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(54) **SENSOR AND ELECTRONIC DEVICE**

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(73) Assignee: **KABUSHIKI KAISHA TOSHIBA**, Tokyo (JP)

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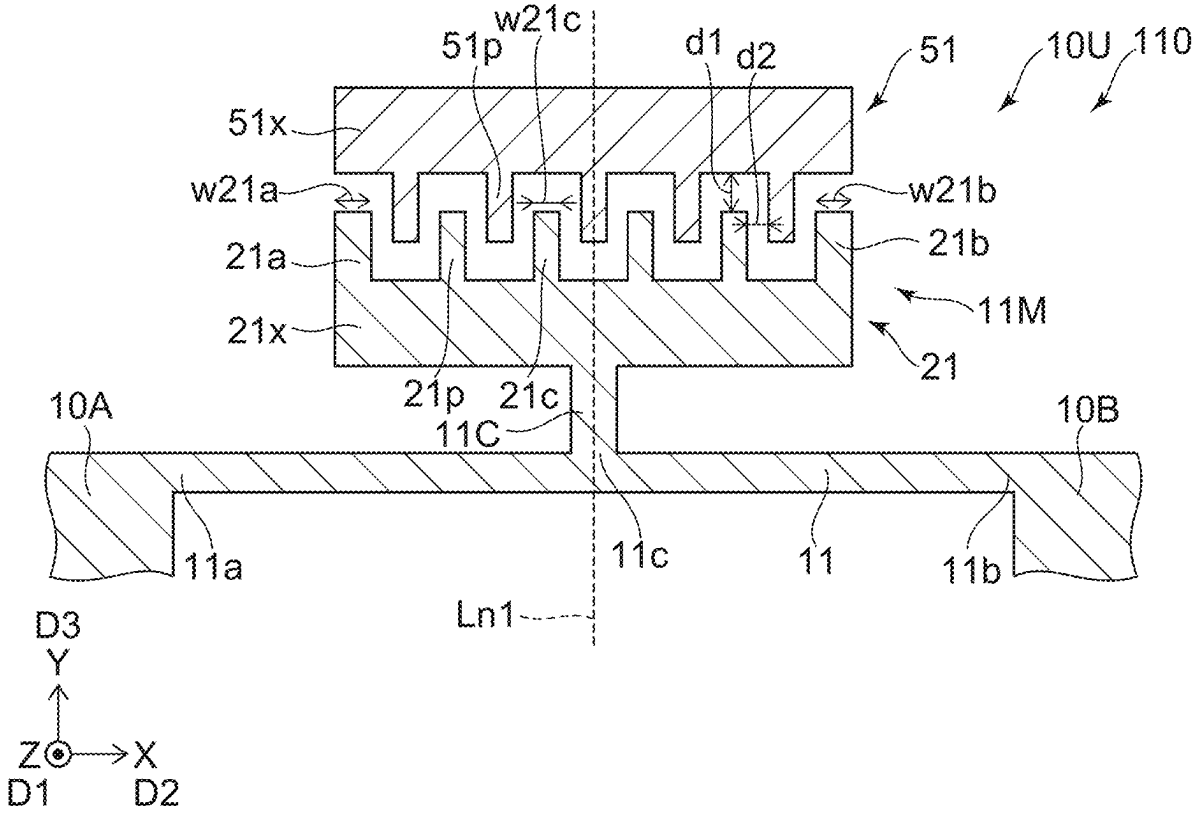
G01P 15/125 (2006.01)

(52) **U.S. Cl.**
CPC ***G01P 15/135*** (2013.01); ***G01P 15/125*** (2013.01)

(57) **ABSTRACT**

According to one embodiment, a sensor includes a base and an element section. The element section includes a first fixed portion fixed to the base, a first fixed electrode fixed to the base, and a first movable portion. A first gap is provided between the base and the first movable portion. The first movable portion includes a first movable base portion supported by the first fixed portion, a first other movable base portion connected to the first movable base portion, and a first movable structure. The first movable structure includes a first beam, a first movable electrode, and a first connecting portion. The first beam include a first beam portion, a first other beam portion, and a first intermediate beam portion between the first beam portion and the first other beam portion.



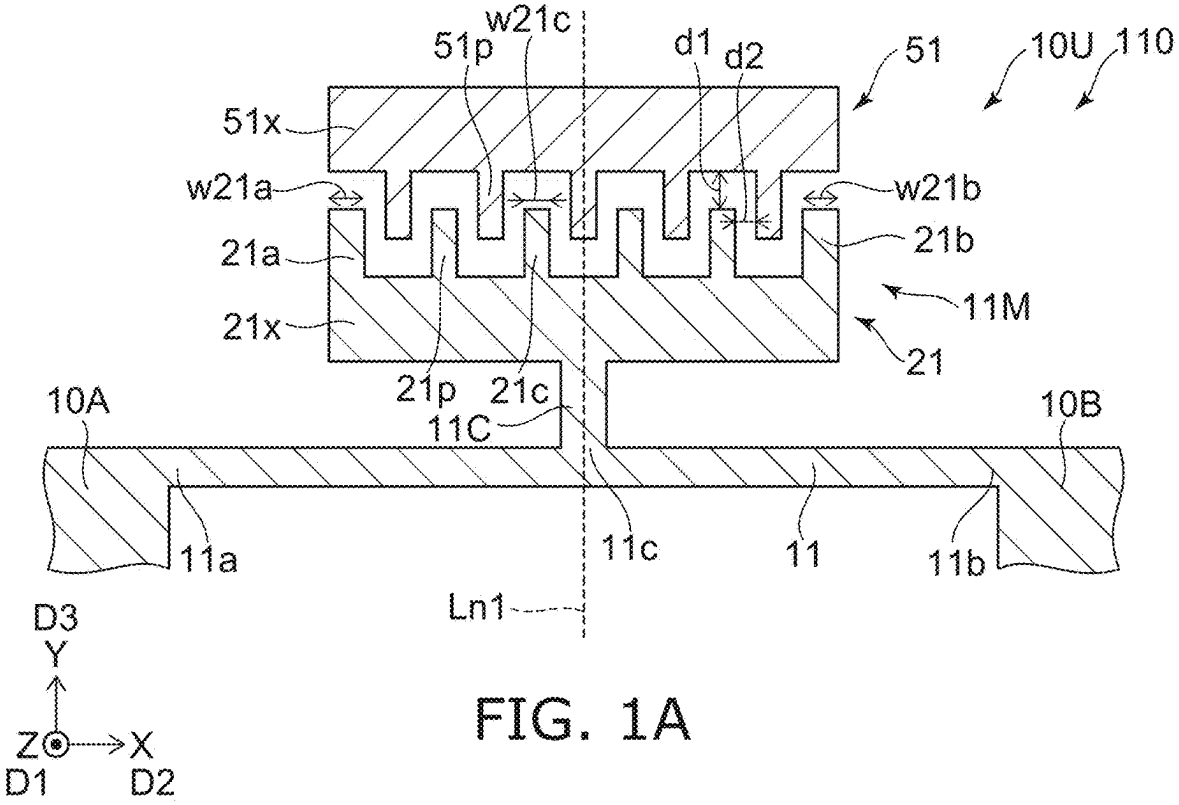

w21c
51p
d1
d2
51
10U
110
51x
w21a
w21b
21a
21b
11M
21x
21
21p
21c
11C
10A
10B
11a
11c
11
11b
Ln1
D3
Y
Z
X
D1
D2

FIG. 1A

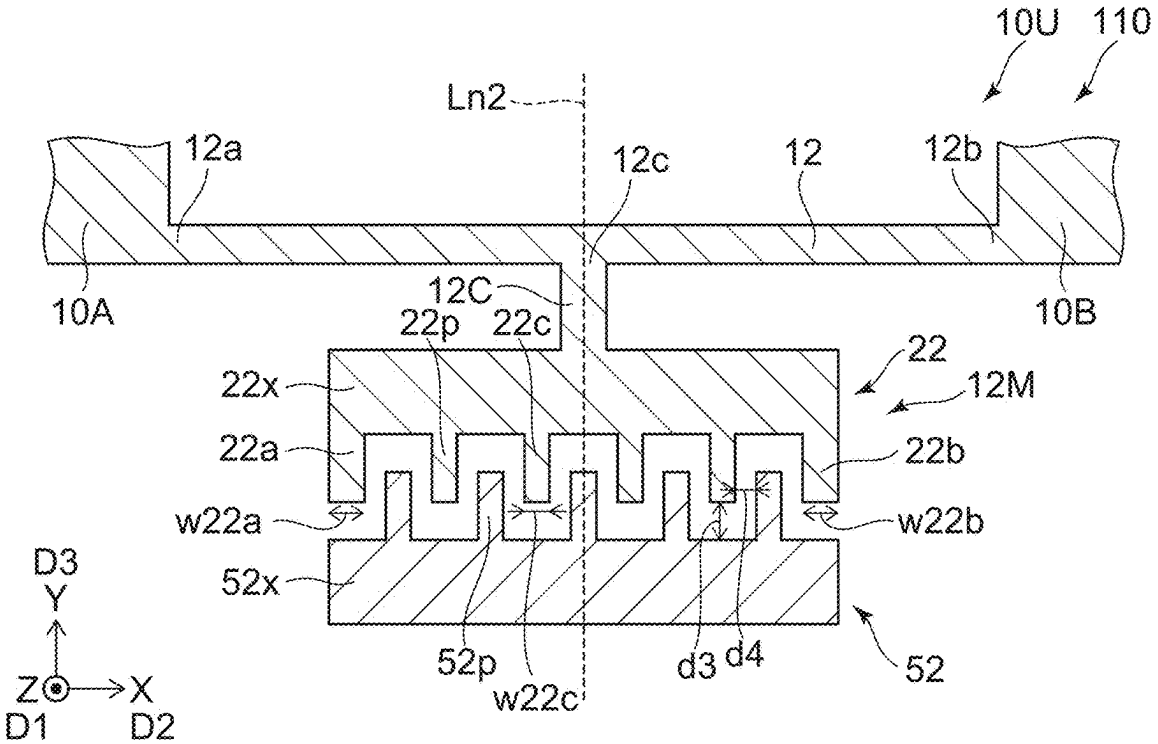

10U
110
Ln2
12a
12c
12
12b
10A
12C
10B
22p
22c
22
22x
12M
22a
22b
w22a
w22b
52x
D3
Y
Z
X
D1
D2
52p
d3
d4
52
w22c

FIG. 1B

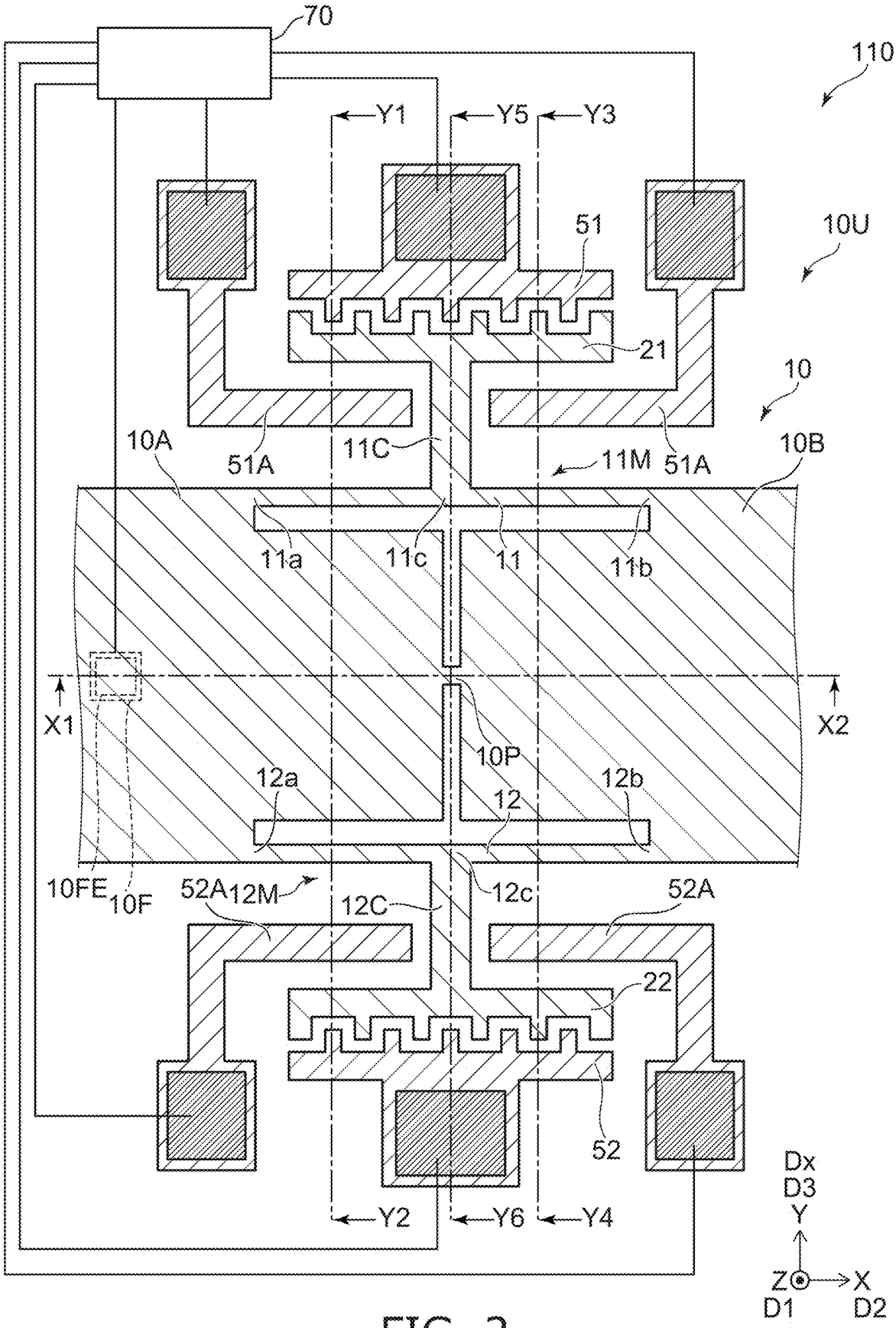

70
110
Y1
Y5
Y3
51
10U
21
10
10A
51A
11C
11M
51A
10B
11a
11c
11
11b
X1
X2
10P
12a
12b
12
10FE
10F
52A
12M
12C
12c
52A
22
52
Y2
Y6
Y4
Dx
D3
Y
Z
X
D1
D2

FIG. 2

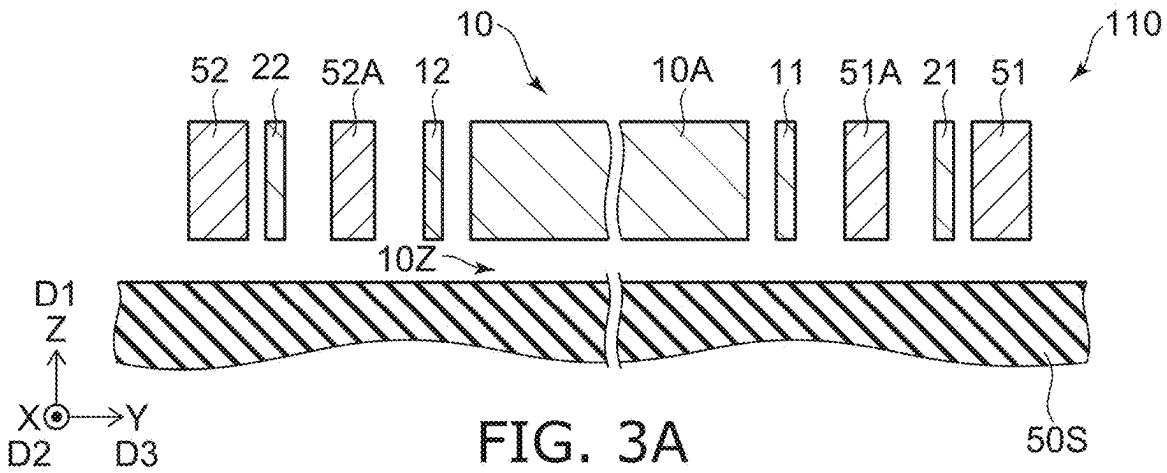


FIG. 3A

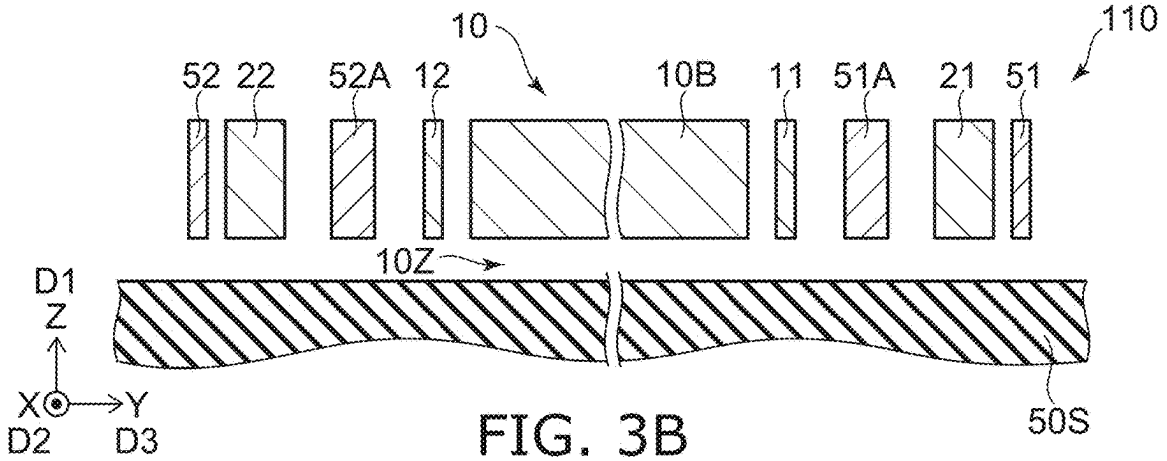


FIG. 3B

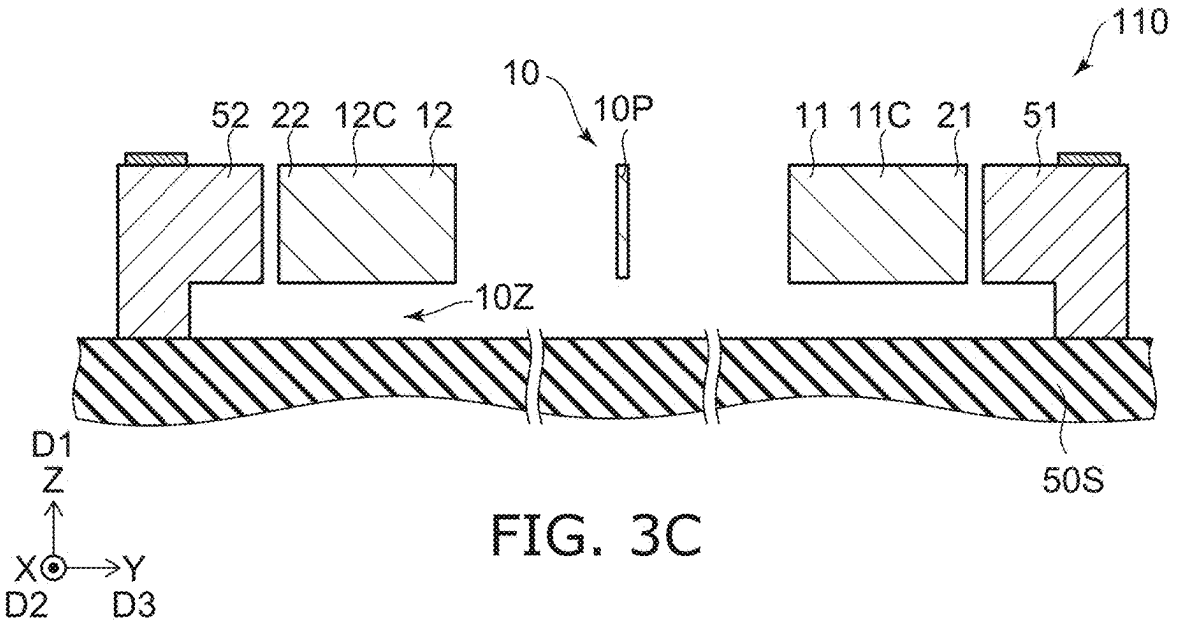


FIG. 3C

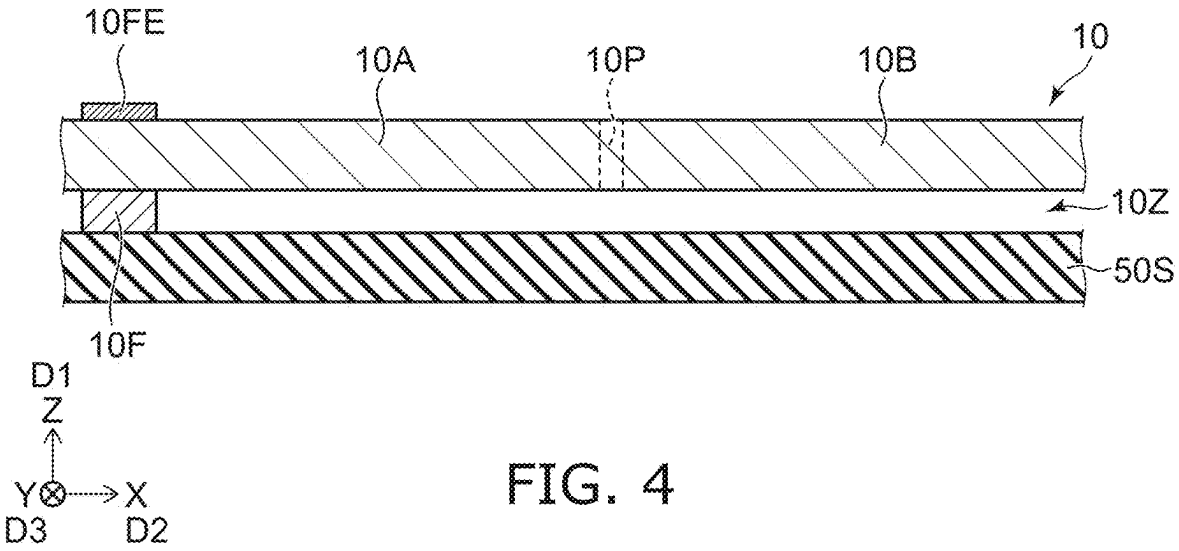


FIG. 4

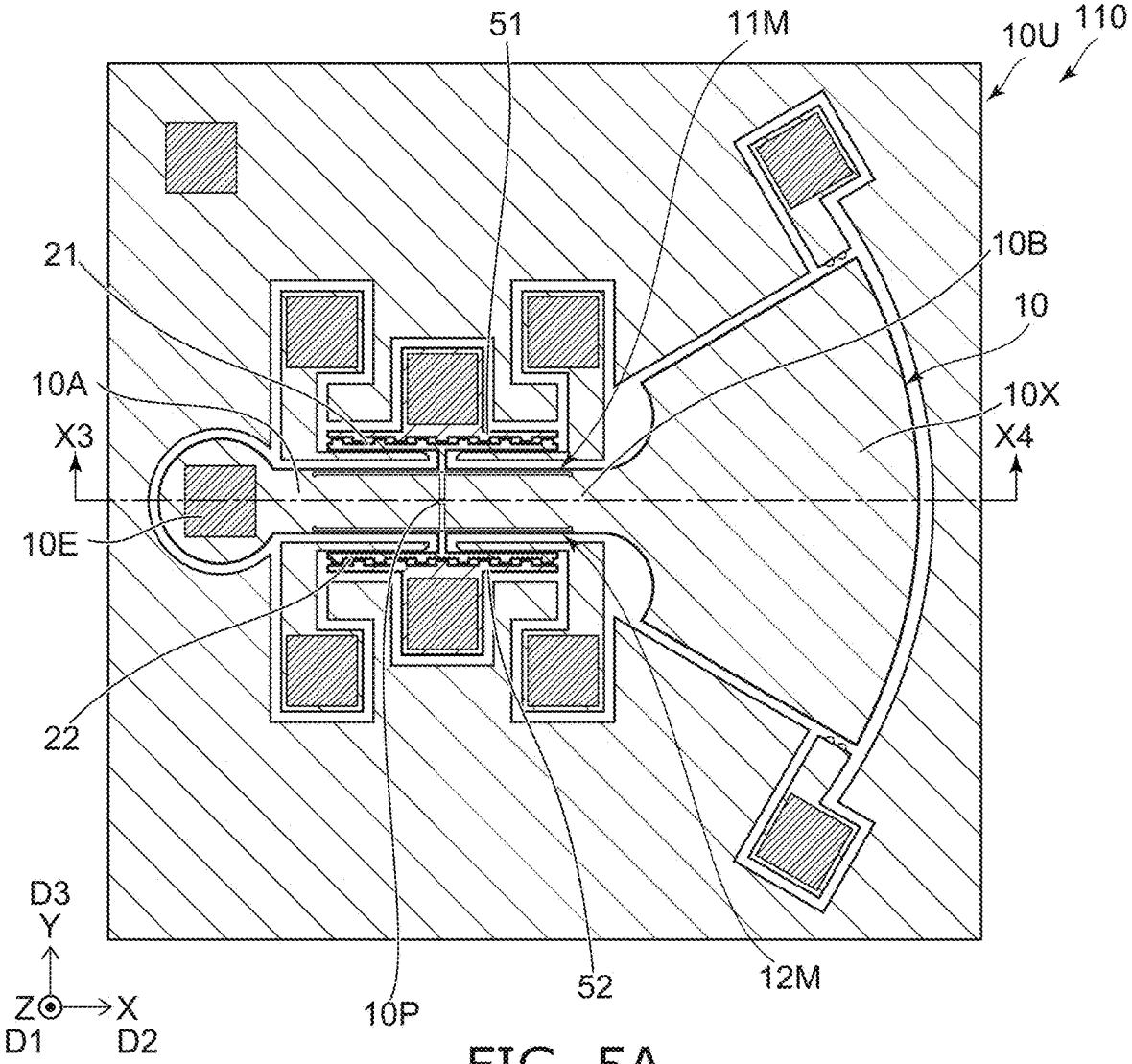

51
11M
10U
110
21
10B
10
10A
10X
X3
X4
10E
22
52
12M
10P
D3
Y
Z
X
D1
D2

FIG. 5A

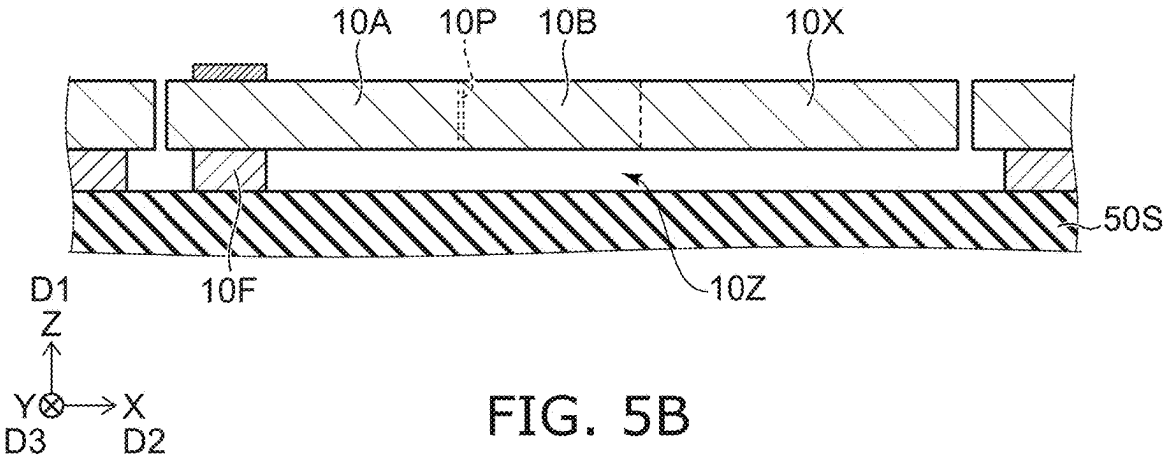

10A
10P
10B
10X
50S
10F
10Z
D1
Z
Y
X
D3
D2

FIG. 5B

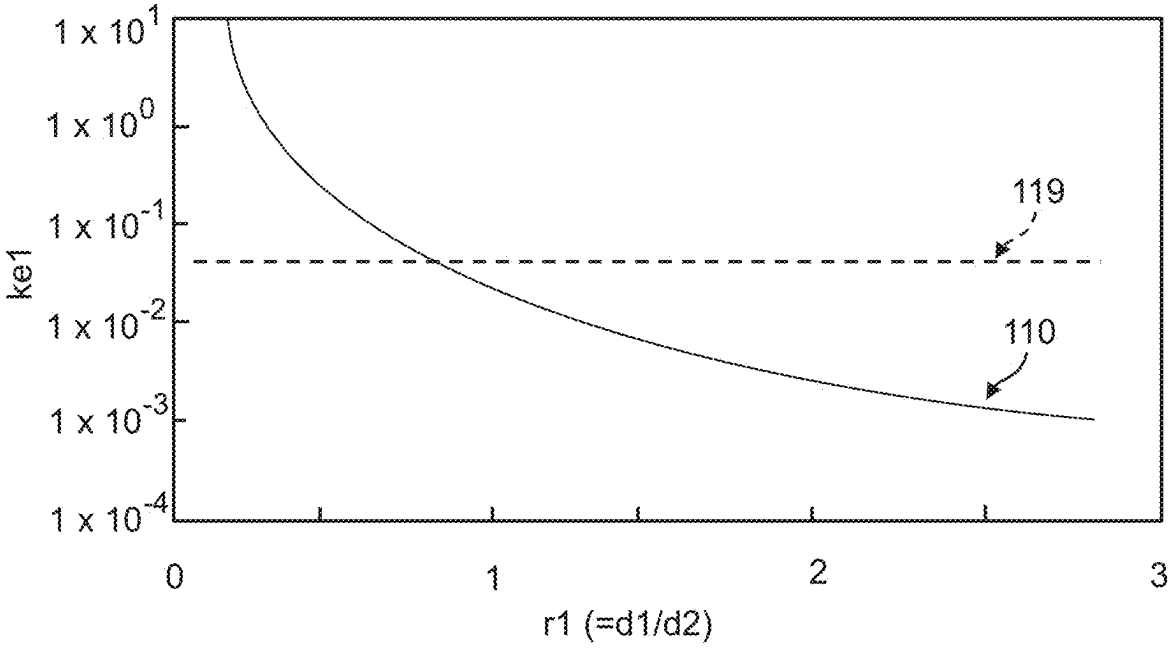


FIG. 6

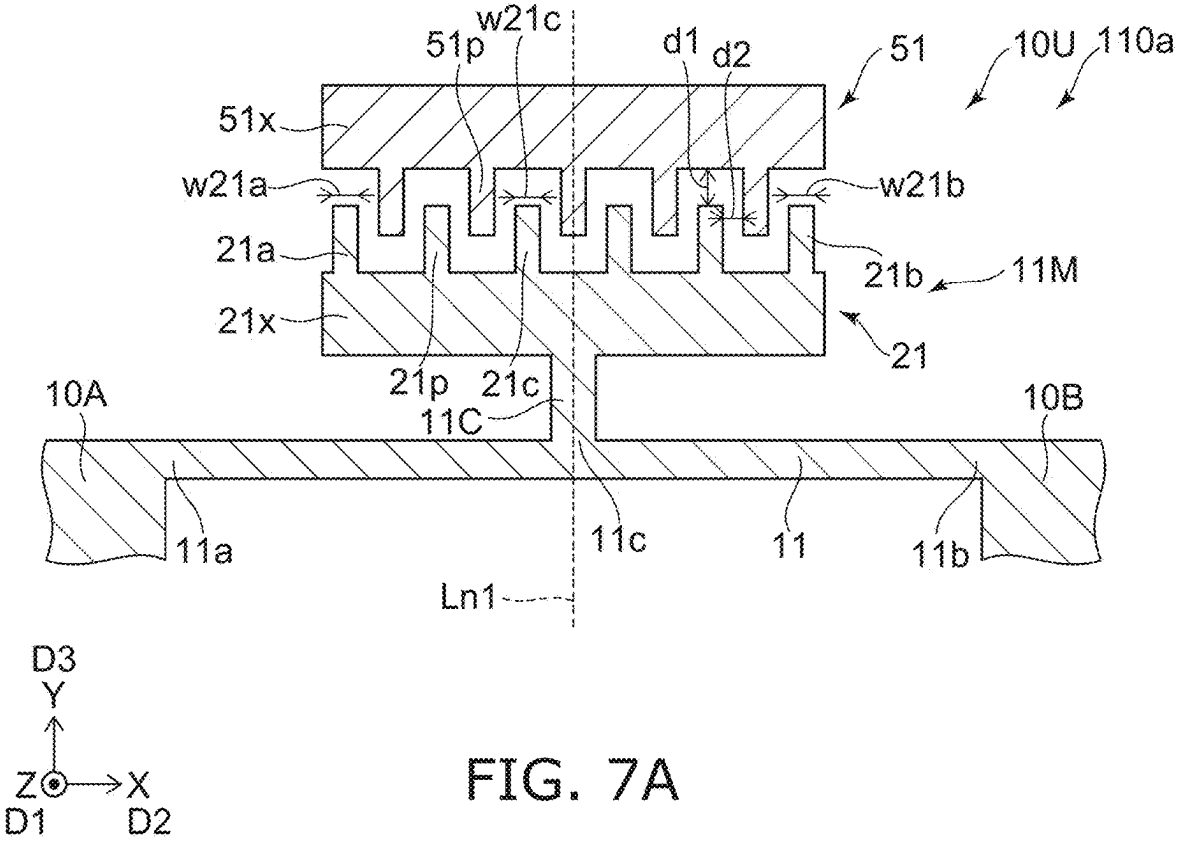

w21c
51p
d1
d2
51
10U
110a
51x
w21a
w21b
21a
21b
11M
21x
21
21p
21c
11C
10A
10B
11a
11c
11
11b
Ln1
D3
Y
Z
X
D1
D2

FIG. 7A

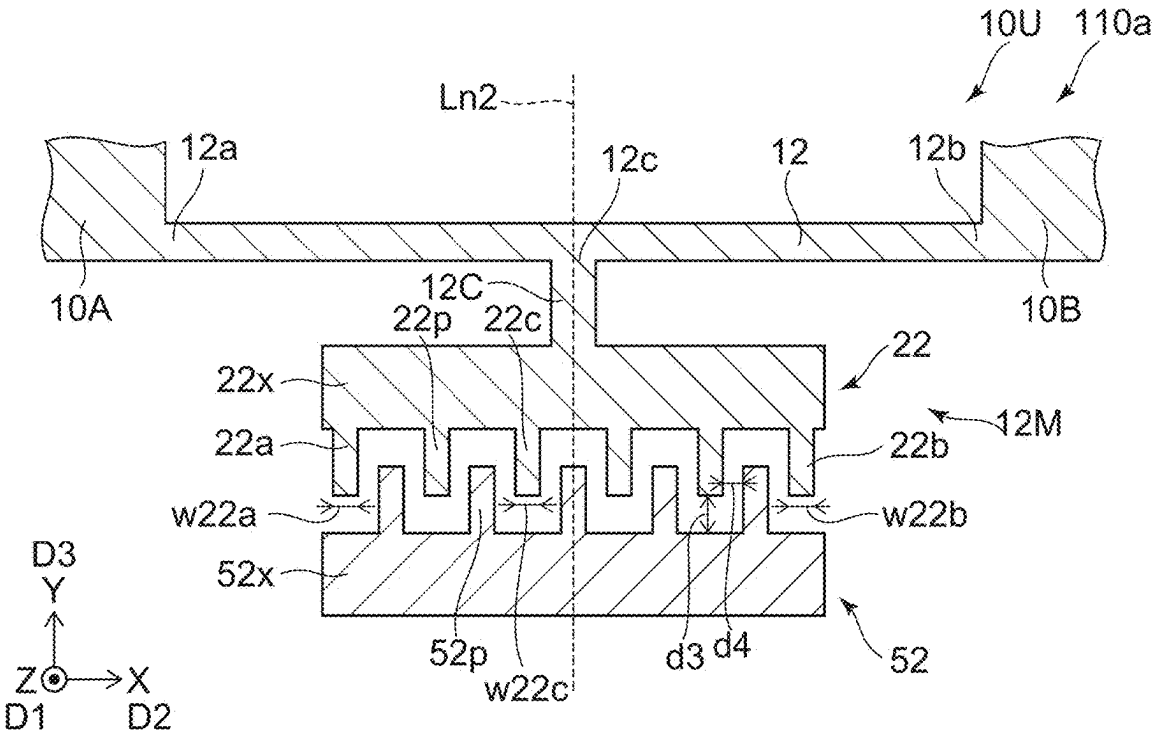

10U
110a
Ln2
12a
12c
12
12b
10A
12C
10B
22p
22c
22
22x
12M
22a
22b
w22a
w22b
52x
D3
Y
Z
X
D1
D2
52p
w22c
d3
d4
52

FIG. 7B

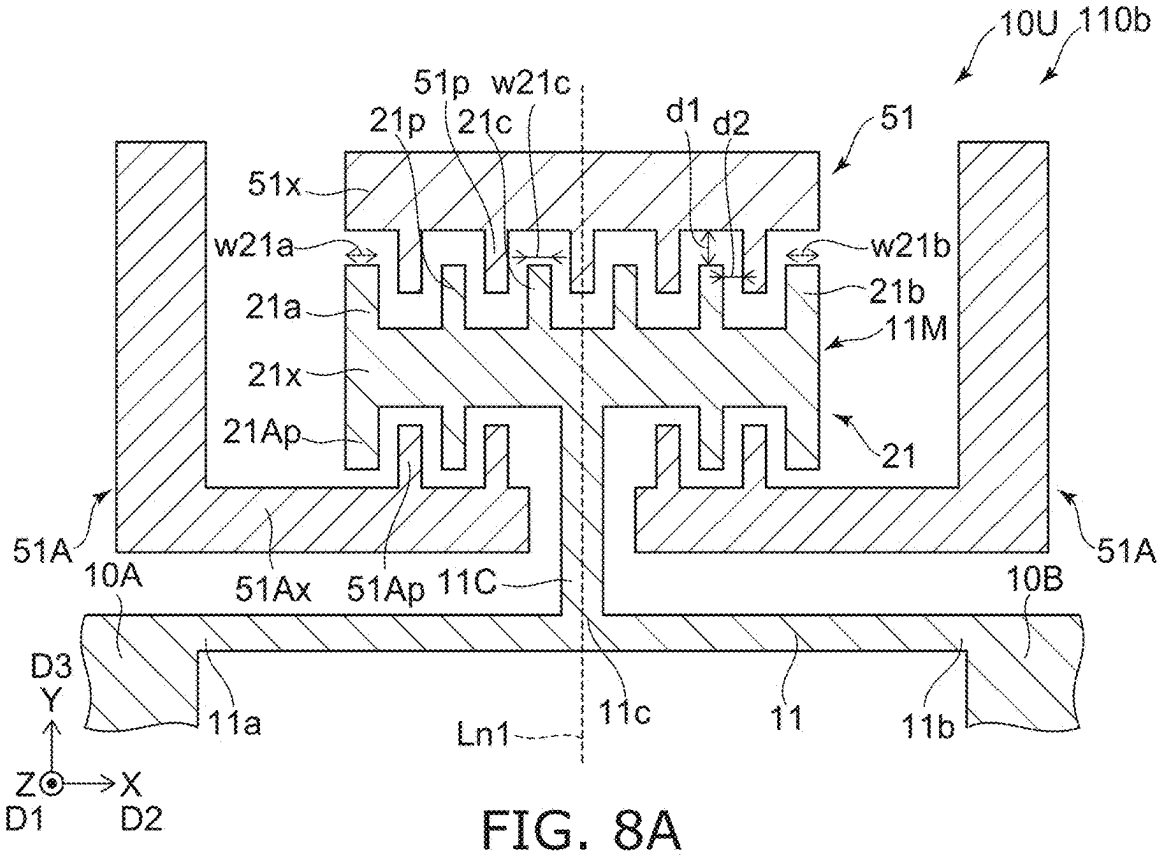
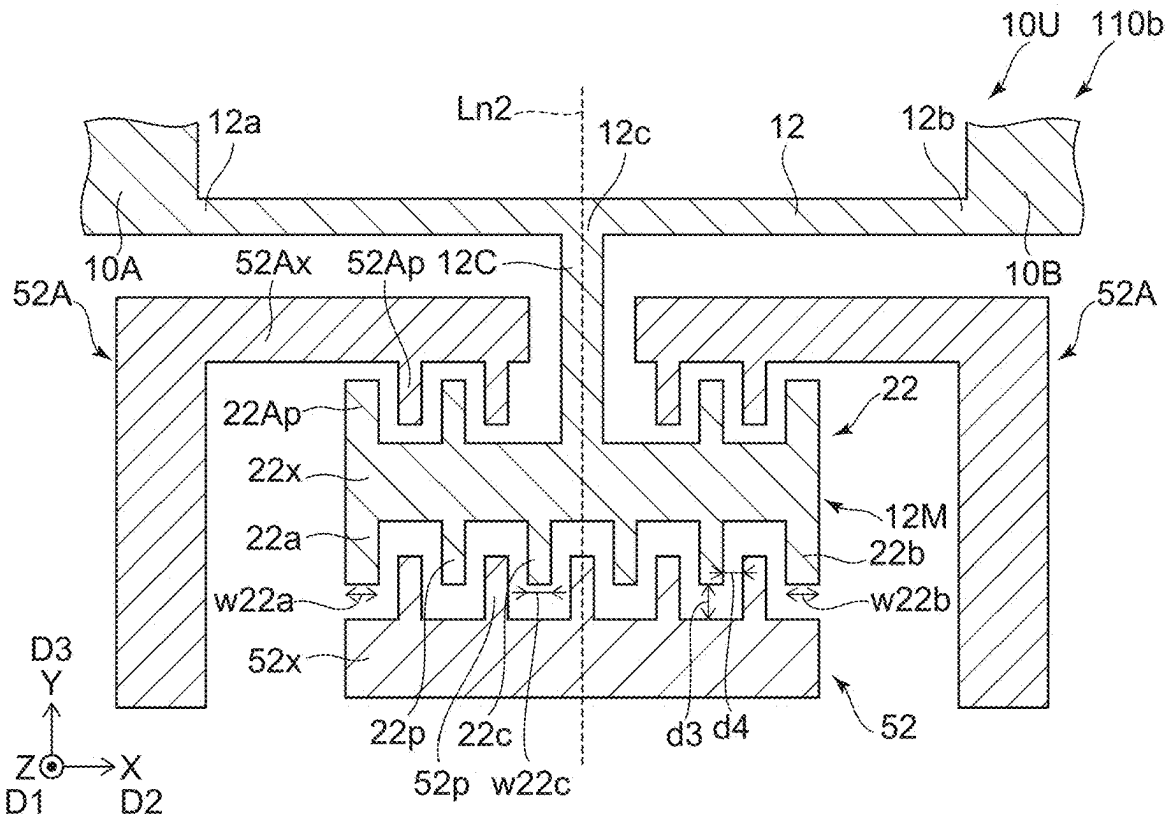

10U
110b
51p
w21c
21p
21c
d1
d2
51
51x
w21a
w21b
21b
21a
11M
21x
21Ap
21
51A
51A
10A
51Ax
51Ap
11C
10B
D3
Y
11a
Ln1
11c
11
11b
Z
X
D1
D2

FIG. 8A


10U
110b
12a
Ln2
12c
12
12b
10A
52Ax
52Ap
12C
10B
52A
52A
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22x
12M
22a
22b
w22a
w22b
52x
D3
Y
22p
22c
d3
d4
52
Z
X
D1
D2
52p
w22c

FIG. 8B

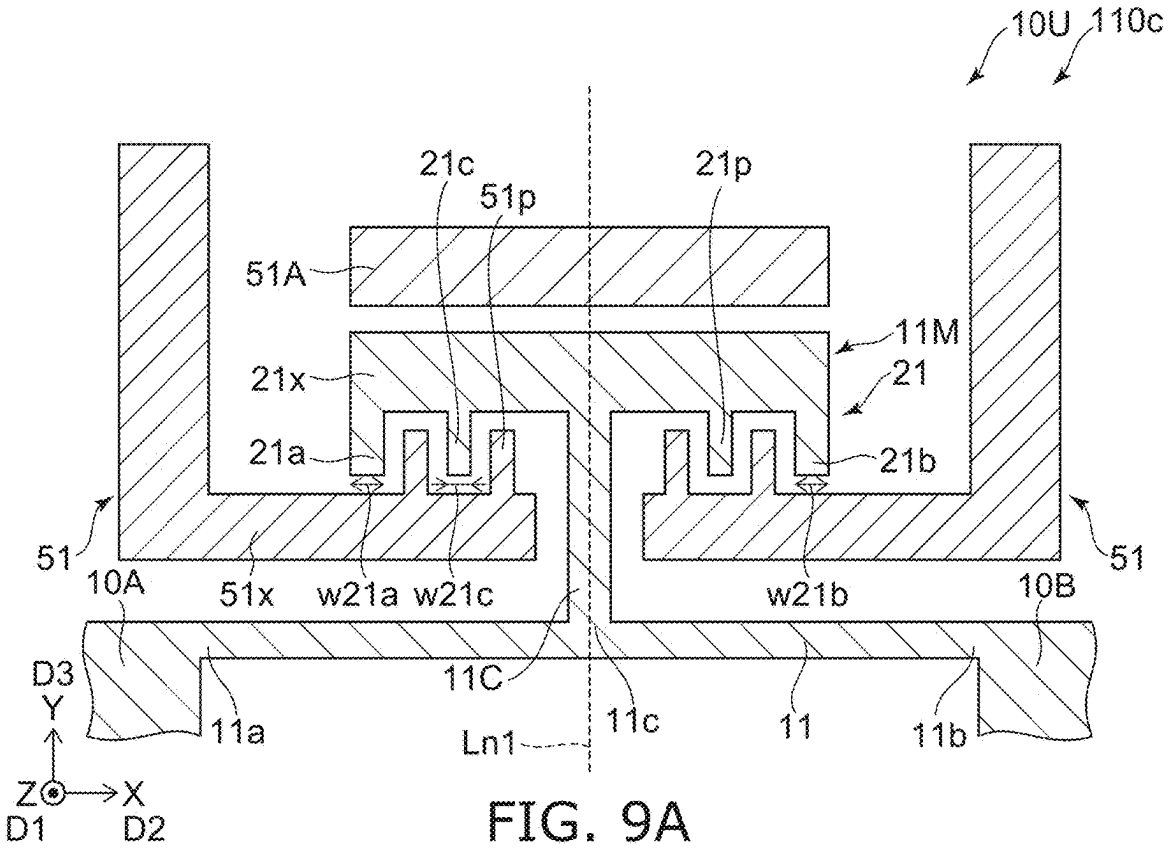
10U
110c
21c
51p
21p
51A
11M
21x
21
21a
21b
51
51
10A
51x
w21a
w21c
w21b
10B
D3
Y
11C
11a
11c
11
11b
Ln1
Z
X
D1
D2

FIG. 9A

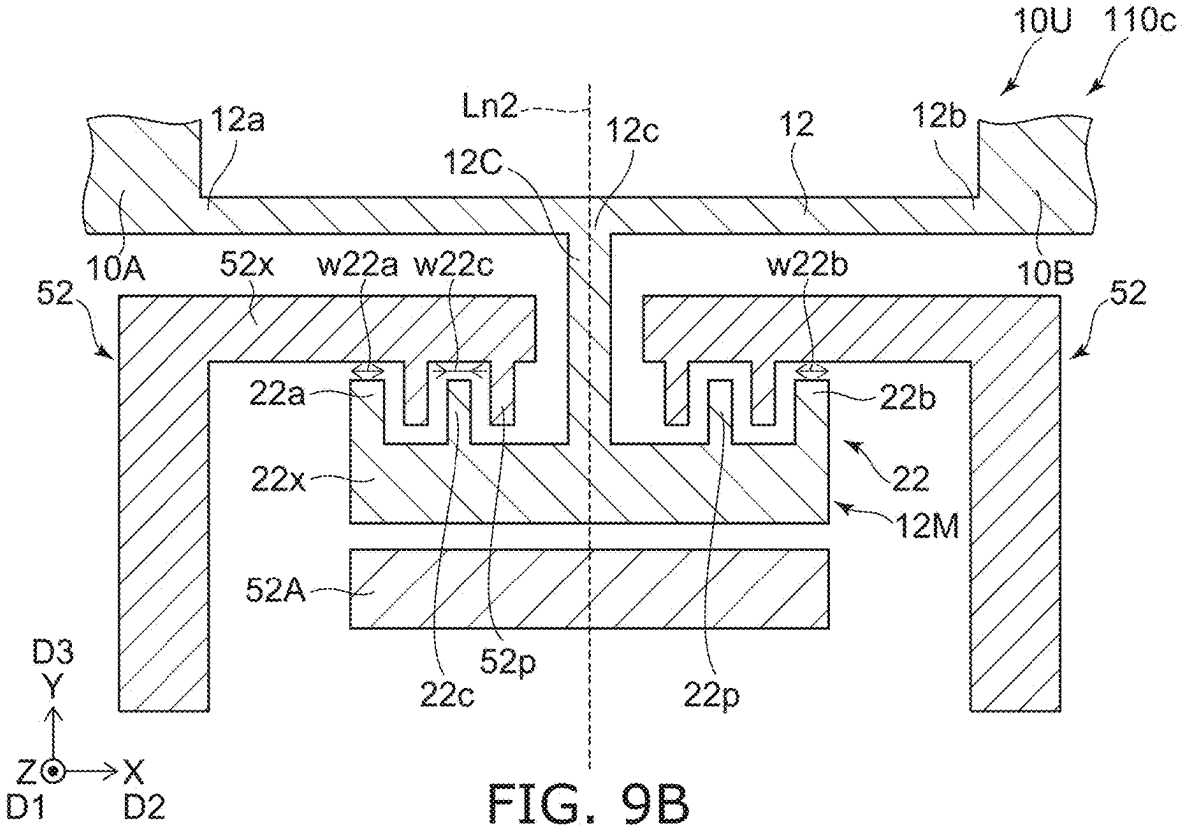
10U
110c
Ln2
12a
12c
12
12b
12C
10A
52x
w22a
w22c
w22b
10B
52
52
22a
22b
22x
22
12M
52A
D3
Y
52p
22c
22p
Z
X
D1
D2

FIG. 9B

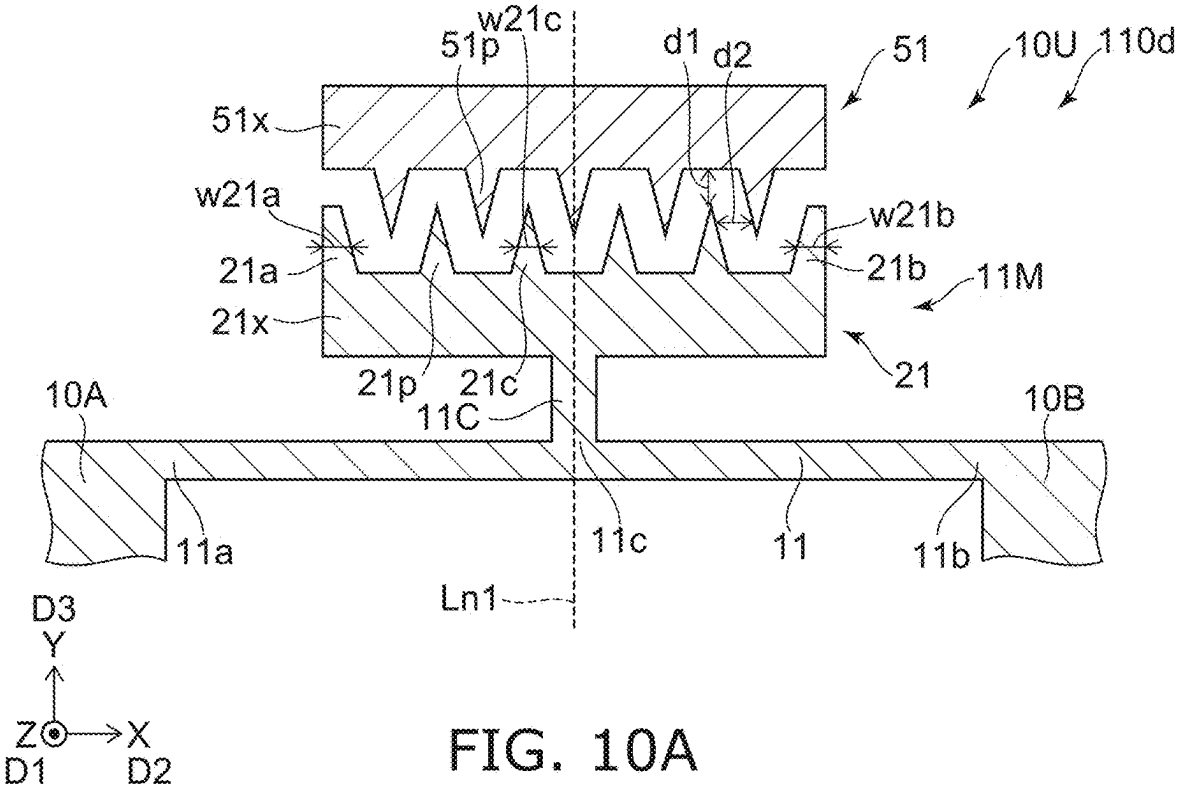

FIG. 10A

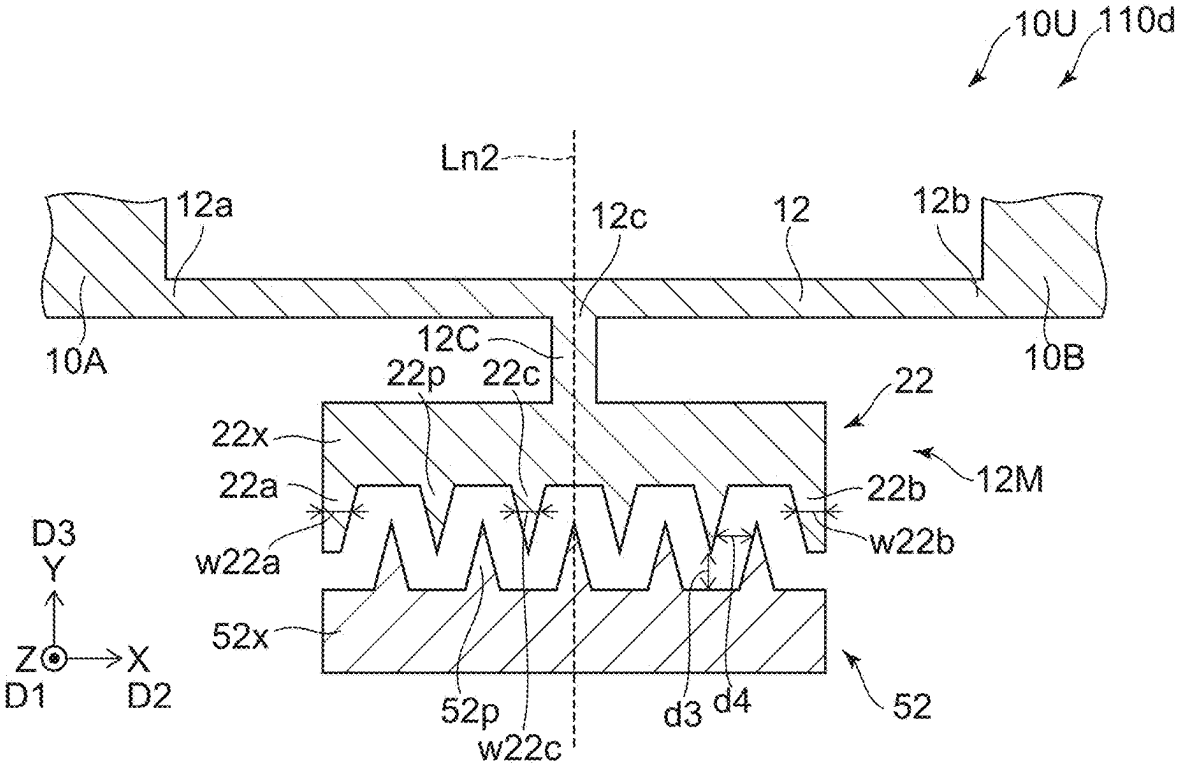

FIG. 10B

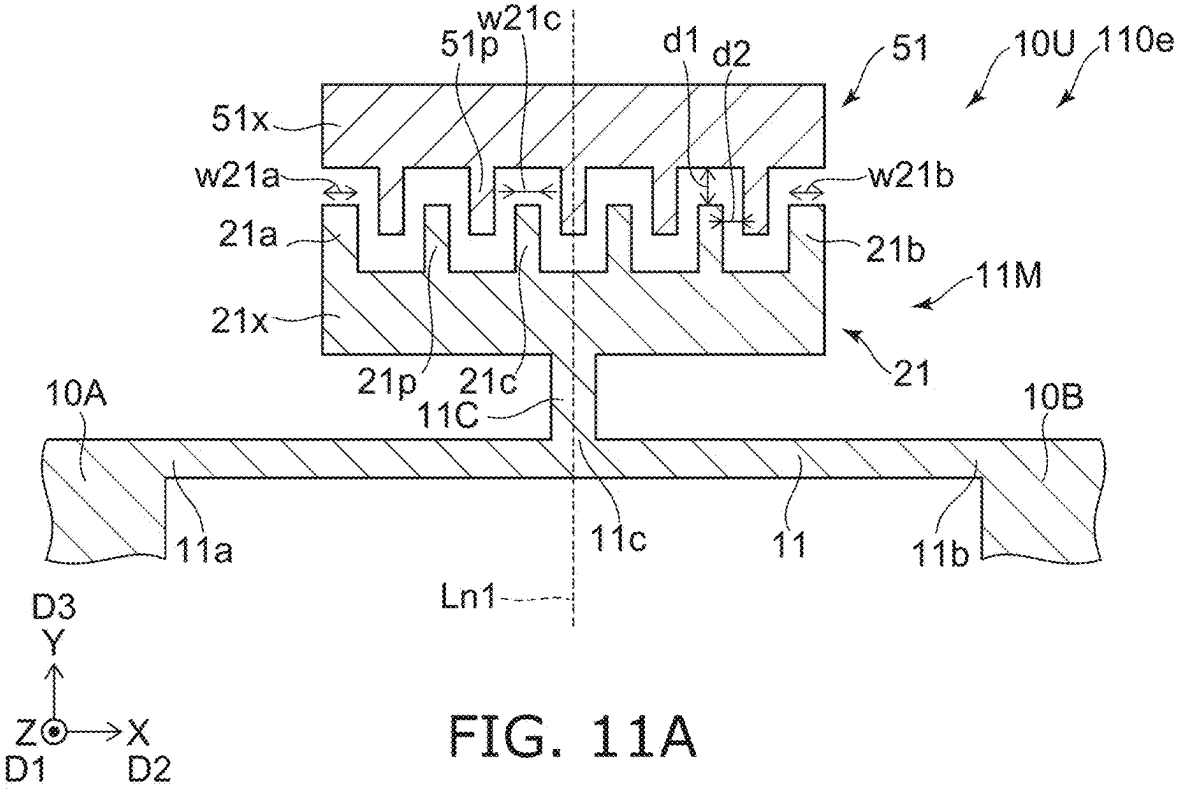

FIG. 11A

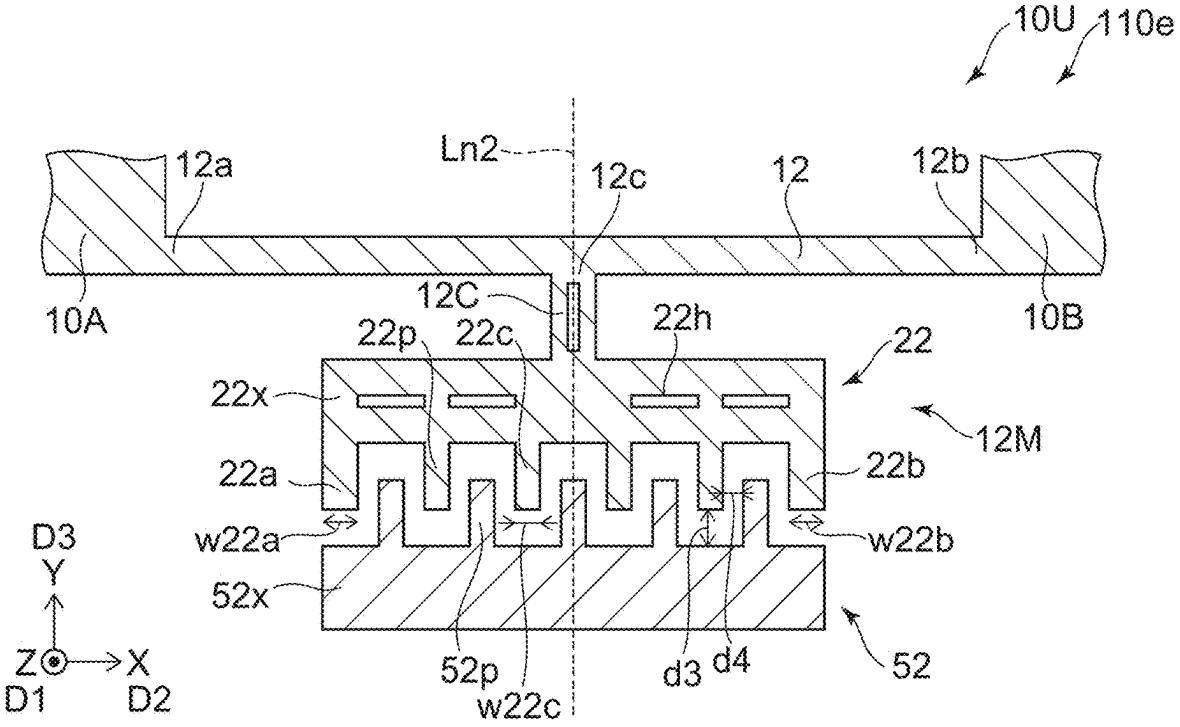

FIG. 11B

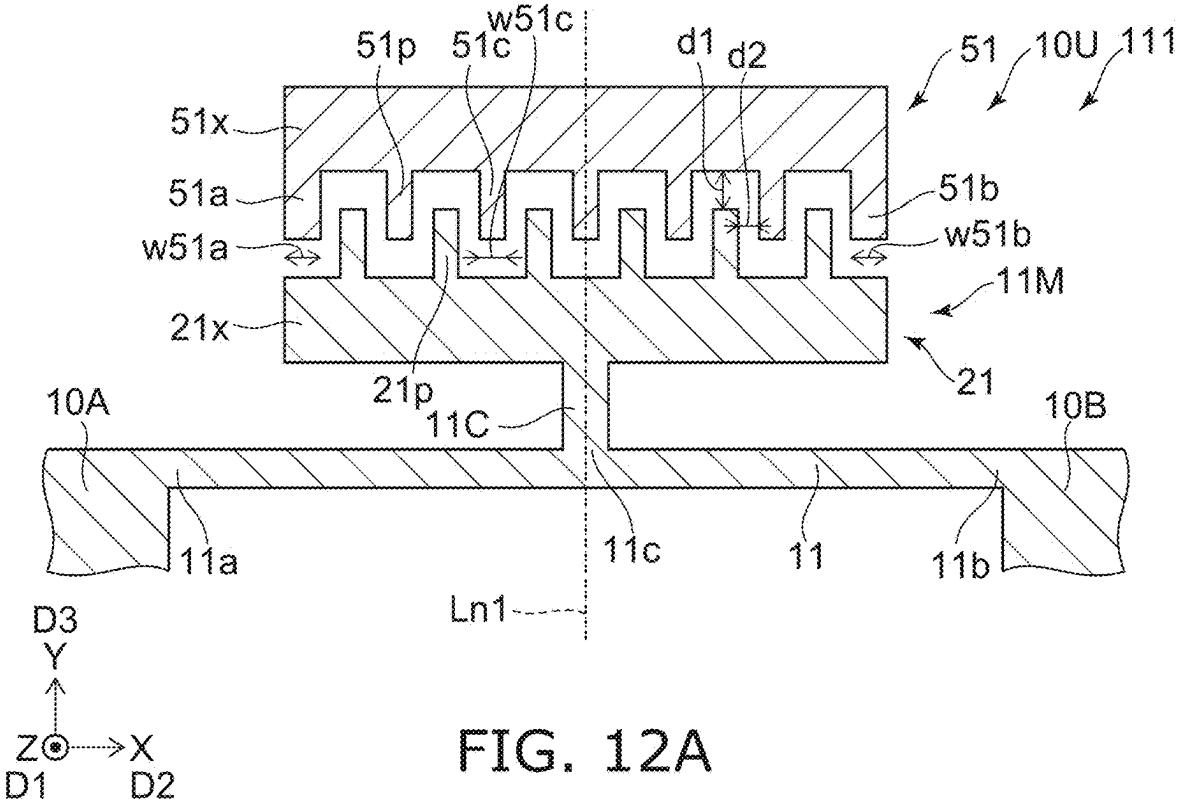

FIG. 12A

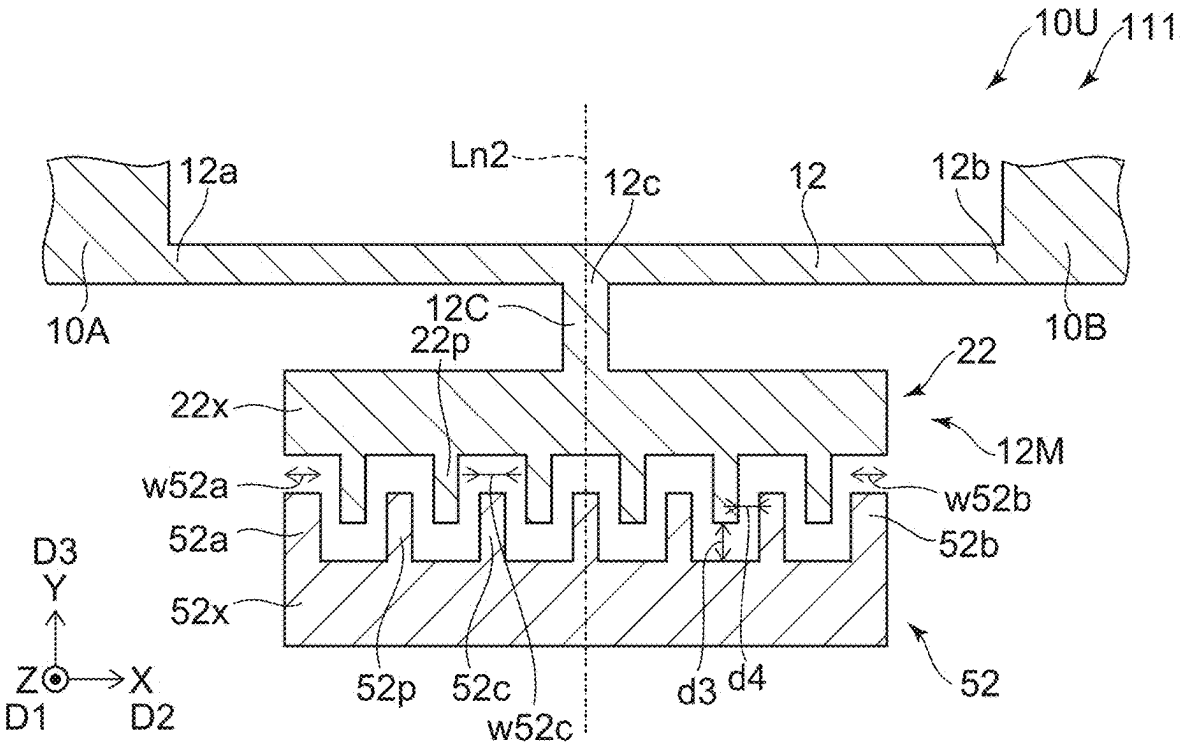

FIG. 12B

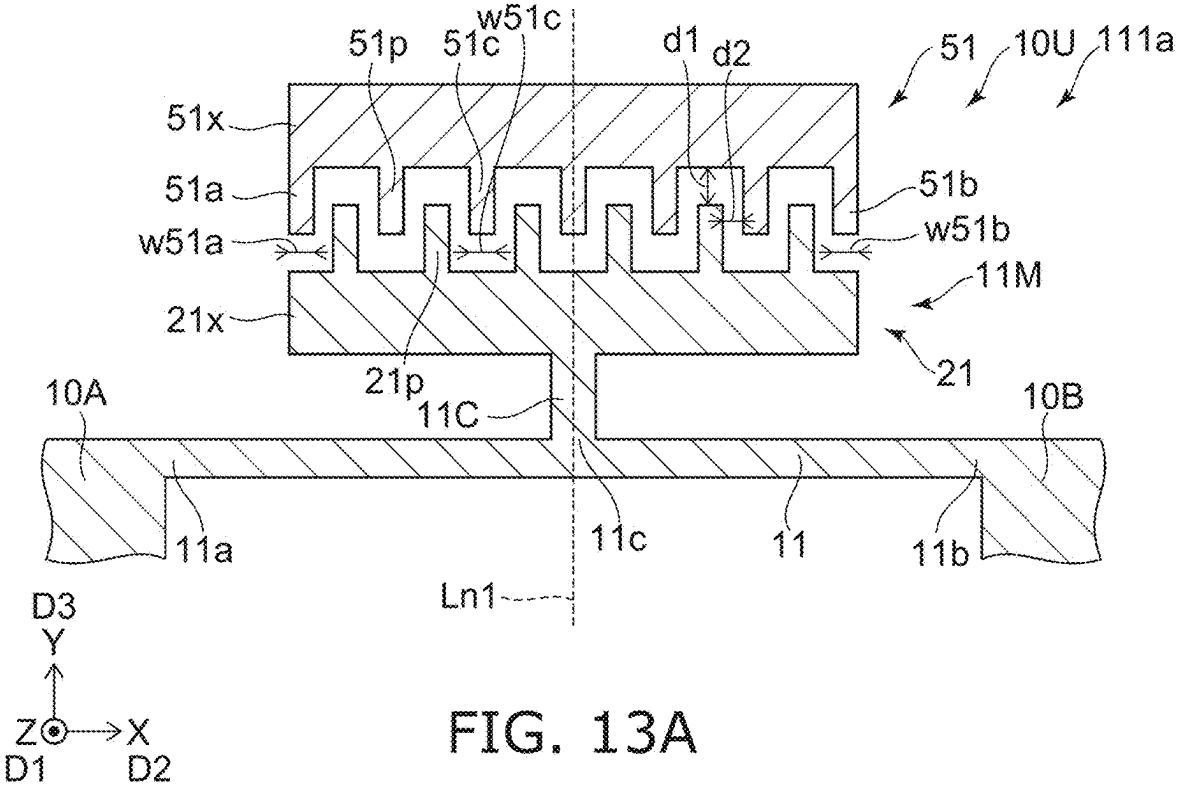

FIG. 13A

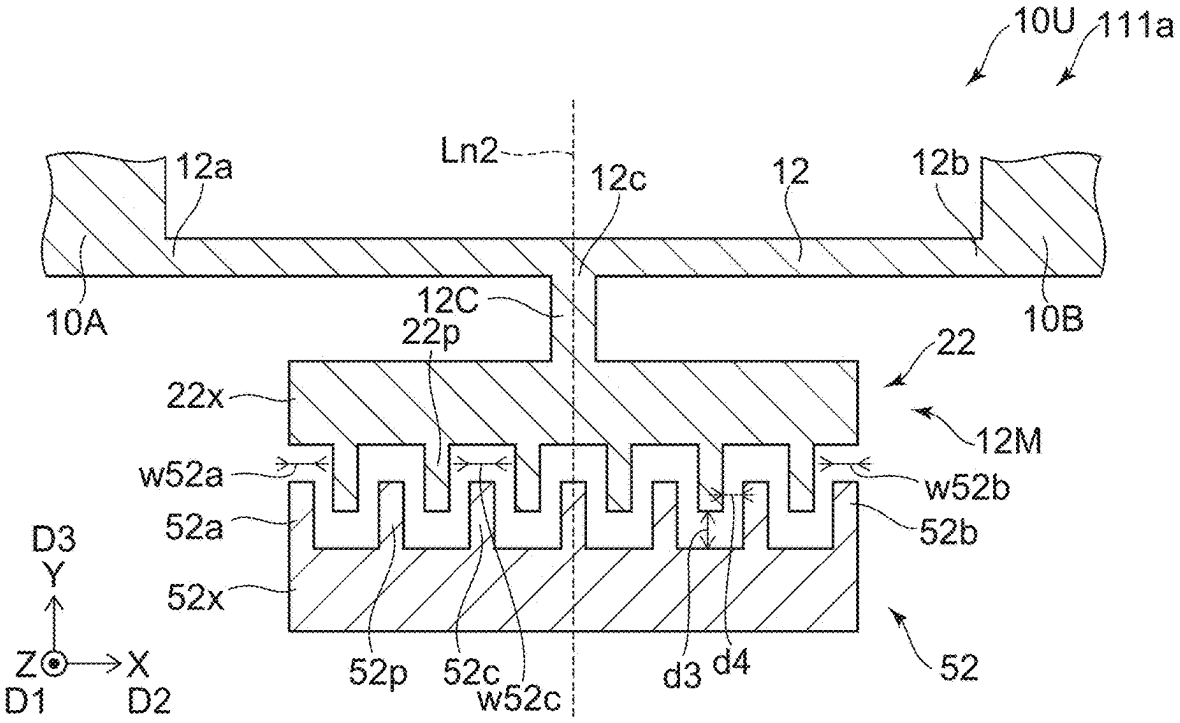

FIG. 13B

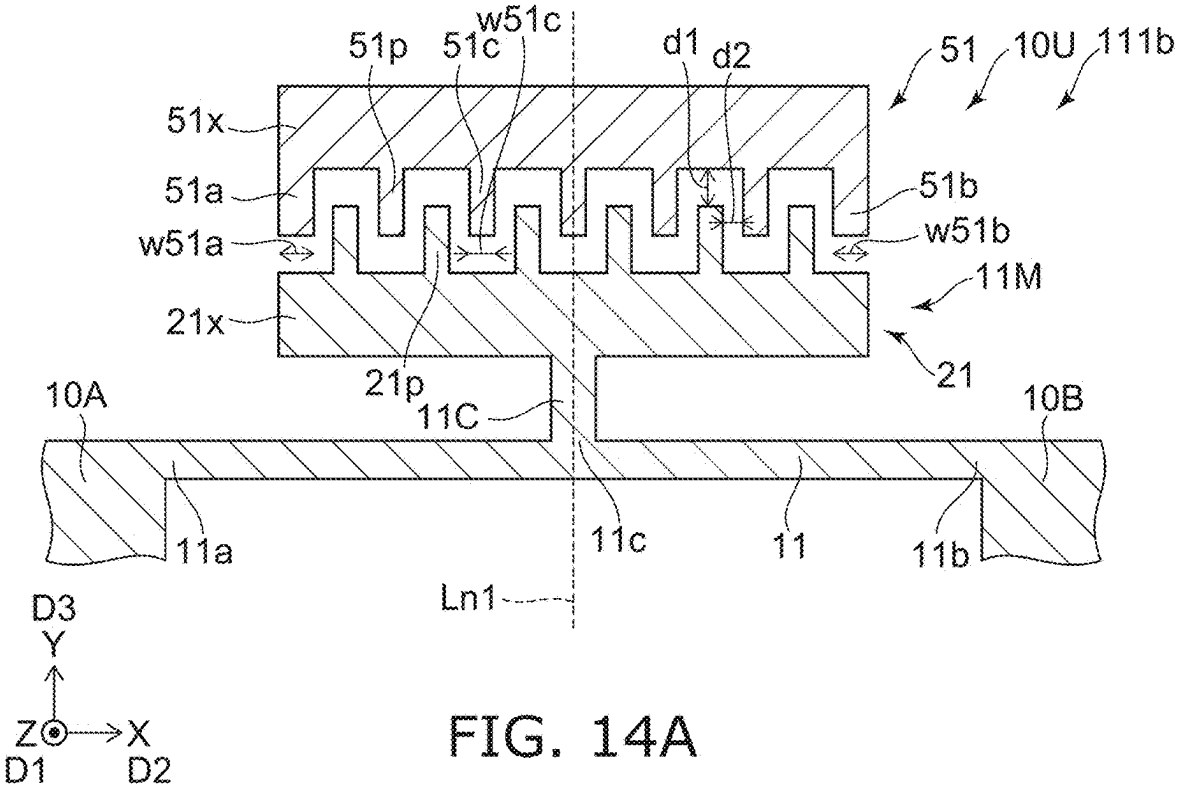

FIG. 14A

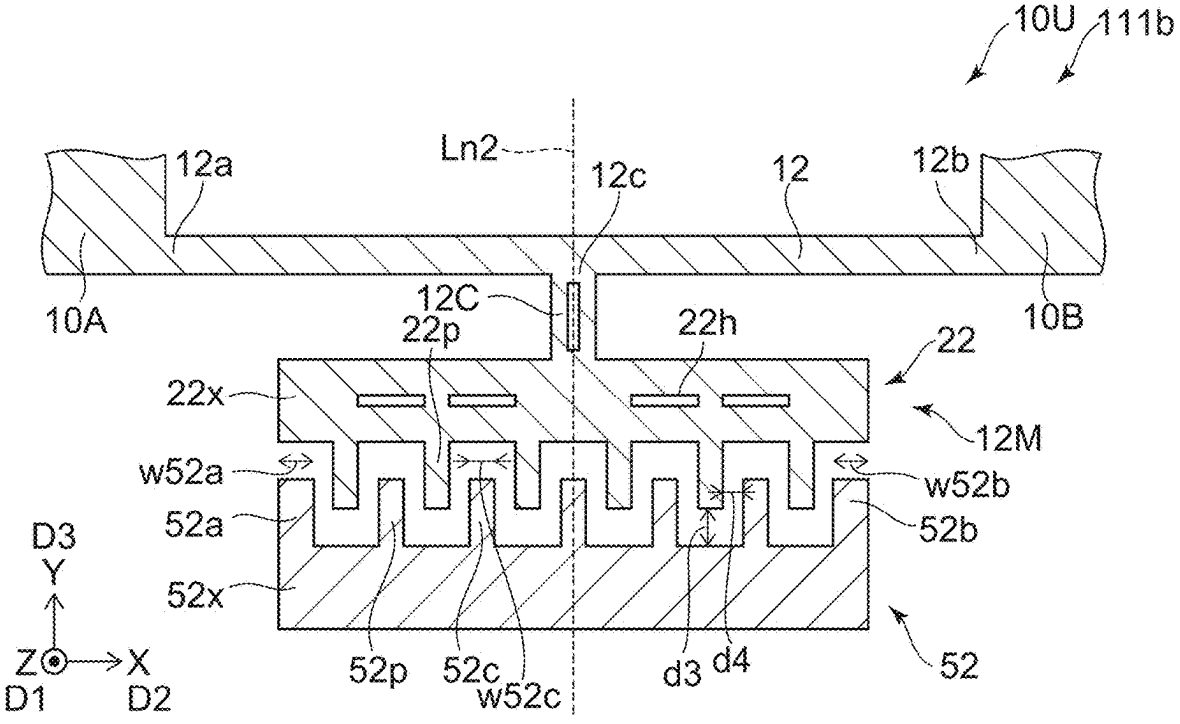

FIG. 14B

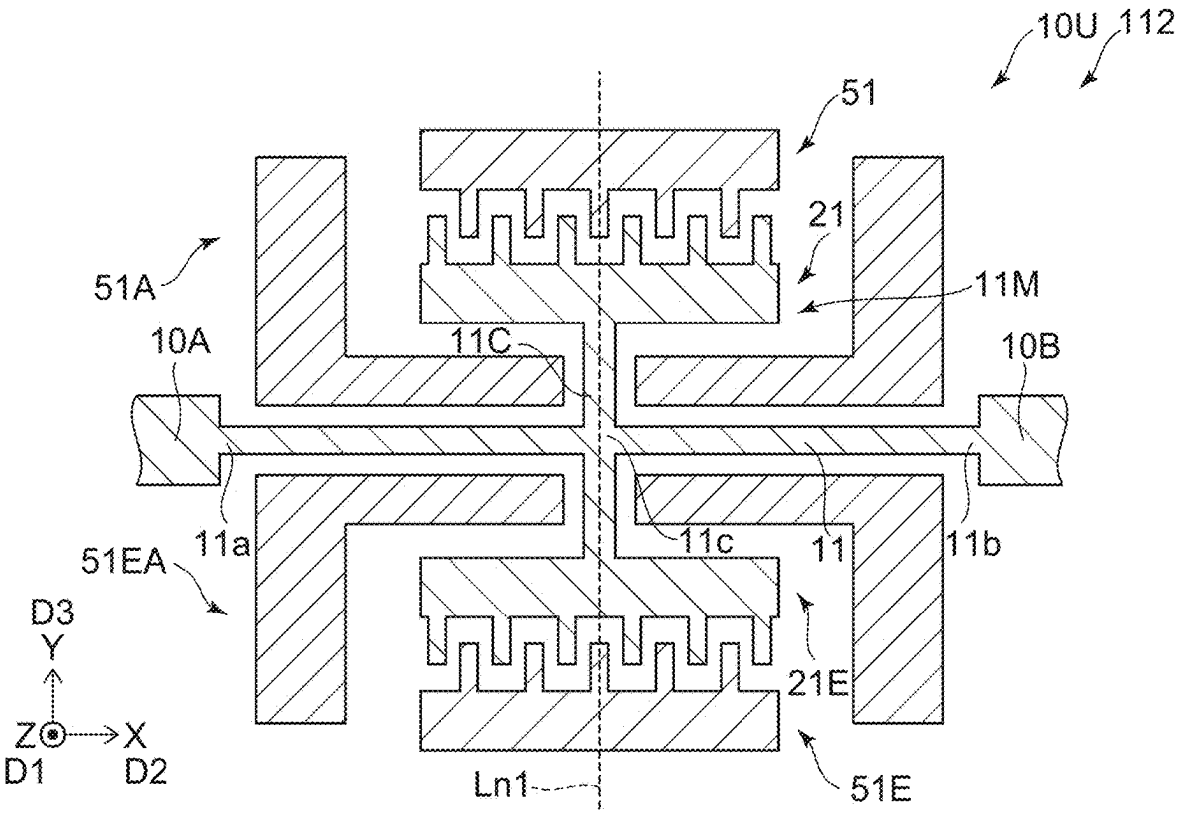
10U
112
51
21
51A
11M
10A
11C
10B
11a
11c
11
11b
51EA
D3
Y
Z
X
D1
D2
21E
Ln1
51E

FIG. 15

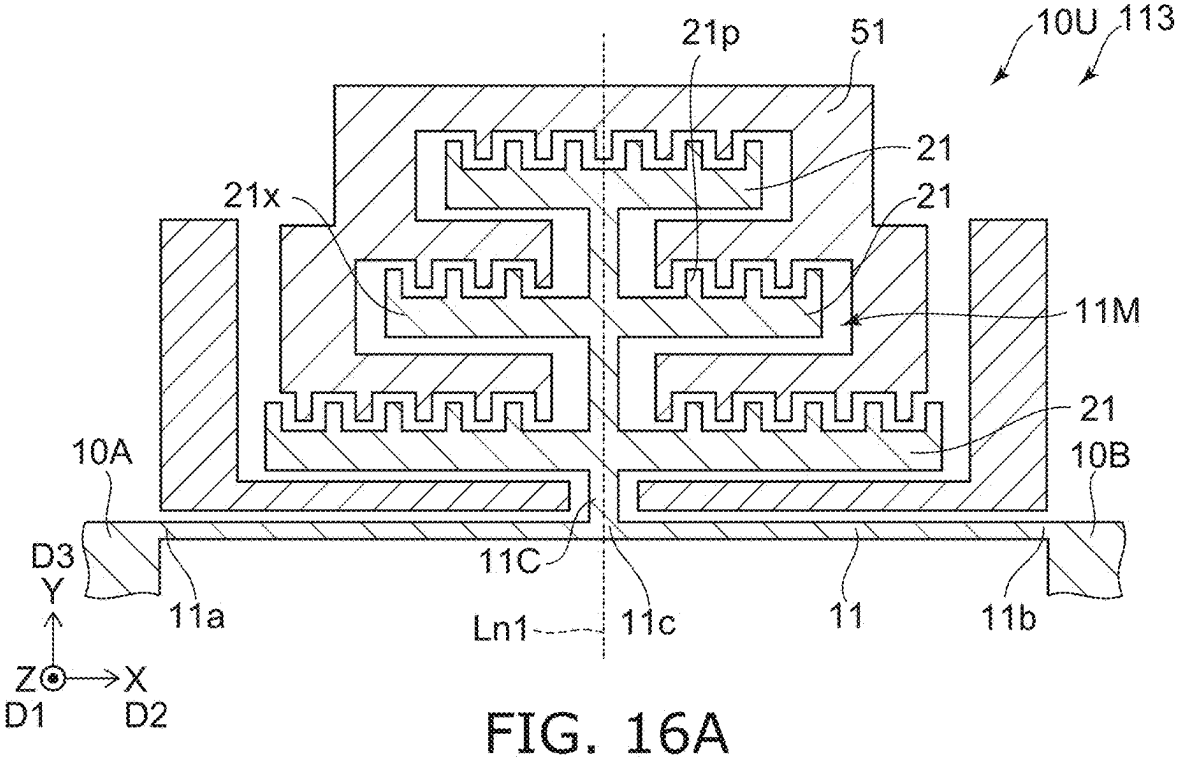

FIG. 16A

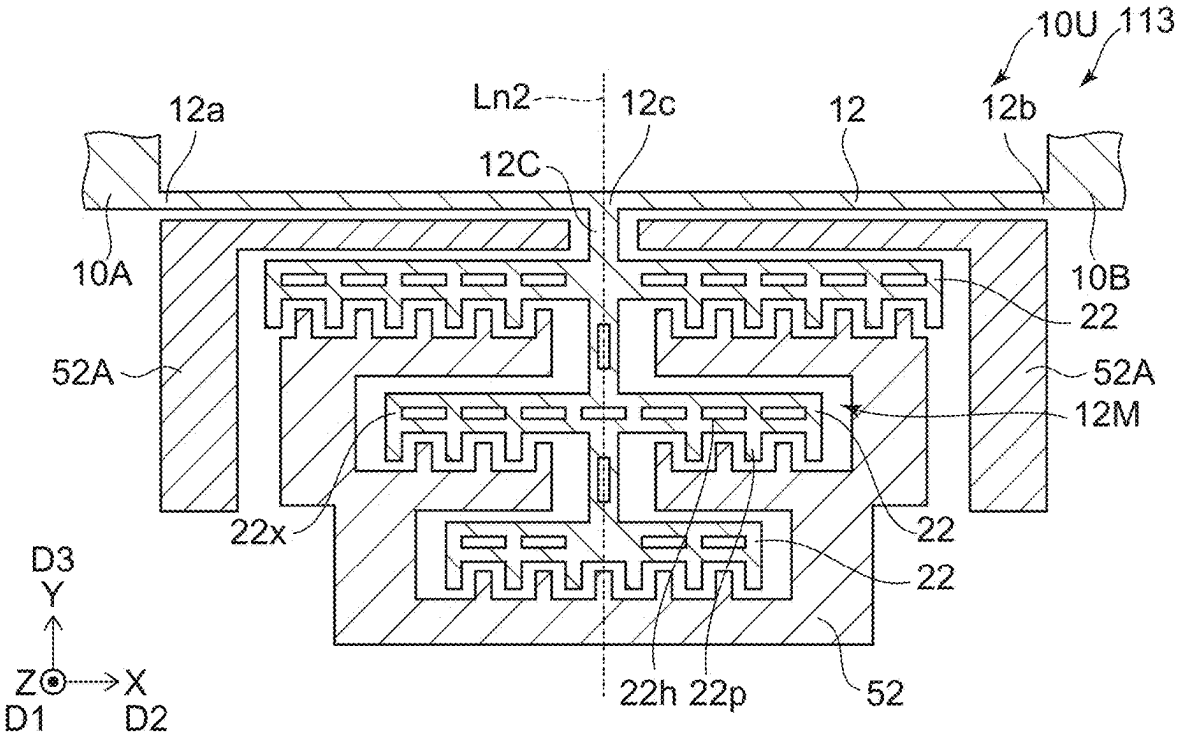

FIG. 16B

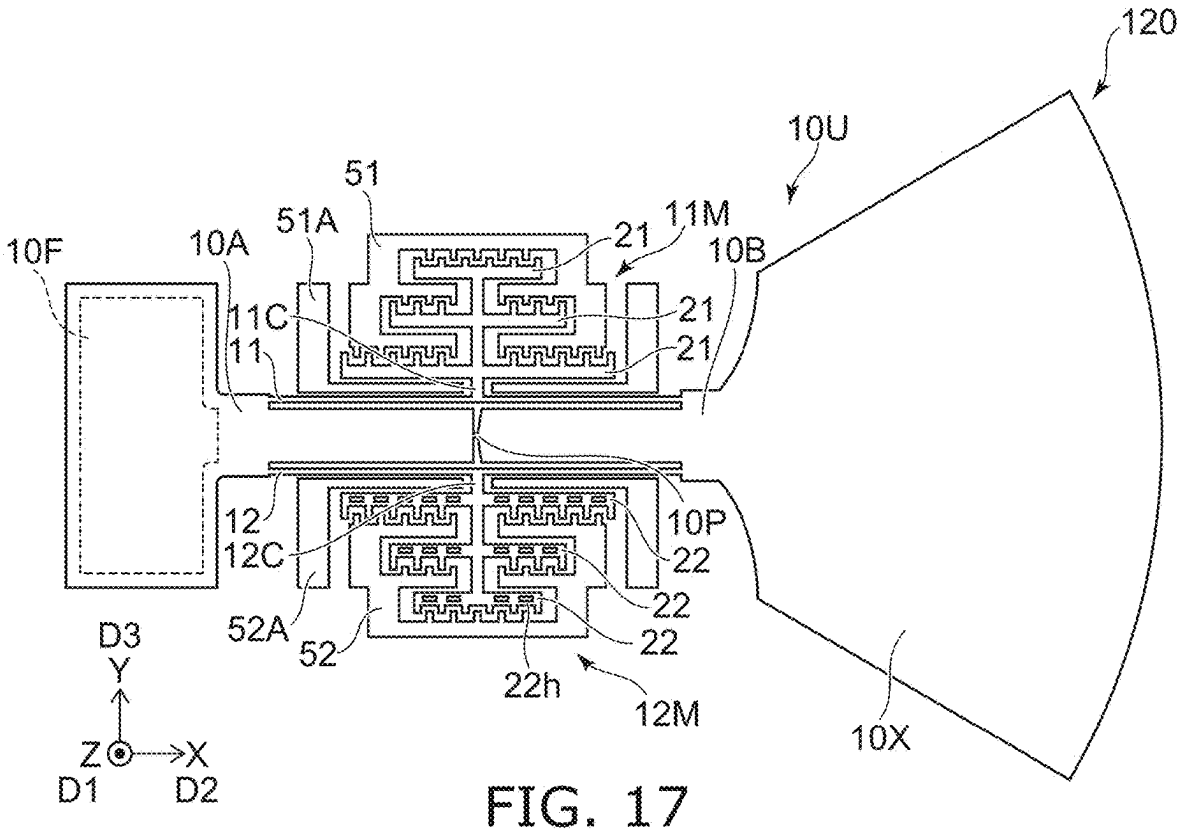
120
10U
51
51A
11M
21
10F
10A
10B
11C
11
21
21
12
12C
10P
22
22
52A
52
22
22h
12M
10X
D3
Y
Z
X
D1
D2

FIG. 17

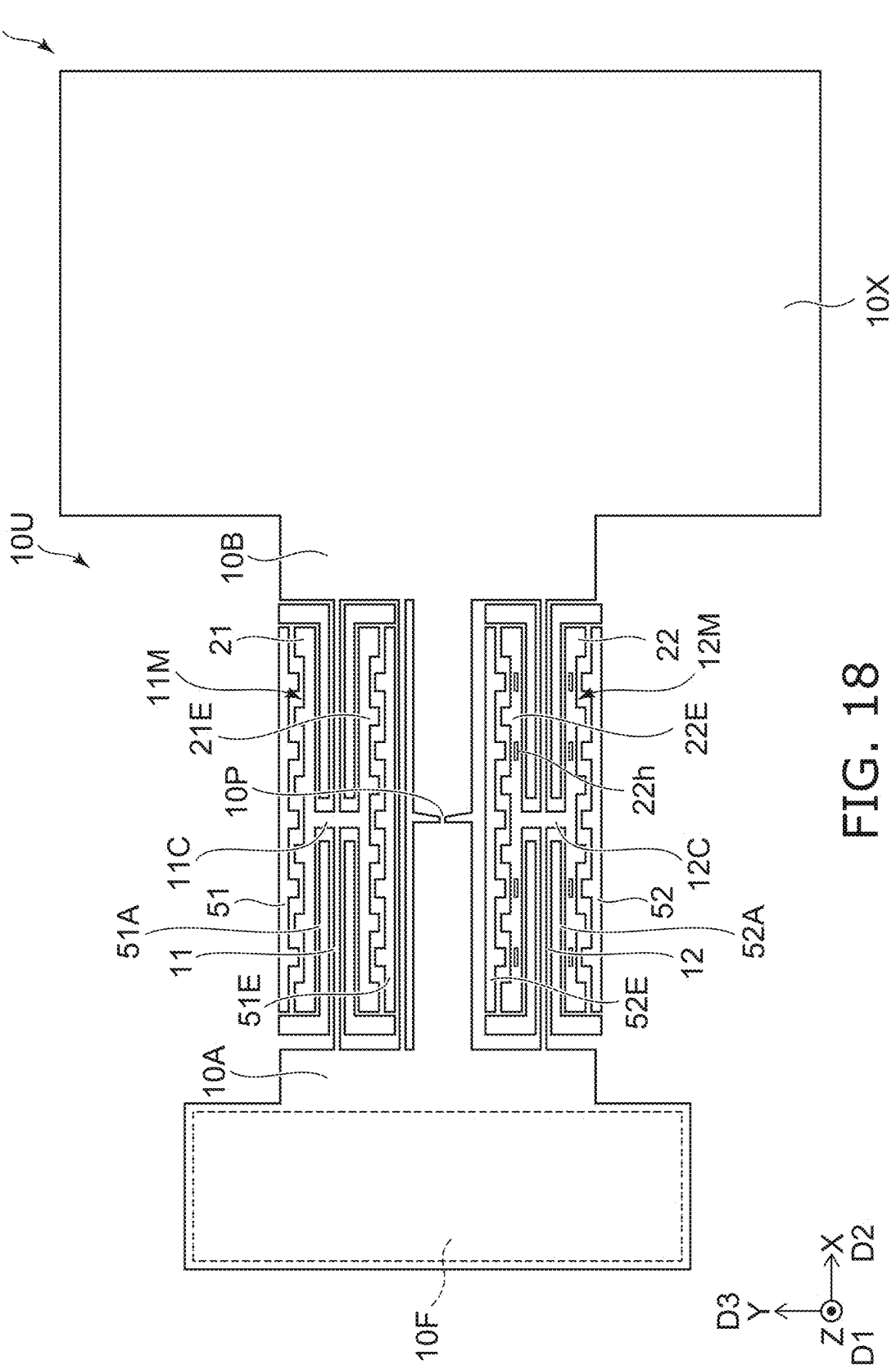
121
10X
10U
10B
21
11M
21E
10P
11C
51
51A
11
51E
10A
10F
22
12M
22E
22h
12C
52
52A
12
52E
D3
Y
X
D2
Z
D1

FIG. 18

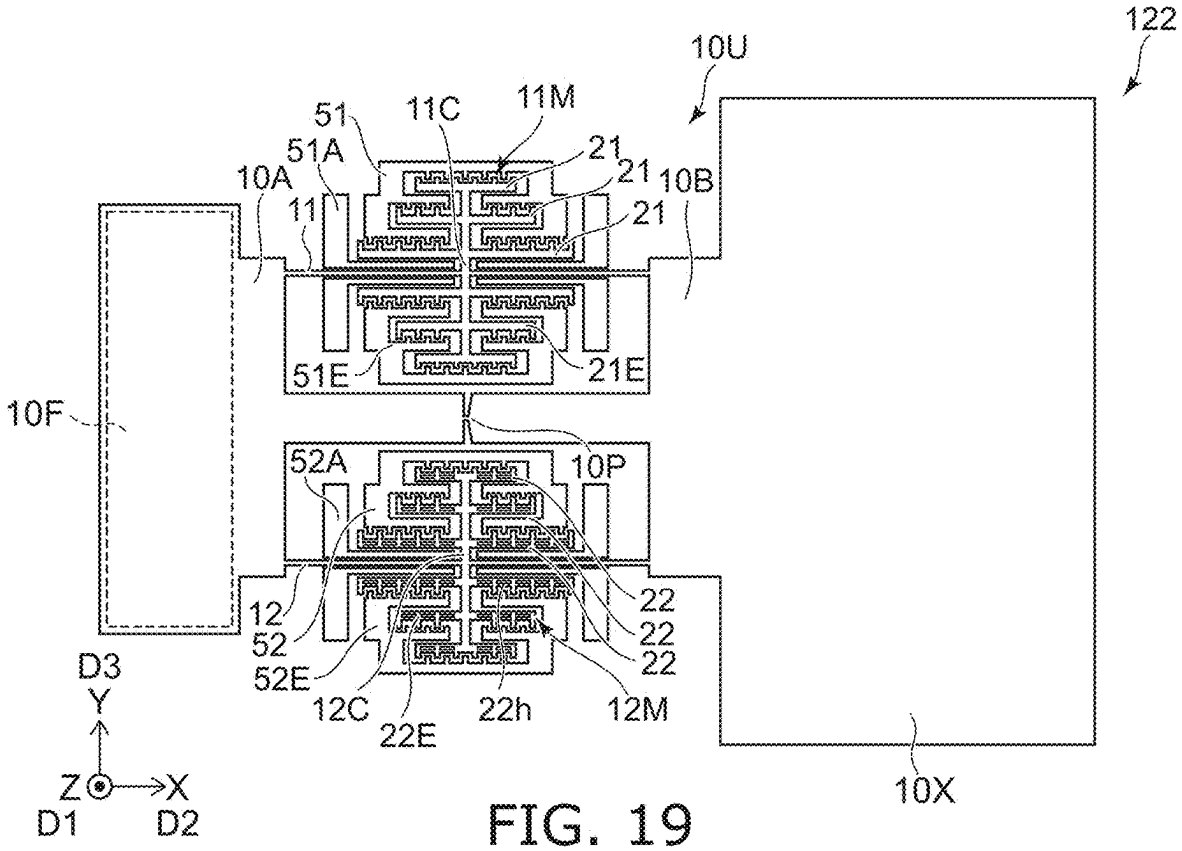
122
10U
51
11C
11M
51A
21
21
10A
10B
11
21
51E
21E
10F
52A
10P
12
52
52E
12C
22E
22h
12M
22
22
22
10X
D3
Y
Z
X
D1
D2

FIG. 19

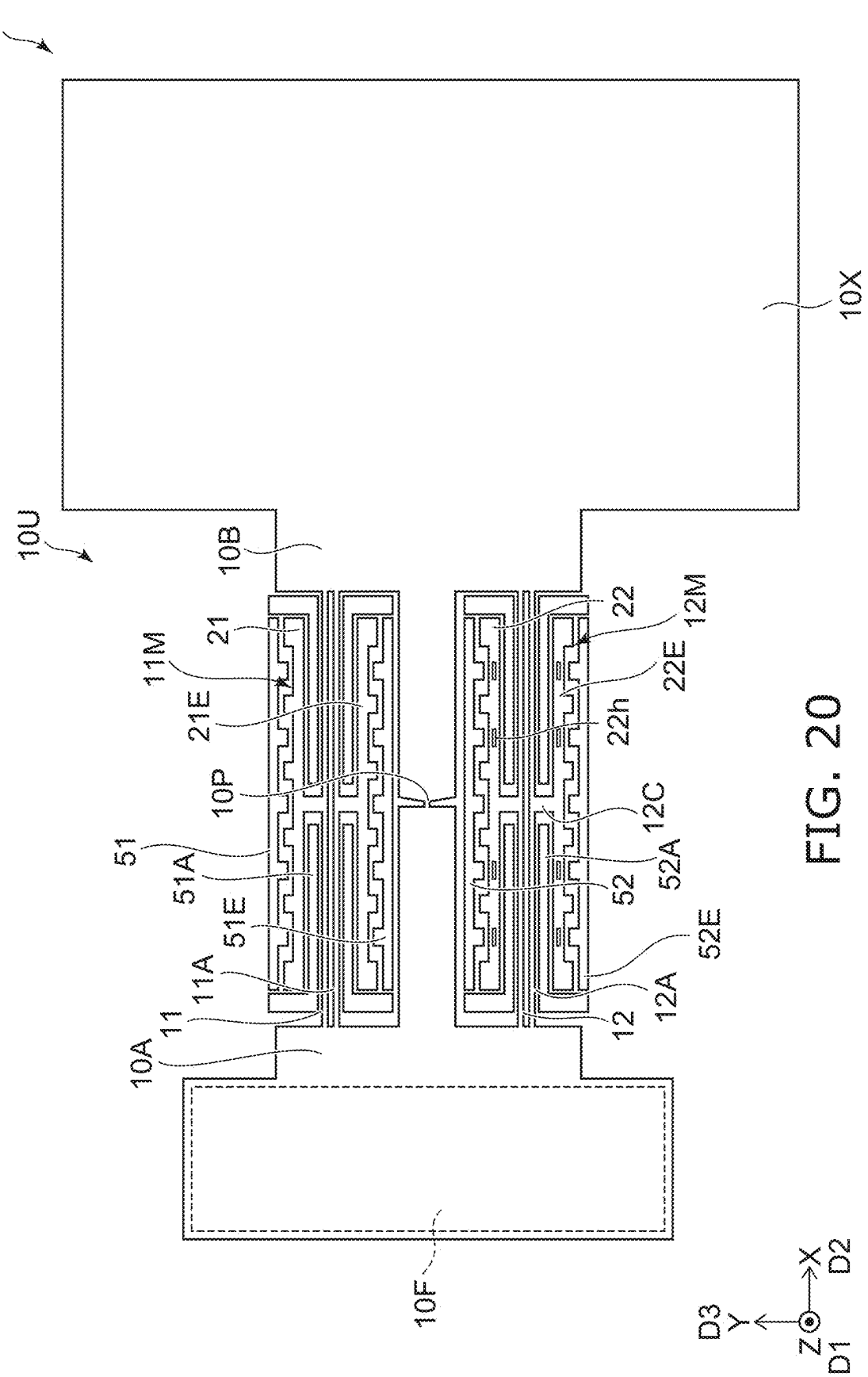
123
10X
10U
10B
21
11M
21E
10P
51
51A
51E
11A
11
10A
22
12M
22E
22h
12C
52A
52
52E
12A
12
10F
D3
Y
X
D2
Z
D1

FIG. 20

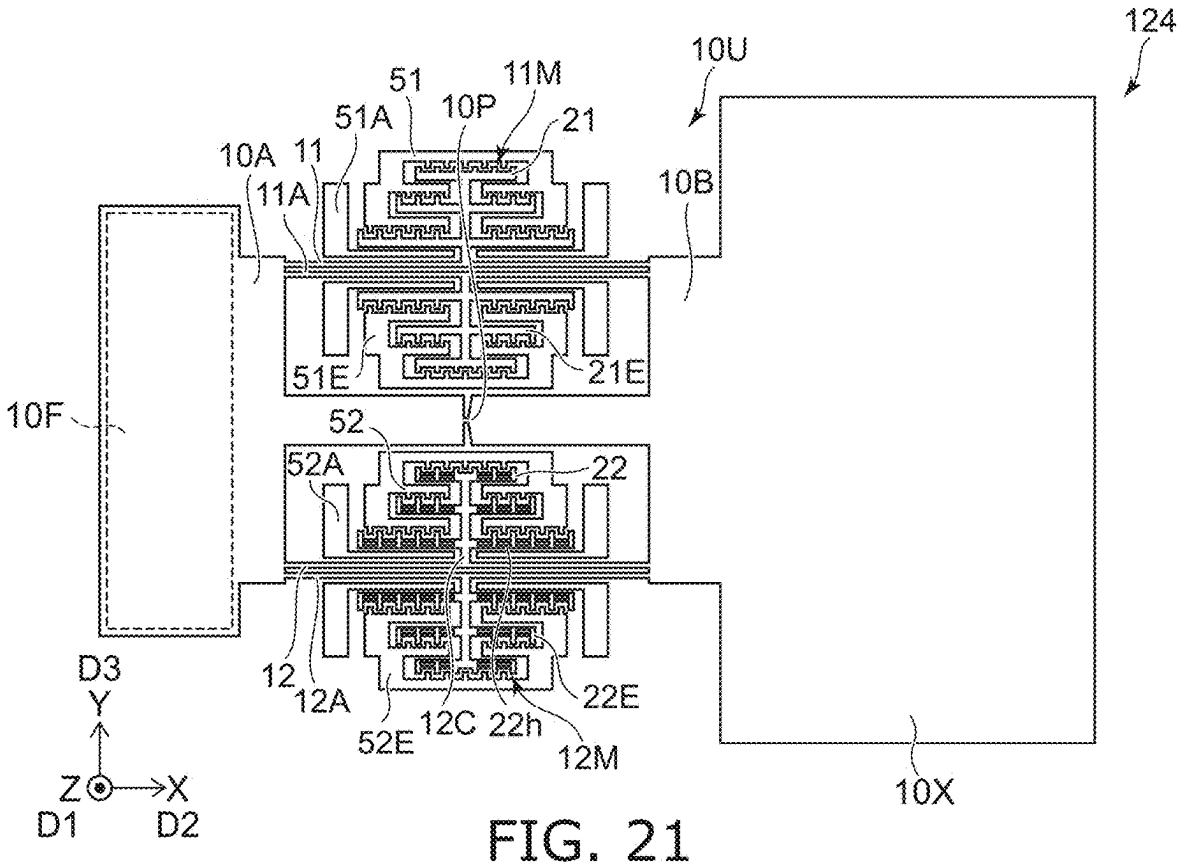
124
10U
51
11M
10P
21
51A
10A
11
11A
10B
51E
21E
10F
52
52A
22
12
12A
52E
12C
22h
12M
22E
10X
D3
Y
Z
X
D1
D2

FIG. 21

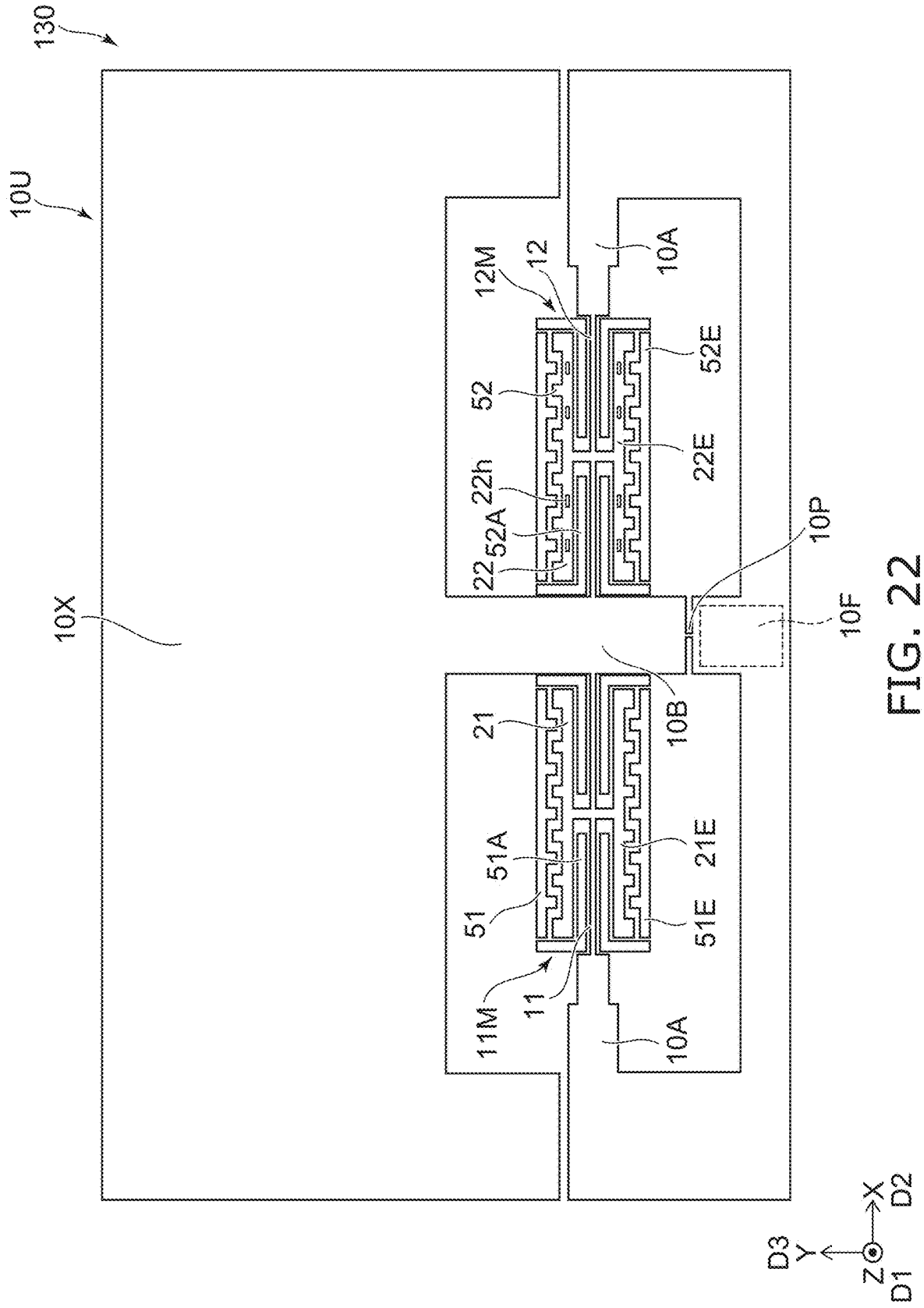
130
10U
10X
10A
12M
12
52E
52
22E
22h
52A
22
10P
10F
10B
21
51A
21E
51
51E
11M
11
10A
D2
X
D3
Y
Z
D1

FIG. 22

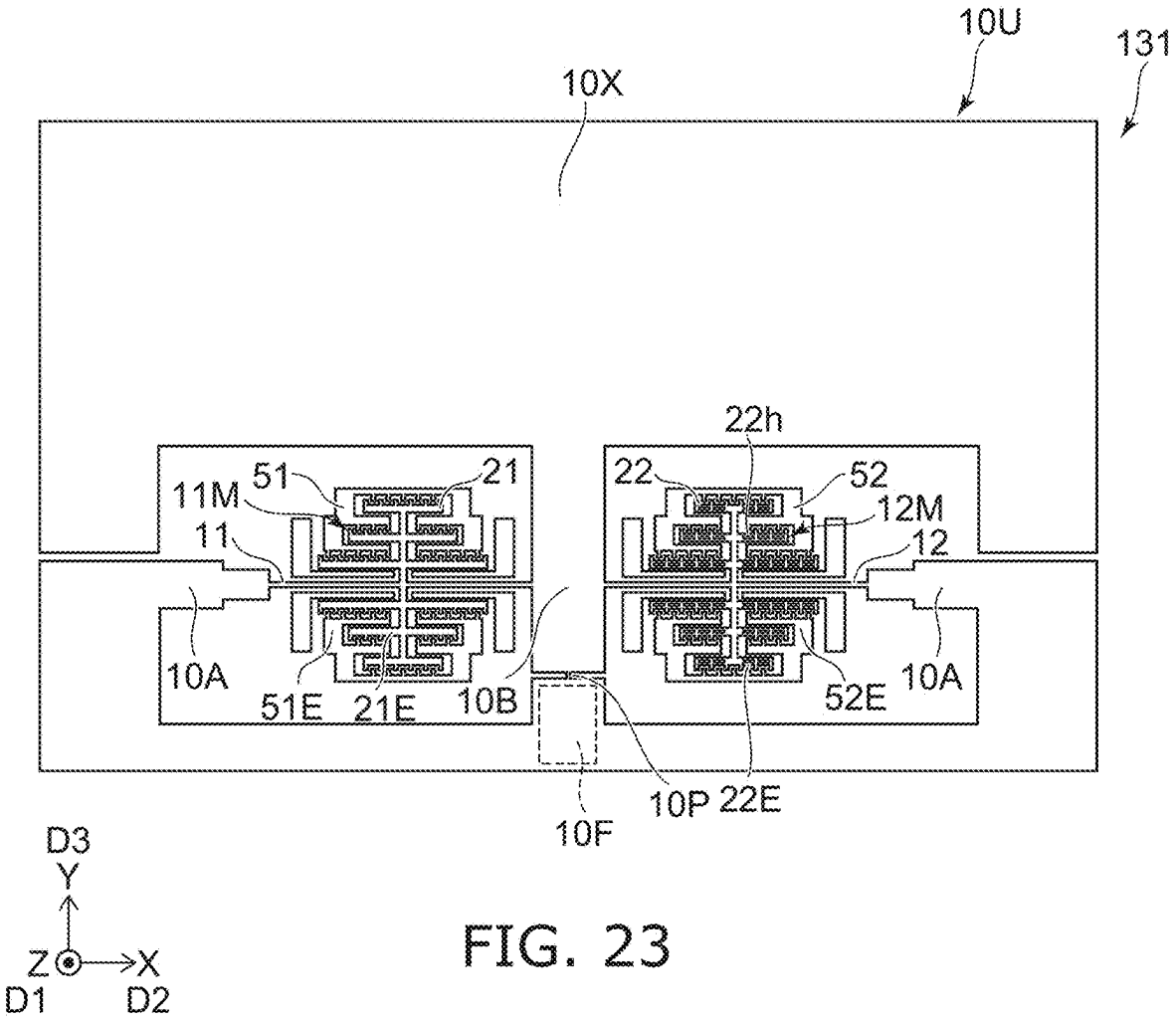
10U
131
10X
22h
11M
51
21
22
52
12M
11
12
10A
51E
21E
10B
52E
10A
10F
10P
22E
D3
Y
Z
X
D1
D2

FIG. 23

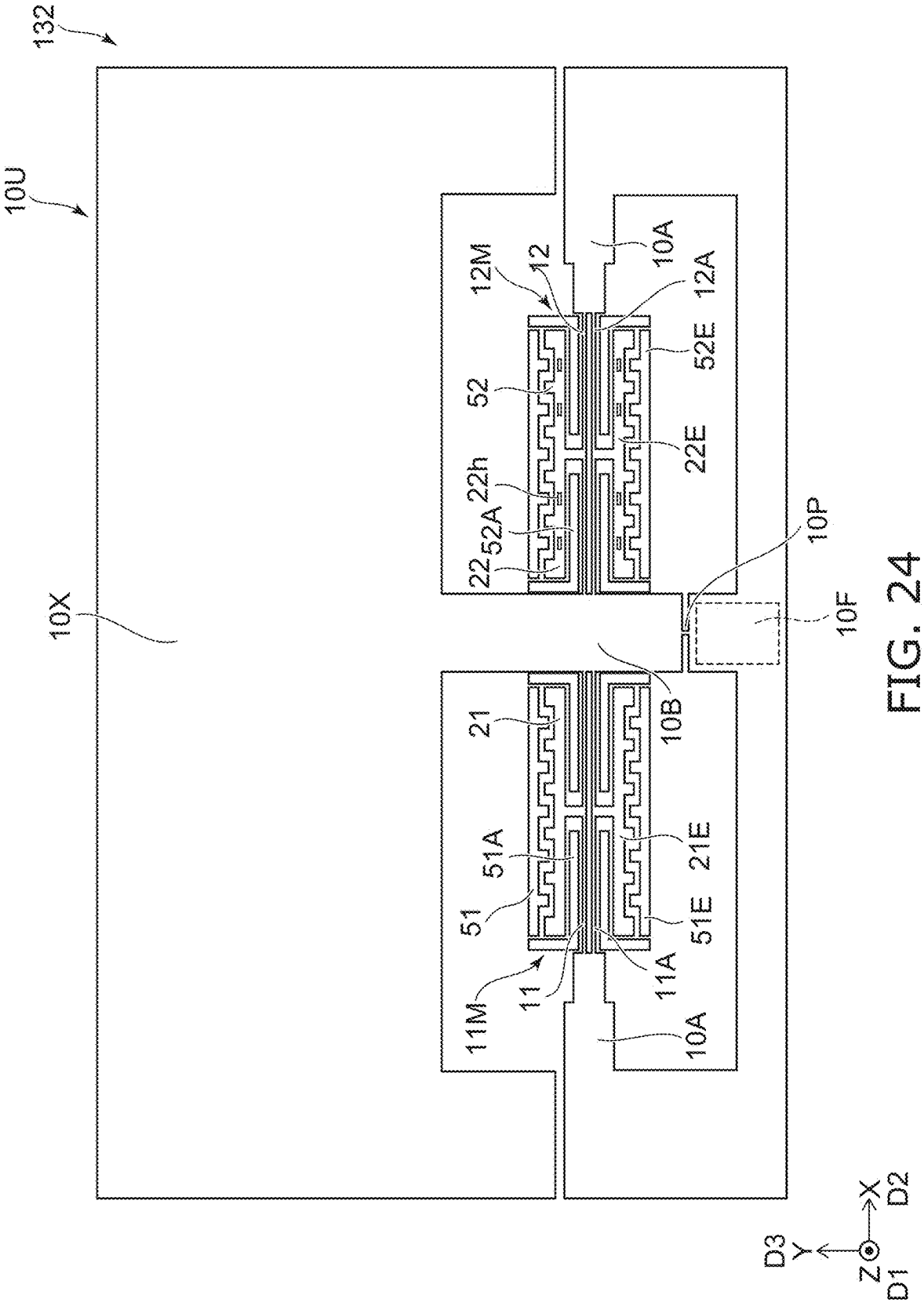
132
10U
10X
12M
12
10A
12A
52E
52
22E
22h
52A
22
10P
10F
10B
21
51A
21E
51
51E
11M
11
11A
10A
D3
Y
X
D2
Z
D1

FIG. 24

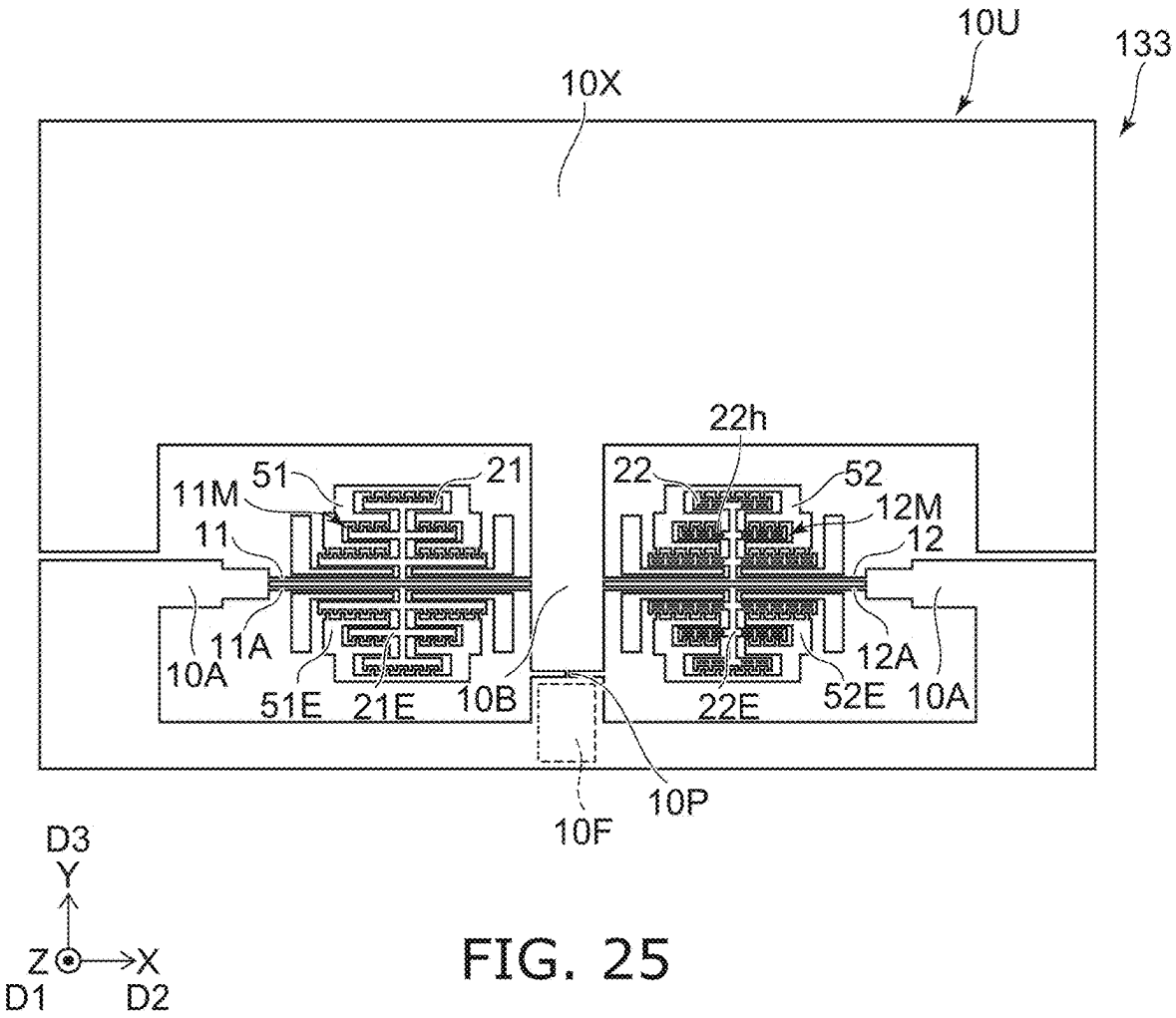
10U
133
10X
22h
11M
51
21
22
52
12M
11
12
10A
11A
51E
21E
10B
22E
52E
12A
10A
10F
10P
D3
Y
Z
X
D1
D2

FIG. 25

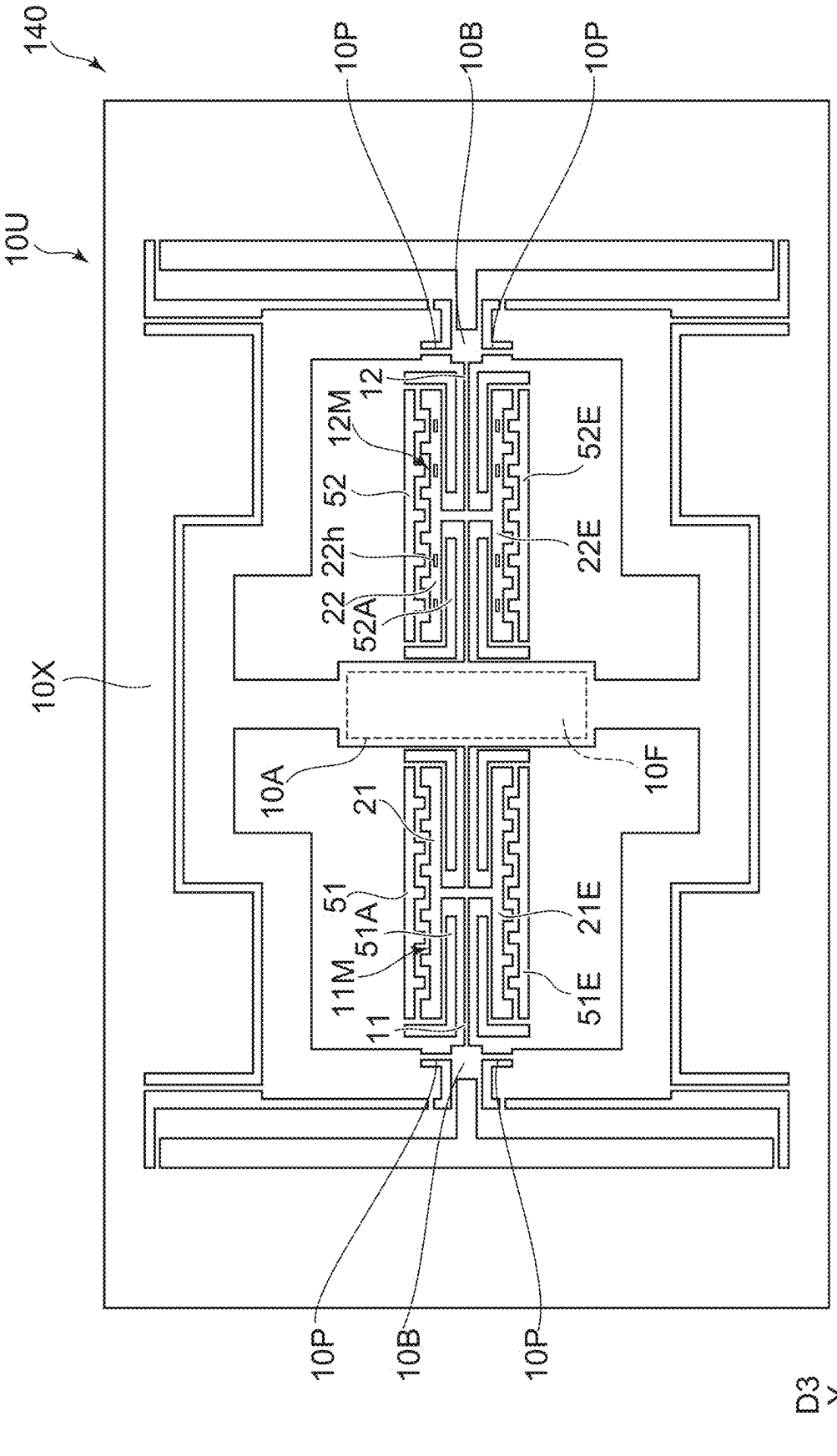
140
10U
10X
10P
10B
10P
12
12M
52
22h
22
52A
52E
22E
10A
21
51
51A
11M
11
21E
51E
10F
10P
10B
10P
D3
Y
Z
X
D2
D1

FIG. 26

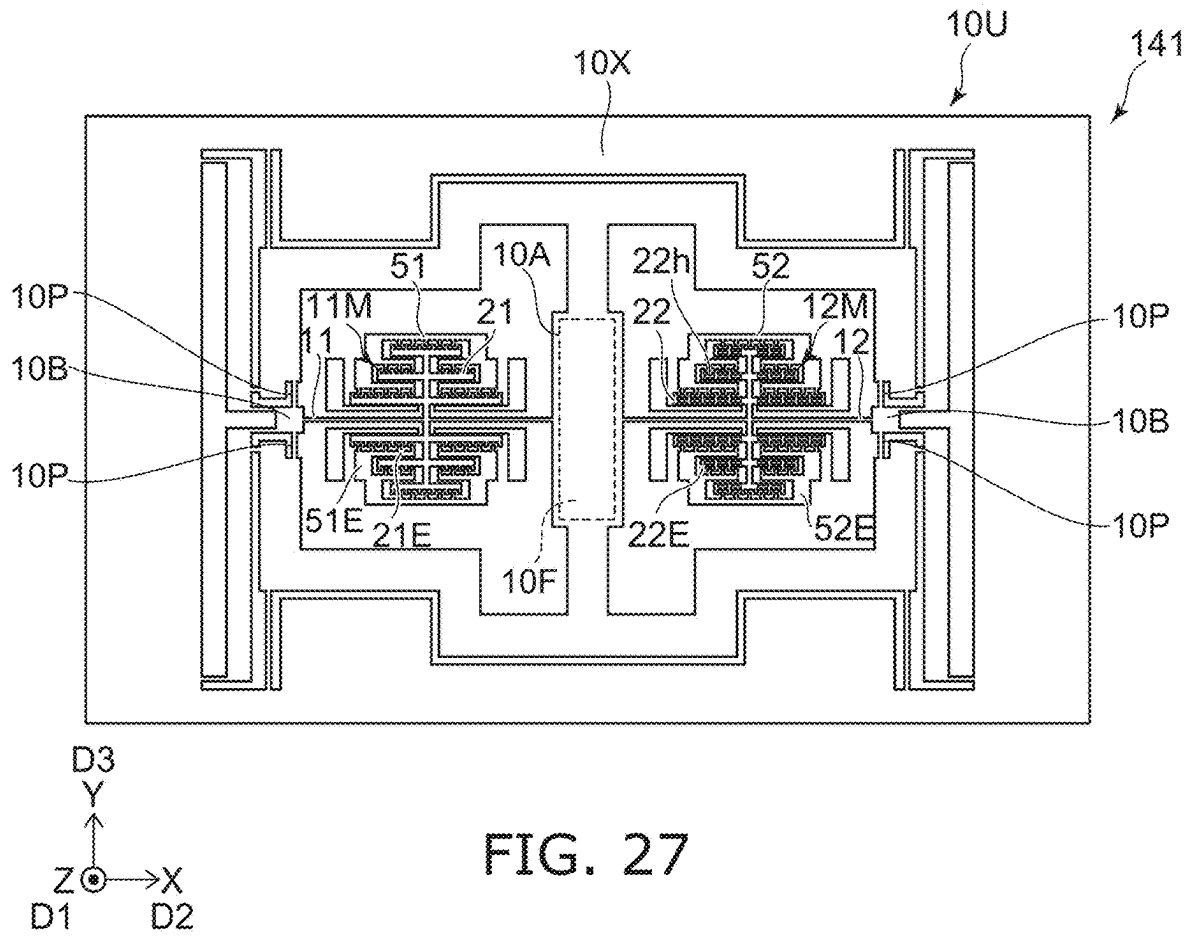
10U
141
10X
10P
10B
10P
51
10A
22h
52
11M
21
22
12M
11
12
10P
10B
10P
51E
21E
22E
52E
10F
D3
Y
Z
X
D1
D2

FIG. 27

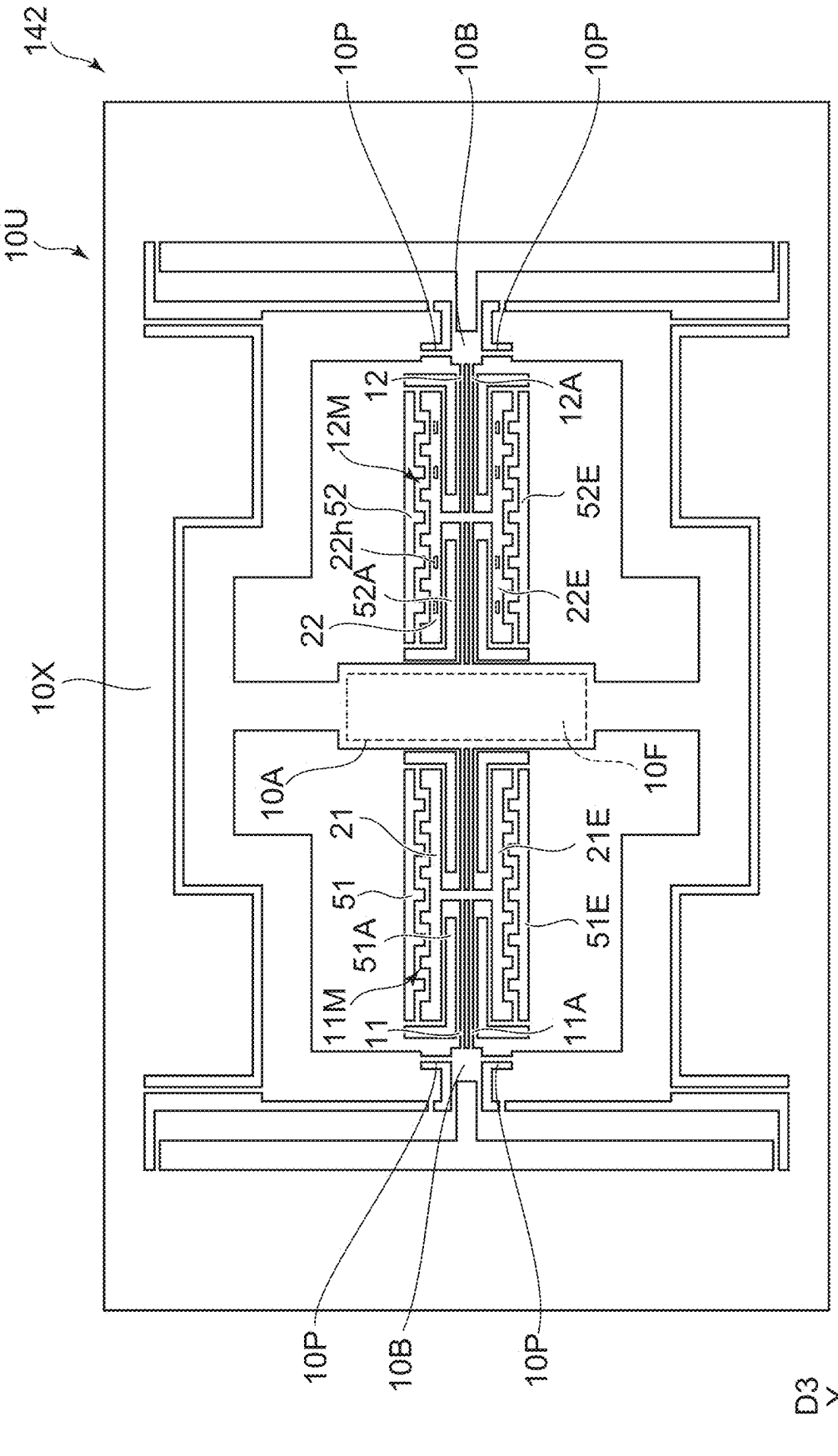
142
10P
10B
10P
10U
12
12M
12A
52
52E
22h
52A
22E
22
10X
10A
10F
21
21E
51
51A
51E
11M
11
11A
10P
10B
10P
D3
Y
X
D2
Z
D1

FIG. 28

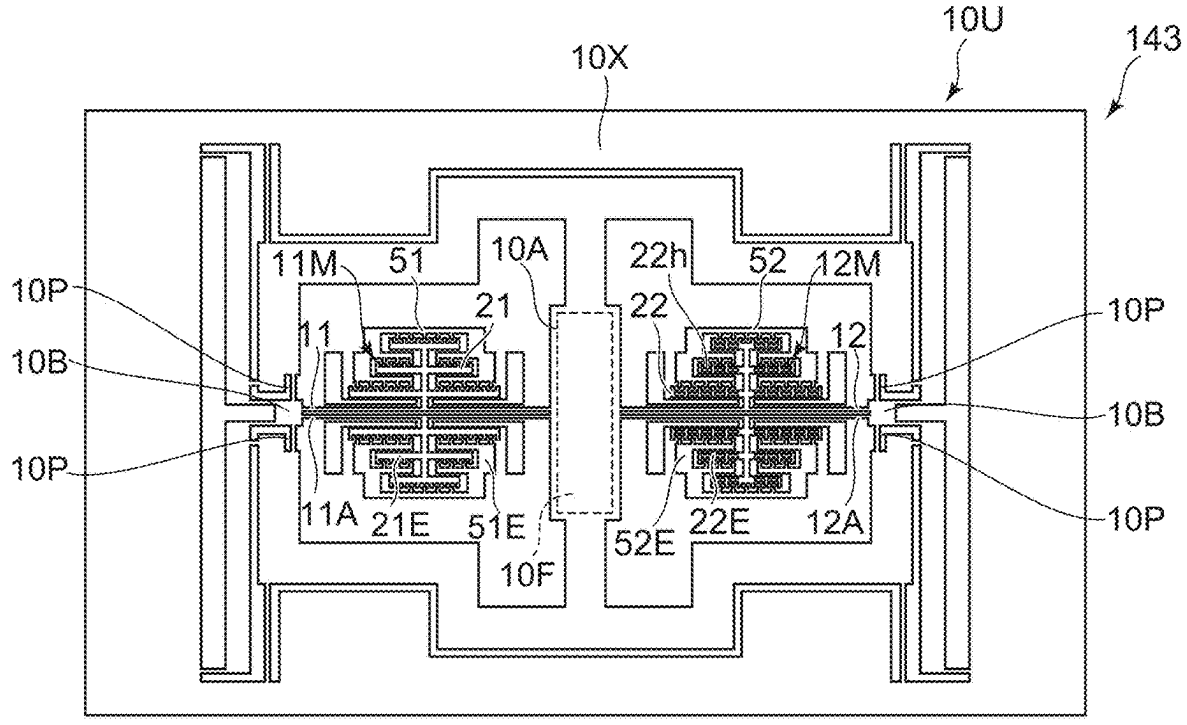
10U
143
10X
11M
51
10A
22h
52
12M
10P
21
22
10P
11
12
10B
10B
10P
11A
21E
51E
52E
22E
12A
10P
10F
D3
Y
Z
X
D1
D2

FIG. 29

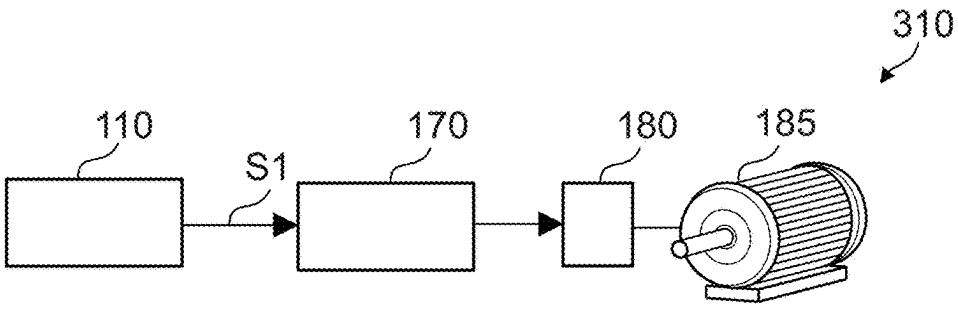
310
110
S1
170
180
185

FIG. 30

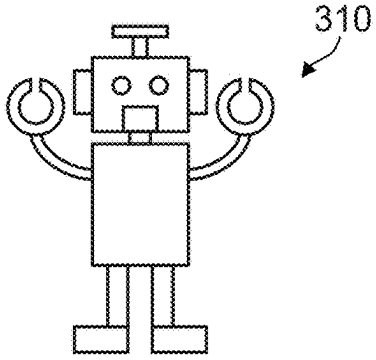

FIG. 31A

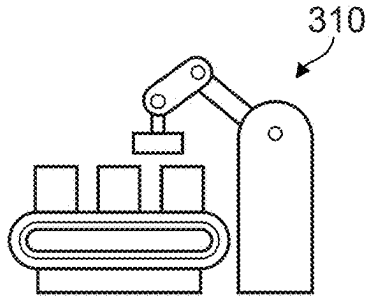

FIG. 31B

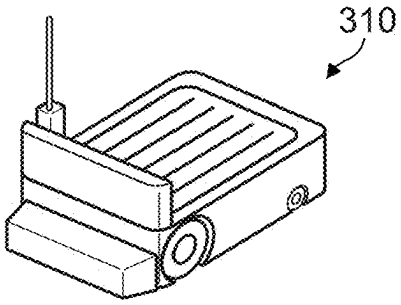

FIG. 31C

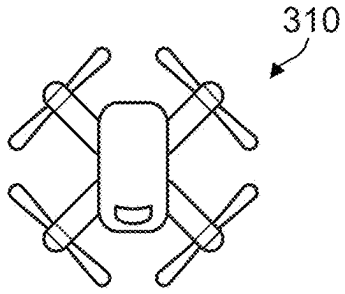

FIG. 31D

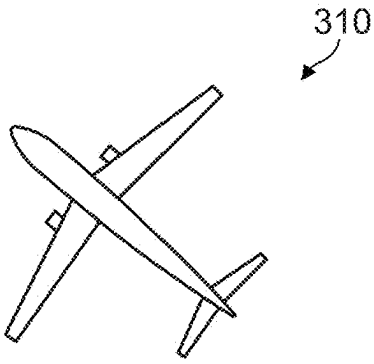

FIG. 31E

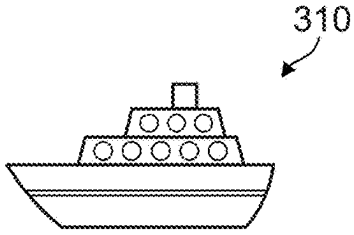

FIG. 31F

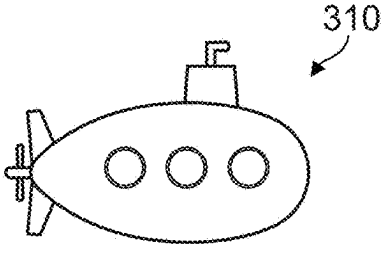

FIG. 31G

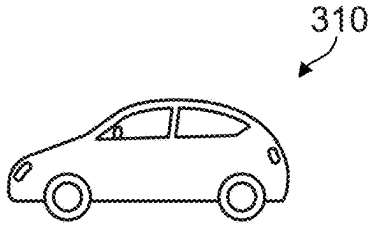

FIG. 31H

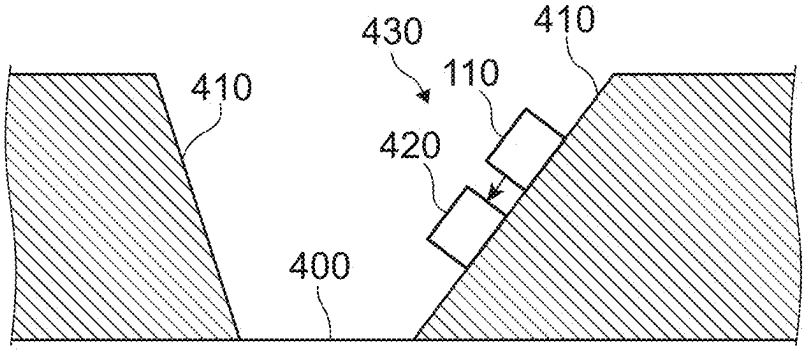

FIG. 32A

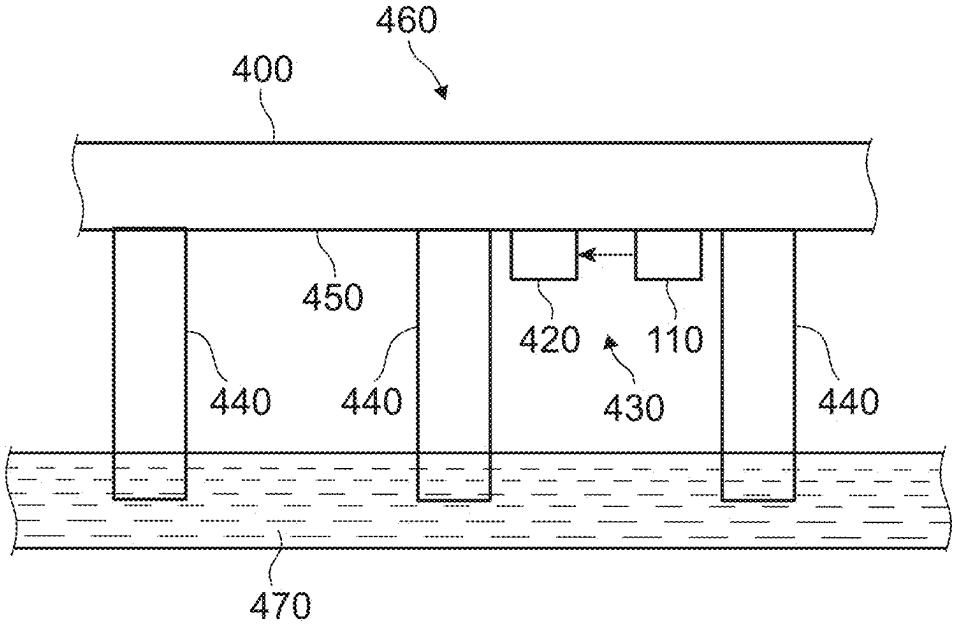

FIG. 32B

SENSOR AND ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2024-024740, filed on Feb. 21, 2024; the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to a sensor and an electronic device.

BACKGROUND

[0003] For example, there are sensors that utilize a MEMS structure. Stable characteristics are desired in sensors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIGS. **1**A and **1**B are schematic plan views illustrating a part of the sensor according to a first embodiment;
[0005] FIG. **2** is a schematic plan view illustrating the sensor according to the first embodiment;
[0006] FIGS. **3**A to **3**C are schematic cross-sectional views illustrating the sensor according to the first embodiment;
[0007] FIG. **4** is a schematic cross-sectional view illustrating the sensor according to the first embodiment;
[0008] FIGS. **5**A and **5**B are schematic views illustrating the sensor according to the first embodiment;
[0009] FIG. **6** is a graph illustrating the characteristics of the sensor according to the first embodiment;
[0010] FIGS. **7**A and **7**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0011] FIGS. **8**A and **8**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0012] FIGS. **9**A and **9**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0013] FIGS. **10**A and **10**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0014] FIGS. **11**A and **11**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0015] FIGS. **12**A and **12**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0016] FIGS. **13**A and **13**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0017] FIGS. **14**A and **14**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0018] FIG. **15** is a schematic plan view illustrating a part of a sensor according to the first embodiment;
[0019] FIGS. **16**A and **16**B are schematic plan views illustrating a part of a sensor according to the first embodiment;
[0020] FIG. **17** is a schematic plan views illustrating the sensor according to the first embodiment;
[0021] FIG. **18** is a schematic plan views illustrating the sensor according to the first embodiment;
[0022] FIG. **19** is a schematic plan views illustrating the sensor according to the first embodiment;
[0023] FIG. **20** is a schematic plan views illustrating the sensor according to the first embodiment;
[0024] FIG. **21** is a schematic plan views illustrating the sensor according to the first embodiment;
[0025] FIG. **22** is a schematic plan views illustrating the sensor according to the first embodiment;
[0026] FIG. **23** is a schematic plan views illustrating the sensor according to the first embodiment;
[0027] FIG. **24** is a schematic plan views illustrating the sensor according to the first embodiment;
[0028] FIG. **25** is a schematic plan views illustrating the sensor according to the first embodiment;
[0029] FIG. **26** is a schematic plan views illustrating the sensor according to the first embodiment;
[0030] FIG. **27** is a schematic plan views illustrating the sensor according to the first embodiment;
[0031] FIG. **28** is a schematic plan views illustrating the sensor according to the first embodiment;
[0032] FIG. **29** is a schematic plan views illustrating the sensor according to the first embodiment;
[0033] FIG. **30** is a schematic diagram illustrating an electronic device according to the second embodiment;
[0034] FIGS. **31**A to **31**H are schematic diagrams illustrating applications of the electronic device according to the embodiment; and
[0035] FIGS. **32**A and **32**B are schematic diagrams illustrating applications of the sensor according to the embodiment.

DETAILED DESCRIPTION

[0036] According to one embodiment, a sensor includes a base and an element section. The element section includes a first fixed portion fixed to the base, a first fixed electrode fixed to the base, and a first movable portion. A first gap is provided between the base and the first movable portion. The first movable portion includes a first movable base portion supported by the first fixed portion, a first other movable base portion connected to the first movable base portion, and a first movable structure. The first movable structure includes a first beam, a first movable electrode, and a first connecting portion. The first beam include a first beam portion, a first other beam portion, and a first intermediate beam portion between the first beam portion and the first other beam portion. A second direction from the first beam portion to the first other beam portion crosses a first direction from the base to the first fixed portion. The first beam portion is connected to the first movable base portion. The first other beam portion is connected to the first other movable base portion. A third direction from the first beam to the first movable electrode crosses a plane including the first direction and the second direction. The first connecting portion connects the first movable electrode to the first intermediate beam portion. The first movable electrode includes a first movable electrode base portion and a plurality of first movable protruding portions connected to the first movable electrode base portion. The plurality of first movable protruding portions are arranged along the second direction. The first fixed electrode includes a first fixed electrode base portion and a plurality of first fixed protruding portions connected to the first fixed electrode base portion. The plurality of first fixed protruding portion are arranged along the second direction. The plurality of first movable protruding portions meshes with the plurality of first fixed protruding portions in a comb-teeth shape. The plurality of first

movable protruding portions include a first movable end protruding portions, a first movable other end protruding portion, and a plurality of first movable intermediate protruding portions. The first movable end protruding portion is one end in the second direction among the plurality of first movable protruding portions. The first movable other end protruding portion being another end in the second direction among the plurality of first movable protruding portions. The plurality of first movable intermediate protruding portions are between the first movable end protruding portion and the first movable other end protruding portion. A first movable end protruding portion width of the first movable end protruding portion along the second direction is the same as a first movable other end protruding portion width of the first movable other end protruding portion along the second direction.

[0037] Various embodiments are described below with reference to the accompanying drawings.

[0038] The drawings are schematic and conceptual; and the relationships between the thickness and width of portions, the proportions of sizes among portions, etc., are not necessarily the same as the actual values. The dimensions and proportions may be illustrated differently among drawings, even for identical portions.

[0039] In the specification and drawings, components similar to those described previously or illustrated in an antecedent drawing are marked with like reference numerals, and a detailed description is omitted as appropriate.

First Embodiment

[0040] FIGS. **1**A and **1**B are schematic plan views illustrating a part of the sensor according to a first embodiment.

[0041] FIG. **2** is a schematic plan view illustrating the sensor according to the first embodiment.

[0042] FIGS. **3**A to **3**C are schematic cross-sectional views illustrating the sensor according to the first embodiment.

[0043] FIG. **4** is a schematic cross-sectional view illustrating the sensor according to the first embodiment.

[0044] FIG. **3**A is a cross-sectional view taken along the line Y**1**-Y**2** in FIG. **2**. FIG. **3**B is a sectional view taken along the line Y**3**-Y**4** in FIG. **2**. FIG. **3**C is a sectional view taken along the line Y**5**-Y**6** in FIG. **2**. FIG. **4** is a sectional view taken along the line X**1**-X**2** in FIG. **2**.

[0045] As shown in FIGS. **2**, **3**A to **3**C, and FIG. **4**, a sensor **110** according to the embodiment includes a base **50**S and an element section **10**U. The element section **10**U includes a first fixed portion **10**F fixed to the base **50**S, a first fixed electrode **51** fixed to the base **50**S, and a first movable portion **10**. A first gap **10**Z is provided between the base **50**S and the first movable portion **10**.

[0046] The first movable portion **10** includes a first movable base portion **10**A supported by the first fixed portion **10**F, a first other movable base portion **10**B connected to the first movable base portion **10**A, and a first movable structure **11**M.

[0047] The first movable structure **11**M includes a first beam **11**, a first movable electrode **21**, and a first connecting portion **11**C. The first beam **11** includes a first beam portion **11***a*, a first other beam portion **11***b*, and a first intermediate beam portion **11***c*. The first intermediate beam portion **11***c* is provided between the first beam portion **11***a* and the first other beam portion **11***b*.

[0048] A second direction D**2** from the first beam portion **11***a* to the first other beam portion **11***b* crosses a first direction D**1** from the base **50**S to the first fixed portion **10**F. The first direction D**1** is defined as a Z-axis direction. One direction perpendicular to the Z-axis direction is defined as an X-axis direction. A direction perpendicular to the Z-axis direction and the X-axis direction is defined as a Y-axis direction. The second direction D**2** may be, for example, the X-axis direction.

[0049] The first beam **11** extends, for example, along the second direction D**2**. The first beam portion **11***a* is connected to the first movable base portion **10**A. The first other beam portion **11***b* is connected to the first other movable base portion **10**B.

[0050] In this example, the first movable portion **10** further includes a first movable connecting portion **10**P. The first movable connecting portion **10**P is provided between the first movable base portion **10**A and the first other movable base portion **10**B. The first movable connecting portion **10**P is connected to the first movable base portion **10**A and the first other movable base portion **10**B. A direction crossing a direction from the first movable base portion **10**A to the first other movable base portion **10**B is defined as a cross direction Dx (see FIG. **2**). The cross direction Dx crosses the first direction D**1**. The cross direction Dx is, for example, the Y-axis direction. A width of the first movable connecting portion **10**P in the cross direction Dx is narrower than a width of the first movable base portion **10**A in the cross direction Dx, and narrower than a width of the first other movable base portion **10**B in the cross direction Dx.

[0051] A third direction D**3** from the first beam **11** to the first movable electrode **21** crosses a plane including the first direction D**1** and the second direction D**2**. The third direction D**3** may be, for example, the Y-axis direction. The cross direction Dx may be substantially parallel to the third direction D**3**.

[0052] The first connecting portion **11**C connects the first movable electrode **21** to the first intermediate beam portion **11***c*. The first connecting portion **11**C extends, for example, along the third direction D**3**.

[0053] FIG. **1**A illustrates the first movable electrode **21** and the first fixed electrode **51**. The first movable electrode **21** includes a first movable electrode base portion **21***x* and a plurality of first movable protruding portions **21***p*. The plurality of first movable protruding portions **21***p* are connected to the first movable electrode base portion **21***x*. The plurality of first movable protruding portions **21***p* are arranged along the second direction D**2**.

[0054] As shown in FIG. **1**A, the first fixed electrode **51** includes a first fixed electrode base portion **51***x* and a plurality of first fixed protruding portions **51***p*. The plurality of first fixed protruding portions **51***p* are connected to the first fixed electrode base portion **51***x* and arranged along the second direction D**2**. The plurality of first movable protruding portions **21***p* mesh with the plurality of first fixed protruding portions **51***p* in a comb-teeth shape.

[0055] The plurality of first movable protruding portions **21***p* include a first movable end protruding portion **21***a*, a first movable other end protruding portion **21***b*, and a plurality of first movable intermediate protruding portions **21***c*. The first movable end protruding portion **21***a* is one end in the second direction D**2** among the plurality of first movable protruding portions **21***p*. The first movable other

end protruding portion **21***b* is another end in the second direction D**2** among the plurality of first movable protruding portions **21***p*. The plurality of first movable intermediate protruding portions **21***c* are provided between the first movable end protruding portion **21***a* and the first movable other end protruding portion **21***b*.

[0056] A width of the first movable end protruding portion **21***a* along the second direction D**2** is defined as a first movable end protruding portion width w**21***a*. A width of the first movable other end protruding portion **21***b* along the second direction D**2** is defined as a first movable other end protruding portion width w**21***b*. In the embodiment, the first movable end protruding portion width w**21***a* is substantially the same as the first movable other end protruding portion width w**21***b*.

[0057] In the embodiment, as shown in FIG. **2**, the element section **10**U may further include a first opposing fixed electrode **51**A. The first opposing fixed electrode **51**A is fixed to the base **50**S. At least a part of the first movable electrode **21** is provided between the first fixed electrode **51** and the first opposing fixed electrode **51**A in the third direction D**3**. In one example, a first AC signal (drive signal) is applied between the first movable electrode **21** and the first opposing fixed electrode **51**A. Thereby, the first movable structure **11**M vibrates. By the vibration, the first intermediate beam portion **11***c* of the first beam **11** vibrates. The vibration includes a component in the third direction D**3**.

[0058] The plurality of first movable protruding portions **21***p* and the plurality of first fixed protruding portions **51***p* form a comb-teeth electrode pair. A signal (detection signal) generated between the first movable electrode **21** and the first fixed electrode **51** is detected. In this case, the first movable electrode **21** and the first fixed electrode **51** function as detection electrodes. For example, a change in resonance frequency is detected by tracking the phase of vibration (synchronous detection) based on a change in capacitance of a pair of comb-teeth electrodes. In the detection electrode, the widths of the two protruding portions located at the ends in the second direction D**2** are set to be the same. Highly accurate detection can be performed stably.

[0059] For example, force is applied to the sensor **110** (for example, the first movable portion **10**). As a result, the first other movable base portion **10**B is displaced. The displacement includes a component in the third direction D**3**. Stress is applied to the first beam **11** due to the displacement of the first other movable base portion **10**B. The stress can be compressive stress or tensile stress. The resonance frequency of the first beam **11** changes depending on the stress applied to the first beam **11**. By detecting a change in the resonance frequency, a force (for example, acceleration) applied to the sensor **110** can be detected.

[0060] In the embodiment, the first movable end protruding portion width w**21***a* is substantially the same as the first movable other end protruding portion width w**21***b*. Thereby, deterioration in detection accuracy is suppressed. According to the embodiment, it is possible to provide a sensor that can obtain stable characteristics.

[0061] As shown in FIG. **1**A, it is preferable that the first movable electrode **21** is line symmetrical with respect to a first line Ln**1**. The first line Ln**1** passes through the first intermediate beam portion **11***c* and extends in the third direction D**3**. Higher accuracy can be stably obtained. The first fixed electrode **51** may be line symmetrical with respect to the first line Ln**1**.

[0062] For example, it is desirable that the first intermediate beam portion **11***c* is preferably at a center of the first beam **11** in the second direction D**2**. Detection with higher accuracy is possible.

[0063] As shown in FIG. **1**A, the plurality of first fixed protruding portions **51***p* are provided between the first movable end protruding portion **21***a* and the first movable other end protruding portion **21***b*. A width of each of the plurality of first movable intermediate protruding portions **21***c* along the second direction D**2** is defined as a first movable intermediate protruding portion width w**21***c*. The first movable end protruding portion width w**21***a* is larger than the first movable intermediate protruding portion width w**21***c*. The first movable other end protruding portion width w**21***b* is larger than the first movable intermediate protruding portion width w**21***c*.

[0064] The plurality of first movable intermediate protruding portions **21***c* are not end protruding portions. Each of the plurality of first movable intermediate protruding portions **21***c* is sandwiched between one of the plurality of first fixed protruding portions **51***p* and another one of the plurality of first fixed protruding portions **51***p*. On the other hand, the first movable end protruding portion **21***a* and the first movable other end protruding portion **21***b* located at the ends are not sandwiched between the plurality of first fixed protruding portions **51***p*. The width of the protruding portions located at such an end is set larger than the width of the other protruding portions. Thereby, unintended deformation caused by asymmetric electrostatic attraction on the side faces of the comb teeth can be suppressed. It becomes easier to obtain more stable characteristics.

[0065] The first movable end protruding portion width w**21***a* may be 1.2 times or more the first movable intermediate protruding portion width w**21***c*. The first movable other end protruding portion width w**21***b* may be 1.2 times or more the first movable intermediate protruding portion width w**21***c*.

[0066] Practically, the first movable end protruding portion width w**21***a* may be the width along the second direction D**2** of the first movable end protruding portion **21***a* at the center of the first movable end protruding portion **21***a* in the third direction D**3**. Practically, the first movable other end protruding portion width w**21***b* may be the width of the first movable other end protruding portion **21***b* along the second direction D**2** at the center of the first movable other end protruding portion **21***b* in the third direction D**3**. Practically, the first movable intermediate protruding portion width w**21***c* may be a width along the second direction D**2** of one of the plurality of first movable intermediate protruding portions **21***c* at the center in the third direction D**3** of one of the plurality of first movable intermediate protruding portions **21***c*. As will be described later, these widths may change along the third direction D**3**. In such a case, practically, the above definition for the width may be applied.

[0067] The above drive signal is supplied, for example, from the controller **70** (see FIG. **2**). The above detection signal is detected by the controller **70**. For example, the controller **70** is configured to detect a signal generated between the first movable electrode **21** and the first fixed electrode **51**. Electrical connection between the controller **70**

and the first movable electrode **21** may be performed, for example, via an electrode **10**FE provided on the first fixed portion **10**F.

[0068] As shown in FIG. **2**, the element section **10**U may further include a second fixed electrode **52**. The second fixed electrode **52** is fixed to the base **50**S. The first movable portion **10** may further include a second movable structure **12**M. The second movable structure **12**M includes a second beam **12**, a second movable electrode **22**, and a second connecting portion **12**C.

[0069] The second beam **12** includes a second beam portion **12***a*, a second other beam portion **12***b*, and a second intermediate beam portion **12***c*. The second intermediate beam portion **12***c* is provided between the second beam portion **12***a* and the second other beam portion **12***b*. A direction from the second beam portion **12***a* to the second other beam portion **12***b* is along the second direction D**2**.

[0070] The second beam portion **12***a* is connected to the first movable base portion **10**A. The second other beam portion **12***b* is connected to the first other movable base portion **10**B. The second connecting portion **12**C connects the second movable electrode **22** to the second intermediate beam portion **12***c*.

[0071] In this example, the second beam **12** is provided between the second movable electrode **22** and the first movable electrode **21**. The first beam **11** is provided between the second beam **12** and the first movable electrode **21**. The first movable connecting portion **10**P is provided between the second beam **12** and the first beam **11** in the third direction D**3**. The second movable electrode **22** is provided between the second fixed electrode **52** and the second beam **12**.

[0072] As shown in FIG. **1**B, the second movable electrode **22** includes a second movable electrode base portion **22***x* and a plurality of second movable protruding portions **22***p* connected to the second movable electrode base portion **22***x* and arranged along the second direction D**2**. The second fixed electrode **52** includes a second fixed electrode base portion **52***x* and a plurality of second fixed protruding portions **52***p* connected to the second fixed electrode base portion **52***x* and arranged along the second direction D**2**. The plurality of second movable protruding portions **22***p* mesh with the plurality of second fixed protruding portions **52***p* in a comb-teeth shape.

[0073] The element section **10**U may further include a second opposing fixed electrode **52**A. The second opposing fixed electrode **52**A is fixed to the base **50**S. At least a part of the second movable electrode **22** is provided between the second fixed electrode **52** and the second opposing fixed electrode **52**A in the third direction D**3**.

[0074] In the embodiment, a signal (detection signal) generated between the second movable electrode **22** and the second fixed electrode **52** may be detected. In this case, the second movable electrode **22** and the second fixed electrode **52** function as detection electrodes. On the other hand, an AC signal (drive signal) may be applied between the second movable electrode **22** and the second opposing fixed electrode **52**A, so that the second beam **12** may vibrate. In this case, the second movable electrode **22** and the second opposing fixed electrode **52**A function as driving electrodes.

[0075] For example, force is applied to the sensor **110** (for example, the first movable portion **10**). As a result, the first other movable base portion **10**B is displaced. Stress is applied to the second beam **12** due to the displacement of the first other movable base portion **10**B. The stress can be compressive stress or tensile stress. Either compressive stress or tensile stress is applied to the first beam **11**. In this case, the other of the compressive stress and the tensile stress is applied to the second beam **12**.

[0076] For example, detection with higher accuracy is possible by detecting a difference between a first signal obtained from the first movable electrode **21** and the first fixed electrode **51** and a second signal obtained from the second movable electrode **22** and the second fixed electrode **52**.

[0077] As shown in FIG. **1**B, the plurality of second movable protruding portions **22***p* include a second movable end protruding portion **22***a*, a second movable other end protruding portion **22***b*, and a plurality of second movable intermediate protruding portions **22***c*. The second movable end protruding portion **22***a* is one end in the second direction D**2** among the plurality of second movable protruding portions **22***p*. The second movable other end protruding portion **22***b* is another end in the second direction D**2** among the plurality of second movable protruding portions **22***p*. The plurality of second movable intermediate protruding portions **22***c* are provided between the second movable end protruding portion **22***a* and the second movable other end protruding portion **22***b*.

[0078] A width of the first movable end protruding portion **21***a* along the second direction D**2** is defined as a first movable end protruding portion width w**21***a*. A width of the first movable other end protruding portion **21***b* along the second direction D**2** is defined as a first movable other end protruding portion width w**21***b*. In the embodiment, the first movable end protruding portion width w**21***a* is substantially the same as the first movable other end protruding portion width w**21***b*. Detection with higher accuracy is possible.

[0079] As shown in FIG. **1**B, it is desirable that the second movable electrode **22** is line symmetrical with respect to a second line Ln**2**. The second line Ln**2** passes through the second intermediate beam portion **12***c* and extends in the third direction D**3**. Higher accuracy can be stably obtained. The second fixed electrode **52** may be line symmetrical with respect to the second line Ln**2**.

[0080] For example, it is preferable that the second intermediate beam portion **12***c* is at a center of the second beam **12** in the second direction D**2**. Detection with higher accuracy is possible. As shown in FIG. **1**B, the plurality of second fixed protruding portions **52***p* are provided between the second movable end protruding portion **22***a* and the second movable other end protruding portion **22***b*. A width of each of the plurality of second movable intermediate protruding portions **22***c* along the second direction D**2** is defined as a second movable intermediate protruding portion width w**22***c*. The second movable end protruding portion width w**22***a* is larger than the second movable intermediate protruding portion width w**22***c*. The second movable other end protruding portion width w**22***b* is larger than the second movable intermediate protruding portion width w**22***c*. For example, it is possible to suppress unintended deformation caused by asymmetric electrostatic attraction on the comb tooth side face of the end protruding portion. It becomes easier to obtain more stable characteristics.

[0081] The second movable end protruding portion width w**22***a* may be 1.2 times or more the second movable intermediate protruding portion width w**22***c*. The second

movable other end protruding portion width w**22***b* may be 1.2 times or more the second movable intermediate protruding portion width w**22***c*.

[0082] FIGS. **5**A and **5**B are schematic views illustrating the sensor according to the first embodiment.

[0083] FIG. **5**A is a plan view. FIG. **5**B corresponds to the cross-sectional view taken along the line X**3**-X**4** in FIG. **5**A.

[0084] As shown in FIG. **5**A, the first movable portion **10** may include a first movable member **10**X. The first other movable base portion **10**B is provided between the first movable base portion **10**A and the first movable member **10**X in the second direction D**2**. The first movable member **10**X functions, for example, as a proof mass. A width of the first movable member **10**X in the third direction D**3** is larger than the width of the first other movable base portion **10**B in the third direction D**3**. The force applied from the outside is efficiently transmitted to the first beam **11** and the second beam **12** by the first movable member **10***x*. For example, high sensitivity can be obtained.

[0085] As shown in FIG. **1**A, a distance along the third direction D**3** between one of the plurality of first movable protruding portions **21***p* and the first fixed electrode base portion **51***x* is defined as a first distance d**1**. A distance along the second direction D**2** between one of the plurality of first movable protruding portions **21***p* and one of the plurality of first fixed protruding portions **51***p* is defined as a second distance d**2**. The one of the plurality of first fixed protruding portions **51***p* is closest to one of the plurality of first movable protruding portions **21***p* among the plurality of first fixed protruding portions **51***p*. For example, no other first fixed protruding portions **51***p* are provided between the one of the first movable protruding portions **21***p* and the one of the first fixed protruding portions **51***p*.

[0086] For example, a first capacitance is formed between the tips of each of the plurality of first movable protruding portions **21***p* and the first fixed electrode base portion **51***x*. For example, a second capacitance is formed between the side faces of the plurality of first movable protruding portions **21***p* and the side faces of the plurality of first fixed protruding portions **51***p*. An electrostatic spring is formed depending on the change rate of these capacitances.

[0087] It is preferable that the change in the electrostatic spring constant is small when the first movable electrode **21** is displaced along the third direction D**3**. Thereby, detection with higher accuracy becomes easy. For example, when the first movable electrode **21** is displaced along the third direction D**3**, the change in the first capacitance is small. There is almost no change in the second capacitance when the first movable electrode **21** is displaced along the third direction D**3**.

[0088] For example, if the first distance d**1** is too short, the change in the first capacitance with respect to the change in the first distance d**1** becomes excessively large. By making the first distance d**1** longer than a certain level, the change in the first capacitance with respect to the change in the first distance d**1** can be kept small. For example, it is preferable that the first distance d**1** is 0.79 times or more the second distance d**2**. Thereby, it becomes possible to reduce the influence of changes in capacitance. For example, higher accurate detection becomes easier.

[0089] FIG. **6** is a graph illustrating the characteristics of the sensor according to the first embodiment.

[0090] The horizontal axis in FIG. **6** is a first ratio r**1**. The first ratio r**1** is the ratio (d**1**/d**2**) of the first distance d**1** to the second distance d**2**. The vertical axis is the electrostatic spring constant ke**1** (μN/μm). FIG. **6** illustrates the characteristics of the sensor **110** and the characteristics of the sensor **119** as a reference example. As already explained, the sensor **110** is provided with a pair of comb-teeth electrodes. In the sensor **119**, a pair of parallel plate electrodes is provided.

[0091] As shown in FIG. **6**, in the sensor **110**, as the first ratio r**1** increases, the electrostatic spring constant ke**1** decreases. When the first ratio r**1** is 0.79 or more, the electrostatic spring constant ke**1** in the sensor **110** becomes less than or equal to the electrostatic spring constant ke**1** in the sensor **119**. For example, when the first ratio r**1** is 0.79 or more, an electrostatic spring constant ke**1** less than the value in the parallel plate electrode pair can be obtained. Thereby, it becomes possible to reduce the influence of changes in the electrostatic spring constant. It is possible to suppress changes in characteristics due to changes in the electrostatic spring constant caused by warping of the base **50**S due to thermal stress or the like and changes in the first distance d**1**. For example, the influence of characteristic fluctuations due to creep can be reduced. It becomes easier to stably obtain higher precision.

[0092] As shown in FIG. **1**B, a distance along the third direction D**3** between one of the plurality of second movable protruding portions **22***p* and the second fixed electrode base portion **52***x* is defined as a third distance d**3**. A distance along the second direction D**2** between one of the plurality of second movable protruding portions **22***p* and one of the plurality of second fixed protruding portions **52***p* is defined as a fourth distance d**4**. The one of the plurality of second fixed protruding portions **52***p* is closest to one of the plurality of second movable protruding portions **22***p* among the plurality of second fixed protruding portions **52***p*. For example, no other second fixed protruding portions **52***p* are provided between the one of the second movable protruding portions **22***p* and the one of the second fixed protruding portions **52***p*.

[0093] For example, it is preferable that the third distance d**3** is 0.79 times or more the fourth distance d**4**. For example, the influence of electrostatic springs can be reduced. For example, changes in characteristics caused by changes in the electrostatic spring constant caused by warping of the base **50**S due to thermal stress or the like and changes in the third distance d**3** can be suppressed. For example, the influence of characteristic fluctuations due to creep can be reduced. It becomes easier to stably obtain higher accuracy.

[0094] FIGS. **7**A and **7**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0095] FIG. **7**A illustrates the first movable electrode **21** in a sensor **110***a* according to the embodiment. FIG. **7**B illustrates the second movable electrode **22** in the sensor **110***a*. The configuration of the sensor **110***a* may be the same as the configuration of the sensor **110**, except for the configuration of these movable electrodes.

[0096] In the sensor **110***a*, the first movable end protruding portion width w**21***a* and the first movable other end protruding portion width w**21***b* are substantially the same as the first movable intermediate protruding portion width w**21***c*. In this case as well, for example, the first movable electrode **21** is line symmetrical with respect to the first line Ln**1**. By the high symmetry, high detection accuracy can be obtained in the sensor **110***a*. Stable characteristics can be obtained.

[0097] In the sensor **110***a*, the second movable end protruding portion width w**22***a* and the second movable other end protruding portion width w**22***b* are substantially the same as the second movable intermediate protruding portion width w**22***c*. In this case as well, for example, the second movable electrode **22** is line symmetrical with respect to the second line Ln**2**. By the high symmetry, high detection accuracy can be obtained in the sensor **110***a*. Stable characteristics can be obtained.

[0098] FIGS. **8**A and **8**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0099] These figures illustrate the configuration of the element section **10**U in a sensor **110***b* according to the embodiment. As shown in FIG. **8**A, in the sensor **110***b*, the element section **10**U further includes the first opposing fixed electrode **51**A. As shown in FIG. **8**B, in the sensor **110***b*, the element section **10**U further includes the second opposing fixed electrode **52**A. The configuration of the sensor **110***b* may be the same as the configuration of the sensor **110**, except for these opposing fixed electrodes.

[0100] The first opposing fixed electrode **51**A is fixed to the base **50**S. At least a part of the first movable electrode **21** is provided between the first opposing fixed electrode **51**A and the first fixed electrode **51** in the third direction D**3**.

[0101] The first movable electrode **21** further includes a plurality of first opposing movable protruding portions **21**Ap. The plurality of first opposing movable protruding portions **21**Ap are connected to the first movable electrode base portion **21***x* and are arranged along the second direction D**2**. The first movable electrode base portion **21***x* is provided between the plurality of first opposing movable protruding portions **21**Ap and the plurality of first movable protruding portions **21***p*.

[0102] The first opposing fixed electrode **51**A includes a first opposing fixed electrode base portion **51**Ax and a plurality of first opposing fixed protruding portions **51**Ap. The plurality of first opposing fixed protruding portions **51**Ap are connected to the first opposing fixed electrode base portion **51**Ax and are arranged along the second direction D**2**. The plurality of first opposing movable protruding portions **21**Ap mesh with the plurality of first opposing fixed protruding portions **51**Ap in a comb-teeth shape.

[0103] An AC signal may be applied between the first movable electrode **21** and the first opposing fixed electrode **51**A. A signal between the first movable electrode **21** and the first opposing fixed electrode **51**A may be detected.

[0104] In the embodiment, an AC signal may be applied between the first movable electrode **21** and the first fixed electrode **51**. A signal between the first movable electrode **21** and the first fixed electrode **51** may be detected.

[0105] The second opposing fixed electrode **52**A is fixed to the base **50**S. At least a part of the second movable electrode **22** is provided between the second opposing fixed electrode **52**A and the second fixed electrode **52** in the third direction D**3**.

[0106] The second movable electrode **22** further includes a plurality of second opposing movable protruding portions **22**Ap.

[0107] The plurality of second opposing movable protruding portions **22**Ap are connected to the second movable electrode base portion **22***x* and are arranged along the second direction D**2**. The second movable electrode base portion **22***x* is provided between the plurality of second opposing movable protruding portions **22**Ap and the plurality of second movable protruding portions **22***p*. The second opposing fixed electrode **52**A includes a second opposing fixed electrode base portion **52**Ax and a plurality of second opposing fixed protruding portions **52**Ap. The plurality of second opposing fixed protruding portions **52**Ap are connected to the second opposing fixed electrode base portion **52**Ax and are arranged along the second direction D**2**. The plurality of second opposing movable protruding portions **22**Ap mesh with the plurality of second opposing fixed protruding portions **52**Ap in a comb-teeth shape.

[0108] An AC signal may be applied between the second movable electrode **22** and the second opposing fixed electrode **52**A. A signal between the second movable electrode **22** and the second opposing fixed electrode **52**A may be detected.

[0109] In the embodiment, an AC signal may be applied between the second movable electrode **22** and the second fixed electrode **52**. A signal between the second movable electrode **22** and the second fixed electrode **52** may be detected.

[0110] FIGS. **9**A and **9**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0111] These figures illustrate the configuration of the element section **10**U in a sensor **110***c* according to the embodiment. As shown in FIG. **9**A, in the sensor **110***c*, at least a part of the first fixed electrode **51** is provided between at least a part of the first movable electrode **21** and the first beam **11**. As shown in FIG. **9**B, in the sensor **110***c*, at least a part of the second fixed electrode **52** is provided between at least a part of the second movable electrode **22** and the second beam **12**. In the sensor **110***c*, the first opposing fixed electrode **51**A and the first movable electrode **21** form a parallel plate electrode pair. In the sensor **110***c*, the second opposing fixed electrode **52**A and the second movable electrode **22** form a parallel plate electrode pair. Except for these points, the configuration of the sensor **110***c* may be the same as the configuration of the sensor **110**. Stable characteristics can also be obtained in the sensor **110***c*.

[0112] FIGS. **10**A and **10**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0113] These figures illustrate the configuration of the element section **10**U in a sensor **110***d* according to the embodiment. In the sensor **110***d*, the width of the protruding portions changes. Except for this, the configuration of the sensor **110***d* may be the same as the configuration of the sensor **110**.

[0114] In the sensor **110***d*, the first movable intermediate protruding portion width w**21***c* decreases as the distance from the first movable electrode base portion **21***x* increases. The width of one of the plurality of first fixed protruding portions **51***p* along the second direction D**2** decreases as the distance from the first fixed electrode base portion **51***x* increases.

[0115] In the sensor **110***d*, the second movable intermediate protruding portion width w**22***c* decreases as the distance from the second movable electrode base portion **22***x* increases. The width of one of the plurality of second fixed protruding portions **52***p* along the second direction D**2** decreases as the distance from the second fixed electrode base portion **52***x* increases.

[0116] In in the sensor **110***d* as well, the first movable end protruding portion width w**21***a* is substantially the same as the first movable other end protruding portion width w**21***b*.

For example, the first movable electrode **21** may be line symmetrical with respect to the first line Ln**1**. For example, the first movable end protruding portion width w**21***a* may be larger than the first movable intermediate protruding portion width w**21***c*. The first movable other end protruding portion width w**21***b* may be larger than the first movable intermediate protruding portion width w**21***c*.

[0117] In the sensor **110***d* as well, the second movable end protruding portion width w**22***a* is substantially the same as the second movable other end protruding portion width w**22***b*. For example, the second movable electrode **22** may be line symmetrical with respect to the second line Ln**2**. For example, the second movable end protruding portion width w**22***a* may be larger than the second movable intermediate protruding portion width w**22***c*. The second movable other end protruding portion width w**22***b* may be larger than the second movable intermediate protruding portion width w**22***c*.

[0118] FIGS. **11**A and **11**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0119] These figures illustrate the configuration of the element section **10**U in a sensor **110***e* according to the embodiment. In the sensor **110***e*, the configuration of the second movable electrode **22** is different from the configuration of the first movable electrode **21**. Except for this, the configuration of the sensor **110***e* may be the same as the configuration of the sensor **110**.

[0120] In the sensor **110***e*, the second movable electrode **22** includes a second hole **22***h*, and the first movable electrode **21** does not include a first hole. With such a configuration, the resonance frequency of the second movable structure **12**M including the second movable electrode **22** is different from the resonance frequency of the first movable structure **11**M including the first movable electrode **21**. For example, a wide dynamic range can be obtained. For example, it is possible to detect a wide dynamic range with high accuracy. For example, the signal obtained from the first movable electrode **21** and the signal obtained from the second movable electrode **22** may be processed.

[0121] In the embodiment, the first movable electrode **21** and the second movable electrode **22** may satisfy at least one of a first condition, a second condition, a third condition, a fourth condition, a fifth condition, a sixth condition, a seventh condition, an eighth condition, and a nine condition.

[0122] In the first condition, a second mass of the second movable electrode **22** is different from a first mass of the first movable electrode **21**. In the second condition, a second thickness of the second movable electrode **22** along the first direction D**1** is different from a first thickness of the first movable electrode **21** along the first direction D**1**. In the third condition, at least a part of a second material included in the second movable electrode **22** is different from at least a part of a first material included in the first movable electrode **21**.

[0123] In the fourth condition, the second movable electrode **22** includes the second hole **22***h*, and the first movable electrode **21** does not include the first hole. In the fifth condition, a second size of the second hole **22***h* included in the second movable electrode **22** is different from a first size of the first hole included in the first movable electrode **21**. In the sixth condition, a second density of the second holes **22***h* is different from a first density of the first holes.

[0124] In the seventh condition, a second number of the second holes **22***h* is different from a first number of the first holes. In the eighth condition, a second shape of the second hole **22***h* is different from a first shape of the first hole. In the ninth condition, a second layer structure of the second movable electrode **22** is different from a first layer structure of the first movable electrode **21**.

[0125] FIGS. **12**A and **12**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0126] These figures illustrate the configuration of the element section **10**U in a sensor **111** according to the embodiment. In the sensor **111**, the configuration of the movable electrode and the fixed electrode is different from the configuration in the sensor **110**. Except for this, the configuration of the sensor **111** may be the same as the configuration of the sensor **110**.

[0127] In the sensor **111**, the plurality of first fixed protruding portions **51***p* include a first fixed end protruding portion **51***a*, a first fixed other end protruding portion **51***b*, and a plurality of first fixed intermediate protruding portions **51***c*. The first fixed end protruding portion **51***a* is one end in the second direction D**2** among the plurality of first fixed protruding portions **51***p*. The first fixed other end protruding portion **51***b* is another end in the second direction D**2** among the plurality of first fixed protruding portions **51***p*. The plurality of first fixed intermediate protruding portions **51***c* are provided between the first fixed end protruding portion **51***a* and the first fixed other end protruding portion **51***b*.

[0128] In the embodiment, a first fixed end protruding portion width w**51***a* of the first fixed end protruding portion **51***a* along the second direction D**2** is substantially the same as a first fixed other end protruding portion width w**51***b* of the first fixed other end protruding portion **51***b* along the second direction D**2**.

[0129] For example, the plurality of first movable protruding portions **21***p* are provided between the first fixed end protruding portion **51***a* and the first fixed other end protruding portion **51***b*. The first fixed end protruding portion width w**51***a* is larger than the first fixed intermediate protruding portion width w**51***c* along the second direction D**2** of each of the plurality of first fixed intermediate protruding portions **51***c*. The first fixed other-end protruding portion width w**51***b* is larger than the first fixed intermediate protruding portion width w**51***c*.

[0130] For example, the first fixed electrode **51** may be line symmetrical with respect to the first line Ln**1**. The first line Ln**1** passes through the first intermediate beam portion **11***c* and extends in the third direction D**3**. The first movable electrode **21** may be line symmetrical with respect to the first line Ln**1**. For example, unintended deformation of the protruding portions is suppressed. Deterioration of detection accuracy is suppressed. According to the embodiment, it is possible to provide a sensor that can obtain stable characteristics.

[0131] FIGS. **13**A and **13**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0132] These figures illustrate the configuration of the element section **10**U in a sensor **111***a* according to the embodiment. In the sensor **111***a*, the first fixed end protruding portion width w**51***a* is substantially the same as the first fixed intermediate protruding portion width w**51***c*. The first fixed other end protruding portion width w**51***b* is substan-

tially the same as the first fixed intermediate protruding portion width w**51***c*. Except for this, the configuration of the sensor **111***a* may be the same as the configuration of the sensor **111**. In the sensor **111***a*, for example, the first fixed electrode **51** is line symmetrical with respect to the first line Ln**1**. The first movable electrode **21** is line symmetrical with respect to the first line Ln**1**.

[0133] In the sensor **111***a*, the second fixed end protruding portion width w**52***a* is substantially the same as the second fixed intermediate protruding portion width w**52***c*. The second fixed other end protruding portion width w**52***b* is substantially the same as the second fixed intermediate protruding portion width w**52***c*. In the sensor **111***a*, for example, the second fixed electrode **52** may be line symmetrical with respect to the second line Ln**2**. The second movable electrode **22** may be line symmetrical with respect to the second line Ln**2**.

[0134] FIGS. **14**A and **14**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0135] These figures illustrate the configuration of the element section **10**U in a sensor **111***b* according to the embodiment. In the sensor **111***b*, the second movable electrode **22** includes a second hole **22***h*. Except for this, the configuration of the sensor **111***b* may be the same as the configuration of the sensor **111**.

[0136] In the sensor **111***b*, the first movable electrode **21** and the second movable electrode **22** satisfy at least any one of the first to ninth conditions described above.

[0137] FIG. **15** is a schematic plan view illustrating a part of a sensor according to the first embodiment.

[0138] FIG. **15** illustrates the configuration of the element section **10**U in a sensor **112** according to the embodiment. In the sensor **112**, the first movable structure **11**M includes a first other movable electrode **21**E. The element section **10**U includes a first other fixed electrode **51**E. The configuration of the sensor **112** other than these may be the same as the configuration of the sensor **110** and the like.

[0139] The first other movable electrode **21**E is connected to the first intermediate beam portion **11***c*. In the third direction D**3**, the first beam **11** is provided between the first other movable electrode **21**E and the first movable electrode **21**. The first other movable electrode **21**E is line symmetrical with the first movable electrode **21** with the first beam **11** as the axis of symmetry. The first other movable electrode **21**E faces the first other fixed electrode **51**E.

[0140] The element section **10**U may further include a first other opposing fixed electrode **51**EA. The first other opposing fixed electrode **51**EA is fixed to the base **50**S. At least a part of the first other movable electrode **21**E is provided between the first other fixed electrode **51**E and the first other opposing fixed electrode **51**EA in the third direction D**3**.

[0141] FIGS. **16**A and **16**B are schematic plan views illustrating a part of a sensor according to the first embodiment.

[0142] These figures illustrate the configuration of the element section **10**U in a sensor **113** according to the embodiment. In the sensor **113**, a plurality of first movable electrodes **21** are provided. Except for this, the configuration of the sensor **113** may be the same as the configuration of the sensor **110**.

[0143] In the sensor **113**, the first movable structure **11**M includes the plurality of first movable electrodes **21**. The first connecting portion **11**C connects the plurality of first movable electrodes **21** to the first intermediate beam portion **11***c*. One of the plurality of first movable electrodes **21** is provided between another one of the plurality of first movable electrodes **21** and the first beam **11**. A length of one of the plurality of first movable electrodes **21** along the second direction D**2** is longer than a length of another one of the plurality of first movable electrodes **21** along the second direction D**2**.

[0144] In the sensor **113**, the second movable structure **12**M includes a plurality of second movable electrodes **22**. The second connecting portion **12**C connects the plurality of second movable electrodes **22** to the second intermediate beam portion **12***c*. One of the plurality of second movable electrodes **22** is provided between another one of the plurality of second movable electrodes **22** and the second beam **12**. A length of one of the plurality of second movable electrodes **22** along the second direction D**2** is longer than a length of another one of the plurality of second movable electrodes **22** along the second direction D**2**. In the sensor **113**, for example, higher sensitivity can be easily obtained by using a plurality of movable electrodes.

[0145] Hereinafter, some examples of sensors according to embodiments will be described. The configuration of the sensor may be the same as the configuration of the sensor described above, except for the configuration described below.

[0146] FIGS. **17** to **29** are schematic plan views illustrating the sensor according to the first embodiment.

[0147] As shown in FIG. **17**, in a sensor **120**, the first movable structure **11**M includes the plurality of first movable electrodes **21**. The second movable structure **12**M includes the plurality of second movable electrodes **22**. The first movable structure **11**M is connected to the first beam **11**. The second movable structure **12**M is connected to the second beam **12**.

[0148] As shown in FIG. **18**, in a sensor **121**, the first movable structure **11**M includes the first movable electrode **21** and the first other movable electrode **21**E. The second movable structure **12**M includes the second movable electrode **22** and the second other movable electrode **22**E. The first movable electrode **21** faces the first fixed electrode **51**. The first other movable electrode **21**E faces the first other fixed electrode **51**E. The second movable electrode **22** faces the second fixed electrode **52**. The second other movable electrode **22**E faces the second other fixed electrode **52**E.

[0149] As shown in FIG. **19**, in a sensor **122**, the first movable structure **11**M includes the plurality of first movable electrodes **21**. The second movable structure **12**M includes the plurality of second movable electrodes **22**. The first movable structure **11**M is connected to the first beam **11**. The second movable structure **12**M is connected to the second beam **12**.

[0150] As shown in FIG. **20**, in a sensor **123**, the first movable structure **11**M includes the first movable electrode **21** and the first other movable electrode **21**E. The second movable structure **12**M includes the second movable electrode **22** and the second other movable electrode **22**E. The first movable portion **10** includes the first other beam **11**A and the second other beam **12**A. One end of the first other beam **11**A is connected to the first movable base portion **10**A. The other end of the first other beam **11**A is connected to the first other movable base portion **10**B. One end of the second other beam **12**A is connected to the first movable base portion **10**A. The other end of the second other beam

12A is connected to the first other movable base portion 10B. The first other beam 11A and the second other beam 12A extend along the second direction D2. The first other movable electrode 21E is connected to the first other beam 11A. The first other beam 11A is provided between the first other movable electrode 21E and the first beam 11 in the second direction D2. The second other movable electrode 22E is connected to the second other beam 12A. The second other beam 12A is provided between the second other movable electrode 22E and the second beam 12 in the second direction D2.

[0151] As shown in FIG. 21, in a sensor 124, the first movable portion 10 includes the first other beam 11A and the second other beam 12A. The first other movable electrode 21E is connected to the first other beam 11A. The second other movable electrode 22E is connected to the second other beam 12A. In the sensor 124, the plurality of first movable electrodes 21 and the plurality of first other movable electrodes 21E are provided. The plurality of second movable electrodes 22 and the plurality of second other movable electrodes 22E are provided.

[0152] As shown in FIG. 22, in a sensor 130, the first movable base portion 10A includes a plurality of regions. One end of the first beam 11 is connected to one of the plurality of regions of the first movable base portion 10A. The other end of the first beam 11 is connected to the first other movable base portion 10B.

[0153] One end of the second beam 12 is connected to another one of the plurality of regions of the first movable base portion 10A. The other end of the second beam 12 is connected to the first other movable base portion 10B. The direction from the first beam 11 to the second beam 12 is along the second direction D2. The first movable electrode 21 and the first other movable electrode 21E included in the first movable structure 11M are connected to the first beam 11. The second movable electrode 22 and the second other movable electrode 22E included in the second movable structure 12M are connected to the second beam 12.

[0154] As shown in FIG. 23, in a sensor 131, the plurality of first movable electrodes 21 and the plurality of first other movable electrodes 21E are connected to the first beam 11. The plurality of second movable electrodes 22 and the plurality of second other movable electrodes 22E are connected to the second beam 12. The configuration of the sensor 131 except for this may be the same as the configuration of the sensor 130.

[0155] As shown in FIG. 24, in a sensor 132, the first movable electrode 21 is connected to the first beam 11. The first other movable electrode 21E is connected to the first other beam 11A. The second movable electrode 22 is connected to the second beam 12. The second other movable electrode 22E is connected to the second other beam 12A. The configuration of the sensor 132 except for this may be the same as the configuration of the sensor 130. The direction from the first other beam 11A to the second other beam 12A is along the second direction D2.

[0156] As shown in FIG. 25, in a sensor 133, the plurality of first movable electrodes 21 are connected to the first beam 11. The plurality of first other movable electrodes 21E are connected to the first other beam 11A. The plurality of second movable electrodes 22 are connected to the second beam 12. The second other movable electrode 22E is connected to the second other beam 12A. The configuration of the sensor 133 except for this may be the same as the configuration of the sensor 132.

[0157] As illustrated in FIG. 26, in the sensor 140, the first other movable base portion 10B includes a plurality of regions. One of the plurality of regions included in the first other movable base portion 10B is connected to the first movable base portion 10A by the plurality of first movable connecting portions 10P. One of the plurality of regions included in the first other movable base portion 10B is provided between one of the plurality of first movable connecting portions 10P and another one of the plurality of first movable connecting portions 10P in the third direction D3. Another one of the plurality of regions included in the first other movable base portion 10B is connected to the first movable base portion 10A by the plurality of first movable connecting portions 10P. Another one of the plurality of regions included in the first other movable base portion 10B is provided between one of the plurality of first movable connecting portions 10P and another one of the plurality of first movable connecting portions 10P in the third direction D3.

[0158] In the sensor 140, the first movable electrode 21 and the first other movable electrode 21E are connected to the first beam 11. The second movable electrode 22 and the second other movable electrode 22E are connected to the second beam 12.

[0159] As illustrated in FIG. 27, the plurality of first movable electrodes 21 and the plurality of first other movable electrodes 21E are provided in the sensor 141. The plurality of second movable electrodes 22 and the plurality of second other movable electrodes 22E are provided. Except for these, the configuration of the sensor 133 may be the same as the configuration of the sensor 140.

[0160] As shown in FIG. 28, in a sensor 142, the first other beam 11A and the second other beam 12A are provided. A direction from the first beam 11 to the second beam 12 is along the second direction D2. Ae direction from the first other beam 11A to the second other beam 12A is along the second direction D2. A direction from the first other beam 11A to the first beam 11 is along the third direction D3. A direction from the second other beam 12A to the second beam 12 is along the third direction D3. The configuration of the sensor 142 except for this may be the same as the configuration of the sensor 140.

[0161] As shown in FIG. 29, in a sensor 143, the plurality of first movable electrodes 21 and the plurality of first other movable electrodes 21E are provided. The plurality of second movable electrodes 22 and the plurality of second other movable electrodes 22E are provided. The plurality of first other movable electrodes 21E are connected to the first other beam 11A. The plurality of second other movable electrodes 22E are connected to the second other beam 12A. The configuration of the sensor 143 except for this may be the same as the configuration of the sensor 142.

[0162] In the sensors 120 to 124, 130 to 133, and 140 to 143, the first movable structure 11M and the second movable structure 12M may satisfy at least one of the first to ninth conditions described above. In one example, the second movable electrode 22 included in the second movable structure 12M includes the second hole 22*h*. The first movable electrode 21 included in the first movable structure 11M does not include a first hole. Alternatively, the number or size of the second holes 22*h* is different from the number or size of the first holes.

Second Embodiment

[0163] The second embodiment relates to an electronic device.

[0164] FIG. **30** is a schematic diagram illustrating an electronic device according to the second embodiment.

[0165] As shown in FIG. **30**, an electronic device **310** according to the embodiment includes the sensor according to the first embodiment and a circuit controller **170**. In the example of FIG. **30**, the sensor **110** is drawn as the sensor. The circuit controller **170** is configured to control a circuit **180** based on a signal S**1** obtained from the sensor. The circuit **180** is, for example, a control circuit of a driving device **185** or the like. According to the embodiment, for example, the circuit **180** for controlling the driving device **185** can be controlled with high accuracy.

[0166] FIGS. **31**A to **31**H are schematic diagrams illustrating applications of the electronic device according to the embodiment. As shown in FIG. **31**A, the electronic device **310** may be at least a part of a robot. As shown in FIG. **31**B, the electronic device **310** may be at least a part of a work robot provided in a manufacturing factory or the like. As shown in FIG. **31**C, the electronic device **310** may be at least a part of an automated guided vehicle such as in a factory. As shown in FIG. **31**D, the electronic device **310** may be at least a part of a drone (unmanned aerial vehicle). As shown in FIG. **31**E, the electronic device **310** may be at least a part of an airplane. As shown in FIG. **31**F, the electronic device **310** may be at least a part of a vessel. As shown in FIG. **31**G, the electronic device **310** may be at least a part of a submarine. As shown in FIG. **31**H, the electronic device **310** may be at least a part of an automobile. The electronic device **310** may include, for example, at least one of a robot or a mobile object.

[0167] FIGS. **32**A and **32**B are schematic diagrams illustrating applications of the sensor according to the embodiment.

[0168] As shown in FIG. **32**A, a sensor **430** according to the embodiment includes the sensor according to the first embodiment and a transmitter/receiver **420**. In the example of FIG. **32**A, the sensor **110** is drawn as the sensor. The transmitter/receiver **420** is configured to transmit the signal obtained from the sensor **110** by at least one of wireless or wired methods, for example. The sensor **430** is provided, for example, on a slope surface **410** such as a road **400**. The sensor **430** may, for example, monitor conditions such as facilities (e.g., infrastructure). The sensor **430** may be, for example, a condition monitoring device.

[0169] For example, the sensor **430** detects changes in the state of the slope surface **410** of the road **400** with high accuracy. A change in the state of the slope surface **410** includes, for example, at least one of a change in tilt angle or a change in vibration state.

[0170] The signal (test result) obtained from the sensor **110** is transmitted by the transmitter/receiver **420**. The condition of facilities (e.g., infrastructure) can be monitored, e.g., continuously.

[0171] As shown in FIG. **32**B, the sensor **430** is provided on a part of a bridge **460**, for example. The bridge **460** is provided over a river **470**. For example, the bridge **460** includes at least one of main girder **450** and a bridge pier **440**. The sensor **430** is provided on at least one of the main girder **450** and the bridge pier **440**. For example, the angle of at least one of the main girder **450** and the bridge pier **440** may change due to deterioration or the like. For example, in at least one of the main girder **450** and the bridge pier **440**, the vibration state may change. The sensor **430** detects these changes with high accuracy. A detection result can be transmitted to an arbitrary place by the transmitter/receiver **420**. Anomalies can be effectively detected.

[0172] The embodiments include the following Technical proposals:

(Technical Proposal 1)

[0173] A sensor, comprising:

[0174] a base; and

[0175] an element section,

[0176] the element section including:

[0177] a first fixed portion fixed to the base,

[0178] a first fixed electrode fixed to the base, and

[0179] a first movable portion,

[0180] a first gap being provided between the base and the first movable portion,

[0181] the first movable portion including:

[0182] a first movable base portion supported by the first fixed portion,

[0183] a first other movable base portion connected to the first movable base portion, and

[0184] a first movable structure,

[0185] the first movable structure including:

[0186] a first beam,

[0187] a first movable electrode, and

[0188] a first connecting portion,

[0189] the first beam including a first beam portion, a first other beam portion, and a first intermediate beam portion between the first beam portion and the first other beam portion,

[0190] a second direction from the first beam portion to the first other beam portion crossing a first direction from the base to the first fixed portion,

[0191] the first beam portion being connected to the first movable base portion,

[0192] the first other beam portion being connected to the first other movable base portion,

[0193] a third direction from the first beam to the first movable electrode crossing a plane including the first direction and the second direction,

[0194] the first connecting portion connecting the first movable electrode to the first intermediate beam portion,

[0195] the first movable electrode including a first movable electrode base portion and a plurality of first movable protruding portions connected to the first movable electrode base portion, the plurality of first movable protruding portions being arranged along the second direction,

[0196] the first fixed electrode including a first fixed electrode base portion and a plurality of first fixed protruding portions connected to the first fixed electrode base portion, the plurality of first fixed protruding portion being arranged along the second direction,

[0197] the plurality of first movable protruding portions meshing with the plurality of first fixed protruding portions in a comb-teeth shape,

[0198] the plurality of first movable protruding portions including a first movable end protruding portions, a first movable other end protruding portion, and a plurality of first movable intermediate protruding portions,

[0199] the first movable end protruding portion being one end in the second direction among the plurality of first movable protruding portions,

[0200] the first movable other end protruding portion being another end in the second direction among the plurality of first movable protruding portions,

[0201] the plurality of first movable intermediate protruding portions being between the first movable end protruding portion and the first movable other end protruding portion,

[0202] a first movable end protruding portion width of the first movable end protruding portion along the second direction being the same as a first movable other end protruding portion width of the first movable other end protruding portion along the second direction.

(Technical Proposal 2)

[0203] The sensor according to Technical proposal 1, wherein the plurality of first fixed protruding portions are between the first movable end protruding portion and the first movable other end protruding portion,

[0204] the first movable end protruding portion width is larger than a first movable intermediate protruding portion width along the second direction of each of the plurality of first movable intermediate protruding portions, and

[0205] the first movable other end protruding portion width is larger than the first movable intermediate protruding portion width.

(Technical Proposal 3)

[0206] The sensor according to Technical proposal 1 or 2, wherein

[0207] the first movable electrode is line symmetrical with respect to a first line, and

[0208] the first line passes through the first intermediate beam portion and is along the third direction.

(Technical Proposal 4)

[0209] The sensor according to any one of Technical proposals 1-3, wherein

[0210] the first intermediate beam portion is a center of the first beam in the second direction.

(Technical Proposal 5)

[0211] The sensor according to Technical proposal 2, wherein

[0212] the first movable end protruding portion width is a width of the first movable end protruding portion along the second direction at a center of the first movable end protruding portion in the third direction,

[0213] the first movable other end protruding portion width is a width of the first movable other end protruding portion along the second direction at a center of the first movable other end protruding portion in the third direction, and

[0214] the first movable intermediate protruding portion width is a width along the second direction of one of the plurality of first movable intermediate protruding portions at a center in the third direction of the one of the plurality of first movable intermediate protruding portions.

(Technical Proposal 6)

[0215] The sensor according to Technical proposal 5, wherein

[0216] the first movable intermediate protruding portion width decreases as a distance from the first movable electrode base portion increases, and

[0217] a width along the second direction of one of the plurality of first fixed protruding portions decreases as a distance from the first fixed electrode base portion increases.

(Technical Proposal 7)

[0218] The sensor according to Technical proposal 1, wherein

[0219] the plurality of first fixed protruding portions include a first fixed end protruding portion, a first fixed other end protruding portion, and a plurality of first fixed intermediate protruding portion,

[0220] the first fixed end protruding portion is one end in the second direction among the plurality of first fixed protruding portions,

[0221] the first fixed other end protruding portion is another end in the second direction among the plurality of first fixed protruding portions,

[0222] the plurality of first fixed intermediate protruding portions are between the first fixed end protruding portion and the first fixed other end protruding portion, and

[0223] a first fixed end protruding portion width along the second direction of the first fixed end protruding portion is the same as a first fixed other end protruding portion width along the second direction of first fixed other end protruding portion.

(Technical Proposal 8)

[0224] The sensor according to Technical proposal 7, wherein

[0225] the plurality of first movable protruding portions are between the first fixed end protruding portion and the first fixed other end protruding portion,

[0226] the first fixed end protruding portion width is larger than a first fixed intermediate protruding portion width along the second direction of each of the plurality of first fixed intermediate protruding portions, and

[0227] the first fixed other end protruding portion width is larger than the first fixed intermediate protruding portion width.

(Technical Proposal 9)

[0228] The sensor according to Technical proposal 7 or 8, wherein

[0229] the first movable electrode is line symmetrical with respect to a first line, and

[0230] the first line passes through the first intermediate beam portion and is along the third direction.

(Technical Proposal 10)

[0231] The sensor according to any one of Technical proposals 7-9, wherein

[0232] the first intermediate beam portion is a center of the first beam in the second direction.

(Technical Proposal 11)

[0233] The sensor according to Technical proposal 8, wherein

[0234] the first fixed end protruding portion width is a width of the first fixed end protruding portion along the second direction at a center of the first fixed end protruding portion in the third direction,

[0235] the first fixed other end protruding portion width is a width of the first fixed other end protruding portion along the second direction at a center of the first fixed other end protruding portion in the third direction, and

[0236] the first fixed intermediate protruding portion width is a width along the second direction of one of the plurality of first fixed intermediate protruding portions at a center in the third direction of one of the plurality of first fixed intermediate protruding portions.

(Technical Proposal 12)

[0237] The sensor according to Technical proposal 11, wherein

[0238] the first fixed intermediate protruding portion width decreases as a distance from the first fixed electrode base portion increases, and

[0239] a width along the second direction of one of the plurality of first movable protruding portions decreases as a distance from the first movable electrode base portion increases.

(Technical Proposal 13)

[0240] The sensor according to any one of Technical proposals 1-12, wherein

[0241] a first distance along the third direction between one of the plurality of first movable protruding portions and the first fixed electrode base portion is not less than 0.79 times a second distance along the second direction between the one of the plurality of first movable protruding portions and one of the plurality of first fixed protruding portions, and

[0242] other of the plurality of first fixed protruding portions is not provided between the one of the plurality of first movable protruding portions and the one of the plurality of first fixed protruding portions.

(Technical Proposal 14)

[0243] The sensor according to any one of Technical proposals 1-13, further comprising:

[0244] a controller,

[0245] the controller being configured to detect a signal generated between the first movable electrode and the first fixed electrode.

(Technical Proposal 15)

[0246] The sensor according to any one of Technical proposals 1-14, wherein

[0247] the first movable structure includes a plurality of the first movable electrodes,

[0248] the first connecting portion connects the plurality of first movable electrodes to the first intermediate beam portion,

[0249] one of the plurality of first movable electrodes is provided between another one of the plurality of first movable electrodes and the first beam, and

[0250] a length along the second direction of the one of the plurality of first movable electrodes is longer than a length along the second direction of the other one of the plurality of first movable electrodes.

(Technical Proposal 16)

[0251] The sensor according to any one of Technical proposals 1-15, wherein

[0252] the element section further includes a second fixed electrode fixed to the base,

[0253] the first movable portion further includes a second movable structure,

[0254] the second movable structure includes:

[0255] a second beam,

[0256] a second movable electrode, and

[0257] a second connecting portion,

[0258] the second beam includes a second beam portion, a second other beam portion, and a second intermediate beam portion between the second beam portion and the second other beam portion,

[0259] a direction from the second beam portion to the second other beam portion is along the second direction,

[0260] the second beam portion is connected to the first movable base portion,

[0261] the second other beam portion is connected to the first other movable base portion,

[0262] the second connecting portion connects the second movable electrode to the second intermediate beam portion,

[0263] the second movable electrode includes a second movable electrode base portion and a plurality of second movable protruding portions connected to the second movable electrode base portion and arranged along the second direction,

[0264] the second fixed electrode includes a second fixed electrode base portion and a plurality of second fixed protruding portions connected to the second fixed electrode base portion and arranged along the second direction, and

[0265] the plurality of second movable protruding portions mesh with the plurality of second fixed protruding portions in a comb shape.

(Technical Proposal 17)

[0266] The sensor according to any one of Technical proposals 1-16, wherein

[0267] the element section further includes a first opposing fixed electrode fixed to the base, and

[0268] at least a part of the first movable electrode is between the first opposing fixed electrode and the first fixed electrode in the third direction.

(Technical Proposal 18)

[0269] The sensor according to any one of Technical proposals 1-16, wherein

[0270] the element section further includes a first opposing fixed electrode fixed to the base,

[0271] at least a part of the first movable electrode is between the first opposing fixed electrode and the first fixed electrode in the third direction,

[0272] the first movable electrode further includes a plurality of first opposing movable protruding portions

connected to the first movable electrode base portion and arranged along the second direction,

[0273] the first movable electrode base portion is provided between the plurality of first opposing movable protruding portions and the plurality of first movable protruding portions,

[0274] the first opposing fixed electrode includes a first opposing fixed electrode base portion and a plurality of first opposing fixed protruding portions connected to the first opposing fixed electrode base portion and arranged along the second direction, and

[0275] the plurality of first opposing movable protruding portions mesh with the plurality of first opposing fixed protruding portions in a comb-teeth shape.

(Technical Proposal 19)

[0276] The sensor according to Technical proposal 16, wherein

[0277] the first movable electrode and the second movable electrode satisfy at least one of a first condition, a second condition, a third condition, a fourth condition, a fifth condition, a sixth condition, a seventh condition, an eighth condition, or a ninth condition,

[0278] in the first condition, a second mass of the second movable electrode is different from a first mass of the first movable electrode,

[0279] in the second condition, a second thickness of the second movable electrode along the first direction is different from a first thickness of the first movable electrode along the first direction,

[0280] in the third condition, at least a part of a second material included in the second movable electrode is different from at least a part of a first material included in the first movable electrode,

[0281] in the fourth condition, the second movable electrode includes a second hole, and the first movable electrode does not include a first hole,

[0282] in the fifth condition, a second size of the second hole included in the second movable electrode is different from a first size of the first hole included in the first movable electrode,

[0283] in the sixth condition, a second density of the second holes is different from a first density of the first holes,

[0284] in the seventh condition, a second number of the second holes is different from a first number of the first holes,

[0285] in the eighth condition, a second shape of the second hole is different from a first shape of the first hole, and

[0286] in the ninth condition, a second layer structure of the second movable electrode is different from a first layer structure of the first movable electrode.

(Technical Proposal 20)

[0287] An electronic device, comprising:

[0288] the sensor according to any one of Technical proposals 1-19;

[0289] a circuit controller configured to control a circuit based on a signal obtained from the sensor.

(Technical Proposal 21)

[0290] The sensor according to any one of Technical proposals 1-19, wherein

[0291] the first movable portion further includes a first movable connecting portion,

[0292] the first movable connecting portion is provided between the first movable base portion and the first other movable base portion,

[0293] the first movable connecting portion is connected to the first other movable base portion and the first movable base portion,

[0294] a width of the first movable connecting portion in a crossing direction crossing a direction from the first movable base portion to the first other movable base portion is narrower than a width of the first movable base portion in the crossing direction and narrower than a width of the first other movable base portion in the crossing direction.

(Technical Proposal 22)

[0295] The sensor according to any one of Technical proposals 1-15, wherein

[0296] the element section further includes a second fixed electrode fixed to the base,

[0297] the first movable portion further includes a second movable structure,

[0298] the second movable structure includes:

[0299] a second movable electrode, and

[0300] a second connecting portion,

[0301] the second connecting portion connects the second movable electrode to the first intermediate beam portion,

[0302] the first beam is provided between the second movable electrode and the first movable electrode in the third direction,

[0303] the second movable electrode includes a second movable electrode base portion, and a plurality of second movable protruding portions connected to the second movable electrode base portion and arranged along the second direction,

[0304] the second fixed electrode includes a second fixed electrode base portion, and a plurality of second fixed protruding portions connected to the second fixed electrode base portion and arranged along the second direction, and

[0305] the plurality of second movable protruding portions mesh with the plurality of second fixed protruding portions in a comb shape.

(Technical Proposal 23)

[0306] The sensor according to Technical proposals 22, wherein

[0307] the first movable electrode and the second movable electrode satisfy at least one of a first condition, a second condition, a third condition, a fourth condition, a fifth condition, a sixth condition, a seventh condition, an eighth condition, or a ninth condition,

[0308] in the first condition, a second mass of the second movable electrode is different from a first mass of the first movable electrode,

[0309] in the second condition, a second thickness of the second movable electrode along the first direction is

different from a first thickness of the first movable electrode along the first direction,

[0310] in the third condition, at least a part of a second material included in the second movable electrode is different from at least a part of a first material included in the first movable electrode,

[0311] in the fourth condition, the second movable electrode includes a second hole, and the first movable electrode does not include a first hole,

[0312] in the fifth condition, a second size of the second hole included in the second movable electrode is different from a first size of the first hole included in the first movable electrode,

[0313] in the sixth condition, a second density of the second holes is different from a first density of the first holes,

[0314] in the seventh condition, a second number of the second holes is different from a first number of the first holes,

[0315] in the eighth condition, a second shape of the second hole is different from a first shape of the first hole, and

[0316] in the ninth condition, a second layer structure of the second movable electrode is different from a first layer structure of the first movable electrode.

[0317] According to the embodiments, a sensor and an electronic device that can obtain stable characteristics are provided.

[0318] Hereinabove, exemplary embodiments of the invention are described with reference to specific examples. However, the embodiments of the invention are not limited to these specific examples. For example, one skilled in the art may similarly practice the invention by appropriately selecting specific configurations of components included in sensors such as bases, element sections, fixed portions, controllers, etc., from known art. Such practice is included in the scope of the invention to the extent that similar effects thereto are obtained.

[0319] Further, any two or more components of the specific examples may be combined within the extent of technical feasibility and are included in the scope of the invention to the extent that the purport of the invention is included.

[0320] Moreover, all sensors and electronic devices practicable by an appropriate design modification by one skilled in the art based on the sensors and the electronic devices described above as embodiments of the invention also are within the scope of the invention to the extent that the purport of the invention is included.

[0321] Various other variations and modifications can be conceived by those skilled in the art within the spirit of the invention, and it is understood that such variations and modifications are also encompassed within the scope of the invention.

[0322] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

What is claimed is:

1. A sensor, comprising:

a base; and

an element section,

the element section including:

a first fixed portion fixed to the base,

a first fixed electrode fixed to the base, and

a first movable portion,

a first gap being provided between the base and the first movable portion,

the first movable portion including:

a first movable base portion supported by the first fixed portion,

a first other movable base portion connected to the first movable base portion, and

a first movable structure,

the first movable structure including:

a first beam,

a first movable electrode, and

a first connecting portion,

the first beam including a first beam portion, a first other beam portion, and a first intermediate beam portion between the first beam portion and the first other beam portion,

a second direction from the first beam portion to the first other beam portion crossing a first direction from the base to the first fixed portion,

the first beam portion being connected to the first movable base portion,

the first other beam portion being connected to the first other movable base portion,

a third direction from the first beam to the first movable electrode crossing a plane including the first direction and the second direction,

the first connecting portion connecting the first movable electrode to the first intermediate beam portion,

the first movable electrode including a first movable electrode base portion and a plurality of first movable protruding portions connected to the first movable electrode base portion, the plurality of first movable protruding portions being arranged along the second direction,

the first fixed electrode including a first fixed electrode base portion and a plurality of first fixed protruding portions connected to the first fixed electrode base portion, the plurality of first fixed protruding portion being arranged along the second direction,

the plurality of first movable protruding portions meshing with the plurality of first fixed protruding portions in a comb-teeth shape,

the plurality of first movable protruding portions including a first movable end protruding portions, a first movable other end protruding portion, and a plurality of first movable intermediate protruding portions,

the first movable end protruding portion being one end in the second direction among the plurality of first movable protruding portions,

the first movable other end protruding portion being another end in the second direction among the plurality of first movable protruding portions,

the plurality of first movable intermediate protruding portions being between the first movable end protruding portion and the first movable other end protruding portion,

a first movable end protruding portion width of the first movable end protruding portion along the second direction being the same as a first movable other end protruding portion width of the first movable other end protruding portion along the second direction.

2. The sensor according to claim **1**, wherein

the plurality of first fixed protruding portions are between the first movable end protruding portion and the first movable other end protruding portion,

the first movable end protruding portion width is larger than a first movable intermediate protruding portion width along the second direction of each of the plurality of first movable intermediate protruding portions, and

the first movable other end protruding portion width is larger than the first movable intermediate protruding portion width.

3. The sensor according to claim **1**, wherein

the first movable electrode is line symmetrical with respect to a first line, and

the first line passes through the first intermediate beam portion and is along the third direction.

4. The sensor according to claim **1**, wherein

the first intermediate beam portion is a center of the first beam in the second direction.

5. The sensor according to claim **2**, wherein

the first movable end protruding portion width is a width of the first movable end protruding portion along the second direction at a center of the first movable end protruding portion in the third direction,

the first movable other end protruding portion width is a width of the first movable other end protruding portion along the second direction at a center of the first movable other end protruding portion in the third direction, and

the first movable intermediate protruding portion width is a width along the second direction of one of the plurality of first movable intermediate protruding portions at a center in the third direction of the one of the plurality of first movable intermediate protruding portions.

6. The sensor according to claim **5**, wherein

the first movable intermediate protruding portion width decreases as a distance from the first movable electrode base portion increases, and

a width along the second direction of one of the plurality of first fixed protruding portions decreases as a distance from the first fixed electrode base portion increases.

7. The sensor according to claim **1**, wherein

the plurality of first fixed protruding portions include a first fixed end protruding portion, a first fixed other end protruding portion, and a plurality of first fixed intermediate protruding portion,

the first fixed end protruding portion is one end in the second direction among the plurality of first fixed protruding portions,

the first fixed other end protruding portion is another end in the second direction among the plurality of first fixed protruding portions,

the plurality of first fixed intermediate protruding portions are between the first fixed end protruding portion and the first fixed other end protruding portion, and

a first fixed end protruding portion width along the second direction of the first fixed end protruding portion is the same as a first fixed other end protruding portion width along the second direction of first fixed other end protruding portion.

8. The sensor according to claim **7**, wherein

the plurality of first movable protruding portions are between the first fixed end protruding portion and the first fixed other end protruding portion,

the first fixed end protruding portion width is larger than a first fixed intermediate protruding portion width along the second direction of each of the plurality of first fixed intermediate protruding portions, and

the first fixed other end protruding portion width is larger than the first fixed intermediate protruding portion width.

9. The sensor according to claim **7**, wherein

the first movable electrode is line symmetrical with respect to a first line, and

the first line passes through the first intermediate beam portion and is along the third direction.

10. The sensor according to claim **7**, wherein

the first intermediate beam portion is a center of the first beam in the second direction.

11. The sensor according to claim **8**, wherein

the first fixed end protruding portion width is a width of the first fixed end protruding portion along the second direction at a center of the first fixed end protruding portion in the third direction,

the first fixed other end protruding portion width is a width of the first fixed other end protruding portion along the second direction at a center of the first fixed other end protruding portion in the third direction, and

the first fixed intermediate protruding portion width is a width along the second direction of one of the plurality of first fixed intermediate protruding portions at a center in the third direction of one of the plurality of first fixed intermediate protruding portions.

12. The sensor according to claim **11**, wherein

the first fixed intermediate protruding portion width decreases as a distance from the first fixed electrode base portion increases, and

a width along the second direction of one of the plurality of first movable protruding portions decreases as a distance from the first movable electrode base portion increases.

13. The sensor according to claim **1**, wherein

a first distance along the third direction between one of the plurality of first movable protruding portions and the first fixed electrode base portion is not less than 0.79 times a second distance along the second direction between the one of the plurality of first movable protruding portions and one of the plurality of first fixed protruding portions, and

other of the plurality of first fixed protruding portions is not provided between the one of the plurality of first movable protruding portions and the one of the plurality of first fixed protruding portions.

14. The sensor according to claim **1**, further comprising:
a controller,
the controller being configured to detect a signal generated between the first movable electrode and the first fixed electrode.

15. The sensor according to claim **1**, wherein
the first movable structure includes a plurality of the first movable electrodes,
the first connecting portion connects the plurality of first movable electrodes to the first intermediate beam portion,
one of the plurality of first movable electrodes is provided between another one of the plurality of first movable electrodes and the first beam, and
a length along the second direction of the one of the plurality of first movable electrodes is longer than a length along the second direction of the other one of the plurality of first movable electrodes.

16. The sensor according to claim **1**, wherein
the element section further includes a second fixed electrode fixed to the base,
the first movable portion further includes a second movable structure,
the second movable structure includes:
a second beam,
a second movable electrode, and
a second connecting portion,
the second beam includes a second beam portion, a second other beam portion, and a second intermediate beam portion between the second beam portion and the second other beam portion,
a direction from the second beam portion to the second other beam portion is along the second direction,
the second beam portion is connected to the first movable base portion,
the second other beam portion is connected to the first other movable base portion,
the second connecting portion connects the second movable electrode to the second intermediate beam portion,
the second movable electrode includes a second movable electrode base portion and a plurality of second movable protruding portions connected to the second movable electrode base portion and arranged along the second direction,
the second fixed electrode includes a second fixed electrode base portion and a plurality of second fixed protruding portions connected to the second fixed electrode base portion and arranged along the second direction, and
the plurality of second movable protruding portions mesh with the plurality of second fixed protruding portions in a comb shape.

17. The sensor according to claim **1**, wherein
the element section further includes a first opposing fixed electrode fixed to the base, and
at least a part of the first movable electrode is between the first opposing fixed electrode and the first fixed electrode in the third direction.

18. The sensor according to claim **1**, wherein
the element section further includes a first opposing fixed electrode fixed to the base,
at least a part of the first movable electrode is between the first opposing fixed electrode and the first fixed electrode in the third direction,
the first movable electrode further includes a plurality of first opposing movable protruding portions connected to the first movable electrode base portion and arranged along the second direction,
the first movable electrode base portion is provided between the plurality of first opposing movable protruding portions and the plurality of first movable protruding portions,
the first opposing fixed electrode includes a first opposing fixed electrode base portion and a plurality of first opposing fixed protruding portions connected to the first opposing fixed electrode base portion and arranged along the second direction, and
the plurality of first opposing movable protruding portions mesh with the plurality of first opposing fixed protruding portions in a comb-teeth shape.

19. The sensor according to claim **16**, wherein
the first movable electrode and the second movable electrode satisfy at least one of a first condition, a second condition, a third condition, a fourth condition, a fifth condition, a sixth condition, a seventh condition, an eighth condition, or a ninth condition,
in the first condition, a second mass of the second movable electrode is different from a first mass of the first movable electrode,
in the second condition, a second thickness of the second movable electrode along the first direction is different from a first thickness of the first movable electrode along the first direction,
in the third condition, at least a part of a second material included in the second movable electrode is different from at least a part of a first material included in the first movable electrode,
in the fourth condition, the second movable electrode includes a second hole, and the first movable electrode does not include a first hole,
in the fifth condition, a second size of the second hole included in the second movable electrode is different from a first size of the first hole included in the first movable electrode,
in the sixth condition, a second density of the second holes is different from a first density of the first holes,
in the seventh condition, a second number of the second holes is different from a first number of the first holes,
in the eighth condition, a second shape of the second hole is different from a first shape of the first hole, and
in the ninth condition, a second layer structure of the second movable electrode is different from a first layer structure of the first movable electrode.

20. An electronic device, comprising:
the sensor according to claim **1**;
a circuit controller configured to control a circuit based on a signal obtained from the sensor.

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