US 20090240145A1

(19) United States
(12) Patent Application Publication
OTSUKA
(10) Pub. No.: US 2009/0240145 A1
(43) Pub. Date: Sep. 24, 2009

(54) PRESSING MECHANISM AND ULTRASOUND DIAGNOSTIC APPARATUS

(75) Inventor: Toshiki OTSUKA, Tokyo (JP)

Correspondence Address:
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 CONNECTICUT AVENUE, NW, SUITE 700
WASHINGTON, DC 20036 (US)

(73) Assignee: ALOKA CO., LTD., Tokyo (JP)

(21) Appl. No.: 12/051,677

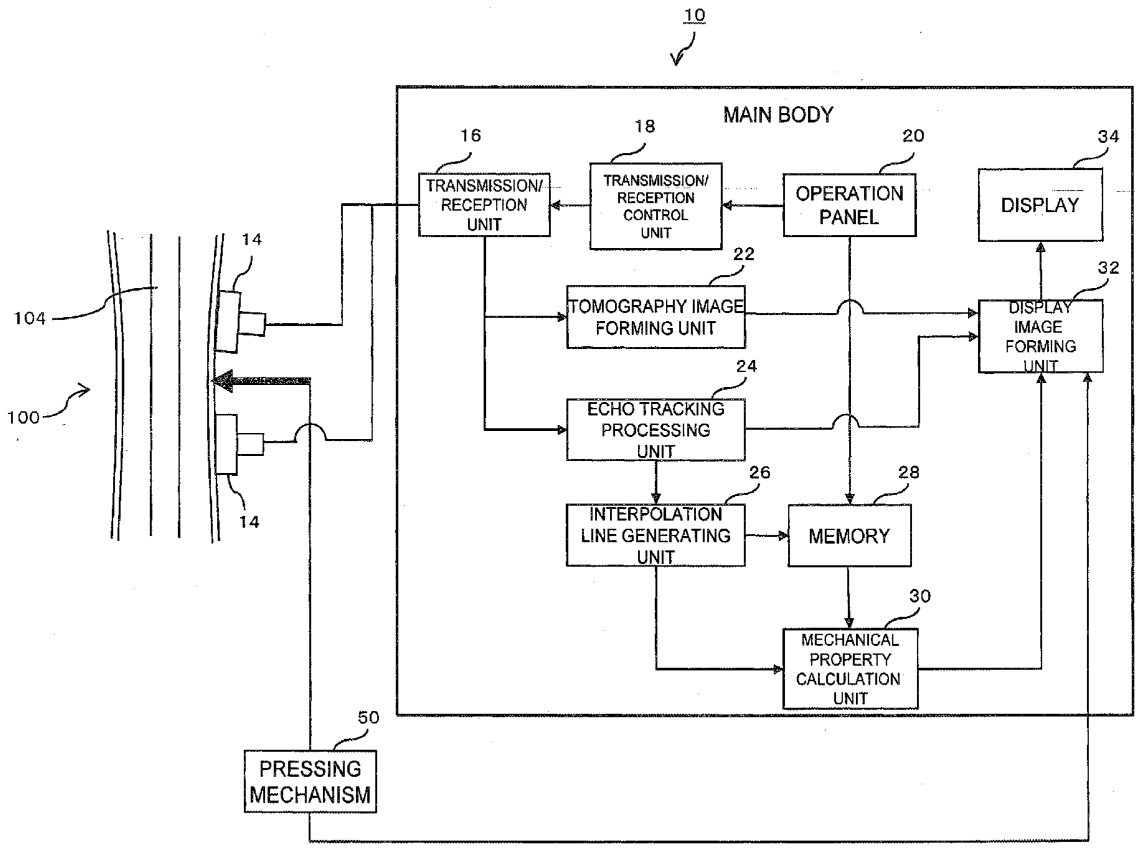
(22) Filed: Mar. 19, 2008

Publication Classification

(51) Int. Cl.
A61B 8/00 (2006.01)
A61F 5/01 (2006.01)
(52) U.S. Cl. 600/439; 606/53

(57) ABSTRACT

An ultrasound diagnostic apparatus according to the present invention includes a pressing mechanism capable of appropriately applying a pressing force to a predetermined position on a fractured bone. The pressing mechanism includes an annular belt detachably hung around a leg in which a shinbone (i.e., a target bone) is present, a deadweight connected to a lower end of the annular belt and having a weight value corresponding to a desired pressing force, and a mobile base positioned under the deadweight and movable in an up-and-down direction. If the mobile base moves downward, the deadweight separates from the mobile base and is brought into a free state where a pressing force acts on the target bone. If the mobile base moves upward, the deadweight is supported by the mobile base and the target bone is released from the pressing force.



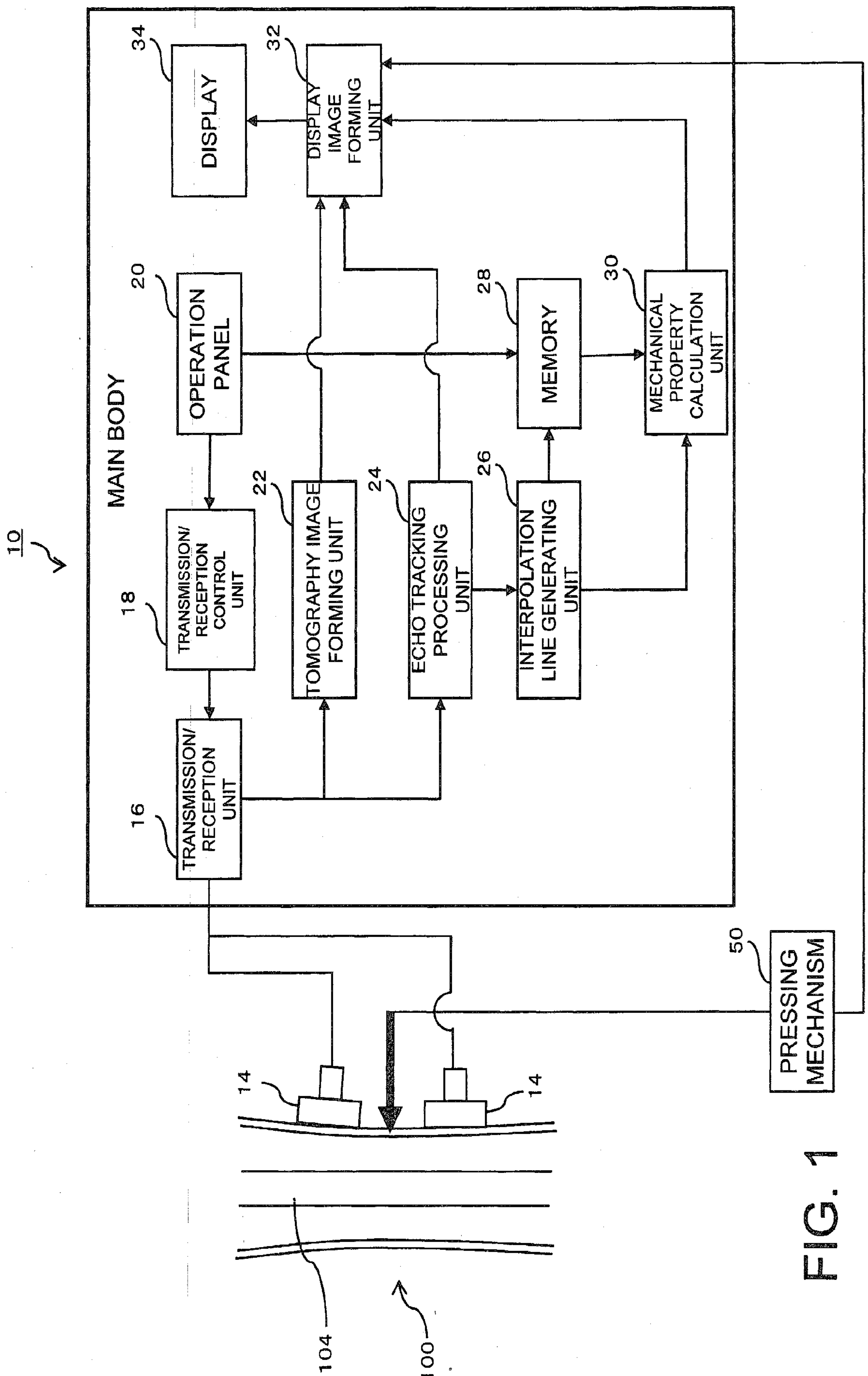

10
MAIN BODY
34
DISPLAY
32
DISPLAY IMAGE FORMING UNIT
20
OPERATION PANEL
28
MEMORY
30
MECHANICAL PROPERTY CALCULATION UNIT
18
TRANSMISSION/ RECEPTION CONTROL UNIT
22
TOMOGRAPHY IMAGE FORMING UNIT
24
ECHO TRACKING PROCESSING UNIT
26
INTERPOLATION LINE GENERATING UNIT
16
TRANSMISSION/ RECEPTION UNIT
50
PRESSING MECHANISM
14
14
104
100

FIG. 1

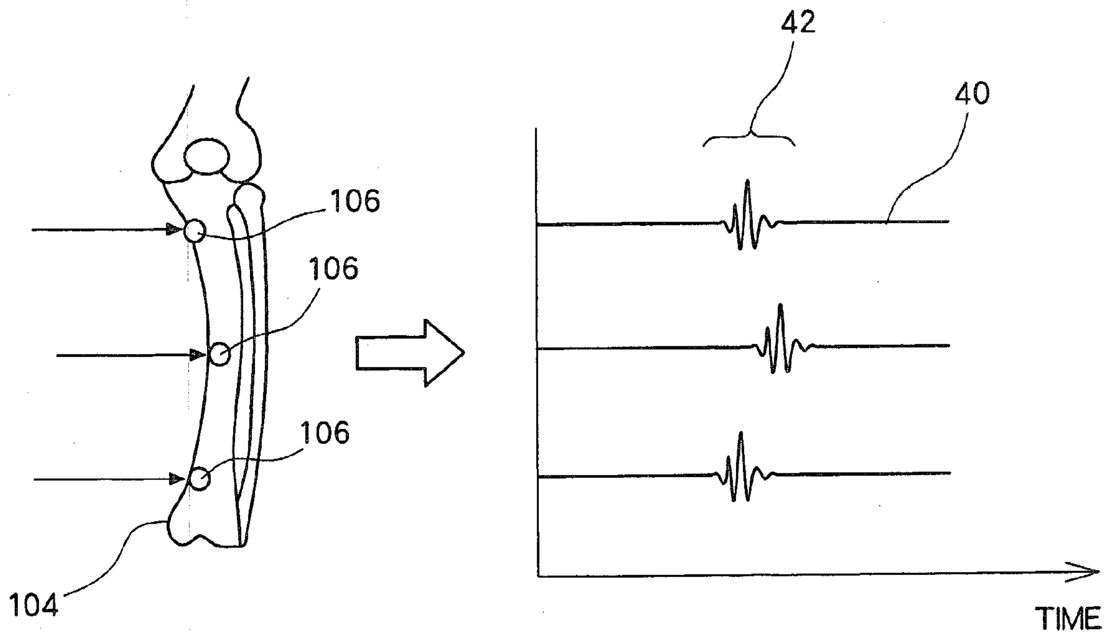


FIG. 2

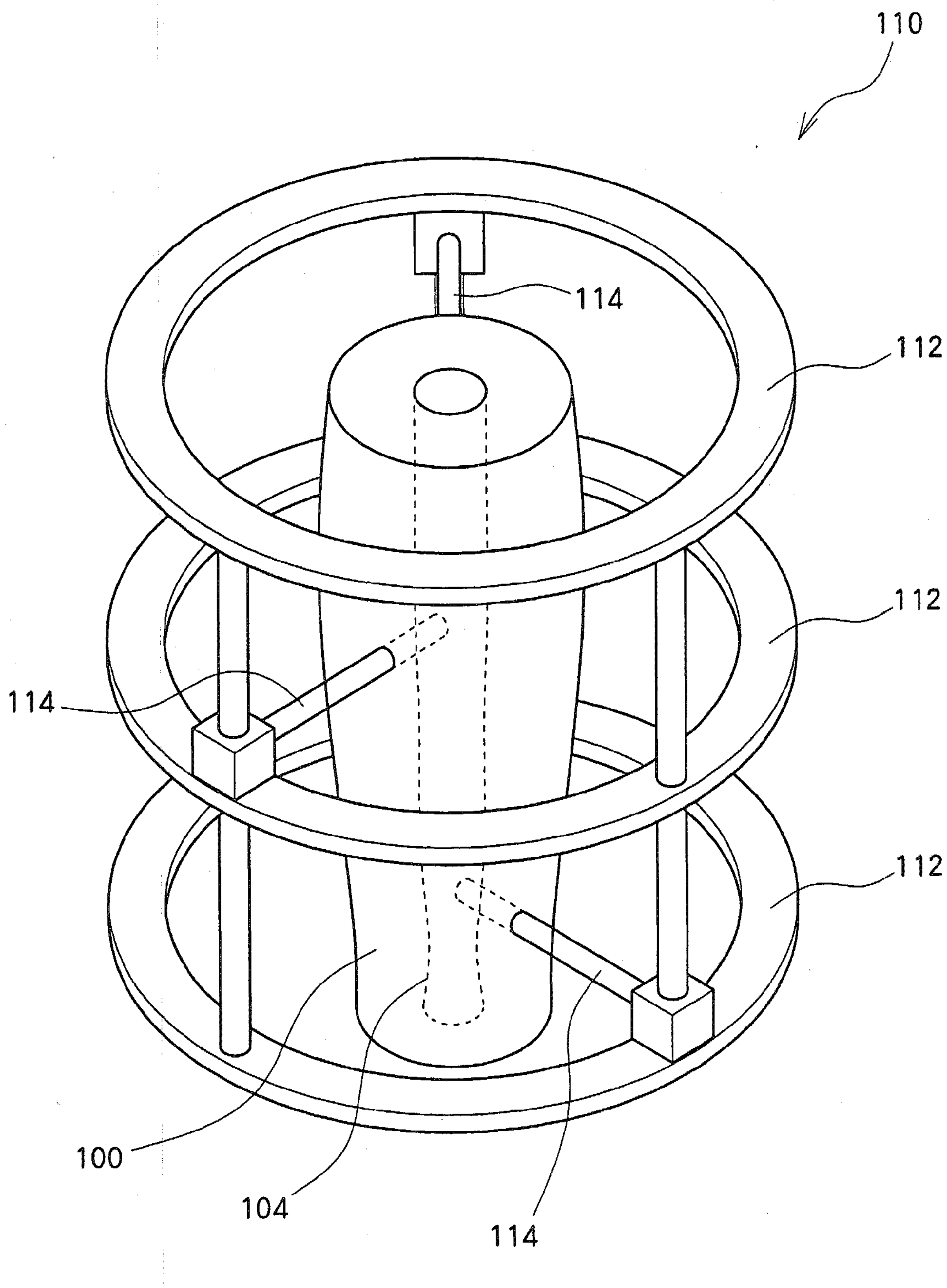


FIG. 3

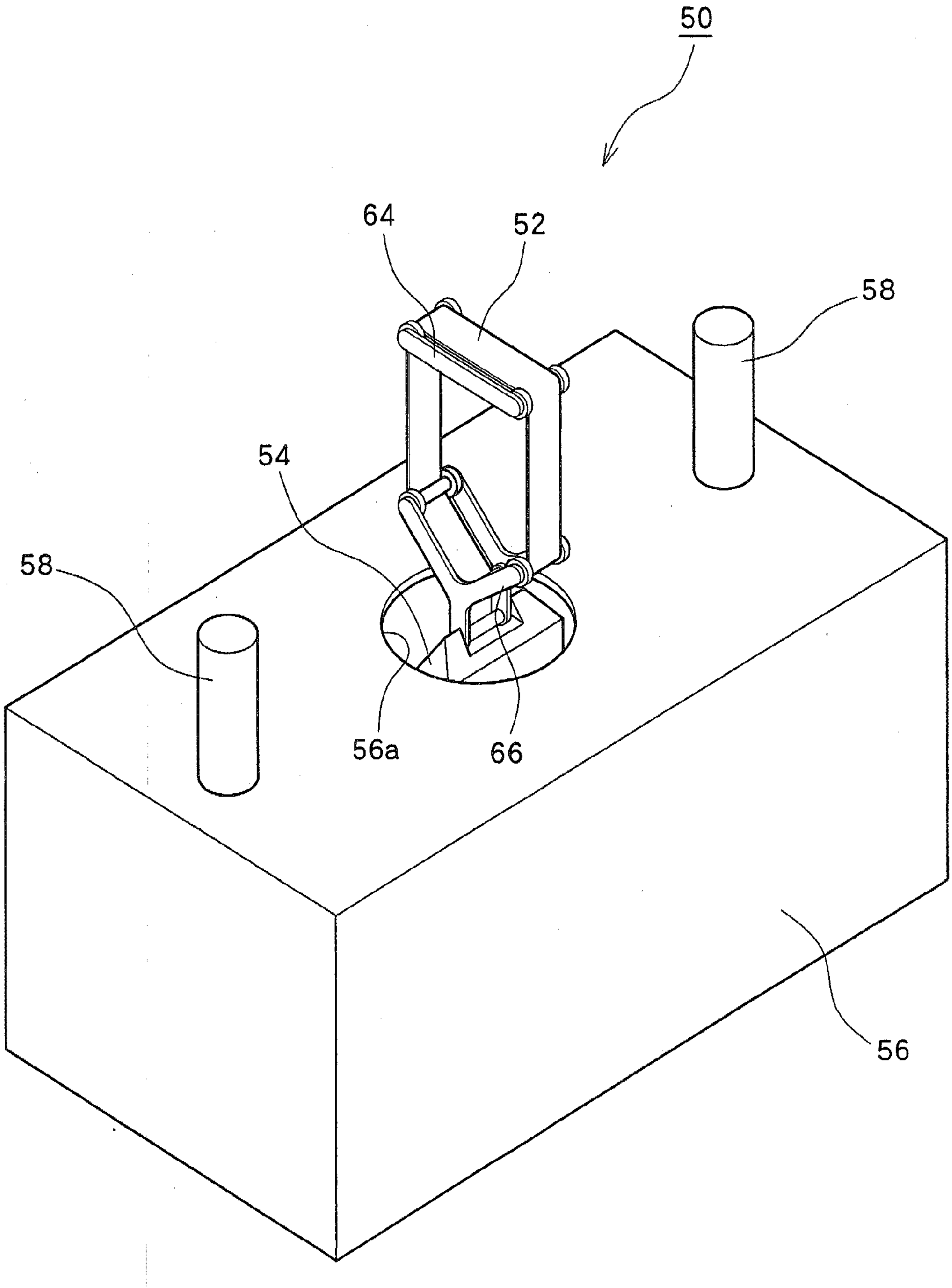
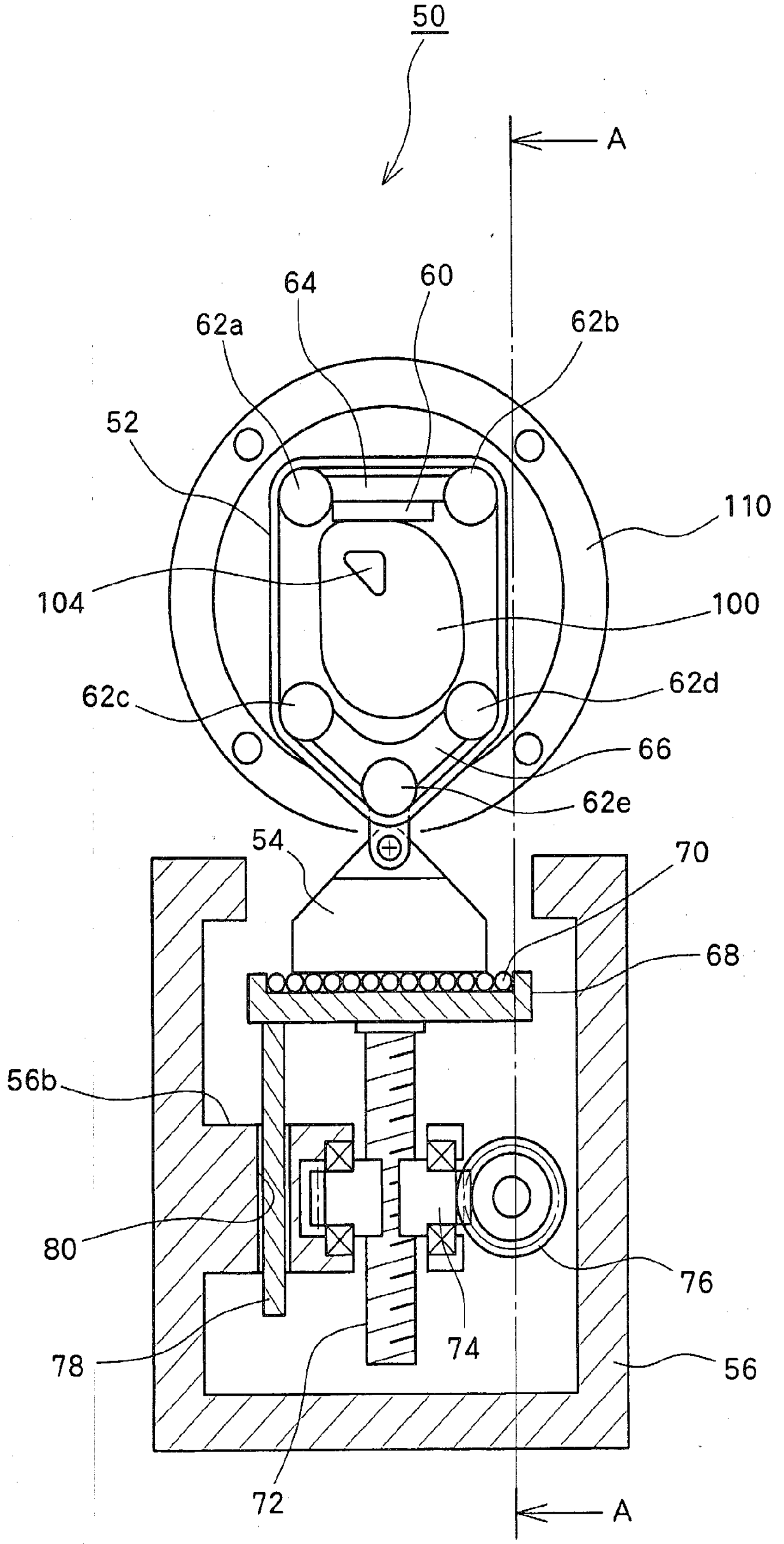


FIG. 4



50
A
64
60
62a
62b
52
110
104
100
62c
62d
66
62e
54
70
68
56b
80
76
78
74
56
72
A

FIG. 5

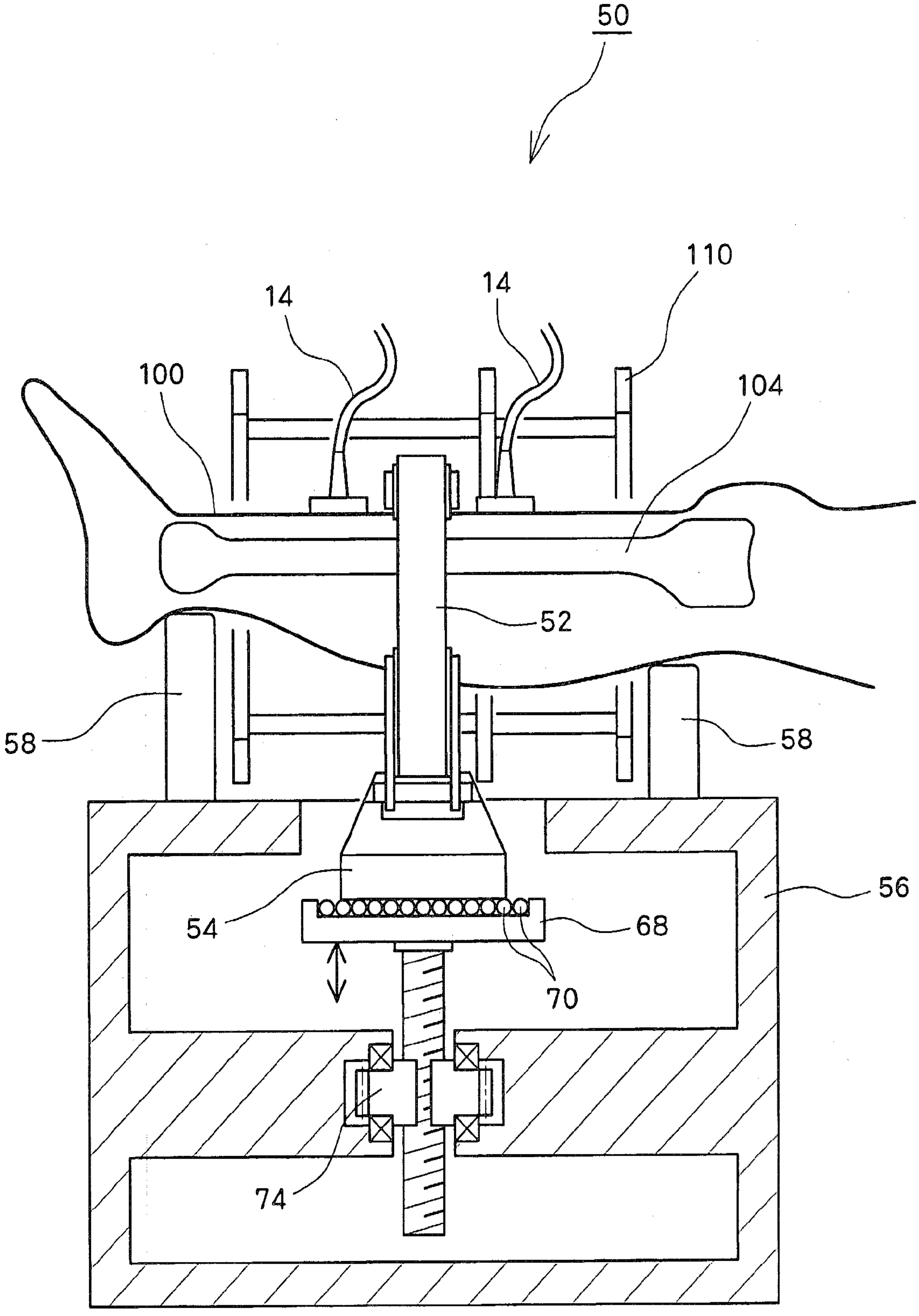


FIG. 6

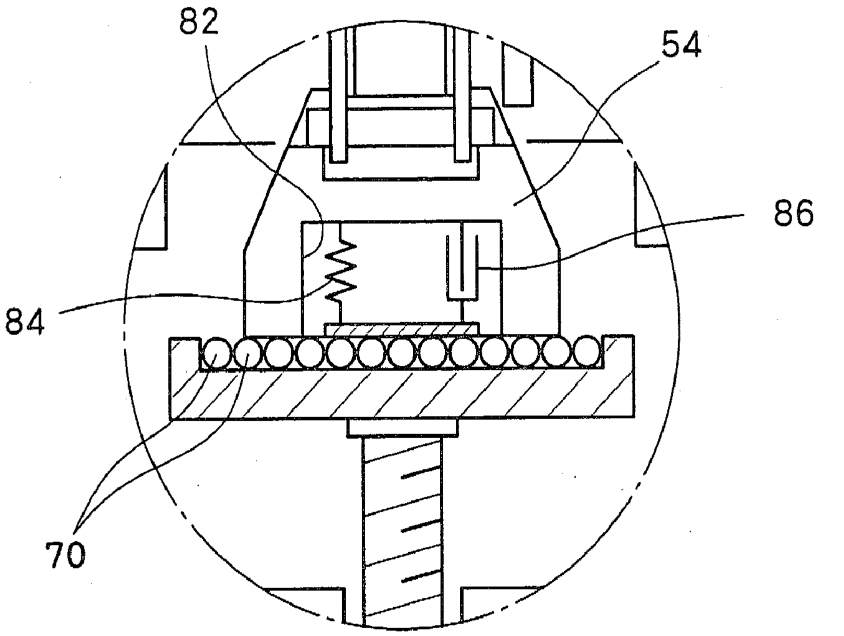


FIG. 7A

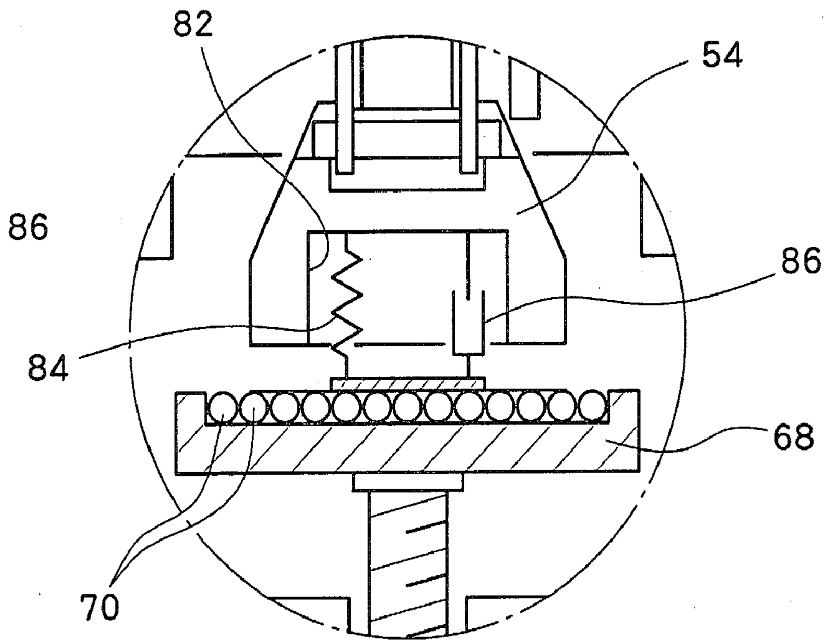


FIG. 7B

PRESSING MECHANISM AND ULTRASOUND DIAGNOSTIC APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a pressing mechanism that applies a pressing force to a target bone in the diagnosis of mechanical properties, and also relates to an ultrasound diagnostic apparatus including the pressing mechanism.

[0003] 2. Description of the Related Art

[0004] Easy quantitative measurement of mechanical properties is desired for diagnosing bone metabolic diseases such as osteoporosis, judging fracture risk, and quantitatively diagnosing bone union after treatment of bone fracture. The evaluation of mechanical properties of a bone (including strength and elasticity) greatly depends on X-ray photography, but quantitatively diagnosing bone strength by means of X-ray photography is very difficult. X-ray irradiation may also have adverse effects on the human body.

[0005] On the other hand, to simply evaluate mechanical properties (e.g., bone strength) of a bone, an ultrasound diagnostic apparatus discussed in Japanese Patent Laid-Open Publication No. 2004-298205 measures the shape of a target bone which deforms when a stress is applied, and diagnoses mechanical properties of the bone based on a measurement result.

[0006] A conventional diagnostic apparatus includes a dedicated pressing mechanism that can control a load value applied to a target bone and a position where the load is added, in the diagnosis of mechanical properties. For example, a conventional pressing mechanism includes a rigid pressing member which can be brought into contact with a surface of a human body which includes a bone to be pressed. The pressing mechanism is configured to control a load value applied to the bone by adjusting an advancing amount of the pressing member relative to the body.

[0007] A user can evaluate bone union of a fractured bone if mechanical properties of the bone are obtainable through the above-described diagnosis. In other words, the diagnosis of mechanical properties can be preferably executed for a fractured bone. In general, a plaster or an external fixation device can tightly hold a fractured bone. The external fixation device includes a plurality of screws and pins which are partly inserted into a human body to fix the bone in position. The external fixation device is fixed to the body in a stationary manner unless the fractured bone is completely cured.

[0008] In a state where an external fixation device is attached around a target body, a user cannot smoothly perform the ultrasonic mechanical property diagnosis on a fractured bone. Namely, if an external fixation device is attached around a target body, the above-described pressing mechanism of the diagnostic apparatus interferes with metal fittings of the external fixation device in the vicinity of the body. As a result, a user cannot apply an appropriate load to the fractured bone. Furthermore, regardless of the presence of an external fixation device, a conventional pressing mechanism is unable to apply an appropriate pressing force to a target bone if the type of diagnosis object is inappropriate, or if another method or device for curing a fractured bone is employed.

SUMMARY OF THE INVENTION

[0009] The present invention is directed to a pressing mechanism capable of accurately pressing a predetermined pressing position, and an ultrasound diagnostic apparatus capable of appropriately performing diagnosis of mechanical properties.

[0010] According to an aspect of the present invention, a pressing mechanism applies a pressing force to a target bone when a diagnosis of mechanical properties is performed for the target bone. The pressing mechanism includes an annular belt detachably hung around a diagnosis object in which the target bone is present, a deadweight connected to a lower end of the annular belt and having a weight value corresponding to a desired pressing force, and a mobile base positioned under the deadweight and movable in an up-and-down direction. If the mobile base moves downward, the deadweight separates from the mobile base and is brought into a free state where a pressing force acts on the target bone. If the mobile base moves upward, the deadweight is supported by the mobile base and the target bone is released from the pressing force.

[0011] In a preferred embodiment, the annular belt is entrained around a plurality of rollers which are spaced from the diagnosis object. In this case, the rollers include a group of fixed rollers which are symmetrically disposed with respect to a pressing position in the right-and-left direction, and are in a fixed relationship relative to the annular belt, and a group of movable rollers which can slide along an inner surface of the annular belt and automatically move to a position where the gravity acting on the annular belt is balanced in the right-and-left direction.

[0012] In a preferred embodiment, the mobile base supports the deadweight via a plurality of balls that permits horizontal movement of the deadweight relative to the mobile base. In a preferred embodiment, an urging member is disposed between the mobile base and the deadweight to urge the deadweight in the upward direction.

[0013] According to another aspect of the present invention, an ultrasound diagnostic apparatus is configured to transmit/receive ultrasonic waves to/from a target bone in a state where a pressing force is applied to the target bone, and to obtain deformation properties of the target bone subjected to the pressing force. The ultrasound diagnostic apparatus includes a pressing mechanism configured to press a predetermined position on a target bone, an ultrasonic probe configured to transmit and receive ultrasonic wave to and from the target bone, and a calculation unit configured to calculate a change in the target bone before and after the target bone is pressed by the pressing mechanism based on an echo signal obtained via the ultrasonic probe that performs transmission/reception of ultrasonic wave. The pressing mechanism includes an annular belt detachably hung around a diagnosis object in which the target bone is present, a deadweight connected to a lower end of the annular belt and having a weight value corresponding to a desired pressing force, and a mobile base positioned under the deadweight and movable in an up-and-down direction. If the mobile base moves downward, the deadweight separates from the mobile base and is brought into a free state where a pressing force acts on the target bone. If the mobile base moves upward, the deadweight is supported by the mobile base and the target bone is released from the pressing force.

[0014] According to the present invention, the gravity of a deadweight hung around a diagnosis object can be applied as a pressing force via an annular belt to a target bone. The annular belt is sufficiently compact in size and can be positioned closely to a pressing position. As a result, the main body of the pressing mechanism does not interfere with an external fixation device or another medical instrument. Thus, the pressing mechanism can appropriately apply a pressing force to a predetermined pressing position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

[0016] FIG. **1** is a block diagram illustrating an ultrasound diagnostic apparatus according to an embodiment of the present invention;

[0017] FIG. **2** illustrates example tracking processing for obtaining echo signals from a bone surface;

[0018] FIG. **3** illustrates a perspective view of an example external fixation device;

[0019] FIG. **4** illustrates a perspective view of a pressing mechanism;

[0020] FIG. **5** illustrates a cross-sectional view of the pressing mechanism;

[0021] FIG. **6** illustrates a cross-sectional view taken along a line A-A of FIG. **5**;

[0022] FIG. **7**A illustrates a partly enlarged view of another pressing mechanism; and

[0023] FIG. **7**B illustrates a partly enlarged view of another pressing mechanism.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0024] An embodiment of the present invention is described below with reference to the drawings. FIG. **1** is a block diagram illustrating an ultrasound diagnostic apparatus according to an embodiment of the present invention. An ultrasound diagnostic apparatus **10** is configured to diagnose mechanical properties of a bone (e.g., diagnosis object). For example, the diagnosis object is a shinbone **104** in a human leg **100**.

[0025] The ultrasound diagnostic apparatus **10** according to the present embodiment includes two probes **14** which are brought into contact with a body surface of a measurement target. The probe **14** is, for example, an ultrasonic probe capable of emitting ultrasonic beams toward the shinbone **104** (target bone) inside the body of the measurement target.

[0026] A transmission/reception unit **16** controls each probe **14** that performs electronic scanning with ultrasonic beams on a tomography surface. For example, if the probe **14** is a linear probe, the probe **14** successively emits a total of 120 ultrasonic beams for electronic scanning. The transmission/reception unit **16** obtains an echo signal from each ultrasonic beam. A transmission/reception control unit **18** controls the transmission/reception unit **16** according to a user's instruction input via an operation panel **20**.

[0027] The transmission/reception unit **16** outputs a plurality of echo signals (i.e., the signals having been obtained as described above) to a tomography image forming unit **22**. The tomography image forming unit **22** forms a tomography image (B mode image) of a target bone based on the received echo signals. The transmission/reception unit **16** also outputs the obtained echo signals to an echo tracking processing unit **24**. The echo tracking processing unit **24** performs echo tracking processing (i.e., extracts bone surface portions from the echo signals and performs tracking). For example, a technique discussed in Japanese Patent Laid-Open Publication No. 2001-309918 can be used for the echo tracking processing. The echo tracking processing uses a plurality of (e.g., three) tracking echo signals. The tracking echo signals can be selected from echo signals used for tomography image formation (e.g., 120 echo signals). Alternatively, three echo signals dedicated to the tracking can be used if available during interruption of the tomography image formation.

[0028] FIG. **2** illustrates example tracking processing for obtaining three echo signals **40** from a surface portion of the bone **104**. Three echo signals **40**, corresponding to three ultrasonic beams emitted toward the bone **104**, have a large value in amplitude (amplitude maximized portion **42**) at a portion corresponding to the bone surface. The echo tracking processing unit **24** identifies the position on a bone surface based on the position of the amplitude maximized portion **42** (i.e., acquiring time of a corresponding waveform). Although the example tracking processing illustrated in FIG. **2** uses three echo signals for echo tracking, the number of echo signals used for the measurement can be changed arbitrarily. In the echo tracking processing, a surface point being tracked for each echo signal **40** (i.e., for each ultrasonic beam) can be referred to as tracking point **106**.

[0029] An interpolation line generation unit **26** (refer to FIG. **1**) generates an interpolation line connecting three tracking points **106**. Namely, the interpolation line generation unit **26** generates an interpolated curve connecting respective tracking points **106** according to the spline interpolation or the least squares method interpolation. The generated interpolation line is a curve representing the shape of a target bone surface. The interpolation line, which can more accurately represent the surface shape of a target bone, can be obtained if the number of echo signals for the echo tracking processing is increased. The generated interpolation line can be temporarily stored in a memory **28**. A mechanical property calculation unit **30** calculates a mechanical property value (e.g., deflection amount) of a target bone with reference to the information (i.e., information relating to the shape of a bone surface) temporarily stored in the memory **28**.

[0030] A display image forming unit **32** forms an image to be displayed on a display unit **34**, as a result of diagnosis. The display image forming unit **32** receives a tomography image formed by the tomography image forming unit **22**, a mechanical property value (e.g., deflection amount) calculated by the mechanical property calculation unit **30**, and a load value applied to the target bone from the pressing mechanism **50**. The display image forming unit **32** forms a display image of a graph representing the received mechanical property value and/or the load value, and outputs the display image to the display unit **34**. For example, the display image forming unit **32** directly outputs the display image to the display unit **34**. Alternatively, the display image forming unit **32** can combine the display image with the B mode image. The display unit **34** displays the mechanical properties of a target bone to enable a user to evaluate the union or the strength of a fractured bone.

[0031] A pressing mechanism **50** is configured to apply a predetermined load to the shinbone **104** (i.e., a target bone to be diagnosed). As illustrated in FIG. **1**, two probes **14** are disposed at both sides of a pressing position of the pressing mechanism **50**. Each probe **14** can measure a displacement of the shinbone **104** caused when the shinbone **104** is pressed by the pressing mechanism **50**.

[0032] The deflection amount, or another physical amount indicating mechanical properties, varies significantly depending on an applied load and a pressing position. For example, if the shinbone **104** (target bone) is in a fractured state, the strength of the bone **104** varies significantly depending on the distance from a fractured portion. Therefore, even if the applied load is set to the same value, the measured deflection varies significantly depending on the pressing position. If the deflection amount varies according to the pressing position, a user cannot accurately evaluate the strength of a target bone or the union of a fractured bone. Hence, the user determines a pressing position of the pressing mechanism for each measurement target considering the position of a fracture portion or the shape of a target bone. Then, to accurately perform the diagnosis of mechanical properties, the user is required to accurately press the determined pressing position.

[0033] A user can evaluate the union of a fractured bone based on a diagnosis result of mechanical properties. In this case, the fractured bone may be fixed by an external fixation device. FIG. **3** illustrates a perspective view of an example external fixation device **110**. The external fixation device **110** includes a plurality of pins **114** which are inserted into a human body to fix the fractured bone in position and supported by metal fittings **112** As will be apparent from FIG. **3**, when each pin **114** fixes the fractured bone at one end, the other end of the pin **114** and the metal fittings **112** holding the pin **114** are positioned outside the body.

[0034] If the external fixation device **110** is attached around a target body, a conventional pressing mechanism interferes with the external fixation device **110** and cannot appropriately press a pressing position determined based on the position of a fracture portion and the shape of a target bone. Hence, the pressing mechanism **50** according to the present embodiment is configured to overcome the above-described problems.

[0035] FIG. **4** illustrates a perspective view of the pressing mechanism **50** according to an embodiment. FIG. **5** illustrates a cross-sectional view of the pressing mechanism **50**. FIG. **6** is a cross-sectional view taken along a line A-A of FIG. **5**. The pressing mechanism **50** is configured to apply a pressing force to the shinbone **104** (target bone) by hanging a deadweight **54** having a predetermined weight value on the leg **100** which includes the shinbone **104**. The deadweight **54** is connected to an annular belt **52** which is detachable from the leg **100**. The annular belt **52** is a belt-like member having separable/connectable end parts equipped with an appropriate fastener (e.g., hook). The annular belt **52** becomes an endless shape when the end parts of the belt-like member are connected to each other by the fastener.

[0036] More specifically, before attaching the annular belt **52** around the leg **100**, a user disengages the fastener of the annular belt **52**. In this state, the belt **52** is in an extended state with separated end parts. Next, the user ties the belt **52** around the leg **100** loosely and engages the fastener to connect the belt **52** into an endless shape. In this manner, the annular belt **52** can be temporarily extended into a belt with separated end parts and can be easily attached around the leg **100** even in a state where the leg **100** is supported by the external fixation device **110**.

[0037] A pressing board **60** is made of a rigid member and is fixedly bonded to an inner surface of the annular belt **52**. The pressing board **60** (pressing member) can apply a pressing force to the shinbone **104** when it is brought into contact with a surface of the leg **100**. Namely, a user adjusts the position of the annular belt **52** attached around the leg **100** so that the pressing board **60** is brought into contact with a predetermined pressing position. In this state, if the annular belt **52** is pulled downward by the deadweight **54**, the pressing board **60** can apply a pressing force to the leg **100** (namely, the shinbone **104** included in the leg **100**).

[0038] The annular belt **52** is entrained around five rollers **62** disposed in a pentagonal shape so that an appropriate tension acts on the annular belt **52**. The five rollers **62** are appropriately spaced from an outer surface of the leg **100**. The annular belt **52**, when entrained around the rollers **62**, does not directly contact the leg **100**. In other words, the annular belt **52** can maintain good balance without causing any lack of uniformity due to frictional force.

[0039] Two rollers **62***a* and **62***b* are positioned at both sides of the pressing board **60** and are supported and connected by an upper metal holder **64** extending parallel to the pressing board **60**. The upper metal holder **64** and the pressing board **60** are physically connected with each other. Thus, the positional relationship between upper metal holder **64** (namely, the rollers **62***a* and **62***b* connected to the upper metal holder **64**) and the pressing board **60** can be regulated. Two rollers **62***a* and **62***b* are symmetrical with respect to the pressing position in the right-and-left direction. Furthermore, two rollers **62***a* and **62***b* are in a fixed positional relationship relative to the annular belt **52**. In this respect, two rollers **62***a* and **62***b* function together as a "fixed roller group."

[0040] On the other hand, three rollers **62***c*, **62***d*, and **62***e* are supported and connected by a lower metal holder **66** configured into a Y shape. Two rollers **62***c* and **62***d* are symmetrical with respect to the roller **62***e* in the right-and-left direction. More specifically, three rollers **62***c*, **62***d*, and **62***e* are disposed in a reversed isosceles triangular shape. Three rollers **62***c*, **62***d*, and **62***e* can slide along an inner surface of the annular belt **52**. If any unbalance occurs in the gravity acting on the annular belt **52**, three rollers **62***c*, **62***d*, and **62***e* automatically move to a position where the gravity acting on the annular belt **52** is balanced. As a result, the downward force acting on the annular belt **52** can be automatically adjusted to be symmetrical in the right-and-left direction. Namely, three rollers **62**, **62***d*, and **62***e* can slide along the inner surface of the annular belt **52** when the gravity is unbalanced in the right-and-left direction and adjust the gravity acting on the annular belt **52** to be symmetrical with respect to the pressing position. In this respect, three rollers **62**, **62***d*, and **62***e* function as a "movable roller group."

[0041] The deadweight **54** having a predetermined weight is attached to a proximal end of the lower metal holder **66**. When the deadweight **54** is pulled downward due to its gravity, a downward pressing force is applied to the annular belt **52** as well as to the pressing board **60** bonded together with the annular belt **52**. The downward pressing force acts on the shinbone **104** (i.e., target bone). The weight of the deadweight **54** is determined considering a load value to be applied to a target bone. If the purpose of diagnosis or the type of a target bone is changed, the deadweight **54** can be replaced with another deadweight having a different weight value.

[0042] A base **68**, movable in the up-and-down direction, is positioned under the deadweight **54**. If no pressing force is required for the shinbone **104**, the mobile base **68** can move upward to a higher position where the base **68** supports the bottom of the deadweight **54**. In the raised state where the mobile base **68** mounts and supports the deadweight **54**, no downward force acts on the annular belt **52** and the pressing board **60**. On the other hand, if a pressing force acting on the shinbone **104** is required, the mobile base **68** can move downward to a lower position where the deadweight **54** separates from the mobile base **68** and is kept in a free state. In this state, the deadweight **54** pulls the annular belt **52** with the pressing board **60** downward due to its gravity. The pulling force (i.e., pressing force) acts on the shinbone **104**.

[0043] A plurality of steel balls **70**, provided on an upper surface of the mobile base **68**, enables the deadweight **54** to easily move in the horizontal direction relative to the mobile base **68**. Namely, to accurately diagnose mechanical properties of the shinbone **104**, it is desirable to subject the shinbone **104** to only the force acting in the vertical direction. In other words, it is desirable to eliminate any deviation in the direction of the pressing force acting on the shinbone **104**. In a state where the deadweight **54** is mounted on the mobile base **68**, the deadweight **54** does not constantly exist directly below the pressing board **60** and therefore the deadweight **54** may be offset from the pressing board **60**.

[0044] If the mobile base **68** moves downward from the above-described state, the deadweight **54** is brought into a free state and the deadweight **54** automatically moves to a balanced position due to its gravity and stays directly below the pressing board **60**. In this movement, the pressing board **60** is subjected to not only a vertical force but also a horizontal force. As a result, a significant deviation is caused in the direction of the force acting on the shinbone **104**. To reduce such a deviation, the deadweight **54** is required to be constantly held at the position directly below the pressing board **60** in a state where the deadweight **54** is mounted on the mobile base **68**. Hence, the present embodiment provides a plurality of steel balls **70** on the upper surface of the mobile base **68** so that the deadweight **54** can easily change the horizontal position on the mobile base **68** in accordance with the movement of the pressing board **60** and the annular belt **52**.

[0045] The up-and-down movement of the mobile base **68** can be realized by a motor (i.e., a driving source not illustrated) and a transmission mechanism capable of transmitting driving force of the motor to the mobile base **68**. The transmission mechanism includes a screw **72** extending downward from the bottom surface of the mobile base **68**, a wheel **74** mating with the screw **72**, and a worm wheel **76** mating with the wheel **74**. The worm wheel **76** is connected to the output shaft of the motor and driven by the motor. The wheel **74** rotates when the worm wheel **76** rotates. The screw **72** rotates and shifts in the axial direction when the wheel **74** rotates. Thus, the mobile base **68** connected to the screw **72** can move in the up-and-down direction. The above-described arrangement of the driving mechanism is merely an example, and can be appropriately modified if necessary.

[0046] The mobile base **68** and the transmission mechanism are accommodated in a base body **56**. The base body **56** is a hollow box member. The base body **56** includes an intermediate support **56***b* protruding in the horizontal direction from the inner wall. The intermediate support **56***b* includes a guide hole **80** extending in the vertical direction. A guide shaft **78**, extending downward from the bottom surface of the mobile base **68**, is inserted into the guide hole **80**. The guide shaft **78** and the guide hole **80** cooperatively function as "guide unit" configured to regulate the moving direction of the mobile base **68**.

[0047] An internal space of the base body **56** communicates with an external space via an opening **56***a* formed on an upper surface of the base body **56**. The opening **56***a* has a sufficient size so that the deadweight **54** can be inserted via the opening **56***a* into the internal space of the base body **56**. The upper surface of the base body **56** is covered by a steel or other ferromagnetic member. A mount base **58**, including a magnet, is detachably mounted on the upper surface of the base body **56**. The mount base **58** supports the leg **100** in which the shinbone **104** is present. Each mount base **58** has a sufficient height so that the external fixation device **110**, when attached around the leg **100**, does not interfere with the upper surface of the base body **56**. However, the number of mount bases **58** and the shape of each mount base **58** can be appropriately changed considering the type of target bone or the shape of the external fixation device **110**.

[0048] A user can perform the diagnosis of mechanical properties of the shinbone **104**, using the above-described pressing mechanism **50** in the following manner. First, as a preparation for the diagnosis, a user determines a pressing position and a pressing force beforehand according to the purpose of the diagnosis and the type of bone (diagnosis object) and also considering the presence of any bone fracture. Then, the user selects the deadweight **54** having an appropriate weight value corresponding to the pressing force determined beforehand and hangs the selected deadweight **54** on the lower metal holder **66** of the pressing mechanism **50**. Furthermore, the user raises the mobile base **68** to a higher position where the bottom of the deadweight **54** can be supported by the mobile base **68**.

[0049] Then, the user puts the diagnosis object (the leg **100**) on two mount bases **58** placed on the upper surface of the base body **56**, so that the pressing position determined beforehand can be roughly positioned above the opening **56***a*.

[0050] Subsequently, the user ties the annular belt **52** around the leg **100**. More specifically, before attaching the annular belt **52** around the leg **100**, the user temporarily disengages the fastener of the annular belt **52**. Next, the user ties the belt **52** (in an extended state with separated end parts) around the leg **100** loosely and engages the fastener to connect the belt **52** into an endless shape. At this moment, the deadweight **54** is supported by the mobile base **68**. Therefore, no downward force acts on the annular belt **52** and the pressing board **60**, and no pressing force is applied to the shinbone **104**.

[0051] Then, the user performs a positional adjustment for the annular belt **52** so that the pressing board **60** can be accurately positioned at the pressing position determined beforehand. Furthermore, in addition to the positional adjustment for the annular belt **52**, the user can adjust the position of the deadweight **54** connected to the annular belt **52** so that the deadweight **54** can be positioned directly below the pressing board **60** in the vertical direction. The plurality of steel balls **70** provided on the upper surface of the mobile base **68** can reduce frictional force caused when the deadweight **54** moves. Therefore, the user can easily perform the positional adjustment for the deadweight **54**. In this case, instead of manually moving the deadweight **54**, a user can temporarily lower the mobile base **68** to a position where the deadweight **54** is kept in a free state and can automatically move to a correct position.

[0052] After completing the positional adjustment for the pressing board **60** and the deadweight **54**, the user attaches the probes **14** on an upper surface of the leg **100** at both sides of the pressing board **60** (i.e., pressing position).

[0053] Then, the user causes the ultrasound diagnostic apparatus **10** to start transmission/reception of ultrasonic waves using the probes **14**. The ultrasound diagnostic apparatus **10** obtains surface shape data of the shinbone **104** in a state free from any pressing force, based on echo signals obtained by transmission/reception of ultrasonic waves.

[0054] Subsequently, the user moves the mobile base **68** downward while the ultrasound diagnostic apparatus **10** continues transmission/reception of ultrasonic waves. If the deadweight **54** is brought into a free state, the downward force (i.e., the gravity of the deadweight **54**) acts on the annular belt **52** as well as on the pressing board **60** bonded to the annular belt **52**. Thus, a downward pressing force acts on the shinbone **104**.

[0055] If a pressing force is applied to the shinbone **104**, the shinbone **104** causes a deformation in shape (e.g., deflection). The ultrasound diagnostic apparatus **10** obtains surface shape data of the shinbone **104** in a state where the shinbone **104** is subjected to the pressing force, based on echo signals obtained by transmission/reception of ultrasonic waves. After completing the measurement of surface shape data, the user moves the mobile base **68** upward to release the shinbone **104** from the gravity of the deadweight **54**. Meanwhile, the ultrasound diagnostic apparatus **10** calculates a mechanical property value (e.g., deflection amount) of the shinbone **104** based on the surface shape data obtained before and after application of a pressing force. If the mechanical property value is obtained, the user completes the diagnosis of mechanical properties.

[0056] As will be apparent from the foregoing description and FIGS. **4** through **6**, in the pressing mechanism **50** according to the present embodiment, the components located in the vicinity of a pressing position are limited to the annular belt **52**, the pressing board **60**, and the roller **62**, which are compact in size. Therefore, even if the pins **114** and the metal fittings **112** (i.e., constituent members of the external fixation device **110**) are present in the vicinity of the pressing position, the pressing mechanism **50** can accurately press a designated pressing position without causing any interference with the constituent members of the external fixation device **110**. As a result, the present embodiment enables a user to appropriately perform the diagnosis of mechanical properties even in a state where the external fixation device **110** is attached around a target body.

[0057] The arrangement of the above-described pressing mechanism is merely an example, and can be appropriately modified if an appropriate pressing force can be applied to a target bone when a deadweight having a predetermined weight value is hung. For example, a pressing mechanism according to another embodiment may not include the rollers **62**, the pressing board **60**, and the steel balls **70**.

[0058] In the above-described embodiment, the mobile base **68** directly supports the deadweight **54**. However, if an appropriate urging member is provided between the deadweight **54** and the mobile base **68**, the urging member can gradually apply a force to the deadweight **54** in the upper direction. The pressing force can be slowly applied to the shinbone **104** via the urging member. The deflection amount of a bone or other mechanical property value is variable depending on how a pressing force is applied. Namely, a mechanical property value obtained when the pressing force is slowly applied is different from a mechanical property value obtained when the pressing force is quickly applied.

[0059] Furthermore, according to the purpose of mechanical diagnosis, it may be necessary to obtain a mechanical property value under a static load. In such a case, it is preferable to provide an urging member between the deadweight **54** and the mobile base **68** so that the pressing force can be slowly applied to the deadweight **54**.

[0060] FIGS. 7A and 7B illustrate a shock absorbing mechanism including a coil spring **84** and a damper **86** which are provided in a recessed portion **82** formed on the bottom of the deadweight **54**. If a user slowly moves the mobile base **68** downward and the mobile base **68** starts separating from the deadweight **54**, the shock absorbing mechanism can continue supporting the deadweight **54**. The weight of deadweight **54** supported by the shock absorbing mechanism gradually decreases with increasing distance between the mobile base **68** and the deadweight **54**. Finally, the entire weight of the deadweight **54** acts on the pressing board **60**. Namely, if an appropriate shock absorbing mechanism is provided between the deadweight **54** and the mobile base **68**, the load amount acting on the shinbone **104** can be gradually increased.

[0061] Furthermore, the above-described embodiment uses transmission/reception of ultrasonic waves to detect a change in the shape of a target bone subjected to a pressing force. However, according to another embodiment, indirectly measuring a change in the shape of a target bone is feasible. For example, a laser displacement gauge can be used to measure a bending amount of a body part in which a target bone is present (e.g., a leg if the target bone is a shinbone) and diagnose mechanical properties of the target bone based on a measurement result. In this case, although the tissues of a human body have some effect on a measurement result, a user can easily diagnose mechanical properties of a target bone.

[0062] Although the preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes only, and it is to be understood that modifications and variations may be made without departing from the spirit or scope of the appended claims.

What is claimed is:

1. A pressing mechanism configured to apply a pressing force to a target bone when a diagnosis of mechanical properties is performed for the target bone, comprising:

an annular belt detachably hung around a diagnosis object in which the target bone is present;

a deadweight connected to a lower end of the annular belt and having a weight value corresponding to a desired pressing force; and

a mobile base positioned under the deadweight and movable in an up-and-down direction,

wherein if the mobile base moves downward the deadweight separates from the mobile base and is brought into a free state where a pressing force acts on the target bone, and if the mobile base moves upward the deadweight is supported by the mobile base and the target bone is released from the pressing force.

2. The pressing mechanism according to claim **1**, wherein the annular belt is entrained around a plurality of rollers which are spaced from the diagnosis object.

3. The pressing mechanism according to claim **2**, wherein the rollers include a group of fixed rollers which are symmetrically disposed with respect to a pressing position in the right-and-left direction and are in a fixed relationship relative to the annular belt, and a group of movable rollers which can slide along an inner surface of the annular belt and automatically move to a position where the gravity acting on the annular belt is balanced in the right-and-left direction.

4. The pressing mechanism according to claim 1, wherein the mobile base supports the deadweight via a plurality of balls that permits horizontal movement of the deadweight relative to the mobile base.

5. The pressing mechanism according to claim 1, further comprising an urging member disposed between the mobile base and the deadweight, to urge the deadweight in the upper direction.

6. An ultrasound diagnostic apparatus configured to transmit and receive ultrasonic waves to and from a target bone in a state where a pressing force is applied to the target bone, and obtain deformation properties of the target bone subjected to the pressing force, comprising:

a pressing mechanism configured to press a predetermined position on a target bone;

an ultrasonic probe configured to transmit and receive ultrasonic waves to and from the target bone; and

a calculation unit configured to calculate a change in the target bone before and after the target bone is pressed by the pressing mechanism based on an echo signal obtained via the ultrasonic probe that performs transmission and reception of ultrasonic waves,

wherein the pressing mechanism comprises:

an annular belt detachably hung around a diagnosis object in which the target bone is present;

a deadweight connected to a lower end of the annular belt and having a weight value corresponding to a desired pressing force; and

a mobile base positioned under the deadweight and movable in an up-and-down direction, wherein if the mobile base moves downward the deadweight separates from the mobile base and is brought into a free state where a pressing force acts on the target bone, and if the mobile base moves upward the deadweight is supported by the mobile base and the target bone is released from the pressing force.

* * * * *

专利名称(译)	按压机构和超声诊断设备		
公开(公告)号	US20090240145A1	公开(公告)日	2009-09-24
申请号	US12/051677	申请日	2008-03-19
[标]申请(专利权)人(译)	日立阿洛卡医疗株式会社		
申请(专利权)人(译)	ALOKA CO. , LTD.		
当前申请(专利权)人(译)	ALOKA CO. , LTD.		
[标]发明人	OTSUKA TOSHIKI		
发明人	OTSUKA, TOSHIKI		
IPC分类号	A61B8/00 A61F5/01		
CPC分类号	A61B8/0875 A61B8/485 A61B8/4209 A61B8/4227		
外部链接	Espacenet USPTO		

摘要(译)

根据本发明的超声波诊断装置包括按压机构，该按压机构能够适当地将按压力施加到骨折骨上的预定位置。按压机构包括环形带，该环形带可拆卸地悬挂在腿部中，其中存在胫骨（即，目标骨），自重连接到环形带的下端并且具有与期望的按压力对应的重量值，以及移动基座位于自重下方并可在上下方向上移动。如果移动基座向下移动，则自重与移动基座分离并且进入自由状态，其中压力作用在目标骨上。如果移动基座向上移动，则移动基座支撑自重，并且目标骨骼从按压力释放。