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(54) **PET-MRI DEVICE**

PET-MRT-VORRICHTUNG

DISPOSITIF DE TEP-IRM

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Description

Field

[0001] Embodiments relate to a positron emission tomography (PET)-magnetic resonance imaging (MRI) apparatus.

Background

[0002] In recent years, PET-MRI apparatuses having a combination of positron emission tomography (PET) apparatuses and magnetic resonance imaging (MRI) apparatuses have been made into products. Generally, the PET-MRI apparatuses are realized by attaching PET detectors to the MRI apparatuses, and in many cases, the positions of the PET detectors are fixed. However, when the PET detectors are fixed in the vicinity of magnetic field centers of the MRI apparatuses, the PET detectors may interfere with high power radio frequency (RF) magnetic fields generated in the magnetic field centers and radio frequency coils (RF coils) detecting generated magnetic resonance signals, which may cause data acquisition not to be properly made.

[0003] US 2009/0221903 discloses a magnetic resonance device having a PET unit for acquiring positron emission tomography data and a gradient coil. The PET unit includes a carrier tube on which at least one PET detector is arranged. The carrier tube is arranged inside the gradient coil and is displaceably mounted in such a way that access to the PET detector is made possible by its displacement.

[0004] JP 2011 185796 discloses PET/MRI equipment constituted of MRI equipment having a measurement port, and a PET detector which can be inserted into the measurement port. A mechanism which allows the PET detector to slide and move into and out of the MRI measurement port is provided, so that the PET detector comes close to a measurement target and enables performing PET measurement, at the same time as the MRI measurement.

KR20080105443 discloses a retractable PET-and-MRI integrated unit in which a PET part and an RF coil are integrated.

KR20080105442 discloses an open PET-and-MRI integrated unit.

Brief Description of Drawings

[0005]

FIG. 1 is a schematic diagram illustrating the overall structure of a PET-MRI apparatus according to a first embodiment.

FIG. 2 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to the first embodiment.

FIG. 3 is a schematic diagram illustrating an example

of the moving mechanism of a PET detector according to a second embodiment.

FIG. 4 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a third embodiment.

FIG. 5 is a first schematic diagram illustrating an example of the moving mechanism of a PET detector according to a fourth embodiment.

FIG. 6 is a second schematic diagram illustrating the example of the moving mechanism of the PET detector according to the fourth embodiment.

FIG. 7 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a fifth embodiment.

FIG. 8 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a sixth embodiment.

FIG. 9 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a seventh embodiment.

FIG. 10 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to an eighth embodiment.

FIG. 11 is a first schematic diagram illustrating an example of effective imaging regions of the PET detector according to the eighth embodiment.

FIG. 12 is a second schematic diagram illustrating an example of the effective imaging regions of the PET detector according to the eighth embodiment.

Description of Embodiments

[0006] A positron emission tomography (PET)-magnetic resonance imaging (MRI) apparatus according to the present embodiment is defined by the appended set of claims.

(First embodiment)

[0007] FIG. 1 is a schematic diagram illustrating the overall structure of a PET-MRI apparatus according to a first embodiment not being part of the invention. As illustrated in FIG. 1, a PET-MRI apparatus 100 according to the first embodiment includes a static magnetic field magnet 1, a couch 2, a gradient coil 3, a gradient coil driving circuit 4, a transmitting radio frequency coil 5, a transmitter 6, a receiving radio frequency coil 7, a receiver 8, an MR data acquisition unit 9, a computer (a position detection unit) 10, a console 11, a display 12, a PET detector 13, signal lines 14, a PET data acquisition unit 15, a PET image reconstruction unit 16, a sequence controller 17, a radio frequency shield 18, and a bore cover 19.

[0008] The static magnetic field magnet 1 generates a static magnetic field in a bore B having an approximately cylindrical shape. The couch 2 has a couchtop 2a on which an object P is placed. When the object P is imaged, the couch 2 causes the couchtop 2a to move into the bore B with the longitudinal direction of the couchtop 2a

being along the axial direction of the bore B, thereby moving the object P into the static magnetic field.

[0009] The gradient coil 3 applies gradient magnetic fields G_x, G_y, and G_z on the object P. The magnetic field intensities of the gradient magnetic fields G_x, G_y, and G_z change linearly in the X, Y, and Z directions, respectively. The gradient coil 3 is formed in an approximately cylindrical shape and disposed on an inner circumference side of the static magnetic field magnet 1. The gradient coil driving circuit 4 drives the gradient coil 3 under control of the sequence controller 17.

[0010] The transmitting radio frequency coil 5 applies a radio frequency magnetic field on the object P placed in the static magnetic field on the basis of a radio frequency pulse transmitted from the transmitter 6. The transmitting radio frequency coil 5 is formed in an approximately cylindrical shape and disposed on an inner circumference side of the gradient coil 3. The transmitter 6 transmits the radio frequency pulse to the transmitting radio frequency coil 5 under control of the sequence controller 17.

[0011] The receiving radio frequency coil 7 detects a magnetic resonance signal emitted from the object P due to the application of the radio frequency magnetic field and the gradient magnetic field. For example, the receiving radio frequency coil 7 is a surface coil disposed on the surface of the object P depending on a portion to be imaged. For example, when a body portion of the object P is imaged, two receiving radio frequency coils 7 are disposed on the upper part and the lower part of the object P. The receiver 8 receives the magnetic resonance signal detected by the receiving radio frequency coil 7 and sends the received magnetic resonance signal to the MR data acquisition unit 9, under control of the sequence controller 17.

[0012] The MR data acquisition unit 9 acquires the magnetic resonance signal sent from the receiver 8, under control of the sequence controller 17. The MR data acquisition unit 9 amplifies the acquired magnetic resonance signal and performs detection on the amplified signal. Thereafter, the MR data acquisition unit 9 A/D-converts the signal after the detection and sends the converted signal to the computer 10. The computer 10, which is controlled by the console 11, reconstructs an MR image on the basis of the magnetic resonance signal sent from the MR data acquisition unit 9. The computer 10 causes the display 12 to display the reconstructed MR image.

[0013] The PET detector 13 detects, as counting information, gamma rays (including annihilation radiation) emitted from positron-emitting radionuclides injected into the object P. The PET detector 13 is formed in a ring shape and disposed on an inner circumference side of the transmitting radio frequency coil 5. For example, the PET detector 13 is formed by arranging detector modules including scintillators and photodetectors in a ring shape. Examples of the scintillator include lutetium yttrium oxyorthosilicate (LYSO), lutetium oxyorthosilicate (LSO), and lutetium gadolinium oxyorthosilicate (LGSO). The

photodetector is, for example, a semiconductor detector such as an avalanche photodiode (APD) element or a SiPM (Silicon Photomultiplier), or a photomultiplier tube (PMT). The PET detector 13 sends the detected counting information to the PET data acquisition unit 15 through the signal lines 14.

[0014] The PET data acquisition unit 15 produces simultaneous counting information under control of the sequence controller 17. The PET data acquisition unit 15 produces, as the simultaneous counting information, a combination of counting information of gamma rays that are emitted from the positron-emitting radionuclides and approximately simultaneously detected, using the counting information of the gamma rays detected by the PET detector 13.

[0015] The PET image reconstruction unit 16 reconstructs a PET image using the simultaneous counting information produced by the PET data acquisition unit 15 as projection data. The PET image reconstructed by the PET image reconstruction unit 16 is transmitted to the computer 10 and displayed on the display 12. The sequence controller 17 receives, from the computer 10, information on various types of imaging sequences executed when the object is imaged and controls the above-described components.

[0016] The radio frequency shield 18 is disposed between the gradient coil 3 and the transmitting radio frequency coil 5 and shields the radio frequency magnetic field generated by the transmitting radio frequency coil 5. The bore cover 19 is a cover covering an inner circumference side of the transmitting radio frequency coil 5. The bore cover 19 forms the bore B, which is a space having an approximately cylindrical shape, inside an approximately cylindrical structure composed of the static magnetic field magnet 1, the gradient coil 3, the radio frequency shield 18, and the transmitting radio frequency coil 5.

[0017] The PET-MRI apparatus 100 according to the first embodiment further includes a moving mechanism 20 that causes the PET detector 13 to move along the axial direction of the bore, in addition to the above-described structure.

[0018] FIG. 2 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to the first embodiment. As illustrated in FIG. 2, in the first embodiment, the PET detector 13 is disposed between the transmitting radio frequency coil 5 and the bore cover 19. The moving mechanism 20 is also disposed between the transmitting radio frequency coil 5 and the bore cover 19.

[0019] As illustrated in FIG. 2, the moving mechanism 20 causes the PET detector 13 to move in a gantry along the axial direction of the bore. For example, the moving mechanism 20 causes the PET detector 13 to move, in a space formed between the transmitting radio frequency coil 5 and the bore cover 19, in the Z-axis direction of the bore B (in a direction indicated by the double-headed arrow A illustrated in FIG. 2). The moving mechanism 20

causes the PET detector 13 to move by being driven by a driving device 21, for example.

[0020] For example, the moving mechanism 20 is composed of at least two rotational shafts disposed along the axial direction of the bore B at the ends of the gantry including the static magnetic field magnet 1, the gradient coil 3, the transmitting radio frequency coil 5, and the bore cover 19, and a belt wound between the rotational shafts. The driving device 21 rotationally drives the rotational shafts, so that the PET detector 13 fixed to a part of the belt is moved in the Z-axis direction of the bore B.

[0021] The PET-MRI apparatus according to the first embodiment is described as above. In the PET-MRI apparatuses having been made into products in recent years, the positions of the PET detectors are fixed in many cases. In some of the PET-MRI apparatuses, the PET detectors are removable. Even in such cases, the positions of most of the PET detectors are fixed. Although PET-MRI apparatuses have been also developed in which two PET detectors are disposed spaced apart from each other, the PET detectors need not always be disposed around the imaging center and may be allowed to be somewhat off the imaging center.

[0022] In fact, if the PET detectors and the radio frequency coil are in different positions in the axial direction of the bore, it would be more preferable for data acquisition, as interference would become smaller. Although imaging by the MRI can be performed only at the central position in the axial direction of the bore, imaging by the PET is executable at any position in the axial direction of the bore. Since the imaging by the MRI and the imaging by the PET differ from each other in data acquisition time, that the position of the object in PET imaging is always the center of the magnetic field is in some cases inconvenient for constructing an imaging protocol combining MRI imaging and PET imaging.

[0023] In contrast, in the PET-MRI apparatus 100 according to the first embodiment, the PET detector 13 is caused to move in the axial direction of the bore by the moving mechanism 20, and thereby the PET detector 13 can be moved to a position distant from the magnetic field center. As a result, effect of interference between the PET detector and the magnetic field on data acquisition can be lessened. In addition, a degree of freedom in establishing the imaging protocol in a combination of MRI and PET can be increased.

[0024] The moving mechanism of the PET detector is not limited to the example illustrated in FIG. 2. Other examples of the moving mechanism are described below as second to eighth embodiments.

(Second embodiment)

[0025] FIG. 3 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a second embodiment not being part of the invention. As illustrated in FIG. 3, in the second embodiment, the PET detector 13 is disposed between the gra-

dient coil 3 and the radio frequency shield 18. The moving mechanism 20 is also disposed between the gradient coil 3 and the radio frequency shield 18. As illustrated in FIG. 3, the moving mechanism 20 causes the PET detector 13 to move in the gantry along the axial direction of the bore. For example, the moving mechanism 20, by being driven by the driving device 21, causes the PET detector 13 to move in a space formed between the gradient coil 3 and the radio frequency shield 18 in the Z-axis direction of the bore (in a direction indicated by the double-headed arrow A illustrated in FIG. 3).

(Third embodiment)

[0026] FIG. 4 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a third embodiment not being part of the invention.

[0027] As illustrated in FIG. 4, in the third embodiment, the couchtop is divided into the couchtop 2a on which the object P is placed and a couchtop 2b that supports the couchtop 2a from the lower side of the couchtop 2a. The couchtop 2a is placed on the couchtop 2b such that the position of the couchtop 2a relative to the couchtop 2b is not changed. The couch 2 causes the couchtop 2b to move into the bore B while the couchtop 2a is placed on the couchtop 2b (in a direction indicated by the double-headed arrow A1 illustrated in FIG. 4).

[0028] The PET detector 13 is provided to the couchtop such that it is movable in the longitudinal direction of the couchtop. For example, the PET detector 13 is disposed to a groove formed on the couchtop 2b along the longitudinal direction of the couchtop 2b, and supported such that it is movable in the longitudinal direction of the couchtop 2b. The moving mechanism 20 is provided in the couchtop. For example, the moving mechanism 20 is driven by the driving device 21 and causes the PET detector 13 to move in the longitudinal direction of the couchtop 2b (in a direction indicated by the double-headed arrow A2 illustrated in FIG. 4).

[0029] That is, in the third embodiment, it is also possible to cause the PET detector 13 to move in the Z-axis direction of the bore B along with the movement of the couchtop 2b, and it is also possible to cause the PET detector 13 to move in the Z-axis direction of the bore B along the longitudinal direction of the couchtop 2b even if the position of the couchtop 2b is fixed. The PET detector 13 may be provided to the couchtop 2b in a detachable manner. In such a case, a connector connecting a control line and a power source line of the PET detector 13 is disposed to the couchtop 2b, for example.

(Fourth embodiment)

[0030] FIGS. 5 and 6 are schematic diagrams illustrating an example of the moving mechanism of a PET detector according to a fourth embodiment not being part of the invention.

[0031] As illustrated in FIG. 5, in the fourth embodiment, the couchtop is divided into the couchtop 2a on which the object P is placed and the couchtop 2b on which the couchtop 2a is placed, in the same manner as the third embodiment. The positional relation between the couchtop 2a and the couchtop 2b, and the operation of the couch 2 are the same as those in the third embodiment.

[0032] The PET detector is divided into a first PET detector 13a and a second PET detector 13b. The first PET detector 13a is disposed around the bore B while the second PET detector 13b is disposed to the couchtop. The moving mechanism is also divided into a first moving mechanism 20a and a second moving mechanism 20b. As illustrated in FIG. 5, the first moving mechanism 20a causes the first PET detector 13a to move in the gantry along the axial direction of the bore. For example, the first moving mechanism 20a is driven by a driving device 21a and causes, around the bore B, the first PET detector 13a to move along the Z-axis direction of the bore B (in a direction indicated by the double-headed arrow A1 illustrated in FIG. 5). For example, the second moving mechanism 20b is driven by a driving device 21b and causes the second PET detector 13b to move along the longitudinal direction of the couchtop 2b (in a direction indicated by the double-headed arrow A2 illustrated in FIG. 5).

[0033] FIG. 6 illustrates a view of the first PET detector 13a and the second PET detector 13b and their surroundings when viewed from the Z-axis direction of the bore B. As illustrated in FIG. 6, the first PET detector 13a and the second PET detector 13b are each formed in an arc shape. The first PET detector 13a is disposed on the upper side of the bore B such that the inner circumference side of the arc faces the bore B side. The second PET detector 13b is disposed on the couchtop 2b such that the inner circumference side of the arc faces the bore B side.

[0034] That is, in the fourth embodiment, the PET detector is divided into the first PET detector 13a provided on the gantry side and the second PET detector 13b provided on the couchtop side, and they can be caused to move independently from each other in the Z-axis direction of the bore B. Data acquisition is performed when the couchtop 2b is inserted in the bore B and the position of the first PET detector 13a and the position of the second PET detector 13b become the same position in the Z-axis direction of the bore B.

[0035] The second PET detector 13b may be provided to the couchtop 2b in a detachable manner. In such a case, a connector connecting a control line and a power source line of the second PET detector 13b is disposed to the couchtop 2b, for example. The first PET detector 13a may be controlled such that it cannot move at least in a time period when the object P is inserted.

(Fifth embodiment)

[0036] FIG. 7 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a fifth embodiment not being part of the invention.

[0037] As illustrated in FIG. 7, in the fifth embodiment, the first moving mechanism 20a illustrated in FIG. 5 causes the first PET detector 13a to move additionally in the up-down direction with an up-down moving mechanism 20d (in a direction indicated by the double-headed arrow A illustrated in FIG. 7). As illustrated in FIG. 7, the first moving mechanism 20a also causes the first PET detector 13a to move in the gantry along the axial direction of the bore.

[0038] That is, in the fifth embodiment, the first PET detector 13a can be caused to move not only in the Z-axis direction of the bore B but also in the up-down direction. As a result, the distance between the two PET detectors can be adjusted in accordance with the body size of the object P, for example.

(Sixth embodiment)

[0039] FIG. 8 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to a sixth embodiment not being part of the invention.

[0040] As illustrated in FIG. 8, in the sixth embodiment, the PET detector 13 is provided such that it can move outside the static magnetic field magnet 1. For example, as illustrated in FIG. 8, the bore cover 19 is formed such that it protrudes from the static magnetic field magnet 1 on a side where the couch 2 is not placed.

[0041] The moving mechanism 20 is provided such that it extends in a space formed inside the protruding portion of the bore cover 19. The moving mechanism 20 causes the PET detector 13 to move along the Z-axis direction of the bore B (in a direction indicated by the double-headed arrow A illustrated in FIG. 8). In addition, as illustrated in FIG. 8, the moving mechanism 20 causes the PET detector 13 to move in the gantry along the axial direction of the bore. As a result, the moving mechanism 20 causes the PET detector 13 to move inside the portion protruding from the static magnetic field magnet 1 of the bore cover 19, thereby making it possible to move the PET detector 13 outside the static magnetic field magnet 1.

[0042] That is, in the sixth embodiment, because the PET detector 13 can be caused to move outside the static magnetic field magnet 1, effect of interference between the first PET detector 13 and the magnetic field on data acquisition can be surely lessened.

(Seventh embodiment)

[0043] FIG. 9 is a schematic diagram illustrating an example of the moving mechanism of a PET detector ac-

ording to a seventh embodiment being part of the invention.

[0044] As illustrated in FIG. 9, in the seventh embodiment, the PET detector is divided into the first PET detector 13a and the second PET detector 13b. The first PET detector 13a and the second PET detector 13b are disposed such that they face to each other with respect to the Z-axis of the bore B interposed therebetween.

[0045] For example, as illustrated in FIG. 9, a retainer 30a is provided that retains the first PET detector 13a such that the first PET detector 13a is movable in the bore B. As illustrated in FIG. 9, the retainer 30a causes the first PET detector 13a to move in the gantry along the axial direction of the bore. For example, the retainer 30a causes the first PET detector 13a to move along the Z-axis direction of the bore B (in a direction indicated by the double-headed arrow A1 illustrated in FIG. 9). For example, the retainer 30a can be realized using an arm having a plurality of joints. The retainer 30a may cause the first PET detector 13a to move by being driven by a driving device or may cause the first PET detector 13a to move by being manually operated by an operator.

[0046] As illustrated in FIG. 9, the moving mechanism 20 causes the second PET detector 13b to move in the gantry along the axial direction of the bore. For example, the moving mechanism 20 causes the second PET detector 13b to move along the Z-axis direction of the bore B in coordination with the movement of the first PET detector 13a (in a direction indicated by the double-headed arrow A2 illustrated in FIG. 9). The second PET detector 13b has a width larger than that of the first PET detector 13a in the Z-axis direction of the bore B. When the width of the second PET detector 13b in the Z-axis direction of the bore B is sufficiently large, the position of the second PET detector 13b may be fixed, thereby making it possible to eliminate the moving mechanism 20.

(Eighth embodiment)

[0047] FIG. 10 is a schematic diagram illustrating an example of the moving mechanism of a PET detector according to an eighth embodiment being part of the invention.

[0048] As illustrated in FIG. 10, in the eighth embodiment, included are the first PET detector 13a, the second PET detector 13b, and a PET detector 13c.

[0049] The first PET detector 13a and the second PET detector 13b are each formed in a ring shape and each have a detection surface on the inner circumference of the ring. The first PET detector 13a and the second PET detector 13b are disposed side by side along the Z-axis of the bore B. The first PET detector 13a is caused to move in the Z-axis direction of the bore B by the first moving mechanism 20a (in a direction indicated by the double-headed arrow A1 illustrated in FIG. 10) while the second PET detector 13b is caused to move in the Z-axis direction of the bore B by the second moving mechanism 20b (in a direction indicated by the double-headed

arrow A2 illustrated in FIG. 10). As illustrated in FIG. 10, the first PET detector 13a and the second PET detector 13b are caused to move in the gantry by the first moving mechanism 20a and the second moving mechanism 20b. As a result, the distance between the first PET detector 13a and the second PET detector 13b are arbitrarily adjusted.

[0050] The PET detector 13c has a detection surface that is approximately perpendicular to the Z-axis direction of the bore B. The PET detector 13c is caused to move along the Z-axis direction of the bore B by a moving mechanism 20c (in a direction indicated by the double-headed arrow A3 illustrated in FIG. 10). As illustrated in FIG. 10, the PET detector 13c is also caused to move in the gantry by the moving mechanism 20c. The moving mechanism 20c causes the PET detector 13c to move to a position adjacent to the first PET detector 13a in the Z-axis direction of the bore B.

[0051] FIGS. 11 and 12 are schematic diagrams each illustrating an example of effective imaging regions of the PET-MRI apparatus according to the eighth embodiment. In FIGS. 11 and 12, the PET detectors and the bore cover 19 are illustrated but illustration of other components is omitted.

[0052] FIG. 11 illustrates an example of effective imaging regions when the PET detector 13c (not illustrated) is distantly separated from the first PET detector 13a. In this case, a region 31 surrounded by the inner circumference of the first PET detector 13a, a region 32 surrounded by the inner circumference of the second PET detector 13b, and a region 33 formed between the inner circumference of the first PET detector 13a and the inner circumference of the second PET detector 13b are the respective effective imaging regions in which PET images can be taken. A straight line 34 illustrated in FIG. 11 indicates the central position in the axial direction of the bore B and a spherical region 35 illustrated in FIG. 11 is the effective imaging region of MR images.

[0053] FIG. 12 illustrates the effective imaging regions when the PET detector 13c is placed adjacent to the first PET detector 13a. In this case, in addition to the regions 31 to 33 illustrated in FIG. 11, a region 36 formed between the detection surface of the PET detector 13c and the inner circumference of the first PET detector 13a, and a region 37 formed between the detection surface of the PET detector 13c and the inner circumference of the second PET detector 13b serve as the additional effective imaging regions in which PET images can be taken.

[0054] As is obvious also from FIGS. 11 and 12, by placing the PET detector 13c adjacent to the first PET detector 13a, the detection probability of gamma rays emitted from the object P inside the first PET detector 13a can be increased. As a result, the spatial resolution of PET images inside the first PET detector 13a can be increased. FIGS. 11 and 12 each illustrate an example when the head portion of the object P is disposed inside the first PET detector 13a. Similar effect can be obtained also in a case where the foot portion of the object P is

disposed there. That is, imaging performed by placing the PET detector 13c adjacent to the first PET detector 13a is preferable when an end portion of the object P is imaged.

[0055] In the above-described embodiments, the moving mechanisms of the PET detectors are described. For example, the position of the PET detector caused to move by the moving mechanisms may be detected and the detected position of the PET detector may be displayed on a display unit. In such a case, the computer 10 illustrated in FIG. 1 acquires the amount of movement from the driving device driving the moving mechanism or the position of the PET detector from a position sensor provided to the PET detector, for example. Then, the computer 10 causes the display 12 to display the detected position of the PET detector together with a PET image and an MR image, for example. Meanwhile, the computer 10 may display the position of the magnetic field center together with them.

[0056] In the above-described embodiments, the examples are described in which the moving mechanisms are caused to be driven by the driving devices. However, for example, the moving mechanism may be manually operated by an operator.

[0057] The dispositions of the PET detectors and the structures of the moving mechanisms described in the above-described embodiments can be arbitrarily combined and implemented. For example, the fourth embodiment illustrated in FIG. 5 may be combined with the sixth embodiment illustrated in FIG. 8 so as to provide the first PET detector 13a disposed on the upper side of the bore B in such a manner that the first PET detector 13a can move outside the static magnetic field magnet 1. In such a case, the bore cover 19 is formed such that it protrudes from the static magnetic field magnet 1 on the side where the couch 2 is not placed, and the first moving mechanism 20a is provided such that it extends in a space formed inside the protruding portion of the bore cover 19.

[0058] The respective embodiments described above can lessen effects of interference between the PET detector and the magnetic field on data acquisition.

[0059] While the embodiments of the present invention have been described, the embodiments have been presented by way of examples only, and are not intended to limit the scope of the invention. The embodiments described herein may be implemented in other various forms.

Claims

1. A positron emission tomography (PET)-magnetic resonance imaging (MRI) apparatus (100), comprising:

a gantry including:

a static magnetic field magnet (1) config-

ured to generate a static magnetic field in a bore having an approximately cylindrical shape;

a gradient coil (3) disposed on an inner circumference side of the static magnetic field magnet (1) and configured to apply a gradient magnetic field to an object disposed in the bore; and

a radio frequency coil (5) disposed on an inner circumference side of the gradient coil (3) and configured to apply a radio frequency magnetic field to the object; and

a PET detector (13a,13c) configured to detect gamma rays emitted from a positron-emitting radionuclide injected into the object;

CHARACTERISED BY:

a retainer (30a) or a moving mechanism (20c) supported by the static magnetic field magnet outside the gantry and configured to cause the PET detector (13a, 13c) to move in the gantry along the axial direction of the bore.

2. The PET-MRI apparatus (100) according to claim 1, wherein the PET detector (13a) is a first PET detector (13a), the PET-MRI apparatus further comprising:

a bore cover (19) configured to cover an inner circumference side of the radio frequency coil, and

a second PET detector (13b) disposed between the radio frequency coil (5) and the bore cover (19).

3. The PET-MRI apparatus (100) according to claim 2, further comprising a radio frequency shield (18) disposed between the gradient coil (3) and the radio frequency coil (5) and configured to shield the radio frequency magnetic field generated by the radio frequency coil (5), wherein the second PET detector (13b) is disposed between the gradient coil (3) and the radio frequency shield (18).

4. The PET-MRI apparatus according to claim 1, wherein the PET detector (13a, 13c) is a first PET detector (13a, 13c) and the retainer (30a) or the moving mechanism (20c) is a first moving mechanism (30a,20c), the PET-MRI apparatus further comprising:

a couchtop on which the object is placed;

a couch (2) configured to cause the couchtop to move into the bore with the longitudinal direction of the couchtop being along the axial direction of the bore;

a second PET detector (13b, 13a) configured to

- be movable in the longitudinal direction of the couchtop; and
a second moving mechanism (20,20a) configured to cause the second PET detector (13b,13a) to move in the longitudinal direction of the couchtop.
5. The PET-MRI apparatus (100) according to claim 4, the first moving mechanism (20c) cause the first PET detector (13c) to move independently from the second PET detector (13a). 10
6. The PET-MRI apparatus (100) according to claim 4, , wherein the first moving mechanism (30a) causes the first PET detector (13a) to move along the axial direction of the bore in coordination with movement of the second PET detector (13b). 15
7. The PET-MRI apparatus (100) according to claim 4 or 6, wherein the second PET detector (13b) has a width larger than the width of the first PET detector (13a) in the axial direction of the bore. 20
8. The PET-MRI apparatus according to claim 4 or 5, wherein 25
- the second PET detector (13a) is formed in a ring shape and has a detection surface on an inner circumference of the ring and
the first PET detector (13c) has a detection surface that is approximately perpendicular to the axial direction of the bore, and
the first moving mechanism (20c) causes the first PET detector (13c) to move to a position adjacent to the second PET detector (13a) in the axial direction of the bore. 30 35
9. The PET-MRI apparatus according to any one of claims 1 to 8, further comprising: 40
- a position detection unit (10) configured to detect a position of the PET detector (13a,13c); and
a display unit (12) configured to display the position of the PET detector (13a, 13c) detected by the position detection unit (10). 45
10. The PET-MRI apparatus (100) according to any one of claims 1 to 9, wherein the PET detector (13a,13c) is provided such that the PET detector (13a,13c) is capable of moving outside the static magnetic field magnet (1). 50
11. The PET-MRI apparatus (100) according to any one of claims 1 to 10, wherein the moving mechanism (20c) causes the PET detector (13a, 13c) to additionally move in the up-down direction. 55

Patentansprüche

1. Positronen-Emissions-Tomografie- bzw. PET-Magnetresonanz-Bildgebung- bzw. -MRI-Vorrichtung (100), umfassend:

ein Portal, enthaltend:

einen Magneten für ein statisches Magnetfeld (1), konfiguriert zum Erzeugen eines statischen Magnetfelds in einer Bohrung mit einer ungefähr zylindrischen Form;
eine Gradientenspule (3), angeordnet an einer inneren Umfangsseite des Magneten für ein statisches Magnetfeld (1) und konfiguriert zum Anwenden eines Funkfrequenzmagnetfelds auf das Objekt; und
eine Funkfrequenzspule (5), angeordnet an einer inneren Umfangsseite der Gradientenspule (3), und konfiguriert zum Anwenden eines Funkfrequenzmagnetfelds auf das Objekt; und
einen PET-Detektor (13a, 13c), konfiguriert zum Detektieren von Gammastrahlen, abgegeben von einem in das Objekt injizierten Positronen abgebenden Radionuklid;

gekennzeichnet durch:

eine Halterung (30a) oder einen Bewegungsmechanismus (20c), getragen durch den Magneten für das statische Magnetfeld außerhalb des Portals und konfiguriert zum Bewirken, dass der PET-Detektor (13a, 13c) sich in das Portal entlang der Axialrichtung der Bohrung bewegt.

2. PET-MRI-Vorrichtung (100) nach Anspruch 1, wobei der PET-Detektor (13a) ein erster PET-Detektor (13a) ist, die PET-MRI-Vorrichtung ferner umfassend:

eine Bohrungsabdeckung (19), konfiguriert zum Abdecken einer inneren Umfangsseite der Funkfrequenzspule, und
einen zweiten PET-Detektor (13b), angeordnet zwischen der Funkfrequenzspule (5) und der Bohrungsabdeckung (19).

3. PET-MRI-Vorrichtung (100) nach Anspruch 2, ferner umfassend eine Funkfrequenzabschirmung (18), angeordnet zwischen der Gradientenspule (3) und der Funkfrequenzspule (5) und konfiguriert zum Abschirmen des durch die Funkfrequenzspule (5) erzeugten Funkfrequenzmagnetfelds, wobei der zweite PET-Detektor (13b) zwischen der Gradientenspule (3) und der Funkfrequenzabschirmung (18) angeordnet ist.

4. PET-MRI-Vorrichtung nach Anspruch 1, wobei der PET-Detektor (13a, 13c) ein erster PET-Detektor (13a, 13c) ist und die Halterung (30a) oder der Bewegungsmechanismus (20c) ein erster Bewegungsmechanismus (30a, 20c) ist, die PET-MRI-Vorrichtung ferner umfassend:
- eine Couchoberseite, auf die das Objekt platziert wird;
- eine Couch (2), konfiguriert zum Bewirken, dass die Couchoberseite sich in die Bohrung bewegt, wobei die Längsrichtung der Couchoberseite entlang der Axialrichtung der Bohrung ist;
- einen zweiten PET-Detektor (13b, 13a), konfiguriert, in der Längsrichtung der Couchoberseite bewegbar zu sein; und
- einen zweiten Bewegungsmechanismus (20, 20a), konfiguriert zum Bewirken, dass der zweite PET-Detektor (13b, 13a) sich in der Längsrichtung der Couchoberseite bewegt.
5. PET-MRI-Vorrichtung (100) nach Anspruch 4, wobei der erste Bewegungsmechanismus (20c) bewirkt, dass der erste PET-Detektor (13c) sich unabhängig von dem zweiten PET-Detektor (13a) bewegt.
6. PET-MRI-Vorrichtung (100) nach Anspruch 4, wobei der erste Bewegungsmechanismus (30a) bewirkt, dass der erste PET-Detektor (13a) sich entlang der Axialrichtung der Bohrung in Koordination mit der Bewegung des zweiten PET-Detektors (13b) bewegt.
7. PET-MRI-Vorrichtung (100) nach Anspruch 4 oder 6, wobei der zweite PET-Detektor (13b) eine Breite aufweist, die in der Axialrichtung der Bohrung größer ist als die Breite des ersten PET-Detektors (13a).
8. PET-MRI-Vorrichtung nach Anspruch 4 oder 5, wobei der zweite PET-Detektor (13a) in einer Ringform gebildet ist und eine Detektionsoberfläche an einem inneren Umfang des Rings aufweist und der erste PET-Detektor (13c) eine Detektionsoberfläche aufweist, die ungefähr senkrecht zur Axialrichtung der Bohrung ist, und der erste Bewegungsmechanismus (20c) bewirkt, dass der erste PET-Detektor (13a) sich zu einer Position angrenzend ab dem zweiten PET-Detektor (13a) in der Axialrichtung der Bohrung bewegt.
9. PET-MRI-Vorrichtung nach einem der Ansprüche 1 bis 8, ferner umfassend:
- eine Positionsdetektionseinheit (10), konfiguriert zum Detektieren einer Position des PET-Detektors (13a, 13c); und

eine Anzeigeeinheit (12), konfiguriert zum Anzeigen der durch die Positionsdetektionseinheit (10) detektierten Position des PET-Detektors (13a, 13c).

10. PET-MRI-Vorrichtung (100) nach einem der Ansprüche 1 bis 9, wobei der PET-Detektor (13a, 13c) bereitgestellt ist, so dass der PET-Detektor (13a, 13c) imstande ist, sich außerhalb des Magneten für das statische Magnetfeld (1) zu bewegen.
11. PET-MRI-Vorrichtung (100) nach einem der Ansprüche 1 bis 10, wobei der Bewegungsmechanismus (20c) bewirkt, dass der PET-Detektor (13a, 13c) sich zusätzlich in der Oben-Unten-Richtung bewegt.

Revendications

1. Appareil de tomographie par émission de positrons (PET)-d'imagerie par résonance magnétique (MRI) (100), comprenant :

un portique qui inclut :

un aimant de champ magnétique statique (1) qui est configuré de manière à ce qu'il génère un champ magnétique statique dans un alésage qui présente une forme approximativement cylindrique ;

une bobine de gradient (3) qui est disposée sur un côté de circonférence interne de l'aimant de champ magnétique statique (1) et qui est configurée de manière à ce qu'elle applique un champ magnétique à gradient sur un objet qui est disposé dans l'alésage ;

et

une bobine radiofréquence (5) qui est disposée sur un côté de circonférence interne de la bobine de gradient (3) et qui est configurée de manière à ce qu'elle applique un champ magnétique radiofréquence sur l'objet ;

un détecteur de PET (13a, 13c) qui est configuré de manière à ce qu'il détecte des rayons gamma qui sont émis depuis un radionucléide d'émission de positrons qui est injecté à l'intérieur de l'objet ;

caractérisé par :

un moyen de retenue (30a) ou un mécanisme de déplacement (20c) qui est supporté par l'aimant de champ magnétique statique à l'extérieur du portique et qui est configuré de manière à ce qu'il force le détecteur de PET (13a, 13c) à se déplacer dans le portique suivant la direction axiale de l'alésage.

2. Appareil de PET-MRI (100) selon la revendication 1, dans lequel le détecteur de PET (13a) est un premier détecteur de PET (13a), l'appareil de PET-MRI comprenant en outre :

un couvercle d'alésage (19) qui est configuré de manière à ce qu'il recouvre un côté de circonférence interne de la bobine radiofréquence ; et un second détecteur de PET (13b) qui est disposé entre la bobine radiofréquence (5) et le couvercle d'alésage (19).

3. Appareil de PET-MRI (100) selon la revendication 2, comprenant en outre :

un moyen de protection contre les radiofréquences (18) qui est disposé entre la bobine de gradient (3) et la bobine radiofréquence (5) et qui est configuré de manière à ce qu'il assure une protection contre le champ magnétique radiofréquence qui est généré par la bobine radiofréquence (5) ; dans lequel :

le second détecteur de PET (13b) est disposé entre la bobine de gradient (3) et le moyen de protection contre les radiofréquences (18).

4. Appareil de PET-MRI (100) selon la revendication 1, dans lequel :

le détecteur de PET (13a, 13c) est un premier détecteur de PET (13a, 13c) ; et le moyen de retenue (30a) ou le mécanisme de déplacement (20c) est un premier mécanisme de déplacement (30a, 20c) ;

l'appareil de PET-MRI comprenant en outre :

un dessus de table d'examen sur lequel l'objet est placé ;
une table d'examen (2) qui est configurée de manière à ce qu'elle force le dessus de table d'examen à se déplacer à l'intérieur de l'alésage tandis que la direction longitudinale du dessus de table d'examen est suivant la direction axiale de l'alésage ;
un second détecteur de PET (13b, 13a) qui est configuré de manière à ce qu'il puisse être déplacé dans la direction longitudinale du dessus de table d'examen ; et
a second mécanisme de déplacement (20, 20a) qui est configuré de manière à ce qu'il force le second détecteur de PET (13b, 13a) à se déplacer dans la direction longitudinale du dessus de table d'examen.

5. Appareil de PET-MRI (100) selon la revendication

4, dans lequel le premier mécanisme de déplacement (20c) force le premier détecteur de PET (13c) à se déplacer indépendamment du second détecteur de PET (13a).

6. Appareil de PET-MRI (100) selon la revendication 4, dans lequel :

le premier mécanisme de déplacement (30a) force le premier détecteur de PET (13a) à se déplacer suivant la direction axiale de l'alésage en coordination avec le déplacement du second détecteur de PET (13b).

7. Appareil de PET-MRI (100) selon les revendications 4 ou 6, dans lequel le second détecteur de PET (13b) présente une largeur plus importante que la largeur du premier détecteur de PET (13a) dans la direction axiale de l'alésage.

8. Appareil de PET-MRI (100) selon les revendications 4 ou 5, dans lequel :

le second détecteur de PET (13a) est formé selon une forme d'anneau et il comporte une surface de détection sur une circonférence interne de l'anneau ; et

le premier détecteur de PET (13c) comporte une surface de détection qui est approximativement perpendiculaire à la direction axiale de l'alésage ; et

le premier mécanisme de déplacement (20c) force le premier détecteur de PET (13c) à se déplacer jusqu'à une position qui est adjacente au second détecteur de PET (13a) dans la direction axiale de l'alésage.

9. Appareil de PET-MRI (100) selon l'une quelconque des revendications 1 à 8, comprenant en outre :

une unité de détection de position (10) qui est configurée de manière à ce qu'elle détecte une position du détecteur de PET (13a, 13c) ; et une unité d'affichage (12) qui est configurée de manière à ce qu'elle affiche la position du détecteur de PET (13a, 13c) qui est détectée par l'unité de détection de position (10).

10. Appareil de PET-MRI (100) selon l'une quelconque des revendications 1 à 9, dans lequel le détecteur de PET (13a, 13c) est constitué de telle sorte que le détecteur de PET (13a, 13c) dispose de la capacité de se déplacer à l'extérieur de l'aimant de champ magnétique statique (1).

11. Appareil de PET-MRI (100) selon l'une quelconque des revendications 1 à 10, dans lequel le mécanisme de déplacement (20c) force le détecteur de PET

(13a, 13c) à se déplacer de façon additionnelle dans la direction haut-bas.

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FIG.1

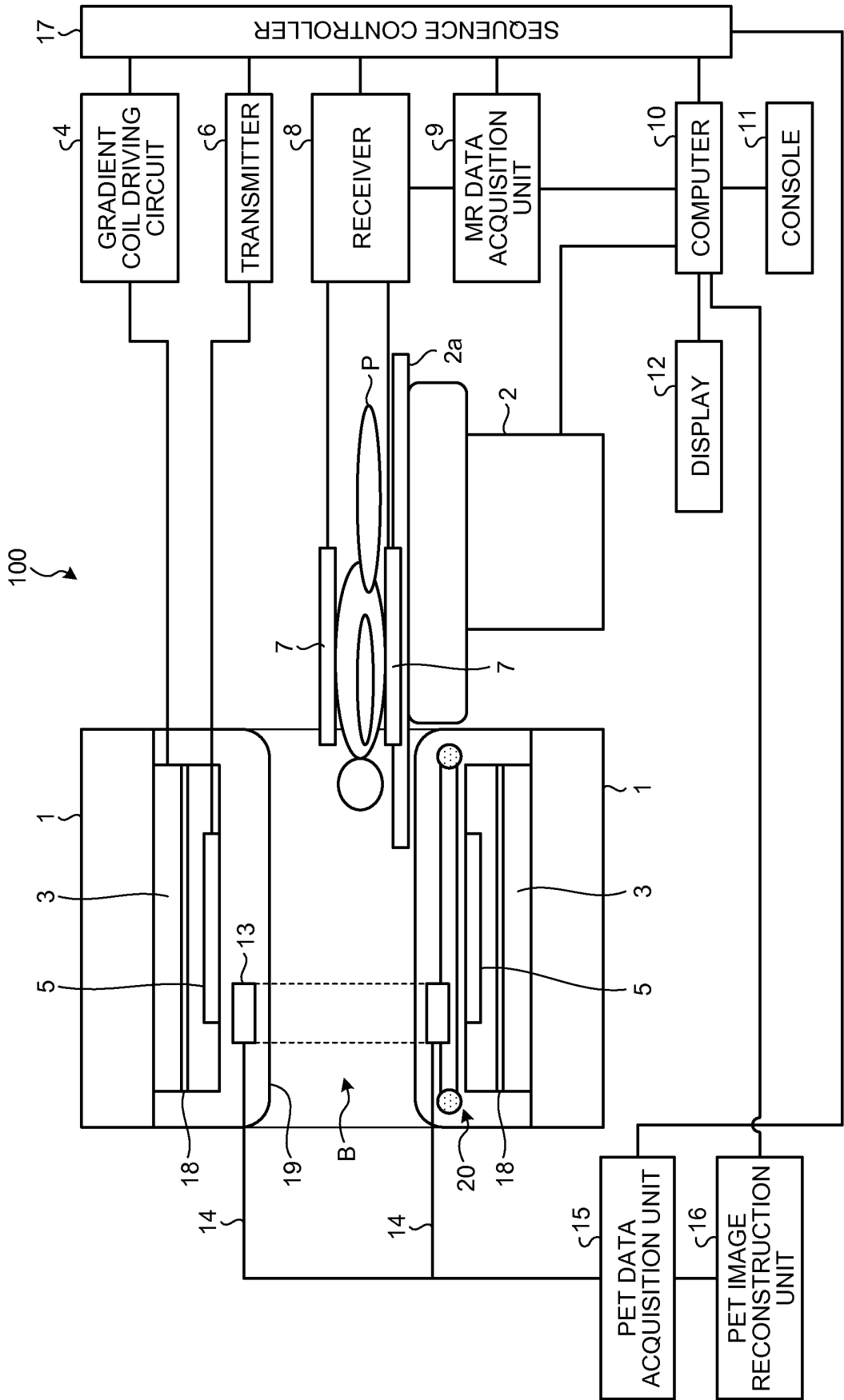


FIG.2

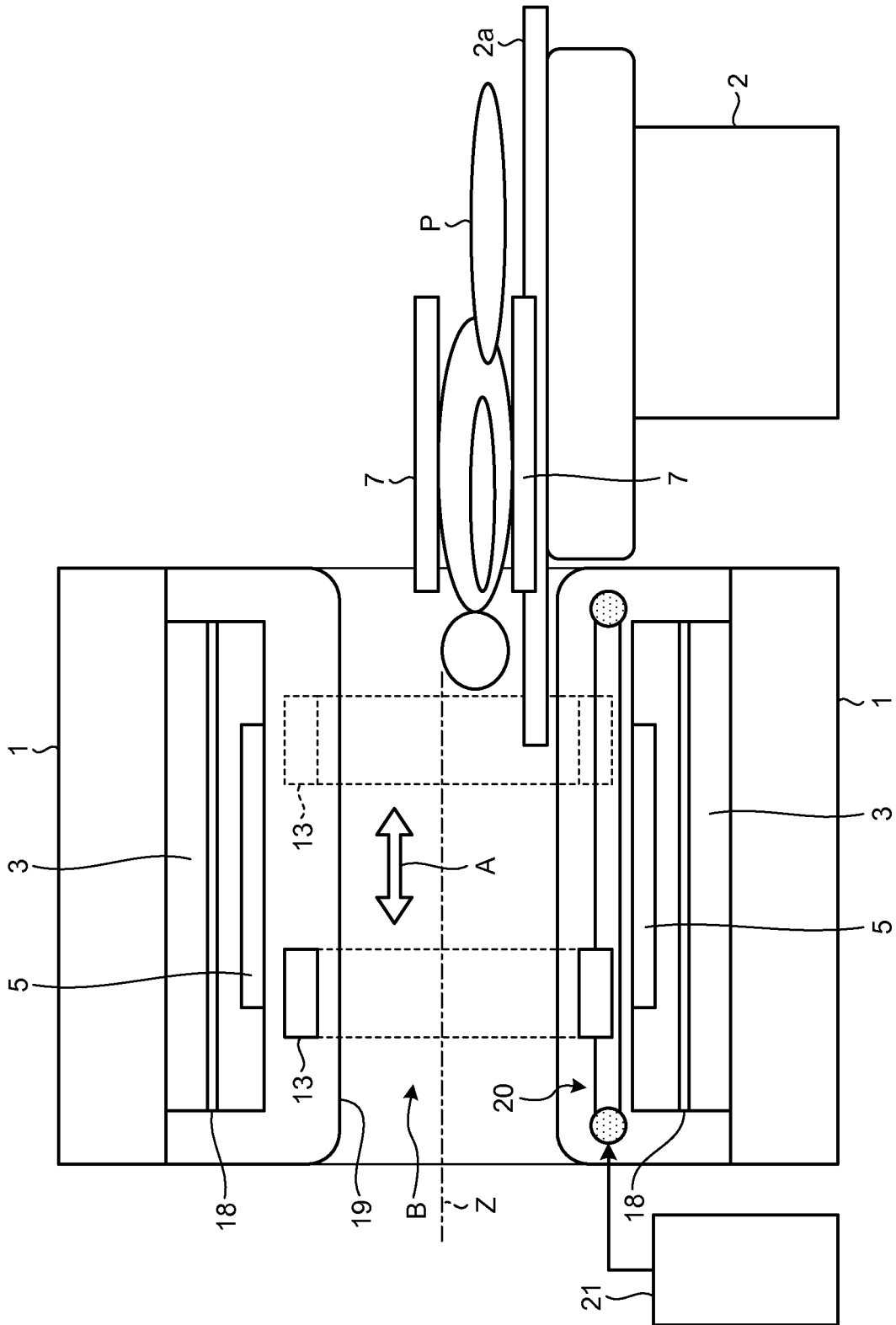


FIG.3

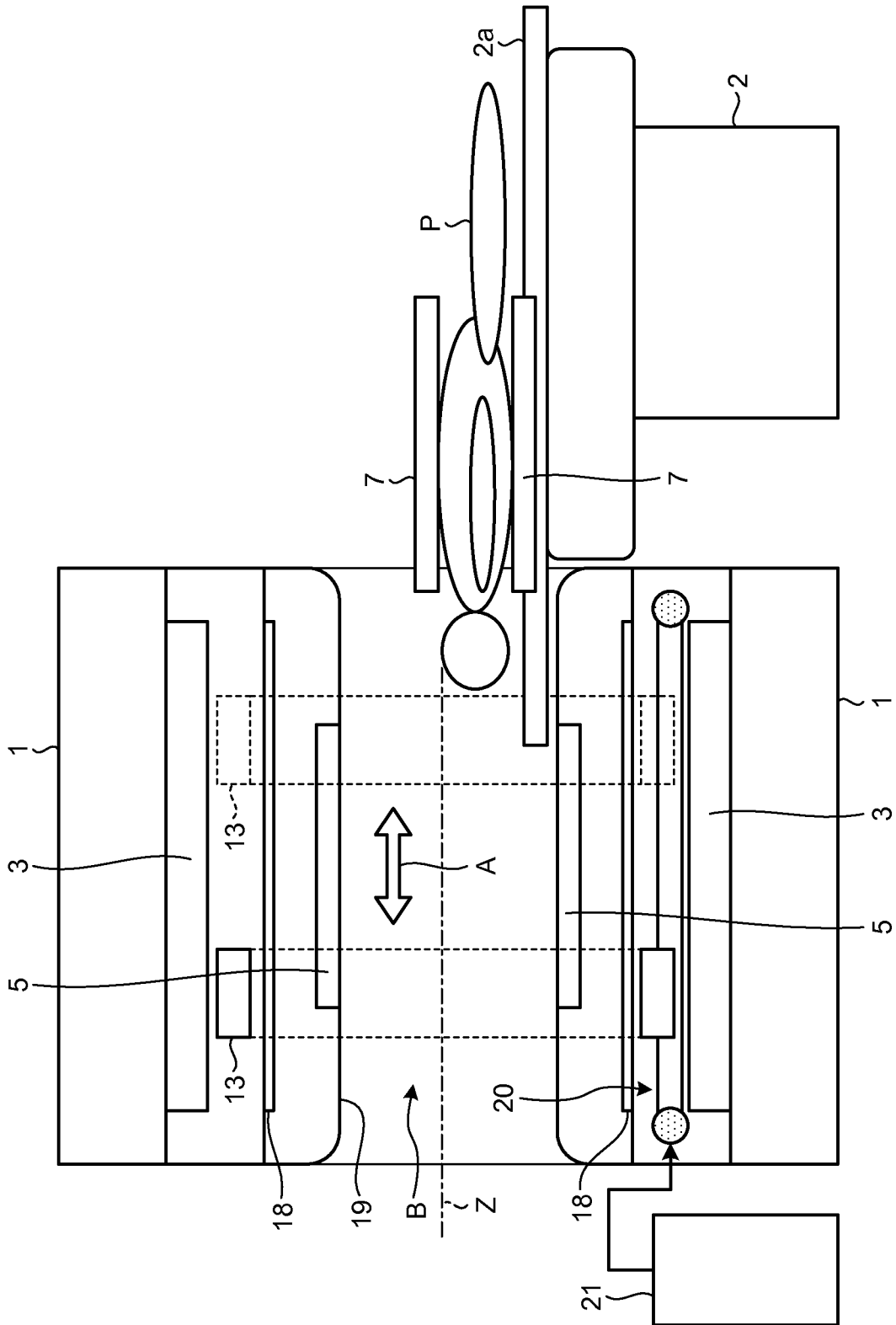


FIG.4

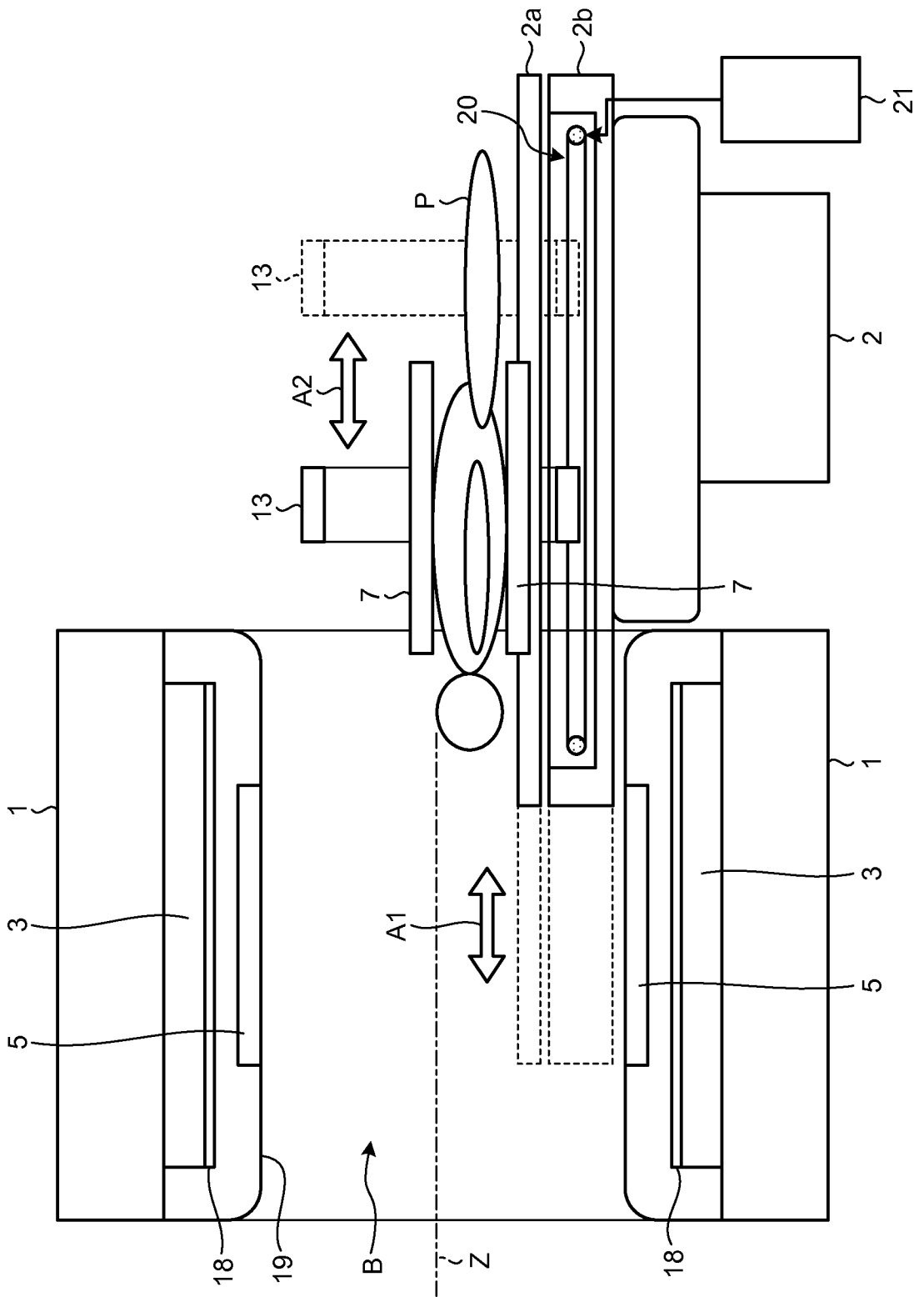


FIG.5

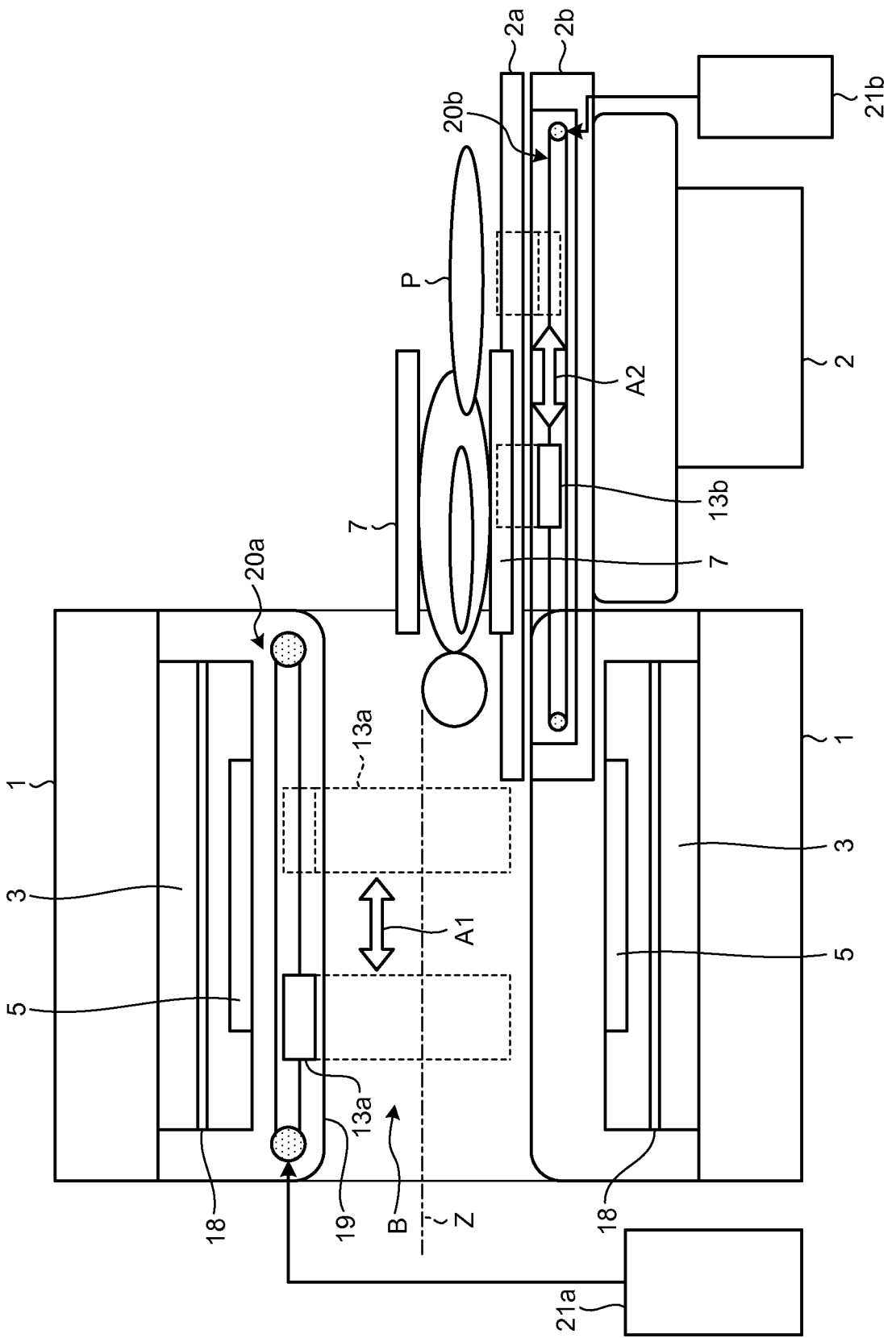


FIG.6

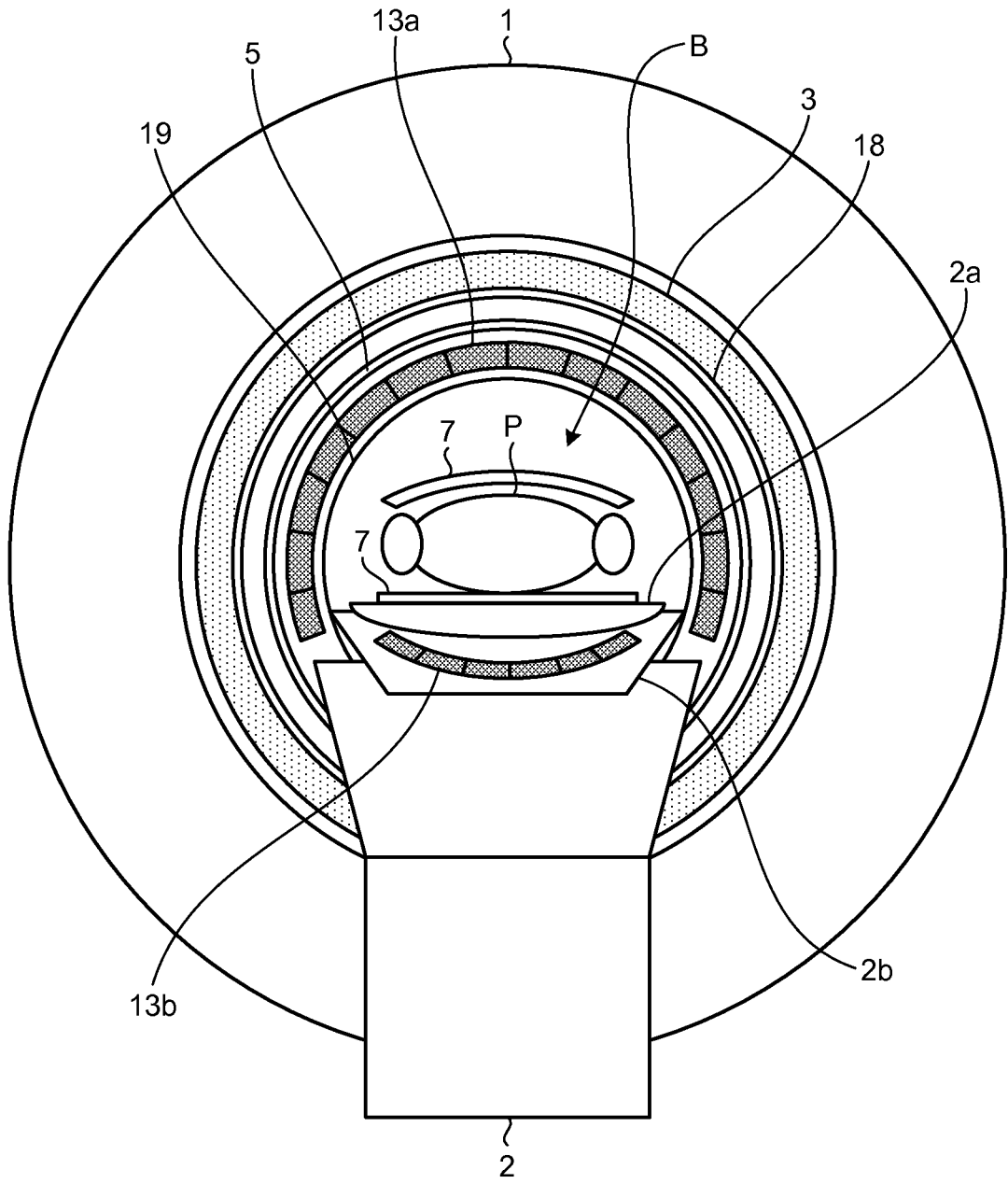


FIG.7

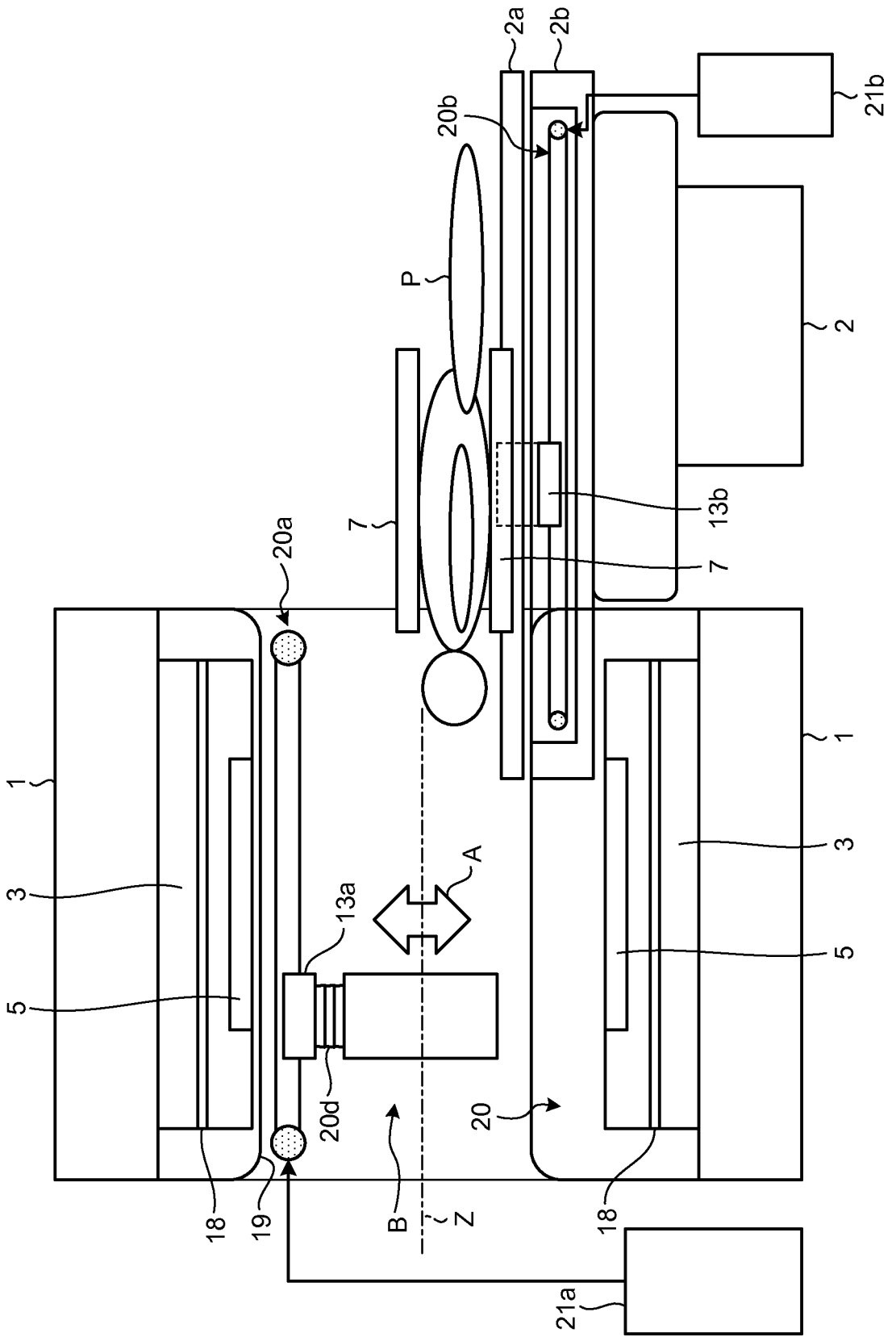


FIG.8

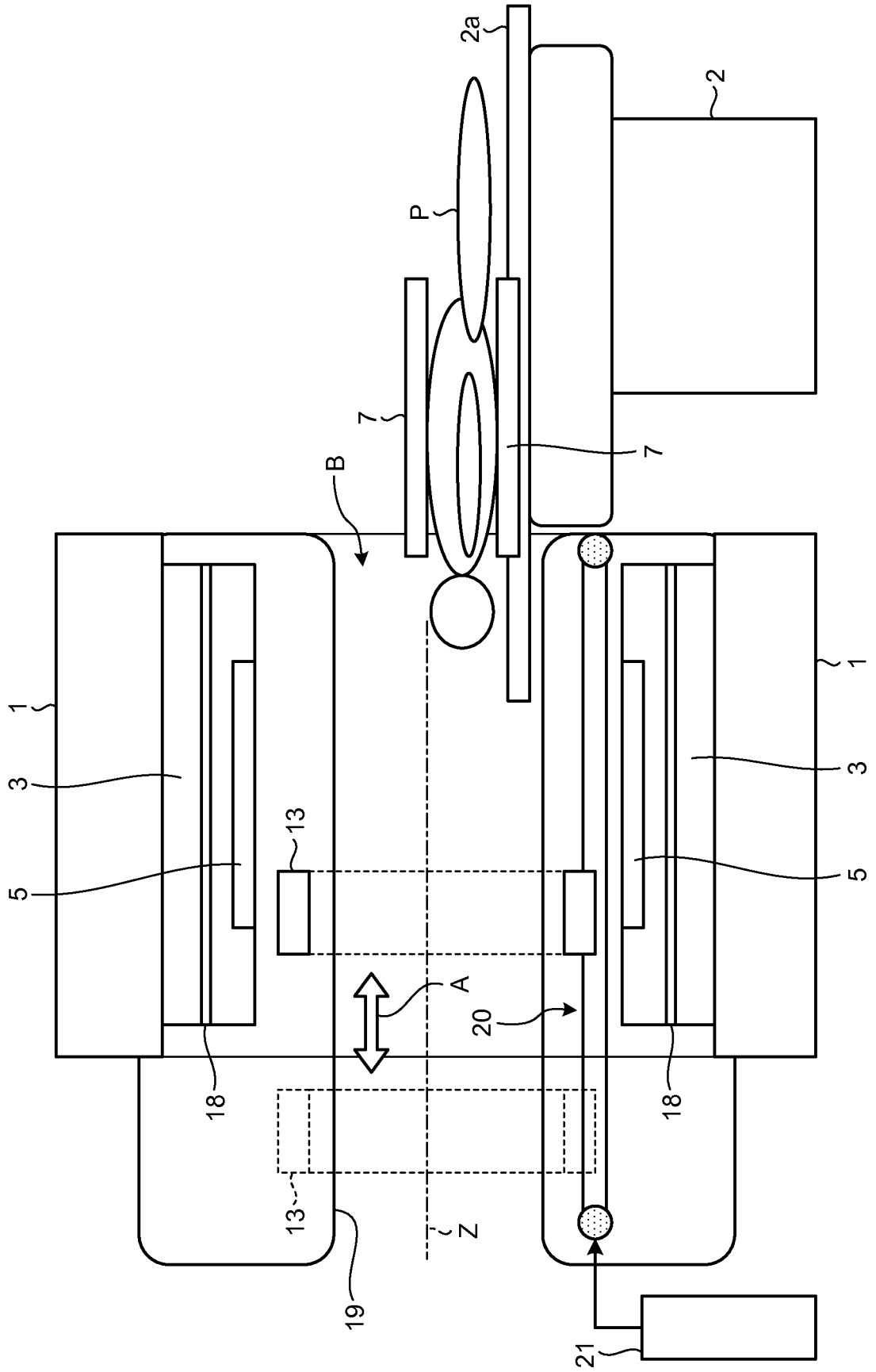


FIG.9

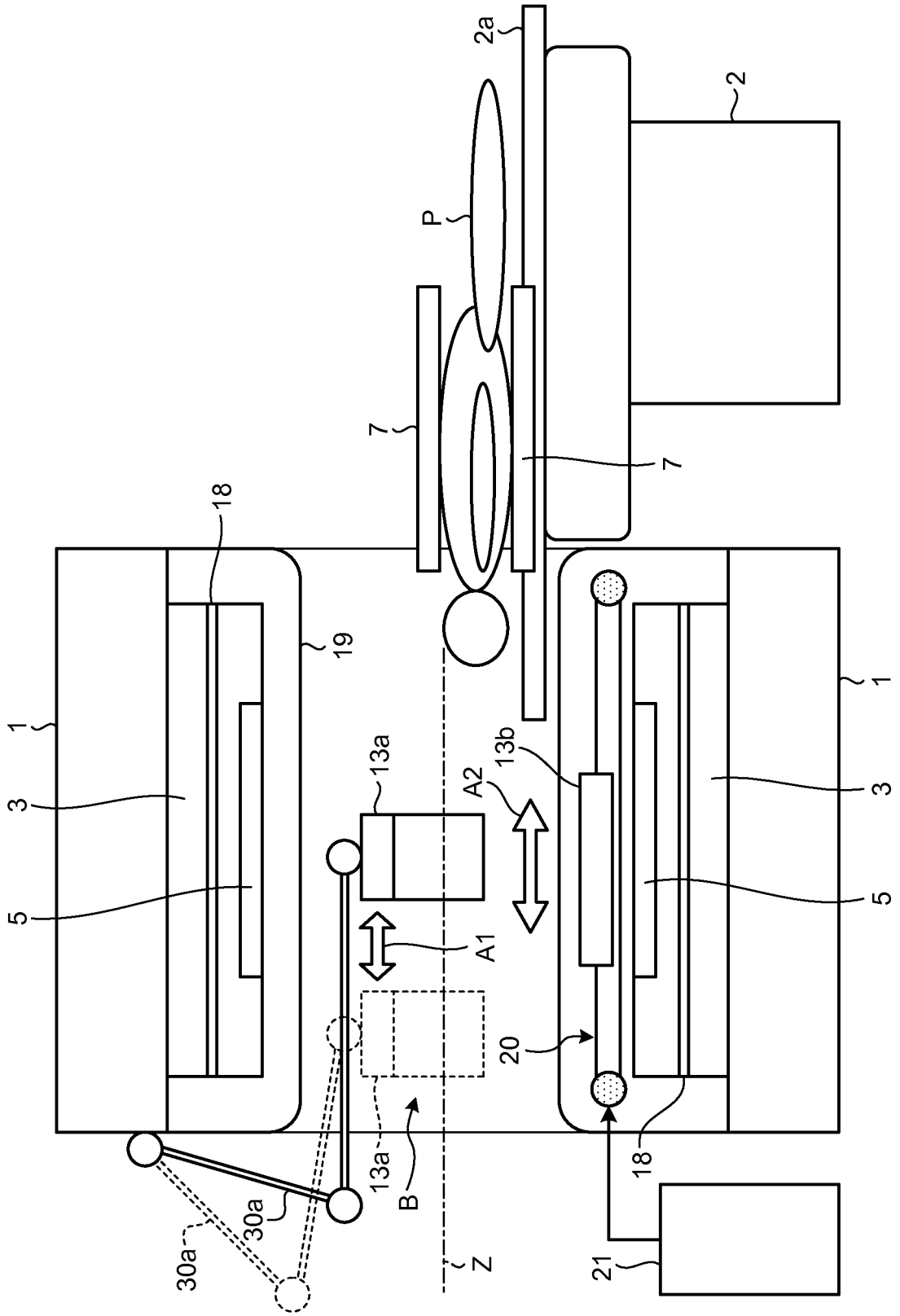


FIG.10

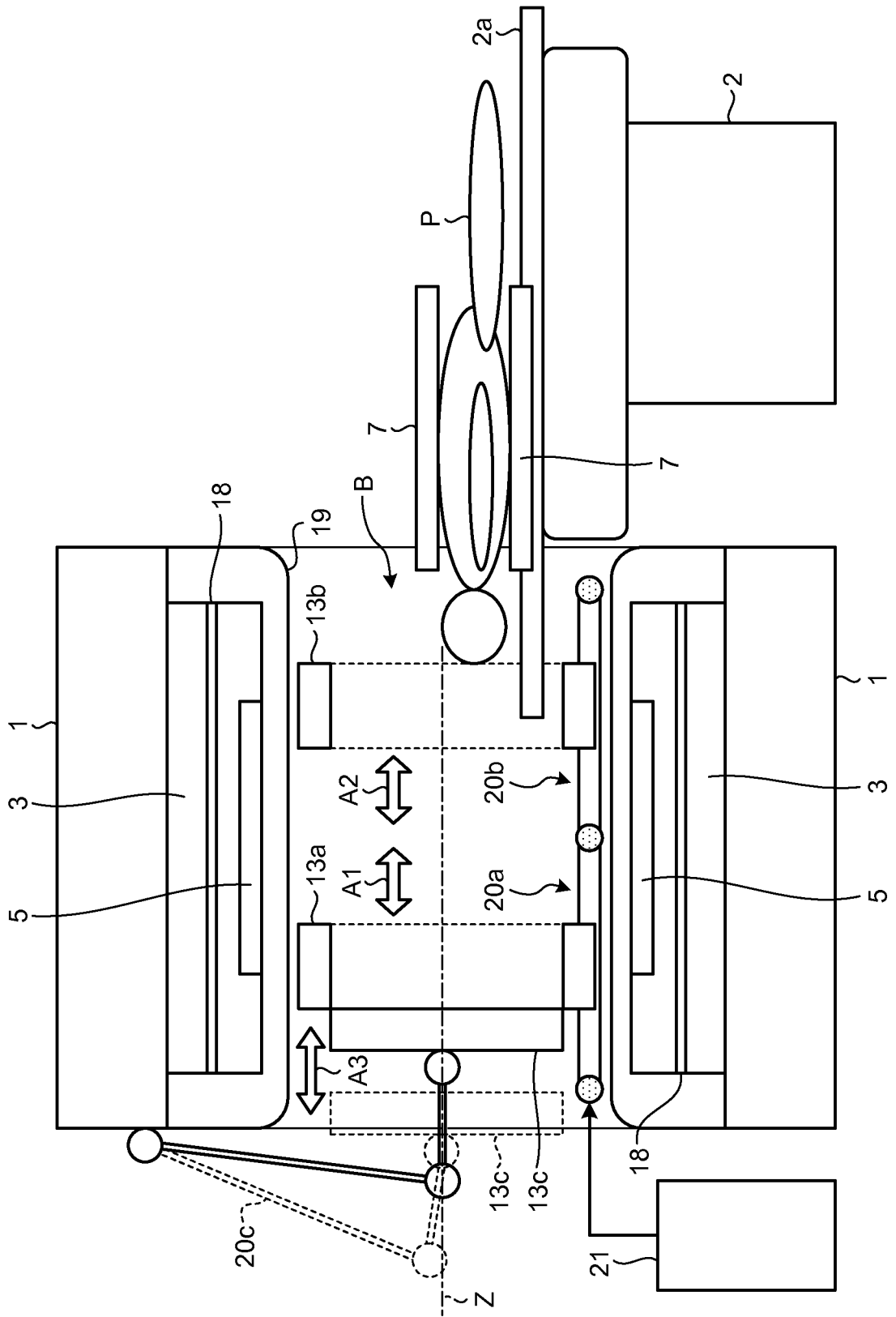


FIG.11

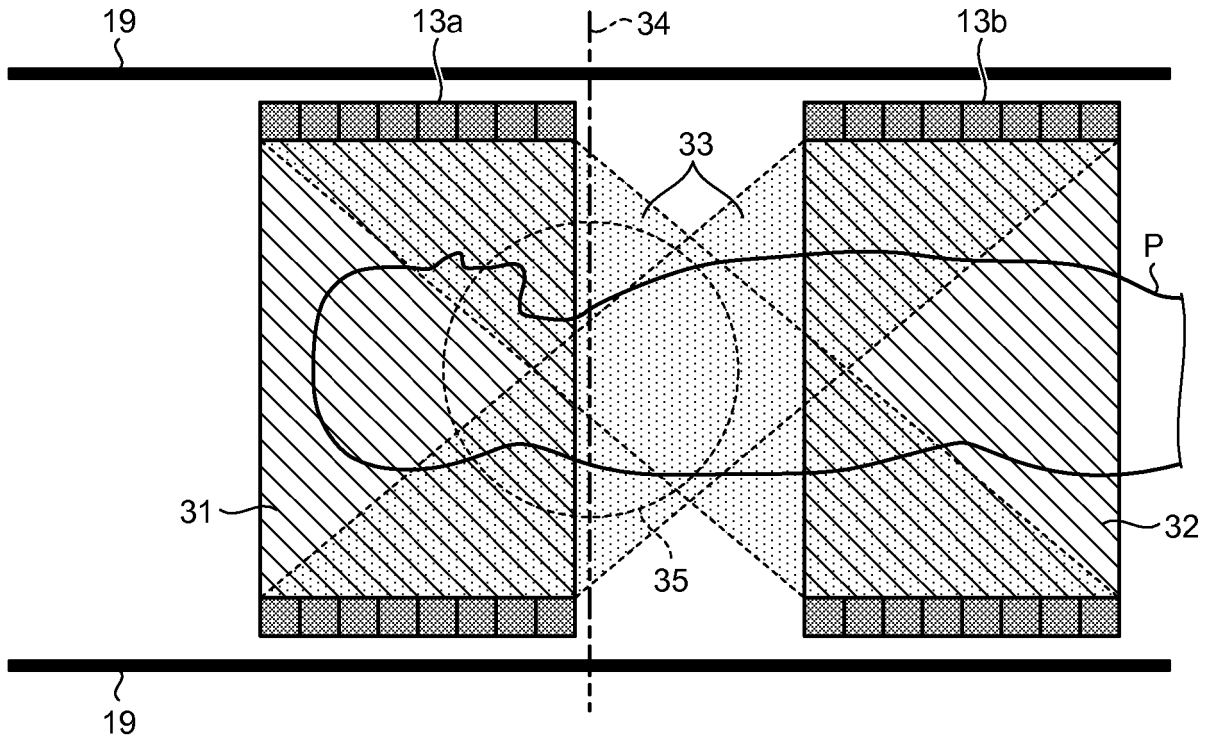
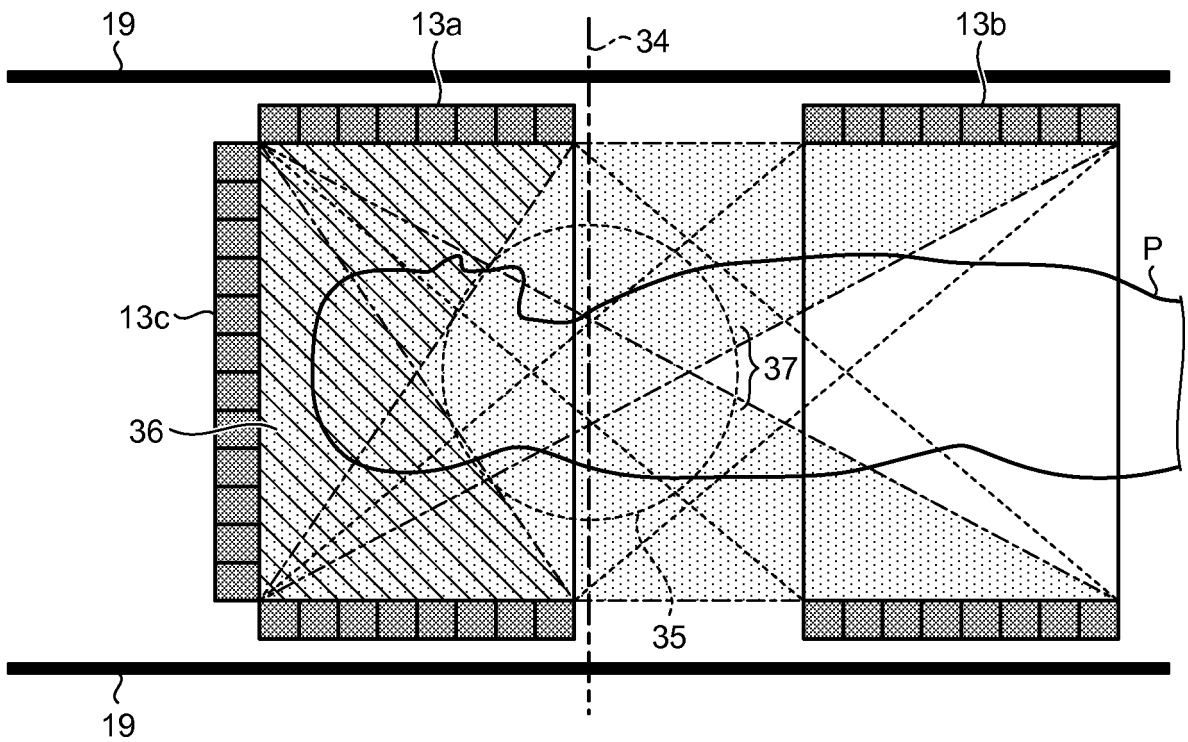


FIG.12



REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	Pet-mri设备		
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摘要(译)

根据实施例的正电子发射断层摄影 (PET) - 磁共振成像 (MRI) 设备 (100) 包括具有静磁场磁体 (1), 梯度线圈 (3) 和射频线圈 (5) 的机架PET检测器 (13,13a, 13b, 13c) 和移动机构 (20,20a, 20b, 20c)。静磁场磁体 (1) 在具有近似圆柱形状的孔中产生静磁场。梯度线圈 (3) 设置在静磁场磁体 (1) 的内周侧, 并将梯度磁场施加到设置在孔中的物体上。射频线圈 (5) 配置在梯度线圈 (3) 的内周侧, 对物体施加射频磁场。PET检测器 (13,13a, 13b, 13c) 检测从注入物体的正电子发射放射性核素发射的伽马射线。移动机构 (20,20a, 20b, 20c) 沿着孔的轴向在机架中引起PET检测器 (13,13a, 13b, 13c)。

