
(Continued)

Primary Examiner — J M Saint Surin
(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(57) **ABSTRACT**

A mounting unit (**16**) is aligned by using a mounting unit frame (**58**) touching the thigh and a knee-contacting portion (**62**) touching the knee, with the knee being bent. The mounting unit is also equipped with a probe support frame (**60**) used for moving an ultrasonic probe along the knee cap. The probe support frame moves rotationally about the mechanical center of the knee joint, thereby allowing the ultrasonic probe (**78**) to move along the knee cap while facing toward the mechanical center of the knee joint and to perform scanning of an ultrasonic beam.

10 Claims, 11 Drawing Sheets



U.S. PATENT DOCUMENTS

7,731,662	B2 *	6/2010	Anderson et al.	600/459
2004/0243002	A1 *	12/2004	Nakamura et al.	600/439
2011/0112650	A1 *	5/2011	Masini	623/20.15
2011/0304332	A1 *	12/2011	Mahfouz	324/309
2012/0029345	A1 *	2/2012	Mahfouz et al.	600/427

FOREIGN PATENT DOCUMENTS

JP	11-056845	A	3/1999
JP	2002-345821	A	12/2002
WO	2007/014292	A2	2/2007
WO	2008/012820	A2	1/2008

OTHER PUBLICATIONS

Kasukawa, Reiji et al. "Ultrasonographic findings of calcification in articular cartilage," Jan. 28, 2005, vol. 33, No. 1, pp. 111-112, w/ partial English translation.

Saho, Yasuaki et al. "Knee Cartilage Evaluation by B mode Ultrasound Method and Age Change of Thickness of Cartilage," Dec. 2007, vol. 56, No. 6, p. 719, w/ partial English translation.

International Search Report of PCT/JP2009/062982, mailing date Aug. 25, 2009.

Notification Concerning Transmittal of International Preliminary Report on Patentability (Chapter I of the Patent Cooperation Treaty)(Form PCT/IB/326) of International Application No. PCT/JP2009/062982 mailed Feb. 3, 2011 with Forms PCT/IB/373 and PCT/ISA/237.

Notification Transmittal of Translation of the International Preliminary Report on Patentability (Form PCT/IB/338) of International Application No. PCT/JP2009/062982 mailed Mar. 17, 2011 with Forms PCT/IB/373 and PCT/ISA/237.

* cited by examiner

FIG. 1

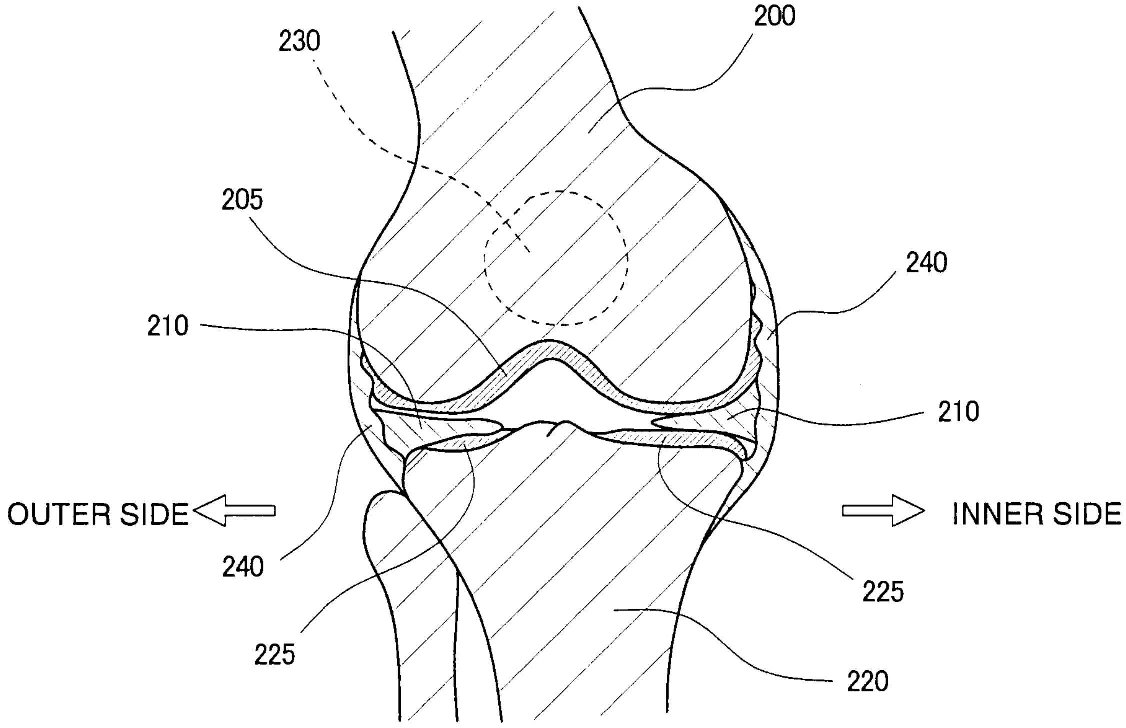

230
200
205
240
210
210
OUTER SIDE
INNER SIDE
240
225
225
220

FIG. 2

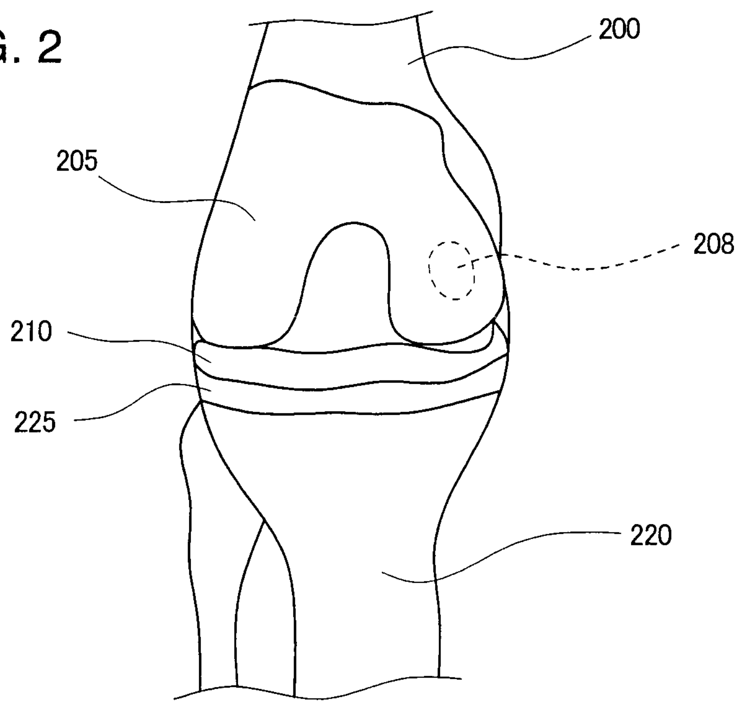

200
205
208
210
225
220

FIG. 3

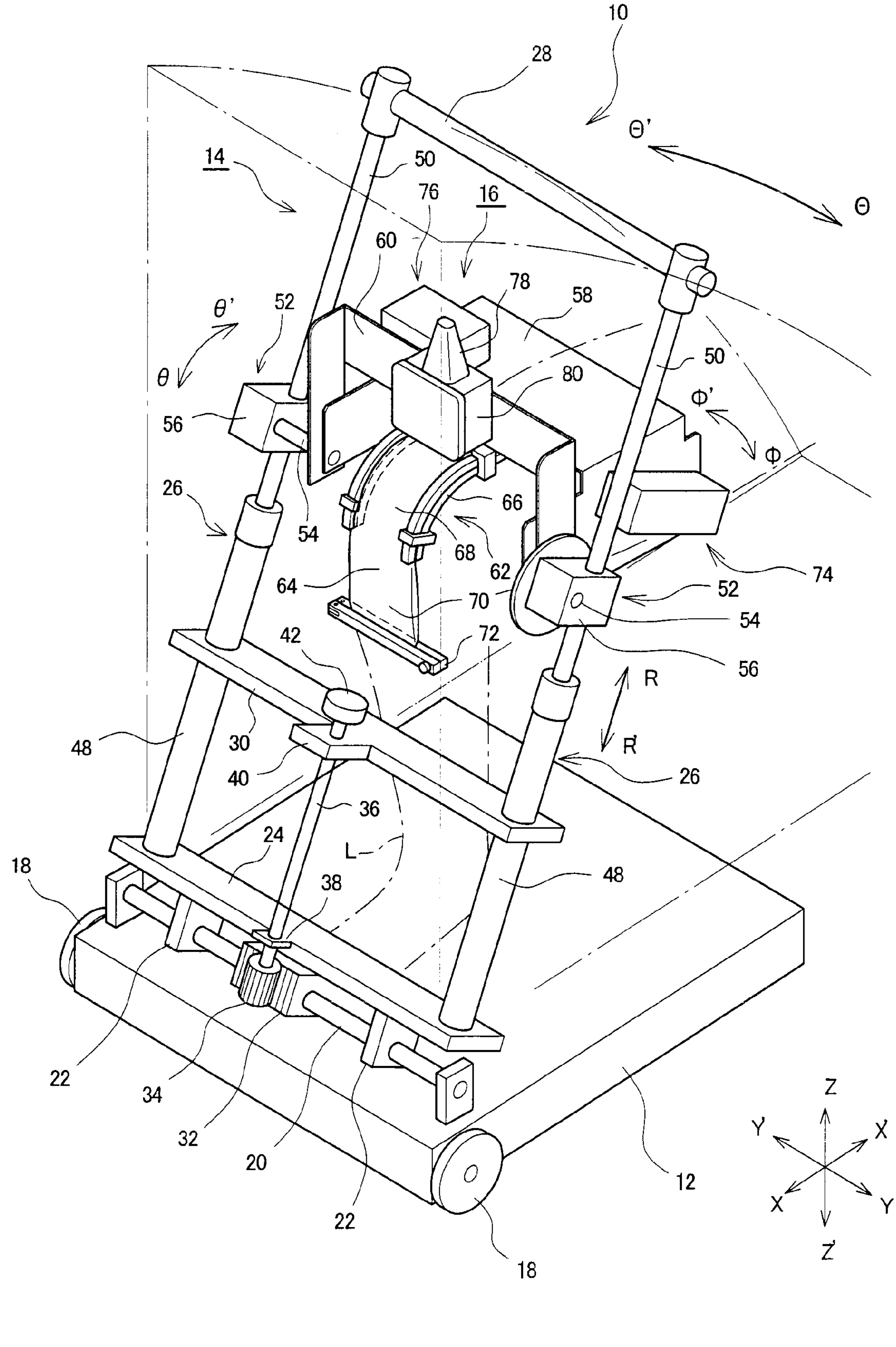

10
28
14
50
76
16
60
78
58
θ'
θ
52
56
80
50
Φ'
Φ
Θ'
Θ
26
54
66
68
62
74
64
70
52
54
42
72
56
R
R'
48
30
40
26
36
L
24
48
18
38
22
34
32
20
22
12
18
Z
Z'
Y
X
X'
Y

FIG. 4

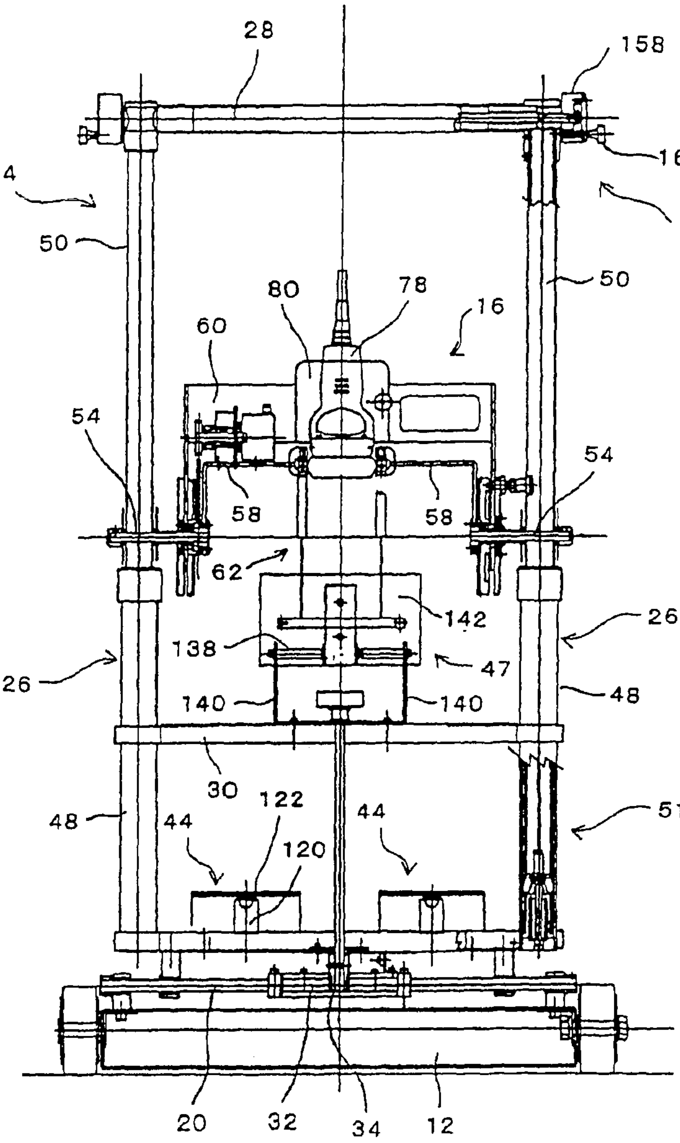

28
158
160
14
51(148)
50
50
80
78
16
60
54
54
58
58
62
142
138
47
26
26
48
140
140
30
48
122
44
44
51(146)
120
20
32
34
12

FIG. 5

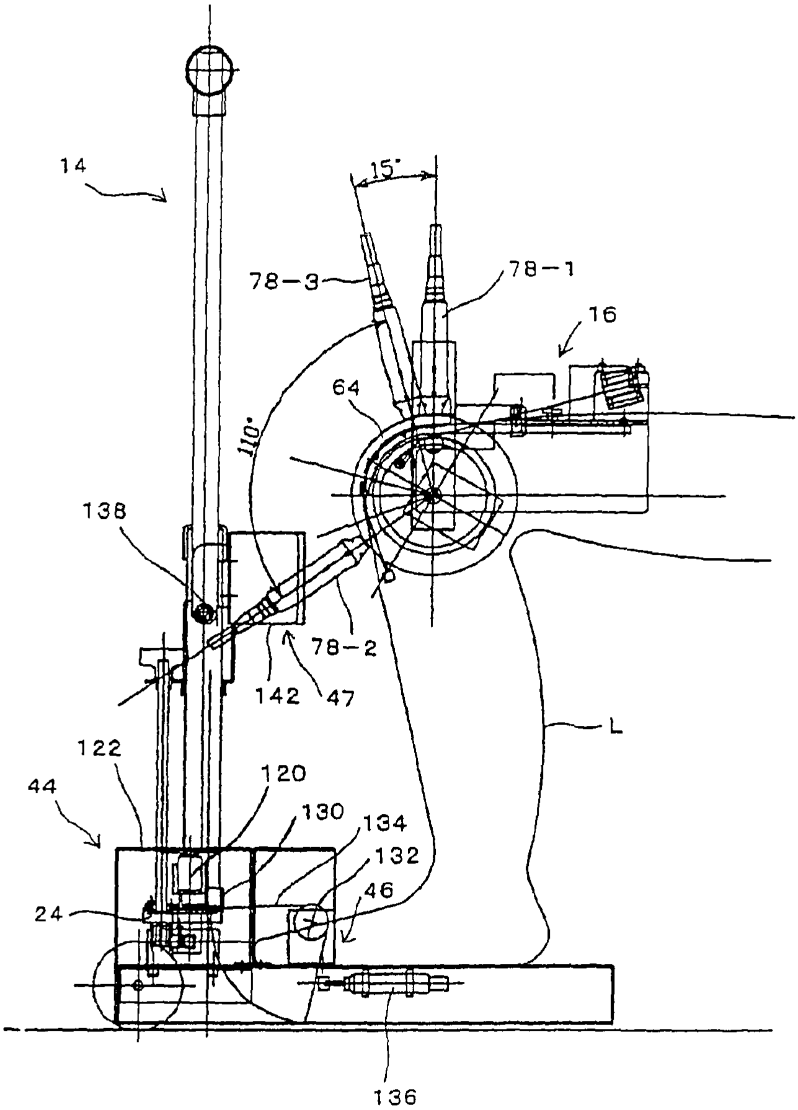

14
15°
78-3
78-1
16
64
110°
138
78-2
142
47
L
122
120
44
130
134
132
46
24
136

FIG. 6

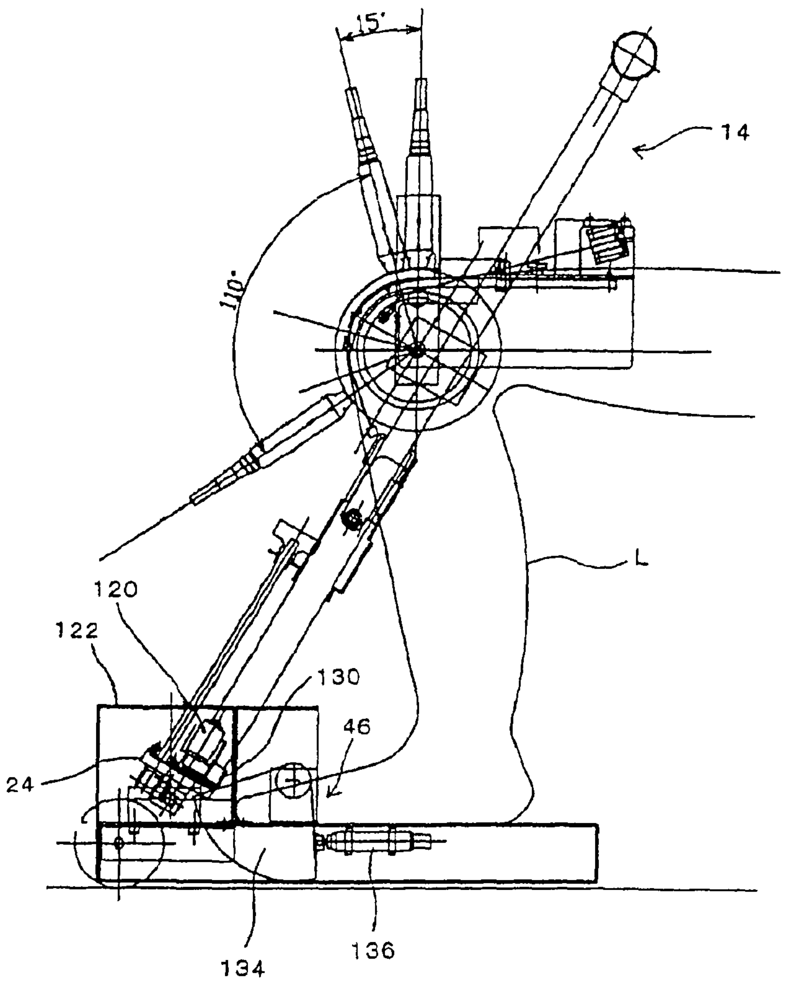


FIG. 7

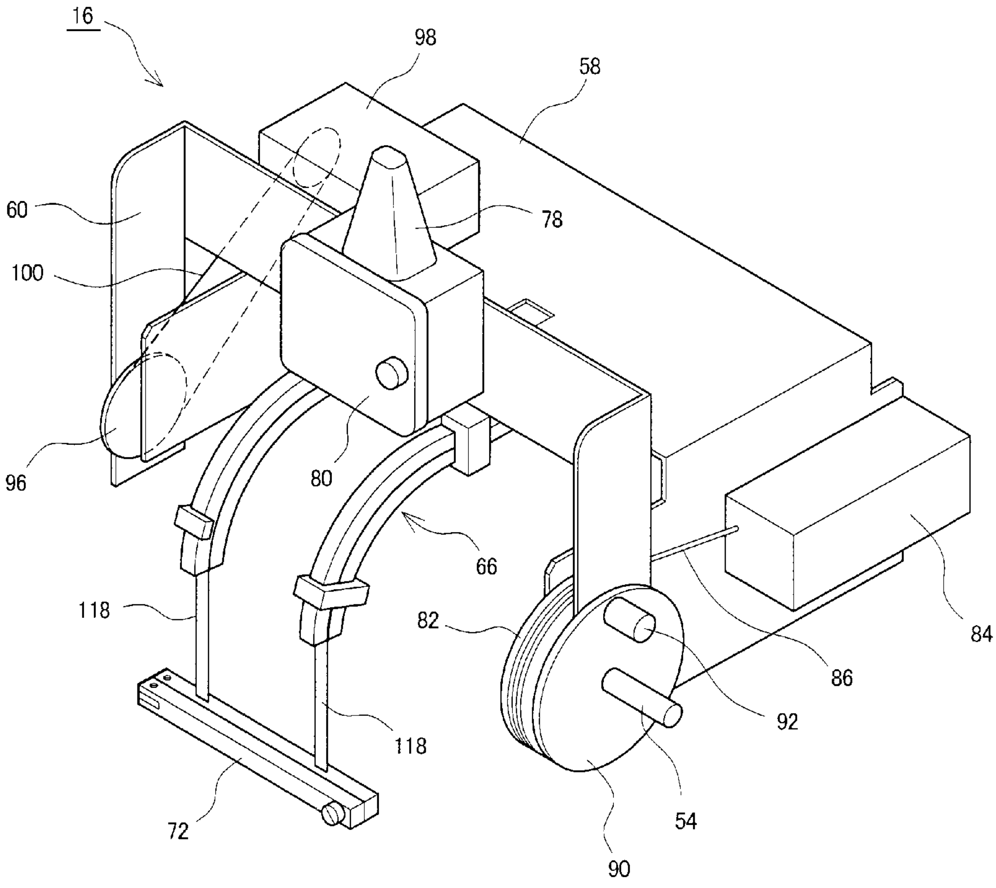


FIG. 8

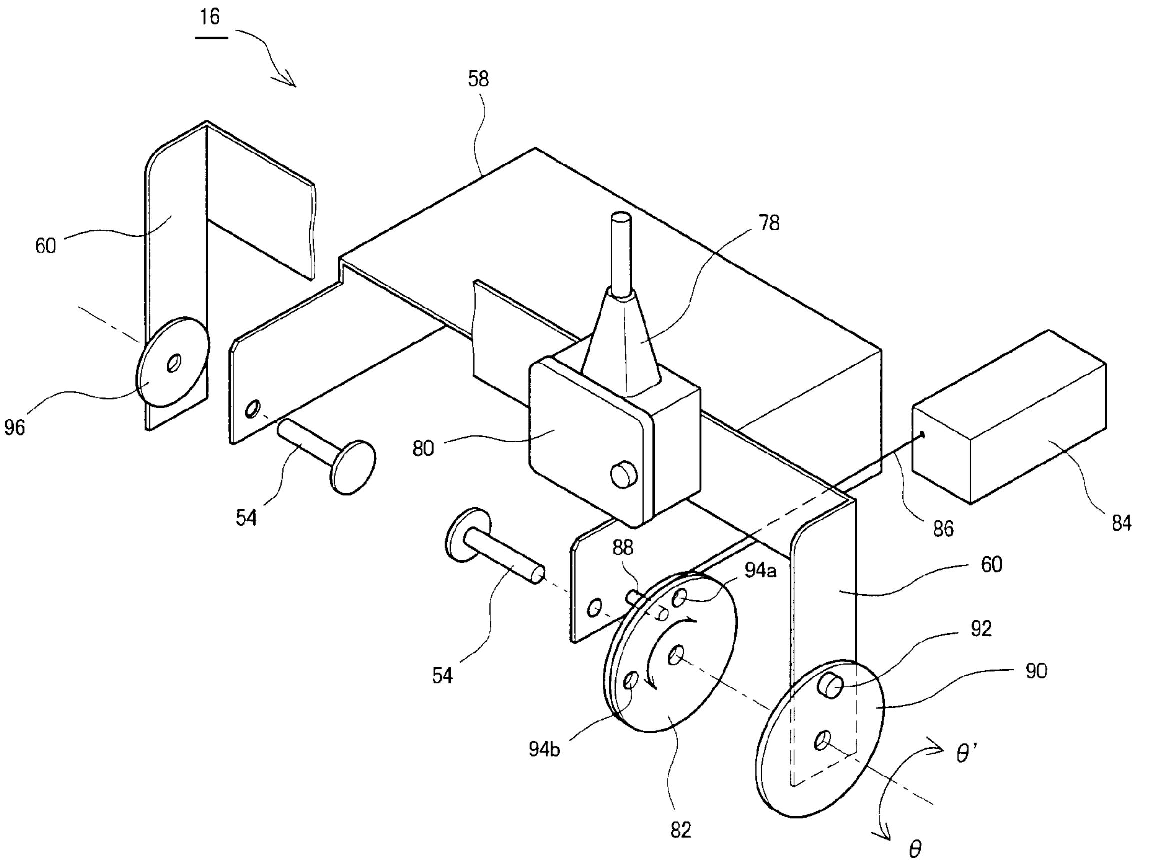


FIG. 9

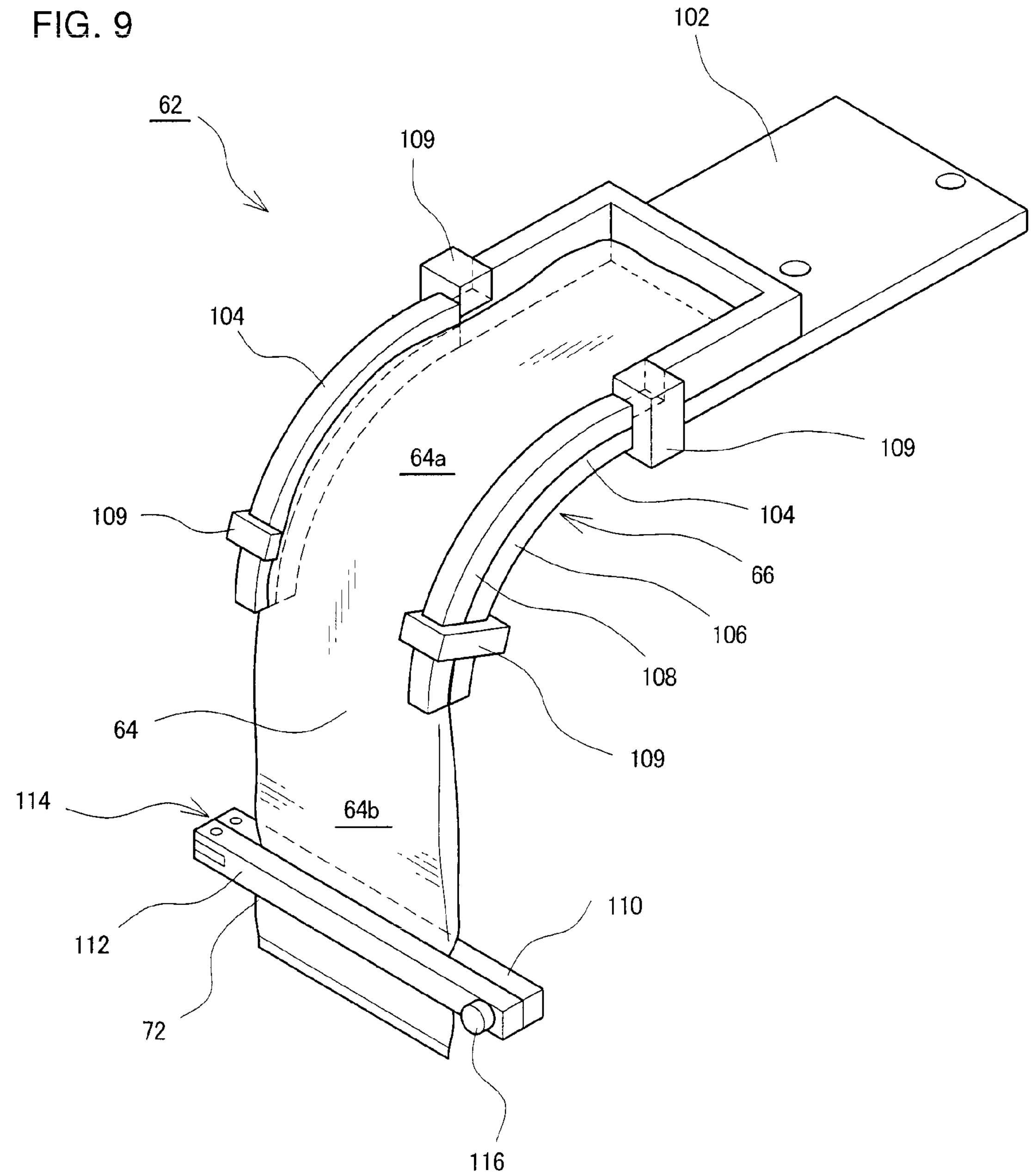

102
62
109
104
64a
109
109
104
66
106
108
109
64
114
64b
110
112
72
116

FIG. 10

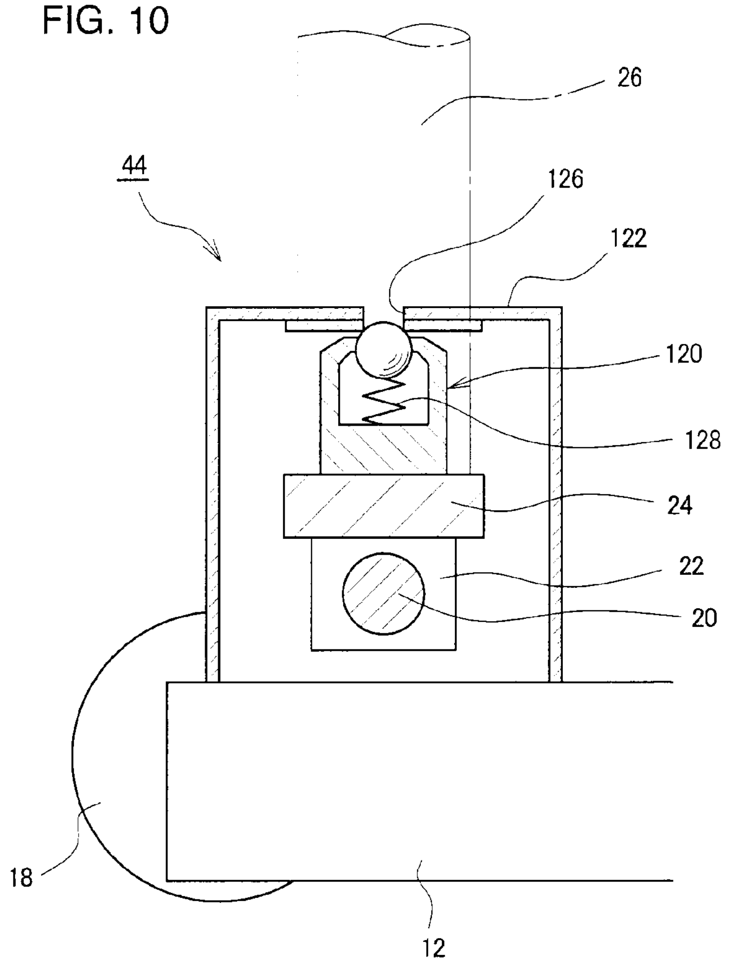


FIG. 11

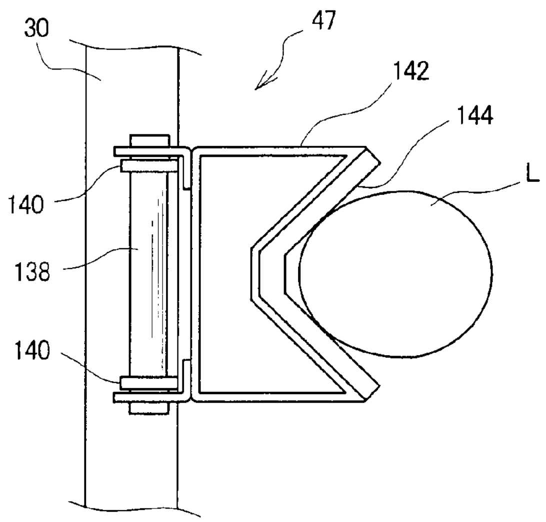


FIG. 12

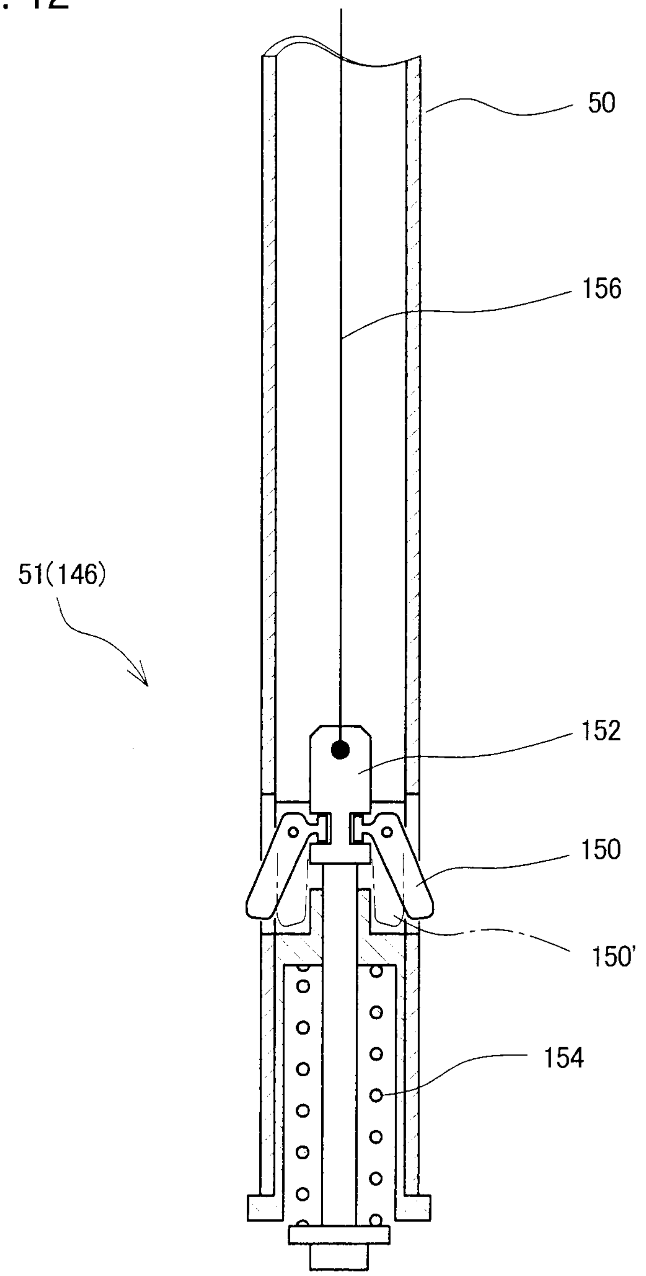
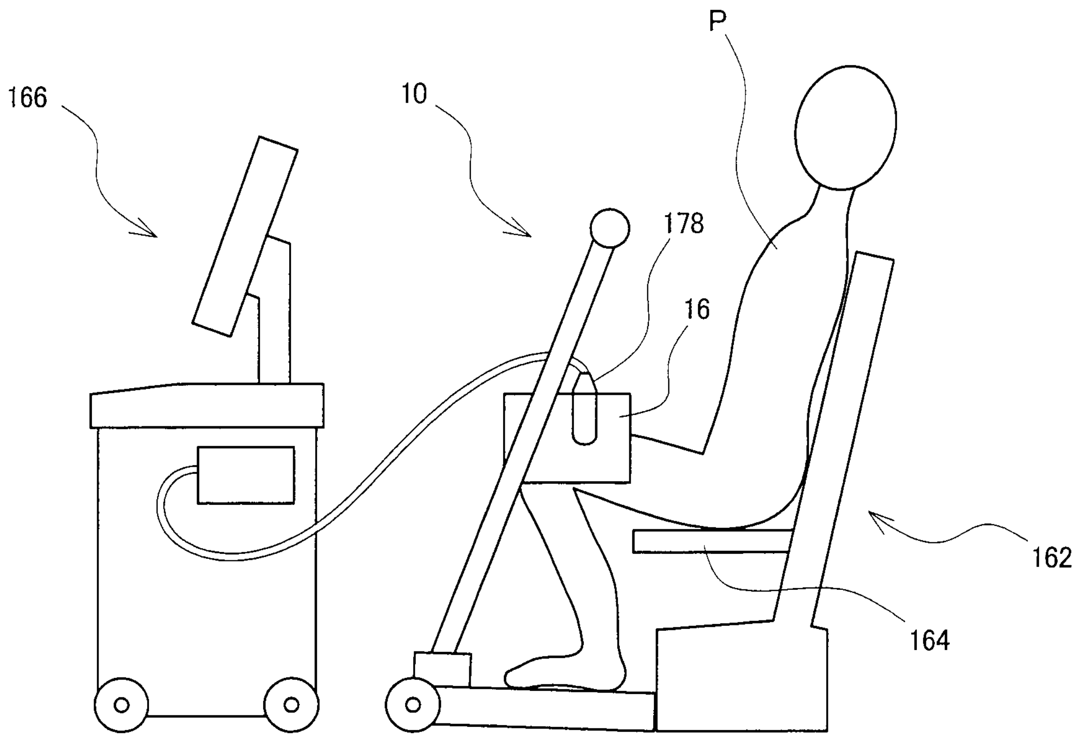


FIG. 13



ULTRASONIC PROBE SUPPORT DEVICE

TECHNICAL FIELD

The present invention relates to a technique for supporting an ultrasonic probe of an ultrasound diagnostic apparatus used for diagnosis of cartilage of the knee, which allows the ultrasonic probe to move along a predetermined path.

BACKGROUND ART

Gonarthrosis is a disorder in which wear of cartilage which functions as a cushion of the knee joint causes inflammation or deformation of the knee joint, resulting in pain. The number of patients suffering gonarthrosis increases with age. However, if the thickness and surface shape of the cartilage of the femur can be accurately known before the condition reaches crisis, a preventive action can be taken. With the population increase of the elderly, the number of gonarthrosis patients is currently expected to increase, and a simple diagnosis method is desired.

Known methods of diagnosing gonarthrosis include a method in which an arthroscope (endoscope) is inserted into the knee and a state of the surface of the cartilage is observed, and a method in which gonarthrosis is estimated based on the degree of opening of a gap in the joint through X-ray examination. However, these diagnosis methods cannot measure the thickness of the cartilage or obtain a three-dimensional shape of the cartilage.

In consideration of this, Patent Literature 1 discloses a system wherein an in-joint probe is inserted into the knee joint and ultrasound is transmitted and received, to evaluate the thickness of the cartilage of the knee joint. However, because this system is invasive, the system cannot be easily used. Therefore, this system is not suited for examination of many examinees such as a periodical medical examination.

An MRI (Magnetic Resonance Imaging) device is a non-invasive image diagnosis device, can in principle image the cartilage distinguished from the bone, muscle, body fluids, etc., and can measure the thickness of the cartilage. However, the usage cost for MRI is high and the measurement requires a long time, and thus, the MRI is not suited for use in examination of many examinees.

RELATED ART REFERENCES

Patent Literature

Patent Literature 1: JP 2002-345821 A

DISCLOSURE OF INVENTION

Problem to be Solved

In the diagnosis by ultrasound, ultrasound is transmitted to and received from a surface of the body, and the shape of the internal tissues such as organs and bones can be obtained based on the received ultrasound echo. With regard to the knee cartilage also, this characteristic can be taken advantage of, and a non-invasive and simple diagnostic device can be provided. In this process, an ultrasonic probe which transmits and receives ultrasound to and from the body surface must be positioned at a suitable position for measuring the shape of the knee cartilage, and must be moved in a suitable path for scanning.

The present invention advantageously provides a supporting device which positions an ultrasonic probe of an ultrasound diagnosis apparatus at a suitable position for measurement of cartilage of the knee, and which allows movement of the ultrasonic probe in a suitable path.

Means for Solving the Problem

According to one aspect of the present invention, there is provided an ultrasonic probe support device which supports an ultrasonic probe at a preferable position with respect to a knee which is in a bent state, and which guides the ultrasonic probe so that the ultrasonic probe moves along the knee cap in a state where the ultrasonic probe is directed toward a mechanical center of the knee joint.

Because the knee is in the bent state, the cartilage around the medial condyle of the femur can be observed. The orientation of the examinee may be any orientation so long as the knee is in the bent state, but typically, is a sitting position. It is also preferable that the knee is bent at a right angle or an angle greater than a right angle. The support device comprises a mounting unit frame which contacts the thigh and a knee-contacting portion which contacts the knee or a region below the knee, in order to position the ultrasonic probe with respect to the knee of the examinee. In the case where the examinee is in the sitting position, the mounting unit frame is placed over the thigh so that the device is positioned in the up and down direction, and the knee-contacting portion contacts the knee or a region below the knee so that the device is positioned in the forward and rear direction. With such a configuration, the position of the support device with respect to the knee joint is determined.

The mounting unit comprises a probe support frame which supports the ultrasonic probe. The probe support frame supports the ultrasonic probe with respect to the mounting unit frame such that the movement of the ultrasonic probe along the knee cap is realized. The ultrasound is preferably transmitted and received at an angle of incidence perpendicular to the cartilage, and, in order to realize such a configuration, the ultrasonic probe is moved in a state where the ultrasonic probe is directed toward the center of the knee joint, and ultrasound echoes at a plurality of cross sections are obtained. The movement of the ultrasonic probe in this case is movement from the side of the knee cap near the shin, along the surface of the knee cap, and toward the side of the knee cap near the thigh, or movement in the reverse direction, while a state is maintained where the ultrasound is applied approximately perpendicular to the surface of the knee cap. The joint surface of the distant end of the femur has an approximate arc shape centered at a mechanical center of the joint in a sagittal plane, due to the mechanism of the knee joint. In other words, when the shin is to be rotated with respect to the thigh, a connecting surface between the femur and tibia must have an arc shape with respect to the center of rotation (mechanical center) of the shin. Therefore, the ultrasonic probe is also desirable to move along a path corresponding to the arc. The probe support frame can be rotatably supported on the mounting unit frame, and, with a rotational movement of the probe support frame, movement of the ultrasonic probe along the knee cap or movement corresponding to the joint surface of the distant end of the femur is realized. For example, the ultrasonic probe can be moved on an arc which is concentric with the arc of the joint surface, in a state where the ultrasonic probe is directed toward the center of the arc; that is, the mechanical center of the knee joint. In this process, the mounting unit is preferably positioned such that the center of rotation of the probe support frame matches the mechanical center of the knee joint.

According to another aspect of the present invention, preferably, in the ultrasonic probe support device, the knee-contacting portion comprises an acoustic matching member which realizes acoustic matching of the transmitted and received ultrasound. The acoustic matching member has a shape curved along the knee cap, contacts the knee, and is interposed between the knee and the ultrasonic probe. According to another aspect of the present invention, preferably, in the ultrasonic probe support device, the knee-contacting portion comprises two matching member support frames which support the acoustic matching member at a right side and a left side of the knee. The matching member support frame may be fixed on the mounting unit frame, and may have a shape curved along the knee cap from a distal portion of the thigh to a proximate portion of the shin. When the matching member does not have its own defined shape, the matching member may be set in the curved shape by being supported with the matching member support frame.

According to another aspect of the present invention, preferably, in the ultrasonic probe support device, the matching member comprises a fixed portion which is fixedly supported on the matching member support frame at a left side and a right side, and a free portion which extends from the fixed portion toward a tip and which is allowed to move in a front and rear direction. The free portion follows the knee when the knee is deeply bent. The fixed portion contributes to the positioning of the mounting unit in the front and rear direction, and, with the provision of the free portion, the mounting unit can be more easily mounted and a sufficient range of measurement can be secured.

According to another aspect of the present invention, preferably, in the ultrasonic probe support device, the matching member support frame has an arc shape. In particular, preferably, the mechanical center of the knee joint is positioned at a center of the arc of the matching member support frame when the mounting unit is mounted on the knee.

According to another aspect of the present invention, preferably the ultrasonic probe support device further comprises a base which is placed on a floor, and a rotational frame which is provided on the base in a standing manner and which is rotatably supported on the base. The rotational frame is preferably supported by the base at a lower end of the rotational frame. The above-described mounting unit is rotatably supported on the rotational frame. When the mounting unit is mounted on the examinee, the rotational frame is rotated from a standing state and tilted, and the mounting unit frame and the knee-contacting portion are positioned such that the mounting unit frame is in contact with the thigh of the examinee and the knee-contacting portion is in contact with the knee or a region below the knee.

According to another aspect of the present invention, preferably, in the ultrasonic probe support device, the rotational frame comprises a lower frame which is rotatably supported on a base member, and an upper frame which slides, with respect to the lower frame, in a radial direction of the rotation, and which rotatably supports the mounting unit.

Advantages

According to various aspects of the present invention, the ultrasonic probe can be suitably positioned for measuring the shape of the cartilage of the knee joint, and the ultrasonic probe can be supported such that a suitable movement of the ultrasonic probe is realized.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic cross sectional diagram for explaining the structure of a knee joint.

FIG. **2** is a diagram showing the knee joint in a sitting posture, as viewed from the front.

FIG. **3** is a perspective view showing the structure of primary portions of an ultrasonic probe support device **10** according to a preferred embodiment of the present invention.

FIG. **4** is a front view of the ultrasonic probe support device **10**.

FIG. **5** is a side view of the ultrasonic probe support device **10**.

FIG. **6** is a side view of the ultrasonic probe support device **10**.

FIG. **7** is a perspective view schematically showing the structure of a mounting unit **16**.

FIG. **8** is an exploded perspective view of the mounting unit **16**.

FIG. **9** is a perspective view showing a knee-contacting portion **62**.

FIG. **10** is a schematic diagram schematically showing the structure of a standing-straight orientation maintaining mechanism **44**.

FIG. **11** is a schematic diagram schematically showing the structure of a left-and-right position determining mechanism **47**.

FIG. **12** is a diagram showing a lock portion **146** of an extension/contraction lock mechanism **51**.

FIG. **13** is a schematic diagram of a system for diagnosing cartilage of a knee joint.

BEST MODE FOR CARRYING OUT THE INVENTION

Prior to the description of an example device structure of a preferred embodiment of the present invention, an internal structure of a knee joint (in particular, a human knee joint) to which the device is applied will first be briefly described with reference to FIG. **1**. FIG. **1** is a schematic cross sectional diagram of a knee joint of a right leg in a standing posture, as viewed from the front side of the body.

As shown in FIG. **1**, the knee joint comprises a distal end portion of the femur **200**, a proximal end portion of the tibia **220**, and the patella **230**. A surface of a distal end of the femur **200** is covered with cartilage **205**, and a surface of the proximal end of the tibia **220** is covered with cartilage **225**. Of the surface of the bone (for example, the femur **200**), the portion covered with the cartilage is called a subcartilaginous bone. A meniscus **210** is present between the cartilage **205** of the femur **200** and the cartilage **225** of the tibia. The distal end of the femur **200** projects in two branches (which are called the medial condyle and the lateral condyle, respectively) as shown in the figures, when viewed from the front direction of the body in a standing posture, and the cartilage **205** of the medial condyle and that of lateral condyles are in contact with the cartilage **225** on the proximal end of the tibia **220** via holes formed in the medial and lateral meniscuses **210**. The knee joint portion as described above is covered with synovium and a capsular ligament **240**.

The cartilage **205** on the distal end of the femur **200** widely covers the surface of the distal end portion, and a portion of the cartilage **205** which contacts the cartilage **225** on the proximal end of the tibia **220** in the standing posture is a portion where the load of the upper body is strongly applied. This portion is called a cartilage load portion. The cartilage load portion tends to be worn, and, when the wear becomes significant, gonarthrosis is caused. For diagnosing gonarthrosis, the thickness of the cartilage of the cartilage load portion is an important judgment criterion.

The thickness of the cartilage **205** on the distal end of the femur **200** of a human is thin and is approximately 2 mm~3 mm for a healthy person. Therefore, in order to measure the thickness with high precision with the method of ultrasound diagnosis, the ultrasound beam is desirably applied at an angle which is as close to perpendicular as possible with respect to the surface of the cartilage **205**. However, in the standing posture, because the cartilage load portion on the distal end of the femur **200** is in contact with the cartilage **225** of the tibia **220**, if the ultrasound beam is to be applied at an angle close to perpendicular with respect to the surface of the cartilage load portion in this state, the ultrasound beam must be applied from the side of the tibia toward an upward direction. However, application of the ultrasonic probe in such a position is not possible. Even if the ultrasonic probe can be placed on such a position, the cartilage would be in shadow of the femur or tibia, and, thus, the ultrasound tends not to reach the cartilage and consequently the cartilage cannot be imaged.

On the other hand, when the knee is significantly bent (for example, to approximately 90°) such as, for example, in the case where person sits on a chair, as shown in FIG. **2**, a load portion **208** of the cartilage **205** on the distal end of the femur **200** is deviated from the side of the tibia **220**, and faces the front side of the knee cap (in FIG. **2**, the load portion **208** is a load portion for the medial condyle, and the load portion for the lateral condyle is not shown). Therefore, if the probe is applied from the front side of the knee cap, the ultrasound beam can be applied at an angle close to perpendicular with respect to the surface of the load portion **208**. In addition, it is also preferable to measure the cartilage around the load portion **208** for purpose of comparison with the load portion **208**, and, thus, the probe must be moved while the probe is maintained at an orientation in which the ultrasound beam can be transmitted and received at approximately a perpendicular angle with respect to the cartilage.

In consideration of this, in the present embodiment, a support device of a probe is provided for realizing a movement of the ultrasonic probe suited for obtaining an ultrasound echo of the inside of the knee including the load portion of the cartilage on the distal end of the femur in a state where the knee is significantly bent such as the case where the person is sitting in the chair.

A preferred embodiment of the present invention will now be described with reference to the drawings. FIGS. **3-6** are diagrams schematically showing the structure of an ultrasonic probe support device **10** according to the present embodiment. FIG. **3** is a perspective view, FIG. **4** is a front view, and FIGS. **5** and **6** are side views.

The ultrasonic probe support device **10** comprises a base **12** which is placed on a floor, a rotational frame **14** which is rotatably supported on the base **12**, and amounting unit **16** rotatably supported on the rotational frame **14**. As shown with a reference symbol L in FIGS. **3**, **5**, and **6**, an examinee places one of the left and right legs on the base **12**. In the following description, the left and right, up and down, and front and rear directions and orientation are described with reference to the orientation of the examinee when one leg is in the state shown by reference symbol L in the figures. More specifically, the X-X' direction in FIG. **3** is referred to as the front and rear direction, the Y-Y' direction is referred to as the left and right direction, and Z-Z' is referred to as the up and down direction. The respective directions are defined such that the orientation X is front, the orientation Y is left, and the orientation Z is up. In addition, in the state where the examinee sits with the two legs aligned with each other, the shin and thigh are approximately present in a sagittal plane (plane parallel to the median plane) passing through the center of the knee. In the following description, for the sake of explanation, regardless of the orientation of the median plane, the plane formed by the shin and the thigh when the knee is bent is described as the sagittal plane.

The base **12** has an approximate rectangular plate shape, is placed on a floor, and comprises a pair of casters **18** at a front end. When the support device **10** is moved, a rear end of the base **12** is lifted so that only the casters **18** contact the floor. At a region near the front edge of the base **12**, a rotational frame support shaft **20** which extends in the left and right direction and which rotatably supports the rotational frame **14** is provided.

The rotational frame **14** comprises a lower lateral member **24** having two bearings **22** which engage the rotational frame support shaft **20**, left and right radial members **26** which extend in a radial direction of the rotational movement, and an upper lateral member **28** which connects the left and right radial members **26** at the tip of the left and right radial members **26**. An auxiliary lateral member **30** is provided between the upper and lower lateral members **24** and **28**, bridging the left and right radial members **26**. The rotational frame **14** has an overall ladder-like shape.

The bearing **22** engages the support shaft **20** such that the rotational frame **14** is rotatable about the support shaft **20** and moveable in a direction along the support shaft **20**. The rotational direction around the support shaft **20** will hereinafter referred to as the Θ-Θ' direction, and the direction when the rotational frame is tilted in the downward direction will hereinafter referred to as Θ. A rack **32** is fixed on the support shaft **20**, and a pinion **34** which engages the rack **32** is placed on the rotational frame **14**. The pinion **34** is fixed at a lower end of a pinion shaft **36**, and the pinion shaft **36** is held by pinion shaft holding portions **38** and **40** which are integrally or fixedly provided on the lower lateral member **24** and the auxiliary lateral member **30**, respectively. A knob **42** is fixed at an upper end of the pinion shaft **36**. When the knob **42** is rotated, the pinion **34** is integrally rotated, and the entire rotational frame **14** is moved in the Y-Y' direction.

The rotational frame **14** is tilted in the downward direction from a standing-straight position shown in FIG. **5**, is rotated in the Θ direction as shown in FIG. **3** or **6**, and is allowed to be positioned in an inclined position. A standing-straight orientation maintaining mechanism **44** for maintaining the rotational frame **14** in a standing-straight orientation is provided on the base **12** and rotational frame **14** (refer to FIGS. **4** and **5**). In addition, a damper mechanism **46** which limits the speed of tilt when the rotational frame **14** is inclined in the Θ direction is further provided on the base **12** (refer to FIGS. **5** and **6**). Moreover, a left-and-right direction positioning mechanism **47** which determines the position on the left and right direction by contacting a recess having a V-shape or a U-shape on the shin of the examinee is provided on the rotational frame **14**. In FIG. **3**, for the sake of simplicity, the standing-straight orientation maintaining mechanism **44**, the damper mechanism **46**, and the left-and-right direction positioning mechanism **47** are not shown, and the detailed description of these elements will be given later.

The radial member **26** of the rotational frame **14** has an extension/contraction function in an R-R' direction shown in the figures. The orientation R is the direction of extension of the radial member. The extension/contraction function is realized by forming the radial member **26** with two lower rods **48** and two upper rods **50** in a nested structure. In other words, the upper rod **50** enters the inside of the lower rod **48** and the upper rod **50** moves out from the inside of the lower rod **48**, to achieve contraction and extension of the radial member **26**.

An extension/contraction lock mechanism **51** (refer to FIG. **4**) for locking at a predetermined extension/contraction position is built in the rotational frame **14**. The auxiliary lateral member **30** may be fixed on either of the upper and lower rods **48** and **50**. In the present embodiment, in order to simplify the structure such that the extension/contraction of the pinion shaft **36** does not need to be considered, the auxiliary lateral member **30** is fixed on the lower rod **48**. With the radial member **26** having the extension/contraction function, the rotational frame **14** extends/contracts with sliding of the two upper and lower frames. With this extension/contraction, a distance between a position for supporting the mounting frame **16** and the rotational frame supporting shaft **20** can be varied.

A mounting unit support portion **52** for supporting the mounting unit **16** is fixed on the upper frame of the rotational frame **14**; more specifically, the upper rod **50**. The mounting unit support portion **52** comprises a mounting unit support shaft **54** which rotatably supports the mounting unit **16**, and a mounting unit support block **56** which connects the mounting unit support shaft **54** and the upper rod **50**.

The mounting unit **16** comprises a mounting unit frame **58**, a probe support frame **60**, and a knee-contacting portion **62**. For the purpose of simplifying the structure, in the present embodiment, both the mounting unit frame **58** and the probe support frame **60** are rotatably supported on the mounting unit support shaft **54**. However, these shafts are not necessarily common, and the probe support frame may be rotatably supported by another shaft provided on the mounting unit frame **58**. In addition, the shaft is typically parallel to the mounting unit support shaft **54**. The rotational direction of the mounting unit frame **58** about the support shaft **54** is set as ϕ-ϕ', and the orientation ϕ is set as a direction where the mounting unit frame **58** moves toward the thigh of the examinee. Moreover, the rotational direction of the probe support frame **60** about the support shaft **54** is set as θ-θ' and the orientation of the probe support frame **60** tilting toward the front is set as θ.

The mounting unit frame **58** has a gate shape viewed from the front side; that is, an angular C-shape opened toward the downward direction, and the mounting unit support shaft **54** is provided separately at the left and right such that the mounting unit support shaft **54** does not enter the space inside the angular C-shape. Because the leg of the examinee enters the inside of the angular C-shape, there is employed a configuration in which no shaft passes through the inner space of the angular C-shape.

As shown in FIG. **9**, the knee-contacting portion **62** comprises an acoustic matching member **64** which extends from the mounting unit frame **58** to the front and is curved toward the downward direction. The acoustic matching member **64** is curved along the knee cap, and is in contact with the knee cap to position the mounting unit **16** in the front and rear direction. The acoustic matching member **64** is typically a rubber bag containing water (hereinafter referred to as "water bag **64**"). When the maintenance of the shape of the member cannot be expected such as in the case of the water bag, a matching member support frame (water bag support frame) **66** for maintaining the above-described curved shape and supporting the curved shape is provided. The water bag support frame **66** is fixed on the mounting unit frame **58**, and comprises a portion which is curved and which extends to the left and right sides of the knee when the mounting unit **16** is mounted on the leg of the examinee. The water bag **64** supported on the left and right by this portion of the water bag support frame **66** is maintained in the shape which is curved according to the shape of the water bag support frame **66**. The water bag **64** comprises a free portion **64***b* which is a portion which is not supported on the left and right and which can move in the front and rear direction, at the tip of a fixed portion **64***a* having the left and right sides supported by the water bag support frame; that is, at a distal side of the leg. A distal side frame **72** for setting the shape of the end of the water bag **64** is provided at an end of the free portion **64***b*; that is, an end of the water bag **64**. The water bag **64** is maintained in the curved plate shape by the water bag support frame **66** and the distal side frame **72**.

The mounting unit frame **58** is equipped with a probe-driving mechanism **74** which rotationally drives the probe support frame **60**, and a probe angle measuring mechanism **76** which measures an angle of the probe. Details of these mechanisms will be described later.

Similar to the mounting unit frame **58**, the probe support frame **60** has an angular C-shape opened to the downward direction viewed from the front side. A probe holder **80** which detachably holds an ultrasonic probe **78** is fixed on the vertical portion of the angular C-shape; that is, the beam portion of the gate shape. The probe support frame **60** can be rotated independent from the mounting unit frame **58**, and, with the rotational operation, movement of the ultrasonic probe **78** along the knee cap is achieved. The ultrasonic probe **78** may be of a linear type, and is supported by the probe holder **80** such that the scanning plane is a plane orthogonal to the XY plane.

FIG. **7** is an enlarged perspective view of the mounting unit **16**, and FIG. **8** is an exploded perspective view of the mounting unit frame **58** and the probe support frame **60**. As described above, the mounting unit frame **58** and the probe support frame **60** are rotatably supported in an independent manner on the mounting unit support shaft **54**. In addition, a drive drum **82** is rotatably supported on the mounting unit support shaft **54**. A wire **86** connected to a drive source **84** is wound around an outer periphery of the drive drum **82**. The drive source **84** applies a tension force to the wire **86** in a direction of winding the wire **86**. A stopper pin **88** is provided on the drive drum **82**, and the pin **88** contacts the mounting unit frame **58** to form a rotation stopper of the drive drum **82** in the θ direction. A connecting plate **90** is fixed on the probe support frame **60**, and these members are integrally rotated about the supporting shaft **54**. An index plunger **92** is provided on the connecting plate **90**. The index plunger **92** comprises a plunger rod which extends through the connecting plate **90** and toward the back side, and can be maintained at a state where the rod is projected to the back side and a state where the rod is withdrawn. Two index holes **94***a* and **94***b* are formed in the drive drum **82** to which the projected plunger rod is inserted. In a state where the plunger rod projects and is engaged to one of the index holes **94***a* and **94***b*, the drive drum **82**, the connecting plate **90**, and the probe support frame **60** are integrally rotated. In the state where the plunger rod is withdrawn, the drive drum **82** and the connecting plate **90** can be independently rotated.

The index hole **94***a* is formed at a position where, when the stopper pin **88** is at a position of contact with the mounting unit frame (hereinafter simply referred to as "reference position of the drive drum"), if the plunger rod is inserted into the hole **94***a* and is engaged, the probe support frame **60** is set in a vertical orientation. In this process, the ultrasonic probe **78** is also at the vertical position and in a standing-straight state. This position of the ultrasonic probe **78** is defined as $\theta=0°$. The other index hole **94***b* is formed at a position where, when the drive drum **82** is at its reference position, if the index rod is inserted and is engaged, the probe support frame **60** and the ultrasonic probe **78** are set to a position tilted by 90° to the front (θ=90°).

When the probe support frame is tilted to the front while the rod of the index plunger **92** is engaged to the index hole **94***a*, the wire **86** is unreeled from the drive source **84** due to the rotation of the drive drum **82**. A tension force is applied to the wire **86** by the drive source **84**, and, when the force for tilting to the front direction is released, the drive drum **82** is driven in the direction of θ' by the tension force. With this process, the ultrasonic probe also returns toward θ=0°. The drive source **84** preferably rotates the drive drum **82** at a constant speed.

In addition, an encoder drum **96** is fixed on the probe support frame **60** coaxially with the mounting unit supporting shaft **54**. A belt **100** is wound around a rotary encoder **98** equipped on the encoder drum **96** and the mounting unit frame **58**. The rotary encoder **98** detects a rotational angle of the probe support frame **60**; that is, a rotational angle of the ultrasonic probe. In the present embodiment, the drive drum **82** and the encoder drum **96** are separately placed on the left and right of the mounting unit frame **58**, but alternatively, both drums may be placed at one of the left and right sides.

FIG. **9** is a diagram showing details of the knee-contacting portion **62**. The knee-contacting portion **62** comprises the water bag **64** functioning as the acoustic matching member, and functions as an acoustic matching device which is fitted on the knee and which achieves acoustic matching between the ultrasonic probe which moves along the knee cap and the knee. The support frame **66** comprises a base portion **102** fixed on the mounting unit frame **58**, and two arm portions **104** which extend from the base portion **102** to the front and which are curved toward the downward direction. The base portion **102** and two arm portions **104** form an approximate angular C-shape as an overall shape. The curved portion of the arm portion **104** is an arc in the present embodiment, and a central angle assumed by the arc is 90°. The center of the arc is on a rotational axis of the probe supporting frame. The supporting frame is divided into an inner periphery side and an outer periphery side. An inner frame **106** on the inner periphery side and an outer frame **108** on the outer periphery side each have an approximate angular C-shape, and the inner frame **106** and the outer frame **108** are connected by four clips **109**. The base portion **102** of the inner frame **106** extends toward the rear direction, where the inner frame **106** is fixed on the mounting unit frame **58** by a bolt or the like.

The water bag **64** which functions as the acoustic matching member is sandwiched and supported by the inner frame **106** and the outer frame **108**. The water bag **64** has a proximal side of left and right edges sandwiched and supported by portions belonging to the arm portions of the inner and outer frames **106** and **108**, and an edge of the proximal side sandwiched and supported by a portion belonging to the base portion. With this structure, the water bag **64** between the left and right arm portions **104** is set as the fixed portion **64***a* having an approximate rectangular cross section and maintained in the curved plate shape. The water bag **64** further extends to the portion beyond the arm portion **104**; that is, toward the distal side, and is sandwiched by the distal end frame **72** at a position distanced from the arm portion **104**. The distal end frame **72** closes and seals the opening of the water bag **64**. The distal frame has a structure wherein two rod-shaped frames; that is, an inner frame **110** and an outer frame **112**, are connected at one end with a hinge **114** and are fixed by the other end being fastened by a screw. The water bag **64** is sandwiched between the inner and outer frames **110** and **112**, to seal the water inside the water bag.

The water bag **64** between the tip of the arm portion **104** and the distal end frame **72** forms the free portion **64***b* in which the shape is not fixed and which can swing in the front and rear direction in the manner of a pendulum. The distal end frame **72** may be constructed so as to be hung by the water bag **64**. In addition, the distal end frame **72** may be hung and supported by a wire extending from tips of the two arm portions **104** or a thin plate-shaped flexible frame **118**. FIG. **6** shows a thin plate-shaped member as an example of the flexible frame **118**. The thin plate is placed such that the width direction of the plate is the left and right direction, and, with this thin plate, the swinging of the free portion of the water bag **64** in the front and rear direction is secured. In addition, when a thin plate is employed, the swinging in the left and right direction can be inhibited.

In a state where the knee-contacting portion **62** is in contact with the knee, the ultrasonic probe **78** is moved in a tracing manner on a surface of an outer periphery of the water bag **64**, and ultrasound information is obtained. The fixed portion **64***a* of the water bag contacts the knee cap and contributes to positioning in the front and rear direction of the mounting unit **16**. In this configuration, because the fixed portion does not extend from the front to a region below the knee, the fixed portion does not obstruct mounting of the mounting unit **16**. On the other hand, because of the flexibility of the free portion, during the measurement, the ultrasonic probe can be moved to a region further below the horizontal direction, and the ultrasound can be transmitted to and from a knee joint from a position of, for example, 35° below the horizontal direction. Alternatively, so long as the positioning function in the front and rear direction of the mounting unit **16** can be achieved, the fixed portion **64***a* of the water bag may have an angle assuming the center of the arc of the fixed portion being an angle less than 90°.

The knee-contacting portion **62** has both the function to position the mounting unit **16** in the front and rear direction and a function to achieve acoustic matching during the transmission and reception of ultrasound. Alternatively, the knee-contacting portion **62** may be configured to have only the positioning function. For example, a plate which contacts a region near a proximal end of the tibia below the knee may be fixed to the mounting unit frame **58** and the positioning of the front and rear direction may be achieved with this plate. In this case, the acoustic matching member is not provided on the mounting unit, and it is possible to apply an acoustic jelly or the like on the knee cap and execute the measurement.

FIG. **10** is a cross sectional diagram schematically showing the structure of the standing-straight orientation maintaining mechanism **44**. The standing-straight orientation maintaining mechanism **44** comprises a ball plunger **120** which is fixedly provided on the lower lateral member **24**, and a ball-receiving box **122** fixed on the base **12**. A ball-receiving slit **126** which engages a ball **124** of the ball plunger is formed on an upper surface of the ball-receiving box **122**. The ball-receiving slit **126** extends in a left and right direction; that is, a direction through the page of FIG. **10**, so that, even when the rotational frame moves to the left and right, the engagement between the ball and the slit is achieved. The ball **124** is urged by a spring **128**, the engagement between the ball and the slit is maintained, and, in this state, the rotational frame is maintained at the standing-straight position. When the rotational frame **14** is moved in the tilting direction, the ball **124** is pressed into the plunger against the urging force of the spring **128**, and the engagement between the slit and the ball is released (refer to FIG. **6**).

FIGS. **5** and **6** show the damper mechanism **46** for inhibiting the speed of tilt of the rotational frame **14** and for carrying at least a part of its weight. A pressurizing member **130** is fixed on the lower lateral member **24**, and a transfer plate **134** which rotates about a shaft **132** is in contact with the pressurizing member **130**. The transfer plate **134** has an approximate fan shape, with the pressuring member **130** being in contact with one radius and a rod of a damper **136** in contact with the other radius. The damper **136** is stored in the base so that its axis is on the horizontal direction, and contributes to inhibition of the height of the base. When the rotational frame **14** is moved to tilt from the standing straight state (FIG. **5**), the pressurizing member **130** pushes the transfer plate **134**. Because of this process, the transfer plate **134** is rotated in the counterclockwise direction in the figure, and presses the rod of the damper **136**. In this process, because of a resistance caused by the damper **136**, the speed of tilt of the rotational frame **14** is inhibited. In addition, the damper applies an urging force via the transfer plate **134** so that the rotational frame **14** is rotated in a direction toward standing straight; that is, an orientation Θ'. Because of this, the weights of the rotational frame **14** and the mounting unit **16** are at least partially cancelled.

FIGS. **4**, **5**, and **11** show the left-and-right direction positioning mechanism **47** which positions the rotational frame **14** in the left and right according to the legs of the examinee. FIG. **11** is a plan view schematically showing the left-and-right positioning mechanism **47**. A bracket **140** for supporting a shaft **138** is fixed on the auxiliary lateral member **30**. A contact block **142** which contacts the leg of the examinee; in particular, the shin, is supported in a rotatable manner on the shaft **138**. The contact block **142** does not move in the left and right direction with respect to the rotational frame **14**. As shown in FIG. **11**, a concave portion with respect to the shin; typically a V-shaped channel **144**, is formed in the contact block **142**. The rotational frame **14** is moved in the left and right direction such that the channel **144** contacts the shin and the position is adjusted such that the leg is positioned at the center of the rotational frame **14** in the left and right direction. The movement in the left and right direction is achieved by rotating the knob **42** as described above. In addition, by contacting the contact block **142** to the shin, it is possible to prevent a state where the shin is tilted drastically in the left or right when viewed from the front.

As described above, the rotational frame **14** comprises the extension/contraction lock mechanism **51** which can be extended/contracted, and which fixes the position of the rotational frame **14**. The extension/contraction lock mechanism **51** comprises a lock portion **146** provided on a lower end of the upper rod **50** which enters the inside of the lower rod **48**, and a drive portion **148** provided at an end of the upper lateral member **28**. FIG. **12** shows a detailed structure of the lock portion **146**. The upper rod **50** is hollow, and comprises a pair of lock arms **150** which open and close inside the upper rod **50**. A position indicated in the figure with reference numeral **150** represents an open state and a position indicated in the figure with reference numeral **150'** represents a closed state. A connecting rod **152** is connected to the lock arm **150**, and the lock arm **150** is opened and closed by upward and downward movements of the connecting rod **152**. The connecting rod **152** is connected to a spring **154** at a lower end of the figure, and is constantly urged in the downward direction by the spring **154**. A wire **156** which extends in the upper rod **50** in the upward direction is connected to the upper end of the connecting rod **152**. The wire **156** extends to the upper end of the upper rod **50** and reaches the inside of the upper lateral member **28**. A lock knob **158** is provided on the end of the upper lateral member **28**, and an end of the wire **156** is connected to a cylindrical portion of the lock knob **158** extending inside the upper lateral member **28**. A plunger **160** is provided on the lock knob **158**, and is pressurized toward the upper rod **50** with a spring. Because of this structure, when a tip of the plunger **160** enters a hole formed in the upper rod **50**, the rotation of the lock knob **158** can be stopped.

Normally, the lock arm **150** is maintained in the open state because the connecting rod **152** is urged in the downward direction by the spring. In this process, the tip of the lock arm **150** protrudes from the outer peripheral surface of the upper rod **50**, contacts the inner peripheral surface of the lower rod **48** which is in a nested structure with the upper rod **50**, and locks the upper and lower rods by friction. When the lock knob **158** is rotated and the wire **156** is wound around the cylindrical portion thereof, the connecting rod **152** is pulled by the wire and moves upward against the urging force of the spring **154**, and the lock arm **150** is closed. With this structure, the engagement of the tip of the lock arm **150** with the inner peripheral surface of the lower rod **48** is released, and the upper and lower rods are set in a slidable state. After the upper and lower rods **50** and **48** are slid and the length of the rotational frame **14** is set to a suitable length, the lock knob **158** is rotated in a reverse direction to loosen the tension force applied to the wire **156** and open the lock arm **150**. With this process, the upper and lower rods are again locked.

FIG. **13** is a diagram showing a system summary of an ultrasonic probe support device and an ultrasound diagnosis apparatus for diagnosing the cartilage of the knee joint; in particular, the cartilage at a distal end of the femur. An examinee P sits on a chair **162**, in a state where the knee is bent. A sitting surface **164** of the chair **162** can be moved up and down so that the height can be adjusted to achieve a suitable orientation of the examinee for observation of the cartilage of the knee joint. The figure shows a state where the mounting unit **16** of the ultrasonic probe support device **10** described above is mounted on the knee of the examinee P. The ultrasonic probe **178** is connected to an ultrasound diagnosis apparatus **166**. The ultrasound diagnosis apparatus **166** is a well-known apparatus, and will not be described here.

An actual operation during the measurement will now be described. In an initial state, as shown in FIG. **5**, the rotational frame **14** is in a standing straight state. In FIG. **5**, the mounting unit **16** is shown not in the initial state, but in a position of mounting, for the purpose of later description. After the examinee P sits on the chair **162**, the leg is placed on the base such that the thighs are approximately parallel to each other and the sagittal plane is approximately parallel to the front and rear axis (X-X' axis) of the device. The knob **42** is rotated to roughly position the rotational frame **14** in the left and right direction by visual observation. The rotational frame **14** is tilted in the orientation G and extended in the orientation R, the mounting unit frame **58** is placed on the upper surface of the thigh, and the knee contacting portion **62** is contacted to the knee cap. With this process, the mounting unit **16** is positioned in the up and down direction and the front and rear direction. In addition, the knob **42** is adjusted and the position in the left and right direction is determined so that the shin enters without being contacted with the channel **144** of the contact block **142**. FIG. **6** shows a state where the rotational frame **14** is tilted. In FIG. **6**, however, the left-and-right positioning mechanism **47** is not shown.

The index plunger **92** is operated to release the connection between the connecting plate **90** and the drive drum **82**, so that the probe support frame **60** can be manually moved. The operator manually moves the probe support frame **60** and checks whether or not desired ultrasound echo information can be obtained while viewing the monitor of the ultrasound diagnosis apparatus **166**. If there is no problem, the index plunger **92** is engaged with the index hole **94***a*, to achieve a standing straight position of the ultrasonic probe **78**. The probe in this state is shown in FIG. **5** with a reference numeral **78-1**. The operator manually rotates the probe supporting frame **60** in the orientation θ, and moves the probe to the position of a reference numeral **78-2** in FIG. **5**. This position is a position which is 35° further in the downward direction from the horizontal direction. As described above, the free portion **64***b* which can swing in the front and rear direction is provided at the distal side of the water bag **64**. The free portion is pushed by the ultrasonic probe **78-2** moved to a region below the knee and swings to the rear direction, and closely contacts a region below the knee or above the shin.

With the rotation of the probe support frame **60** in the orientation θ, the drive drum **82** is also rotated, and the wire **86** is unreeled from the drive source **84**. When the probe support frame **60** is released, the probe support frame **60** is rotated in the orientation θ' by the tension force from the drive source **84**. The ultrasonic probe **78** moves along an arc of the sagittal plane passing through the center of the knee and while maintaining a state of directed toward the center of the arc. The center of the arc of the trajectory of the ultrasonic probe approximately matches the mechanical center of the knee joint. A radius of the trajectory (arc) of movement of the probe tip is preferably 40 mm~60 mm plus the thickness of the water bag **64**, and, in the present embodiment, is set to 70 mm because the thickness of the water bag is 10 mm~20 mm. The center of the arc of the trajectory of the ultrasonic probe approximately matches the mechanical center of the knee joint. In addition, in order to achieve an approximate constant movement speed of the ultrasonic probe, the tension force generated by the drive source **84** is approximately constant. Moreover, the ultrasonic probe **78** moves constantly in contact with the surface of the water bag **64**, tracing the surface of the water bag **64**. While the frame **60** is rotated, the rotational angle is detected by the rotary encoder **98**. Echo information of the ultrasound is obtained for each predetermined angle, and the information is stored in the storage of the ultrasound diagnosis apparatus **166**. With this process, mechanical scanning of the ultrasound; in particular, concave scanning, is realized. The scanning direction of the concave scanning and the scanning surface of the ultrasonic probe **78** which is of the linear type are orthogonal to each other, and, thus, three-dimensional information of the knee joint can be obtained. When the probe is tilted from the standing straight position to a position of 15° to the front (which is shown with a reference numeral **78-3**), the measurement is completed. Afterwards, the probe support frame **60** is rotated to the standing straight position (**78-1**). When the rotation of the ultrasonic probe is completed, the rotational frame **14** is moved to the standing straight position, the lock of the extension/contraction lock mechanism **51** is released, and the rotational frame **14** is contracted. With the rotational frame **14** being contracted, the ease of storage of the support device **10** can be improved.

EXPLANATION OF REFERENCE NUMERALS

10 ULTRASONIC PROBE SUPPORT DEVICE; **14** ROTATIONAL FRAME; **16** MOUNTING UNIT; **54** MOUNTING UNIT SUPPORT SHAFT; **58** MOUNTING UNIT FRAME; **60** PROBE SUPPORT FRAME; **62** KNEE-CONTACTING PORTION; **64** ACOUSTIC MATCHING MEMBER (WATER BAG); **64***a* FIXED PORTION; **64***b* FREE PORTION; **66** WATER BAG SUPPORT FRAME; **72** DISTAL SIDE FRAME; **78** ULTRASONIC PROBE; **82** DRIVE DRUM; **86** WIRE; **90** CONNECTING PLATE; **162** CHAIR; **166** ULTRASOUND DIAGNOSIS APPARATUS

The invention claimed is:

1. An ultrasonic probe support device which supports, in a state where a knee is bent, an ultrasonic probe in a movable manner along a knee cap, the ultrasonic probe support device comprising:

a mounting unit which is mounted on a thigh and a knee, wherein

the mounting unit comprises:

a mounting unit frame which contacts the thigh;

a knee-contacting portion which contacts the knee or a region below the knee; and

a probe support frame which supports the ultrasonic probe with respect to the mounting unit frame, and which supports the ultrasonic probe such that the ultrasonic probe moves along the knee cap in a state where the ultrasonic probe is directed toward a center of a knee joint.

2. The ultrasonic probe support device according to claim **1**, wherein

the knee-contacting portion comprises an acoustic matching member which is in contact with the knee cap and which realizes acoustic matching of transmitted and received ultrasound, and the acoustic matching member has a shape curved along the knee cap.

3. The ultrasonic probe support device according to claim **2**, wherein

the knee-contacting portion comprises a matching member support frame which is fixed on the mounting unit frame and which supports the acoustic matching member at a right side and a left side of the knee, and the matching member support frame has a shape curved along the knee cap, and

the acoustic matching member is set in the curved shape according to the curved shape of the matching member support frame.

4. The ultrasonic probe support device according to claim **1**, wherein

the matching member comprises a fixed portion which is supported on a matching member support frame, and a free portion which extends from the fixed portion and which is allowed to move in a front and rear direction.

5. The ultrasonic probe support device according to claim **3**, wherein

the matching member support frame has an arc shape.

6. The ultrasonic probe support device according to claim **4**, wherein

the matching member support frame has an arc shape.

7. The ultrasonic probe support device according to claim **1**, wherein

the probe support frame is rotatably supported with respect to the mounting unit frame, and the movement of the ultrasonic probe along the knee cap is realized by a rotation of the probe support frame.

8. The ultrasonic probe support device according to claim **1**, further comprising:

a base which is placed on a floor; and

a rotational frame which is provided on the base in a standing manner and which is rotatably supported on the base, wherein

the mounting unit is rotatably supported on the rotational frame, and

the rotational frame is rotated in a manner to be tilted toward the knee, and the mounting unit is contacted with the thigh and knee or a region below the knee.

9. The ultrasonic probe support device according to claim **8**, wherein

the rotational frame comprises:

a lower frame which is rotatably supported on the base; and

an upper frame which slides, with respect to the lower frame, in a radial direction of the rotation, and which rotatably supports the mounting unit.

10. An ultrasound diagnosis apparatus comprising the ultrasonic probe support device according to claim **1** and an ultrasound unit having an ultrasonic probe which is supported by the ultrasonic probe support device, wherein ultrasound information of cartilage at a distal end of a femur is obtained based on ultrasound transmitted and received by the ultrasonic probe.

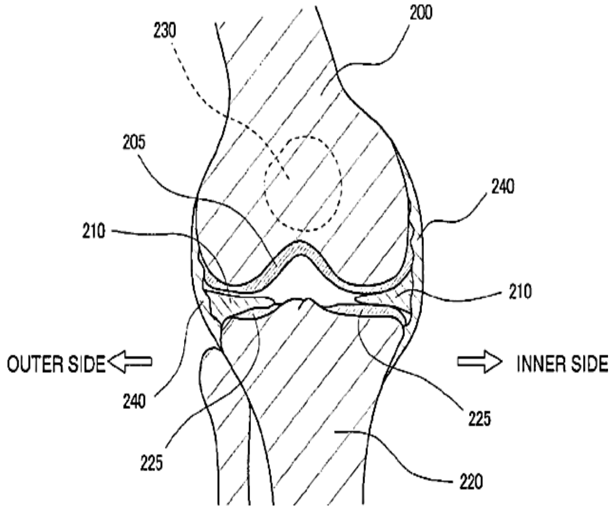
* * * * *

patsnap

专利名称(译)	超声波探头支撑装置		
公开(公告)号	US8453511	公开(公告)日	2013-06-04
申请号	US13/055376	申请日	2009-07-17
[标]申请(专利权)人(译)	国立大学法人 东京大学 日立阿洛卡医疗株式会社		
申请(专利权)人(译)	东京大学 ALOKA CO.，LTD.		
当前申请(专利权)人(译)	东京大学 日立ALOKA MEDICAL.，LTD.		
[标]发明人	NAKAMURA KOZO ONISHI ISAO OHASHI SATORU MINAGAWA EIICHI HIROTA KOJI SAKAI RYOICHI OGAWA KOJI MIYASAKA KOICHI MURASHITA MASARU		
发明人	NAKAMURA, KOZO ONISHI, ISAO OHASHI, SATORU MINAGAWA, EIICHI HIROTA, KOJI SAKAI, RYOICHI OGAWA, KOJI MIYASAKA, KOICHI MURASHITA, MASARU		
IPC分类号	G01D21/00 A61B8/13		
CPC分类号	A61B8/0858 A61B8/4209 A61B19/26 A61B5/4514 A61B5/4528 A61B8/4281 A61B8/4405 A61B2019/5276 A61B90/50 A61B2090/378		
优先权	2008188709 2008-07-22 JP		
其他公开文献	US20110132094A1		
外部链接	Espacenet USPTO		

摘要(译)

通过使用接触大腿的安装单元框架（58）和接触膝盖的膝盖接触部分（62）对准安装单元（16），膝盖弯曲。安装单元还配备有探针支撑框架（60），用于沿着膝盖移动超声波探头。探针支撑框架围绕膝关节的机械中心旋转地移动，从而允许超声探头（78）在面向膝关节的机械中心的同时沿着膝盖移动并且执行超声波束的扫描。



230
200
205
240
210
210
OUTER SIDE
INNER SIDE
240
225
225
220