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TASHIRO

(54) ULTRASOUND DIAGNOSTIC APPARATUS

(75) Inventor: **Rika TASHIRO**, Ashigara-kami-gun (JP)

(73) Assignee: **FUJIFILM CORPORATION**, Tokyo (JP)

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(57) **ABSTRACT**

An ultrasound diagnostic apparatus includes an ultrasound probe, an image producer, a monitor, a position designating unit for designating a target position when paracentesis is performed, an insertion position calculating unit for calculating an insertion position from information on the target position designated by the position designating unit and a predetermined insertion angle and an insertion position display unit for displaying the insertion position calculated by the insertion position calculating unit. The ultrasound diagnostic apparatus ensures that a puncture needle inserted from a position away from an ultrasound probe to reduce the insertion angle so as to be imaged at a higher definition can also reach a target site.

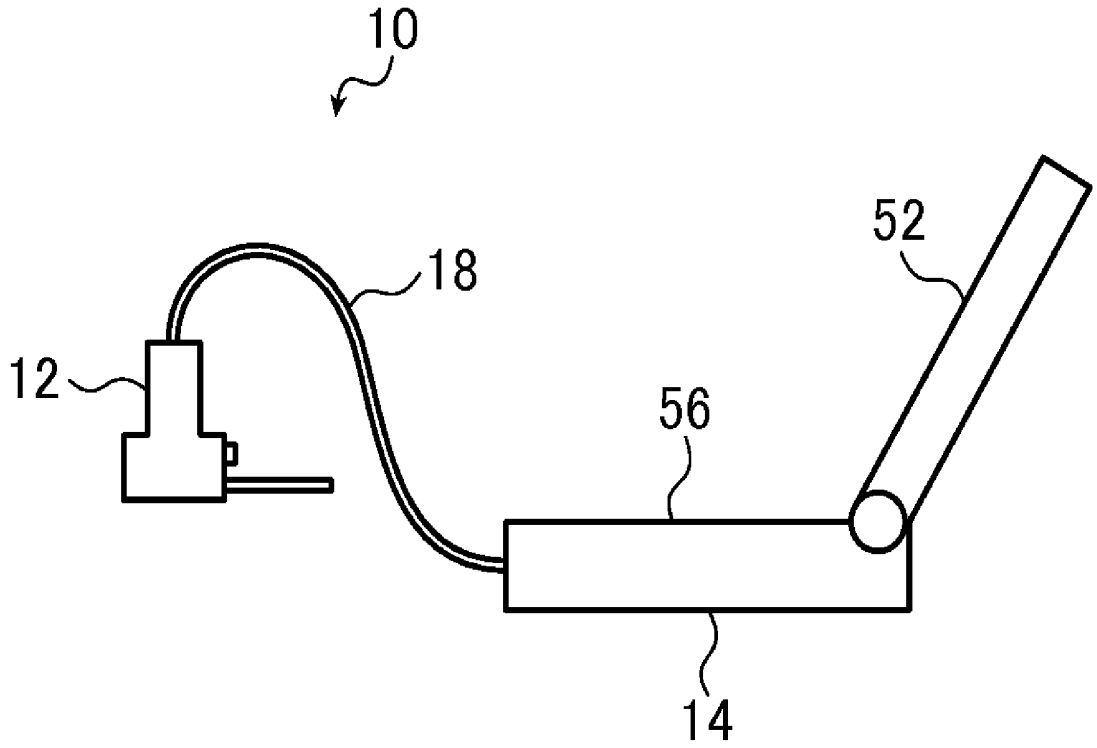


FIG. 1

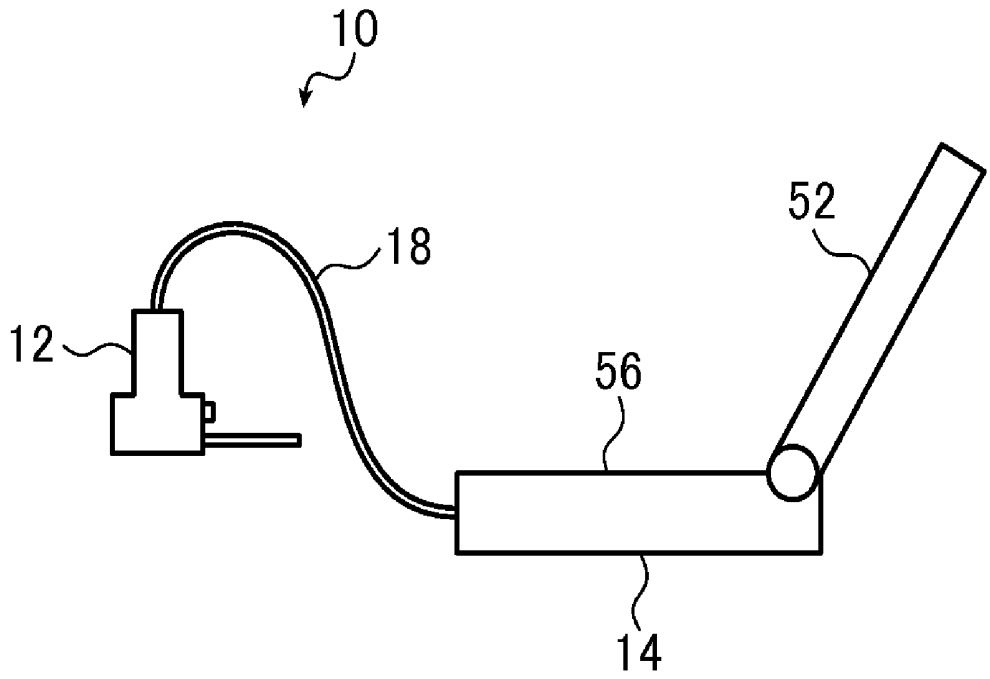


FIG. 2A

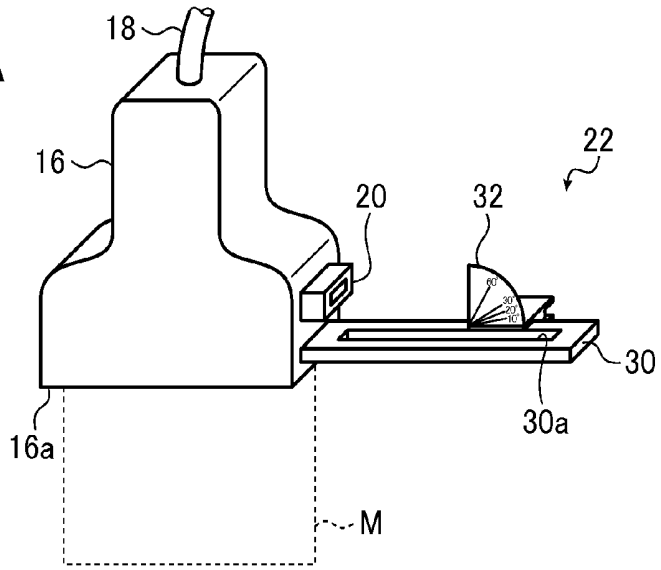


FIG. 2B

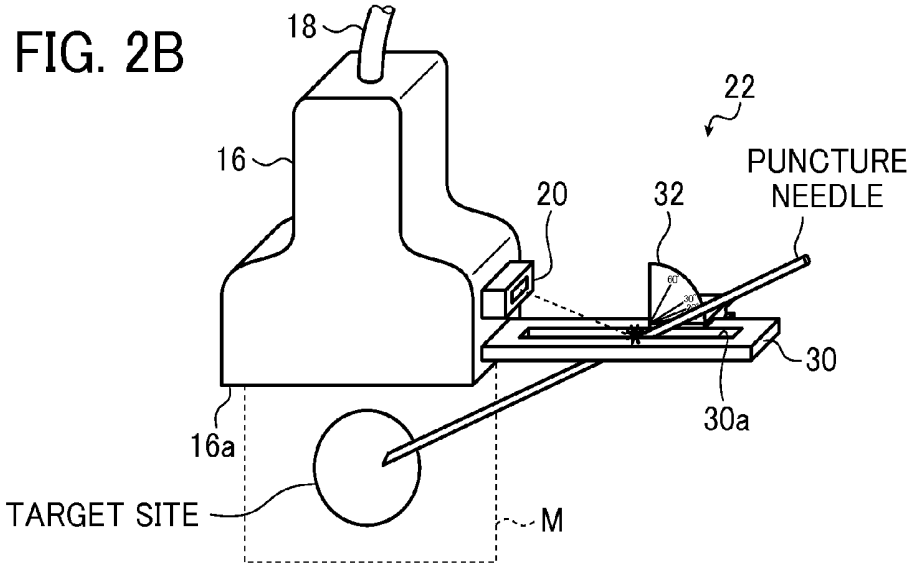


FIG. 2C

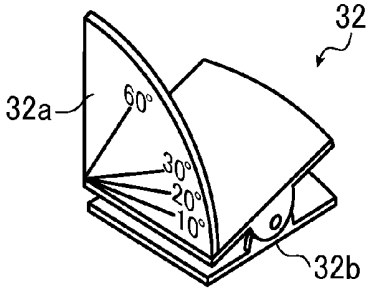
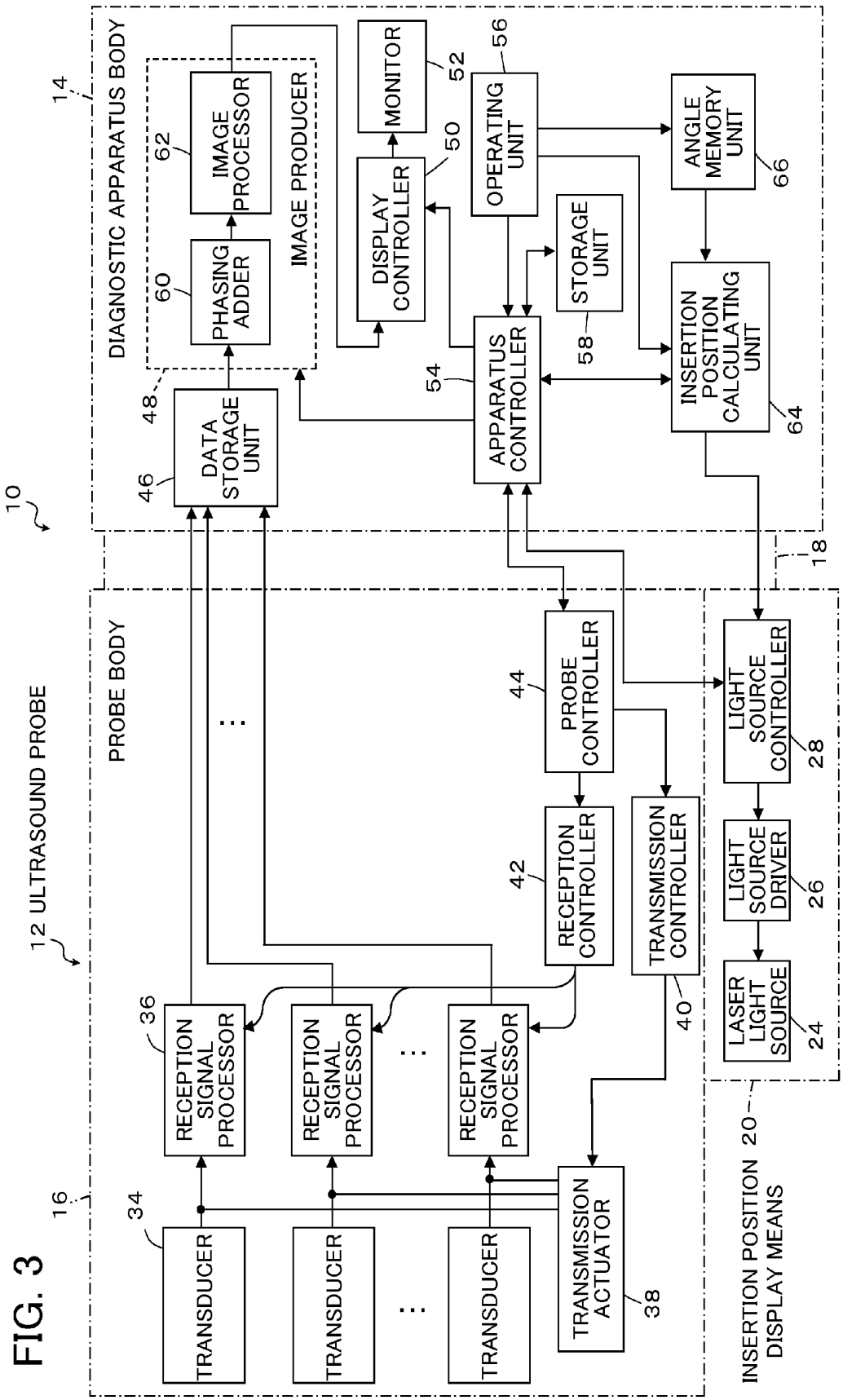


FIG. 3


10
12 ULTRASOUND PROBE
14
DIAGNOSTIC APPARATUS BODY
16
PROBE BODY
18
20
INSERTION POSITION DISPLAY MEANS
IMAGE PRODUCER
TRANSDUCER
RECEPTION SIGNAL PROCESSOR
PHASING ADDER
IMAGE PROCESSOR
DATA STORAGE UNIT
DISPLAY CONTROLLER
MONITOR
OPERATING UNIT
ANGLE MEMORY UNIT
STORAGE UNIT
APPARATUS CONTROLLER
INSERTION POSITION CALCULATING UNIT
PROBE CONTROLLER
RECEPTION CONTROLLER
TRANSMISSION CONTROLLER
TRANSMISSION ACTUATOR
LIGHT SOURCE CONTROLLER
LIGHT SOURCE DRIVER
LASER LIGHT SOURCE
34
36
38
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44
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48
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52
54
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28

FIG. 4A

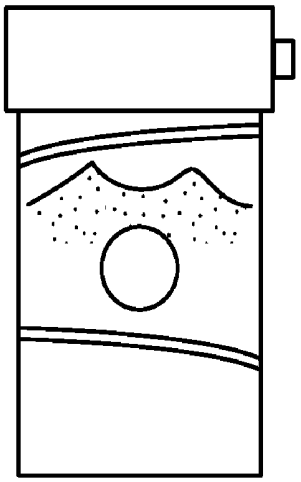


FIG. 4B

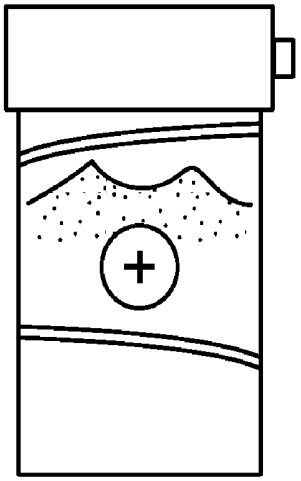


FIG. 4C

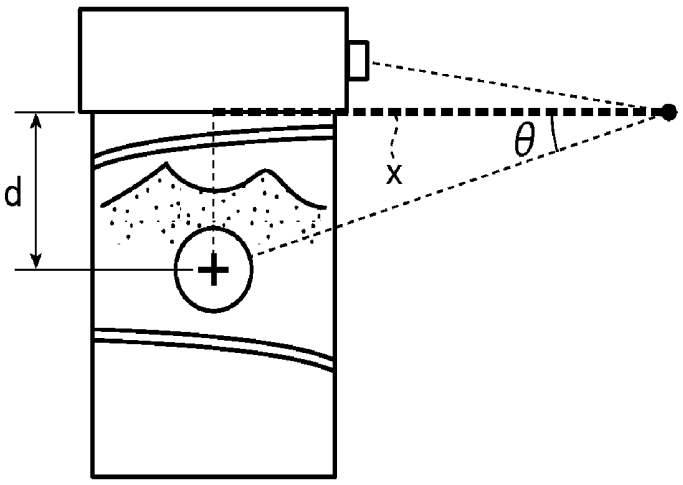


FIG. 5

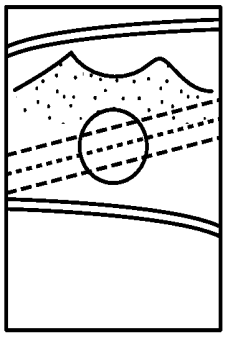
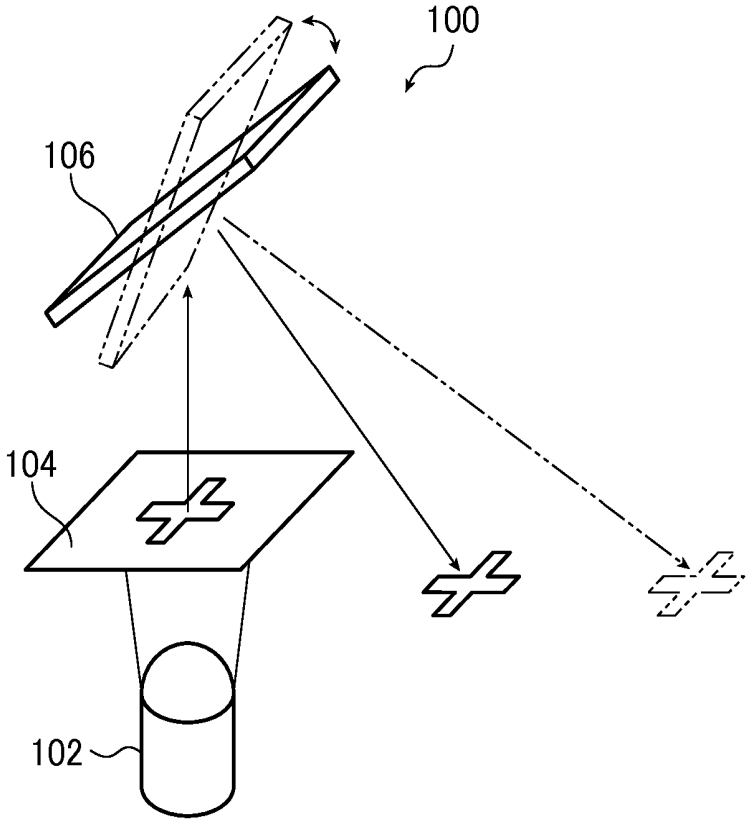


FIG. 6



ULTRASOUND DIAGNOSTIC APPARATUS

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an ultrasound diagnostic apparatus and more specifically to an ultrasound diagnostic apparatus that may be used in paracentesis.

[0002] Heretofore, ultrasound diagnostic apparatuses that use ultrasound images have been put to use in the medical field. In general, this type of ultrasound diagnostic apparatus includes an ultrasound probe equipped with a built-in oscillator array and an apparatus body connected to the ultrasound probe. The ultrasound probe transmits ultrasonic waves toward a subject and receives ultrasonic echoes from the subject. The received signals are then electrically processed in the apparatus body to generate an ultrasound image.

[0003] The ultrasound diagnostic apparatus is also used in paracentesis in which a doctor inserts a puncture device such as a puncture needle to a desired site and collects a tissue sample to make a cell/tissue diagnosis.

[0004] In order-to ensure that the puncture needle reaches a target object or site in paracentesis, the doctor inserts the puncture needle into a subject along a predetermined insertion path while seeing an ultrasound image.

[0005] It is important in such paracentesis that the puncture needle can be confirmed on a monitor (ultrasound image) and that the puncture needle can be made to reach the target object or site.

[0006] To this end, JP 2010-115246 A describes forming a groove for guiding a puncture needle on a lateral side of an ultrasound probe to stably insert the puncture needle according to an insertion path, and vertically providing a plurality of laser light sources on the lateral side of the ultrasound probe to determine the orientation of the puncture needle based on laser beams from the laser light sources so that the puncture needle may be displayed on an ultrasound image corresponding to the ultrasound irradiation surface (scan surface).

[0007] JP 2000-166918 A describes interposing a polymer gel between a subject and an ultrasound probe and displaying a guideline indicating the insertion direction of a puncture needle based on the image of the puncture needle in the polymer gel portion so that it can be confirmed whether the puncture needle reaches a target site, that is, the puncture needle is correctly aimed at the target site.

SUMMARY OF THE INVENTION

[0008] In paracentesis, thinner needles reduce patient burdens and invasiveness and therefore the smallest possible puncture needle is selected in consideration of the risk or the like. However, the thinner the needle is, the more the capability of imaging the needle on the ultrasound image is reduced. The needle is imaged discontinuously and the position or the shape of the puncture needle cannot be clearly displayed.

[0009] Since ultrasonic waves reflected on the puncture needle return toward the ultrasound probe at a smaller insertion angle of the puncture needle with respect to a subject, that is, at a larger angle formed between the puncture needle and a direction in which the ultrasound probe transmits the ultrasonic waves. Therefore, the puncture needle is displayed on the ultrasonic image at a higher definition and is more clearly seen.

[0010] Therefore, a doctor may insert a puncture needle from a position away from an ultrasound probe or shift the position of a target site in the image to reduce the insertion angle of the puncture needle so as to perform paracentesis in a state in which the puncture needle is more clearly seen on the ultrasound image.

[0011] There is a limit on the positional shift of the target site on the image and therefore the insertion angle cannot be significantly reduced. Accordingly, it is necessary to insert the puncture needle from a position away from the ultrasound probe so that the puncture needle may be inserted at a smaller insertion angle.

[0012] However, in the case of guiding the puncture needle in the groove formed on one lateral side of the ultrasound probe as described in JP 2010-115246 A, the puncture needle is to be brought into contact with the ultrasound probe and therefore the puncture needle cannot be guided along a predetermined insertion path if it is inserted at a position away from the ultrasound probe.

[0013] Also in the case of displaying the guidelines indicating the insertion direction of the puncture needle based on the image of the puncture needle in the polymer gel portion as in JP 2000-166918 A, the puncture needle in the polymer gel portion is to be displayed on the ultrasound image and therefore the guideline indicating the insertion direction of the puncture needle cannot be displayed if it is inserted at a position away from the ultrasound probe.

[0014] Accordingly, high levels of techniques and doctor's skills for paracentesis are necessary to insert a puncture needle from a position away from an ultrasound probe so that the puncture needle may correctly reach a target site.

[0015] An object of the present invention is to solve the foregoing prior art problems and to provide an ultrasound diagnostic apparatus which ensures that a puncture needle inserted from a position away from an ultrasound probe to reduce the insertion angle can also reach a target site.

[0016] In order to achieve the above object, the invention provides the ultrasound diagnostic apparatus comprising: an ultrasound probe which transmits ultrasonic waves toward a subject, receives ultrasonic echoes reflected on the subject and output reception signals; image production means for producing an ultrasound image of the subject based on the reception signals outputted from said ultrasound probe; image display means for displaying said ultrasound image generated by said image production means; position designating means for designating a target position where paracentesis is performed; insertion position calculating means for calculating an insertion position from information on the target position designated by said position designating means and a predetermined insertion angle; and insertion position display means for displaying the insertion position calculated by said insertion position calculating means.

[0017] In this case, it is preferred that said insertion position display means displays said insertion position by irradiation of the insertion position with light.

[0018] Further, it is preferred that said insertion position display means displays said insertion position by irradiation with a laser beam.

[0019] Alternatively, it is preferred that said insertion position display means displays said insertion position by showing on said image display means a distance value from said ultrasound probe to said insertion position.

[0020] Preferably, the ultrasound diagnostic apparatus further comprise a plate-like position guide member fixed to said ultrasound probe.

[0021] Alternatively, the ultrasound diagnostic apparatus further comprise a puncture guide having a plate-like position guide member fixed to said ultrasound probe and an angle guide member movably fixed to said position guide member and displaying an insertion angle for use in paracentesis, said insertion position display means displaying said insertion position by irradiation of said position guide member with light.

[0022] Further, it is preferred that said image display means displays said ultrasound image and guidelines obtained by calculating an insertion path of a puncture needle in the paracentesis from the information on the target position designated by said position designating means and the predetermined insertion angle.

[0023] Preferably, the ultrasound diagnostic apparatus further comprise angle adjustment means for changing said predetermined insertion angle.

[0024] Further, it is preferred that said predetermined insertion angle is appropriately determined in a range of 10° to 20°.

[0025] Further, it is preferred that said position designating means designates the target position on the ultrasound image displayed in said image display means according to an inputted instruction.

[0026] Alternatively, it is preferred that said position designating means analyzes said ultrasound image to calculate the target position.

[0027] The ultrasound diagnostic apparatus of the invention which is configured to include position designating means for designating a target position in paracentesis on an ultrasound image; insertion position calculating means for calculating an insertion position from information on the designated target position and a predetermined insertion angle and insertion position display means for displaying the insertion position calculated by the insertion position calculating means, ensures that a puncture needle inserted at a position away from an ultrasound probe can also reach a target site.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. **1** is a conceptual diagram showing an embodiment of an ultrasound diagnostic apparatus of the invention.

[0029] FIG. **2**A is a conceptual diagram showing an ultrasound probe that may be used in the ultrasound diagnostic apparatus shown in FIG. **1**, FIG. **2**B is a conceptual diagram showing the ultrasound probe shown in FIG. **2**A, a puncture needle and a target site, and FIG. **2**C is a conceptual diagram showing an angle guide member of the ultrasound probe shown in FIG. **2**A.

[0030] FIG. **3** is a block diagram showing the configuration of the ultrasound diagnostic apparatus shown in FIG. **1**.

[0031] FIGS. **4**A to **4**C each schematically show an ultrasound image for illustrating the operation of the ultrasound diagnostic apparatus shown in FIG. **1** when the insertion Position is calculated.

[0032] FIG. **5** is a schematic diagram of an ultrasound image on which guidelines for the puncture needle are shown.

[0033] FIG. **6** is a schematic diagram showing another example of the insertion position display means.

DETAILED DESCRIPTION OF THE INVENTION

[0034] Next, the ultrasound diagnostic apparatus of the invention is described in detail by referring to the preferred embodiments shown in the accompanying drawings.

[0035] FIG. **1** is a conceptual diagram showing an embodiment of the ultrasound diagnostic apparatus of the invention.

[0036] The illustrated ultrasound diagnostic apparatus **10** is basically of a known type except that it is configured to calculate the insertion position from the target position inputted by reference to a generated ultrasound image and a preset insertion angle and to display the calculated insertion position.

[0037] The ultrasound diagnostic apparatus **10** of the invention includes an ultrasound probe **12**, and a diagnostic apparatus body **14** which is connected to the ultrasound probe **12** via a communication cable **18**.

[0038] FIG. **2**A is a schematic diagram showing the ultrasound probe **12**. FIG. **2**B is a schematic diagram showing the ultrasound probe **12**, a puncture needle and a target site when paracentesis is performed.

[0039] The ultrasound probe **12** includes a probe body **16**, the communication cable **18**, an insertion position display means **20** and a puncture guide **22**.

[0040] The probe body **16** is basically of a known type and may be of a linear scan type, convex scan type or sector scan type.

[0041] The probe body **16** has an ultrasound transmission/reception surface **16***a* for the transmission and the reception of ultrasonic waves. The insertion position display means **20** and the puncture guide **22** are disposed on one lateral side of the ultrasound transmission/reception surface **16***a* of the probe body **16** in the transverse direction of a scan surface M formed with ultrasonic waves transmitted from the ultrasound transmission/reception surface **16***a*.

[0042] The insertion position display means **20** is disposed on the lateral side of the ultrasound transmission/reception surface **16***a* of the probe body **16** in the lateral direction of the scan surface M and a proper insertion position of the puncture needle is displayed by irradiation of the insertion position with a laser beam when paracentesis is performed using the ultrasound diagnostic apparatus **10**. In the insertion position display means **20**, a light source driver **26** causes a laser light source **24** for emitting laser beams to rotate about an axis perpendicular to the scan surface M to change the laser beam irradiation position to thereby irradiate the insertion position with a laser beam (see FIG. **3**). This point will be described in detail later.

[0043] The insertion position at which the puncture needle can be inserted at a predetermined insertion angle is calculated in an insertion position calculating unit **64** of the diagnostic apparatus body **14** from a predetermined set insertion angle and a designated target position. This point will also be described in detail later.

[0044] The illustrated embodiment preferably includes the puncture guide **22** and therefore a laser beam from the insertion position display means **20** is irradiated on a position guide member **30** of the puncture guide **22** in the vicinity of the insertion position (see FIG. **2**B).

[0045] The predetermined insertion angle is preferably an angle appropriately determined in a range of 10° to 20°. At an insertion angle within the foregoing range, ultrasonic waves reflected on the puncture needle return toward the ultrasound probe and therefore the puncture needle is displayed on the ultrasound image at a higher definition and is more clearly seen on the ultrasound image.

[0046] The insertion position display means **20** displays the insertion position calculated by the insertion position calculating unit **64** by irradiation with a laser beam as described

above. The insertion of the puncture needle from the position at which the laser beam is irradiated ensures that the puncture needle reaches the target site even in cases where a doctor inserts the puncture needle from a position away from the ultrasound probe in paracentesis for the insertion at a predetermined small insertion angle.

[0047] In the preferred embodiment, the illustrated ultrasound diagnostic apparatus **10** includes the puncture guide **22**.

[0048] The puncture guide **22** has the position guide member **30** for guiding the insertion position and an angle guide member **32** for guiding the insertion angle which are used in paracentesis.

[0049] The position guide member **30** is an elongated plate-like member fixed to the probe body **16** so that its largest surface is orthogonal to the scan surface M, and has a through slot **30***a* formed in the center in the width direction or lateral direction of the member **30** so that the extension of the scan surface M passes through the slot **30***a* or coincides with one of wall surfaces thereof.

[0050] The through slot **30***a* is preferably formed so that the extension of the scan surface M coincides with one of walls in the direction in which the through slot **30***a* extends or passes through the center of the through slot **30***a*.

[0051] When the insertion position display means **20** displays the insertion position, the laser beam from the insertion position display means **20** is irradiated on the surface of the position guide member **30** to display the insertion position.

[0052] By providing the position guide member **30** on the lateral side of the probe body **16** so that the laser beam is irradiated on the position guide member **30** to display the insertion position, the displayed insertion position may be proper even when a subject has a curved surface.

[0053] The through slot **30***a* of the position guide member **30** through which the puncture needle is inserted in paracentesis may serve as the positional guide in the direction parallel to the scan surface M which enables the insertion path of the puncture needle to be flush with the scan surface M in the direction perpendicular to the scan surface M.

[0054] The method of fixing the position guide member **30** to the probe body **16** is not particularly limited and various known fixing methods such as fixation with screws may be used. Alternatively, the position guide member **30** may be integrally formed with a housing of the probe body **16**.

[0055] FIG. **2**C is a schematic diagram showing the angle guide member **32** of the ultrasound probe **12** shown in FIG. **2**A.

[0056] The angle guide member **32** is attached to the position guide member **30** so as to be movable in its longitudinal direction and has an angle display plate **32***a* on which the angle with respect to the surface of the position guide member **30** is shown.

[0057] In the illustrated embodiment, the angle guide member **32** has a clip portion **32***b* for fixing to the position guide member **30**, and the clip portion **32***b* enables the angle guide member **32** to be movably attached to the position guide member **30**. The angle guide member **32** is attached to the position guide member **30** so that the angle display plate **32***a* may be parallel to the scan surface M.

[0058] When the insertion position display means **20** irradiates a laser beam on the position guide member **30** to display an insertion position, the angle guide member **32** is fixed to the position guide member **30** at the insertion position. The angle display plate **32***a* displays an insertion angle for use in inserting a puncture needle from the displayed insertion position.

[0059] The angle display plate **32***a* is marked with angles such as 10°, 20°, 30° and 60° as in the illustrated case. The angle display plate **32***a* is preferably marked with at least one angle set by default.

[0060] According to such a configuration that the puncture guide includes the angle guide member **32** movably attached to the position guide member **30**, the puncture needle can be easily inserted in paracentesis at a predetermined insertion angle irrespective of doctor's skills by fixing the angle guide member **32** to the position guide member **30** at the insertion position displayed on the position guide member **30** by irradiation with a laser beam from the insertion position display means **20** and inserting the puncture needle at the insertion angle indicated by an angle shown on the angle display plate **32***a*.

[0061] In the illustrated case, the angle guide member **32** is fixed to the position guide member **30** with a clip portion **32***b* but the fixation method is not limited to this. For example, various known methods may be used as exemplified by fixing it with screws and fixing it slidably along the plane parallel to the scan surface M.

[0062] In the illustrated case, the angle guide member **32** has the angle display plate **32***a* marked with an angular scale. However, this is not the sole case of the invention and the angle guide member **32** may have a groove for guiding a puncture needle at the same angle as the predetermined set angle.

[0063] Next, the internal configuration of the ultrasound diagnostic apparatus **10** is shown in FIG. **3**.

[0064] The probe body **16** includes a plurality of ultrasound transducers **34** making up a one-dimensional or two-dimensional oscillator array, and the transducers **34** are connected to their corresponding reception signal processors **36**. The transducers **34** are connected to a transmission controller **40** via a transmission actuator **38**, and the reception signal processors **36** are connected to a reception controller **42**. The transmission controller **40** and the reception controller **42** are connected to a probe controller **44**.

[0065] The reception signal processors **36** and the probe controller **44** are connected via the communication cable to a data storage unit **46** and an apparatus controller **54** of the diagnostic apparatus body **14**, respectively.

[0066] The transducers **34** each transmit ultrasonic waves according to actuation signals supplied from the transmission actuator **38** and receive ultrasonic echoes from the subject to output reception signals. Each of the transducers **34** is composed of an oscillator including, for example, a piezoelectric body made of a piezoelectric ceramic typified by PZT (lead zirconate titanate) or a piezoelectric polymer typified by PVDF (polyvinylidene fluoride) and an electrode provided on each end of the piezoelectric body.

[0067] When the electrodes of each of the oscillators are supplied with a pulsed voltage or a continuous-wave voltage, the piezoelectric body expands and contracts to cause the oscillator to generate pulsed or continuous ultrasonic waves. These ultrasonic waves are synthesized to form an ultrasonic beam. Upon reception of propagating ultrasonic waves, each oscillator expands and contracts to generate an electric signal, which is then outputted as an ultrasonic reception signal.

[0068] The transmission actuator **38** includes, for example, a plurality of pulsers and adjusts the delay amounts of actua-

tion signals for the respective transducers **34** based on a transmission delay pattern selected by the transmission controller **40** so that the ultrasonic waves transmitted from the transducers **34** form a broad ultrasonic beam covering an area of a tissue of the subject and supplies the transducers **34** with the adjusted actuation signals.

[0069] Under the control of the reception controller **42**, the reception signal processor **36** for each channel subjects the reception signal outputted from the corresponding transducer **34** to quadrature detection or quadrature sampling to produce a complex baseband signal and samples the complex baseband signal to generate sample data containing information on the area of the tissue. The reception signal processors **36** may generate sample data by performing data compression for highly efficient coding on the data obtained by sampling the complex baseband signals.

[0070] The probe controller **44** controls various components of the probe body **16** according to various control signals transmitted from the diagnostic apparatus body **14**.

[0071] The diagnostic apparatus body **14** includes the data storage unit **46**, which is connected to an image producer **48**. The image producer **48** is connected to a monitor **52** via a display controller **50**. The apparatus controller **54** is connected to the image producer **48** and the display controller **50**. The apparatus controller **54** is further connected to an operating unit **56** for an operator to perform input operations, a storage unit **58** for storing operation programs, and the insertion position calculating unit **64** for calculating the insertion position. The insertion position calculating unit **64** is connected to an angle memory unit **66** for storing set insertion angles.

[0072] The operating unit **56** sets imaging menus and imaging conditions and issues instructions for imaging of a subject. The operating unit **56** is provided with input means such as an enter key, a dial button, a trackball and a touch panel for setting imaging menus, imaging conditions and the like.

[0073] The ultrasound diagnostic apparatus **10** of the invention calculates the insertion position from the target position (target site position) inputted and set by reference to a generated ultrasound image and the preset insertion angle and displays the calculated insertion position.

[0074] The operating unit **56** also has a function of inputting an instruction for calculating/displaying the insertion position. The operating unit **56** further has a function of inputting instructions for inputting/setting the target position and setting the insertion angle.

[0075] The operating unit **56** supplies to the apparatus controller **54** the instruction inputted for calculating/displaying the insertion position, the instruction inputted for setting the target position, and the instruction inputted for setting the insertion angle.

[0076] The data storage unit **46** is constituted by a memory, a hard disk, or the like and stores at least one frame of sample data transmitted from the reception signal processors **36** of the ultrasound probe **12** via the communication cable **18**.

[0077] The image producer **48** performs reception focusing on each frame of sample data read out from the data storage unit **46** to generate an image signal representing an ultrasound diagnostic image. The image producer **48** includes a phasing adder **60** and an image processor **62**.

[0078] The phasing adder **60** selects one reception delay pattern from a plurality of previously stored reception delay patterns according to the reception direction set in the apparatus controller **54** and, based on the selected reception delay pattern, provides the complex baseband signals represented by the sample data with respective delays and adds them to perform the reception focusing. By this reception focusing, a baseband signal (sound ray signal) where the ultrasonic echoes are well focused is generated.

[0079] The image processor **62** generates a B-mode image signal, which is tomographic image information on a tissue inside the subject, according to the sound ray signal generated by the phasing adder **60**. The image processor **62** includes an STC (sensitivity time control) part and a DSC (digital scan converter). The STC part corrects the sound ray signal for the attenuation due to distance according to the depth to the reflection position of the ultrasonic waves. The DSC converts the sound ray signal corrected by the STC part into an image signal compatible with an ordinary television signal scanning mode (performs raster conversion) and performs required image processing such as gradation processing to generate a B mode image signal.

[0080] The display controller **50** causes the monitor **52** to display an ultrasound diagnostic image according to the image signal generated by the image producer **48**. The monitor **52** includes a display device such as an LCD, for example, and displays an ultrasound diagnostic image under the control of the display controller **50**.

[0081] The angle memory unit **66** is a unit for storing insertion angle values that may be used to calculate the insertion position in the insertion position calculating unit **64**.

[0082] The insertion angle value to be stored in the angle memory unit **66** may be a preset value, an angle appropriately determined in a range of 10° to 20° or a value inputted from the operating unit **56**.

[0083] The insertion position calculating unit **64** calculates the insertion position from the target position information inputted from the operating unit **56** and the insertion angle value stored in the angle memory unit **66**. The distance x between the target and the insertion position can be determined from the formula: $x=d/\tan\theta$ (where d is the depth from the probe body **16** to the target and θ is the insertion angle).

[0084] The operation of the insertion position calculating unit **64** in calculating the insertion position is described below in detail with reference to FIGS. **4**A to **4**C schematically showing ultrasound images.

[0085] FIG. **4**A is a schematic diagram of a generated ultrasound image. The position of the probe body **16** corresponding to the ultrasound image is shown for the sake of convenience.

[0086] As shown in FIG. **4**A, the generated ultrasound image is a cross-sectional image located under the probe body **16**.

[0087] When an instruction for displaying the insertion position is inputted in the operating unit **56**, a cursor appears on the ultrasound image displayed on the monitor **52** and a screen for making an operator to point the cursor to a target or target site is displayed.

[0088] The operator uses a trackball or the like in the operating unit **56** to point the cursor to the target on the ultrasound image and inputs an instruction for designating the position of the target (FIG. **4**B).

[0089] Upon the designation of the target position, the target position information is supplied to the insertion position calculating unit **64**. From the supplied target position information (target depth d) and the insertion angle θ read out from the angle memory unit **66**, the insertion position calculating unit **64** calculates the distance x between the probe body **16** and the insertion position (FIG. **4**C).

[0090] The insertion position calculating unit **64** supplies the calculated distance x to the insertion position to a light source controller **28**.

[0091] The apparatus controller **54** controls the units in the diagnostic apparatus body **14**. The apparatus controller **54** is connected to the probe controller **44** of the probe body **16** via the communication cable **18** and supplies control signals for controlling the operation of the probe body **16** to the probe controller **44**. The apparatus controller **54** is connected to the light source controller **28** of the insertion position display means **20** via the communication cable **18** and supplies control signals for controlling the operation of the insertion position display means **20** to the light source controller **28**.

[0092] In such a diagnostic apparatus body **14**, while the image producer **48**, the display controller **50**, the apparatus controller **54**, and the insertion position calculating unit **64** are each constituted by a CPU and an operation program for causing the CPU to perform various kinds of processing, they may be constituted by a digital circuit. The aforementioned operation program is stored in the storage unit **58**.

[0093] The insertion position display means **20** includes the laser light source **24** for emitting laser beams, the light source driver **26** in which a drive source such as a motor is used to rotate the laser light source **24** about the axis perpendicular to the scan surface M to modify the laser beam irradiation position thereby showing the insertion position with a laser beam, and the light source controller **28** for controlling the light source driver **26**.

[0094] In the case of using the position guide member **30** as in the illustrated case, the light source driver **26** preferably rotates the laser light source **24** so that the laser beam may move on the position guide member **30** preferably in close proximity to the through slot **30***a* parallel to the extension of the scan surface M. As will be described later, when the position guide member **30** is not used, the light source driver **26** preferably rotates the laser light source so that the laser beam may move on the extension of the scan surface M.

[0095] The light source controller **28** is connected via the communication cable **18** to the apparatus controller **54** and the insertion position calculating unit **64** of the diagnostic apparatus body **14**. The light source controller **28** acquires the insertion position calculated in the insertion position calculating unit **64** and controls the light source driver **26** so that the laser beam from the laser light source **24** may be irradiated on the position guide member **30** at the insertion position. The light source controller **28** controls ON/OFF of the laser light source **24** based on the instruction from the apparatus controller **54**.

[0096] Next, the operation of the ultrasound diagnostic apparatus **10** is described.

[0097] First, a common ultrasound examination is made. An operator brings the ultrasound transmission/reception surface **16***a* of the ultrasound probe **12** into contact with the surface of a subject. In such a state, the transducers **34** transmit ultrasonic waves according to the actuation signals supplied from the transmission actuator **38** of the probe body **16**, and the reception signals outputted from the transducers **34** that have received the ultrasonic echoes from the subject are supplied to the corresponding reception signal processors **36** to generate sample data, which are then transmitted via the communication cable **18** to the diagnostic apparatus body **14** and stored in the data storage unit **46**. Further, the sample data is read out from the data storage unit **46** frame by frame, and the image producer **48** generates the image signal and, based on this image signal, the display controller **50** causes the monitor **52** to display the ultrasound diagnostic image.

[0098] When an instruction for displaying the insertion position is inputted in the operating unit **56** in order to perform paracentesis using the displayed ultrasonic image, a cursor appears on the ultrasound image displayed in the monitor **52** and a screen for making the operator to point the cursor to a target is displayed.

[0099] When the operator designates the target position from the operating unit **56**, the target position information is supplied to the insertion position calculating unit **64**. The insertion position calculating unit **64** calculates the insertion position from the target position information and the insertion angle read out from the angle memory unit **66** and supplies the insertion position information to the light source controller **28** of the insertion position display means **20**.

[0100] The light source controller **28** of the insertion position display means **20** controls the light source driver **26** based on the supplied insertion position information to cause the laser light source **24** to rotate so that a proper insertion position at which the puncture needle is inserted at a predetermined insertion angle is displayed by irradiation of the insertion position with the laser beam from the laser light source.

[0101] Since the insertion position display means **20** displays the insertion position at which the puncture needle is inserted at the predetermined insertion angle as described above, insertion of the puncture needle from the position at which the laser beam is irradiated ensures that the puncture needle can reach the target site even in cases where a doctor inserts the puncture needle from a position away from the ultrasound probe in paracentesis for the insertion at a predetermined small insertion angle.

[0102] The present invention is basically as described above.

[0103] In the illustrated case, the calculated insertion position is only displayed using the insertion position display means **20** including the laser light source but this is not the sole case of the invention.

[0104] For example, the insertion oath of the puncture needle may be calculated from the insertion position information calculated in the insertion position calculating unit **64** and the predetermined insertion angle stored in the angle memory unit **66** and be displayed as guidelines on the ultrasound image displayed in the monitor **52** as in the schematic diagram of the ultrasound image shown in FIG. **5**.

[0105] There are also cases where a doctor performs paracentesis from a direction opposite from the direction on the ultrasound image with respect to the ultrasound probe **12**. Therefore, left and right of the ultrasound image may be reversed according to the instruction from the operating unit **56**. Left and right may also be reversed for the guidelines of the puncture needle if they are displayed.

[0106] The illustrated ultrasound diagnostic apparatus **10** is configured such that an operator manipulates the operating unit **56** to point the cursor to a target site position on the ultrasound image and designate the target position to thereby

acquire the target position information. However, this is not the sole case of the invention and the ultrasound diagnostic apparatus may be, for example, configured to analyze the ultrasound image and calculate the position of a target such as a tumor. In such a case, the ultrasound diagnostic apparatus is preferably configured such that the operator can correct as necessary the target position from the operating unit.

[0107] The illustrated ultrasound diagnostic apparatus **10** is configured such that the ultrasound probe **12** includes the puncture guide **22** and a laser beam from the insertion position display means **20** is irradiated on the surface of the puncture guide **22** (more specifically the position guide member **30**). However, this is not the sole case of the invention. For example, the ultrasound diagnostic apparatus **10** may be configured such that a laser beam from the insertion position display means **20** is irradiated on the skin surface of a subject instead of using the puncture guide **22**.

[0108] The method of displaying the insertion position using the insertion position display means **20** is not limited to one in which the insertion position is displayed by irradiation with a laser beam, and the insertion position may be displayed using a light source other than a laser such as an LED.

[0109] FIG. **6** is a schematic diagram showing another example of the insertion position display means that may be used in the ultrasound diagnostic apparatus of the invention.

[0110] An insertion position display means **100** shown in FIG. **6** includes a light source **102**, a slit member **104** and a reflector **106**.

[0111] The light source **102** is of a known type such as LED. The slit member **104** and the reflector **106** are disposed downward in the direction of light travel from the light source **102** and the light source **102** emits light toward the slit member **104** and the reflector **106**.

[0112] The slit member **104** is a plate-like member having a cross-shaped light-transmitting window formed in the center thereof and the light-transmitting window passes part of light from the light source **102**. Only part of light irradiated on the slit member **104** which corresponds to the shape of the light-transmitting window impinges on the reflector **106**.

[0113] The reflector **106** is used to reflect light which was emitted from the light source **102** and passed through the slit member **104** to irradiate the insertion position.

[0114] The reflector **106** is mounted on the axis perpendicular to the scan surface M so as to be rotatable by a drive source such as motor (not shown). The reflector **106** rotates based on the calculation result of the insertion position in the insertion position calculating unit **64** to irradiate the insertion position with light.

[0115] As described above, a light source other than a laser (e.g., LED) may also be used, and particularly in the case of using a nondirectional light source, a slit member and a reflector may be used as in the insertion position display means **100** shown in FIG. **6** to irradiate the insertion position with light.

[0116] The method of displaying the insertion position is not limited to a method of irradiating the insertion position with light (laser beam) and the distance value from the probe body to the insertion position may be displayed on the monitor **52**. In such a case, the surface of the position guide member **30** in the puncture guide is preferably marked with a distance scale.

[0117] The illustrated ultrasound diagnostic apparatus **10** is configured such that a wired connection is established between the probe body **16** and the diagnostic apparatus body **14** via the communication cable **18** to perform the transmission and reception of various data. However, this is not the sole case of the invention and wireless transmission and reception of data may be performed between the probe body **16** and the diagnostic apparatus body **14**.

[0118] While the ultrasound diagnostic apparatus of the invention has been described above in detail, the invention is by no means limited to the above embodiments, and various improvements or modifications may be made without departing from the scope and spirit of the present invention.

What is claimed is:

1. An ultrasound diagnostic apparatus comprising:

an ultrasound probe which transmits ultrasonic waves toward a subject, receives ultrasonic echoes reflected on the subject and output reception signals;

image production means for producing an ultrasound image of the subject based on the reception signals outputted from said ultrasound probe;

image display means for displaying said ultrasound image generated by said image production means;

position designating means for designating a target position where paracentesis is performed;

insertion position calculating means for calculating an insertion position from information on the target position designated by said position designating means and a predetermined insertion angle; and

insertion position display means for displaying the insertion position calculated by said insertion position calculating means.

2. The ultrasound diagnostic apparatus according to claim **1**, wherein said insertion position display means displays said insertion position by irradiation of the insertion position with light.

3. The ultrasound diagnostic apparatus according to claim **2**, wherein said insertion position display means displays said insertion position by irradiation with a laser beam.

4. The ultrasound diagnostic apparatus according to claim **1**, wherein said insertion position display means displays said insertion position by showing on said image display means a distance value from said ultrasound probe to said insertion position.

5. The ultrasound diagnostic apparatus according to claim **1**, further comprising a position guide member fixed to said ultrasound probe.

6. The ultrasound diagnostic apparatus according to claim **2**, which further comprises a puncture guide having a position guide member fixed to said ultrasound probe and an angle guide member movably fixed to said position guide member and displaying an insertion angle for use in paracentesis, said insertion position display means displaying said insertion position by irradiation of said position guide member with light.

7. The ultrasound diagnostic apparatus according to claim **1**, wherein said image display means displays said ultrasound image and guidelines obtained by calculating an insertion path of a puncture needle in the paracentesis from the information on the target position designated by said position designating means and the predetermined insertion angle.

8. The ultrasound diagnostic apparatus according to claim **1**, further comprising angle adjustment means for changing said predetermined insertion angle.

9. The ultrasound diagnostic apparatus according to claim **1**, wherein said predetermined insertion angle is appropriately determined in a range of 10° to 20°.

10. The ultrasound diagnostic apparatus according to claim **1**, wherein said position designating means designates the target position on the ultrasound image displayed in said image display means according to an inputted instruction.

11. The ultrasound diagnostic apparatus according to claim **1**, wherein said position designating means analyzes said ultrasound image to calculate the target position.

* * * * *

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摘要(译)

超声波诊断装置包括超声波探头，图像产生器，监视器，用于在进行穿刺时指定目标位置的位置指定单元，用于根据由位置指定的目标位置的信息计算插入位置的插入位置计算单元指定单元和预定插入角度以及插入位置显示单元，用于显示由插入位置计算单元计算的插入位置。超声诊断设备确保从远离超声探头的位置插入的穿刺针以减小插入角度以便以更高的清晰度成像也可以到达目标部位。