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Fukada et al.

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(54) **ION GENERATOR**

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(73) Assignee: **KOGANEI CORPORATION**, Tokyo (JP)

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H05F 3/06 (2006.01)
H01T 23/00 (2006.01)
H01T 19/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H05F 3/06*** (2013.01); ***H01T 19/04*** (2013.01); ***H01T 23/00*** (2013.01)

(58) **Field of Classification Search**
CPC H05F 3/06; H01T 23/00
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,462,552 B1 * 10/2002 Suzuki G01R 29/24
324/457
7,586,731 B2 9/2009 Sato et al.
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2005294178 A 10/2005
JP 2006315770 A 11/2006
(Continued)

OTHER PUBLICATIONS

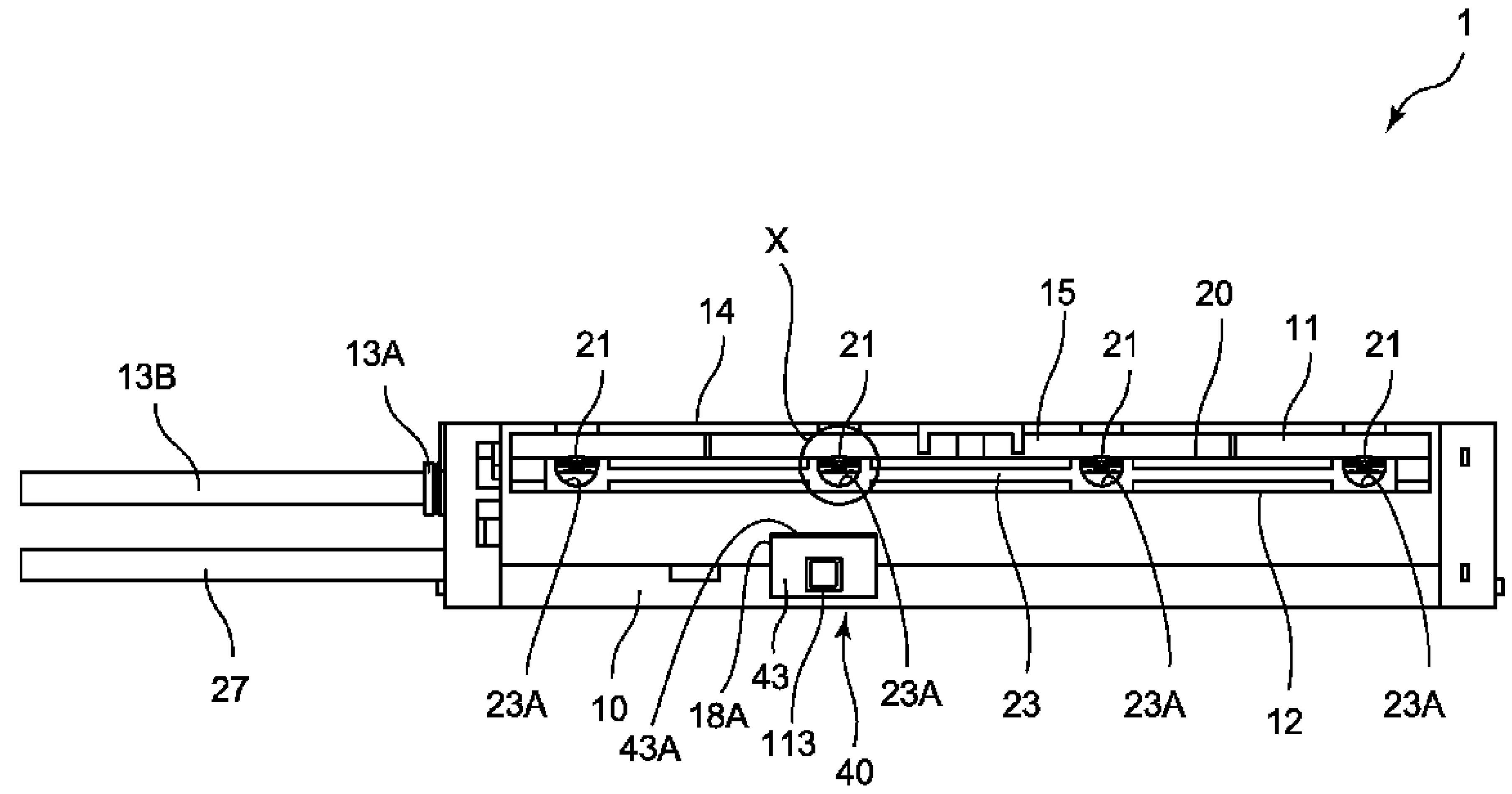
International Search Report corresponding to Application No. PCT/JP2014/060242; Date of Mailing: Jul. 8, 2014.
(Continued)

Primary Examiner — Nicole Ippolito
(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

Provided is an ion generator that has a potential sensor provided integrally inside the main body of the ion generator, and that can measure, with the potential sensor, an electric field that reaches the potential sensor from a member from which static charge is to be eliminated, without being affected by an electric field between a discharge electrode and an opposing electrode. This ion generator comprises a discharge electrode, an opposing electrode, and a main body part including these electrodes, the ion generator sending out, toward a member from which static charge is to be eliminated, air ions generated by applying a high voltage between the electrodes. A potential sensor that measures the potential of the member from which static charge is to be eliminated is provided integrally to the main body part, and a projecting electrostatic-shielding plate that projects from the main body part is provided between the potential sensor and a discharge part constituted by the discharge electrode and the opposing electrode.

7 Claims, 15 Drawing Sheets



(58) **Field of Classification Search**
USPC .... 250/423 R, 424, 423 F; 315/111.01, 315/111.81
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,901,506	B2 *	12/2014	Fukada	G01R 19/0061 250/389
2007/0133145	A1	6/2007	Sato et al.	

FOREIGN PATENT DOCUMENTS

JP	2010085393	A	4/2010
JP	2012242094	A	12/2012
KR	20010040133	A	5/2001
KR	1020070055393	A	5/2007

OTHER PUBLICATIONS

Korean Office Action for Application No. 10-2015-7031097; Dated: Nov. 18, 2016, with English translation.

* cited by examiner

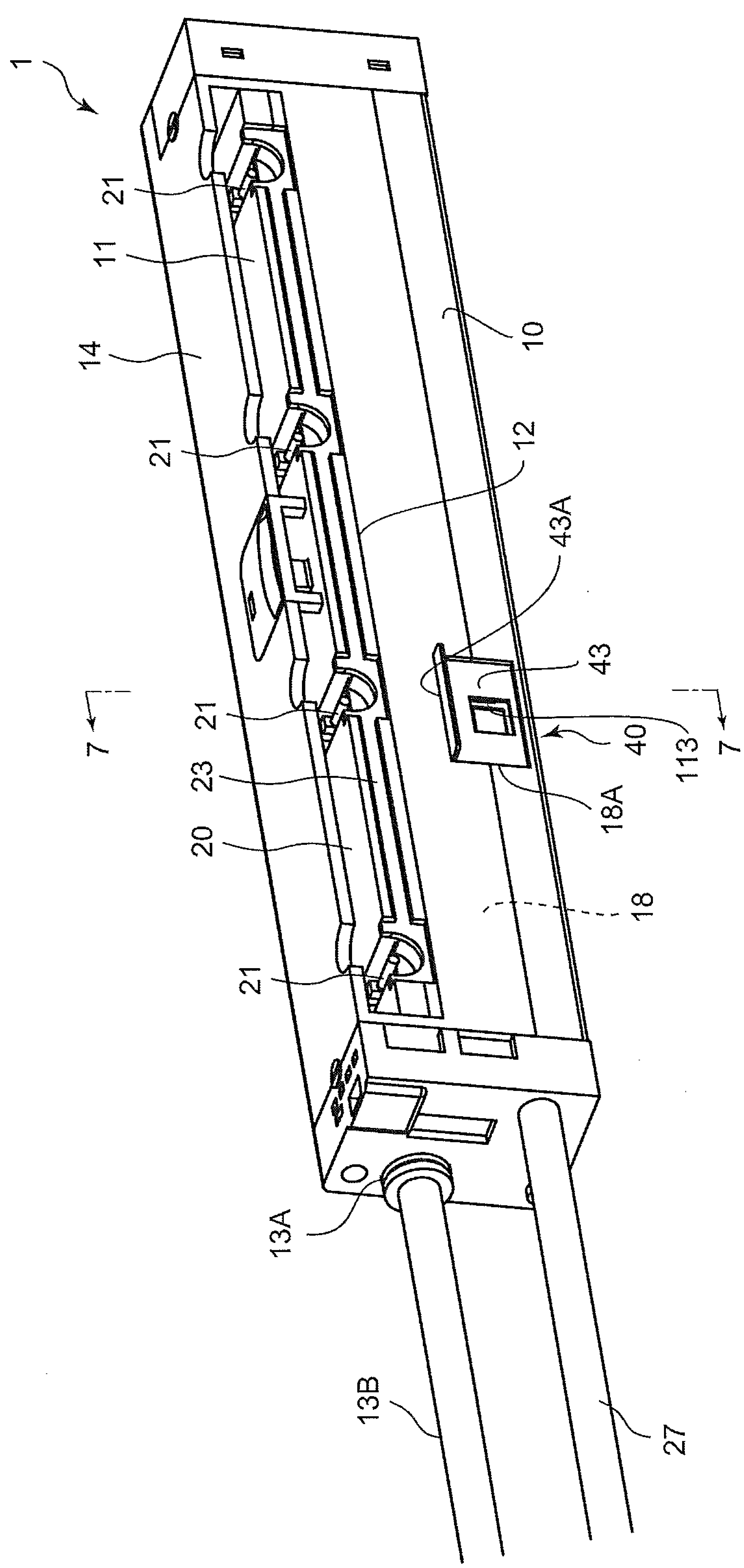


Fig.1

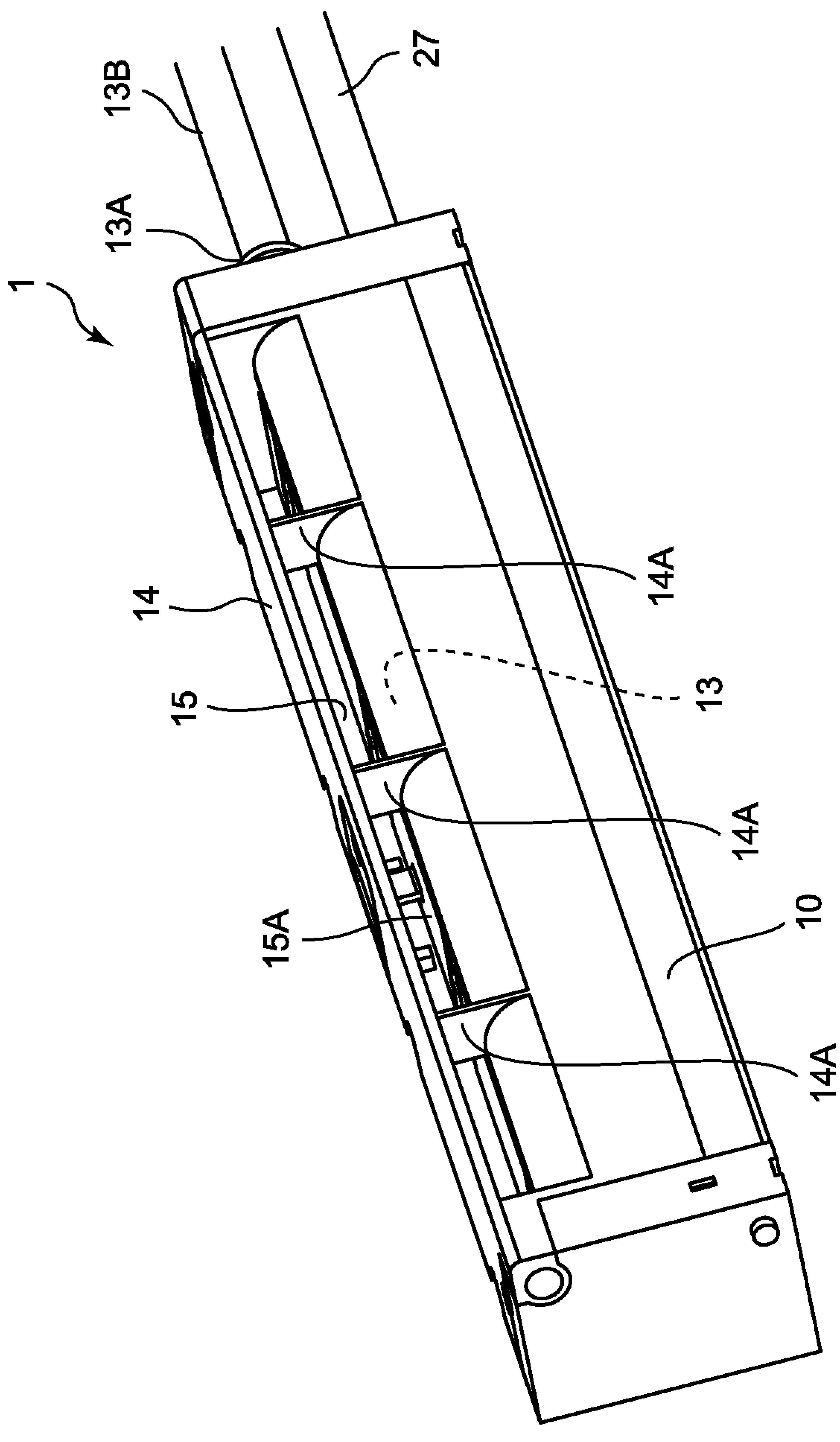


Fig.2

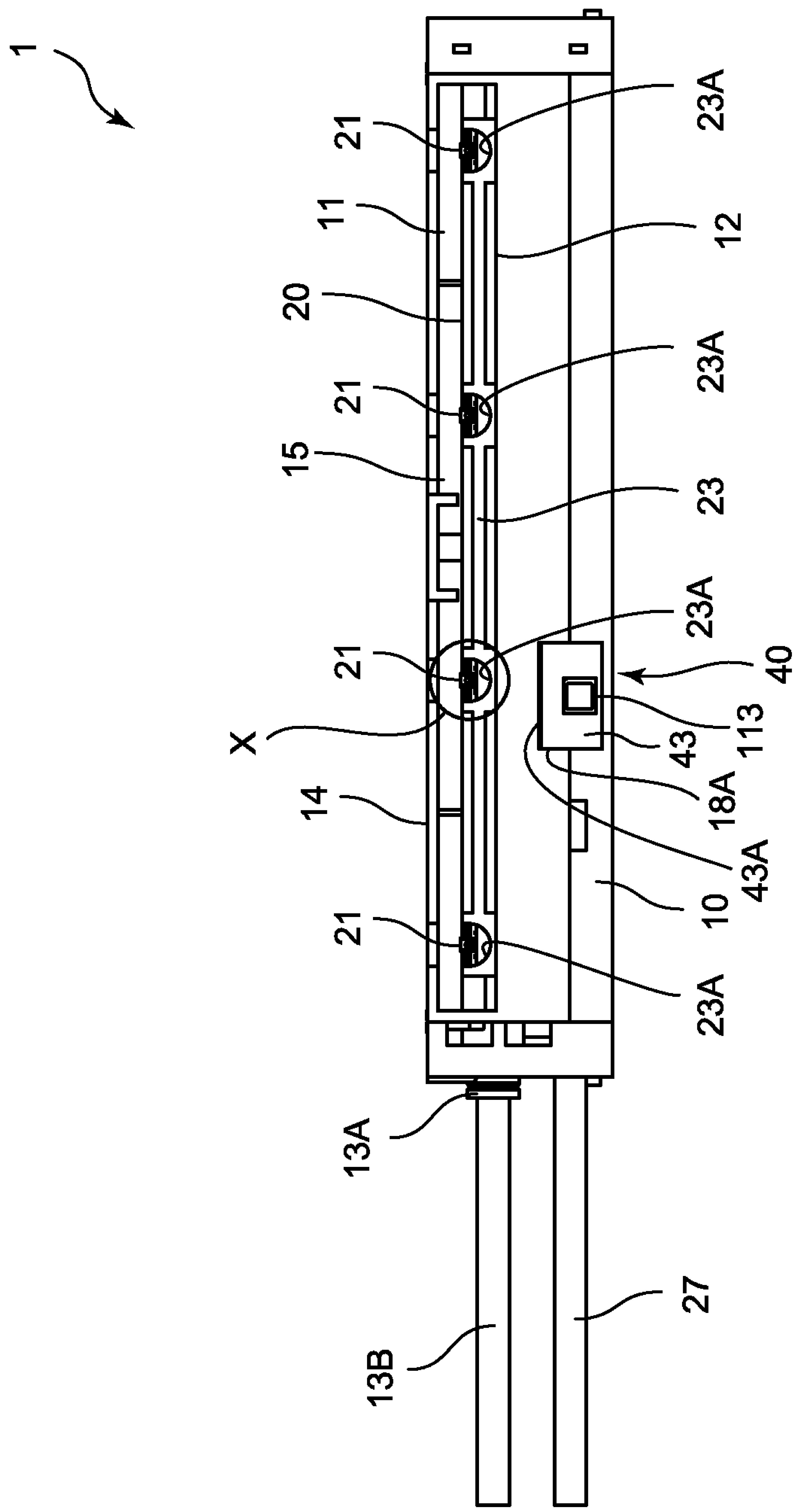

1
21
11
20
21
15
21
X
14
21
13A
13B
23A
12
23A
23
23A
40
113
43
18A
43A
10
23A
27

Fig.3

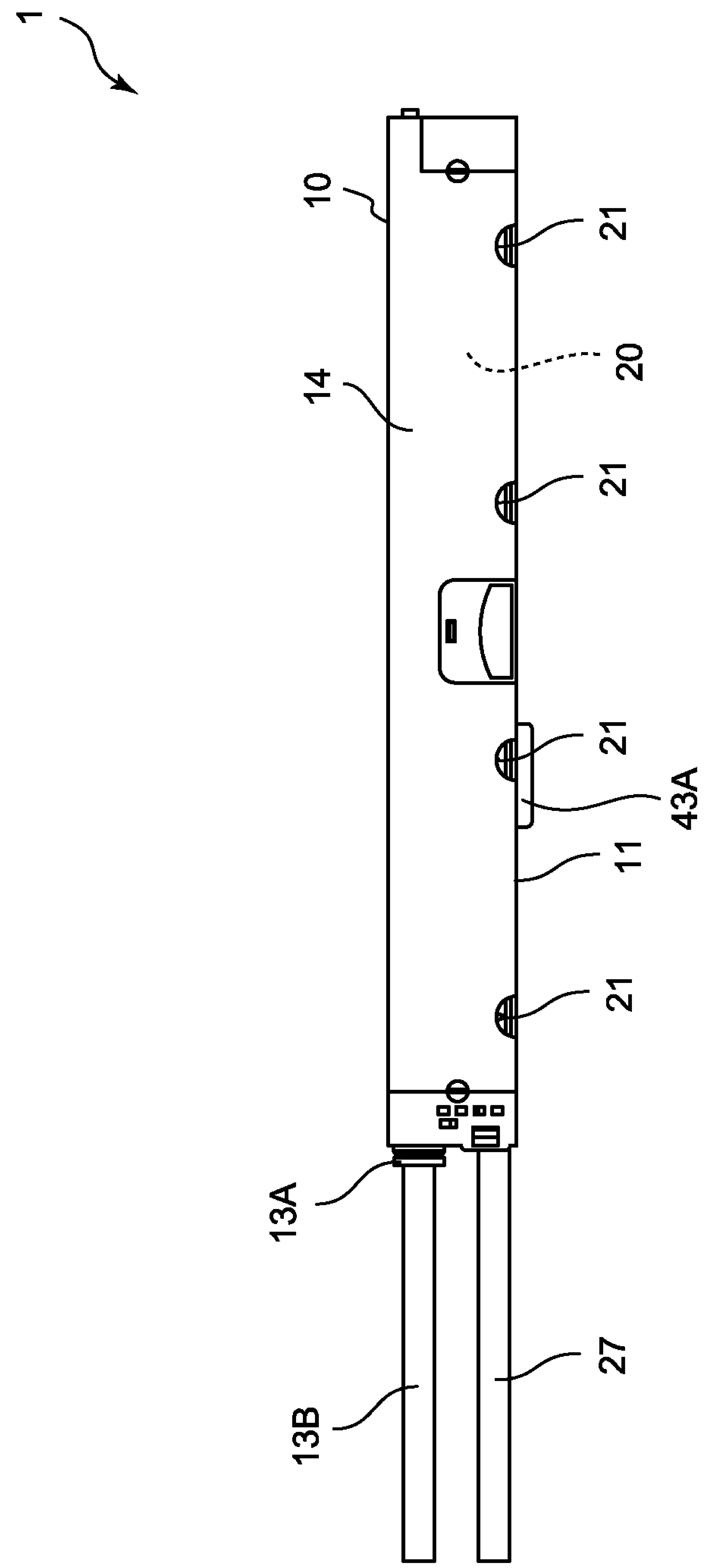


Fig.4

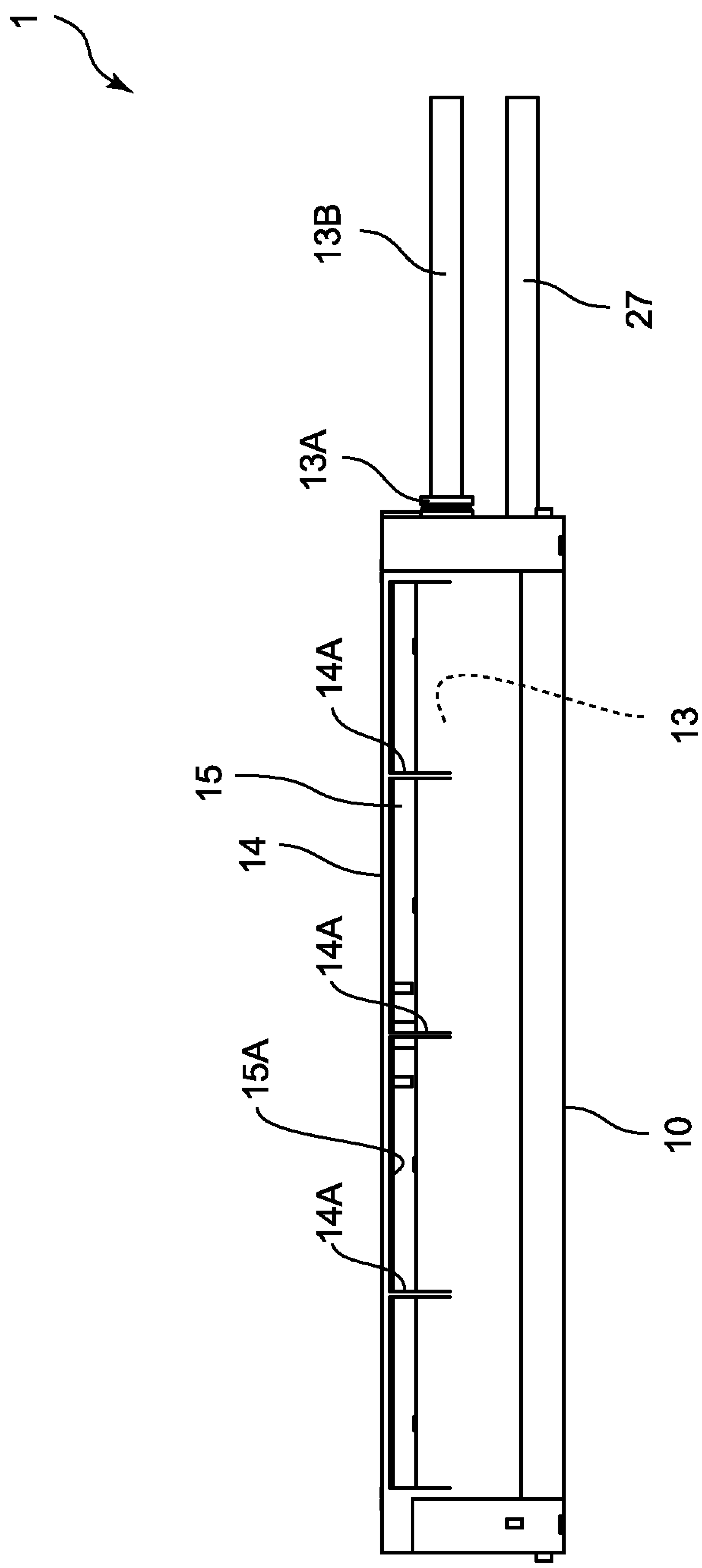


Fig.5

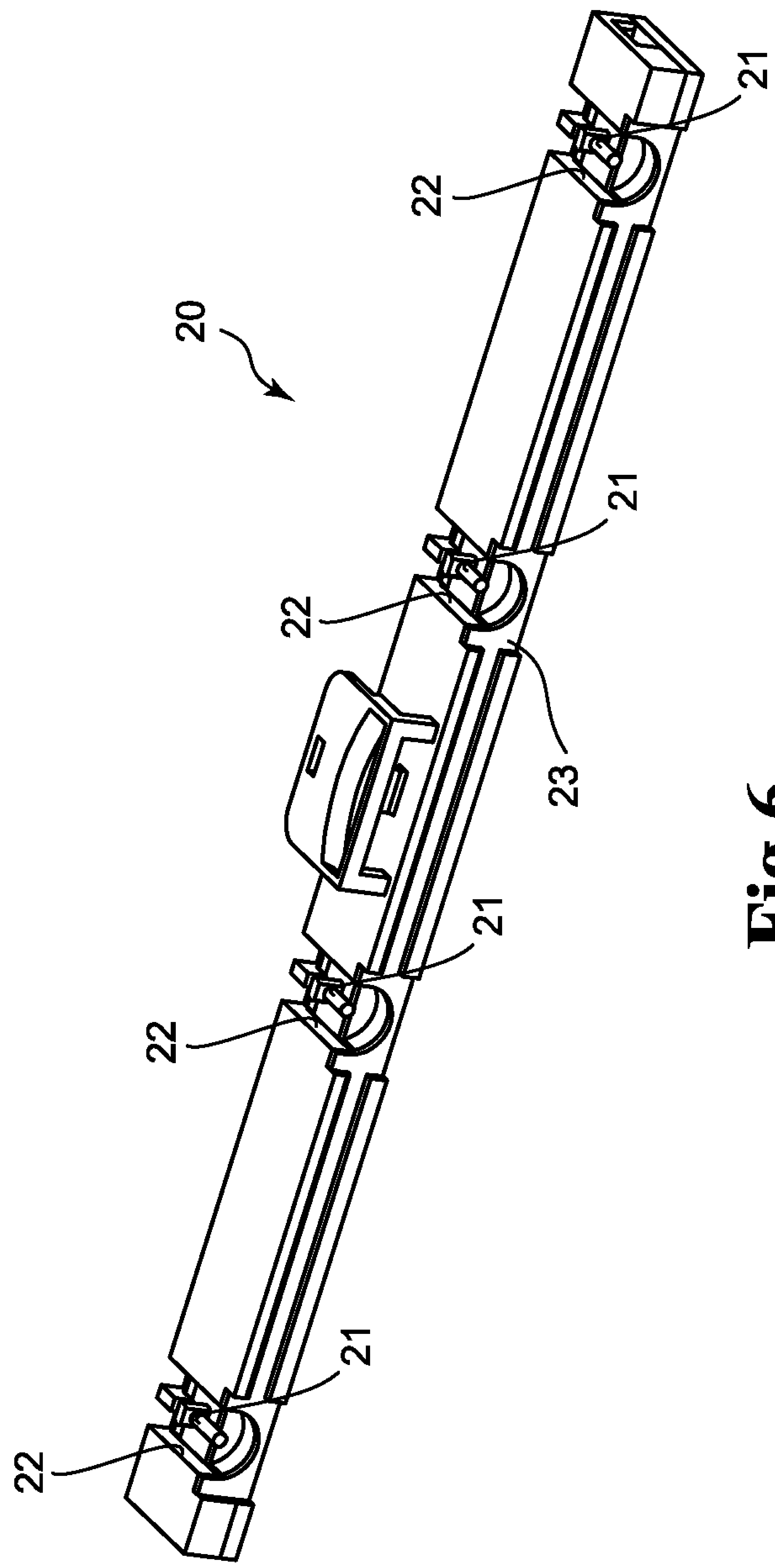
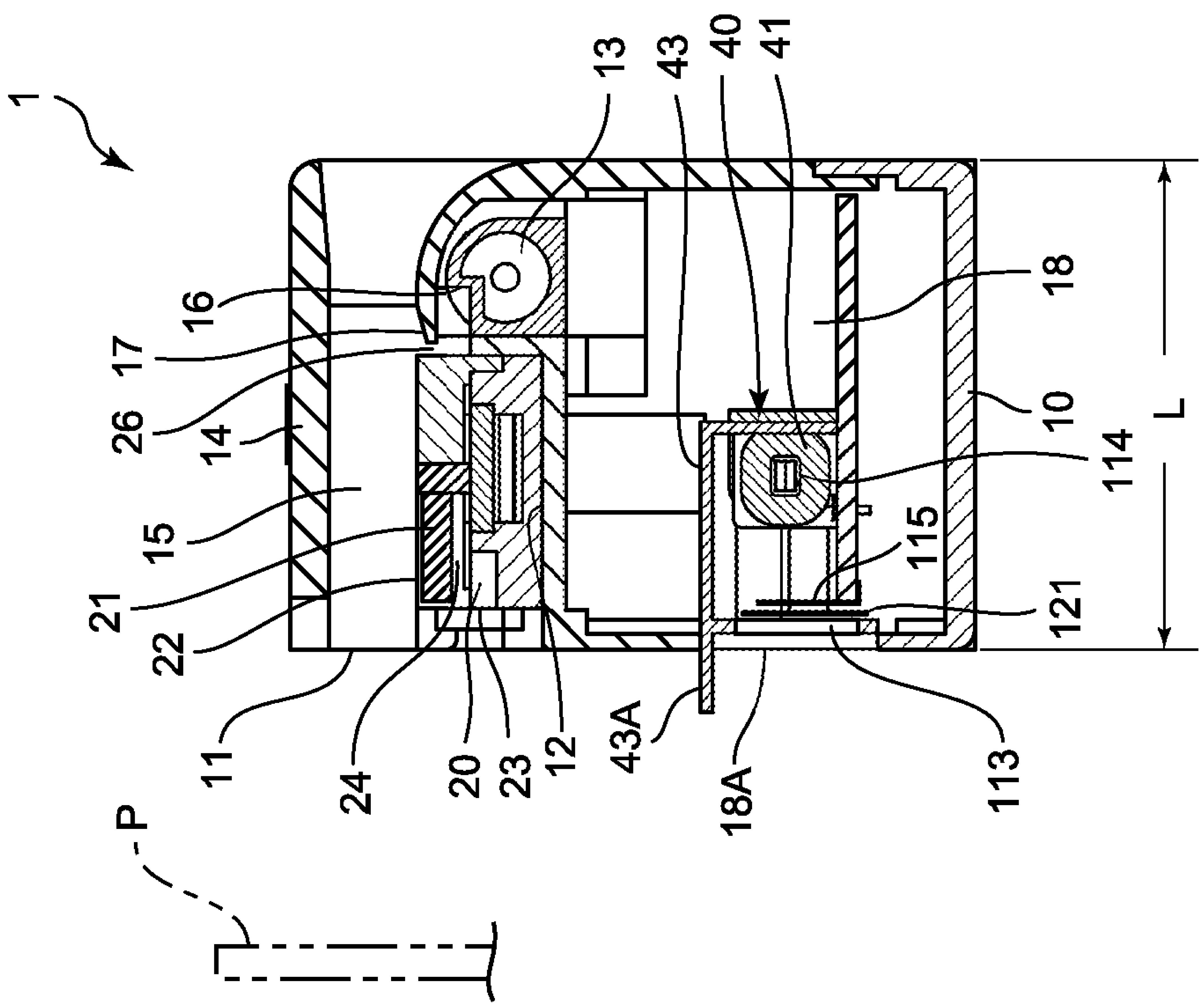


Fig.6


1
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17
26
14
15
21
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L
114
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24
20
23
12
43A
18A
113
P

Fig.7

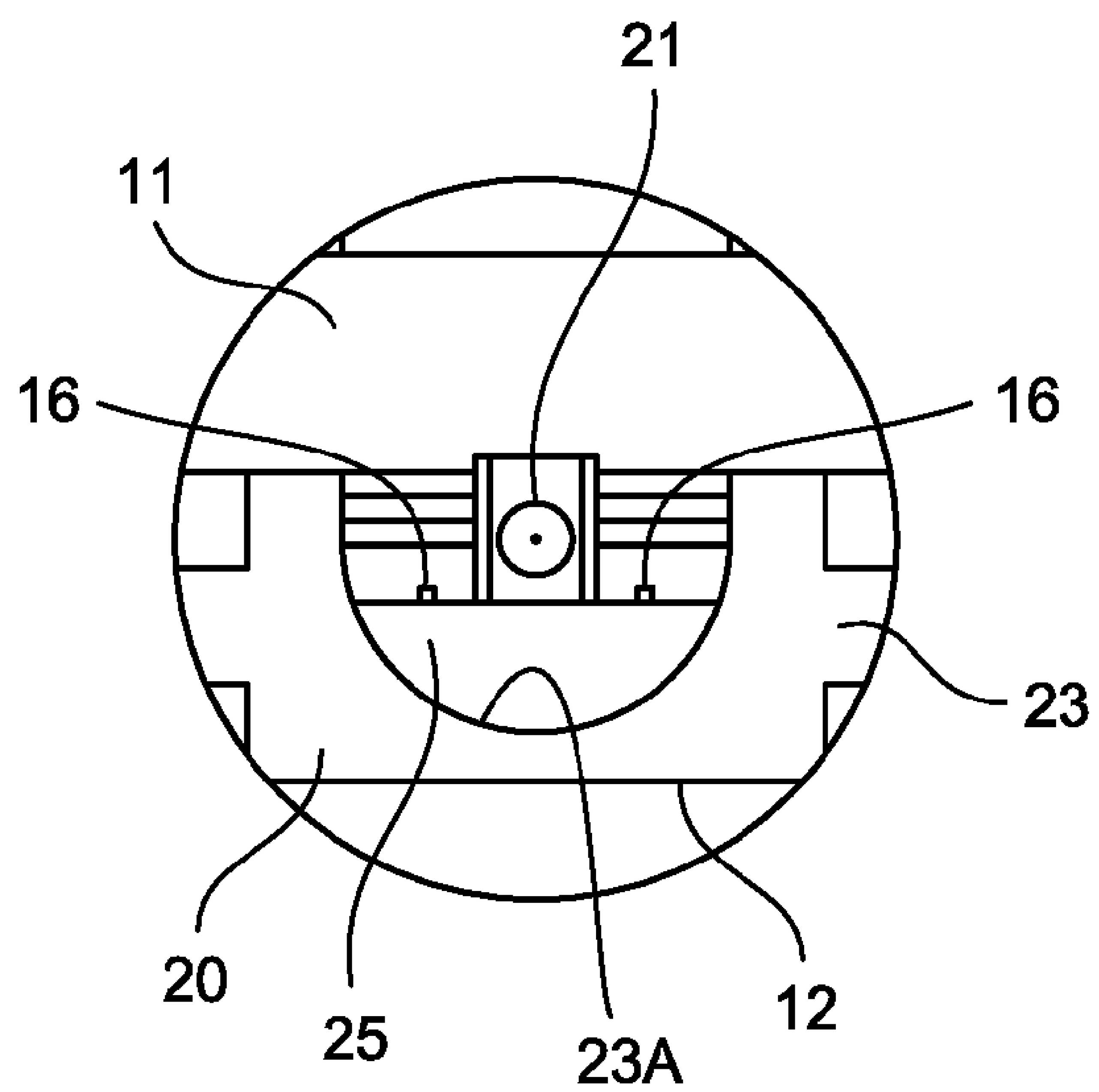


Fig.8

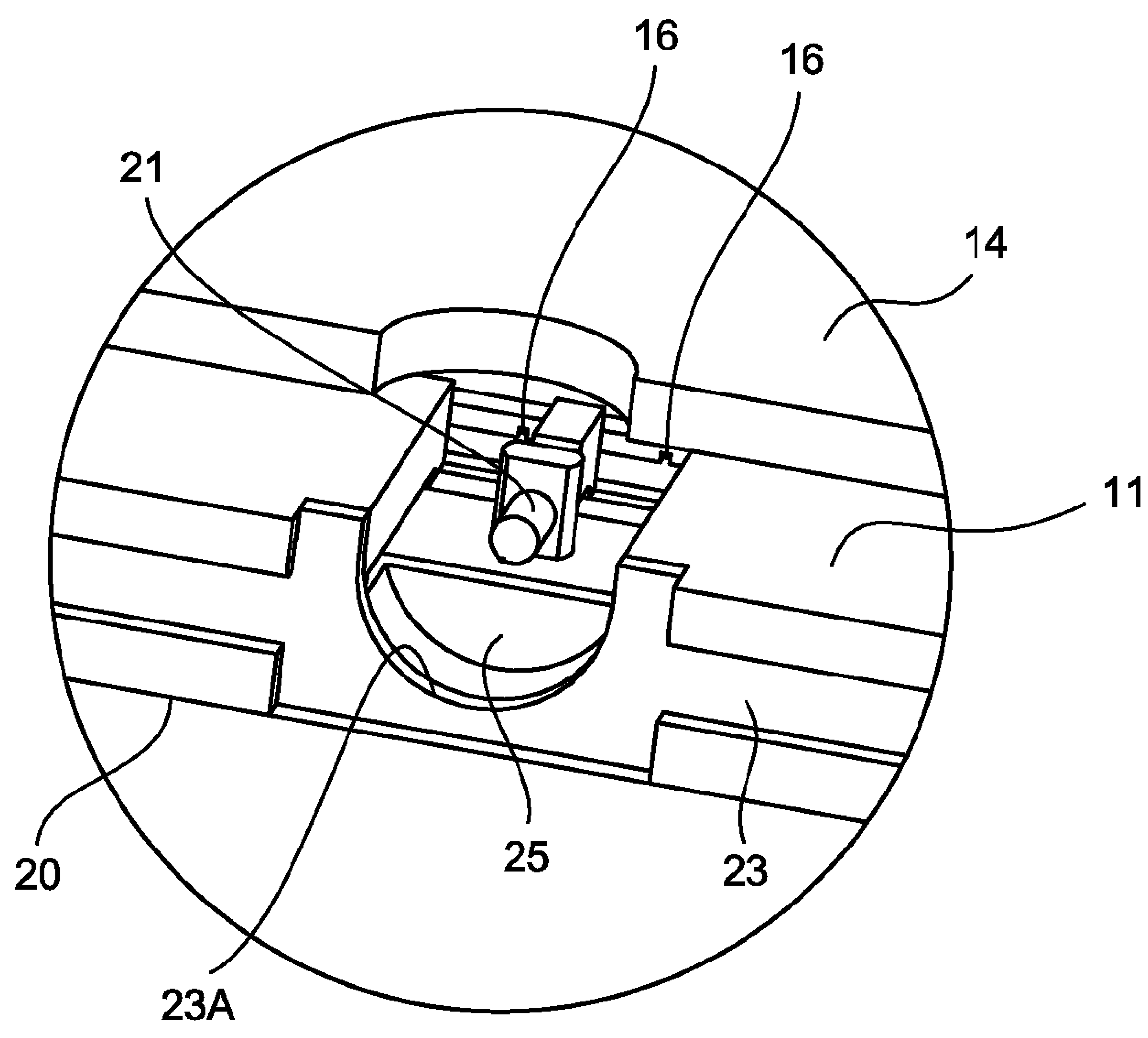


Fig.9

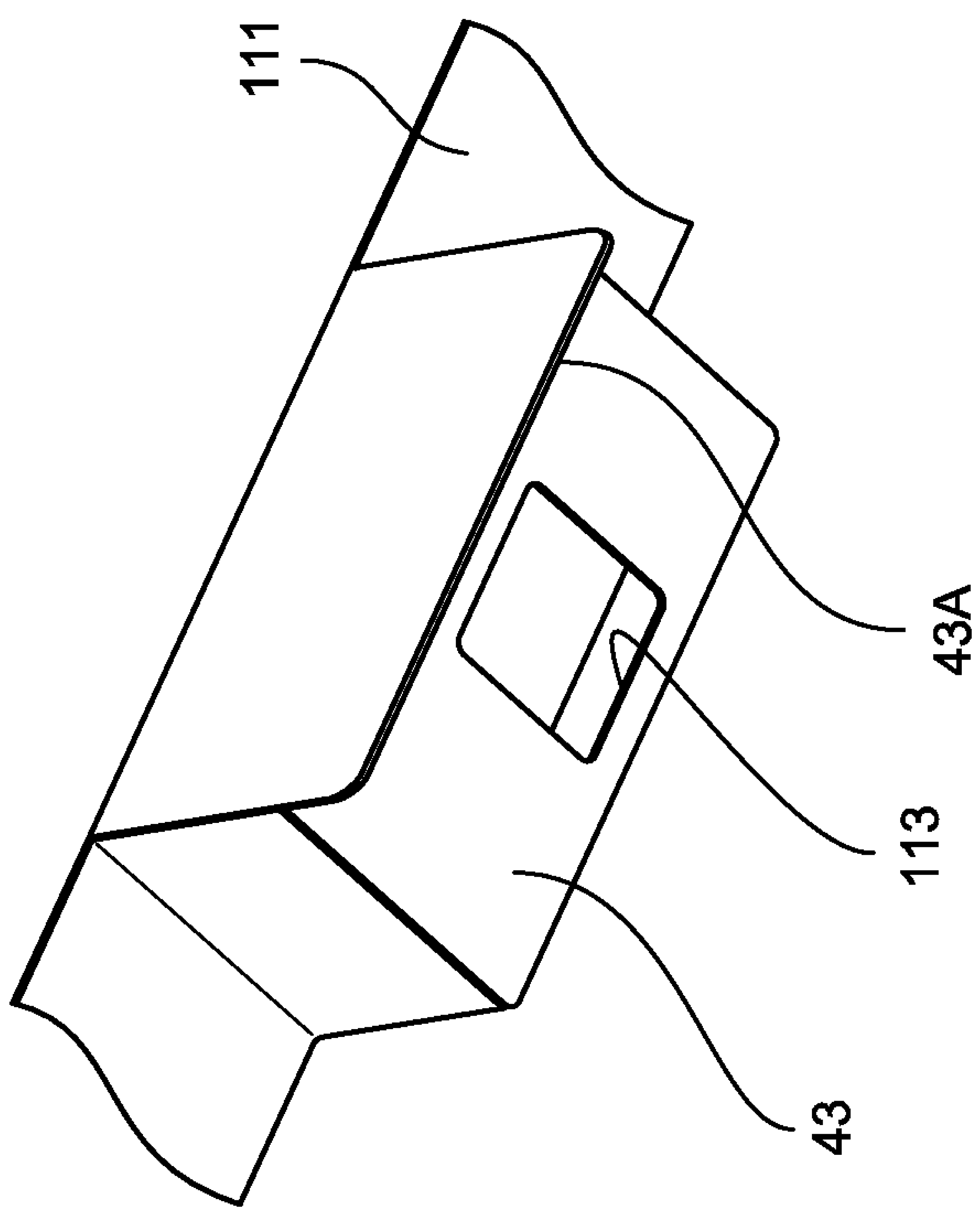
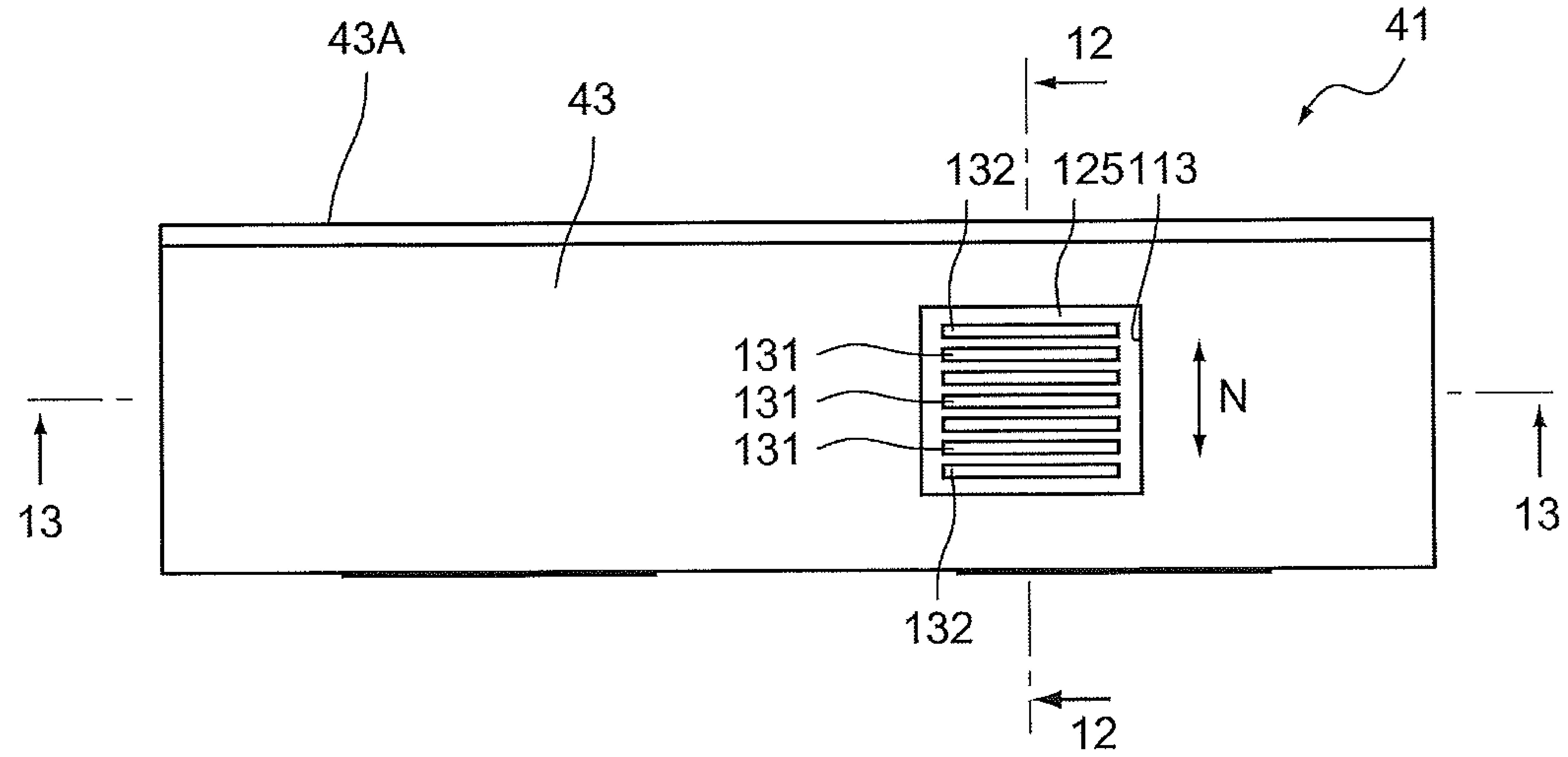


Fig.10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41
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131
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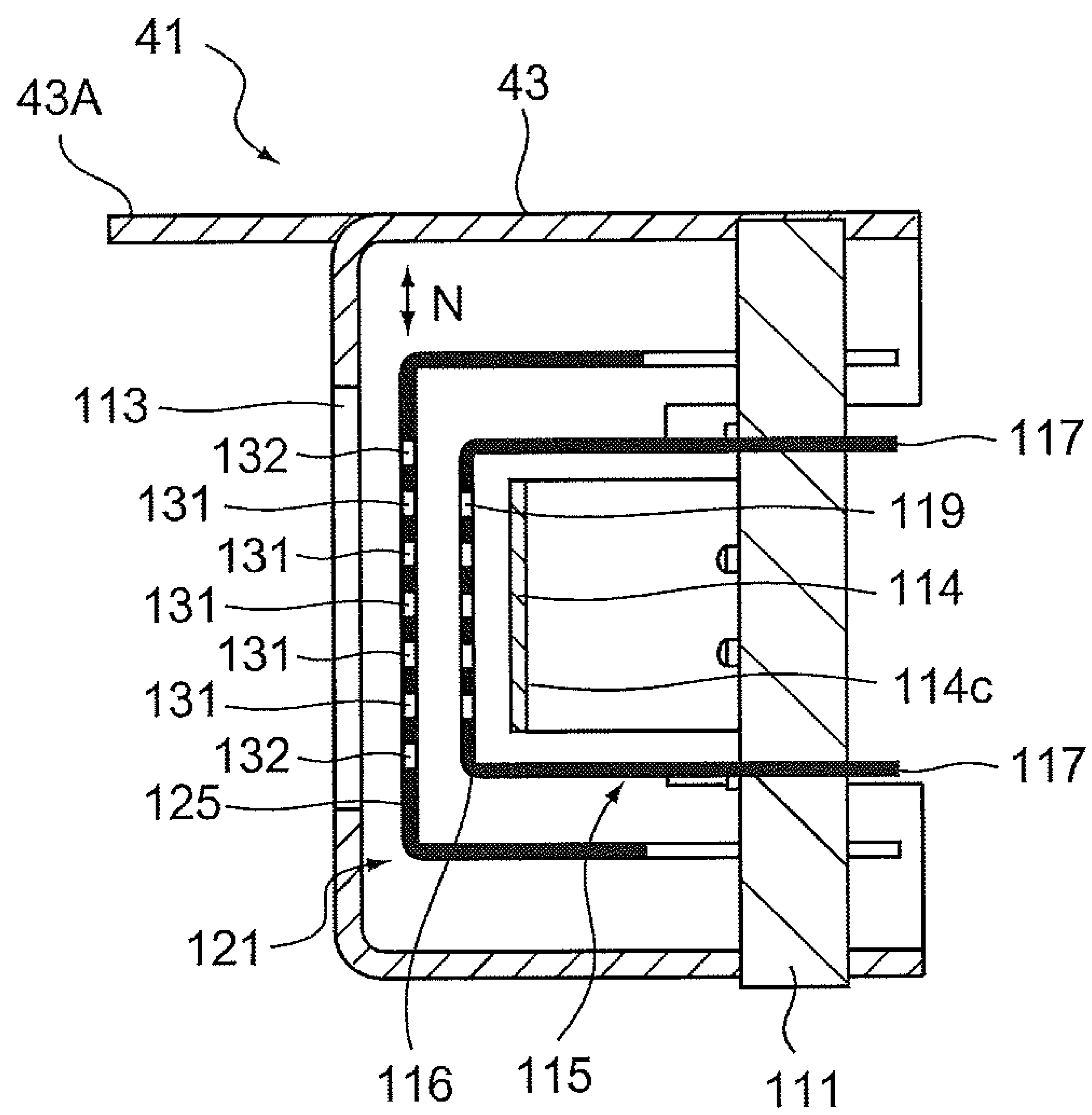
13
13
132
12

Fig.11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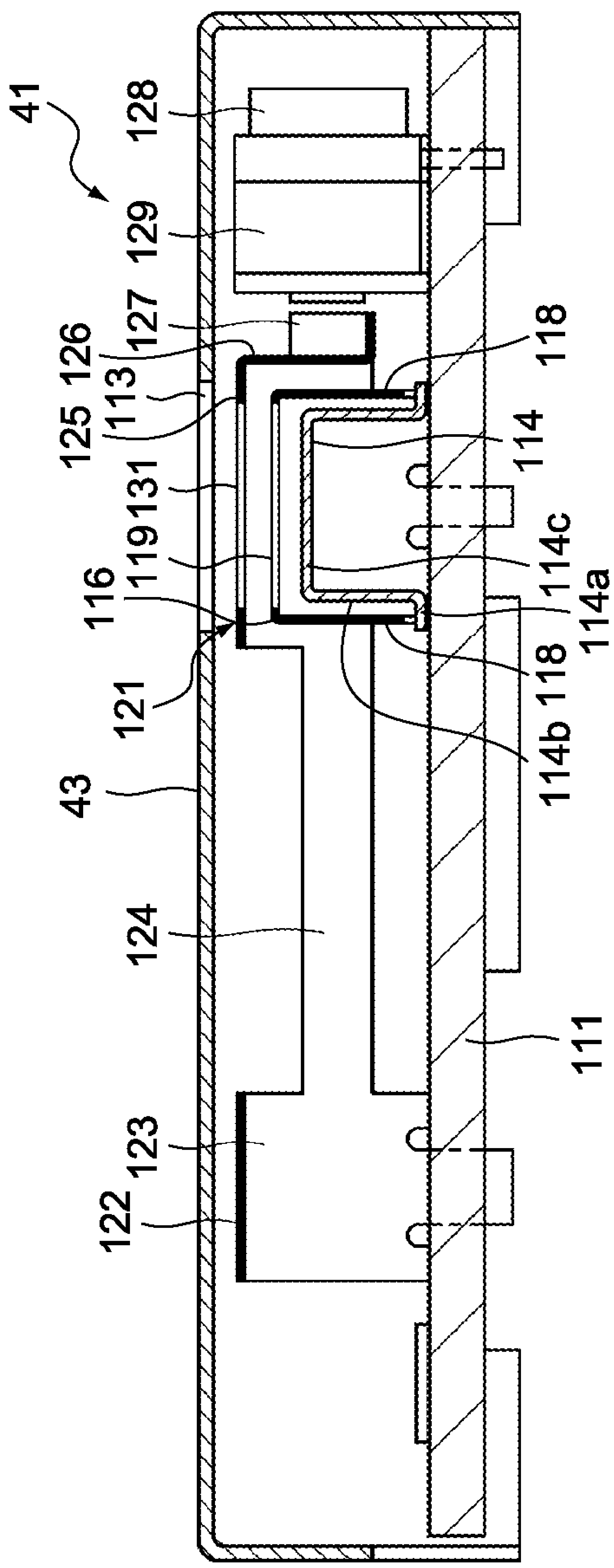
116
115
111
117
119
114
114c
117

Fig.12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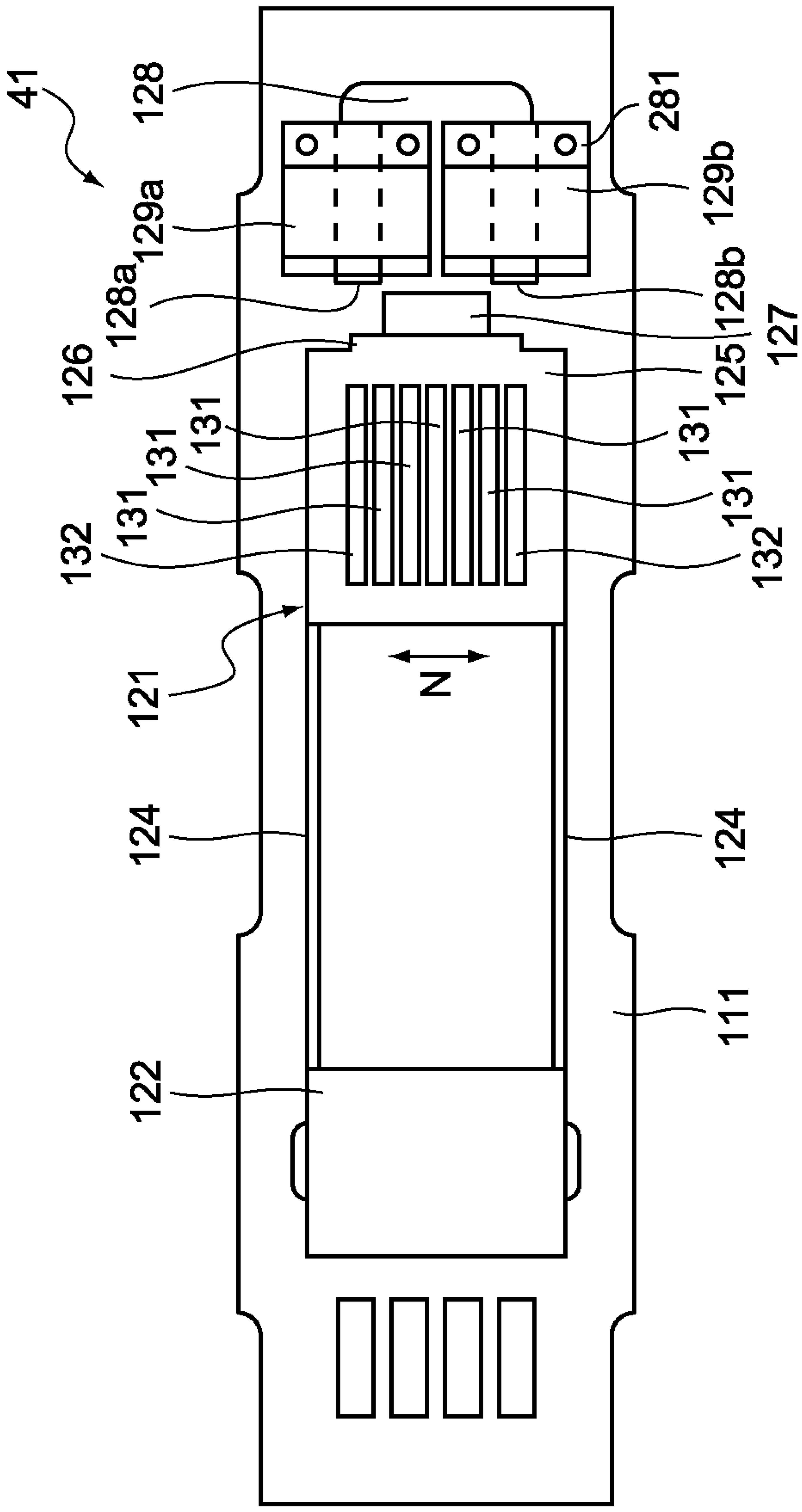
118
114b
111

Fig.13


41
128
281
129a
129b
128a
128b
126
125
127
131
131
131
131
131
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132
132
N
121
124
124
111
122

Fig.14

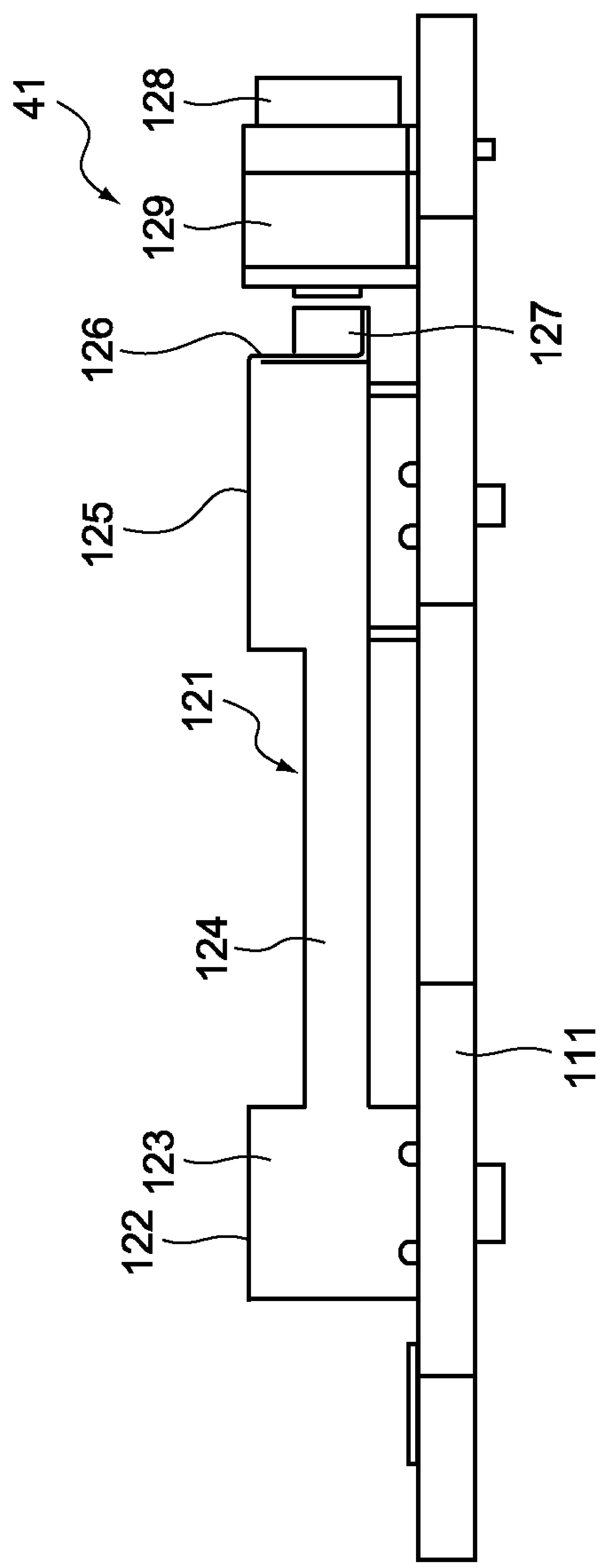

Fig.15

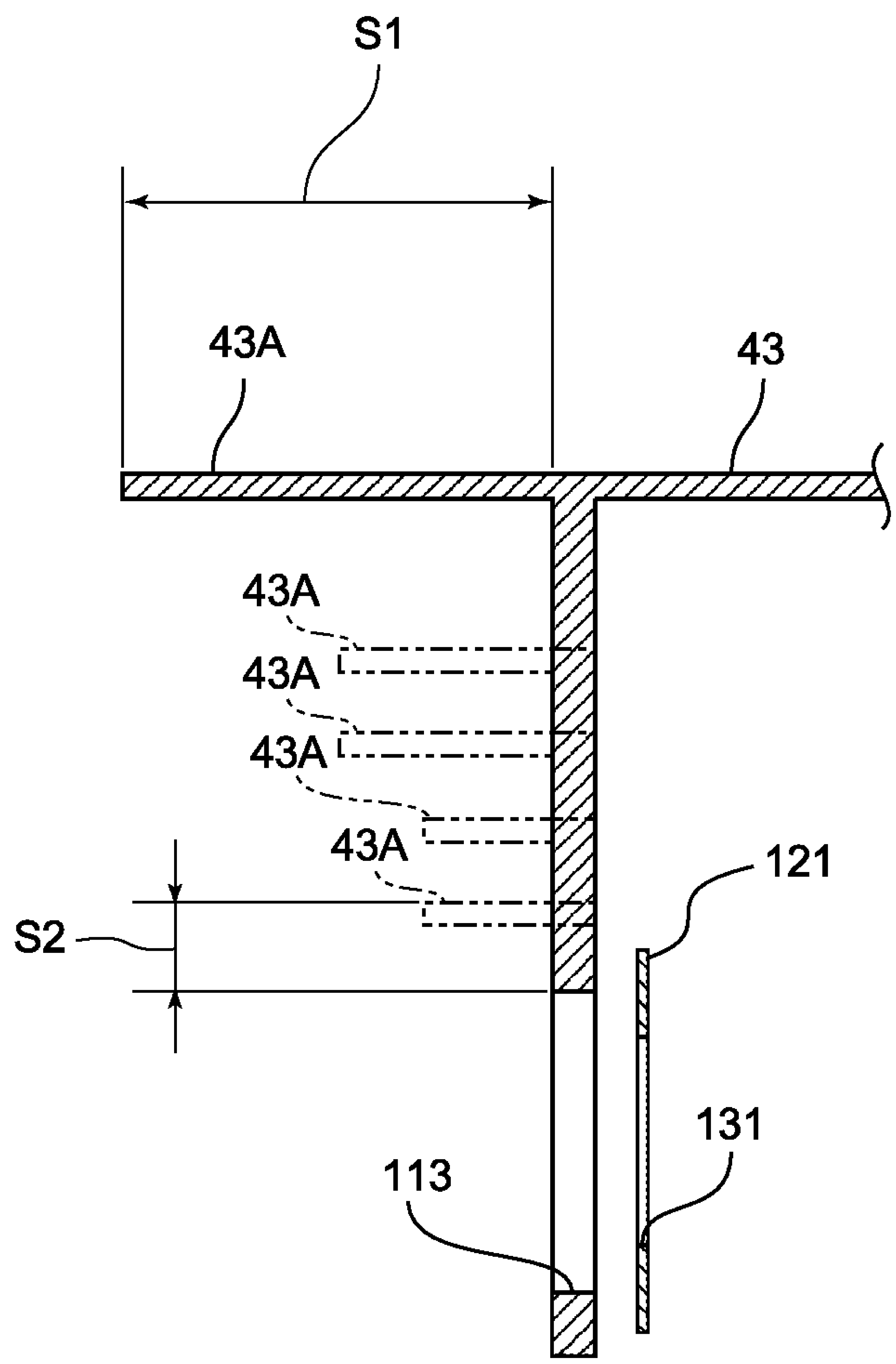

Fig.16

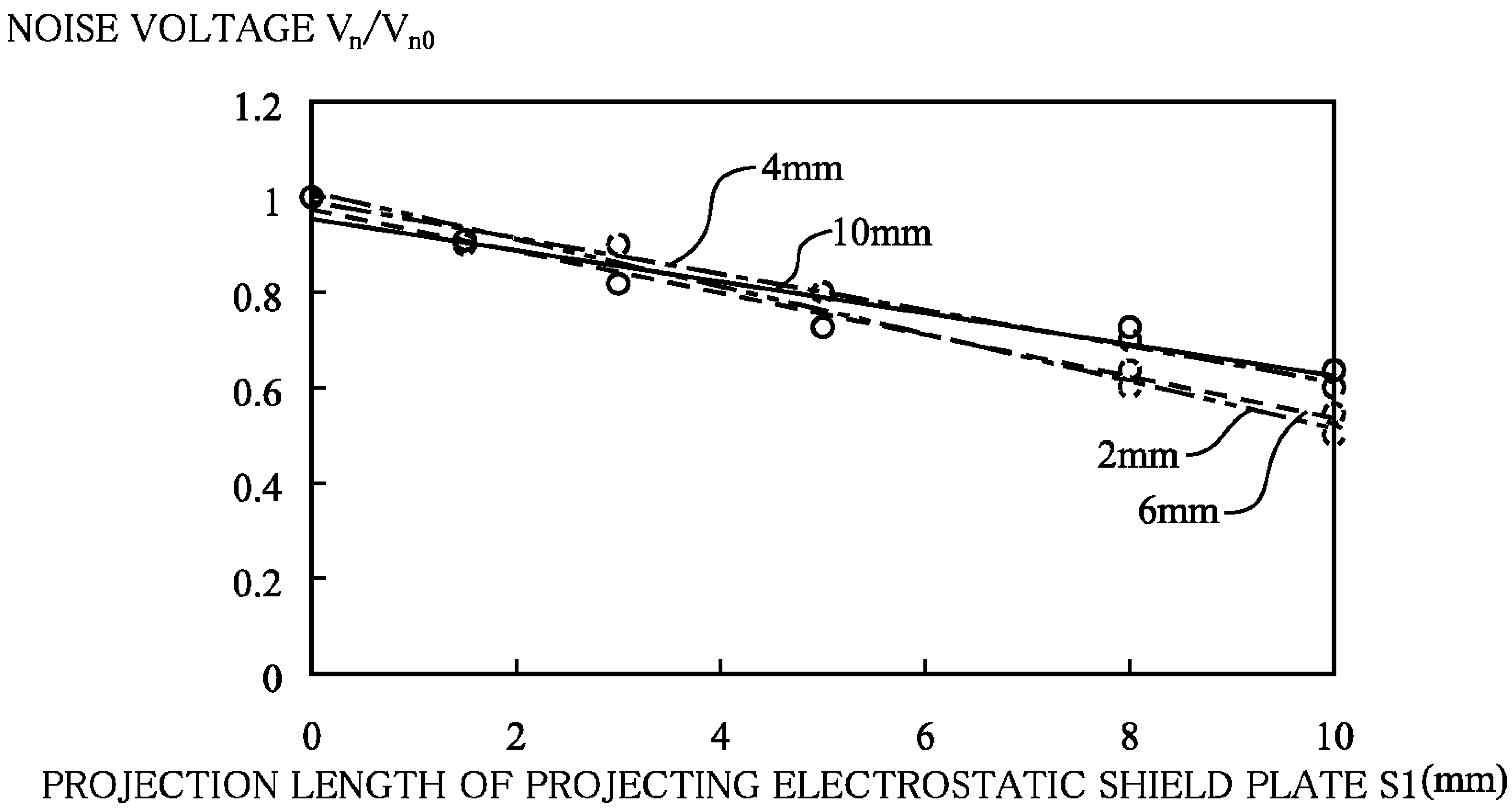
NOISE VOLTAGE V_n/V_{n0}
1.2
1
0.8
0.6
0.4
0.2
0
4mm
10mm
2mm
6mm
0
2
4
6
8
10
PROJECTION LENGTH OF PROJECTING ELECTROSTATIC SHIELD PLATE S1(mm)

Fig.17

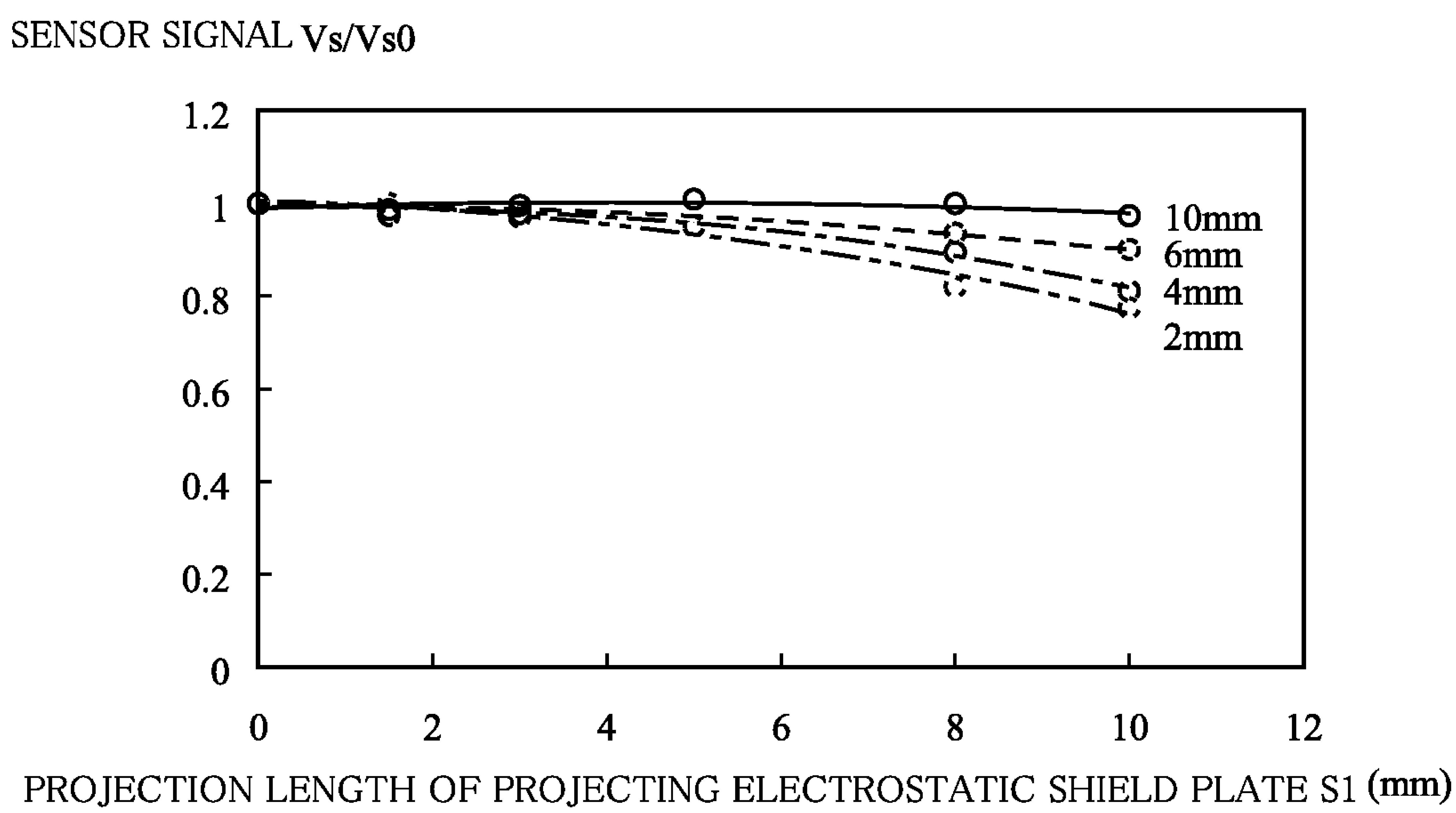
SENSOR SIGNAL Vs/Vs0
1.2
1
0.8
0.6
0.4
0.2
0
10mm
6mm
4mm
2mm
0
2
4
6
8
10
12
PROJECTION LENGTH OF PROJECTING ELECTROSTATIC SHIELD PLATE S1 (mm)

Fig.18

ION GENERATOR

This is a U.S. national stage of application No. PCT/JP2014/060242, filed on Apr. 9, 2014. Priority under 35 U.S.C. §119(a) and 35 U.S.C. §365(b) is claimed from Japanese Patent Applications No. 2013-083022 filed on Apr. 11, 2013, the disclosure of which is also incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to an ion generator that neutralizes charge of an electrically-charged body as an object required to be electrically neutralized (hereinafter "charged member"). The ion generator blows positive or negative air ions generated by corona discharge against the charged member. The present invention relates to, especially an ion generator having an integral potential sensor integrally provided therewith.

BACKGROUND ART

The ion generator is called ionizer or static charge eliminator as well. The ion generator blows air ions against a charged target and eliminates charge. In a manufacture line in which manufacture and assembly of electronic components are conducted, electronic components and manufacture assembly jigs are charged. The electronic components and manufacture assembly jigs are regarded as a charged member, and the ion generator is used. Blowing air ions against the charged member prevents foreign matters from adhering to electronic components by static electricity, prevents electronic components from being destroyed by static electricity, and prevents foreign matters from adhering to jigs.

It is known to measure the potential of the charged member, by using a potential sensor (see, for example, Patent Literatures 1 and 2). If such a potential sensor is used together with the ion generator, it is possible to eliminate charge in the charged member, while measuring the potential of the charged member by using the potential sensor. Such a potential sensor is usually attached separately from the ion generator or externally to the ion generator and used.

CITATION LIST

Patent Literature

{PTL 1} Japan Unexamined Patent Application Publication 2012-242094

{PTL 2} Japan Unexamined Patent Application Publication 2010-85393

SUMMARY OF THE INVENTION

Technical Problem

In a case where the ion generator and the potential sensor are provided separately, the installation space is large. On the other hand, in a case where the ion generator and the potential sensor are provided integrally, the installation space is small. If the ion generator and the potential sensor are provided integrally, however, a problem is posed. For example, since a discharge electrode and an opposite electrode are disposed near the potential sensor, an electric field between the discharge electrode and the opposite electrode with a high voltage applied reaches the potential sensor. The electric field is superposed on an electric field that reaches the potential sensor from the charged member, i.e., an electric field to be measured, and becomes noise. Therefore, it is not possible to measure the potential of the charged member, accurately.

An object of the present invention is to provide, an ion generator that measures potential of a charged member, by using a potential sensor without being influenced by an electric field between a discharge electrode and an opposite electrode, i.e., noise, although the ion generator and the potential sensor are provided integrally.

Solution to Problem

In order to solve the problem, the present invention provides an ion generator that blows air ions generated by applying a high voltage to a discharge unit including discharge electrodes and opposite electrodes, toward a charged member. The ion generator includes a potential sensor provided integrally in a main body unit to measure potential of the charged member, and a projecting electrostatic shield plate disposed between the discharge unit and the potential sensor to project from the main body unit.

It is possible to set a projection length of the projecting electrostatic shield plate in a range of 8 to 10 mm.

An aperture window is formed in the potential sensor to take in an electric field from the charged member. It is possible to set a distance from the projecting electrostatic shield plate to the aperture window in the potential sensor equal to 2 mm or less.

A blow-off opening is formed in the main body unit to blow off the air ions. A plurality of the discharge electrodes is disposed at intervals along the blow-off opening. It is possible to cause the projecting electrostatic shield plate to intervene between any of the discharge electrodes and the aperture window.

It is possible to cause the blow-off opening and the aperture window to be disposed on the same plane in the main body.

Advantageous Effects of the Invention

In the ion generator according to the present invention, the potential sensor is provided integrally in the main body unit. Potential of the charged member is measured by the potential sensor. The discharge unit includes the discharge electrodes and the opposite electrodes. The projecting electrostatic shield plate is provided between the discharge unit and the potential sensor. The projecting electrostatic shield plate projects toward an ion blow-off direction from the main body unit. The high voltage is applied between the discharge electrode and the opposite electrode, and an electric field is generated. The electric field is shielded by the projecting electrostatic shield plate, and the electric field does not reach the potential sensor. Therefore, the potential of the charged member is measured by the potential sensor without being influenced by the electric field between the discharge electrode and the opposite electrode, i.e., noise.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a general perspective view obtained by viewing an ion generator according to an embodiment of the present invention from a front side.

FIG. **2** is a general perspective view obtained by viewing the ion generator illustrated in FIG. **1** from a rear side;

FIG. **3** is a front view of the ion generator.

FIG. **4** is a plan view of FIG. **3**.

FIG. **5** is a rear view of FIG. **3**.

FIG. **6** is a perspective view illustrating a single substance of a discharge electrode unit.

FIG. **7** is a sectional view taking along line A-A in FIG. **1**.

FIG. **8** is an enlarged view of an X portion in FIG. **3**.

FIG. **9** is a perspective view of FIG. **8**.

FIG. **10** is a perspective view illustrating the whole of a potential sensor.

FIG. **11** is a plan view illustrating a configuration of the potential sensor.

FIG. **12** is a front sectional view of the potential sensor illustrated in FIG. **11**, illustrating a state in which the potential sensor is cut along a line indicated by arrows **2-2**.

FIG. **13** is a side sectional view of the potential sensor illustrated in FIG. **11**, illustrating a state in which the potential sensor is cut along a line indicated by arrows **3-3**.

FIG. **14** is a plan view of the potential sensor illustrated in FIG. **11** in a state in which an electrostatic shield plate is removed.

FIG. **15** is a side view of the potential sensor illustrated in FIG. **11** in the state in which the electrostatic shield plate is removed.

FIG. **16** is a diagram illustrating relations between a position of a projecting electrostatic shield plate and a projection length thereof.

FIG. **17** is a graphic diagram illustrating relations between the length of the projecting electrostatic shield plate and noise voltage.

FIG. **18** is a graphic diagram illustrating relations between the length of the projecting electrostatic shield plate and signal voltage.

DESCRIPTION OF EMBODIMENTS

Hereafter, an ion generator according to an embodiment of the present invention will be described in detail with reference to the drawings. "Up-down direction," "left/right direction (width direction)," and "depth direction" used in the following description refer to directions viewed from a front side where the front side (surface side) is this side in FIG. **1**. In the embodiment stated hereafter, a product of wide type will be described. The product of wide type blows off generated air ions from a laterally long blow-off opening.

The whole of an ion generator **1** is illustrated in FIGS. **1** to **5**. The ion generator **1** includes a main body unit **10**, a discharge electrode unit **20** (see FIG. **6**), and a potential sensor unit **40**. The discharge electrode unit **20** is detachably attached to the main body unit **10** from a blow-off opening **11**. The potential sensor unit **40** is housed in the main body unit **10**.

The main body unit **10** is formed into the shape of nearly a rectangular parallelepiped, and the main body unit **10** extends in the left/right direction. As illustrated in FIGS. **1**, **3**, **4** and **7**, the blow-off opening **11** is formed in an upper portion of the front of the main body unit **10** on this side. The blow-off opening **11** extends in the left/right direction.

As illustrated in FIG. **7**, a discharge electrode unit mounting portion **12** is formed within the rear portion of the blow-off opening **11**. The discharge electrode unit mounting portion **12** is recessed in the depth direction, and has the same width as that of the blow-off opening **11**. The discharge electrode unit mounting portion **12** is formed into a rectangular recessed shape. The discharge electrode unit **20** (see FIG. **6**) is fitted in the discharge electrode unit mounting portion **12**.

As illustrated in FIG. **7**, an air supply chamber **13** is provided further behind the discharge electrode unit mounting portion **12**. The air supply chamber **13** is formed over the whole length of the blow-off opening **11** in the left/right direction. As illustrated in FIGS. **1** to **5**, the air supply chamber **13** is supplied with jet air from an air supply port **13**A provided on a left side of the main body unit **10** via a tube **13**B.

As illustrated in FIGS. **7** to **9**, an air discharge opening **16** is provided in an upper portion of the front side of the air supply chamber **13**. The air discharge opening **16** communicates from inside of the air supply chamber **13** to a back portion of the discharge electrode unit mounting portion **12**. The air discharge opening **16** takes the shape of a rectangular hole or a round hole. As illustrated in FIGS. **8** and **9**, two air discharge openings **16** are provided on lower sides of the left and right of each of discharge electrodes **21**. Details of the air discharge openings **16** will be described later. The jet air is jetted forward from the air discharge openings **16**.

As illustrated in FIG. **7**, an air guide portion **17** is provided on an upper portion of the air discharge opening **16**. The air guide portion **17** projects to the upper side of the front of the air discharge opening **16**. The air guide portion **17** enhances the straight advancing property of the jet air blown off from the air discharge opening **16**.

A top face cover **14** is provided over the air supply chamber **13** and the discharge electrode unit mounting portion **12**. As illustrated in FIGS. **1** to **3**, **5** and **7**, an air flow path **15** is formed between the top face cover **14** and the air supply chamber **13**. The air flow path **15** is also formed between the top face cover **14** and the discharge electrode unit mounting portion **12**. The air flow path **15** passes through from a back face of the main body unit **10** to a front face. The air flow path **15** is parallel to a direction in which the above-described air guide portion **17** leads the jet air. In other words, a direction of the jet air flow discharged from the air discharge opening **16** becomes the same as a direction of flow of an external air which flows in the air flow path **15**. The external air is an air rolled from the circumference of the ion generator **1** by the flow of the jet air.

As illustrated in FIGS. **2**, **5** and **7**, an upper portion of the air supply chamber **13** is formed into a curved shape. As a result, an inlet **15**A on the rear face side of the air flow path **15** is spread toward behind. As a result, it is facilitated to take external air behind the ion generator **1** into the air flow path **15**.

On the other hand, as illustrated in FIG. **6**, a plurality of (four in FIG. **6**) discharge electrodes **21** is disposed in the discharge electrode unit **20** at intervals. The discharge electrode **21** is formed in a fine wire form or a needle form. The rectilinear discharge electrode **21** extends toward the blow-off opening **11** on this side in FIG. **6**. Opening portion **22** are formed on a top face of the discharge electrode unit **20** to correspond to respective discharge electrodes **21**. The respective discharge electrodes **21** is exposed from the top face of the discharge electrode unit **20** via the opening portion **22**.

As illustrated in FIGS. **1**, **3** and **6** to **9**, an opposite electrode **23** is provided on the front side of the discharge electrode unit **20**. The opposite electrode **23** is formed of metal having conductivity and formed into the shape of a plate. The opposite electrode **23** is disposed in a lengthwise direction of the discharge electrode unit **20**.

As illustrated in FIGS. **3**, **6**, **8** and **9**, the opposite electrode **23** is provided on a side lower than the discharge electrode **21** when viewed from the front side of the ion generator **1**. A notched portion **23**A is formed in a nearly half circle shape centered the discharge electrode **21** to correspond to the discharge electrode **21**. In other words, the discharge electrode **21** and the opposite electrode **23** are disposed via a gap **25** having a determinate length interposed therebetween.

As illustrated in FIG. **7**, an air supply path **24** is formed within the discharge electrode unit **20**. The jet air flows through the air supply path **24** which extends from the air discharge opening **16** toward the gap **25**.

As illustrated in FIG. **7**, a separation space **26** is provided in a state in which the discharge electrode unit **20** is attached to the main body unit **10**. The separation space **26** is a space extending from a front side tip portion of the air guide portion **17** to a back end portion of the air supply path **24**. The jet air flows fast from the air discharge opening **16** toward the air supply path **24**. The jet air flowing fast and the external air in the air flow path **15** are brought into contact with each other in the separation space **26** and the opening portion **22**.

Power is supplied from an external power supply to the ion generator **1** via a power supply cable **27** (see FIG. **1**). A high voltage is applied between the discharge electrode **21** and the opposite electrode **23**. As a result, corona discharge occurs and air ions are generated. As for an internal configuration for applying a high voltage, detailed description thereof will be omitted.

As illustrated in FIG. **7**, a potential sensor unit housing portion **18** is provided on a lower side within the main body unit **10**, i.e., under the air supply chamber **13** and the discharge electrode unit mounting portion **12**. The potential sensor unit housing portion **18** is provided over the left/right direction of the ion generator **1**. A detection window **18**A is provided in a front side wall of the potential sensor unit housing portion **18**. The detection window **18**A communicates with the potential sensor unit housing portion **18**. The potential sensor unit **40** is attached to the potential sensor unit housing portion **18**. The potential sensor unit **40** measures the potential of the charged member P disposed opposite to the blow-off opening **11**.

The potential sensor unit **40** includes a potential sensor **41** and a power supply unit (not illustrated) that supplies power to the potential sensor **41**. The potential sensor **41** and the power supply unit are attached within the potential sensor unit housing portion **18**.

As illustrated in FIG. **10**, the potential sensor **41** includes a printed circuit board **111** on which a detection electrode **114** (see FIG. **12**) and so forth are mounted, and an electrostatic shield plate **43** to which the printed circuit board **111** is attached. A lengthwise direction of the printed circuit board **111** extends in the left/right direction of the main body unit **10** in the ion generator **1**. By the way, as for the printed circuit board **111** illustrated in FIGS. **11** to **15**, a portion is illustrated, and other portions are omitted.

A rectangular shaped aperture window **113** is formed in the electrostatic shield plate **43**. As illustrated in FIG. **11**, the aperture window **113** is formed by notching the electrostatic shield plate **43**. All main slits **131** are exposed to the outside via the aperture window **113**, and all main slits **131** is visible from the outside. A position of the aperture window **113** coincides with a position of the detection window **18**A in the potential sensor unit housing portion **18**.

As illustrated in FIGS. **10** to **12**, a projecting electrostatic shield plate **43**A is provided continuously from the electrostatic shield plate **43**. The projecting electrostatic shield plate **43**A is provided over the whole length in the left/right direction of the electrostatic shield plate **43**. The projecting electrostatic shield plate **43**A is projected from the ion generator **1**. Details of the projecting electrostatic shield plate **43**A will be described later.

As illustrated in FIGS. **11** to **13**, the detection electrode **114** is attached to the printed circuit board **111**. A flange portion **114***a* of the detection electrode **114** is fixed to the printed circuit board **111**. In addition, a standing portion **114***b* extending from the flange portion **114***a* is nearly perpendicular to the printed circuit board **111**. An electrode portion **114***c* extends from the standing portion **114***b* in parallel with the printed circuit board **111**. The electrode portion **114***c* opposes to the aperture window **113**. The detection electrode **114** is one of elements included in a detection circuit (not illustrated). At least the electrode portion **114***c* included in the detection electrode **114** forms an electric field between a charged substance and the electrode portion **114***c*.

A fixed shutter **115** made of a conductive material is attached to the printed circuit board **111**. The fixed shutter **115** covers the detection electrode **114**. A main body portion **116** of the fixed shutter **115** is provided in parallel with the electrode portion **114***c* of the detection electrode **114**. The main body portion **116** is formed into a nearly rectangular shape. Side wall portions **117** and end wall portions **118** are bent from the main body portion **116** at right angles and are integral with the main body portion **116**. As illustrated in FIG. **12**, tip portions of the side wall portions **117** are inserted into mounting holes formed through the printed circuit board **111**, and the fixed shutter **115** is fixed to the printed circuit board **111**.

Aperture slits **119** are formed in the main body portion **116** of the fixed shutter **115**. The aperture slits **119** extend in the lengthwise direction (left/right direction) of the electrostatic shield plate **43**. Five aperture slits **119** are formed in a width direction (up-down direction) of the main body portion **116**. The aperture slits **119** are disposed at constant intervals.

As illustrated in FIGS. **12** to **15**, a movable shutter **121** is provided on the printed circuit board **111**. The movable shutter **121** is provided outside the fixed shutter **115** to cover the fixed shutter **115**. The movable shutter **121** moves between two positions: a full open position in which the slits **131** and slits **132** of the movable shutter **121** coincide with the aperture slits **119** of the fixed shutter **115**, and an interruption position in which the aperture slits **119** of the fixed shutter **115** are closed. A change of an aperture area of the shutters depending upon the full open position and the interruption position gives a change in an electric field formed between a charged substance and the detection electrode **114** (the electrode portion **114***c*).

A center line (not illustrated) of the aperture slits **119** in the lengthwise direction (left/right direction) is referred to as aperture slit center line. A center line (not illustrated) of the slits **131** and **132** in the lengthwise direction (left/right direction) is referred to as main slit center line. A position of the movable shutter **121** in which the aperture slit center line and the main slit center line coincide with each other is referred to as "full open position."

A center line in the lengthwise direction (left/right direction) of a shield portion (reference numeral is omitted) existing between two main slits **131** is referred to as main shield portion center line. A center line (not illustrated) in the lengthwise direction (left/right direction) of a shield portion (reference numeral is omitted) existing between a main slit **131** and a subsidiary slit **132** is referred to as subsidiary shield portion center line. A position of the movable shutter **121** in which the aperture slit center line coincides with the main shield portion center line or the subsidiary shield portion center line is referred to as "interruption position."

The movable shutter **121** is formed of a material having conductivity. The movable shutter **121** reciprocates in an open-close direction (up-down direction). The movable shutter **121** includes a fixed end portion **122** fixed to the printed circuit board **111**. Leg pieces **123** are integrally provided on both sides of the fixed end portion **122**. The leg pieces **123** are inserted into mounting holes formed in the printed circuit board **111**. The fixed end portion **122** of the movable shutter **121** is attached to the printed circuit board **111**.

An arm portion **124** is provided integrally in each of the leg pieces **123** in the fixed end portion **122**. The arm portion **124** extends to one end side (right side) in the lengthwise direction (left/right direction) of the printed circuit board **111**. As illustrated in FIG. **14**, two arm portions **124** are provided at a predetermined interval in the present embodiment. Each of the arm portions **124** is formed of a flexible plate shaped member. A main body portion **125** is provided integrally on tips of the arm portions **124**. As illustrated in FIGS. **12** and **13**, the main body portion **116** of the fixed shutter **115** is disposed outside the detection electrode **114**. The main body portion **116** covers the detection electrode **114**. The main body portion **125** of the movable shutter **121** is disposed outside the fixed shutter **115**. In addition, the main body portion **125** is exposed to the outside via the aperture window **113**. The main body portion **125** of the movable shutter **121** reciprocates in an open-close direction indicated by an arrow N, and opens and closes the aperture slits **119**.

At least the main body portion **116** of the fixed shutter **115** is grounded. And at least the main body portion **125** of the movable shutter **121** is also grounded.

As illustrated in FIGS. **13** and **14**, a magnet **127** functioning as a magnetic substance is attached to an end wall **126** provided integrally in the main body portion **125**. The magnet **127** has a function of driving the movable shutter **121** to open and close. As indicated by solid lines and dashed lines in FIG. **14**, a U-shaped yoke **128** is attached to one end side (right side) of the printed circuit board **111**. One pair of coils **129***a* and **129***b* is wound round the yoke **128** via bobbins **281**. The coils **129***a* and **129***b* are connected to a power supply unit, which is not illustrated. An alternating current is flown through each of the coils **129***a* and **129***b*. As a result, magnetic fields that are inverse in direction to each other are formed on two magnetic pole surfaces **128***a* and **128***b*. Therefore, the magnet **127** moves between a position opposed to one magnetic pole surface **128***a* and a position opposed to the other magnetic pole surface **128***b*. In this way, a drive means that drives the movable shutter **121** in the reciprocation direction N to open and close is formed by the coils **129***a* and **129***b* wound round the yoke **128** and the magnet **127**.

Five main slits **131** are formed in the main body portion **125** in the movable shutter **121**. The five main slits **131** correspond to the five aperture slits **119** formed in the fixed shutter **115**. The respective main slits **131** extend in the same direction as that of the aperture slits **119**. Adjacent main slits **131** are disposed at a constant interval. The interval is the same as that of the aperture slits **119**.

The movable shutter **121** conducts reciprocal vibration, and moves between the full open position and the interruption position.

FIG. **12** illustrates a state in which the movable shutter **121** is in a neutral position. At this time, all of the five main slits **131** are opposed to the aperture slits **119**. One subsidiary slit **132** is formed on each of outsides of main slits **131** located on both ends of the reciprocation direction N (up-down direction). Each subsidiary slit **132** takes the same shape as that of the main slit **131**. Intervals between the five main slits **131** are the same as intervals between the main slits **131** and the subsidiary slits **132**. The five main slits **131** and the two subsidiary slits **132** take the same shape. These seven slits **131** and **132** formed on the movable shutter **121** take the same shape as that of the aperture slits **119** formed on the fixed shutter **115**. When the movable shutter **121** reciprocates, therefore, the aperture slits **119** are opened and closed by the subsidiary slits **132**.

In this way, one subsidiary slit **132** is formed on the outside of the two main slits **131** located at both ends of the reciprocation direction N, i.e., in an extension direction of the reciprocation direction N. During one period of movement of the movable shutter **121**, the movable shutter **121** moves from the neutral position illustrated in FIG. **12** to a reciprocation end in a left direction in FIG. **12**, then the movable shutter **121** moves to a position of a reciprocation end in a right direction, and returns to the neutral position. During the one period, the five aperture slits **119** on the fixed shutter **115** are opened and closed four times. In other words, the aperture slits **119** are opened and closed with a frequency that is four times the drive frequency of the movable shutter **121**.

A current detection circuit is connected to the detection electrode **114**. In a state in which the detection electrode **114** is opposed to a charged substance via the aperture window **113**, an alternating current in the range of, for example, 600 to 800 Hz is applied to the coils **129***a* and **129***b* to cause the movable shutter **121** to conduct reciprocal vibration. As a result, the aperture slits **119** on the fixed shutter **115** are opened and closed with a frequency that is four times the drive frequency of the movable shutter **121**. With this open/close frequency, an electric field between the detection electrode **114** and the charged substance changes, and an alternating voltage is generated in the detection electrode **114**.

The projecting electrostatic shield plate **43**A provided on the electrostatic shield plate **43** will now be described. In the ion generator **1** with the potential sensor **41** integrally mounted thereon, charge elimination is conducted by blowing generated air ions against the charged member P (see FIG. **7**). At the same time, the potential sensor **41** measures surface potential of the charged member P. In other words, since the ion generator **1** and the potential sensor **41** are provided in the same casing, it is more convenient to use as compared with the case where the ion generator **1** and the potential sensor **41** are provided separately.

It is necessary to dispose both the blow-off opening **11** of air ions and the potential sensor **41** to be opposed to the charged member P. Therefore, the discharge unit (the discharge electrodes **21** and the opposite electrodes **23**) and the aperture window **113** of the potential sensor **41** are provided on the same plane of the main body unit **10**. As a result, not only an electric field from the charged member P but also an electric field between the discharge electrode **21** and the opposite electrode **23**, i.e., a discharge electric field reaches the potential sensor **41**. The discharge electric field becomes noise. In the present embodiment, the blow-off opening **11** and the aperture window **113** of the potential sensor **41** are provided on the same plane of the main body unit **10**. In addition, the projecting electrostatic shield plate **43**A is projected and provided between the blow-off opening **11** and the aperture window **113** to conduct electrostatic shielding between the discharge unit and the potential sensor **41**.

A length **S1** of the forward projection of the projecting electrostatic shield plate **43**A influences a noise voltage and a signal voltage of the potential sensor **41**. Graphs in FIG. **17** represent a ratio of a noise voltage Vn to Vn**0** (Vn/Vn**0**) and a projection length S**1** of the projecting electrostatic shield plate **43**A, where Vn**0** is the noise voltage in a case where the projection length S**1** of the projecting electrostatic shield plate **43**A is 0 mm. A distance S**2** (2, 4, 6 and 10 mm) between the projecting electrostatic shield plate **43**A and the aperture window **113** is set to be a parameter. The ratio Vn/Vn**0** does not largely depend upon the distance S**2** between the projecting electrostatic shield plate **43**A and the aperture window **113**. The ratio Vn/Vn**0** decreases, the longer the projection length S**1** of the projecting electrostatic shield plate **43**A is made. For example, in a case where the projection length S**1** of the projecting electrostatic shield plate **43**A is set equal to 8 or 10 mm, Vn/Vn**0** decreases to 35% or 50%.

Graphs in FIG. **18** represent a ratio of a sensor signal voltage Vs to Vs**0** (Vs/Vs**0**) and a function of the projection length S**1** of the projecting electrostatic shield plate **43**A, where Vs**0** is the signal voltage in a case where the projection length S**1** of the projecting electrostatic shield plate **43**A is 0 mm. A distance S**2** (2, 4, 6 and 10 mm) between the projecting electrostatic shield plate **43**A and the aperture window **113** is set to be a parameter. In a case where the distance S**2** between the projecting electrostatic shield plate **43**A and the aperture window **113** is as short as 2 mm, the signal decreases by approximately 20% as compared with a case where the distance is 10 mm.

The length of the projecting electrostatic shield plate **43**A in the left/right direction is made long enough to be also effective to a plurality of discharge electrodes **21** disposed at intervals along the lengthwise direction of the blow-off opening **11**. Relations between the length of the projecting electrostatic shield plate **43**A and the distance S**2** between the projecting electrostatic shield plate **43**A and the aperture window **113** will be described hereafter. When the projection length of the projecting electrostatic shield plate **43**A is prolonged gradually from 0 mm to 10 mm, attenuation of the sensor signal is in the range of 0% to at most approximately 20% (the distance S2=2 mm). Whereas attenuation of the noise voltage is in the range of 30% (the distance S2=10 mm) to 50% (the distance S2=2 mm). In other words, the sensor signal attenuates little whereas the attenuation of the noise voltage is large. Especially in a case where the projecting electrostatic shield plate **43**A and the aperture window **113** are made close to each other so as to have the distance S2 that is approximately 2 mm and the projection length of the projecting electrostatic shield plate **43**A is set equal to 10 mm, attenuation of the sensor signal is approximately 20%. On the other hand, attenuation of the noise voltage is approximately 50%. Therefore, the signal to noise ratio is improved by 0.8÷0.5=1.6, i.e., 60%.

In the ion generator according to the embodiment of the present invention, the potential sensor **41**, which measures the potential of the charged member P, is provided integrally in the main body unit **10**. In addition, the projecting electrostatic shield plate **43**A projecting from the main body unit **10** is provided between the discharge unit formed of the discharge electrodes **21** and the opposite electrodes **23**, and the potential sensor **41**. Therefore, the electric field between the discharge electrode **21** and the opposite electrode **23** is electrostatically shielded by the projecting electrostatic shield plate **43**A. Accordingly, the electric field is hard to reach the potential sensor **41**. As a result, superposition of noise caused by the electric field between the discharge electrode **21** and the opposite electrode **23** on a value measured by the potential sensor **41** is suppressed. Therefore, the voltage of the charged member P is measured accurately.

The discharge unit formed of the discharge electrodes **21** and the opposite electrodes **23**, and the aperture window **113** of the potential sensor **41** are disposed on the same plane. As a result, a depth dimension L (see FIG. **7**) of the ion generator **1** can be made small. Accordingly, it becomes possible to design an ion generator **1** having a smaller size.

The projection length S**1** of the projecting electrostatic shield plate **43**A is set in the range of 8 to 10 mm from the aperture window **113** of the potential sensor **41**. As compared with the case where the projecting electrostatic shield plate **43**A is not provided, therefore, it is possible to decrease the ratio of the noise voltage Vn to Vn**0** represented by Vn/Vn**0** to a range of 35 to 50%. In addition, the distance S**2** from the projecting electrostatic shield plate **43**A to the aperture window **113** is set equal to or less than 2 mm. As a result, it is possible to suppress the decrease in the ratio of the signal voltage Vs to Vs**0** represented by Vs/Vs**0** to approximately 20%.

In addition, the blow-off opening **11** is formed to be long. And a plurality of discharge electrodes **21** is disposed at intervals along the lengthwise direction of the blow-off opening **11**. In such a configuration, the projecting electrostatic shield plate **43**A is made to intervene between all of the discharge electrodes **21** and the aperture window **113**. As a result, it is possible to suppress noise generation effectively.

Heretofore, the ion generator according to the embodiment of the present invention has been described. However, the present invention is not restricted to the embodiment described above, but various modifications and changes can be made on the basis of the technical thought of the present invention.

For example, in the present embodiment, the ion generator **1** having a plurality of discharge electrodes **21** along the lengthwise direction has been described. However, the present invention can also be applied to an ion generator having one discharge electrode **21** (an ion generator that blows off air ions in a spot way).

REFERENCE SIGNS LIST

1 Ion generator
10 Main body unit
11 Blow-off opening
12 Discharge electrode unit mounting portion
13 Air supply chamber
13A Air supply port
13B Tube
14 Top face cover
15 Air flow path
16 Air discharge opening
17 Air guide portion
18 Potential sensor unit housing portion
18A Detection window
20 Discharge electrode unit
21 Discharge electrode
22 Opening portion
23 Opposite electrode
24 Air supply path
25 Gap
26 Separation space
27 Power supply cable
40 Potential sensor unit

41 Potential sensor
43 Electrostatic shield plate
43A Projecting electrostatic shield plate
111 Printed circuit board
113 Aperture window
114 Detection electrode
114*a* Flange portion
114*b* Standing portion
114*c* Electrode portion
115 Fixed shutter
116 Main body portion
117 Side wall portion
118 End wall portion
119 Aperture slit
121 Movable shutter
122 Fixed end portion
123 Leg piece
124 Arm portion
125 Main body portion
126 End wall
127 Magnet
128 Yoke
128*a* Magnetic pole surface
128*b* Magnetic pole surface
129*a* Coil
131 Slit
131 Main slit
132 Subsidiary slit
281 Bobbin
S**1** Projection length of projecting electrostatic shield plate
S**2** Distance from projecting electrostatic shield plate to aperture window
Vn Noise voltage
Vn**0** Noise voltage in case where projecting electrostatic shield plate is not provided
Vs Signal voltage
Vs**0** Signal voltage in case where projecting electrostatic shield plate is not provided
L Depth dimension
N Reciprocation direction
P Charged member

The invention claimed is:

1. An ion generator that blows air ions generated by applying a high voltage to a discharge unit including discharge electrodes and counter electrodes, toward a charged member, the ion generator comprising:

a main body comprising:

a potential sensor housing portion;

a potential sensor accommodated in the potential sensor housing portion and structured to measure potential of the charged member;

a detection window communicating with the potential sensor housing portion; and

a blow-off opening to blow-off the air ions; and

a projecting electrostatic shield plate disposed between the discharge unit and the potential sensor to project from the main body unit;

wherein the discharge unit is attached to the main body.

2. The ion generator according to claim **1**, wherein a projection length of the projecting electrostatic shield plate is in a range of 8 to 10 mm.

3. The ion generator according to claim **1**, wherein

an aperture window communicating with the detection window is formed in the potential sensor to take in an electric field from the charged member.

4. The ion generator according to claim **3**, wherein

a plurality of the discharge electrodes is disposed at intervals along the blow-off opening, and

the projecting electrostatic shield plate intervenes between any of the discharge electrodes and the aperture window.

5. The ion generator according to claim **4**, wherein the blow-off opening and the aperture window are disposed on same plane in the main body.

6. The ion generator according to claim **3**, wherein a distance from the projecting electrostatic shield plate to the aperture window in the potential sensor is 2 mm or less.

7. The ion generator according to claim **1**, wherein the blow-off opening and the potential sensor are disposed to be opposed to the charged member.

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