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(54) IMAGE DIAGNOSIS DEVICE AND PROBE

BILDDIAGNOSEVORRICHTUNG UND SONDE

DISPOSITIF ET SONDE DE DIAGNOSTIC PAR IMAGERIE

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(73) Proprietor: **Terumo Kabushiki Kaisha**
Tokyo 151-0072 (JP)

(72) Inventors:
- **INOUE, Koichi**
  Ashigarakami-gun
  Kanagawa 259-0151 (JP)
- **FURUICHI, Junya**
  Ashigarakami-gun
  Kanagawa 259-0151 (JP)

(74) Representative: **Casalonga**
Casalonga & Partners
Bayerstraße 71/73
80335 München (DE)

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- **MANABU KASHIWAGI ET AL.: '1. Kandomyaku Kyosaku Byohen no Marker [Hikari Kansho Dansoho(OCT), (Shinkin Ketsuryu Yobiryo Hi(FFR)]' THE LIPID vol. 21, no. 1, 2010, pages 58 - 64, XP008174725**

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Description

Technical Field

[0001] The present invention relates to an imaging apparatus for diagnosis and a probe.

Background Art

[0002] In the related art, an imaging apparatus for diagnosis has been widely used in order to perform diagnosis on arteriosclerosis, to perform preoperative diagnosis when endovascular therapy is performed by using a high-function catheter such as a balloon catheter or a stent, or to verify results after surgery.

[0003] The imaging apparatus for diagnosis includes an intravascular ultrasound (IVUS) device, an optical coherence tomography (OCT) device, and the like. The imaging apparatus for diagnosis is used so as to generate a tomographic image inside a blood vessel. In this manner, it is possible to perform anatomical diagnosis inside the blood vessel.

[0004] Meanwhile, in recent years, it has been discovered that a therapeutic outcome is improved by combinedly using a physiological technique (method for evaluating presence or absence of actual ischemia or a degree of the ischemia) in addition to the above-described anatomical technique, as an intravascular diagnosis technique.

[0005] However, in order to perform intravascular diagnosis by using the physiological technique, it is necessary to use load echocardiography, stress electrocardiography, or stress myocardial scintigraphy. In general, it is difficult to use these devices concurrently with the anatomical technique.

[0006] In particular, during an emergency, or in a case of percutaneous coronary intervention, it becomes more difficult to perform these procedures concurrently with the anatomical technique.

[0007] On the other hand, in recent years, as an evaluation parameter in the physiological technique, a myocardial fractional flow reserve (FFR) has been focused on.

[0008] The myocardial fractional flow reserve is an indicator which indicates that blood flow flowing in a situation where a stenotic lesion is absent when a coronary artery is dilated to the maximum (during maximum coronary artery dilation) becomes a hindrance to some degree for the stenotic lesion. The myocardial fractional flow reserve can be calculated by measuring pressure at a proximal stenosis site and a pressure at a distal stenosis site during the maximum coronary artery dilation.

[0009] Therefore, it is possible to perform the physiological technique by arranging a pressure sensor inside a probe unit and measuring the pressures (for example, refer to PTLs 1 to 4 and NPL 1, or alternatively to WO2011/090744, which shows a probe, sheath and a single deformation portion).

[0010] Furthermore, if the pressure sensor is arranged inside a probe unit of the imaging apparatus for diagnosis so as to be compatible with a transmitting and receiving unit for generating a tomographic image, it is considered that a combined use of the anatomical technique and the physiological technique can be realized.

Citation List

Patent Literature

[0011]

PTL 1: JP-T-2003-525067
PTL 2: JP-A-2007-296354
PTL 3: JP-T-2012-501807
PTL 4: JP-T-2012-502773

Non Patent Literature

[0012] NPL 1: Takashi Akasaka: "Application of a Pressure Guide Wire with Thermography in the Assessment of Coronary Stenotic Lesions", Medical and Biological Engineering 43(1): 24-31, 2005

Summary of Invention

Technical Problem

[0013] However, if a configuration is employed in which in addition to the transmitting and receiving unit for generating a tomographic image, the pressure sensor is further arranged at a distal end position inside the probe unit of the imaging

apparatus for diagnosis, there is a problem in that it is necessary not only to increase a diameter of the probe unit, but also to increase the cost.

[0014] For this reason, it is desirable to use the anatomical technique and the physiological technique in combination by employing a simpler configuration without using the pressure sensor.

[0015] The imaging apparatus for diagnosis disclosed here uses the anatomical technique and the physiological technique in combination by employing the simpler configuration in the imaging apparatus for diagnosis.

Solution to Problem

[0016] In order to achieve the above-described object, an imaging apparatus for diagnosis according to the present invention includes the following configuration.

[0017] That is, there is provided an imaging apparatus for diagnosis including a probe unit that has a sheath and a transmitting and receiving unit inserted into the sheath and transmitting and receiving a signal, in which the transmitting and receiving unit is controlled so as to transmit and receive the signal while rotating inside the sheath in a circumferential direction or while rotating in the circumferential direction and moving in an axial direction, and in which deformation portions whose cross-sectional shape is deformed in response to an external pressure are respectively disposed at different positions of the sheath in the axial direction, first calculation means for calculating multiple parameters which indicate a deformation degree of the respective deformation portions disposed at the different positions in the axial direction, by using a tomographic image including the deformation portions, and second calculation means for calculating a value corresponding to a myocardial fractional flow reserve, based on the multiple parameters.

Advantageous Effects of Invention

[0018] According to the present invention, in an imaging apparatus for diagnosis, it is possible to measure a myocardial fractional flow reserve without providing a pressure sensor.

[0019] Other features and advantages of the present invention will become apparent from the following description made with reference to the accompanying drawings.

[0020] Note that, in the accompanying drawings, the same reference numerals are given to the same or similar configuring elements.

Brief Description of Drawings

[0021] The accompanying drawings are included in the specification, configure a part of the specification, illustrate embodiments of the present invention, and are used so as to describe principles of the present invention together with the description.

[Fig. 1] Fig. 1 is a view illustrating an external configuration of an imaging apparatus for diagnosis 100 according to an embodiment of the present invention.
[Fig. 2] Fig. 2 is a view illustrating an overall configuration of a probe unit.
[Fig. 3] Fig. 3 is a view illustrating a detailed configuration of a distal end portion of a probe unit.
[Fig. 4] Fig. 4 is a flowchart illustrating calculation work flow of a myocardial fractional flow reserve.
[Fig. 5A] Fig. 5A is a flowchart illustrating calculation process flow of a parameter indicating a deformation degree of a measurement slit portion.
[Fig. 5B] Fig. 5B is a flowchart illustrating calculation process flow of a parameter indicating a deformation degree of a measurement slit portion.
[Fig. 6A] Fig. 6A is a view illustrating an example of a generated tomographic image.
[Fig. 6B] Fig. 6B is a view illustrating an example of an enlarged view of a generated tomographic image.
[Fig. 7] Fig. 7 is a view illustrating an example of a schematic view of a measurement slit portion which indicates a relationship with a pulse, and an enlarged view of a generated tomographic image.
[Fig. 8] Fig. 8 is a view for illustrating a myocardial fractional flow reserve.
[Fig. 9] Fig. 9 is a schematic view of a measurement slit portion.

Description of Embodiments

[0022] Hereinafter, each embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[0023] Note that, since the embodiments described below are preferred embodiments of the present invention, there are various limitations which are technically preferable. However, in the following description, unless otherwise described

to limit the present invention, the scope of the present invention is not limited to these embodiments.

[First Embodiment]

<1. Description of Myocardial Fractional Flow Reserve>

[0024] First, an overview of a myocardial fractional flow reserve (FFR) which is an evaluation parameter used in a physiological technique will be described with reference to Fig. 8 cited from NPL 1.

[0025] Fig. 8 is a schematic view for illustrating the myocardial fractional flow reserve (FFR).

[0026] As described above, the myocardial fractional flow reserve is an indicator which indicates that a blood flow flowing in a situation where stenotic lesion is absent during maximum coronary artery dilation becomes a hindrance to some degree for the stenotic lesion. 8a of Fig. 8 illustrates the blood flow flowing in a situation where the stenotic lesion is absent during the maximum coronary artery dilation (when an arteriole is dilated to the maximum by adding a drug thereto), and 8b of Fig. 8 illustrates the blood flow flowing in a situation where the stenotic lesion is present during the maximum coronary artery dilation.

[0027] In 8a of Fig. 8, Pa represents a pressure on an upstream side during the maximum coronary artery dilation, and Pv represents a coronary venous pressure.

[0028] Then, if resistance of a vascular system thereof is assumed to be R, the maximum blood flow Qn flowing in the situation where the stenotic lesion is absent is expressed by $Qn = (Pa - Pv) / R$.

[0029] In contrast, in 8b of Fig. 8, Pa represents a pressure at a proximal site of a stenotic lesion 801, and Pd represents a pressure (equal to Pa in 8a of Fig. 8) at a distal site of the stenotic lesion 801.

[0030] In addition, Pv represents the coronary venous pressure.

[0031] Then, if the resistance of the vascular system during the maximum coronary artery dilation is assumed to be R, the maximum blood flow Qs flowing in the situation where the stenotic lesion is present is expressed by $Qs = (Pd - Pv) / R$.

[0032] Therefore, Qs / Qn which represents the myocardial fractional flow reserve (FFR) is expressed by the following equation.

$$Qs / Qn = (Pd - Pv) / (Pa - Pv)$$

Here, since the relation is expressed by Pd » Pv and Pa » Pv during the maximum coronary artery dilation, the myocardial fractional flow reserve (FFR) can be expressed by $FFR \cong Pd / Pa$.

<2. Calculation of Myocardial Fractional Flow Reserve Using Imaging Apparatus for Diagnosis>

[0033] Next, Fig. 9 which illustrates a calculation method of the myocardial fractional flow reserve using the imaging apparatus for diagnosis is a view for illustrating the calculation method of the myocardial fractional flow reserve using OCT. The reference numeral 900 is a measurement slit portion (deformation portion) in which a predetermined surface 901 is deformed in response to an intravascular pressure.

[0034] As described above, it is necessary to measure the intravascular pressures (Pd and Pa) in order to calculate the myocardial fractional flow reserve. However, if a configuration is employed in which a dedicated pressure sensor is arranged inside the probe unit in order to measure the intravascular pressures, there is a problem in that it is necessary not only to increase a diameter of the probe unit, but also to increase the cost.

[0035] Therefore, the imaging apparatus for diagnosis according to the present embodiment employs a configuration in which the measurement slit portion 900 which is deformed in response to the intravascular pressure is arranged in the probe unit, and in which a deformation degree of the surface 901 in the measurement slit portion 900 is quantitatively calculated based on a tomographic image, thereby measuring intravascular pressure.

[0036] The calculation of the myocardial fractional flow reserve may be sufficiently obtained if a ratio of the intravascular pressures (Pd / Pa) is calculated. The reason is because there is no need to calculate absolute pressure.

[0037] As illustrated in 9a of Fig. 9, the measurement slit portion 900 has a rectangular parallelepiped shape, and only the surface 901 is formed of a member having rigidity lower than that of the other surface.

[0038] If the pressure is applied into the blood vessel, this configuration causes only the surface 901 to be deformed in a predetermined direction, and causes a cross-sectional shape of the measurement slit portion 900 to be deformed.

[0039] That is, with respect to the stenotic lesion, the measurement slit portions 900 are arranged so as to be respectively positioned on the axially distal side and the axially proximal side of the probe unit, and for example, a volume of the measurement slit portion 900 is calculated based on the tomographic image, as a parameter indicating a deformation degree in the respective measurement slit portions 900. According to this configuration, it is possible to calculate the

myocardial fractional flow reserve.

[0040] Specifically, the following relational equation is satisfied if it is assumed that a volume of one measurement slit portion (measurement slit portion located on the axially distal side of the probe unit with respect to the stenotic lesion, when being inserted into the blood vessel) under atmospheric pressure P_0 is V_{f0}, a volume of the other measurement slit portion (measurement slit portion located on the axially proximal side of the probe unit with respect to the stenotic lesion, when being inserted into the blood vessel) is V_{b0}, and further, a volume of the measurement slit portion on the axially distal side in a state of being actually inserted into the blood vessel is V_{f1}, a volume of the measurement slit portion on the axially proximal side in a state of being actually inserted into the blood vessel is V_{b1}, a pressure applied to the measurement slit portion on the axially distal side inside the blood vessel is P_f, and a pressure applied to the measurement slit portion on the axially proximal side inside the blood vessel is P_b.

$$P_f \times V_{f1} = P_0 \times V_{f0}$$

$$P_b \times V_{b1} = P_0 \times V_{b0}$$

[0041] Therefore, the myocardial fractional flow reserve (FFR) is expressed by the following.

$$FFR = P_b / P_f = \{(P_0 \times V_{b0}) / V_{b1}\} / \{(P_0 \times V_{f0}) / V_{f1}\} = (V_{b0} \times V_{f1}) / (V_{b1} \times V_{f0})$$

[0042] That is, it is possible to calculate the myocardial fractional flow reserve by using the tomographic image generated by the imaging apparatus for diagnosis and by respectively calculating the volume of the measurement slit portion on the axially distal side under the atmosphere and the volume inside the blood vessel, and the volume of the measurement slit portion on the axially proximal side under the atmosphere and the volume inside the blood vessel.

[0043] Note that, as apparent from the above description, the imaging apparatus for diagnosis according to the present embodiment calculates the myocardial fractional flow reserve by capturing a change in the pressure as the deformation degree in the measurement slit portion.

[0044] Therefore, if a parameter indicates the deformation degree in the measurement slit portion, the parameter is not limited to the above-described volume of the measurement slit portion. For example, an area S of a specific cross section (cross section at a position in which the surface 901 is deformed the most) of the measurement slit portion may be used as the parameter (refer to 9b of Fig. 9).

[0045] Alternatively, a distortion amount (L1/W) of the surface 901 in the specific cross section (cross section at a position in which the surface 901 is deformed the most) of the measurement slit portion, or a height (L2) from a bottom surface of the surface 901 may be used as the parameter (refer to 9b of Fig. 9).

<3. External Configuration of Imaging Apparatus for Diagnosis>

[0046] Next, an external configuration of the imaging apparatus for diagnosis according to the present embodiment which calculates the above-described myocardial fractional flow reserve will be described.

[0047] Fig. 1 is a view illustrating the external configuration of an imaging apparatus for diagnosis (here, to be described as OCT) 100 according to an embodiment of the present invention.

[0048] As illustrated in Fig. 1, the imaging apparatus for diagnosis 100 includes a probe unit (probe) 101, a scanner and pullback unit (motor drive unit) 102, and an operation control apparatus 103. The scanner and pullback unit 102 and the operation control apparatus 103 are connected to each other by a signal line 104.

[0049] The probe unit 101 is directly inserted into a body lumen such as the blood vessel, and continuously transmits transmitted measurement light toward biological tissues. An imaging core which includes a transmitting and receiving unit continuously receiving reflected light from the biological tissues in a distal end of the imaging core is internally inserted into a catheter sheath, thereby using the imaging core to measure a state of the biological tissues.

[0050] The scanner and pullback unit 102 is configured so that the probe unit 101 is detachably attached to it. A radial operation (operation in the axial direction and operation in the rotation direction inside the body lumen) of the imaging core internally inserted into the probe unit 101 is realized by driving a built-in motor.

[0051] In addition, the scanner and pullback unit 102 acquires the reflected light received by the transmitting and receiving unit, and transmits the acquired reflected light to the operation control apparatus 103 via the signal line 104.

[0052] When the measurement is performed, the operation control apparatus 103 includes a function for inputting various setting values and a function for displaying a measurement result as the tomographic image of the biological

tissues.

[0053] In the operation control apparatus 103, the reference numeral 111 represents a main body control unit. The main body control unit generates interference light data by causing the reflected light obtained by the measurement to interfere with reference light obtained by splitting the measurement light, and performs processing on line data (data of a line in a radiating direction in the tomographic image) generated based on the interference light data, thereby constructing multiple tomographic images inside the body lumen in the axial direction.

[0054] In addition, the myocardial fractional flow reserve is calculated based on the constructed tomographic images.

[0055] The main body control unit 111 has a function of extraction means (to be described later) for performing extraction work of the image and calculation means (first calculation means, second calculation means, and third calculation means) for performing calculation work of the parameter.

[0056] The reference numeral 111-1 represents a printer & DVD recorder, which prints a processing result in the main body control unit 111 or stores the processing result as data.

[0057] The reference numeral 112 represents an operation panel. A user inputs various setting values and instructions via the operation panel 112.

[0058] The reference numeral 113 represents an LCD monitor serving as a display apparatus. The LCD monitor displays the multiple tomographic images of the biological tissues which are constructed in the main body control unit 111.

<4. Configuration of Probe Unit>

[0059] Next, a configuration of the probe unit 101 will be described with reference to Fig. 2.

[0060] As illustrated in Fig. 2, the probe unit 101 is configured to have an elongated catheter sheath 201 to be inserted into the body lumen such as the blood vessel, and a connector 202 which is not inserted into the body lumen such as the blood vessel and is arranged on a user's hand-side for the user's operation.

[0061] A tube for a guidewire lumen 203 which configures a guide wire lumen is disposed in a distal end of the catheter sheath 201.

[0062] The catheter sheath 201 forms a lumen which is continuous from a connection portion with the tube for the guidewire lumen 203 to a connection portion with the connector 202.

[0063] The lumen of the catheter sheath 201 internally includes an optical transmitting and receiving unit 221 for transmitting and receiving light and an optical fiber cable. An imaging core 220 including a coil-shaped drive shaft 222 which transmits a rotational drive force for rotating both of these is inserted into the catheter sheath 201 over substantially the entire length.

[0064] The connector 202 includes a sheath connector 202a configured to be integrated with the proximal end of the catheter sheath 201 and a drive shaft connector 202b configured to rotatably fix the drive shaft 222, in the proximal end of the drive shaft 222.

[0065] An anti-kink protector 211 is disposed in a boundary portion between the sheath connector 202a and the catheter sheath 201.

[0066] This maintains predetermined rigidity. Accordingly, it is possible to prevent bending (kinking) which may occur due to an abrupt change in physical properties.

[0067] The scanner and pullback unit 102 is detachably attached to the proximal end of the drive shaft connector 202b.

<5. Detailed Configuration of Distal End Portion of Probe Unit>

[0068] Next, a detailed configuration of a distal end portion (refer to 230 in Fig. 2) of the probe unit 101 will be described with reference to Fig. 3.

[0069] Fig. 3 is a view illustrating the detailed configuration of the distal end portion of the probe unit 101. Respectively, 3a of Fig. 3 illustrates a cross-sectional view when the distal end portion of the probe unit 101 is viewed from the side surface, and 3b of Fig. 3 illustrates a cross-sectional view at a first position and a second position in 3a of Fig. 3 when the distal end portion of the probe unit 101 is viewed from the distal side (note that, in 3b of Fig. 3, the imaging core 220 is omitted for convenience of description).

[0070] As illustrated in 3a of Fig. 3, a sideways radiation-type ball lens (optical transmitting and receiving unit) 221 is arranged inside a housing 223. An optical fiber cable 301 configured to have a cladding portion and a core portion is arranged inside the drive shaft 222.

[0071] Note that light transmitted from the optical transmitting and receiving unit 221 is radiated to the biological tissues inside the body lumen through the catheter sheath 201.

[0072] In addition, multiple measurement slit portions (311 to 314 and 321 to 324) are disposed in the catheter sheath 201.

[0073] The measurement slit portions (311 to 314 and 321 to 324) are configured to have multiple grooves disposed on an outer surface of the sheath 201, and to have a uniform width parallel to the circumferential direction of the probe

unit 101 and a predetermined length parallel to the axial direction. The measurement slit portions (311 to 314 and 321 to 324) are disposed at a first position in the axial direction and a second position which is apart from the first position by a predetermined distance D.

[0074] All the respective measurement slit portions have the same width, length, and arrangement angle.

[0075] Furthermore, an outer circumferential surface of the catheter sheath 201 is covered with a flexible sheet (cover) 330 which is deformed in response to a pressure change in the external environment.

[0076] The measurement slit portions are disposed at the first position and the second position in the axial direction as described above, so as to capture deformation of the sheet 330 in the measurement slit portion located on the axially distal side of the probe unit 101 and deformation of the sheet 330 in the measurement slit portion located on the axially proximal side, with respect to the stenotic lesion.

[0077] That is, the probe unit 101 is arranged inside the blood vessel so that the stenotic lesion is located between the first position and the second position. In this manner, it is possible to capture the deformation of the sheet 330 which is caused by the blood pressure on further the distal side than the stenotic lesion, and the deformation of the sheet 330 which is caused by the blood pressure further on the proximal side than the stenotic lesion.

[0078] Note that, as illustrated in 3b of Fig. 3, in the present embodiment, four measurement slit portions (311 to 314 and 321 to 324) are respectively disposed at the first position and the second position in the circumferential direction of the catheter sheath 201.

[0079] The multiple measurement slit portions are configured to be respectively disposed at the first position and the second position in the circumferential direction in this manner, so as to more accurately calculate the myocardial fractional flow reserve (FFR) by respectively analyzing a deformation degree of the sheet 330 in the multiple measurement slit portions.

<6. Flow of Calculation Work for Myocardial Fractional Flow Reserve>

[0080] Next, flow of calculation work for the myocardial fractional flow reserve which uses the imaging apparatus for diagnosis 100 will be described with reference to Fig. 4.

[0081] Fig. 4 is a flowchart illustrating the flow of calculation work for the myocardial fractional flow reserve.

[0082] As illustrated in Fig. 4, in Step S401, under atmospheric pressure (that is, in a state before the probe unit 101 is inserted into the blood vessel of a subject), parameters (V_{b0}, V_{f0}) indicating the deformation degree of the sheet 330 in the respective measurement slit portions at the first and second positions are calculated.

[0083] Specifically, in a range including the first and second positions, the measurement is performed while the imaging core 220 is caused to perform a radial operation. In this manner, the parameters indicating the deformation degree of the sheet 330 in the respective measurement slit portions are measured.

[0084] Note that, details of a calculation process for the parameters indicating the deformation degree in the measurement slit portions will be described later with reference to Figs. 5A, 5B, 6A, and 6B.

[0085] In Step S402, the probe unit 101 is inserted into the blood vessel of the subject.

[0086] Furthermore, in Step S403, in the blood vessel of the subject, the measurement slit portion at the first position is arranged to be located on the axially distal side of the probe unit 101 with respect to the stenotic lesion to be diagnosed, and the measurement slit portion at the second position is arranged to be located on the axially proximal side of the probe unit 101 with respect to the stenotic lesion to be diagnosed.

[0087] In order to facilitate this work, an X-ray contrast marker (X-ray opaque portion) for visually checking the first position and the second position during an X-ray contrast inspection may be disposed in the sheath 201.

[0088] Thereafter, the parameters indicating the deformation degree of the sheet 330 in the respective measurement slit portions at the first position and the second position are calculated.

[0089] Specifically, in a range including the first and second positions, parameters (V_{f1}, V_{b1}) indicating the deformation degree of the sheet 330 in the respective measurement slit portions are measured by causing the imaging core 220 to perform the radial operation.

[0090] Note that, a calculation method for the parameters indicating the deformation degree in the measurement slit portions will be described later with reference to Figs. 5A, 5B, 6A, and 6B.

[0091] In Step S404, the myocardial fractional flow reserve is calculated by using the parameters indicating the deformation degree in the respective measurement slit portions which are calculated in Step S401 and Step S403, and then is displayed on the LCD monitor 113.

<7. Parameter Calculation Process>

[0092] Next, details of a process for calculating the parameters (hereinafter, referred to as a parameter calculation process) indicating the deformation degree of the sheet 330 in the measurement slit portion, which is illustrated in Steps S401 and S403 in Fig. 4, will be described with reference to Figs. 5A, 5B, 6A, and 6B.

[0093] Figs. 5A and 5B are flowcharts illustrating flow of parameter calculation processes (three types of process), and Figs. 6A and 6B are views illustrating an example of a tomographic image generated during the parameter calculation processes and enlarged views thereof.

<7.1 Case of Parameter Calculation Process (1)>

[0094] As illustrated in 5a of Fig. 5A, in Step S501, the imaging apparatus for diagnosis 100 starts to transmit and receive light, starts the radial operation, and starts to generate the tomographic image of the catheter sheath 201.

[0095] If scanning of the first position and the second position is completed by the radial operation, in Step S502, the light transmitting and the light receiving are completed, and the radial operation is completed.

[0096] Fig. 6A illustrates an example of the tomographic image generated by performing the measurement in Steps S501 and S502.

[0097] As illustrated in Fig. 6A, the tomographic image of the catheter sheath 201 which is captured immediately after the measurement is started does not include the measurement slit portion (refer to 601). However, if the catheter sheath 201 reaches the measurement slit portion at the first position, the measurement slit portion appears on the tomographic image of the catheter sheath 201 (refer to 602).

[0098] If the measurement progresses further, the measurement slit portion is no longer included again (refer to 603). If the catheter sheath 201 reaches the measurement slit portion at the second position, the measurement slit portion appears again (refer to 604).

[0099] If the radial operation is performed so that the measurement slit portions at the first position and the second position as described above are included, the tomographic image including the measurement slit portion and the tomographic image without including the measurement slit portion are mixed with each other.

[0100] Therefore, in Step S503, extraction means (main body control unit 111) extracts only the tomographic image including the measurement slit portion.

[0101] Furthermore, in Step S504, the tomographic image extracted in Step S503 is classified into a tomographic image (602) including the measurement slit portion at the first position and a tomographic image (604) including the measurement slit portion at the second position.

[0102] Furthermore, first calculation means (main body control unit 111) calculates respective volumes for the measurement slit portions at the first position (in the present embodiment, the measurement slit portions 311 to 314) and the measurement slit portions at the second position (in the present embodiment, the measurement slit portions 321 to 324).

[0103] Fig. 6B illustrates an example of enlarged views of the tomographic image extracted in Step S503.

[0104] As illustrated in Fig. 6B, cross-sectional areas S1 to S7 of the measurement slit portions included in respective tomographic images 611 to 617 are calculated, and these are integrated in the axial direction of the probe unit 101. In this manner, it is possible to calculate the volume of the measurement slit portion.

[0105] In Step S504, volumes V11 to V14 are calculated with regard to the respective measurement slit portions 311 to 314 at the first position, and volumes V21 to V24 are calculated with regard to the respective measurement slit portions 321 to 324 at the second position.

[0106] In Step S505, from among the volumes V11 to V14 of the measurement slit portions 311 to 314 at the first position, the maximum value and the minimum value are excluded without being employed, and an average value of the volumes is calculated by employing the remaining two volumes (that is, the average value is calculated by employing only the volumes of partial measurement slit portions).

[0107] Similarly, from among the volumes V21 to V24 of the measurement slit portions 321 to 324 at the second position, the maximum value and the minimum value are excluded without being employed, and an average value of the volumes is calculated by employing the remaining two volumes.

[0108] These processes are performed in Steps S401 and S403. In this manner, it is possible to calculate parameters (V_{b0}, V_{f1}, V_{b1}, and V_{f0}) illustrating the deformation degrees in the measurement slit portions which are required for second calculation means (main body control unit 111) to calculate the myocardial fractional flow reserve (FFR).

[0109] <7.2 Case of Parameter Calculation Process (2)>

[0110] Next, a parameter calculation process illustrated in 5b of Fig. 5A will be described.

[0111] Note that, processes from Steps S511 to S513 in 5b of Fig. 5A are the same as processes from Steps S501 to S503 in 5a of Fig. 5A. Therefore, description thereof will be omitted herein.

[0112] In Step S514, the tomographic image extracted in Step S513 is classified into a tomographic image (602) including the measurement slit portion at the first position and a tomographic image (604) including the measurement slit portion at the second position.

[0113] Furthermore, heights (L2) of the sheet 330 respectively are calculated with regard to the measurement slit portions at the first position (in the present embodiment, the measurement slit portions 311 to 314) and the measurement slit portions at the second position (in the present embodiment, the measurement slit portions 321 to 324).

[0114] Fig. 6B illustrates an example of enlarged views of the tomographic image extracted in Step S513.

[0115] As illustrated in Fig. 6B, heights L21 to L27 of the sheets 330 are calculated with regard to the respective measurement slit portions included in the respective tomographic images 611 to 617.

[0116] Then, the tomographic image in which the height of the sheet 330 is the lowest (L24) is selected from the respective tomographic images 611 to 617.

[0117] In this manner, the tomographic image in which the height of the sheet 330 is the lowest (normally, a tomographic image at an axially center position of the measurement slit portions) for the respective measurement slit portions can be selected.

[0118] These processes are performed in the measurement slit portions 311 to 314 at the first position. In this manner, four tomographic images are selected from the first position.

[0119] Similarly, four tomographic images are also selected from the measurement slit portions 321 to 324 at the second position.

[0120] In Step S515, with regard to the measurement slit portions 311 to 314 at the first position, the maximum value and the minimum value are excluded from the height (L24) of the sheet 330 in the four tomographic images selected in Step S514, and the average value with regard to the height (L24) of the remaining two sheets 330 is calculated.

[0121] Similarly, with regard to the measurement slit portions 321 to 324 at the second position, the maximum value and the minimum value from among the height (L24) of the sheet 330 in the four tomographic images selected in Step S514 are excluded, and the average value with regard to the height (L24) of the remaining two sheets 330 is calculated.

[0122] These processes are performed in Steps S401 and S403. In this manner, it is possible to calculate parameters ($L24_{b0}$, $L24_{f1}$, $L24_{b1}$, and $L24_{f0}$) illustrating the deformation degrees in the measurement slit portions which are required for calculating the myocardial fractional flow reserve (FFR).

[0123] Note that, herein, a configuration for obtaining the height (L24) from a bottom surface of the measurement slit portion to the sheet 330 is adopted. However, the present invention is not limited thereto, and the same process may be performed for a cross-sectional area (S4) or a distortion amount of the sheet 330 (L14/W).

<7.3 Case of Parameter Calculation Process (3)>

[0124] Next, a parameter calculation process illustrated in Fig. 5B will be described.

[0125] Note that, processes from Steps S521 to S522 in Fig. 5B are the same as processes from Steps S501 to S502 in 5a of Fig. 5A. Therefore, description thereof will be omitted herein.

[0126] In Step S523, based on the tomographic image generated in Steps S521 and S522, third calculation means (main body control unit 111) calculates the axially center position of the measurement slit portions at the first position.

[0127] Similarly, the third calculation means calculates the axially center position of the measurement slit portions at the second position.

[0128] In Step S524, the imaging core 220 is moved so that the optical transmitting and receiving unit 221 is located at the axially center position of the measurement slit portions at the second position which is calculated in Step S523.

[0129] In Step S525, the light transmitting and the light receiving are started at the axially center position of the measurement slit portions at the second position, a rotary operation is started, and the tomographic image of the catheter sheath 201 at the position is generated.

[0130] This can generate the tomographic image corresponding to the tomographic image 614 in Fig. 6B.

[0131] If the generation of the tomographic image is completed, the light transmitting and the light receiving are completed, and the rotary operation is completed.

[0132] In Step S526, the imaging core 220 is moved so that the optical transmitting and receiving unit 221 is located at the axially center position of the measurement slit portions at the first position which is calculated in Step S523.

[0133] In Step S527, the light transmitting and the light receiving are started at the axially center position of the measurement slit portions at the first position, the rotary operation is started, and the tomographic image of the catheter sheath 201 at the position is generated.

[0134] This can generate the tomographic image corresponding to the tomographic image 614 in Fig. 6B.

[0135] If the generation of the tomographic image is completed, the light transmitting and the light receiving are completed, and the rotary operation is completed.

[0136] In Step S528, with regards to the respective measurement slit portions 321 to 324 which are included in the tomographic image generated in Step S525, the heights L2 of the sheets 330 are calculated.

[0137] Furthermore, the maximum value and the minimum value are excluded from the calculated heights of the sheets 330, and the average value is calculated with regard to the heights L2 of the remaining two sheets 330.

[0138] Similarly, with regard to the respective measurement slit portions 311 to 314 included in the tomographic image generated in Step S527, the heights L2 of the sheets 330 are calculated.

[0139] Furthermore, the maximum value and the minimum value are excluded from the calculated heights L2 of the sheets 330, and the average value is calculated with regard to the heights L2 of the remaining two sheets 330.

[0140] These processes are performed in Steps S401 and S403. In this manner, it is possible to calculate parameters

($L2_{b0}$, $L2_{f1}$, $L2_{b1}$, and $L2_{f0}$) illustrating the deformation degrees in the measurement slit portions which are required for calculating the myocardial fractional flow reserve (FFR).

[0141] Note that, herein, a configuration for obtaining the height (L2) from the bottom surface of the measurement slit portion to the sheet 330 is adopted. However, the present invention is not limited thereto, and the same process may be performed for a cross-sectional area (S) or a distortion amount of the sheet 330 (L1/W).

[0142] As is apparent from the above description, the imaging apparatus for diagnosis according to the present embodiment adopts a configuration in which the multiple measurement slit portions are disposed at the first position and the second position in the axial direction of the probe unit 101 and the sheet 330 is further arranged on the outer peripheral surface of the catheter sheath 201 so as to cover the measurement slit portions.

[0143] In this manner, it becomes possible to capture the pressure applied to the probe unit 101 as the deformation of the sheet 330 in the measurement slit portions.

[0144] In addition, the generated tomographic image allows the deformation to be analyzed. Accordingly, it becomes possible to calculate the parameters required for calculating the myocardial fractional flow reserve.

[0145] As described above, a configuration is adopted so as to calculate the pressure applied to the probe unit 101 without arranging a pressure sensor. In this manner, as compared to a case of arranging the pressure sensor inside the probe unit, it is possible to decrease the diameter of the probe unit and to reduce the cost.

[Second Embodiment]

[0146] In the above-described first embodiment, when capturing the deformation of the sheet in the measurement slit portions, an influence of a pulse is not particularly considered. However, without being limited thereto, the present invention may be configured to consider the timing of the pulse.

[0147] In general, when a myocardial fractional flow reserve is calculated, it is desirable to use the parameter acquired in a state where the pressure inside a blood vessel is maximized by the pulse.

[0148] Therefore, the present embodiment adopts a configuration in which the parameter is extracted by a tomographic image at the timing when the pressure inside the blood vessel is maximized by the pulse.

[0149] Hereinafter, referring to Fig. 7, details of the present embodiment will be described.

[0150] Fig. 7 is a view schematically illustrating a relationship between the pulse and the deformation of the measurement slit portions.

[0151] 7a of Fig. 7 illustrates a time series change in the pressure inside the blood vessel when it is assumed that a horizontal axis represents a time period and a vertical axis represents the pressure inside the blood vessel.

[0152] As illustrated in 7a of Fig. 7, the pressure inside the blood vessel is significantly changed by the pulse.

[0153] 7b of Fig. 7 schematically illustrates the deformation of a sheet 330 in measurement slit portions 311 to 314 and 321 to 324.

[0154] As illustrated in 7b of Fig. 7, in a case where the pressure inside the blood vessel is increased by the pulse, the sheet 330 in the measurement slit portion varies to a greater deformation degree, as compared to a state before the pressure inside the blood vessel is increased or a state after the pressure inside the blood vessel is decreased.

[0155] Therefore, the tomographic images at the respective timings are as illustrated in 7c of Fig. 7 (701 to 703).

[0156] That is, the influence of the pulse causes the deformation degree of the sheet 330 in the measurement slit portions to greatly vary. Therefore, in Step S525 in Fig. 5B, the imaging apparatus for diagnosis according to the present embodiment performs measurement during a predetermined time period including at least a single pulse.

[0157] Similarly, in Step S527 of Fig. 5B, the measurement is performed during the predetermined time period (normally, one second or longer) including at least the single pulse.

[0158] Furthermore, in Step S528, with regard to the respective measurement slit portions 321 to 324 included in the multiple tomographic images generated in Step S525, the heights (L2) of the sheets 330 are calculated. The tomographic image in which the height of the sheets 330 is minimized (tomographic image corresponding to 702 of 7c in Fig. 7) is extracted for each measurement slit portion.

[0159] In this manner, the height (L2) of the sheet 330 at the timing when the pressure inside the blood vessel is maximized by the pulse can be calculated for each measurement slit portion.

[0160] Then, the maximum value and the minimum value are excluded from the calculated heights (L2) of the sheets 330 with regard to the four measurement slit portions, and the average value is calculated with regard to the heights (L2) of the remaining two sheets 330.

[0161] Similarly, with regard to the respective measurement slit portions 311 to 314 included in the multiple tomographic images generated in Step S527, the heights (L2) of the sheets 330 are calculated. The tomographic image in which the height (L2) of the sheets 330 is minimized (tomographic image corresponding to 702 of 7c in Fig. 7) is extracted for each measurement slit portion.

[0162] In this manner, the height (L2) of the sheet 330 at the timing when the pressure inside the blood vessel is maximized by the pulse can be calculated for each measurement slit portion.

[0163] Then, the maximum value and the minimum value are excluded from the calculated heights (L2) of the sheets 330 with regard to the four measurement slit portions, and the average value is calculated with regard to the heights (L2) of the remaining two sheets 330.

[0164] As is apparent from the above-description, the imaging apparatus for diagnosis according to the present embodiment can calculate the myocardial fractional flow reserve by using the parameter acquired in a state where the pressure inside the blood vessel is maximized by the pulse.

[0165] Note that, herein, a configuration for obtaining the height (L2) from the bottom surface of the measurement slit portion to the sheet 330 is adopted. However, the present invention is not limited thereto, and the same process may be performed for a cross-sectional area (S) or a distortion amount of the sheet 330 (L1/W).

[Third Embodiment]

[0166] In the above-described first embodiment, the measurement slit portion is formed by cutting out the catheter sheath 201, but the present invention is not limited thereto.

[0167] A configuration may be adopted in which a member having a shape which can form a gap corresponding to the measurement slit portion adheres to the outer periphery of a catheter sheath 201 and is covered with a sheet 330 thereon.

[0168] Note that, in this case, it is desirable to use a member having rigidity higher than that of the sheet 330 as the member adhering to the outer periphery of the catheter sheath 201.

[Fourth Embodiment]

[0169] In the above-described first embodiment, four measurement slit portions are configured to be respectively disposed at the first position and the second position. However, without being limited thereto, the present invention may employ four or more measurement slit portions.

[0170] In addition, the above-described first embodiment adopts the configuration in which the average value is calculated after the maximum value and the minimum value are excluded from the parameters indicating the deformation degree of the measurement slit portions, which are respectively calculated at the first position and the second position. However, the present invention is not limited thereto.

[0171] As long as a method is employed in order to increase reliability of the calculated parameter, the parameter may be calculated by any other method.

[0172] In addition, in the above-described first embodiment, the measurement slit portions are configured to be disposed at two locations of the first position and the second position. Without being limited thereto, the present invention may adopt a configuration in which the measurement slit portions are disposed at three or more positions in the axial direction.

[0173] In addition, in the above-described first embodiment, the case of using the OCT as the imaging apparatus for diagnosis has been described. However, without being limited thereto, the present invention may adopt a configuration of using IVUS to perform the above-described processes.

[Another Embodiment]

[0174] The present invention is not limited to the above-described embodiments, and can be changed and modified in various ways without departing from the scope of the present invention.

[0175] Therefore, in order to officially announce the scope of the present invention, claims are appended as follows.

Claims

1. An imaging apparatus for diagnosis comprising:

a probe unit that has a sheath and a transmitting and receiving unit inserted into the sheath and transmitting and receiving a signal, in which the transmitting and receiving unit is controlled so as to transmit and receive the signal while rotating inside the sheath in a circumferential direction or while rotating in the circumferential direction and moving in an axial direction, **characterised in that** the probe further comprises a plurality of deformation portions (900) whose respective cross-sectional shape is deformable in response to an external pressure, said deformation portions are respectively disposed at different positions of the sheath in the axial direction;

first calculation means for calculating at least one parameter at each deformation portion which indicates a deformation degree of the respective deformation portions disposed at the different positions in the axial direction,

by using a tomographic image including the deformation portions; and
second calculation means for calculating a value corresponding to a myocardial fractional flow reserve, based on the parameter.

2. The imaging apparatus for diagnosis according to Claim 1, wherein each deformation portion has a rectangular parallelepiped shape having a predetermined length in the axial direction, and has one surface forming a circumferential surface of the probe unit within the respective deformation portion and said one surface is configured to have a member having rigidity lower than that of the other surfaces of the respective deformation portion.

3. The imaging apparatus for diagnosis according to Claim 2,
wherein the first calculation means is adapted to calculate as the at least one parameter indicating the deformation degree of the respective deformation portions one of the following: a volume of the deformation portion, an area at a predetermined position of the deformation portion in the axial direction, a height of the surface forming the circumferential surface at the predetermined position of the deformation portion in the axial direction, or a distortion amount of the surface forming the circumferential surface at the predetermined position of the deformation portion in the axial direction.

4. The imaging apparatus for diagnosis according to any one of Claims 1 to 3,
wherein the second calculation means calculates a value corresponding to the myocardial fractional flow reserve by using $(X_{b0} \times X_{f1}) / (X_{b1} \times X_{f0})$, when it is assumed that a parameter under atmospheric pressure P_0 is X_{f0} and a parameter inside a body lumen is X_{f1} which are calculated with regard to a deformation portion disposed at a first position from among the deformation portions disposed at the different positions in the axial direction, and that the parameter under the atmospheric pressure P_0 is X_{b0} and the parameter inside the body lumen is X_{b1} which are calculated with regard to a deformation portion disposed at a second position, from among the deformation portions disposed at the different positions in the axial direction.

5. The imaging apparatus for diagnosis according to Claim 1, further comprising:

extraction means for extracting a tomographic image which includes the respective deformation portion; and
third calculation means for calculating respective center positions in the axial direction of the deformation portions disposed at the different positions in the axial direction, based on the tomographic image extracted by the extraction means,
wherein the first calculation means calculates the parameter by using the tomographic image generated by rotating the transmitting and receiving unit in the circumferential direction, in a state where the transmitting and receiving unit is moved to the respective center positions in the axial direction which are calculated by the third calculation means.

6. The imaging apparatus for diagnosis according to Claim 5,
wherein the first calculation means calculates the parameter by using the tomographic image in which a deformation degree of the deformation portion is the greatest, from among the multiple tomographic images generated by rotating the transmitting and receiving unit in the circumferential direction for a predetermined time period.

7. The imaging apparatus for diagnosis according to Claim 1,
wherein the deformation portions are respectively disposed at a first position in the sheath and at a second position on a further proximal side in the axial direction from the first position, and the multiple deformation portions are disposed at the respective first position and second position in the circumferential direction.

8. The imaging apparatus for diagnosis according to Claim 7,
wherein the first calculation means employs a parameter indicating a deformation degree of partial deformation portions within the multiple deformation portions disposed in the circumferential direction, and calculates the parameter used in the second calculation means without employing a parameter indicating a deformation degree of the other part deformation portion.

9. A probe in which a transmitting and receiving unit configured to transmit and receive a signal is internally inserted into a sheath of the probe, the probe being configured to transmit the signal to an imaging apparatus for diagnosis generating a tomographic image by using the signal acquired while the transmitting and receiving unit is rotated inside the sheath in a circumferential direction, or while the transmitting and receiving unit is rotated in the circumferential direction and is moved in an axial direction, the probe **characterised by** further comprising:

a plurality of deformation portions whose respective cross-sectional shape is deformable in response to a pressure applied to the probe, at different positions in the axial direction,
wherein each deformation portion has a rectangular parallelepiped shape having a predetermined length in the axial direction, and has one surface forming a circumferential surface of the probe within the respective deformation portion, said one surface being configured to have a member having rigidity lower than that of the other surfaces of the deformation portion.

10. The probe according to Claim 9,
wherein the deformation portions are disposed at a first position in the sheath and at a second position on a further proximal side in the axial direction from the first position, and the multiple deformation portions are disposed at the respective first position and second position in the circumferential direction.

Patentansprüche

1. Bildgebungsvorrichtung zur Diagnose, die Folgendes umfasst:

eine Sondeneinheit, die eine Hülle und eine Sende- und Empfangseinheit, die in die Hülle eingefügt ist und ein Signal sendet und empfängt, hat, wobei die Sende- und Empfangseinheit so gesteuert wird, dass die das Signal sendet und empfängt, während sie sich innerhalb der Hülle in einer Umfangsrichtung dreht oder während sie sich in einer Umfangsrichtung dreht und sich in einer axialen Richtung bewegt, **dadurch gekennzeichnet, dass** die Sonde ferner mehrere Verformungsabschnitte (900) umfasst, deren jeweilige Querschnittsform als Reaktion auf einen äußeren Druck verformbar ist, wobei die Verformungsabschnitte jeweils an unterschiedlichen Positionen der Hülle in der axialen Richtung angeordnet sind,
erste Berechnungsmittel zum Berechnen wenigstens eines Parameters an jedem Verformungsabschnitt, der einen Verformungsgrad der jeweiligen Verformungsabschnitte, die an den unterschiedlichen Positionen in der axialen Richtung angeordnet sind, anzeigt, durch die Verwendung eines tomographischen Bildes, das die Verformungsabschnitte einschließt, und
zweite Berechnungsmittel zum Berechnen eines Wertes, der einer myokardialen fraktionellen Flussreserve entspricht, auf der Grundlage des Parameters.

2. Bildgebungsvorrichtung zur Diagnose nach Anspruch 1, wobei jeder Verformungsabschnitt eine rechteckige Parallelepipedform hat, die eine vorbestimmte Länge in der axialen Richtung hat, und eine Fläche hat, die eine Umfangsfläche der Sondeneinheit innerhalb des jeweiligen Verformungsabschnitts bildet, und die eine Fläche so konfiguriert ist, dass sie ein Element hat, das eine Steifigkeit hat, die niedriger ist als diejenige der anderen Flächen des jeweiligen Verformungsabschnitts.

3. Bildgebungsvorrichtung zur Diagnose nach Anspruch 2,
wobei die ersten Berechnungsmittel dafür eingerichtet sind, als den wenigstens einen Parameter, der den Verformungsgrad der jeweiligen Verformungsabschnitte anzeigt, eines der Folgenden zu berechnen:

ein Volumen des Verformungsabschnitts, einen Flächeninhalt an einer vorbestimmten Position des Verformungsabschnitts in der axialen Richtung, eine Höhe der Fläche, welche die Umfangsfläche bildet, an der vorbestimmten Position des Verformungsabschnitts in der axialen Richtung oder ein Verwindungsausmaß der Fläche, welche die Umfangsfläche bildet, an der vorbestimmten Position des Verformungsabschnitts in der axialen Richtung.

4. Bildgebungsvorrichtung zur Diagnose nach einem der Ansprüche 1 bis 3,
wobei die zweiten Berechnungsmittel einen Wert, der einer myokardialen fraktionellen Flussreserve entspricht, durch die Verwendung von $(X_{b0} \times X_{f1}) / (X_{b1} \times X_{f0})$ berechnen, wenn angenommen wird, dass ein Parameter unter atmosphärischem Druck P_0 X_{f0} ist und ein Parameter innerhalb eines Körperlumens X_{f1} ist, die in Bezug auf einen Verformungsabschnitt berechnet werden, der an einer ersten Position unter den Verformungsabschnitten angeordnet ist, die an den unterschiedlichen Positionen in der axialen Richtung angeordnet sind, und dass der Parameter unter dem atmosphärischen Druck P_0 X_{b0} ist und der Parameter innerhalb des Körperlumens X_{b1} ist, die in Bezug auf einen Verformungsabschnitt berechnet werden, der an einer zweiten Position unter den Verformungsabschnitten angeordnet ist, die an den unterschiedlichen Positionen in der axialen Richtung angeordnet sind.

5. Bildgebungsvorrichtung zur Diagnose nach Anspruch 1, die ferner Folgendes umfasst:

Extraktionsmittel zum Extrahieren eines tomographischen Bildes, das den jeweiligen Verformungsabschnitt einschließt, und
dritte Berechnungsmittel zum Berechnen jeweiliger Mittelpositionen in der axialen Richtung der Verformungsabschnitte, die an den unterschiedlichen Positionen in der axialen Richtung angeordnet sind, auf der Grundlage des durch die Extraktionsmittel extrahierten tomographischen Bildes,
wobei die ersten Berechnungsmittel den Parameter berechnen durch die Verwendung des durch das Drehen der Sende- und Empfangseinheit in der Umfangsrichtung erzeugten tomographischen Bildes in einem Zustand, in dem die Sende- und Empfangseinheit zu den jeweiligen Mittelpositionen in der axialen Richtung bewegt wird, die durch die dritten Berechnungsmittel berechnet werden.

6. Bildgebungsvorrichtung zur Diagnose nach Anspruch 5, wobei die ersten Berechnungsmittel den Parameter berechnen durch die Verwendung des tomographischen Bildes, in dem ein Verformungsgrad des Verformungsabschnitts am größten ist, unter den mehreren tomographischen Bildern, die durch das Drehen der Sende- und Empfangseinheit in der Umfangsrichtung erzeugt werden, für einen vorbestimmten Zeitraum.

7. Bildgebungsvorrichtung zur Diagnose nach Anspruch 1,
wobei die Verformungsabschnitte jeweils an einer ersten Position in der Hülle und an einer zweiten Position auf einer von der ersten Position weiter proximalen Seite in der axialen Richtung angeordnet sind und die mehreren Verformungsabschnitte an der jeweiligen ersten Position und zweiten Position in der Umfangsrichtung angeordnet sind.

8. Bildgebungsvorrichtung zur Diagnose nach Anspruch 7,
wobei die ersten Berechnungsmittel einen Parameter einsetzen, der einen Verformungsgrad teilweiser Verformungsabschnitte innerhalb der Verformungsabschnitte, die in der Umfangsrichtung angeordnet sind, anzeigt, und den Parameter, der in den zweiten Berechnungsmitteln verwendet wird, berechnet, ohne einen Parameter einzusetzen, der einen Verformungsgrad des anderen Teil-Verformungsabschnitts anzeigt.

9. Sonde, in der eine Sende- und Empfangseinheit, die dafür konfiguriert ist, ein Signal zu senden und zu empfangen, innen in eine Hülle der Sonde eingefügt ist, wobei die Sonde dafür konfiguriert ist, das Signal an eine Bildgebungsvorrichtung zur Diagnose zu senden, die ein tomographisches Bild erzeugt durch die Verwendung des Signals, das erfasst wird, während die Sende- und Empfangseinheit innerhalb der Hülle in einer Umfangsrichtung gedreht wird oder während die Sende- und Empfangseinheit in der Umfangsrichtung gedreht wird und in einer axialen Richtung bewegt wird, wobei die Sonde **dadurch gekennzeichnet ist, dass** sie ferner Folgendes umfasst:

mehrere Verformungsabschnitte, deren jeweilige Querschnittsform als Reaktion auf einen äußeren Druck, der auf die Sonde ausgeübt wird, verformbar ist, an unterschiedlichen Positionen in der axialen Richtung, wobei jeder Verformungsabschnitt eine rechteckige Parallelepipedform hat, die eine vorbestimmte Länge in der axialen Richtung hat, und eine Fläche hat, die eine Umfangsfläche der Sondeneinheit innerhalb des jeweiligen Verformungsabschnitts bildet, wobei die eine Fläche so konfiguriert ist, dass sie ein Element hat, das eine Steifigkeit hat, die niedriger ist als diejenige der anderen Flächen des Verformungsabschnitts.

10. Sonde nach Anspruch 9,
wobei die Verformungsabschnitte an einer ersten Position in der Hülle und an einer zweiten Position auf einer von der ersten Position weiter proximalen Seite in der axialen Richtung angeordnet sind und die mehreren Verformungsabschnitte an der jeweiligen ersten Position und zweiten Position in der Umfangsrichtung angeordnet sind.

Revendications

1. Dispositif d'imagerie pour diagnostic comprenant :

une unité de sonde qui comporte une gaine et une unité d'émission et de réception insérée dans la gaine et émettant et recevant un signal, dans lequel l'unité d'émission et de réception est commandée de façon à émettre et recevoir le signal tout en tournant à l'intérieur de la gaine dans une direction circonférentielle ou tout en tournant dans la direction circonférentielle et en se déplaçant dans le direction axiale, **caractérisé en ce que** la sonde comprend en outre une pluralité de parties de déformation (900) dont la forme respective en section transversale est déformable en réponse à une pression extérieure, lesdites parties de déformation sont disposées respectivement en différentes positions de la gaine dans la direction axiale ;

des premiers moyens de calcul pour calculer au moins un paramètre au niveau de chaque partie de déformation qui indique un degré de déformation des parties de déformation respectives disposées dans les différentes positions dans la direction axiale, en utilisant une image tomographique incluant les parties de déformation ; et des seconds moyens de calcul pour calculer une valeur correspondant à une fraction de flux de réserve coronarien (FFR), en fonction du paramètre.

2. Dispositif d'imagerie pour diagnostic selon la revendication 1,
dans lequel chaque partie de déformation a une forme de parallélépipède rectangulaire ayant une longueur prédéterminée dans la direction axiale, et a une surface formant une surface circonférentielle de l'unité de sonde dans la partie de déformation respective et ladite une surface est configurée pour avoir un élément ayant une rigidité inférieure à celle des autres surfaces de la partie de déformation respective.

3. Dispositif d'imagerie pour diagnostic selon la revendication 2,
dans lequel les premiers moyens de calcul sont adaptés pour calculer comme l'au moins un paramètre indiquant le degré de déformation des parties de déformation respectives l'un des suivants :

un volume de la partie de déformation, une aire en une position prédéterminée de la partie de déformation dans la direction axiale, une hauteur de la surface formant la surface circonférentielle dans la position prédéterminée de la partie de déformation dans la direction axiale, ou une quantité de distorsion de la surface formant la surface circonférentielle dans la position prédéterminée de la partie de déformation dans la direction axiale.

4. Dispositif d'imagerie pour diagnostic selon l'une quelconque des revendications 1 à 3,
dans lequel les seconds moyens de calcul calculent une valeur correspondant à la fraction de flux de réserve coronarien (FFR) en utilisant $(X_{b0} \times X_{f1})/(X_{b1} \times X_{f0})$, quand on suppose qu'un paramètre sous la pression atmosphérique P_0 est X_{f0} et un paramètre à l'intérieur d'une lumière corporelle est X_{f1} qui sont calculés par rapport à une partie de déformation disposée en une première position parmi les parties de déformation disposées en les différentes positions dans la direction axiale, et que le paramètre sous la pression atmosphérique P_0 est X_{b0} et un paramètre à l'intérieur d'une lumière corporelle est X_{b1} qui sont calculés par rapport à une partie de déformation disposée en une seconde position, parmi les parties de déformation disposées dans les différentes positions dans la direction axiale.

5. Dispositif d'imagerie pour diagnostic selon la revendication 1, comprenant en outre
des moyens d'extraction pour extraire une image tomographique qui inclut la partie de déformation respective ; et des troisièmes moyens de calcul pour calculer des positions centrales respectives dans la direction axiale des parties de déformation disposées dans les différentes positions dans la direction axiale, en fonction de l'image tomographique extraite par les moyens d'extraction,
dans lequel les premiers moyens de calcul calculent le paramètre en utilisant l'image tomographique générée en faisant tourner l'unité d'émission et de réception dans la direction circonférentielle, dans un état où l'unité d'émission et de réception est déplacée vers les positions centrales respectives dans la direction axiale qui sont calculées par les troisièmes moyens de calcul.

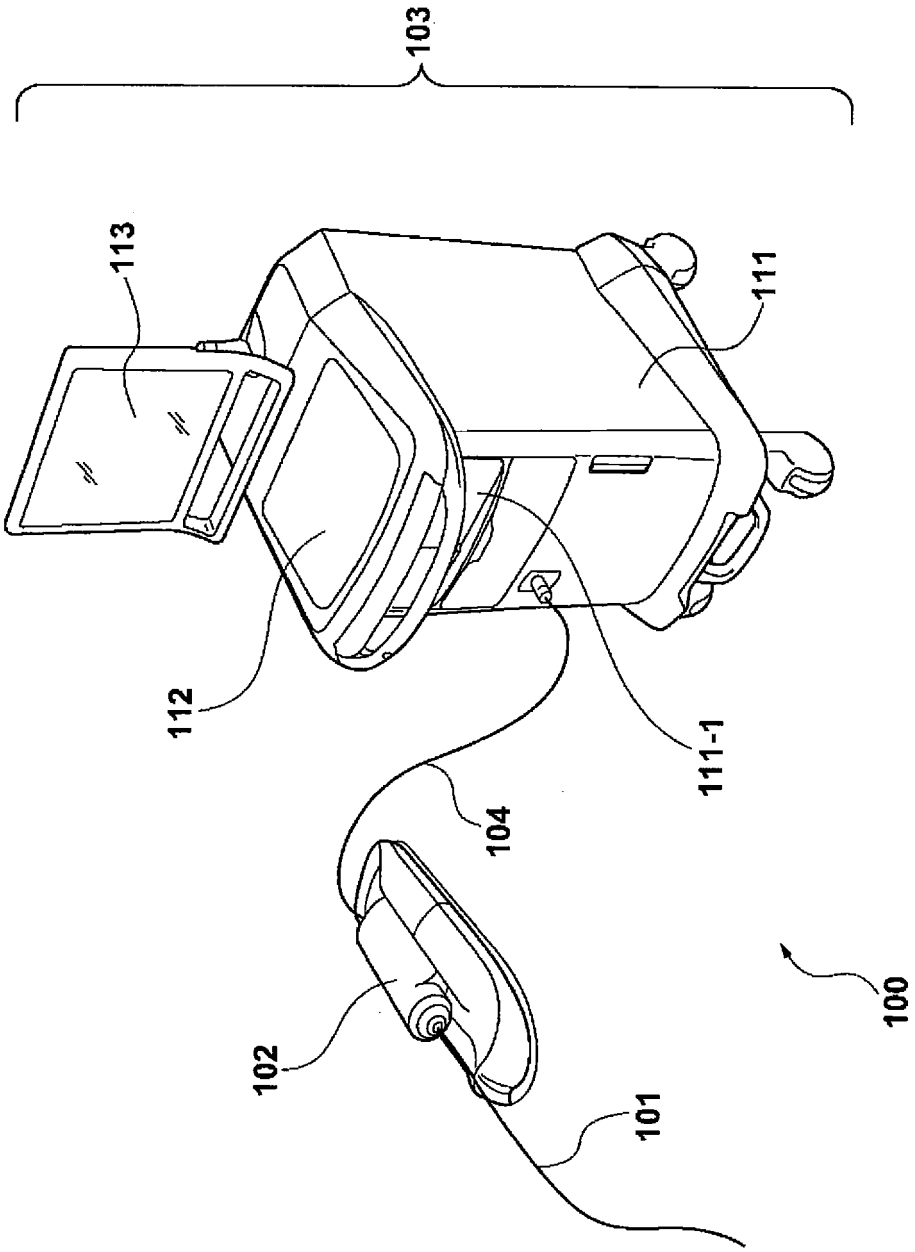
6. Dispositif d'imagerie pour diagnostic selon la revendication 5,
dans lequel les premiers moyens de calcul calculent le paramètre en utilisant l'image tomographique dans laquelle un degré de déformation de la partie de déformation est le plus grand, parmi les multiples images tomographiques générées en faisant tourner l'unité d'émission et de réception dans la direction circonférentielle pendant une période de temps prédéterminée.

7. Dispositif d'imagerie pour diagnostic selon la revendication 1,
dans lequel les parties de déformation sont respectivement disposées dans une première position dans la gaine et dans une seconde position sur un autre côté proximal dans la direction axiale depuis la première position, et les multiples parties de déformation sont disposées dans la première position et la seconde position respectives dans la direction circonférentielle.

8. Dispositif d'imagerie pour diagnostic selon la revendication 7,
dans lequel les premiers moyens de calcul emploient un paramètre indiquant un degré de déformation de parties de déformation partielles dans les des parties de déformation partielles disposées dans la direction circonférentielle, et calculent le paramètre utilisé dans les seconds moyens de calcul sans employer un paramètre indiquant un degré de déformation de l'autre partie de déformation partielle.

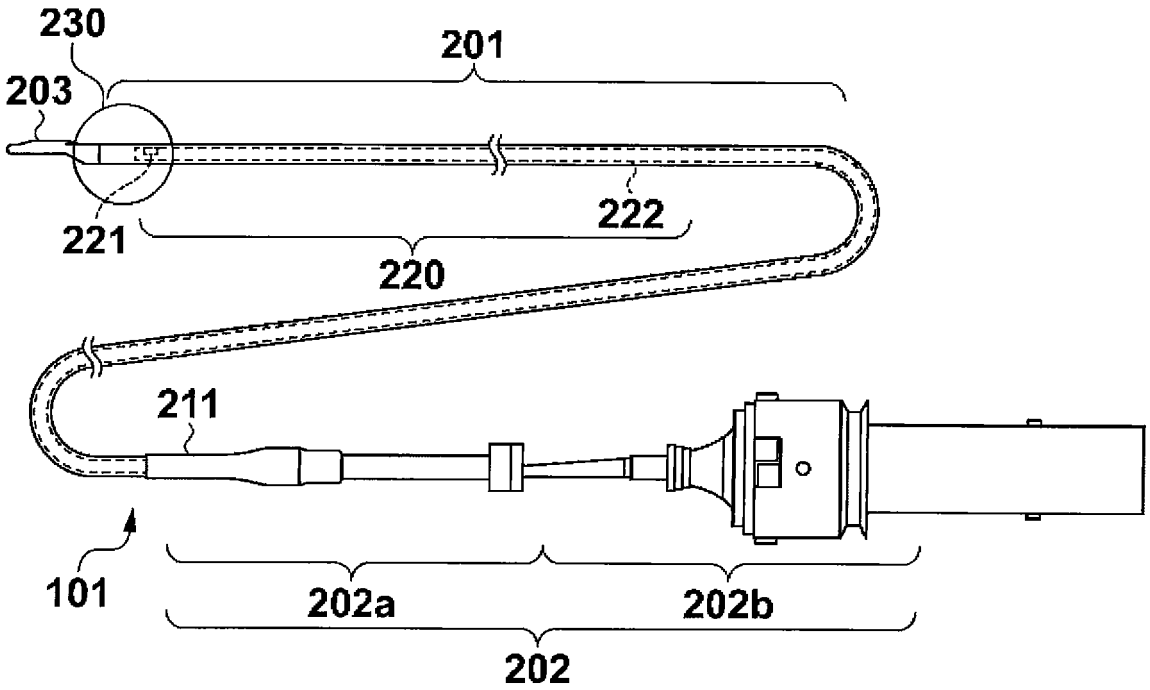
9. Sonde dans laquelle une unité d'émission et de réception configurée pour émettre et recevoir un signal est insérée intérieurement dans une gaine de la sonde, la sonde étant configurée pour transmettre le signal à un dispositif d'imagerie pour un diagnostic générant une image tomographique en utilisant le signal acquis quand l'unité d'émission et de réception est mise en rotation à l'intérieur de la gaine dans une direction circonférentielle, ou quand l'unité d'émission et de réception est mise en rotation dans la direction circonférentielle et est déplacée dans une direction axiale, la sonde étant **caractérisée en ce qu'**elle comprend en outre ;
une pluralité de parties de déformation dont la forme en section transversale respective est déformable en réponse à une pression appliquée sur la sonde, en différentes positions dans la direction axiale ;
dans lequel chaque partie de déformation a une forme de parallélépipède rectangulaire ayant une longueur prédéterminée dans la direction axiale, et a une surface formant une surface circonférentielle de la sonde dans la partie de déformation respective, ladite une surface étant configurée pour avoir un élément ayant une rigidité inférieure à celle des autres surfaces de la partie de déformation.

10. Sonde selon la revendication 9,
dans laquelle les parties de déformation sont disposées dans une première position dans la gaine et dans une seconde position sur un autre côté proximal dans la direction axiale depuis la première position, et les multiples parties de déformation sont disposées dans la première position et la seconde position respectives dans la direction circonférentielle.

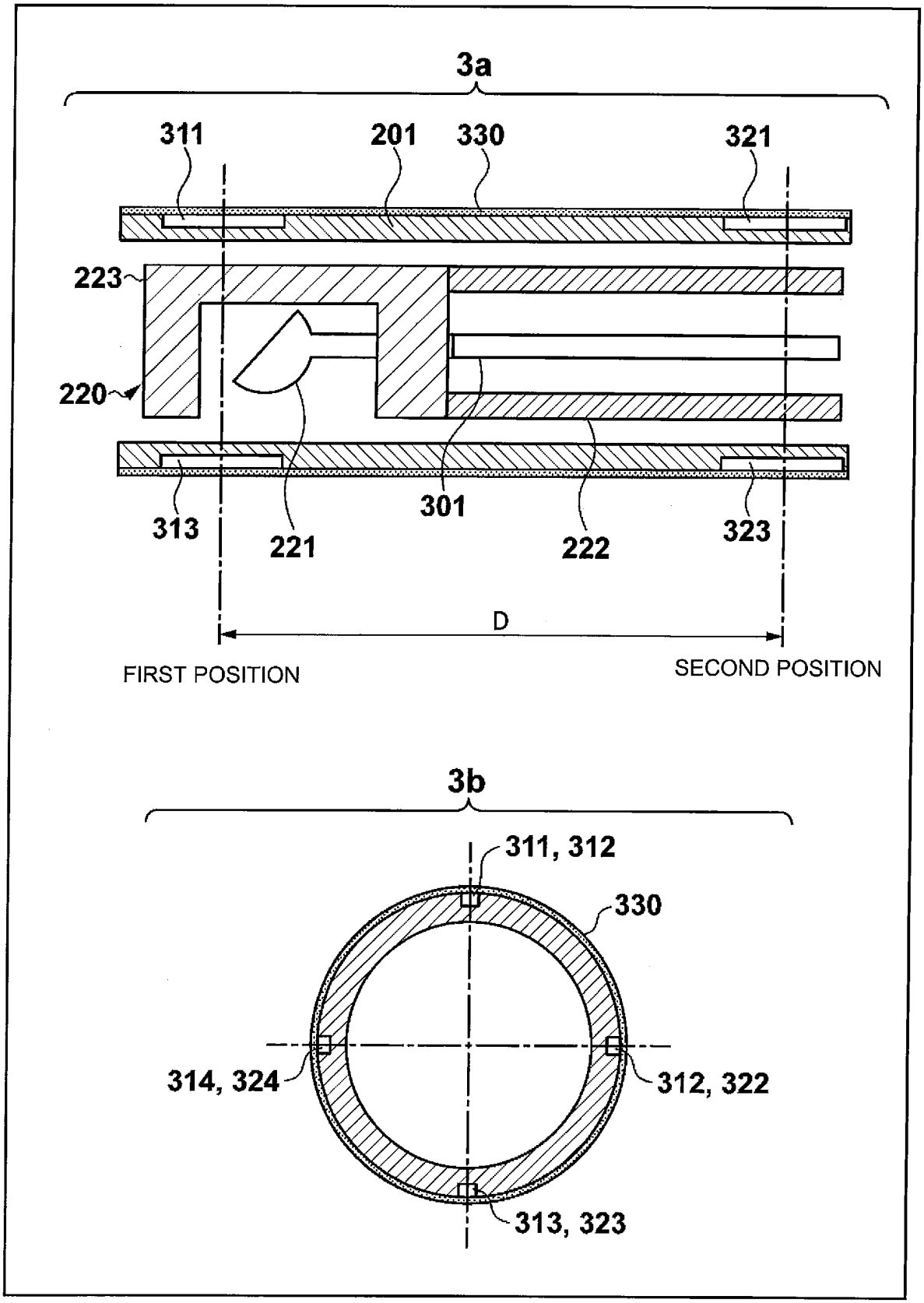


[FIG. 1]

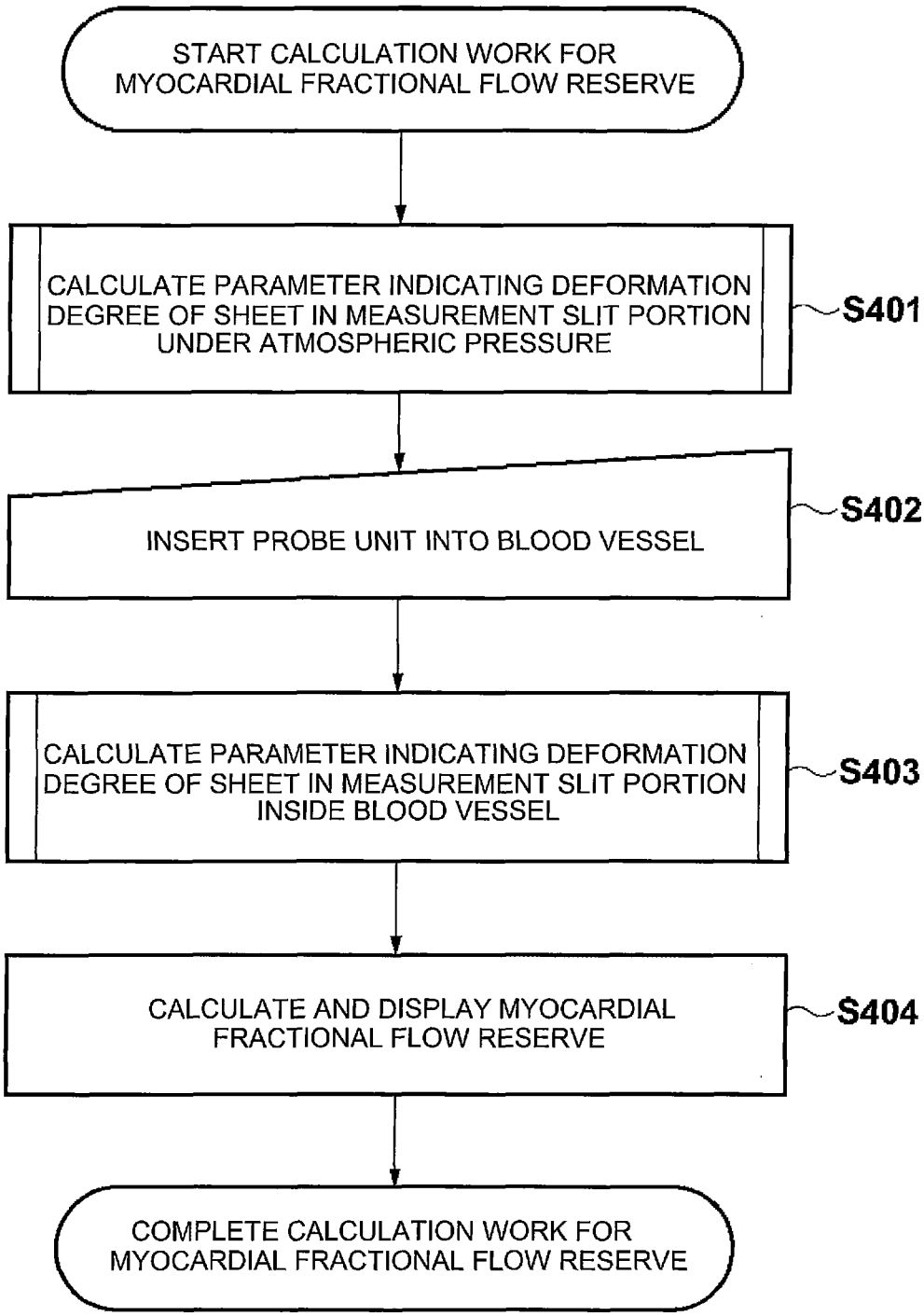
[FIG. 2]



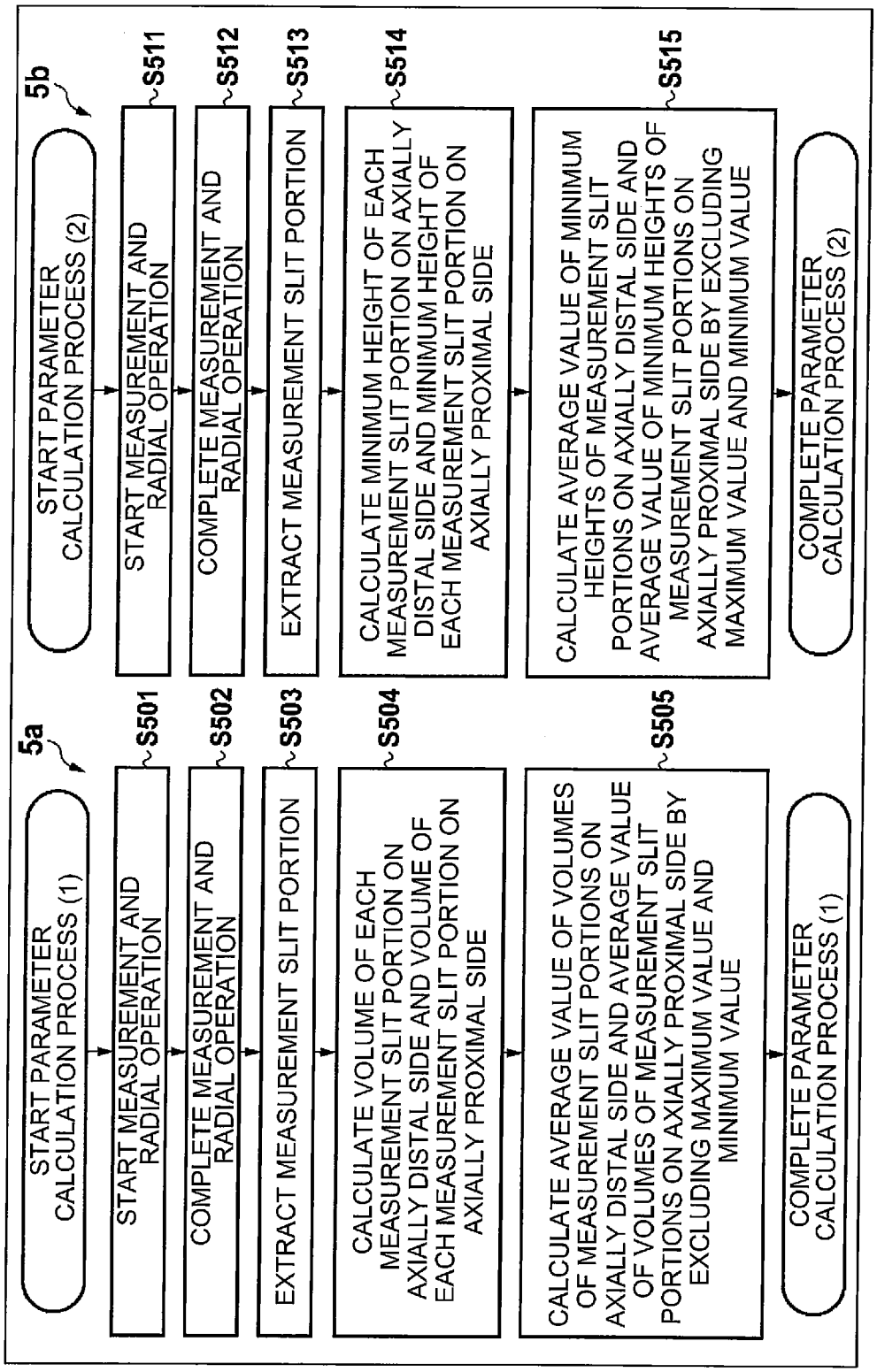
[FIG. 3]


3a
311
201
330
321
223
220
313
221
301
222
323
D
FIRST POSITION
SECOND POSITION
3b
311, 312
330
314, 324
312, 322
313, 323

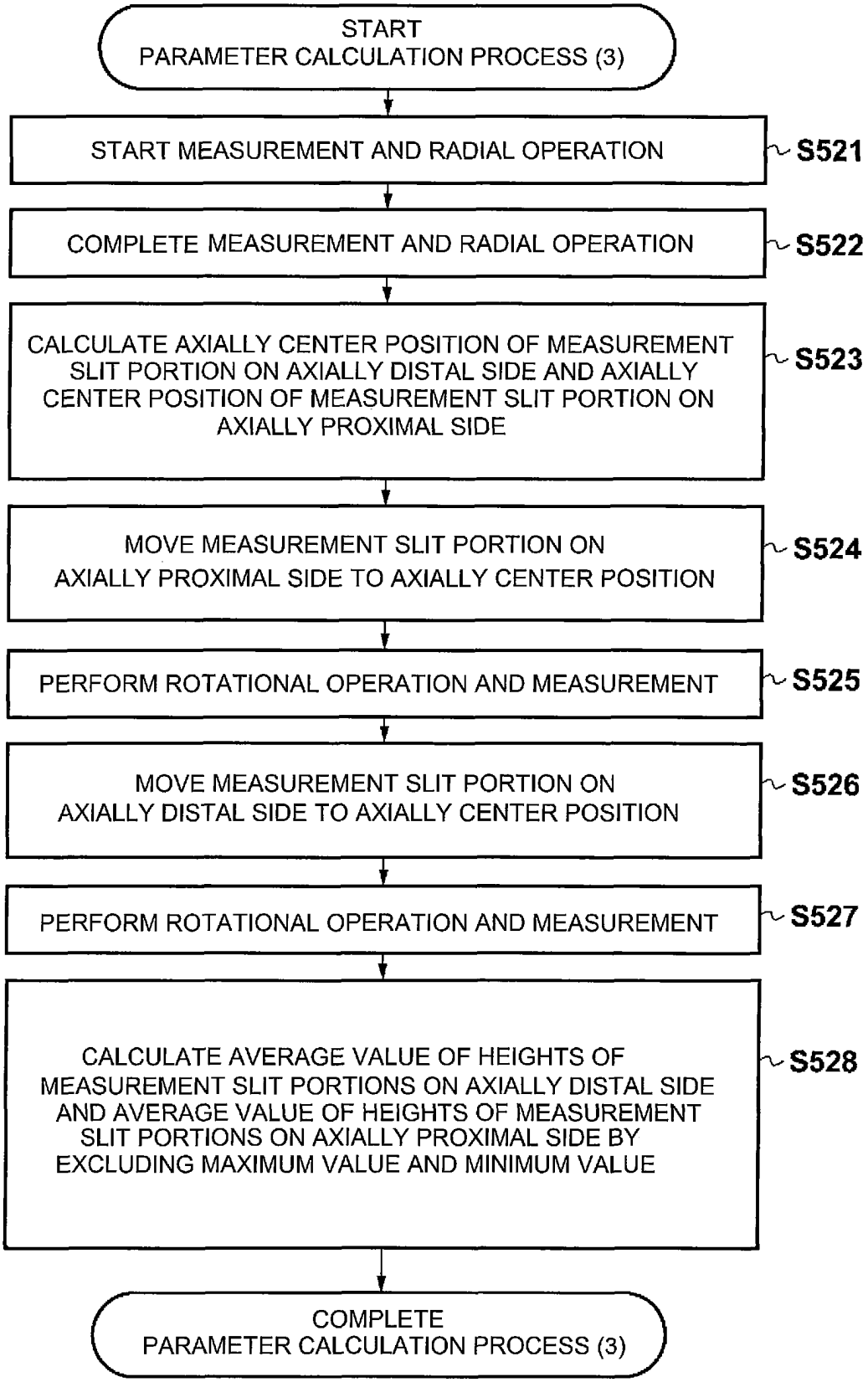
[FIG. 4]


START CALCULATION WORK FOR MYOCARDIAL FRACTIONAL FLOW RESERVE
CALCULATE PARAMETER INDICATING DEFORMATION DEGREE OF SHEET IN MEASUREMENT SLIT PORTION UNDER ATMOSPHERIC PRESSURE
S401
INSERT PROBE UNIT INTO BLOOD VESSEL
S402
CALCULATE PARAMETER INDICATING DEFORMATION DEGREE OF SHEET IN MEASUREMENT SLIT PORTION INSIDE BLOOD VESSEL
S403
CALCULATE AND DISPLAY MYOCARDIAL FRACTIONAL FLOW RESERVE
S404
COMPLETE CALCULATION WORK FOR MYOCARDIAL FRACTIONAL FLOW RESERVE

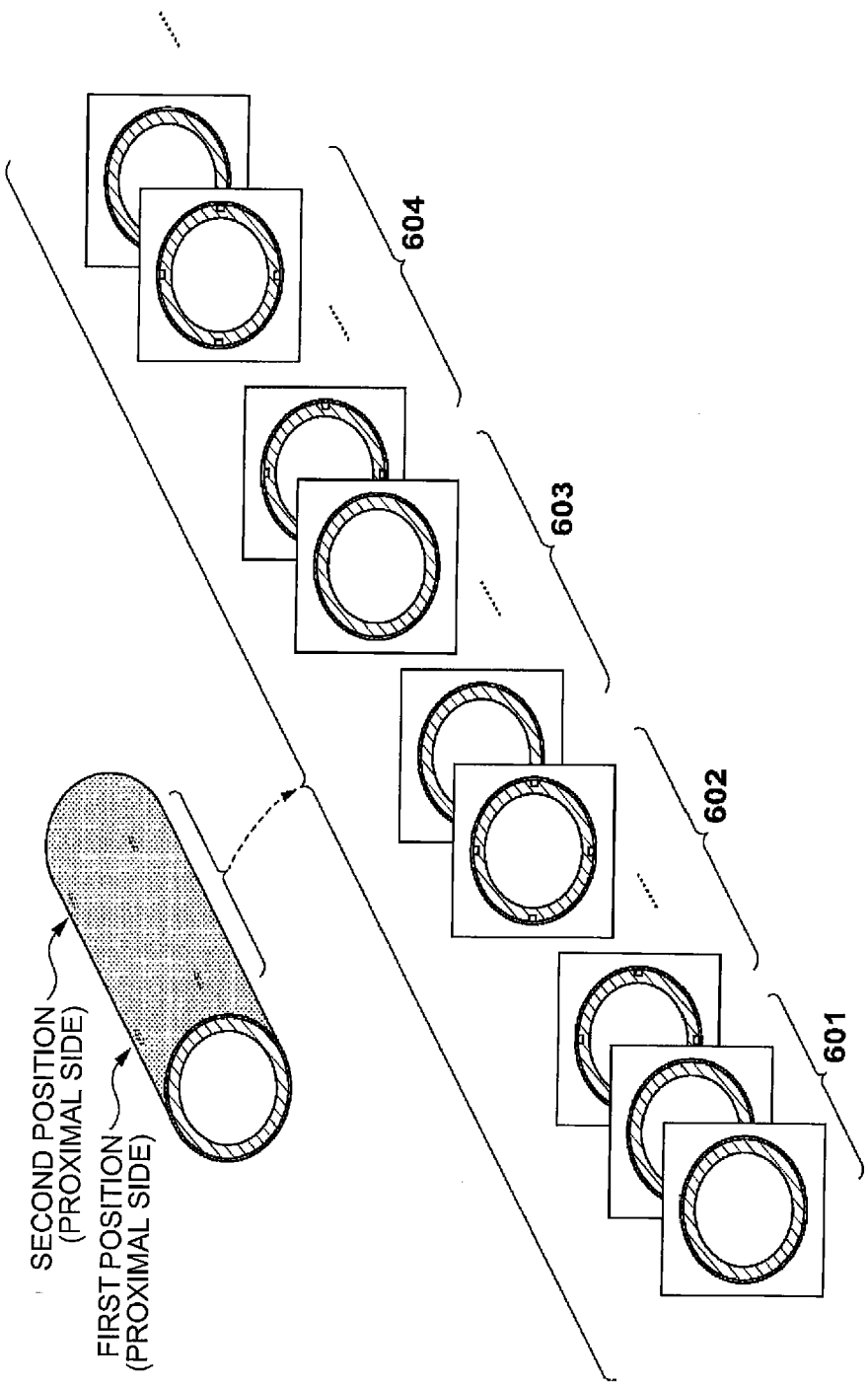
[FIG. 5A]


5a
START PARAMETER CALCULATION PROCESS (1)
START MEASUREMENT AND RADIAL OPERATION
S501
COMPLETE MEASUREMENT AND RADIAL OPERATION
S502
EXTRACT MEASUREMENT SLIT PORTION
S503
CALCULATE VOLUME OF EACH MEASUREMENT SLIT PORTION ON AXIALLY DISTAL SIDE AND VOLUME OF EACH MEASUREMENT SLIT PORTION ON AXIALLY PROXIMAL SIDE
S504
CALCULATE AVERAGE VALUE OF VOLUMES OF MEASUREMENT SLIT PORTIONS ON AXIALLY DISTAL SIDE AND AVERAGE VALUE OF VOLUMES OF MEASUREMENT SLIT PORTIONS ON AXIALLY PROXIMAL SIDE BY EXCLUDING MAXIMUM VALUE AND MINIMUM VALUE
S505
COMPLETE PARAMETER CALCULATION PROCESS (1)
5b
START PARAMETER CALCULATION PROCESS (2)
START MEASUREMENT AND RADIAL OPERATION
S511
COMPLETE MEASUREMENT AND RADIAL OPERATION
S512
EXTRACT MEASUREMENT SLIT PORTION
S513
CALCULATE MINIMUM HEIGHT OF EACH MEASUREMENT SLIT PORTION ON AXIALLY DISTAL SIDE AND MINIMUM HEIGHT OF EACH MEASUREMENT SLIT PORTION ON AXIALLY PROXIMAL SIDE
S514
CALCULATE AVERAGE VALUE OF MINIMUM HEIGHTS OF MEASUREMENT SLIT PORTIONS ON AXIALLY DISTAL SIDE AND AVERAGE VALUE OF MINIMUM HEIGHTS OF MEASUREMENT SLIT PORTIONS ON AXIALLY PROXIMAL SIDE BY EXCLUDING MAXIMUM VALUE AND MINIMUM VALUE
S515
COMPLETE PARAMETER CALCULATION PROCESS (2)

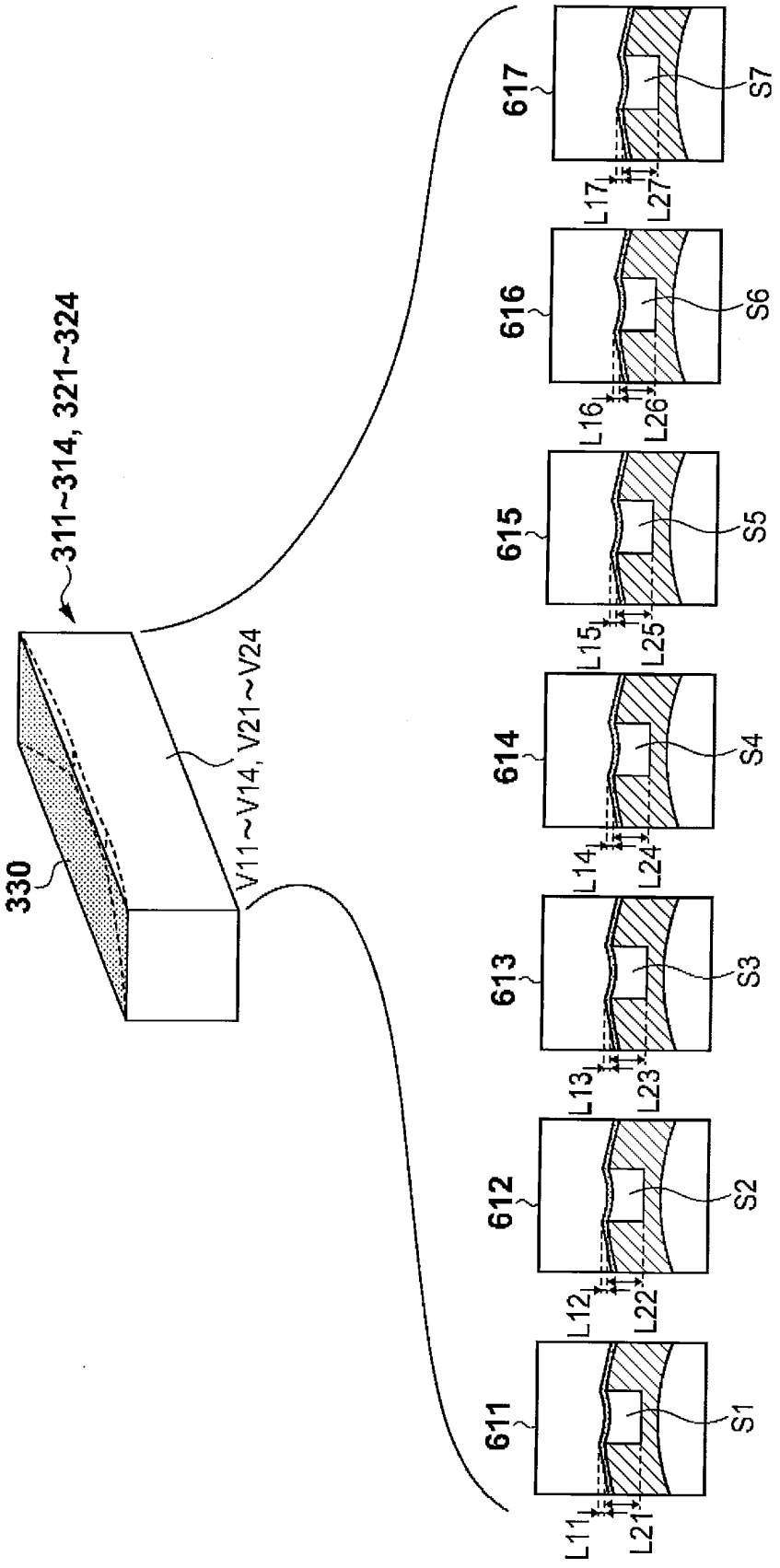
[FIG. 5B]


START
PARAMETER CALCULATION PROCESS (3)
START MEASUREMENT AND RADIAL OPERATION
S521
COMPLETE MEASUREMENT AND RADIAL OPERATION
S522
CALCULATE AXIALLY CENTER POSITION OF MEASUREMENT SLIT PORTION ON AXIALLY DISTAL SIDE AND AXIALLY CENTER POSITION OF MEASUREMENT SLIT PORTION ON AXIALLY PROXIMAL SIDE
S523
MOVE MEASUREMENT SLIT PORTION ON AXIALLY PROXIMAL SIDE TO AXIALLY CENTER POSITION
S524
PERFORM ROTATIONAL OPERATION AND MEASUREMENT
S525
MOVE MEASUREMENT SLIT PORTION ON AXIALLY DISTAL SIDE TO AXIALLY CENTER POSITION
S526
PERFORM ROTATIONAL OPERATION AND MEASUREMENT
S527
CALCULATE AVERAGE VALUE OF HEIGHTS OF MEASUREMENT SLIT PORTIONS ON AXIALLY DISTAL SIDE AND AVERAGE VALUE OF HEIGHTS OF MEASUREMENT SLIT PORTIONS ON AXIALLY PROXIMAL SIDE BY EXCLUDING MAXIMUM VALUE AND MINIMUM VALUE
S528
COMPLETE
PARAMETER CALCULATION PROCESS (3)

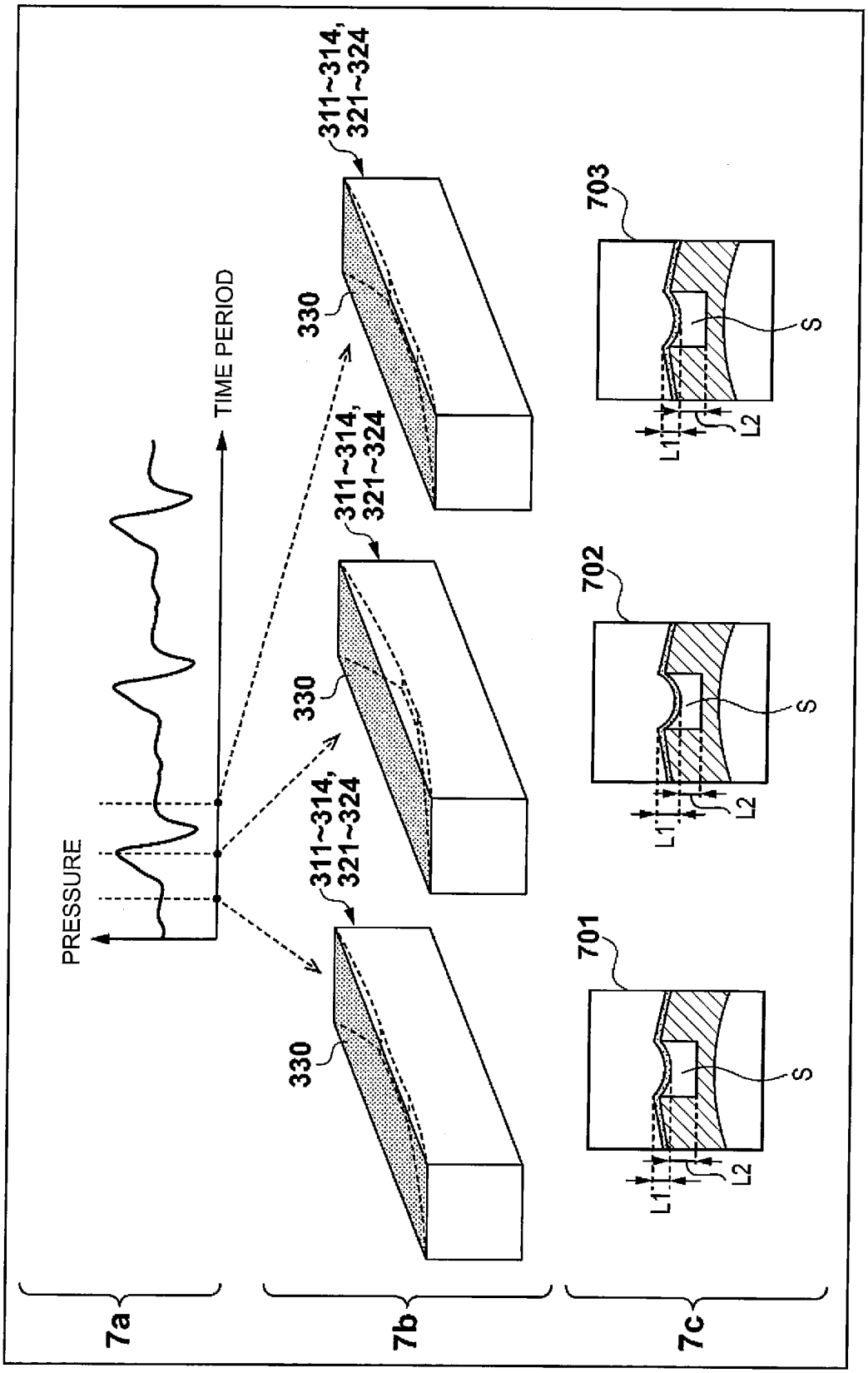
[FIG. 6A]


604
603
602
601
SECOND POSITION
(PROXIMAL SIDE)
FIRST POSITION
(PROXIMAL SIDE)

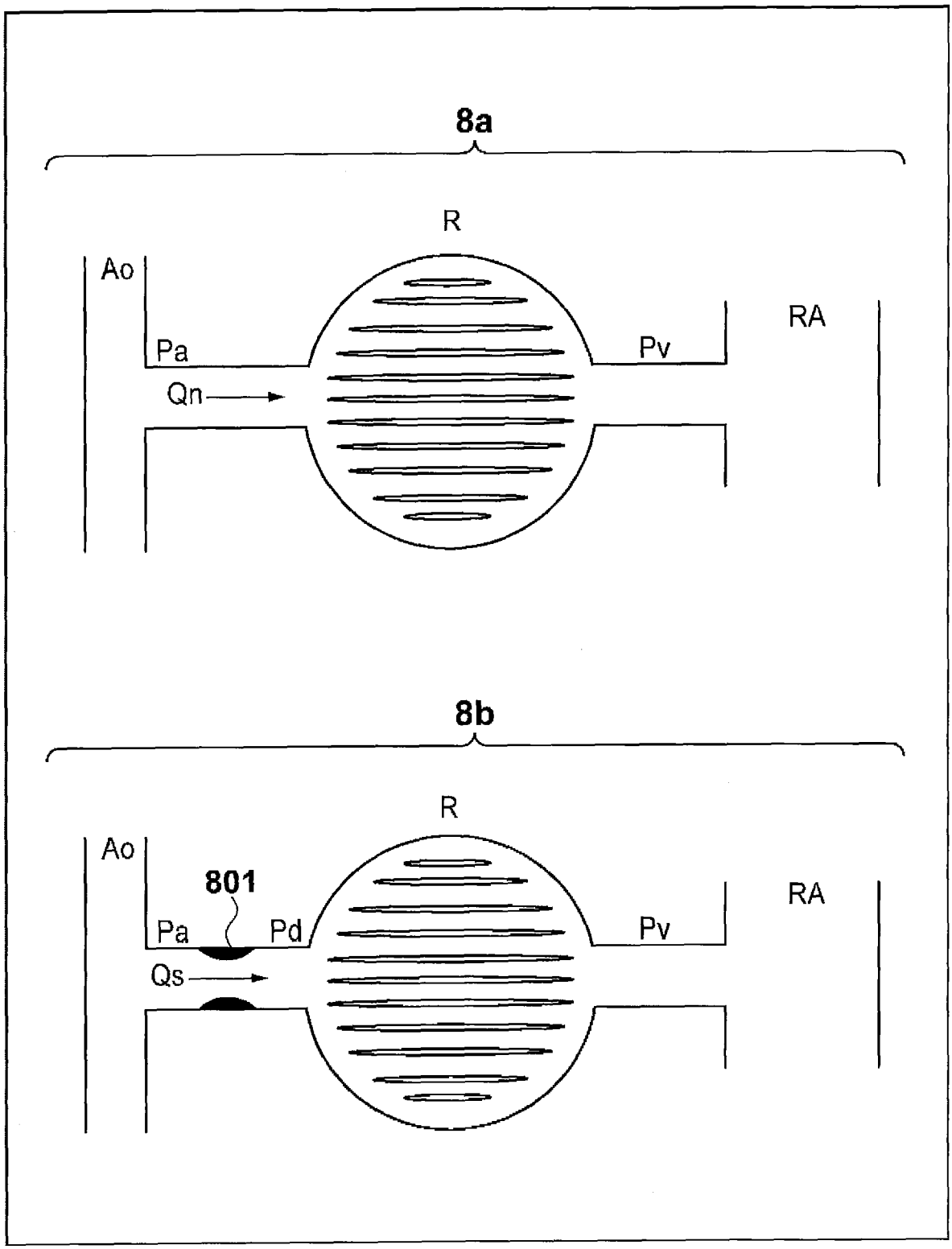
[FIG. 6B]


311~314, 321~324
330
V11~V14, V21~V24
611
612
613
614
615
616
617
S1
S2
S3
S4
S5
S6
S7
L11
L12
L13
L14
L15
L16
L17
L21
L22
L23
L24
L25
L26
L27

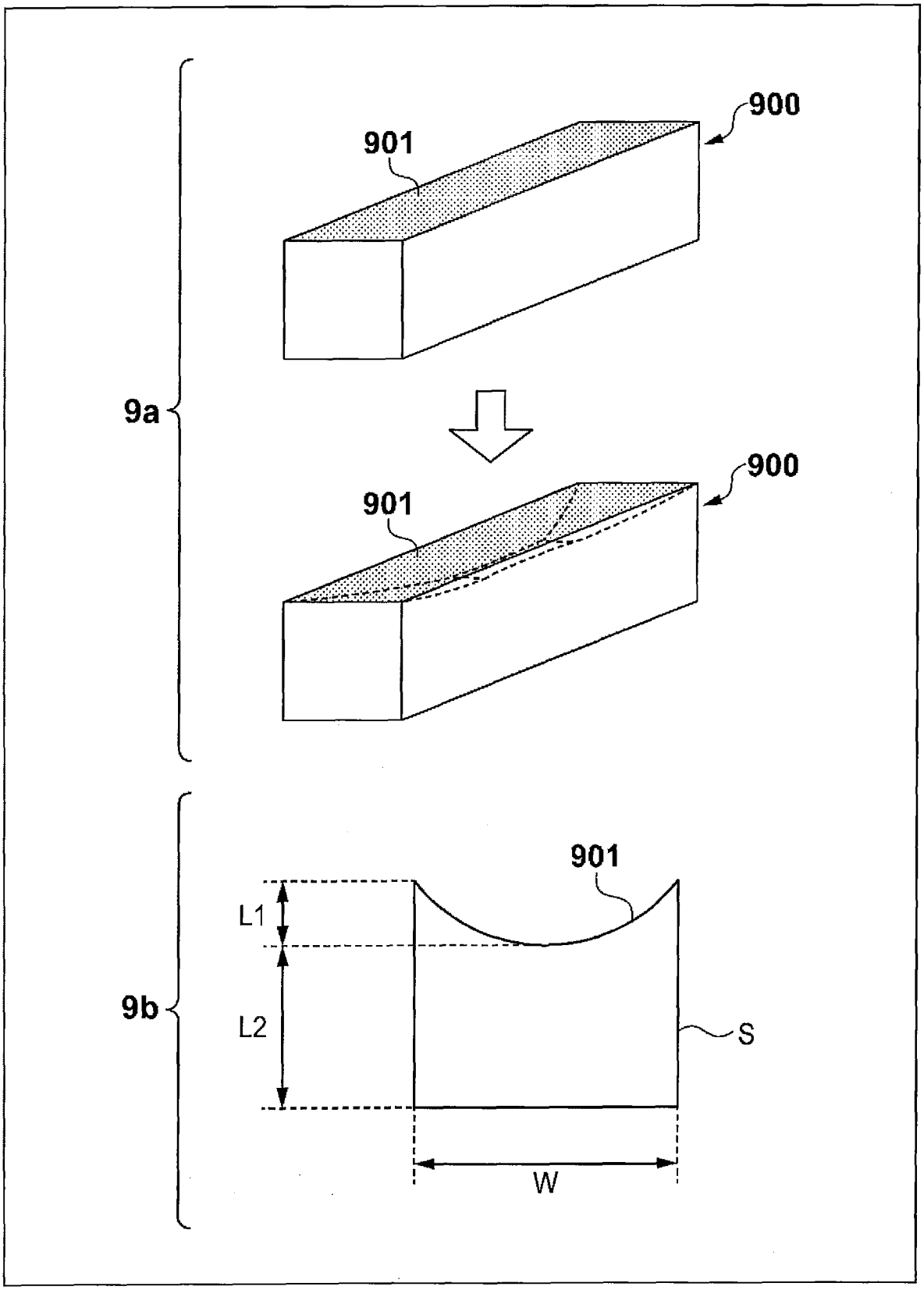
[FIG. 7]


PRESSURE
TIME PERIOD
311~314,
321~324
330
703
702
701
S
L1
L2
7a
7b
7c

[FIG. 8]



[FIG. 9]



REFERENCES CITED IN THE DESCRIPTION

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- WO 2011090744 A **[0009]**
- JP 2003525067 T **[0011]**
- JP 2007296354 A **[0011]**
- JP 2012501807 T **[0011]**
- JP 2012502773 T **[0011]**

Non-patent literature cited in the description

- **TAKASHI AKASAKA.** Application of a Pressure Guide Wire with Thermography in the Assessment of Coronary Stenotic Lesions. *Medical and Biological Engineering,* 2005, vol. 43 (1), 24-31 **[0012]**

专利名称(译)	图像诊断装置和探头		
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[标]申请(专利权)人(译)	泰尔茂株式会社		
申请(专利权)人(译)	泰尔茂株式会社		
当前申请(专利权)人(译)	泰尔茂株式会社		
[标]发明人	INOUE KOICHI FURUICHI JUNYA		
发明人	INOUE, KOICHI FURUICHI, JUNYA		
IPC分类号	A61B5/0215 A61B1/00 A61B5/0295 A61B5/11 A61B5/026 A61B5/025 A61B5/02 A61B5/00 A61B5/029 A61B5/027 A61B8/00 A61B8/06 A61B8/12 A61B8/08		
CPC分类号	A61B5/02007 A61B5/0215 A61B5/0261 A61B5/027 A61B5/029 A61B5/0295 A61B5/1128 A61B5/7225 A61B5/7278 A61B2562/17 A61B2576/00 G16H30/40 A61B8/065 A61B8/12 A61B8/445 A61B8/4461 A61B8/5223		
优先权	2012076730 2012-03-29 JP		
其他公开文献	EP2832287A1 EP2832287A4		
外部链接	Espacenet		

摘要(译)

提供了一种用于诊断的成像设备，其中更简单的配置使得能够组合使用解剖技术和生理技术。这里公开的用于诊断的成像装置包括第一计算装置，用于通过使用包括测量狭缝部分311至314和321至324的断层图像来计算指示测量狭缝部分311至314和321至324的每个变形程度的参数。设置在探头单元的轴向上的不同位置并且其横截面形状响应于施加到探头单元的压力而变形，并且第二计算装置用于计算与心肌分数流量储备相对应的值，基于计算参数。