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(54) **POSITION DETECTING DEVICE AND IMAGE STABILIZATION DEVICE**

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(57) **ABSTRACT**

The position detecting device includes a permanent magnet unit having magnetic pole areas of N-pole and S-pole in a surface thereof, and a magnetic detection device apart from the surface by a distance. The permanent magnet unit has a main magnet element, and an auxiliary magnet element that is located closer to the magnetic detection device. The auxiliary magnet element has an N-pole auxiliary magnet part with the N-pole in the side of the surface and an S-pole auxiliary magnet part with the S-pole in the side of the surface. The main magnet element has an N-pole main magnet part on a side of the N-pole auxiliary magnet part and an S-pole main magnet part on a side of the S-pole auxiliary magnet part. The magnetic detection device is relatively movable in a direction tilted with respect to an area boundary plane that separates magnetic poles of a magnetic field generated by the permanent magnet unit, while keeping the distance. The N-pole auxiliary magnet part and the S-pole auxiliary magnet part are disposed apart from each other by a gap, and the gap is larger than a gap between the N-pole main magnet part and the S-pole main magnet part.

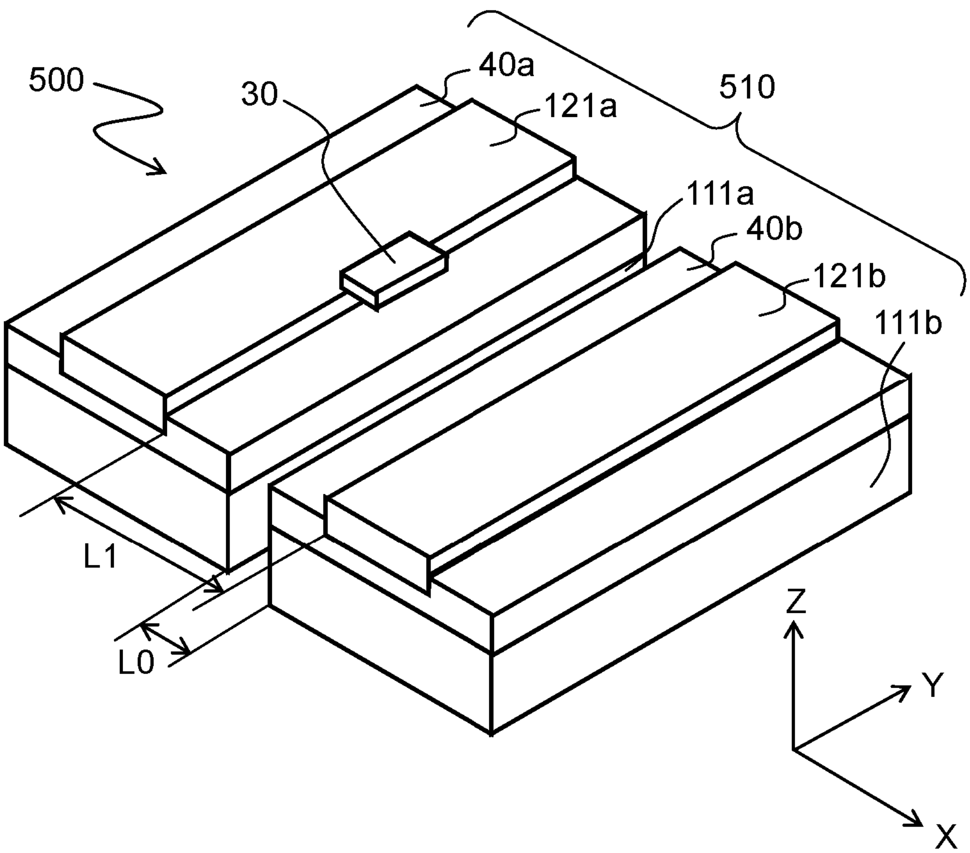


FIG. 1

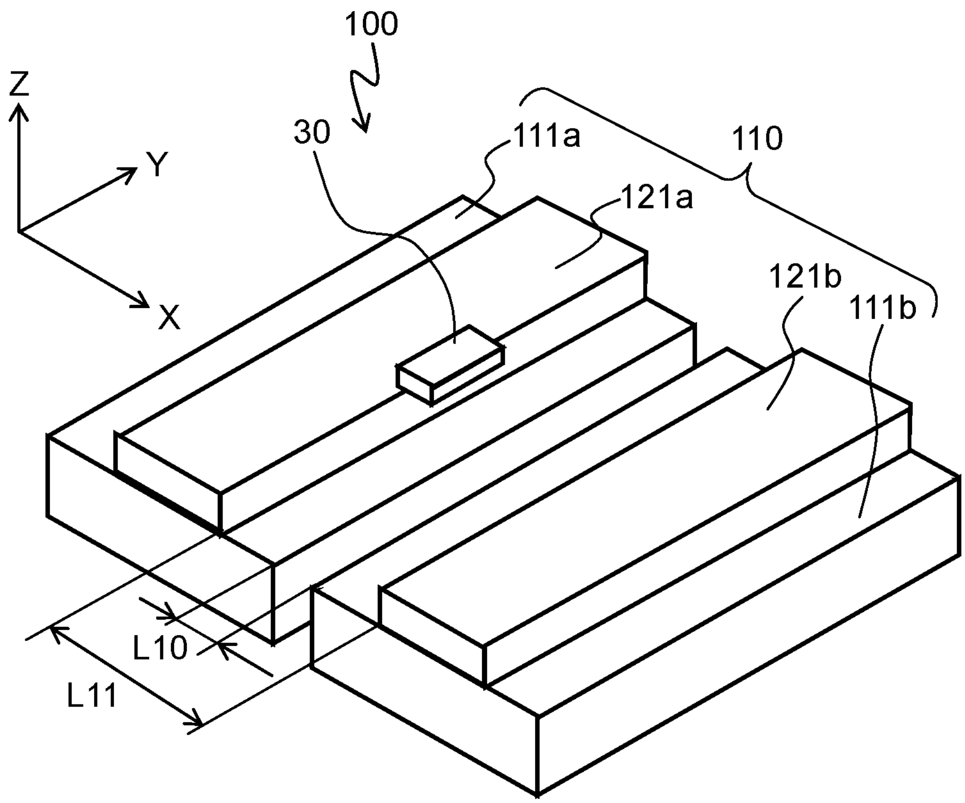

100
Z
Y
X
30
111a
110
121a
121b
111b
L10
L11

FIG. 2

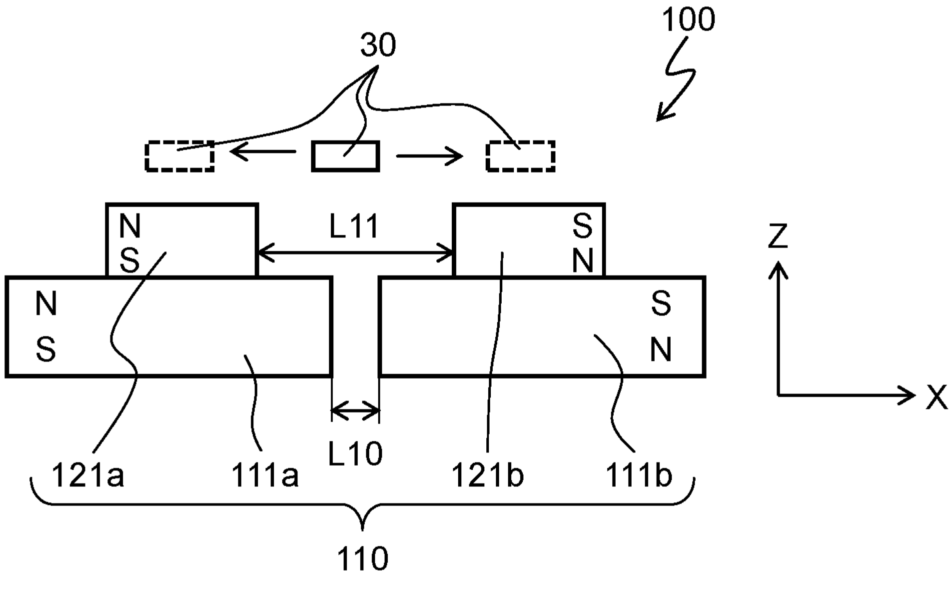

100
30
N
S
L11
S
N
N
S
S
N
Z
X
L10
121a
111a
121b
111b
110

FIG. 3

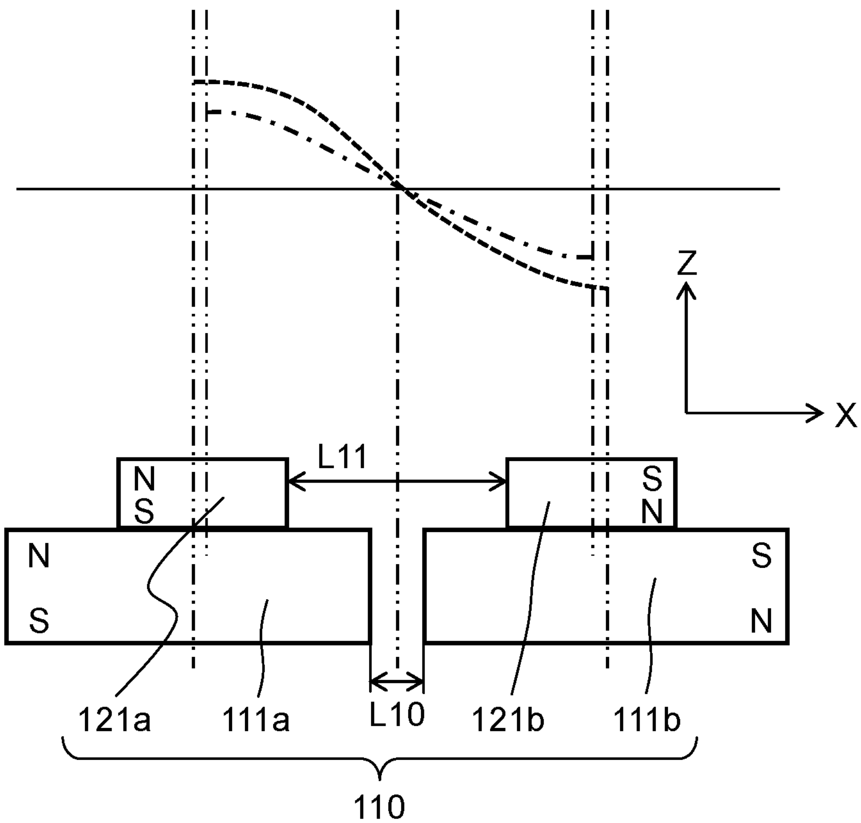


FIG. 4

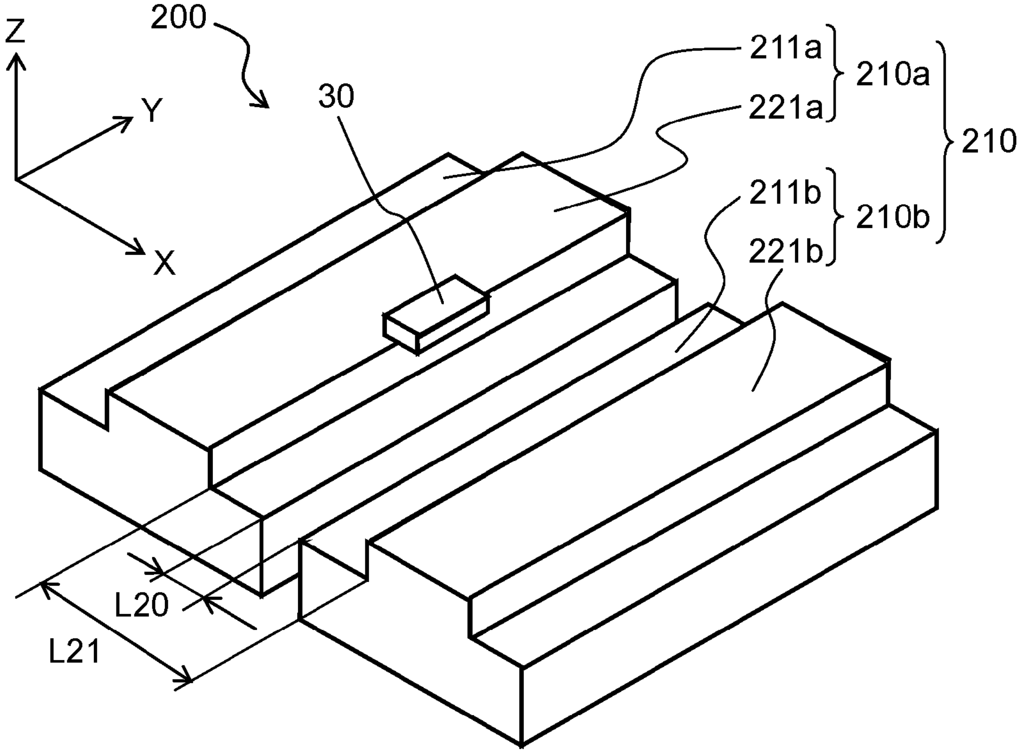

Z
Y
X
200
30
211a
210a
221a
210
211b
210b
221b
L20
L21

FIG. 5

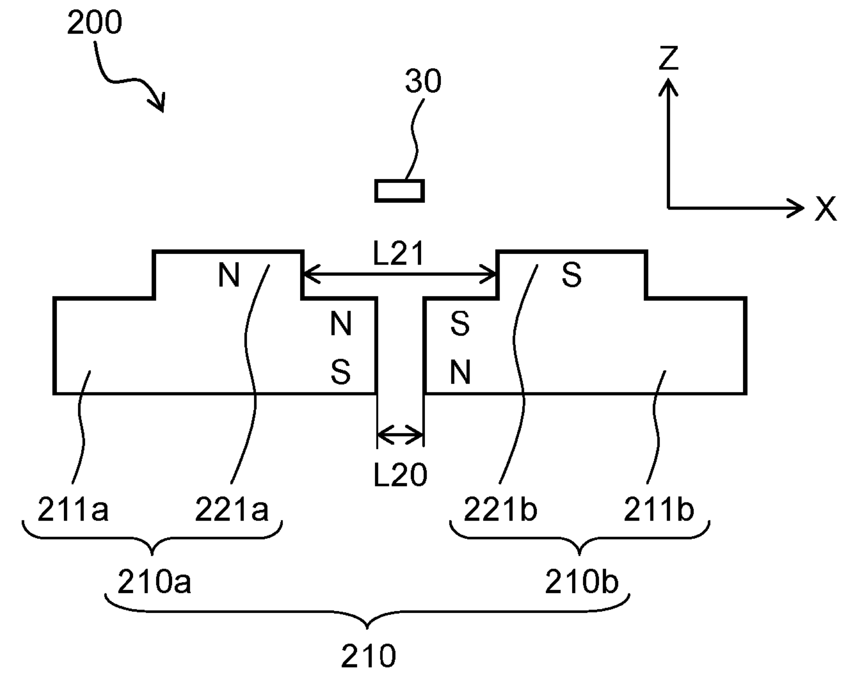

200
30
Z
X
L21
N
S
N
S
S
N
L20
211a
221a
221b
211b
210a
210b
210

FIG. 6

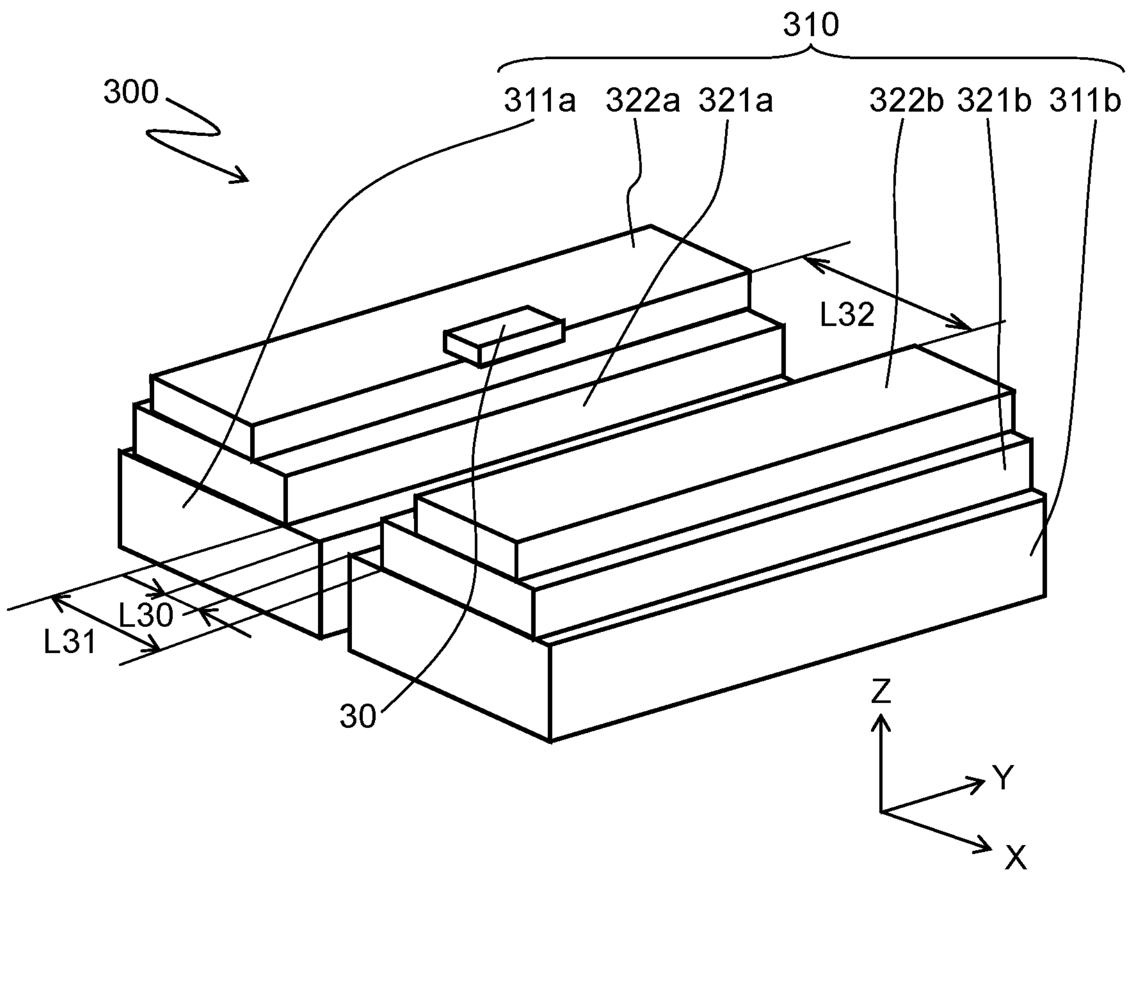
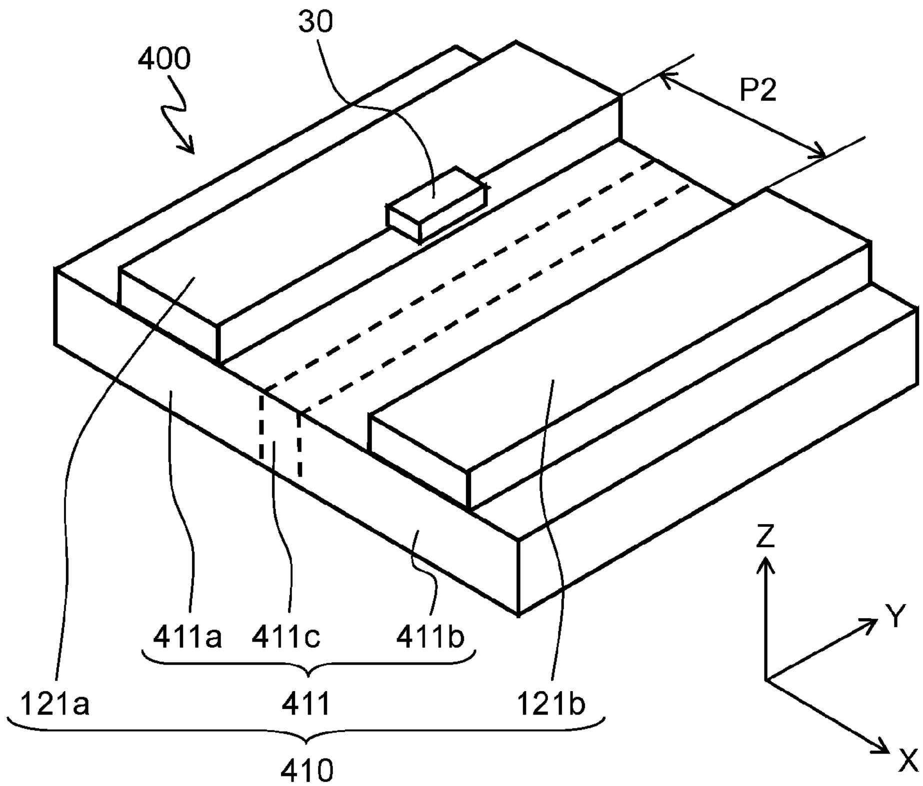
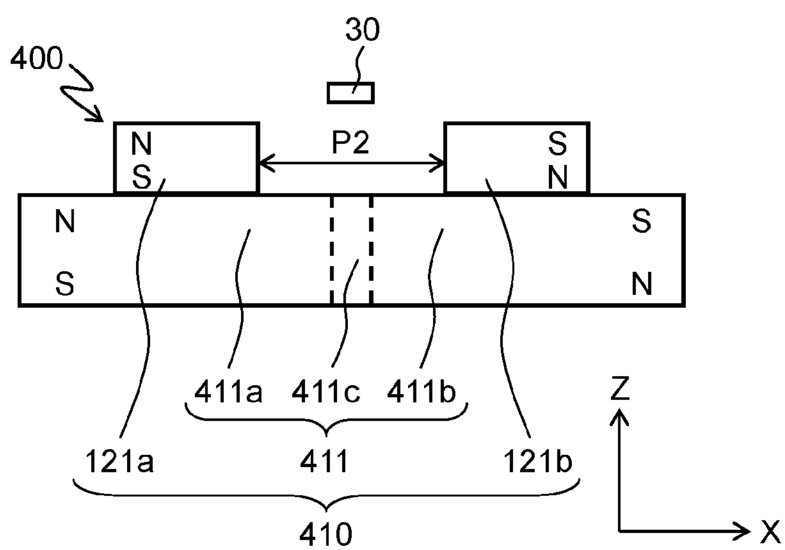


FIG. 7A



400
30
P2
Z
Y
X
411a
411c
411b
121a
411
121b
410

FIG. 7B



30
400
N
S
P2
S
N
N
S
S
N
411a
411c
411b
121a
411
121b
410
Z
X

FIG. 8A

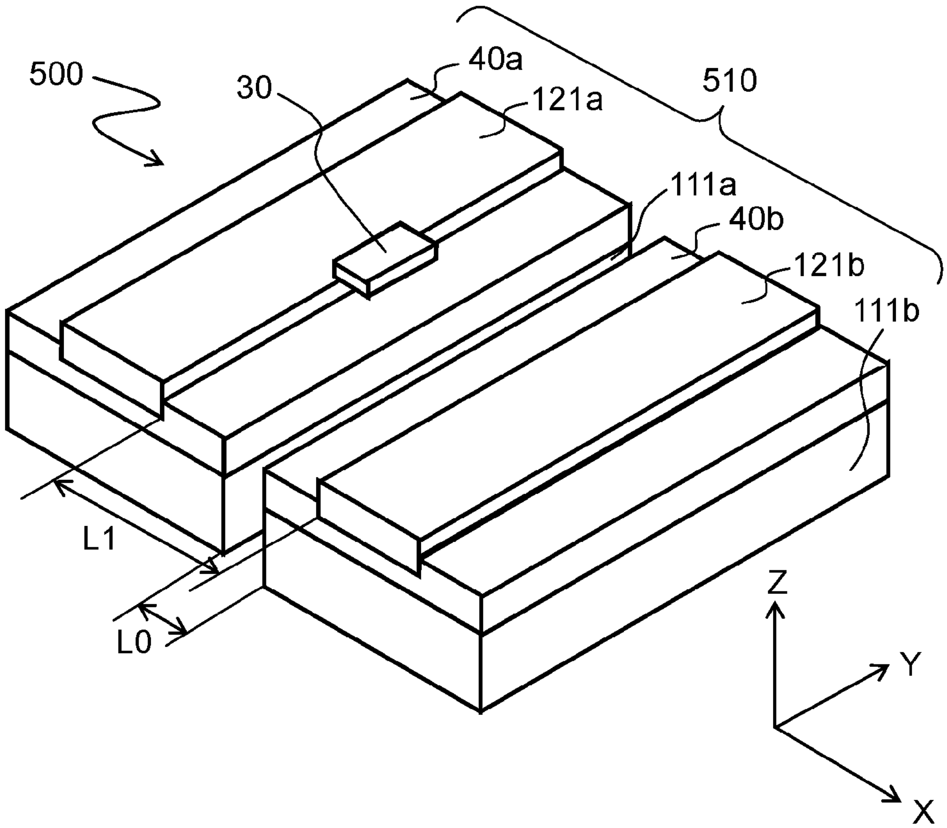

500
30
40a
121a
510
111a
40b
121b
111b
L1
L0
Z
Y
X

FIG. 8B

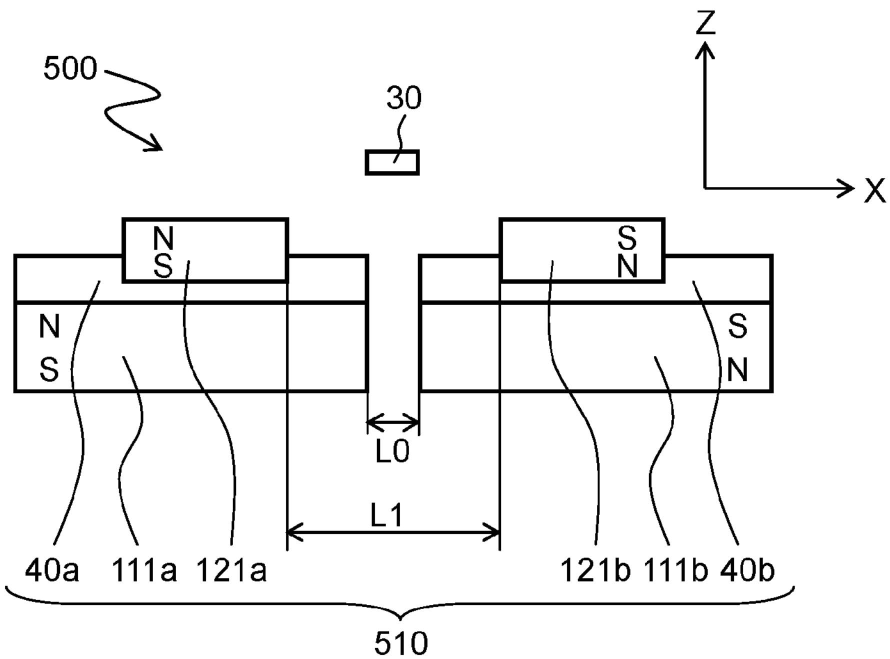

500
30
Z
X
N
S
N
S
S
N
S
N
L0
L1
40a 111a 121a
121b 111b 40b
510

FIG. 9A

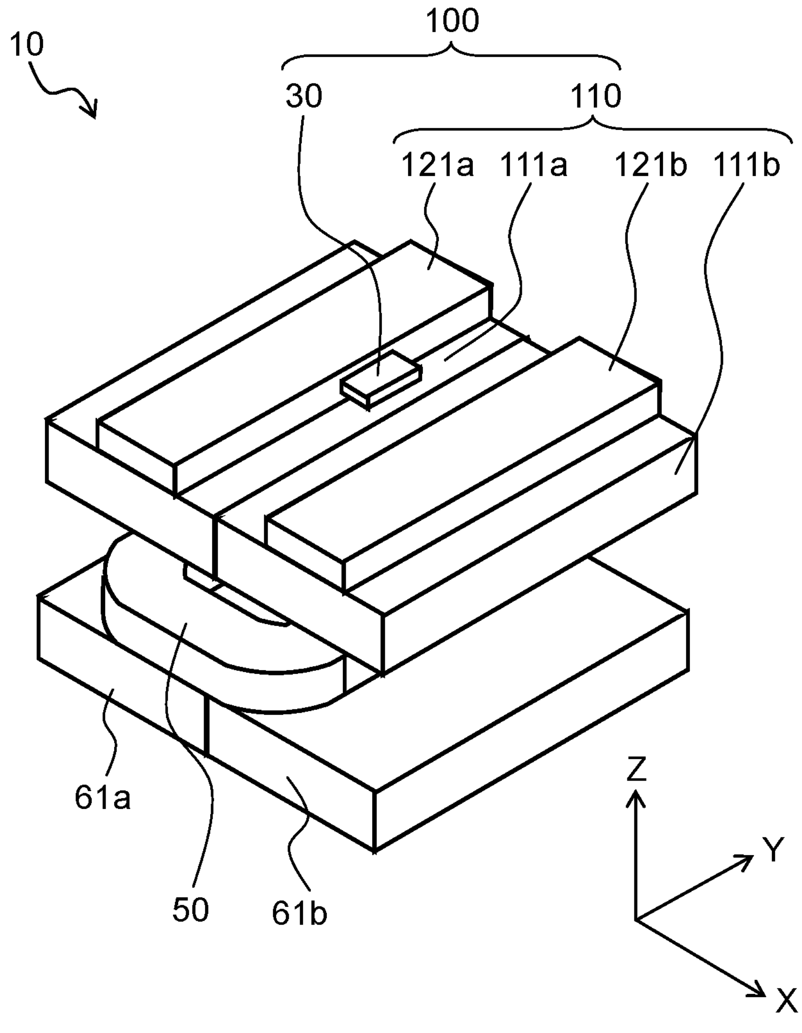


FIG. 9B

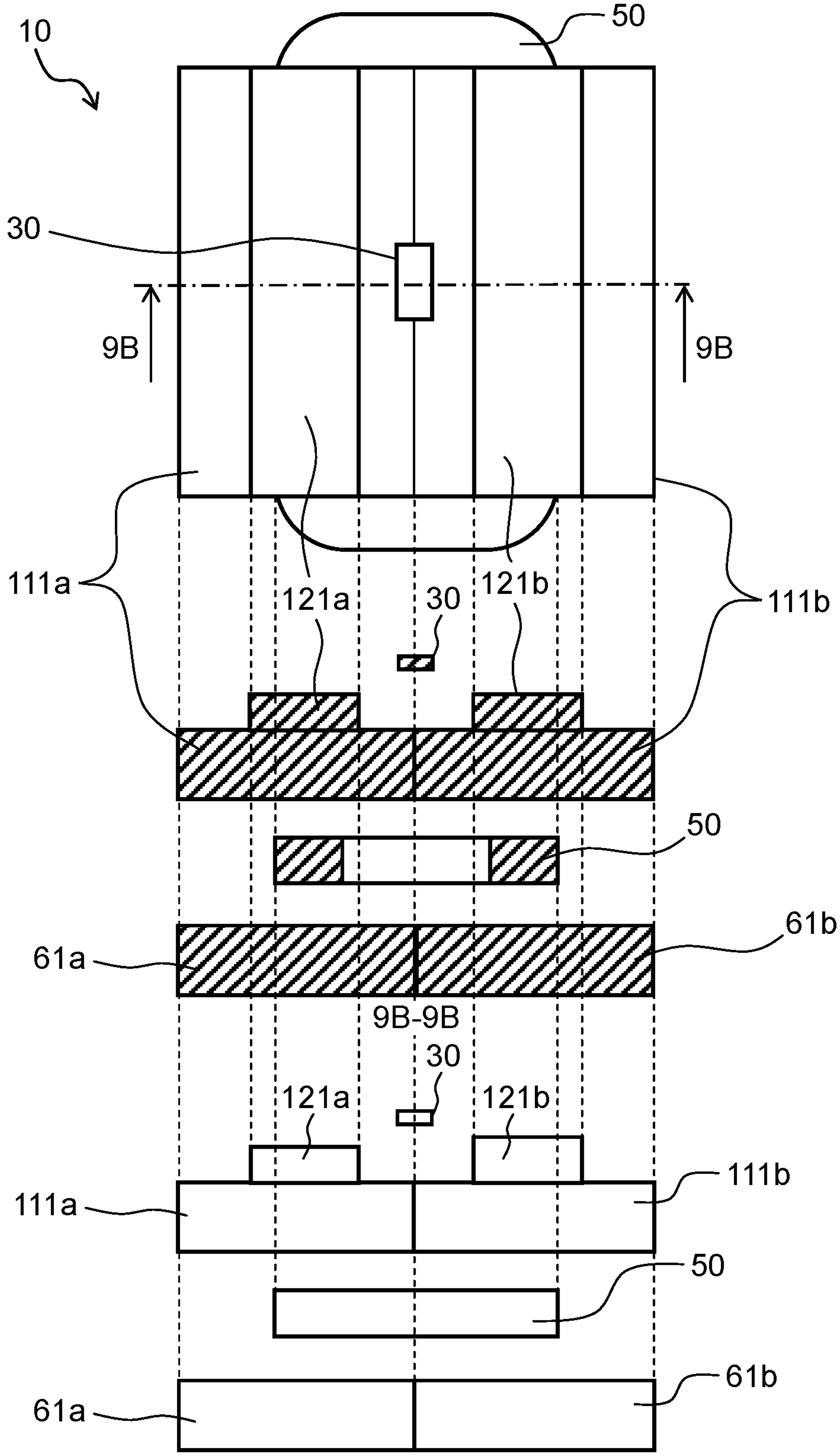

10
50
30
9B
9B
111a
121a
30
121b
111b
50
61a
61b
9B-9B
30
121a
121b
111a
111b
50
61a
61b

FIG. 10

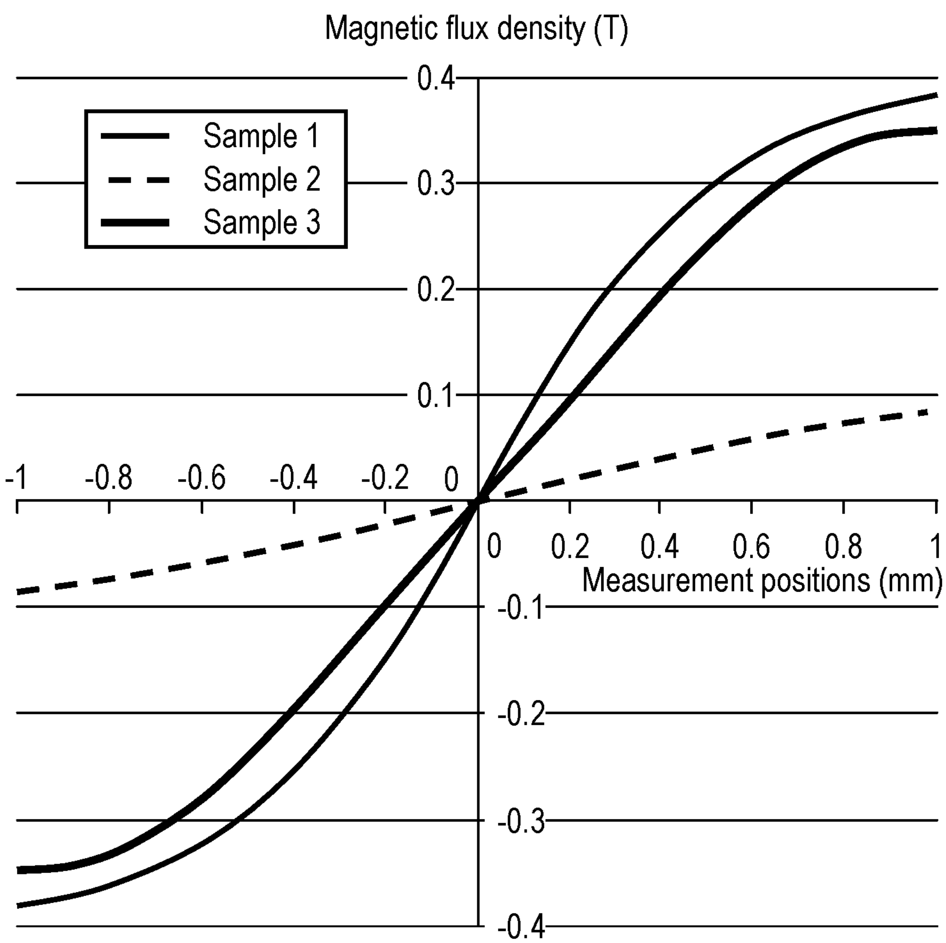
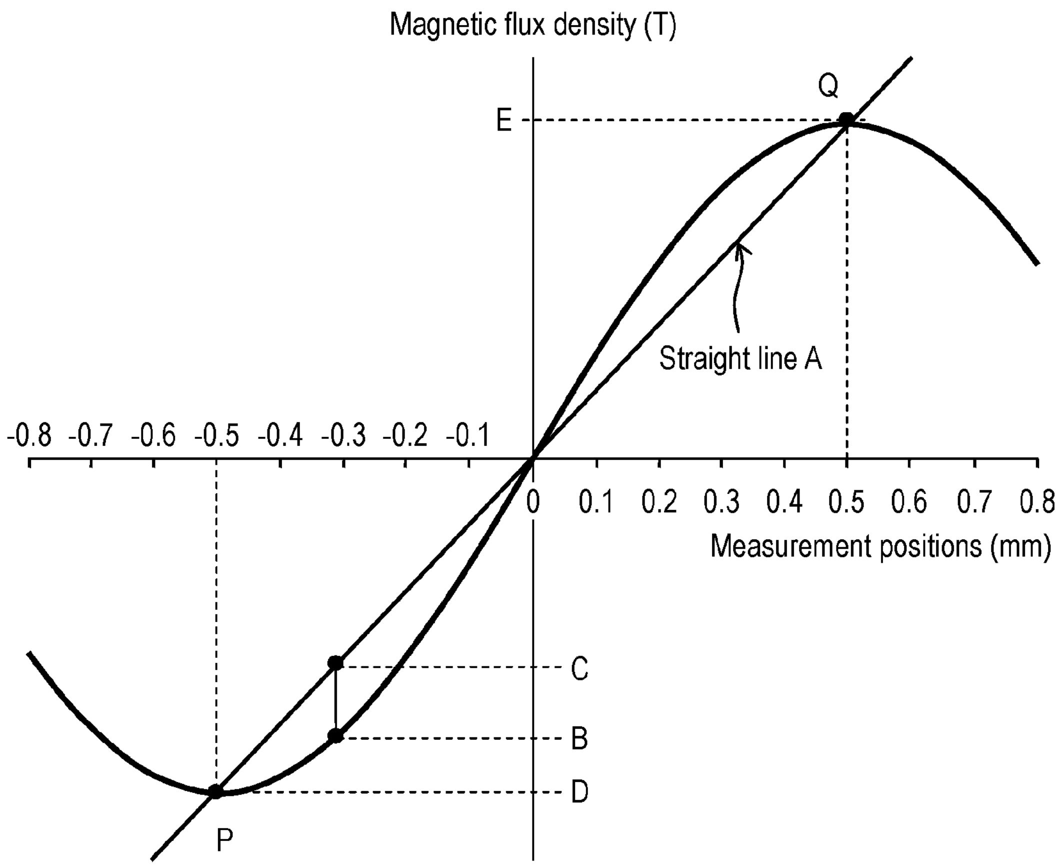

Magnetic flux density (T)
Sample 1
Sample 2
Sample 3
0.4
0.3
0.2
0.1
-1
-0.8
-0.6
-0.4
-0.2
0
0
0.2
0.4
0.6
0.8
1
Measurement positions (mm)
-0.1
-0.2
-0.3
-0.4

FIG. 11



Magnetic flux density (T)
Q
E
Straight line A
-0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
Measurement positions (mm)
C
B
D
P

POSITION DETECTING DEVICE AND IMAGE STABILIZATION DEVICE

BACKGROUND

[0001] 1. Technical Field

[0002] The disclosure relates to a position detecting device using a magnet structure and a magnetic detection device, and especially relates to a highly accurate and improved position detecting device for enlarging a linearity range of an output of magnetic detection means while increasing magnetic flux density of a composite magnetic field in a position detecting area.

[0003] 2. Description of the Related Art

[0004] Patent Literature 1 discloses a position detecting device that enlarges a range in which magnetic flux density varies linearly. The position detecting device includes a permanent magnet unit having a permanent magnet with two magnetized poles. A magnet structure is configured in such a manner that auxiliary magnetic materials or auxiliary magnets are disposed apart from the permanent magnet and their centers each are positioned to deviate outwardly from a peak position of a magnetic field emitted from the respective magnetic poles of the permanent magnet. The position detecting device further includes magnetic detection means that moves, relative to the permanent magnet, in a space between the permanent magnet and auxiliary magnetic materials or auxiliary magnets, and detects a magnetic field of the permanent magnet. Thus, the peak positions of the magnetic field are shifted to separate from each other, thereby enlarging a linearity area of a composite magnetic field generated in between two poles.

CITATION LIST

Patent Literature

[0005] PTL1: Unexamined Japanese Patent Publication No. 2007-225575

SUMMARY

[0006] The present disclosure proposes a position detecting device that increases magnetic field intensity while having a simple magnet structure and enlarges a linearity area of a composite magnetic field generated in between two poles.

[0007] The position detecting device in the present disclosure includes a permanent magnet unit having magnetic pole areas of N-pole and S-pole in a surface thereof, and a magnetic detection device apart from the surface of the permanent magnet unit by a distance. The permanent magnet unit has a main magnet element, and an auxiliary magnet element that is located closer to the magnetic detection device than the main magnet element is. The auxiliary magnet element has an N-pole auxiliary magnet part with the N-pole in the side of the surface and an S-pole auxiliary magnet part with the S-pole in the side of the surface. The main magnet element has an N-pole main magnet part on a side of the N-pole auxiliary magnet part and an S-pole main magnet part on a side of the S-pole auxiliary magnet part. The magnetic detection device is relatively movable in a direction tilted with respect to an area boundary plane that separates magnetic poles of a magnetic field generated by the permanent magnet unit, while keeping the distance from the permanent magnet unit. The N-pole auxiliary magnet part and the S-pole auxiliary magnet part are disposed apart from each other by a gap, and the gap is larger than a gap between the N-pole main magnet part and the S-pole main magnet part.

[0008] The position detecting device in the present disclosure can enlarge a linearity area of a composite magnetic field while increasing magnetic field intensity with a simple structure.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. **1** is a perspective view of a position detecting device in accordance with a first exemplary embodiment.

[0010] FIG. **2** is a schematic diagram showing a movement of a magnetic detection device relative to a permanent magnet unit of the position detecting device in accordance with the first exemplary embodiment.

[0011] FIG. **3** is an explanatory diagram of a composite magnetic field in the position detecting device of the first exemplary embodiment.

[0012] FIG. **4** is a perspective view of a position detecting device in accordance with a second exemplary embodiment.

[0013] FIG. **5** is a front view of the position detecting device in accordance with the second exemplary embodiment. FIG. **6** is a perspective view of a position detecting device in accordance with a third exemplary embodiment.

[0014] FIG. **7**A is a perspective view of a position detecting device in accordance with another exemplary embodiment (first modification example).

[0015] FIG. **7**B is a front view of the position detecting device in accordance with another exemplary embodiment (first modification example).

[0016] FIG. **8**A is a perspective view of a position detecting device in accordance with another exemplary embodiment (second modification example).

[0017] FIG. **8**B is a front view of the position detecting device in accordance with another exemplary embodiment (second modification example).

[0018] FIG. **9**A is a perspective view of the position detecting device including driving means in accordance with another exemplary embodiment.

[0019] FIG. **9**B is an explanatory diagram of the position detecting device shown in FIG. **9**A.

[0020] FIG. **10** is a view showing magnetic flux density curves of the exemplary embodiments.

[0021] FIG. **11** is a view showing a method of calculating linearity (linearity index).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Hereinafter, exemplary embodiments will be described in detail with reference to the drawings as necessary. Note that, unnecessary detail description may be omitted. For instance, detail description of well-known matters or overlapped description of the substantially same configuration may be omitted. This is because that the following description is avoided from being redundant unnecessarily and understood easily by those skilled in the art.

[0023] Note that, the accompanying drawings and the following description is proposed in order for those skilled in the art to fully understand the present disclosure, but not intended to limit subject matter recited in claims.

First Exemplary Embodiment

[0024] Hereinafter, using FIGS. **1** to **3**, position detecting device **100** in accordance with a first exemplary embodiment will be described.

[1-1. Structure]

[0025] FIG. **1** is a schematic perspective view schematically showing a structure of position detecting device **100** in the first exemplary embodiment. Position detecting device **100** includes permanent magnet unit **110** and magnetic detection device **30**. Permanent magnet unit **110** is constituted by main magnets **111***a* (N-pole main magnet part), **111***b* (S-pole main magnet part) and auxiliary magnets **121***a* (N-pole auxiliary magnet part), **121***b* (S-pole auxiliary magnet part). Main magnets **111***a*, **111***b* and auxiliary magnets **121***a*, **121***b* of permanent magnet unit **110** each are constituted as a separate body. In permanent magnet unit **110**, main magnets **111***a*, **111***b* constitute a main magnet element and auxiliary magnets **121***a*, **121***b* constitute an auxiliary magnet element.

[0026] Main magnets **111***a*, **111***b* are magnetized in a direction perpendicular to a plane area in which magnetic detection device **30** moves. Directions of magnetic flux from main magnets **111***a*, **111***b* are opposite to each other, and desirably differ from each other by 180 degree. Auxiliary magnets **121***a*, **121***b* are disposed in direct contact with upper surfaces of main magnets **111***a*, **111***b*. Directions of magnetic flux from auxiliary magnets **121***a*, **121***b* are the same as those of the magnetic flux from main magnets **111***a*, **111***b* respectively. Magnetic detection device **30** is disposed above permanent magnet unit **110** configured in such a manner. Now, the space between auxiliary magnet **121***a* and auxiliary magnet **121***b*, which is a magnetic gap, is wider than the gap between main magnet **111***a* and main magnet **111***b*. Herein, the gap between main magnet **111***a* and main magnet **111***b* and the gap between auxiliary magnet **121***a* and auxiliary magnet **121***b* are preferably determined to satisfy the following conditional expression (1):

$$L10 < L11 \qquad (1)$$

where L**10** is a gap distance between the main magnets, and L**11** is a gap distance between the auxiliary magnets.

[0027] Note that, main magnet **111***a* and main magnet **111***b* may be in direct contact with each other, or may be separated by a magnetic gap. Further, a yoke (not shown) may additionally be attached to an opposite side of main magnets **111***a*, **111***b* with respect to magnetic detection device **30** as necessary.

[0028] FIG. **2** is a schematic diagram showing a movement of magnetic detection device **30** in the first exemplary embodiment. Permanent magnet unit **110** is used as magnetic field generating means. Magnetic detection device **30** moves in the magnetic field generated from each magnetic pole of permanent magnet unit **110** to detect magnetic flux density in Z direction.

[0029] More specifically, magnetic detection device **30** moves in above auxiliary magnets **121***a*, **121***b* (in a space apart from auxiliary magnets **121***a*, **121***b* in Z direction) relatively with respect to permanent magnet unit **110** in approximately X direction, and then generates an output voltage depending on the magnetic flux density in Z direction that is detected at a goal position thereof. This makes it possible to detect a relative position of magnetic detection device **30** to permanent magnet unit **110**. That is, as shown in FIG. **2**, magnetic detection device **30** moves relatively with respect to permanent magnet unit **110** in a direction approximately perpendicular to an area boundary plane that separates the magnetic poles in permanent magnet unit **110** (in X direction) and detects the magnetic flux density in Z direction, thereby detecting the position of magnetic detection device **30** relative to permanent magnet unit **110**. Note that, even if magnetic detection device **30** moves in a direction tilted with respect to the area boundary plane, which separates the magnetic poles in permanent magnet unit **110**, rather than approximately perpendicular to the area boundary plane, the position of magnetic detection device **30** relative to permanent magnet unit **110** will be detected.

[1-2. Magnetic Detection Method]

[0030] A magnetic detection method using position detecting device **100** with the above configuration will be described below.

[0031] FIG. **3** shows magnetic flux density in Z direction along X direction in which magnetic detection device **30** disposed above permanent magnet unit **110** moves. Herein, the dashed line indicates a magnetic flux density curve in Z direction obtained by only main magnets **111***a*, **111***b*. Further, the long dashed short dashed line indicates a magnetic flux density curve obtained by only auxiliary magnets **121***a*, **121***b*. The figure shows that the respective curves have different trajectories. Thus, a sum of the above two curves corresponds to the entire composite magnetic field of permanent magnet unit **110** of position detecting device **100** in accordance with the first exemplary embodiment.

[0032] Note that, in permanent magnet unit **110** shown in FIG. **1**, the length in Y direction of auxiliary magnets **121***a*, **121***b* is equivalent to that of main magnets **111***a*, **111***b*, but may be shorter than the length in Y direction of main magnets **111***a*, **111***b*. The composite magnetic field generated by main magnets **111***a*, **111***b* and auxiliary magnets **121***a*, **121***b* may be detected within a range in which magnetic detection device **30** moves relatively with respect to permanent magnet unit **110**.

[1-3. Effects]

[0033] As above, in position detecting device **100** in accordance with the first exemplary embodiment, auxiliary magnets **121***a*, **121***b* are disposed on main magnets **111***a*, **111***b* respectively, and magnetic detection device **30** is further disposed above auxiliary magnets **121***a*, **121***b*. This configuration ensures a wide range linearity of the composite magnetic field, thereby increasing magnetic flux density. Consequently, position detecting device **100** of the present disclosure can enlarge a position detectable area. Additionally, large enough magnetic field intensity can be obtained. This makes it possible to reduce errors due to influence of surrounding magnetic materials, thereby proposing a position detecting device with small errors. Further, if a yoke is disposed below main magnets **111***a*, **111***b*, larger magnetic flux density will be obtained.

Second Exemplary Embodiment

[0034] Hereinafter, position detecting device **200** in accordance with a second exemplary embodiment will be described using FIG. **4** and FIG. **5**.

[2-1. Structure]

[0035] FIG. **4** is a perspective view showing a structure of position detecting device **200**. FIG. **5** is a front view showing a structure of position detecting device **200**.

[0036] In permanent magnet unit **210** of position detecting device **200**, main magnet **111***a* and auxiliary magnet **121***a*, which are described in the first exemplary embodiment, are integrated. Likewise, main magnet **111***b* and auxiliary magnet **121***b*, which are described in the first exemplary embodiment, are integrated. That is, permanent magnet **210***a* is formed by integrating main magnet **111***a* and auxiliary magnet **121***a* of permanent magnet unit **110** described in the first exemplary embodiment. Likewise, permanent magnet **210***b* is formed by integrating main magnet **111***b* and auxiliary magnet **121***b*. Then, permanent magnet **210***a* and permanent magnet **210***b* constitute permanent magnet unit **110**.

[0037] As shown in FIG. **4**, permanent magnet **210***a* is constituted by base part **211***a* (N-pole main magnet part) and auxiliary part **221***a* (N-pole auxiliary magnet part), and permanent magnet **210***b* is constituted by base part **211***b* (S-pole main magnet part) and auxiliary part **221***b* (S-pole auxiliary magnet part). Base parts **211***a*, **211***b* correspond to the main magnet element, and auxiliary parts **221***a*, **221***b* correspond to the auxiliary magnet element. As shown in FIG. **5**, two permanent magnets **210***a*, **210***b* have a protruded cross section. Herein, the relationship of a gap between base parts **211***a*, **211***b* and a gap between auxiliary parts **221***a*, **221***b* is desired to satisfy the following conditional expression (2):

$$L20<L21 \qquad (2)$$

where L**20** is a gap distance between the base parts, and L**21** is a gap distance between the auxiliary parts.

[0038] Herein, base part **211***a* and base part **211***b* may be in direct contact with each other, or may be separated by a magnetic gap. Further, a yoke (not shown) may additionally be attached to an opposite side of permanent magnets **210***a*, **210***b* with respect to magnetic detection device **30** as necessary.

[0039] Furthermore, the length in Y direction of auxiliary parts **221***a*, **221***b* may be shorter than that of base parts **211***a*, **211***b*.

[2-2. Effects]

[0040] As above, in the present exemplary embodiment, auxiliary parts **221***a*, **221***b* are disposed on base parts **211***a*, **211***b* respectively to constitute permanent magnet unit **210**. Further, magnetic detection device **30** is disposed above permanent magnet unit **210**. This configuration ensures a wide range linearity, thereby increasing magnetic flux density. Consequently, position detecting device **200** of the present disclosure can enlarge a position detectable area. Additionally, large enough magnetic field intensity can be obtained. This makes it possible to reduce errors due to influence of surrounding magnetic materials, thereby proposing position detecting device with small errors.

Third Exemplary Embodiment

[0041] Hereinafter, a third exemplary embodiment will be described using FIG. **6**.

[3-1. Structure]

[0042] FIG. **6** is a schematic perspective view schematically showing a structure of position detecting device **300**. Position detecting device **300** has permanent magnet unit **310** and magnetic detection device **30**. Permanent magnet unit **310** has two main magnets **311***a* (N-pole main magnet part), **311***b* (S-pole main magnet part), first auxiliary magnets **321***a* (N-pole auxiliary magnet part), **321***b* (S-pole auxiliary magnet part) disposed on main magnets **311***a*, **311***b* respectively, and second auxiliary magnets **322***a* (N-pole auxiliary magnet part), **322***b* (S-pole auxiliary magnet part) disposed on the first auxiliary magnets **321***a*, **321***b* respectively. In permanent magnet unit **310**, main magnets **311***a*, **311***b* constitute a main magnet element. Further, first auxiliary magnets **321***a*, **321***b* and the second auxiliary magnets **322***a*, **322***b* constitute an auxiliary magnet element.

[0043] Main magnets **311***a*, **311***b* are magnetized in a direction orthogonal to a plane area in which magnetic detection device **30** moves. Magnetic flux directions of main magnets **311***a*, **311***b* are opposite to each other in up-and-down direction (Z direction), and desirably differ from each other by 180 degree. Magnetic flux directions of first auxiliary magnets **321***a*, **321***b* disposed in direct contact with upper surfaces of main magnets **311***a*, **311***b* are the same as the magnetic flux directions of main magnets **311***a*, **311***b* respectively. Further, magnetic flux directions of second auxiliary magnets **322***a*, **322***b* disposed in direct contact with upper surfaces of first auxiliary magnets **321***a*, **321***b* are the same as the magnetic flux directions of first auxiliary magnets **321***a*, **321***b* respectively.

[0044] Now, a magnetic gap is provided between first auxiliary magnet **321***a* and first auxiliary magnet **321***b*. Likewise, a magnetic gap is provided between second auxiliary magnet **322***a* and second auxiliary magnet **322***b*. Herein, gap distance L**31** between first auxiliary magnet **321***a* and first auxiliary magnet **321***b* and gap distance L**32** between second auxiliary magnet **322***a* and second auxiliary magnet **322***b* are wider than gap distance L**30** between main magnet **311***a* and main magnet **311***b*. Further, gap distance L**32** between second auxiliary magnet **322***a* and second auxiliary magnet **322***b* is wider than gap distance L**31** between first auxiliary magnet **321***a* and first auxiliary magnet **321***b*. Furthermore, gap distance L**30** between main magnet **311***a* and main magnet **311***b*, gap distance L**31** between first auxiliary magnet **321***a* and first auxiliary magnet **321***b*, and gap distance L**32** between second auxiliary magnet **322***a* and second auxiliary magnet **322***b* are determined to satisfy the following conditional expression (3):

$$L30<L31\leq L32 \qquad (3)$$

where L**30** is a gap distance between the main magnets, L**31** is a gap distance between the first auxiliary magnets, and L**32** is a gap distance between the second auxiliary magnets.

[0045] Note that, as shown in conditional expression (3), gap distance L**31** between first auxiliary magnet **321***a* and first auxiliary magnet **321***b* may be equal to gap distance L**32** between second auxiliary magnet **322***a* and second auxiliary magnet **322***b*. Further, main magnets **311***a*, **311***b* may be in direct contact with each other, or may be separated by a magnetic gap. Furthermore, a yoke (not shown) may be additionally attached to an opposite side of main magnets **311***a*, **311***b* with respect to magnetic detection device **30** as necessary. Still further, the lengths in Y direction of the first auxiliary magnets **321***a*, **321***b* and the second auxiliary magnets **322***a*, **322***b* may be shorter than that of main magnets **311***a*, **311***b*. Still furthermore, any auxiliary magnets may be further disposed on the second auxiliary magnets **322***a*, **322***b*. The number of laminated auxiliary magnets may be more than this.

[3-2. Effects]

[0046] In permanent magnet unit **310** in accordance with the third exemplary embodiment, first auxiliary magnets **321***a*, **321***b* and second auxiliary magnets **322***a*, **322***b* are disposed on main magnets **311***a*, **311***b* respectively. Further, magnetic detection device **30** is disposed above second auxiliary magnets **322***a*, **322***b*. This configuration ensures a wide range linearity, thereby increasing magnetic flux density. Consequently, position detecting device **300** of the present disclosure can enlarge a position detectable area. Additionally, large enough magnetic field intensity can be obtained. This makes it possible to reduce errors due to influence of surrounding magnetic materials, thereby proposing a position detecting device with small errors.

Other Exemplary Embodiments

[0047] As above, the first, second, and third exemplary embodiments are described as an example of the technique disclosed in the present application. However, the technique of the present disclosure is not limited to this, but may be applied to exemplary embodiments in which modification, replacement, addition, omission, or the like are made. Further, the respective components described in the first, second, and third exemplary embodiments may be combined to configure a new exemplary embodiment. Hereinafter, other exemplary embodiments will be described as an example.

[0048] FIG. **7**A is a schematic perspective view showing position detecting device **400** in accordance with a first modification example of the first exemplary embodiment. FIG. **7**B is a front view of position detecting device **400** shown in FIG. **7**A. The first modification example differs from the first exemplary embodiment in that main magnets **111***a*, **111***b* of the first exemplary embodiment are formed as a single main magnet **411**.

[0049] Main magnet **411** (main magnet element) is a permanent magnet that is magnetized to have multiple poles. That is, main magnet **411** has non-magnetized area **411***c* located between first main magnet area **411***a* (N-pole main magnet part) and second main magnet area **411***b* (S-pole main magnet part). Herein, first main magnet area **411***a* and second main magnet area **411***b* each serve as a magnetized area. Auxiliary magnets **121***a*, **121***b* are disposed on one surface of main magnet **411** to configure permanent magnet unit **410**. A gap (gap distance P**2**) between auxiliary magnets **121***a*, **121***b* is larger than a width (length in X direction) of non-magnetized area **411***c*.

[0050] Note that, as described in the second exemplary embodiment, main magnet **411** and auxiliary magnets **121***a*, **121***b* may be formed integrally as a permanent magnet.

[0051] FIG. **8**A is a schematic perspective view showing position detecting device **500** in accordance with a second modification example of the first exemplary embodiment. FIG. **8**B is a front view of position detecting device **500** shown in FIG. **8**A. Permanent magnet unit **510** of position detecting device **500** differs from permanent magnet unit **110** of the first exemplary embodiment in that thin spacers **40***a*, **40***b* are disposed between main magnet **111***a* and auxiliary magnet **121***a* and between main magnet **111***b* and auxiliary magnet **121***b*, respectively. Spacers **40***a*, **40***b* are desired to be a nonmagnetic material, but a very thin magnetic material, which is easy to reach magnetic saturation, may be used. Similarly to position detecting device **100** described in the first exemplary embodiment, gap distance L1 between auxiliary magnet **121***a* and auxiliary magnet **121***b* is also larger than gap distance L**0** between main magnet **111***a* and main magnet **111***b* in position detecting device **500**. The main magnet and the auxiliary magnet are not necessary to be in direct contact with each other like position detecting device **500**. Even if the main magnet and the auxiliary magnet are contacted via a spacer or separated by a space, the same effects as the first exemplary embodiment will be obtained.

[0052] In position detecting device **500**, as shown in FIGS. **8**A and **8**B, spacers **40***a*, **40***b* are disposed on the entire surface of main magnets **111***a*, **111***b* on an auxiliary magnet side, respectively. To position auxiliary magnets **121***a*, **121***b* with respect to main magnets **111***a*, **111***b*, spacers **40***a*, **40***b* are formed into a recessed shape into which each of auxiliary magnets **121***a*, **121***b* is to be inserted. Note that, spacers **40***a*, **40***b* may be disposed on only a portion in which each of auxiliary magnets **121***a*, **121***b* is to be disposed, instead of the entire surface of main magnets **111***a*, **111***b* on an auxiliary magnet side.

[0053] Further, main magnets **111***a*, **111***b* of position detecting device **500** may be formed integrally like main magnet **411** shown in the first modification example.

[0054] FIG. **9**A is a schematic perspective view showing position detecting device **10** in which driving means for moving magnetic detection device **30** relatively with respect to permanent magnet unit **110** is added to position detecting device **100** of the first exemplary embodiment. FIG. **9**B illustrates a plan view, a cross-sectional view, and a front view of position detecting device **10** shown in FIG. **9**A. As the driving means, drive coil **50** may be employed. Drive coil **50** is disposed on an opposite side of main magnets **111***a*, **111***b* with respect to auxiliary magnets **121***a*, **121***b*. Thus, large driving force is obtained as compared with the case where only main magnets **111***a*, **111***b* are disposed.

[0055] Furthermore, to increase the driving force, facing magnets **61***a*, **61***b* may be employed as necessary. Facing magnets **61***a*, **61***b* are disposed on an opposite side (lower side in Z direction) of drive coil **50** with respect to main magnets **111***a*, **111***b* as shown in FIGS. **9**A and **9**B. Instead of facing magnets **61***a*, **61***b*, a facing yoke may be employed. Further, various kinds of actuators may be used for driving means, instead of drive coil **50**.

WORKING EXAMPLE

[0056] Hereinafter, to verify effects of the present disclosure, a verification experiment will be described.

[0057] NdFeB-based permanent magnet (10 mm×2 mm×1.5 mm) was used as a main magnet, and a main surface thereof (a surface of 10 mm×2 mm) was magnetized by a single pole. NdFeB-based permanent magnet (4 mm×1 mm×1 mm) was also used as an auxiliary magnet, and a main surface thereof (a surface of 4 mm×1 mm) was magnetized by a single pole.

[0058] Side faces of two main magnets extending in Y axial direction are directly contacted, and an iron yoke is further disposed on a back surface side of the two main magnets. At this time, the main magnets are disposed such that their magnetization directions are opposed to each other. The yoke has substantially the same size as the permanent magnet and its thickness is **1.0** mm. On an upper surface of each main magnet, an auxiliary magnet whose magnetization direction is aligned to that of the main magnet is disposed. Two auxiliary magnets each are apart from a contact face between the main magnets by distance d, and disposed plane-symmetrically. Gap distance L**11** between the two auxiliary magnets is 2d.

(Sample Pattern)

[0059] Samples **1** to **3** of the position detecting device were fabricated. The configuration of each sample is as follows:

[0060] Sample **1**: without disposing any auxiliary magnet in an upper part of the main magnet, magnetic flux density in Z direction was measured at a height of 0.5 mm from the surface of the main magnet (first comparative example).

[0061] Sample **2**: without disposing any auxiliary magnet in an upper part of the main magnet, magnetic flux density in Z direction was measured at a height of 3.4 mm from the surface of the main magnet (second comparative example).

[0062] Sample **3**: auxiliary magnets were disposed in an upper part of the main magnet and separated from each other by a distance d of 0.4 mm, and then magnetic flux density in Z direction was measured at a height of 0.5 mm from the surface of the main magnet (working example).

[0063] FIG. **10** shows results of measuring the magnetic flux densities of Samples **1** to **3**. With respect to wave forms of these magnetic flux densities, linearity (linearity index) was measured. A method of measuring the linearity is as follows.

[0064] FIG. **11** is a view showing a method of measuring linearity. First, as shown in FIG. **11**, point P and point Q are given on the graph which shows the result of measuring magnetic flux density. Herein, point P and point Q indicate magnetic flux densities measured at measurement positions X of −0.5 mm and 0.5 mm, respectively. And then, straight line A is drawn to connect point P and point Q. Subsequently, value D and value E, which are the magnetic flux densities at point P and point Q respectively, are evaluated. Next, slope α of straight line A ($(E-D)/(0.5-(-0.5))$) and Y-intercept β are evaluated, and then the expression of straight line A ($Y=\alpha X+\beta$) is found.

[0065] Secondly, Y-axis value C of straight line A is calculated at each measurement point (e.g., at 0.05 mm intervals in measurement position X), while value B of the magnetic flux density (Y-axis value of the wave form of magnetic flux density) is measured at the same measurement point. Subsequently, an amount of shift ($100\times(B-C)/\alpha$) from straight line A at each measurement point is calculated as a numerical value (%). Thus, a linearity index is obtained by evaluating the maximum absolute value among the numerical values calculated at the respective measurement points.

[0066] Table 1 shows linearity indexes and slopes a of straight line A, which are calculated in the above manner, with respect to above Samples **1** to **3**.

TABLE 1

	linearity index	slope α of straight line
Sample 1	10.3%	0.588
Sample 2	2.2%	0.101
Sample 3	1.3%	0.483

[0067] As obvious from Table 1, the working sample has a small linearity index as compared with the first and second comparative examples (Samples **1**, **2**). The small linearity index means that an amount of shift from the straight line is small and good linearity is obtained. Further, if magnetic flux density has good linearity in a waveform, a position detectable area will be enlarged.

[0068] On the other hand, slope a of straight line of the working sample (Sample **3**) is much larger than that of the second comparative example (Sample **2**), which has a good linearity in the comparative examples. This shows that the working sample has robustness against noises, which serve as an external factor. Consequently, the position detecting device of the present disclosure is obviously effective.

INDUSTRIAL APPLICABILITY

[0069] The present disclosure is applicable to a position detecting device using a magnetic detection device. Specifically, the present disclosure is applicable to devices for performing position detection such as image stabilization mechanism in a digital still camera, valve deflection detecting mechanism in various kinds of devices for opening and closing a valve, and plunger control.

What is claimed is:

1. A position detecting device comprising:

a permanent magnet unit having magnetic pole areas of an N-pole and an S-pole in a surface thereof; and

a magnetic detection device that is apart from the surface of the permanent magnet unit by a distance,

wherein

the permanent magnet unit has a main magnet element, and an auxiliary magnet element that is located closer to the magnetic detection device than the main magnet element is,

the auxiliary magnet element has a N-pole auxiliary magnet part with the N-pole in a surface side, and a S-pole auxiliary magnet part with the S-pole in the surface side,

the main magnet element has an N-pole main magnet part on a side of the N-pole auxiliary magnet part, and an S-pole main magnet part on a side of the S-pole auxiliary magnet part,

the magnetic detection device is relatively movable in a direction tilted with respect to an area boundary plane that separates magnetic poles of a magnetic field generated by the permanent magnet unit, while keeping the distance from the permanent magnet unit, and

the N-pole auxiliary magnet part and the S-pole auxiliary magnet part are disposed apart from each other by a gap,

wherein

the gap is larger than a gap between the N-pole main magnet part and the S-pole main magnet part.

2. The position detecting device according to claim **1**, wherein the main magnet element and the auxiliary magnet element have substantially rectangular shaped cross sections in the direction tilted with respect to the area boundary plane.

3. The position detecting device according to claim **1**, wherein

the main magnet element and the auxiliary magnet element each are constituted as a separate body.

4. The position detecting device according to claim **3**, wherein

a separator is interposed between the main magnet element and the auxiliary magnet element.

5. The position detecting device according to claim **1**, wherein:

the main magnet element are formed integrally and have a non-magnetized area located between the N-pole main magnet part and the S-pole main magnet part; and

the gap between the N-pole auxiliary magnet part and the S-pole auxiliary magnet part is larger than the non-magnetized area.

6. The position detecting device according to claim **1**, wherein

the N-pole auxiliary magnet part is formed integrally with the N-pole main magnet part and the S-pole auxiliary magnet part is formed integrally with the S-pole main magnet part.

7. The position detecting device according to claim **1** further comprising:

a yoke disposed along an side of the permanent magnet unit that is reverse from the surface.

8. The position detecting device according to claim **1** further comprising:

a drive coil disposed along a side of the main magnet element that is reverse from a side thereof where the auxiliary magnet element is disposed.

9. An image stabilization device equipped with the position detecting device according to claim **1**.

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