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(54) **ULTRASOUND OBSERVATION APPARATUS AND CONTROL METHOD OF ULTRASOUND OBSERVATION APPARATUS**

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(57) **ABSTRACT**

An ultrasound observation apparatus of the invention includes: an ultrasound probe portion capable of two-dimensional scanning of an ultrasound beam; a transmission/reception control section for controlling a transmission/reception direction of the ultrasound beam by the ultrasound probe portion; a B-mode image calculation section for generating a B-mode image on a scanning plane based on a result of scanning of the ultrasound beam; a storage section for storing a predetermined sample image determined according to a shape of a treatment instrument in a case where a central axis of the treatment instrument for performing a treatment on a subject and the scanning plane agree with each other; and a correlation calculation section for calculating a correlation value between the B-mode image and the sample image, wherein the transmission/reception control section moves the scanning plane such that the correlation value becomes the maximum.

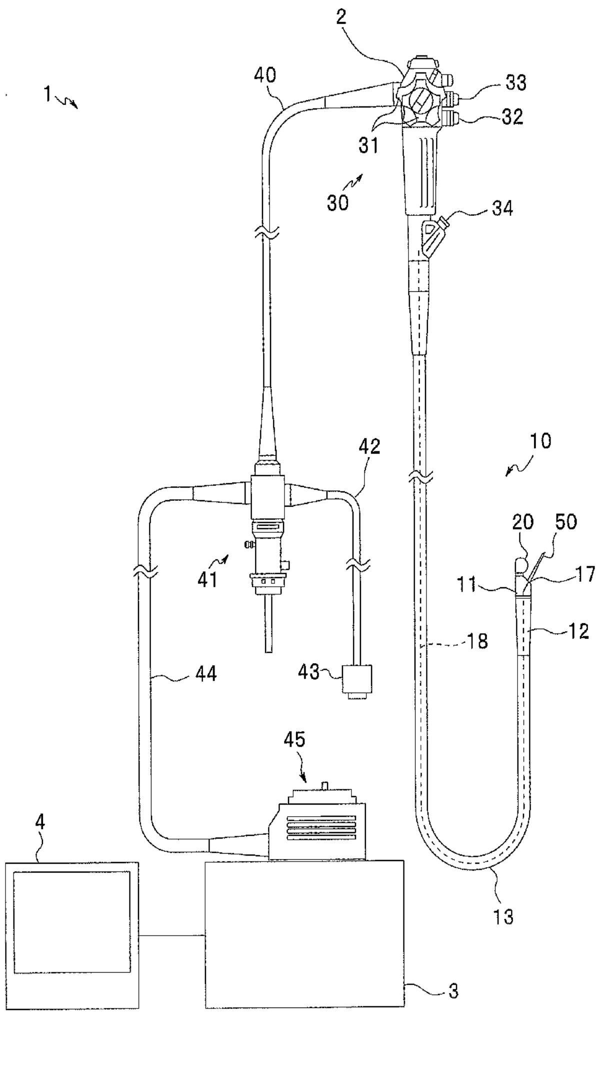


FIG.1

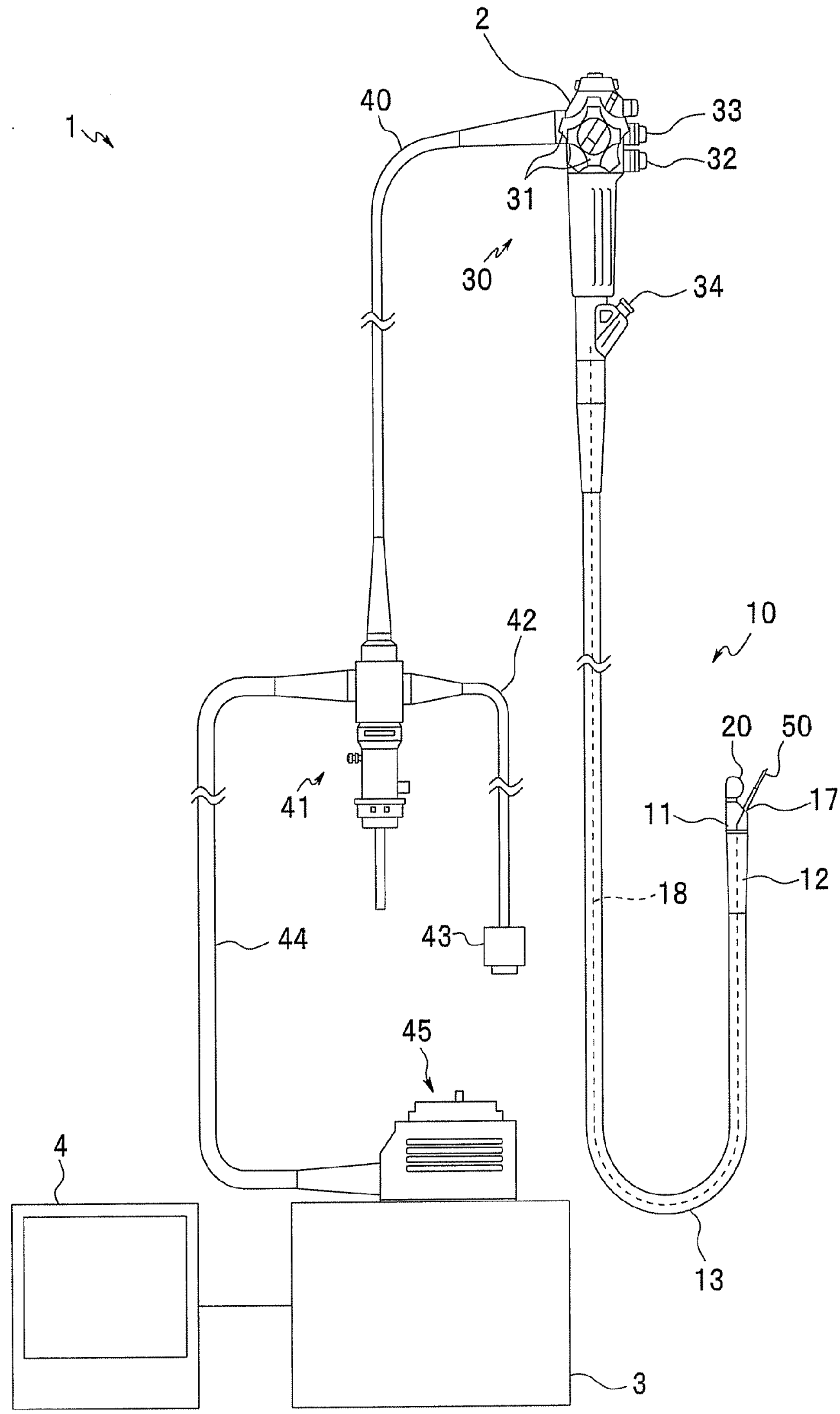


FIG.2

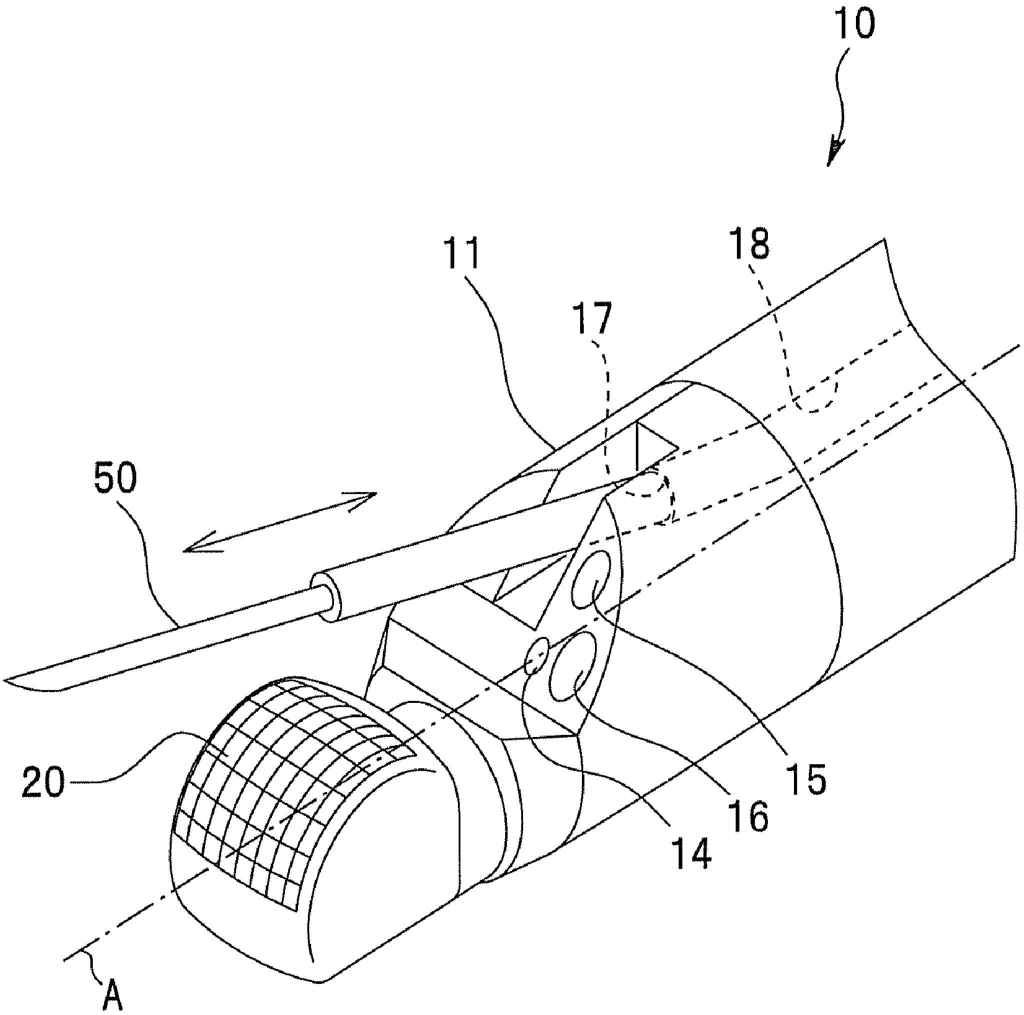


FIG.3

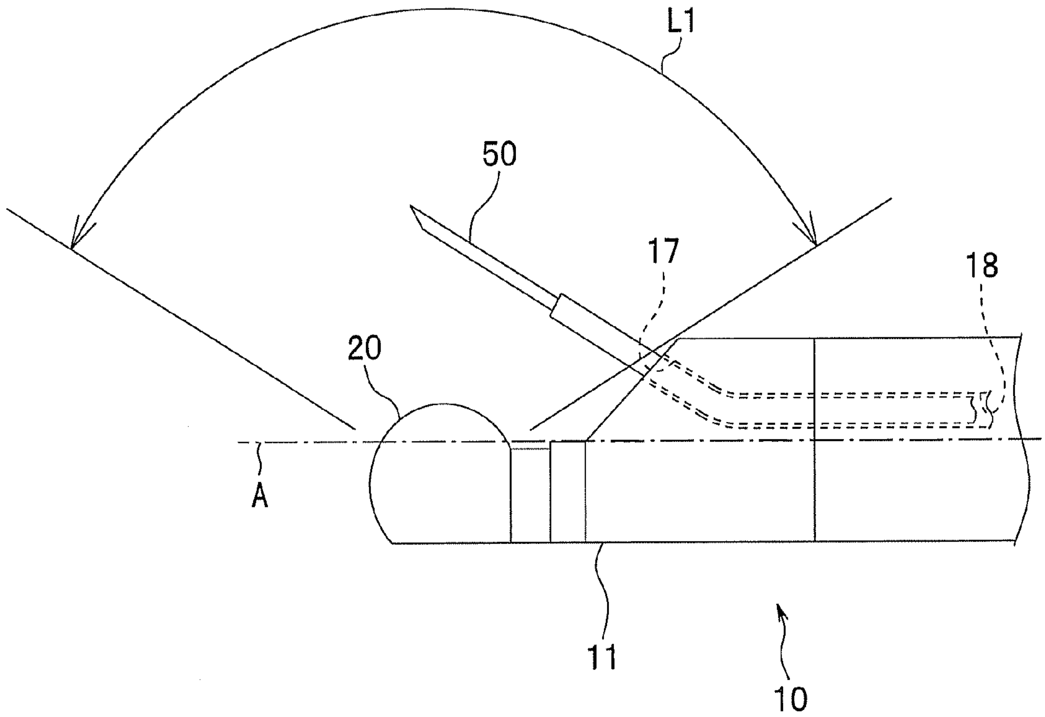


FIG.4

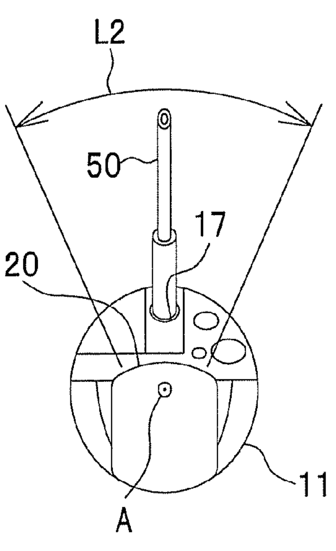


FIG.5

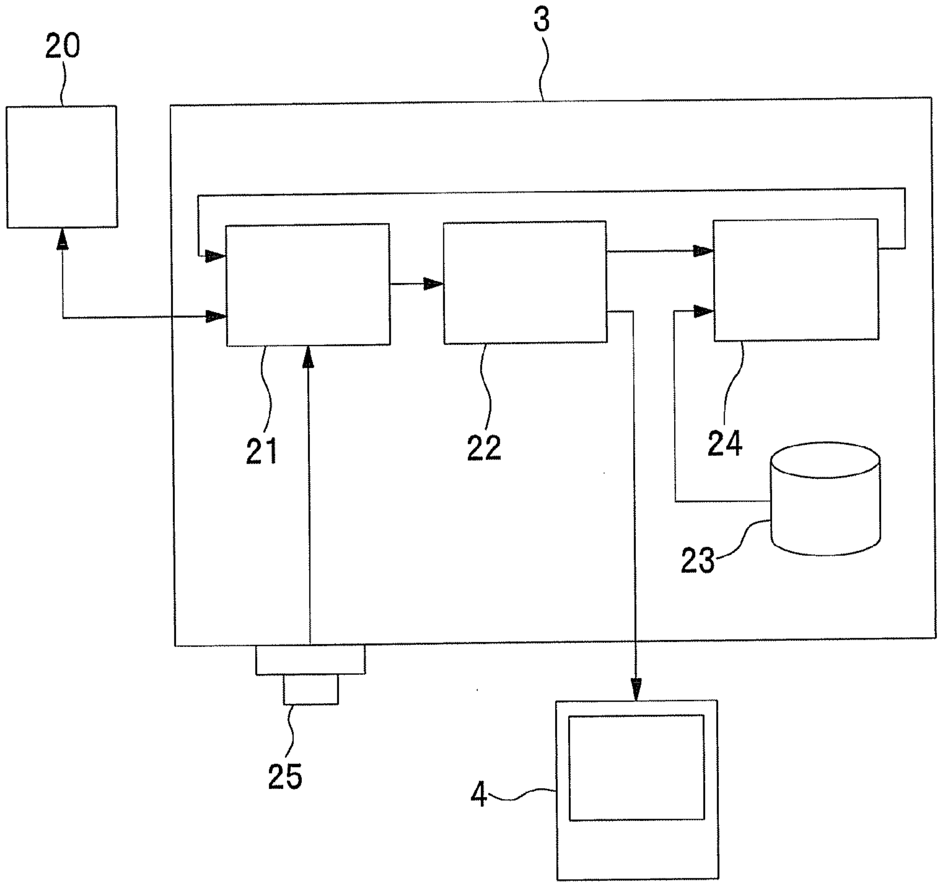


FIG.6

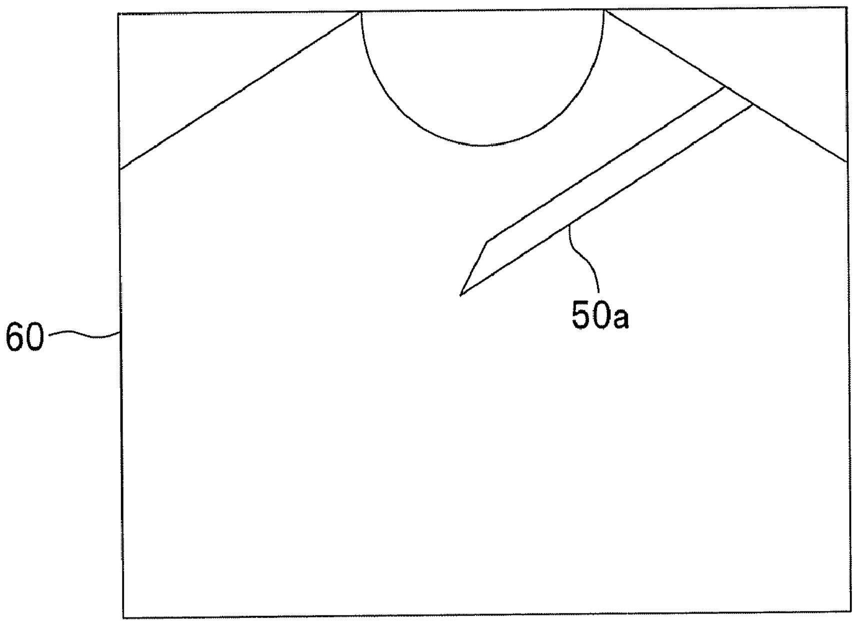


FIG.7

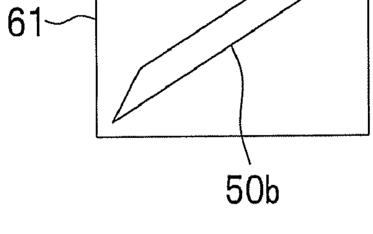


FIG.8

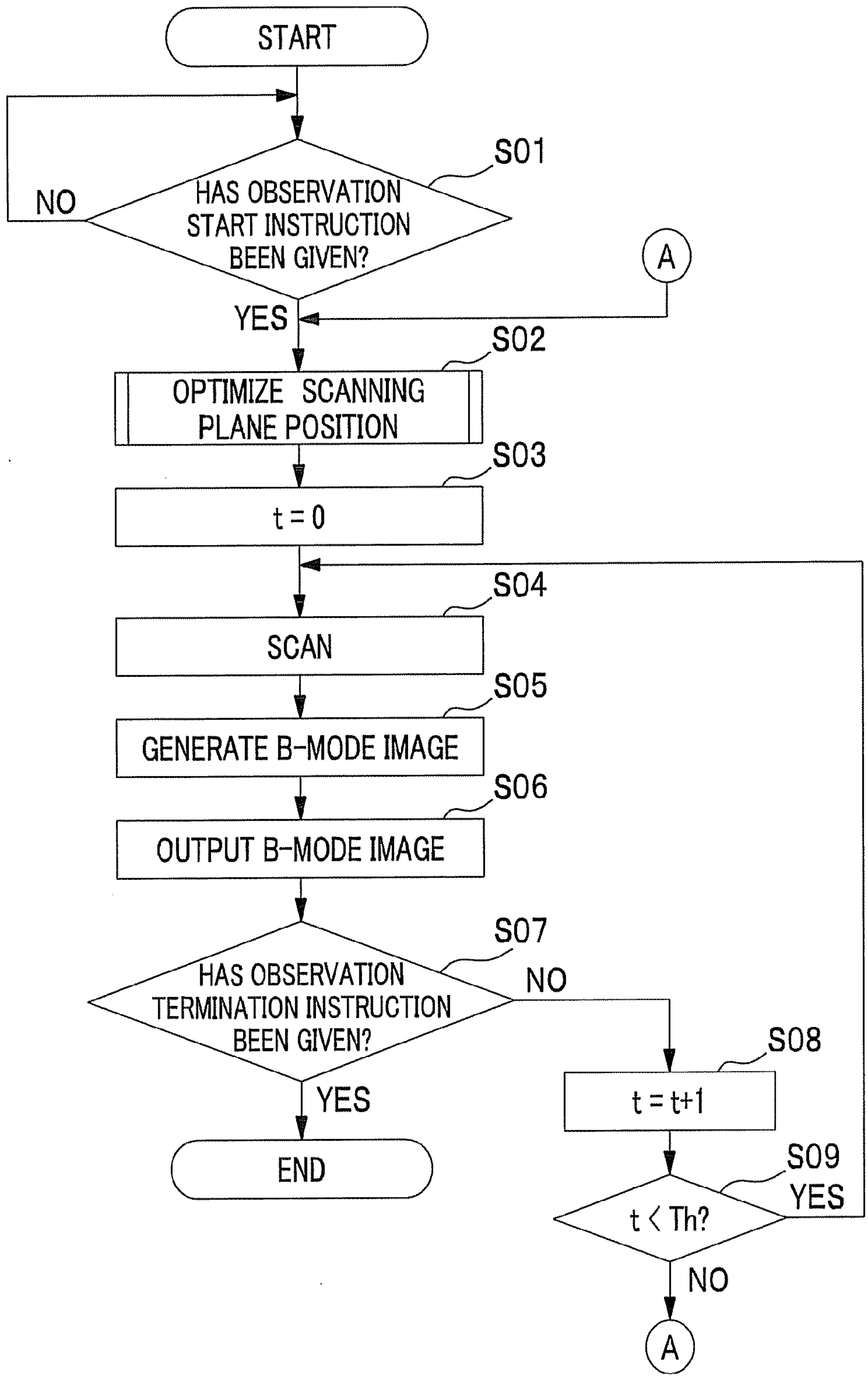

START
S01
HAS OBSERVATION START INSTRUCTION BEEN GIVEN?
NO
YES
A
S02
OPTIMIZE SCANNING PLANE POSITION
S03
t = 0
S04
SCAN
S05
GENERATE B-MODE IMAGE
S06
OUTPUT B-MODE IMAGE
S07
HAS OBSERVATION TERMINATION INSTRUCTION BEEN GIVEN?
NO
YES
END
S08
t = t+1
S09
t < Th?
YES
NO
A

FIG.9

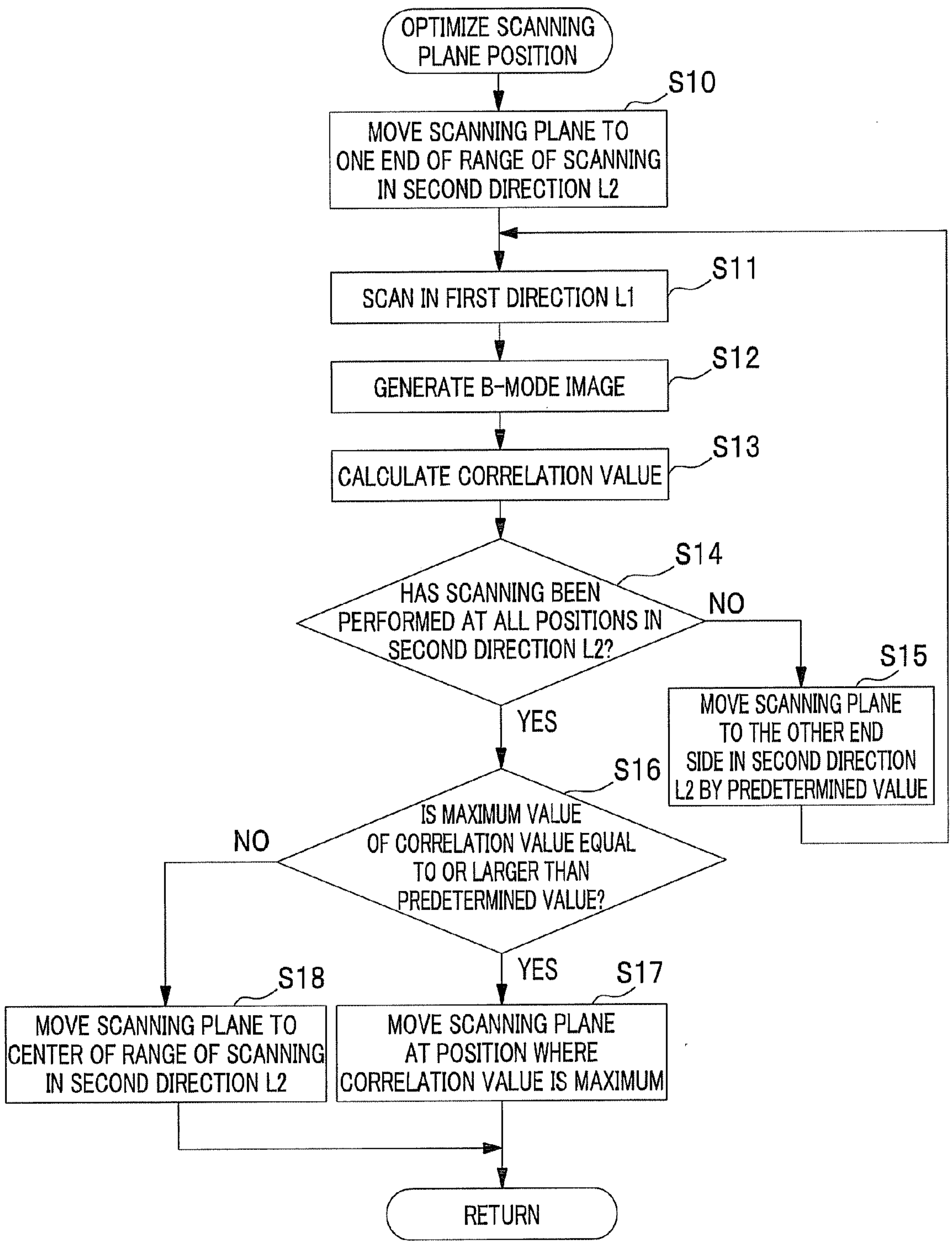

OPTIMIZE SCANNING PLANE POSITION
S10
MOVE SCANNING PLANE TO ONE END OF RANGE OF SCANNING IN SECOND DIRECTION L2
S11
SCAN IN FIRST DIRECTION L1
S12
GENERATE B-MODE IMAGE
S13
CALCULATE CORRELATION VALUE
S14
HAS SCANNING BEEN PERFORMED AT ALL POSITIONS IN SECOND DIRECTION L2?
NO
S15
MOVE SCANNING PLANE TO THE OTHER END SIDE IN SECOND DIRECTION L2 BY PREDETERMINED VALUE
YES
S16
IS MAXIMUM VALUE OF CORRELATION VALUE EQUAL TO OR LARGER THAN PREDETERMINED VALUE?
NO
S18
MOVE SCANNING PLANE TO CENTER OF RANGE OF SCANNING IN SECOND DIRECTION L2
YES
S17
MOVE SCANNING PLANE AT POSITION WHERE CORRELATION VALUE IS MAXIMUM
RETURN

FIG.10

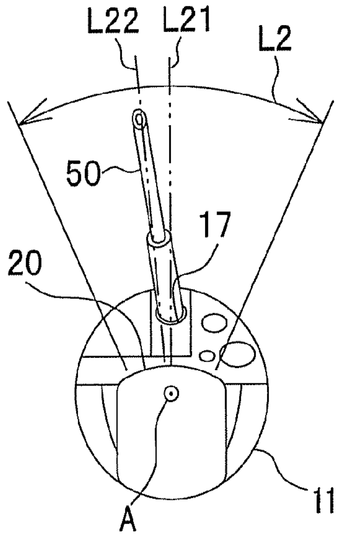


FIG.11

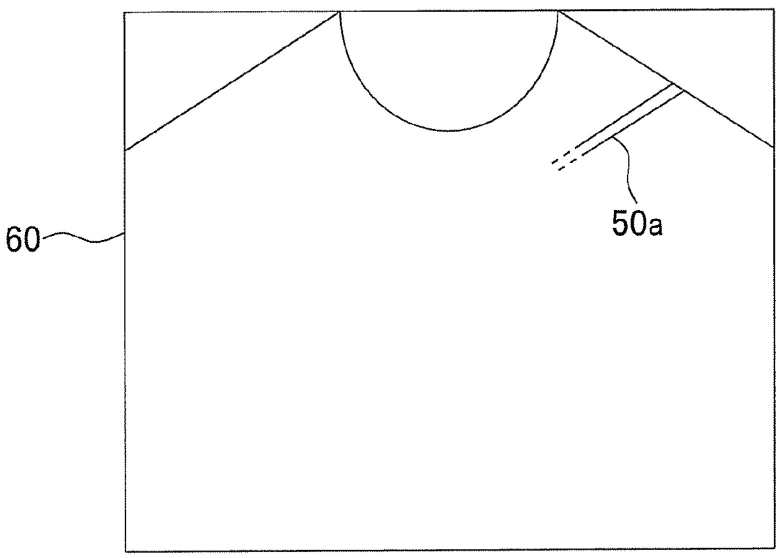


FIG.12

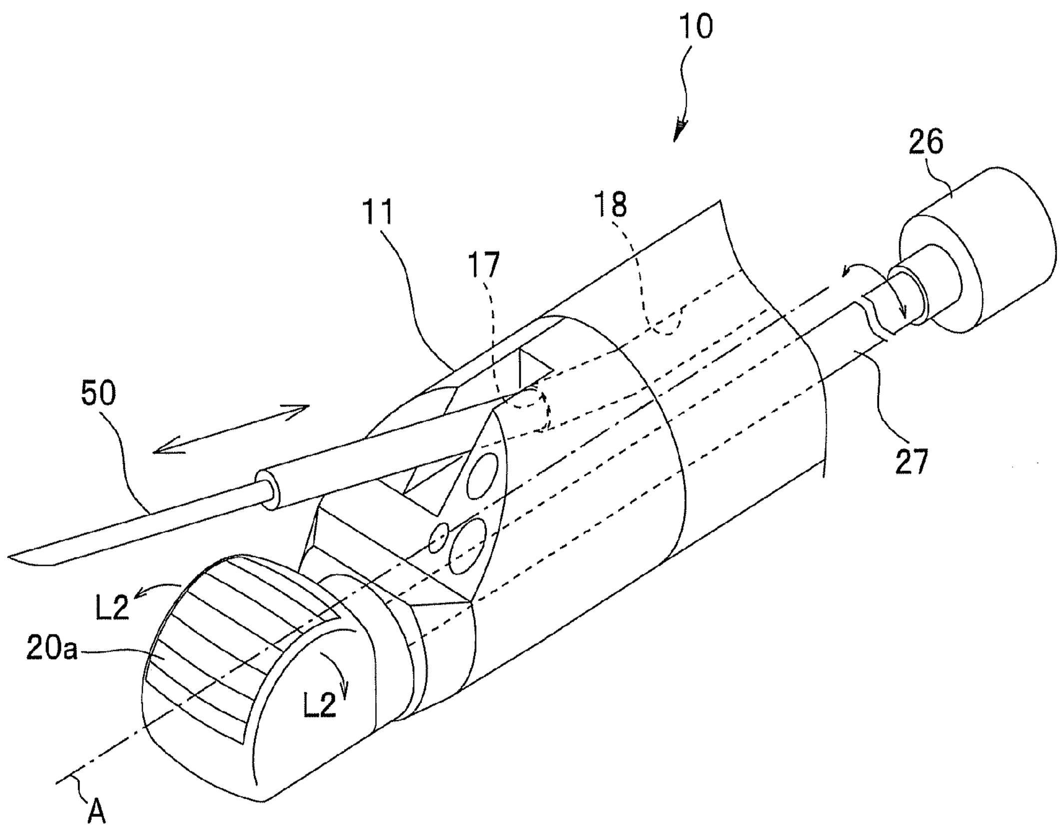
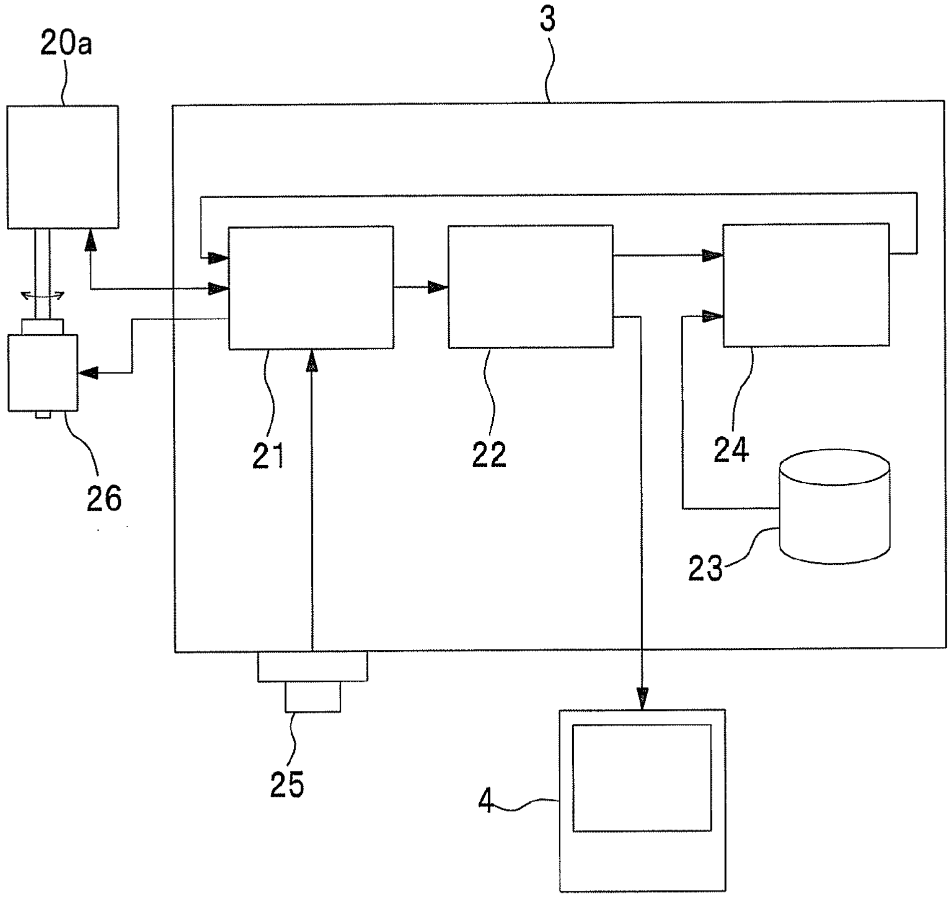


FIG.13



ULTRASOUND OBSERVATION APPARATUS AND CONTROL METHOD OF ULTRASOUND OBSERVATION APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of PCT/JP2010/067950 filed on Oct. 13, 2010 and claims benefit of Japanese Application No. 2009-261153 filed in Japan on Nov. 16, 2009, the entire contents of which are incorporated herein by this reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an ultrasound observation apparatus and a control method of the ultrasound observation apparatus for generating a B-mode image of inside a subject by scanning an ultrasound beam on a predetermined scanning plane in the subject.

[0004] 2. Description of the Related Art

[0005] As disclosed in a patent document 1, for example, an ultrasound observation apparatus used in a medical field and the like is provided with an ultrasound probe capable of transmitting and receiving ultrasound to and from a subject and generates a B-mode image as a cross-sectional image of a subject. The B-mode image is acquired by scanning an ultrasound beam on a predetermined scanning plane.

[0006] As disclosed in the Japanese Patent Application Laid-Open Publication No. 2006-175006, using such an ultrasound observation apparatus makes it possible to perform a treatment while checking on a B-mode image a position and a posture of a treatment instrument such as a puncturing needle, a biopsy forceps, or cytological brush with respect to a predetermined region in a subject.

SUMMARY OF THE INVENTION

[0007] According to one aspect of the present invention, it is possible to provide an ultrasound observation apparatus for generating a B-mode image of inside a subject by scanning an ultrasound beam on a scanning plane in the subject, which includes: an ultrasound probe portion capable of two-dimensional scanning of an ultrasound beam by changing a transmission/reception direction of the ultrasound beam in a first direction and in a second direction; a transmission/reception control section for controlling the transmission/reception direction of the ultrasound beam by the ultrasound probe portion; a B-mode image calculation section for generating the B-mode image based on a result of scanning of the ultrasound beam in the first direction; a storage section for storing a sample image determined according to a shape of a treatment instrument in a case where a central axis of the treatment instrument for performing a treatment on the subject and the scanning plane agree with each other; and a correlation calculation section for calculating a correlation value between the B-mode image and the sample image, wherein the transmission/reception control section moves the scanning plane in the second direction such that the correlation value becomes the maximum.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a view showing a schematic configuration of an ultrasound observation apparatus according to a first embodiment.

[0009] FIG. **2** is a perspective view showing a detailed configuration of a distal end portion of an insertion portion of an ultrasound endoscope according to the first embodiment.

[0010] FIG. **3** shows a side surface part of the distal end portion of the insertion portion according to the first embodiment.

[0011] FIG. **4** is a view of the distal end portion of the insertion portion according to the first embodiment when viewed from a distal end direction of an insertion axis.

[0012] FIG. **5** is a view illustrating a configuration of an ultrasound observation control unit according to the first embodiment.

[0013] FIG. **6** is a view showing an example of a B-mode image in a case where a treatment instrument exists on a scanning plane according to the first embodiment.

[0014] FIG. **7** is a view showing an example of a sample image according to the first embodiment.

[0015] FIG. **8** is a flowchart describing an operation of the ultrasound observation control unit according to the first embodiment.

[0016] FIG. **9** is a flowchart of a scanning plane optimization process according to the first embodiment.

[0017] FIG. **10** is a view showing a state where an advancing direction of the treatment instrument according to the first embodiment is deviated from a central axis of a treatment instrument insertion port.

[0018] FIG. **11** is a view showing an example of a B-mode image in a case where the treatment instrument is deviated from the scanning plane according to the first embodiment.

[0019] FIG. **12** is a view showing a configuration of an ultrasound probe portion according to a second embodiment.

[0020] FIG. **13** is a view showing a configuration of an ultrasound observation control unit according to the second embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Hereinafter, preferred embodiments of the present invention will be described with reference to drawings. Note that, in the drawings used for description below, a different scale size is used for each of the components in order to allow each of the components to be illustrated in a recognizable size in the drawings, and the present invention is not limited to the number, the shapes, the ratio of the sizes of the components, and a relative positional relationship among the components shown in these drawings.

First Embodiment

[0022] The first embodiment of the present invention will be described below. An ultrasound observation apparatus **1** according to the present embodiment shown in FIG. **1** includes an ultrasound endoscope **2** and an ultrasound observation control unit **3**.

[0023] The ultrasound observation apparatus **1** is schematically an apparatus which generates a B-mode image (ultrasound tomographic image) of a predetermined region in a subject by scanning an ultrasound beam in the subject, to output the B-mode image to an image display apparatus **4**.

[0024] The ultrasound endoscope **1** is configured by mainly including an insertion portion **10** which can be introduced in the subject, an operation portion **30** positioned at a proximal end of the insertion portion **10**, a universal cord **40** which extends from a side portion of the operation portion **30**.

[0025] The insertion portion **10** includes the following components in a linked manner: a distal end portion **11** disposed at a distal end of the insertion portion; a bendable bending portion **12** disposed at a proximal end side of the distal end portion **11**, and a flexible tube portion **13** having flexibility which is disposed at a proximal end side of the bending portion **12** and connected to a distal end side of the operation portion **30**. Though detailed description will be made later, the distal end portion **11** is provided with an ultrasound probe portion **20**, a treatment instrument insertion port **17**, a fluid feeding portion **14**, an image pickup apparatus **15**, an illumination device **16**, and the like.

[0026] The insertion portion **10**A includes inside thereof a treatment instrument insertion conduit **18**. The treatment instrument insertion conduit **18** is a conduit for communicating the treatment instrument insertion port **17** as an opening portion provided at the distal end portion **10** with a conduit cap **34** provided at the operation portion **30**.

[0027] The operation portion **30** is provided with an angle knob **31** for operating bending of the bending portion **12**, an air-feeding/water-feeding button **32** for controlling a feeding operation of fluid from the fluid feeding portion **14** provided at the distal end portion **10**, a suction button **33** for controlling a suction operation from the treatment instrument insertion port **17**, the conduit cap **34**, and the like.

[0028] An endoscope connector **41** to be connected to a light source device, not shown, is provided at a proximal end portion of the universal cord **40**. The light emitted from the light source device passes through the universal cord **40**, the operation portion **30**, and an optical fiber cable inserted through the insertion portion **10**, to be emitted from the illumination device **16** of the distal end portion **11**. Note that the ultrasound endoscope **1** may be provided with a light source device such as an LED at the distal end portion **11**.

[0029] An electric cable **42** and an ultrasound cable **44** are extended from the endoscope connector **41**. The electric cable **42** is detachably connected to a camera control unit, not shown, through an electric connector **43**. The camera control unit is electrically connected to the image pickup apparatus **15** provided at the distal end portion **11** through the electric cable **42**. The camera control unit is electrically connected to the image display apparatus **4** and outputs an image picked up by the image pickup apparatus **15** to the image display apparatus **4**.

[0030] The ultrasound cable **44** is detachably connected to the ultrasound observation control unit **3** to be detailed later, through an ultrasound connector **45**.

[0031] Next, description will be made on a detailed configuration of the distal end portion **11** of the insertion portion **10** of the ultrasound endoscope **2**. As shown in FIG. **2**, the distal end portion **11** includes the ultrasound probe portion **20**, the treatment instrument insertion port **17**, the image pickup apparatus **15**, the illumination device **16**, and the fluid feeding portion **14**.

[0032] The ultrasound probe portion **20** is configured to be capable of changing the transmission/reception direction of the ultrasound beam in a first direction L**1** and in a second direction L**2**. That is, the ultrasound probe portion **20** is configured so as to enable two-dimensional scanning of an ultrasound beam.

[0033] The configuration of the ultrasound probe portion **20** is not specifically limited as long as the two-dimensional scanning of the ultrasound beam is possible. In the present embodiment, as an example, the ultrasound probe portion **20** includes a plurality of ultrasound transducers which are aligned in matrix and can be individually driven, and is configured to electronically perform the two-dimensional scanning of the ultrasound beam by controlling a driving timing of each of the ultrasound transducers.

[0034] As the ultrasound transducers constituting the ultrasound probe portion **20**, piezoelectric elements or electrostrictive elements such as piezoelectric ceramics, ultrasonic transducers by micromachine technology (MUT: Micromachined Ultrasonic Transducer), or the like can be applied, for example.

[0035] More specifically, the ultrasound probe portion **20** of the present embodiment can change the transmission/reception direction of the ultrasound beam in a substantially sector shape on a plane parallel to an insertion axis A of the insertion portion **10** to perform scanning of an ultrasound beam, as shown in FIG. **3**. In the present embodiment, as shown by the arrow L1 in FIG. **3**, the amplitude direction of the scanning of the ultrasound beam on the plane substantially parallel to the insertion axis A is defined as a first direction L**1**.

[0036] In addition, in the present embodiment, the plane including a central axis of the ultrasound beam which is scanned in the first direction L**1** is referred to as a scanning plane, and the B-mode image generated by the ultrasound observation apparatus **1** is assumed to be acquired by scanning the ultrasound beam on the scanning plane.

[0037] As shown in FIG. **4**, the ultrasound probe portion **20** of the present embodiment can change the transmission/reception direction of the ultrasound beam in a substantially sector shape on the plane perpendicular to the insertion axis A of the insertion portion **10** to perform scanning of the ultrasound beam. In the present embodiment, as shown by the arrow L**2** in FIG. **4**, the amplitude direction of the scanning of the ultrasound beam on the plane perpendicular to the insertion axis A is defined as a second direction L**2**.

[0038] That is, the ultrasound probe portion **20** of the present embodiment enables the scanning plane to move in the second direction L**2** by changing the transmission/reception direction of the ultrasound beam in the second direction L**2**. In the present embodiment, as an example, the scanning plane can be moved to positions of a plurality of predetermined locations within the range of scanning in the second direction L**2**.

[0039] Note that the ultrasound probe portion **20** according to the present embodiment which is shown in drawings is configured by aligning the ultrasound transducers in a substantially circular arc shape along the first direction L**1** and the second direction L**2**. However, it is needless to say that electronic two-dimensional scanning of the ultrasound beam is possible even if the plurality of ultrasound transducers are aligned in matrix on a plane.

[0040] The treatment instrument insertion port **17** is an opening portion for allowing a treatment instrument **50** to protrude therefrom, and communicates with the treatment instrument insertion conduit **18**. In the ultrasound endoscope **2** according to the present embodiment, the treatment instrument **50** is inserted from the opening portion of the conduit cap **34** to allow the treatment instrument **50** to protrude from the treatment instrument insertion port **17** of the distal end portion **11**, thereby enabling the treatment instrument **50** to be introduced into a body of a subject, for example.

[0041] Note that the type of the treatment instrument **50** is not specifically limited, but a puncture needle, a biopsy forceps, a cytological brush, or the like can be listed, for example. In the present embodiment, the treatment instrument **50** is a puncture needle, as shown in FIG. **2**. The treatment instrument **50** may be provided with an ultrasound scattering portion for scattering ultrasound waves in order to make the echo pattern of the treatment instrument **50** in a B-mode image clearer.

[0042] Furthermore, in the present embodiment, the treatment instrument insertion port **17** is disposed such that the treatment instrument **50** protruded from the treatment instrument insertion port **17** advances in a range of scanning of the ultrasound beam performed by the ultrasound probe portion **20**, as shown in FIGS. **3** and **4**.

[0043] In other words, the ultrasound observation apparatus **1** according to the present embodiment is configured to be able to capture the treatment instrument **50** protruded from the treatment instrument insertion port **17** in a B-mode image by moving the scanning plane.

[0044] In addition, the present embodiment employs, as one example, a configuration in which, when the scanning plane is moved to the center of the range of scanning in the second direction L**2**, the scanning plane and the central axis of the treatment instrument insertion port **17** are positioned on substantially the same plane.

[0045] The image pickup apparatus **15** includes an image-forming optical system member and an image pickup device, and picks up an optical image. The image pickup apparatus **15** is disposed so as to capture the distal end direction along the insertion axis A within the field of view thereof. The illumination device **16** emits the light generated by the light source device into the field of view of the image pickup apparatus **15**. The fluid feeding portion **17** is an opening portion provided at the distal end portion **11**, and fluid is fed from the fluid feeding portion **17** by operating the air-feeding/water-feeding button **32** provided at the operation portion **30**.

[0046] Next, description will be made on the detailed configuration of the ultrasound observation control unit **3**. The ultrasound observation control unit **3** includes a calculation device, a storage device, an input/output device, a power control device and the like, and is a control apparatus which controls operation of the ultrasound probe portion **20** and generates and outputs a B-mode image based on a predetermined program.

[0047] The ultrasound observation control unit **3** includes, as shown in FIG. **5**, a transmission/reception control section **21**, a B-mode image calculation section **22**, a storage section **23**, a correlation calculation section **24**, and an ultrasound observation switch **25**, as components required for achieving the operation to be described later of the ultrasound observation apparatus **1**. Note that the transmission/reception control section **21**, the B-mode image calculation section **22**, and the correlation calculation section **24** may be mounted to the ultrasound observation control unit **3** either in a hardware manner or in a software manner.

[0048] The transmission/reception control section **21** controls the transmission/reception direction of the ultrasound beam transmitted and received by the ultrasound probe portion **20**. That is, the transmission/reception control section **21** controls the position of the scanning plane with respect to the second direction L**2** and the scanning of the ultrasound beam for acquiring the B-mode image on the scanning plane.

[0049] The B-mode image calculation section **22** generates the B-mode image on the scanning plane based on the result of scanning of the ultrasound beam performed by the ultrasound probe portion **20**. When the treatment instrument **50** exists on the scanning plane, for example, an echo pattern **50***a* of the treatment instrument **50** appears in a B-mode image **60**, as shown in FIG. **6**.

[0050] The storage section **23** stores a predetermined sample image determined according to the shape of treatment instrument **50**. Specifically, the sample image is an image showing a shape and a size of an ideal echo pattern of the treatment instrument **50** in the B-mode image in the case where the scanning plane and the central axis of the treatment instrument **50** agree with each other.

[0051] When the treatment instrument **50** is a puncture needle as in the present embodiment, a sample image **61** is an image showing a shape and a size of an echo pattern **50***b* of the distal end portion of the puncture needle in the case where the central axis of the puncture needle agrees with the scanning plane, as shown in FIG. **7**.

[0052] The present embodiment describes, as an example, that the sample image **61** is created in advance according to the type and the shape of the treatment instrument **50**. Note that the sample image **61** may be stored in the storage section **23** as a result of designation of the echo pattern **50***a* of the treatment instrument **50** in the actual B-mode image **60** by a user of the ultrasound observation apparatus **1**, that is, may be stored as the echo pattern **50***a* of the treatment instrument **50** to be actually used, by what is called a teaching operation.

[0053] In addition, the shape of the treatment instrument **50** is hard to appear in the B-mode image **60** in some cases depending on a shape of the treatment instrument **50** or a material configuring the treatment instrument **50**. However, in such a case, the ultrasound scattering portion is provided in a part of the treatment instrument **50**. When the ultrasound scattering portion is provided in the treatment instrument **50**, the sample image **61** is an image showing a shape of an ideal echo pattern of the ultrasound scattering portion in the B-mode image **60**.

[0054] The correlation calculation section **24** calculates a correlation value R between the B-mode image **60** and the sample image **61**. Specifically, the correlation calculation section **24** performs on the B-mode image **60** an image processing referred to as a pattern matching by using the sample image **61** as a template, and calculates a similarity between the echo pattern in the B-mode image **60** and the sample image **61**. The higher the similarity between the echo pattern in the B-mode image **60** and the sample image **61**, the higher the correlation value R. Since the pattern matching is a well-known technology, detailed description thereof will be omitted.

[0055] The ultrasound observation switch **25** is an input device through which a user inputs instructions for starting and terminating the observation using a B-mode image. In the present embodiment, the ultrasound observation switch **25** is provided to the ultrasound observation control unit **3**, as an example. However, the ultrasound observation switch **25** may be provided to the operation portion **30** of the ultrasound endoscope **2**, or may be configured as a switch like a foot switch provided separately from the ultrasound observation control unit **3** and the ultrasound endoscope **2**.

[0056] Next, the operation of the ultrasound observation apparatus **1** will be described with reference to the flowcharts in FIGS. **8** and **9**. Note that description will be made below on the B-mode image generation operation performed by the ultrasound probe portion **20** and the ultrasound observation control unit **3**, and description on the optical image observation operation performed by the image pickup apparatus **15** provided in the ultrasound endoscope **1** will be omitted.

[0057] First, in step S**01**, a stand-by state continues until an instruction for starting the observation using a B-mode image is inputted by operating the ultrasound observation switch **25**. When the instruction for starting the observation using a B-mode image is inputted, the process moves to step S**02**, and the scanning plane position optimization process shown in the flowchart in FIG. **9** is performed.

[0058] In the scanning plane position optimization process, first in step S**10**, the transmission/reception control section **21** moves the scanning plane to one end of the range of scanning in the second direction L**2**. Then, in step S**11**, the transmission/reception control section **21** controls the ultrasound probe portion **20** to cause the ultrasound beam to scan in the first direction L**1** on the scanning plane whose position with respect to the second direction L**2** is determined.

[0059] Next, in step S**12**, the B-mode image calculation section **22** generates a B-mode image based on the result of scanning in the step S**11**. Then, in step S**13**, the correlation calculation section **24** calculates a correlation value between the B-mode image acquired in the step S**12** and the sample image stored in the storage section **23**.

[0060] Next, in step S**14**, it is determined whether or not scanning has been performed at all positions determined in advance, regarding the position of the scanning plane with respect to the second direction L**2**. When scanning has not been performed at all the positions, regarding the second direction L**2**, the process moves to step S**15**. In the step S**15**, after the scanning plane is moved to the next position on the other end side in the second direction L**2**, the processes in the step S**11** to step S**13** are repeated.

[0061] Then, in the step S**14**, when it is determined that scanning has been performed at all the positions determined in advance regarding the position of the scanning plane with respect to the second direction L**2**, the process moves to step S**16**.

[0062] That is, the steps S**10** to S**15** are the processes of acquiring a plurality of B-mode images with the scanning plane positioned at a plurality of locations in the second direction L**2**, and calculating correlation values between the plurality of B-mode images and the sample image.

[0063] In the step S**16**, it is determined whether or not the maximum value of the correlation values between the plurality of B-mode images acquired in the above process and the sample image is equal to or larger than a predetermined threshold. When the maximum value of the correlation values is equal to or larger than the predetermined threshold, the process moves to step S**17**.

[0064] In step S**17**, the transmission/reception control section **21** moves the position of the scanning plane with respect to the second direction L**2** to a position where the maximum correlation value is acquired among the correlation values of the plurality of B-mode images. That is, the step S**17** is a process of moving the scanning plane such that the correlation value between the B-mode image and the sample image becomes the maximum.

[0065] On the other hand, when the maximum value of the correlation values is smaller than the predetermined threshold, the process moves to step S**18**. In the step S**18**, the transmission/reception control section **21** moves the position of the scanning plane with respect to the second direction L**2** to the center of the range of scanning. The state where the maximum value of the correlation values is not equal to or larger than the predetermined threshold is supposed to be the state where the treatment instrument **50** is not protruded from the treatment instrument insertion port **17**. Therefore, in the step S**18**, the scanning plane is moved to a position where the scanning plane and the central axis of the treatment instrument insertion port **17** substantially agree with each other.

[0066] Then, the scanning plane position optimization process is terminated, and the process returns to the step S**03** in FIG. **8**. In the step S**03**, the counter value t is reset to be zero (t=0). Then, in the step S**04**, an ultrasound beam is scanned in the first direction L**1** on the scanning plane whose position has been determined in the scanning plane position optimization process in the step S**02**.

[0067] Next, in the step S**05**, the B-mode image calculation section **22** generates a B-mode image based on the result of the scanning in the step S**04**. Then, in the step S**06**, the generated B-mode image is outputted to the image display apparatus **4**. According to the process, the B-mode image is displayed on the image display apparatus **4**.

[0068] Next, in the step S**07**, it is determined whether or not an instruction for terminating the observation using the B-mode image has been inputted by operating the ultrasound observation switch **25**. When the instruction for terminating the observation using the B-mode image has been inputted, the operation is stopped.

[0069] On the other hand, when the instruction for terminating the observation using B-mode image is not inputted, the process moves to the step S**08**, and one is added to the counter value t (t=t+1). Then, in the step S**09**, it is determined whether or not the counter value t is smaller than a predetermined threshold Th.

[0070] When the counter value t is smaller than the predetermined threshold Th, the process returns to step S**04**, and the scanning of ultrasound beam and the generation of B-mode image are repeated. When the counter value t reaches the predetermined Th, the process returns to the step S**02**, and the scanning plane position optimization process is performed.

[0071] That is, in the present embodiment, after the scanning of the ultrasound beam and the generation of the B-mode image are repeated by a predetermined number of times Th on the scanning plane located at a certain position with respect to the second direction L**2**, the scanning plane position optimization process is performed.

[0072] In the scanning plane position optimization process, the position of the scanning plane is determined such that the correlation value between the B-mode image and the sample image becomes the maximum, that is, the shape of the treatment instrument **50** appears most clearly on the B-mode image.

[0073] For example, as shown in FIG. **10**, in a case where the protruding direction of the treatment instrument **50** protruded from the treatment instrument insertion port **17** is inclined with respect to the central axis of the treatment instrument insertion port **17**, if the scanning plane is remained fixed at a position (position shown by the two-dot-chain line L**21** in FIG. **10**) where the scanning plane substantially agrees with the central axis of the treatment instrument insertion port **17** as in a conventional configuration, observation of the treatment instrument **50** on the B-mode image **60** becomes difficult as shown in FIG. **11**.

[0074] According to the ultrasound observation apparatus **1** in the present embodiment, even in the case where the protruding direction of the treatment instrument **50** is thus inclined, the scanning plane position optimization process is performed, and thereby the scanning plane is automatically moved to the position (position shown by the two-dot-chain line L**22** in FIG. **10**) where the echo pattern of the treatment instrument **50** shows the shape of treatment instrument **50** most clearly.

[0075] In addition, the scanning plane position optimization process is periodically performed in a period during which the observation using the B-mode image is continued. Therefore, even if the treatment instrument **50** is deviated from the scanning plane in the middle of the treatment performed on a subject, the scanning plane automatically moves, which allows the treatment instrument **50** to be captured again in the B-mode image **60** without the need for the user to intentionally perform any operation.

[0076] That is, according to the ultrasound observation apparatus **1** of the present embodiment, it is possible to continue excellent observation of the treatment instrument **50** on the B-mode image **60** without performing any cumbersome operation.

Second Embodiment

[0077] The second embodiment of the present invention will be described below with reference to FIGS. **12** and **13**. The ultrasound observation apparatus according to the present embodiment is different from the first embodiment in the method of scanning of ultrasound beam performed by the ultrasound probe portion **20**. Only the points different from the first embodiment will be described below, and the same components as those in the first embodiment are attached with the same reference numerals and description thereof will be omitted accordingly.

[0078] As shown in FIG. **12**, the ultrasound probe portion **20***a* of the present embodiment has a configuration of what is called a convex scanning type, in which a plurality of ultrasound transducers are aligned in a row in a substantially circular arc shape. A plurality of ultrasound transducers constituting the ultrasound probe portion **20***a* are aligned such that scanning of an ultrasound beam can be performed in substantially sector shape on the plane parallel to the insertion axis A of the insertion portion **10**. That is, the ultrasound probe portion **20***a* is configured to enable electronic scanning of an ultrasound beam in the first direction L**1**.

[0079] In addition, the ultrasound probe portion **20***a* is disposed so as to be oscillatable around the axis parallel to the insertion axis A of the insertion portion **10**. That is, the ultrasound probe portion **20***a* is configured to enable mechanical scanning of an ultrasound beam in the second direction L**2** by oscillating in the second direction L**2**.

[0080] The ultrasound probe portion **20***a* is connected to an electric motor **26** provided in the operation portion **30** via a flexible shaft **27** inserted through the insertion portion **10**. The ultrasound probe portion **20***a* oscillates around the axis parallel to the insertion axis A by the drive force generated by the electric motor **26**. As shown in FIG. **13**, the electric motor **26** is electrically connected to the transmission/reception control section **21**, and the operation of the electric motor **26** is controlled by the transmission/reception control section **21**.

[0081] As described above, the ultrasound probe portion **20***a* according to the present embodiment can perform two-dimensional scanning of the ultrasound beam by combining the electronic scanning and the mechanical scanning. In addition, the direction of the scanning of the ultrasound beam performed by the ultrasound probe portion **20***a* is controlled by the transmission/reception control section similarly as in the first embodiment.

[0082] It is needless to say that the same effects as those in the first embodiment can be obtained also by the present embodiment described above.

[0083] According to the above-described embodiment, it is possible to provide an ultrasound observation apparatus for observing a situation of a treatment using a treatment instrument in a subject, which is capable of continuing excellent observation of the treatment instrument.

[0084] The present invention is not limited to the above-described embodiments, and can be modified as needed without departing from the gist of invention or the spirit of invention which can be read from claims and the whole specification. An ultrasound observation apparatus modified as such is also included in the technical range of the present invention.

[0085] As described above, the present invention is suitable for an ultrasound observation apparatus which observes a situation of a treatment using a treatment instrument in a subject.

What is claimed is:

1. An ultrasound observation apparatus for generating a B-mode image of inside a subject by scanning an ultrasound beam on a scanning plane in the subject, the ultrasound observation apparatus comprising:

an ultrasound probe portion capable of two-dimensional scanning of an ultrasound beam by changing a transmission/reception direction of the ultrasound beam in a first direction and in a second direction;

a transmission/reception control section for controlling the transmission/reception direction of the ultrasound beam by the ultrasound probe portion;

a B-mode image calculation section for generating the B-mode image based on a result of scanning of the ultrasound beam in the first direction;

a storage section for storing a sample image determined according to a shape of a treatment instrument in a case where a central axis of the treatment instrument for performing a treatment on the subject and the scanning plane agree with each other; and

a correlation calculation section for calculating a correlation value between the B-mode image and the sample image,

wherein the transmission/reception control section moves the scanning plane in the second direction such that the correlation value becomes the maximum.

2. The ultrasound observation apparatus according to claim **1**, wherein

the ultrasound probe portion is provided to an ultrasound endoscope which can be introduced into a subject, and

the ultrasound endoscope includes a treatment instrument insertion port for allowing the treatment instrument to protrude into a range of the scanning of the ultrasound beam by the ultrasound probe portion.

3. The ultrasound observation apparatus according to claim **2**, wherein

the ultrasound probe portion is arranged such that the scanning plane is parallel to a central axis of the treatment instrument insertion port and the second direction is along a plane which is perpendicular to the scanning plane, the transmission/reception control section moves the scanning plane to a plurality of locations in the second direction with the treatment instrument protruded from the insertion port,

the B-mode image calculation section generates a plurality of B-mode images acquired in a state where the scanning plane is positioned at the plurality of locations in the second direction,

the correlation calculation section calculates correlation values between the plurality of B-mode images and the sample image, and

the transmission/reception control section moves the scanning plane to a position where the maximum correlation value is acquired among the correlation values of the plurality of B-mode images.

4. The ultrasound observation apparatus according to claim **3**, wherein,

when the maximum value of the correlation values is smaller than a predetermined threshold, the transmission/reception section moves the scanning plane to a predetermined position in the second direction.

5. The ultrasound observation apparatus according to claim **1**, wherein

the transmission/reception control section periodically moves the scanning plane such that the correlation value becomes the maximum.

6. The ultrasound observation apparatus according to claim **5**, wherein,

the transmission/reception control section periodically moves the scanning plane after a predetermined number of times of generation of the B-mode image by the B-mode image calculation section and calculation of the correlation value by the correlation calculation section.

7. The ultrasound observation apparatus according to claim **1**, wherein

the sample image is an image showing a shape and a size of the treatment instrument in the B-mode image in a case where the scanning plane and the central axis of the treatment instrument agree with each other.

8. The ultrasound observation apparatus according to claim **7**, wherein

the sample image is an image stored in the storage section by designating an echo pattern of the treatment instrument in the B-mode image generated by the B-mode image calculation section.

9. The ultrasound observation apparatus according to claim **1**, wherein

the ultrasound probe portion includes a plurality of ultrasound transducers which are aligned in matrix and can be driven individually, and the ultrasound probe portion is configured to electronically perform the two-dimensional scanning of the ultrasound beam by controlling a driving timing of each of the ultrasound transducers.

10. The ultrasound observation apparatus according to claim **1**, wherein

the ultrasound probe portion includes a plurality of ultrasound transducers arranged in a row in a circular arc shape, and the ultrasound probe portion is configured to perform the two-dimensional scanning of the ultrasound beam by performing electronic scanning of the ultrasound beam in the first direction by controlling a driving timing of each of the ultrasound transducers, and by performing mechanical scanning of the ultrasound beam in the second direction.

11. The ultrasound observation apparatus according to claim **1**, wherein

the sample image shows a shape of a puncture needle, a biopsy forceps, or a cytological brush in the B-mode image.

12. A control method of an ultrasound observation apparatus which generates a B-mode image of inside a subject by scanning an ultrasound beam on a scanning plane in the subject, the control method comprising:

performing two-dimensional scanning of an ultrasound beam by changing a transmission/reception direction of the ultrasound beam in a first direction and in a second direction using an ultrasound probe portion;

controlling the transmission/reception direction of the ultrasound beam by the ultrasound probe portion using a transmission/reception control section;

generating the B-mode image based on a result of scanning of the ultrasound beam in the first direction using a B-mode image calculation section;

storing in a storage section a sample image determined according to a shape of a treatment instrument in a case where a central axis of the treatment instrument for performing a treatment on the subject and the scanning plane agree with each other;

calculating a correlation value between the B-mode image and the sample image using a correlation calculation section; and

moving the scanning plane in the second direction such that the correlation value becomes the maximum using the transmission/reception control section.

13. The control method of the ultrasound observation apparatus according to claim **12**, wherein,

when the maximum value of the correlation value is smaller than a predetermined threshold, the scanning plane is moved to a predetermined position in the second direction using the transmission/reception control section.

14. The control method of the ultrasound observation apparatus according to claim **12**, wherein the scanning plane is periodically moved such that the correlation value becomes the maximum using the transmission/reception control section.

15. The control method of the ultrasound observation apparatus according to claim **14**, wherein the scanning plane is periodically moved using the transmission/reception control section after the B-mode image is generated a predetermined number of times using the B-mode image calculation section and the correlation value is calculated using the correlation calculation section.

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摘要(译)

本发明的超声波观测装置包括：超声波探头部分，能够对超声波束进行二维扫描;发送/接收控制部分，用于通过超声波探头部分控制超声波束的发送/接收方向; B模式图像计算部分，用于基于超声波束的扫描结果在扫描平面上生成B模式图像;存储部分，用于存储在用于对对象和扫描平面进行处理的处理器具的中心轴彼此一致的情况下根据处理器具的形状确定的预定样本图像;和相关计算部分，用于计算B模式图像和样本图像之间的相关值，其中发送/接收控制部分移动扫描平面，使得相关值变为最大。