US00RE48587E

(19) **United States**

(12) **Reissued Patent**

Gu

(10) **Patent Number: US RE48,587 E**

(45) **Date of Reissued Patent: Jun. 8, 2021**

---

(54) **ULTRASONIC PROBE APPARATUS AND ULTRASONIC IMAGING APPARATUS USING THE SAME**

(71) Applicant: **SAMSUNG MEDISON CO., LTD.**, Gangwon-do (KR)

(72) Inventor: **Jin Ho Gu**, Seongnam-si (KR)

(73) Assignee: **SAMSUNG MEDISON CO., LTD.**, Gangwon-do (KR)

(21) Appl. No.: **16/528,968**

(22) Filed: **Aug. 1, 2019**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **9,746,448**
Issued: **Aug. 29, 2017**
Appl. No.: **14/684,019**
Filed: **Apr. 10, 2015**

(30) **Foreign Application Priority Data**

Dec. 26, 2014 (KR) 10-2014-0190566

(51) **Int. Cl.**
G01N 29/24 (2006.01)
G01N 29/28 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01N 29/28*** (2013.01); ***B06B 1/0622*** (2013.01); ***G01N 29/24*** (2013.01); ***G10K 11/002*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 8/44; A61B 8/4444; A61B 8/546; A61B 8/4494; G01N 29/28; G01N 29/34;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,424,465 A * 1/1984 Ohigashi B06B 1/0622 310/335
4,917,097 A * 4/1990 Proudian A61B 8/12 600/463
(Continued)

OTHER PUBLICATIONS

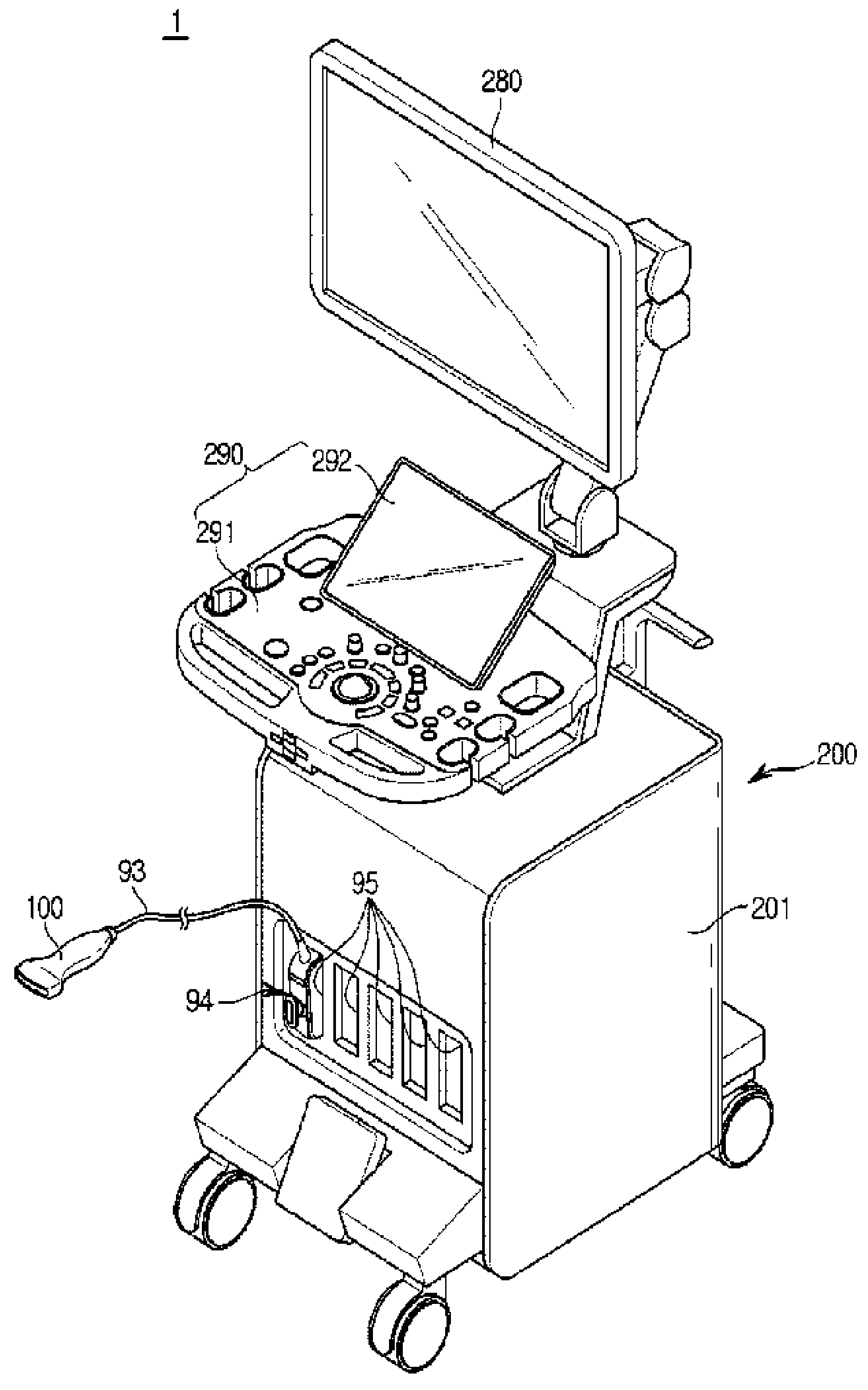
European Communication dated Jan. 27, 2020 issued in European Patent Application No. 15174040.4.
(Continued)

Primary Examiner — Robert L Nasser
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An ultrasonic probe apparatus and an ultrasonic imaging apparatus are disclosed. The ultrasonic probe apparatus includes: an ultrasonic transducer configured to output an electrical signal upon receiving ultrasonic waves; a sound absorption unit, one surface of which is an installation surface of the ultrasonic transducer and is electrically connected to the ultrasonic transducer; a first electronic circuit electrically connected to the sound absorption unit; and a substrate connection unit disposed between the sound absorption unit and the first electronic circuit, configured to electrically interconnect the first electronic circuit and the sound absorption unit. The ultrasonic imaging apparatus includes the above ultrasonic probe and a main body.

34 Claims, 41 Drawing Sheets



(51) **Int. Cl.**
B06B 1/06 (2006.01)
G10K 11/00 (2006.01)
A61B 8/00 (2006.01)

(52) **U.S. Cl.**
CPC *A61B 8/4444* (2013.01); *A61B 8/4494* (2013.01); *G01N 2291/0289* (2013.01); *G01N 2291/269* (2013.01)

(58) **Field of Classification Search**
CPC G01N 2291/0289; G01N 2291/269; G01N 29/2437; B06B 1/0622; B06B 1/0633; G01K 11/002; G01K 11/004
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,625,854	B1	9/2003	Sudol et al.	
2004/0100163	A1	5/2004	Baumgartner et al.	
2005/0146247	A1*	7/2005	Fisher	G01N 29/2406 310/334
2006/0150380	A1	7/2006	Ossmann	
2006/0184035	A1*	8/2006	Kimura	A61B 8/12 600/466
2006/0232164	A1*	10/2006	Kondo	G10K 11/02 310/322
2008/0134793	A1	6/2008	Woychik et al.	
2008/0139945	A1*	6/2008	Hu	A61B 8/00 600/459
2008/0183078	A1*	7/2008	Haider	A61B 1/0005 600/443
2008/0200812	A1	8/2008	Osawa	
2008/0238262	A1*	10/2008	Takeuchi	B06B 1/0622 310/346
2008/0242989	A1*	10/2008	Koide	A61B 8/0833 600/443
2009/0030325	A1*	1/2009	Hyuga	A61B 1/05 600/459
2009/0034370	A1*	2/2009	Guo	B06B 1/0622 367/180
2009/0062656	A1*	3/2009	Hyuga	A61B 8/4488 600/459
2010/0013358	A1*	1/2010	Nakayama	B06B 1/0633 310/348
2010/0324425	A1*	12/2010	Kim	G10K 11/004 600/459
2011/0074244	A1*	3/2011	Osawa	A61B 8/00 310/318
2011/0114303	A1*	5/2011	Rhim	A61B 8/00 165/185
2011/0257532	A1*	10/2011	Sasaki	G01S 7/521 600/459
2011/0295124	A1	12/2011	Shikata et al.	
2013/0145611	A1	6/2013	Guo	
2013/0286593	A1*	10/2013	Cho	G01N 29/326 361/707
2013/0301395	A1*	11/2013	Hebrard	G01S 7/52079 367/189
2013/0315035	A1*	11/2013	Tai	B06B 1/0622 367/140
2014/0033822	A1*	2/2014	Yoon	G01H 9/00 73/643
2014/0249419	A1*	9/2014	Morita	A61B 8/4444 600/459
2014/0323865	A1*	10/2014	Hoppmann	A61B 8/14 600/443
2015/0099960	A1*	4/2015	Ryu	A61B 8/4483 600/407
2015/0157292	A1*	6/2015	Gu	A61B 8/4444 600/459
2015/0164473	A1*	6/2015	Kim	G01S 15/8997 600/443
2015/0265244	A1*	9/2015	Park	A61B 8/12 600/462
2015/0320393	A1*	11/2015	Kim	A61B 8/546 600/459
2016/0007964	A1*	1/2016	Ona	G01S 15/8927 600/459
2016/0066885	A1*	3/2016	Jin	A61B 8/4444 600/459
2016/0143618	A1*	5/2016	Park	G01N 29/226 600/459
2016/0228088	A1*	8/2016	Okuno	H04R 1/06
2016/0282455	A1*	9/2016	Scarsella	G01S 7/5208

OTHER PUBLICATIONS

Chinese Office Action dated Mar. 10, 2020 issued in Chinese Patent Application No. 201510706654.0 (with English translation).

Extended European Search Report issued in European Application No. 15174040.4 dated Jul. 4, 2016.

* cited by examiner

FIG. 1

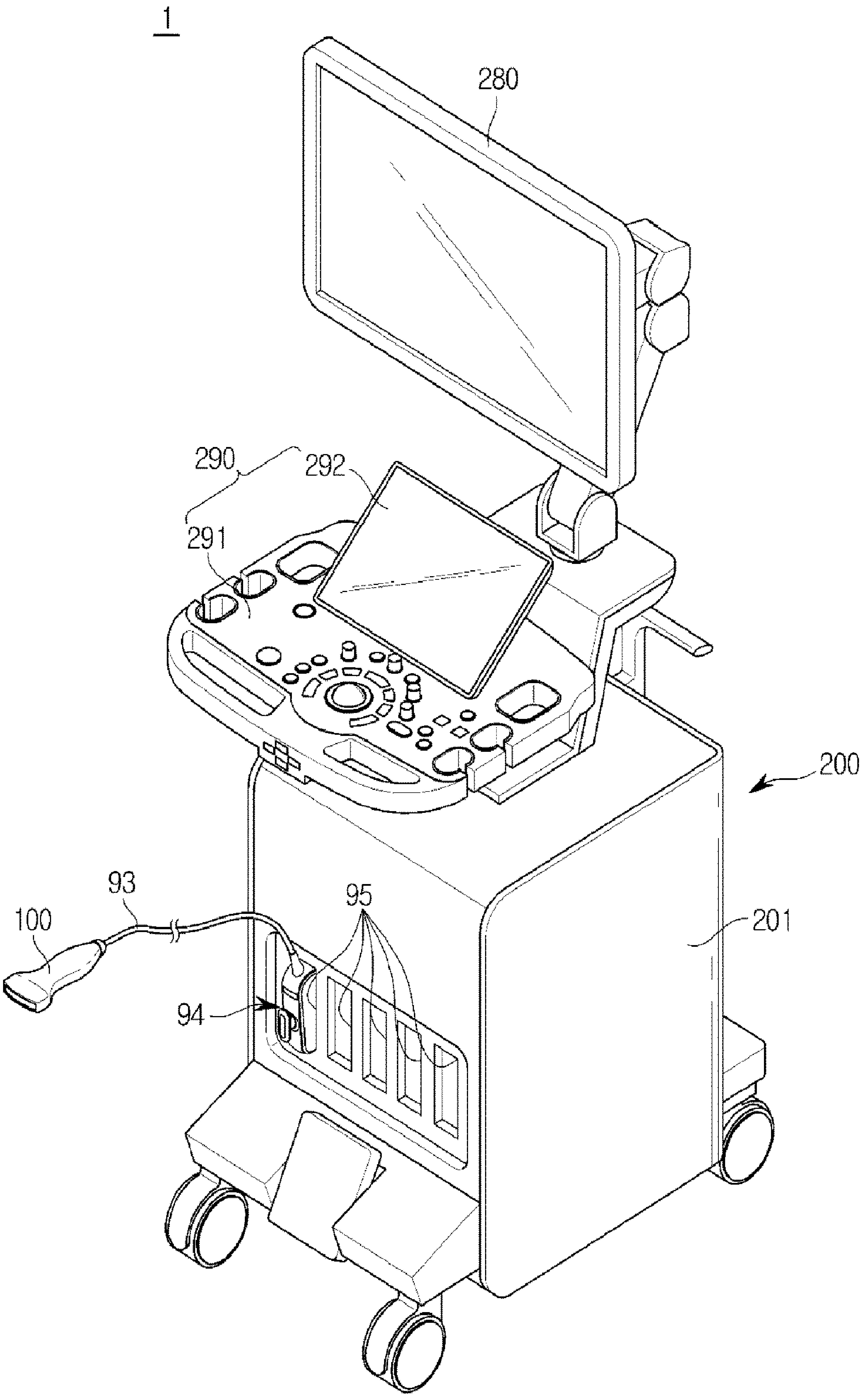


FIG. 2A

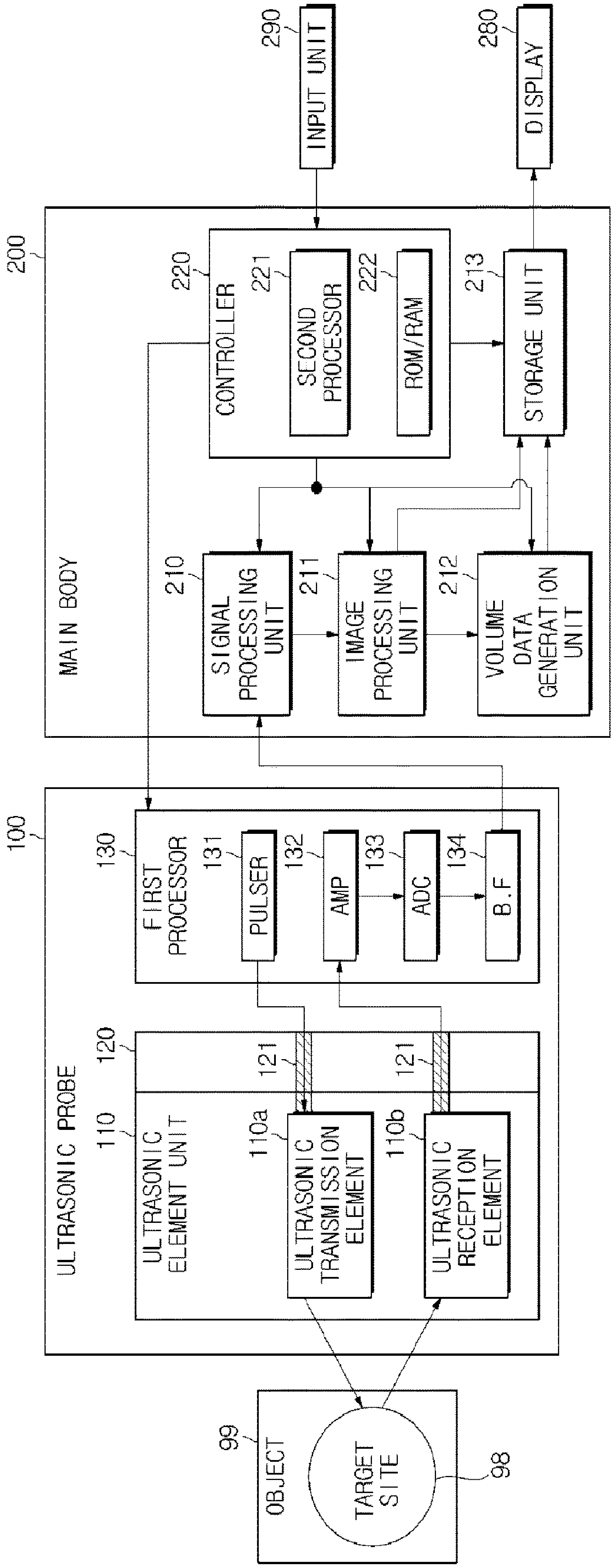

OBJECT
99
TARGET SITE
98
ULTRASONIC PROBE
100
ULTRASONIC ELEMENT UNIT
110
ULTRASONIC TRANSMISSION ELEMENT
110a
ULTRASONIC RECEPTION ELEMENT
110b
120
121
121
FIRST PROCESSOR
130
PULSER
131
AMP
132
ADC
133
B.F
134
MAIN BODY
200
SIGNAL PROCESSING UNIT
210
IMAGE PROCESSING UNIT
211
VOLUME DATA GENERATION UNIT
212
STORAGE UNIT
213
CONTROLLER
220
SECOND PROCESSOR
221
ROM/RAM
222
INPUT UNIT
290
DISPLAY
280

FIG. 2B

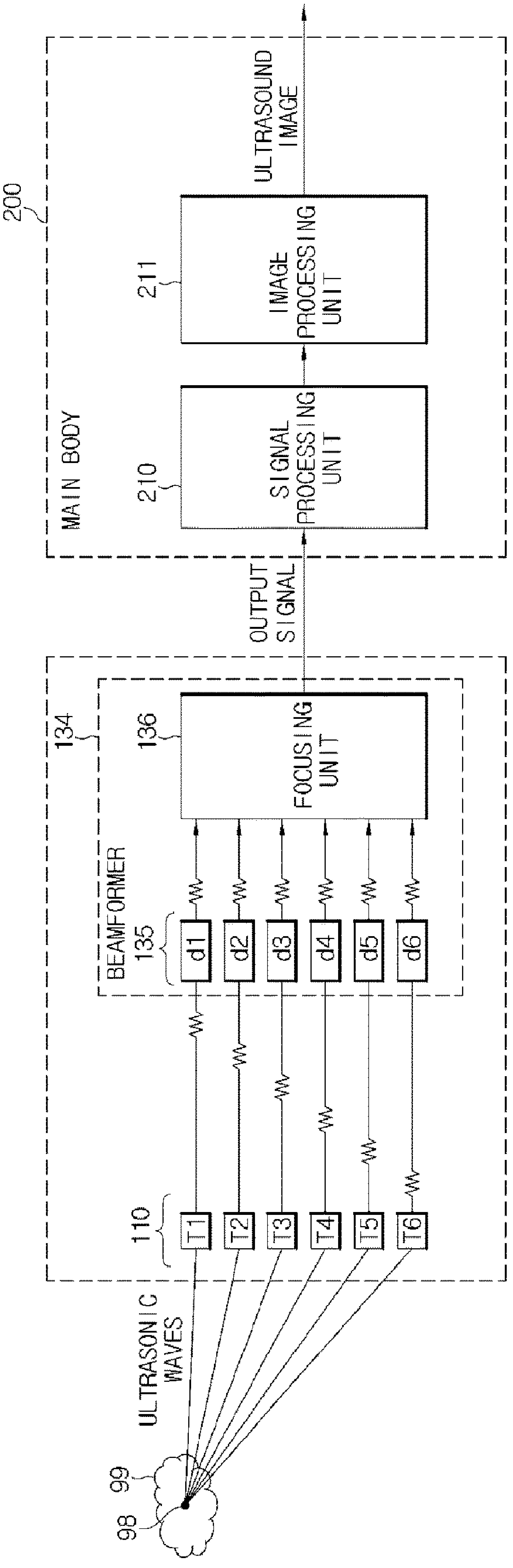

98
99
ULTRASONIC WAVES
110
T1
T2
T3
T4
T5
T6
134
BEAMFORMER
135
d1
d2
d3
d4
d5
d6
136
FOCUSING UNIT
OUTPUT SIGNAL
200
MAIN BODY
210
SIGNAL PROCESSING UNIT
211
IMAGE PROCESSING UNIT
ULTRASOUND IMAGE

FIG. 3

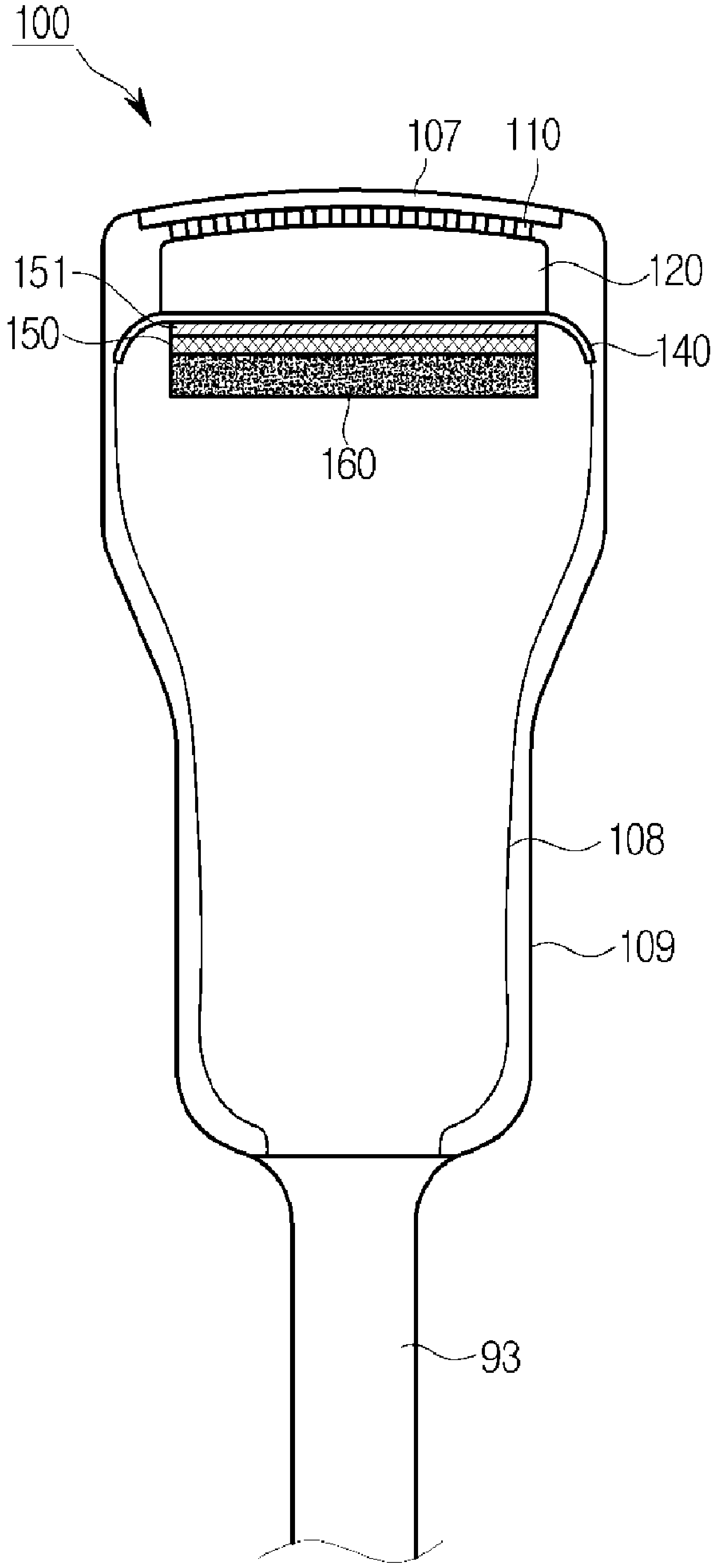


FIG. 4

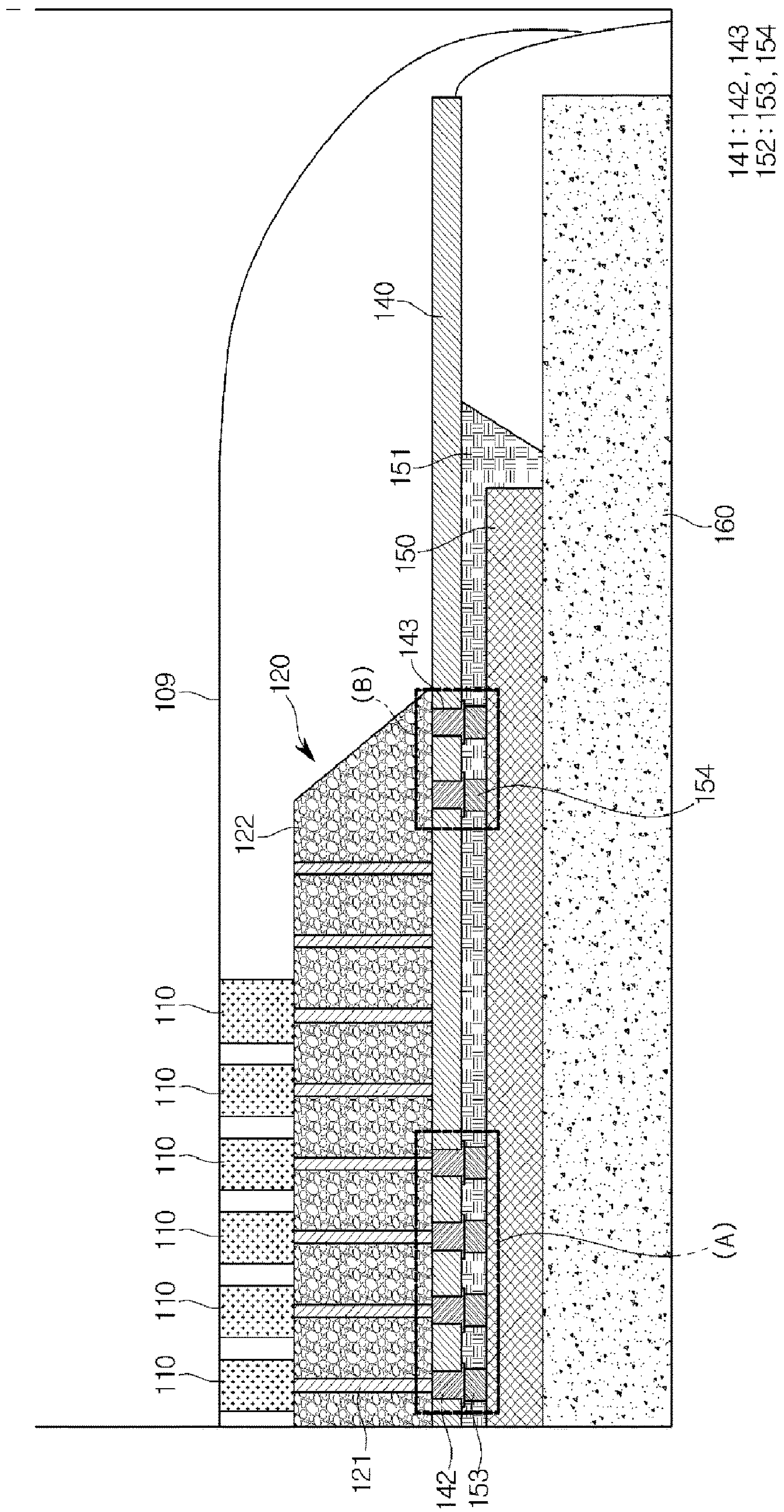

109
120
122
110
110
110
110
110
110
121
142
153
(B)
143
140
151
150
160
154
(A)
141 : 142, 143
152 : 153, 154

FIG. 5A

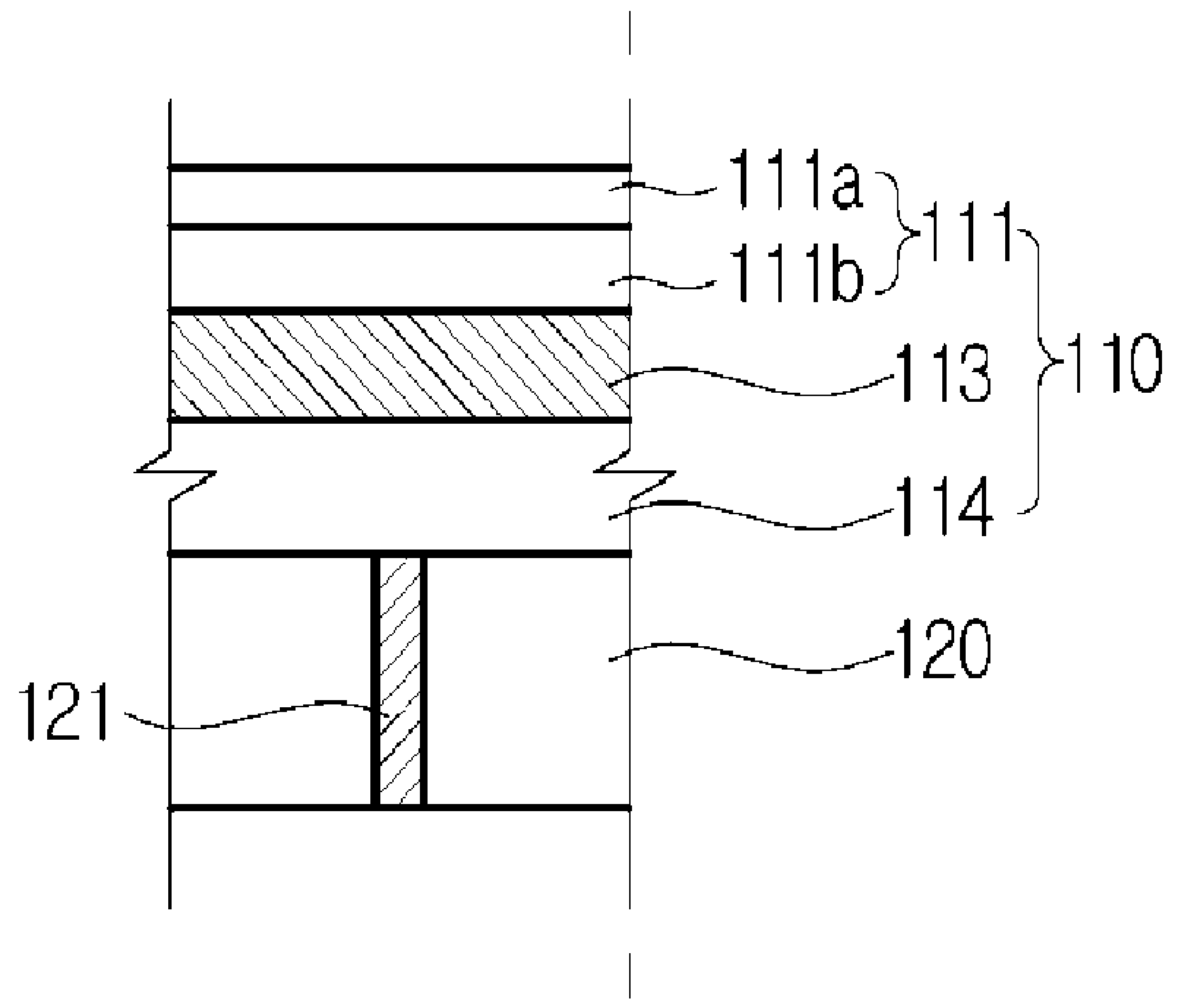


FIG. 5B

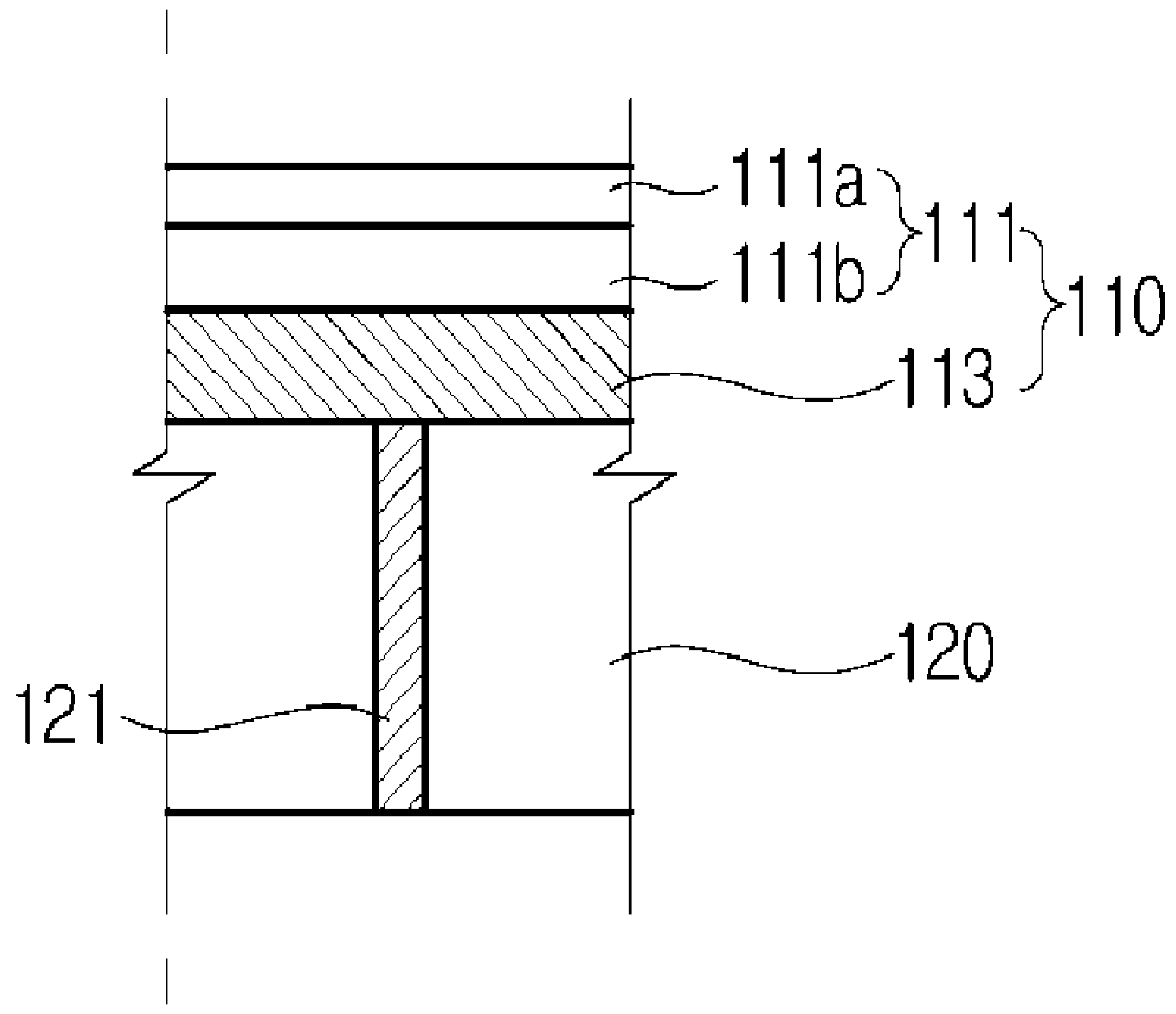


FIG. 6

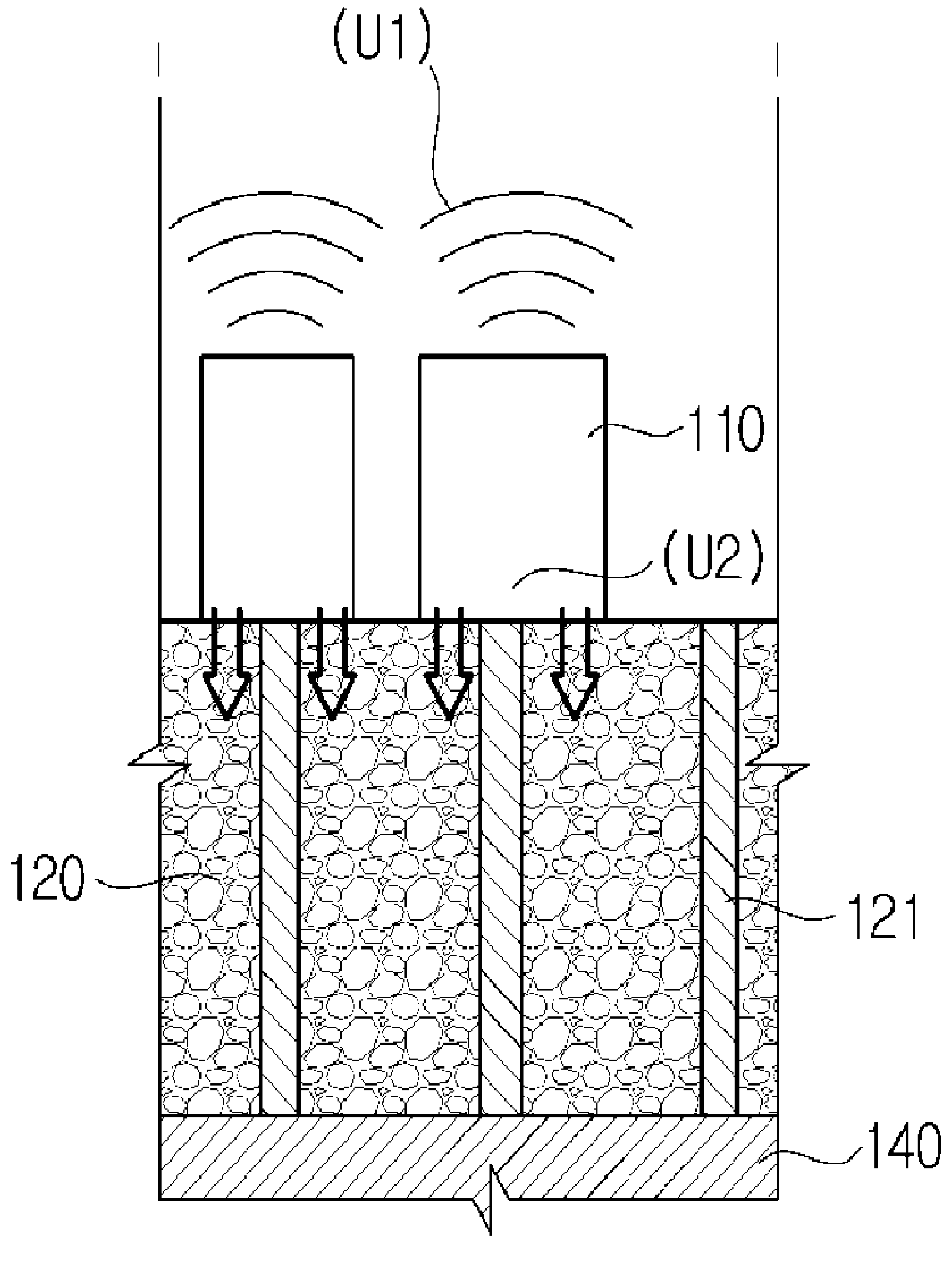


FIG. 7

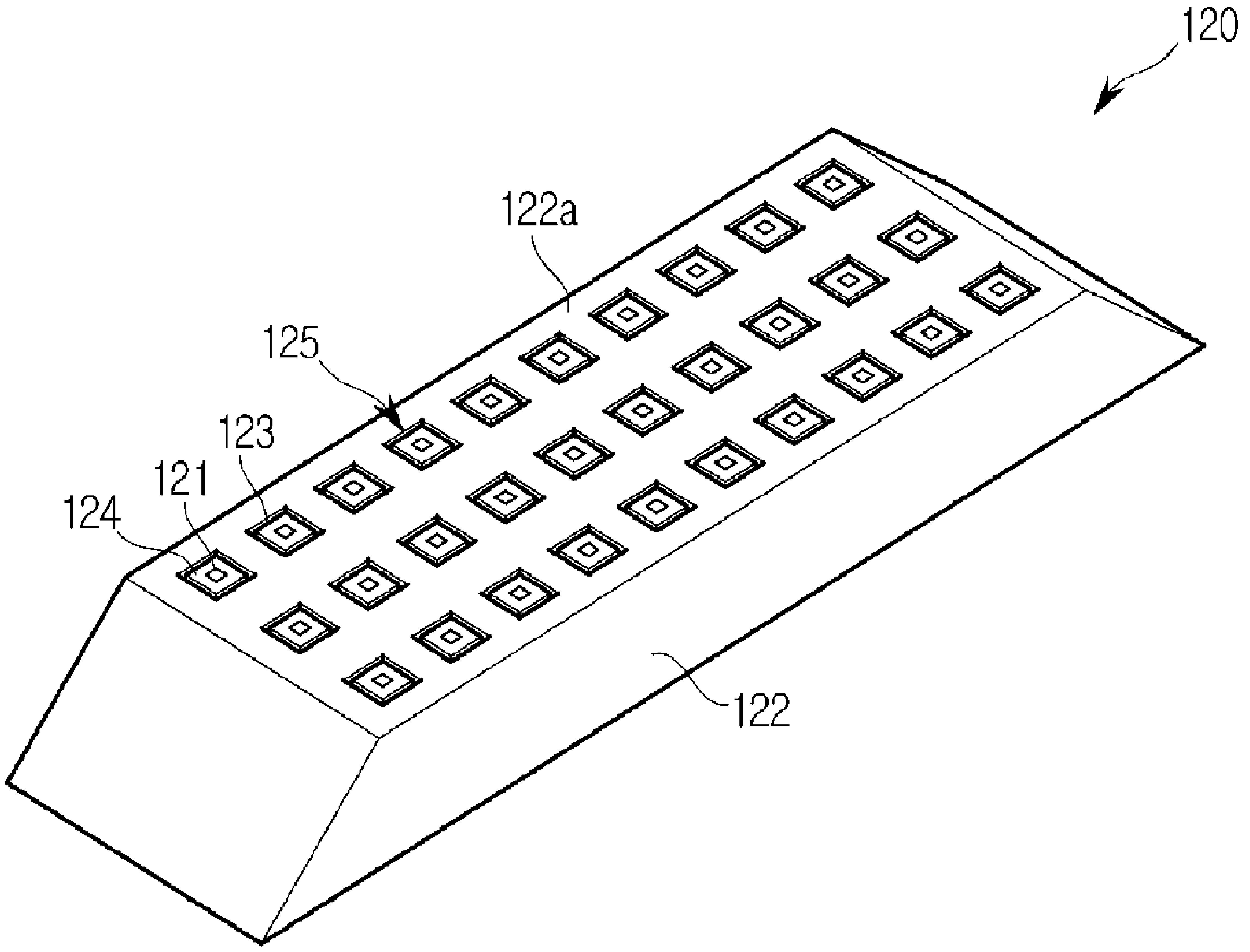


FIG. 8

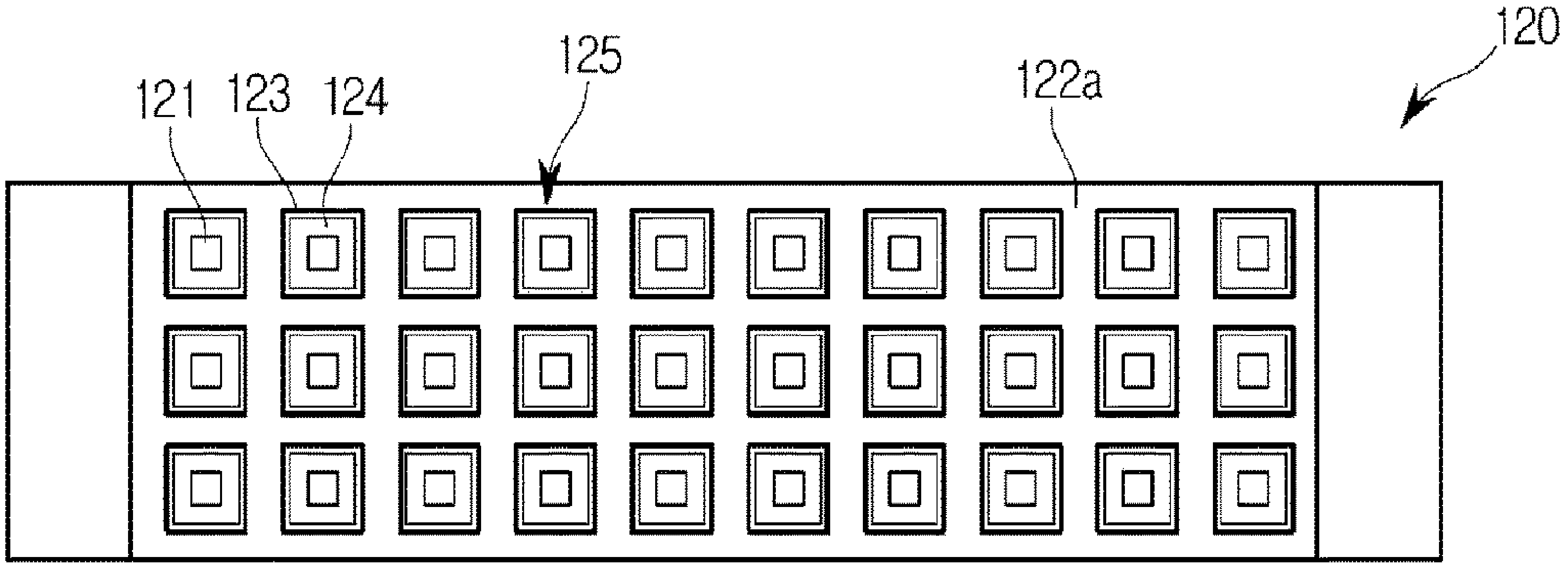


FIG. 9

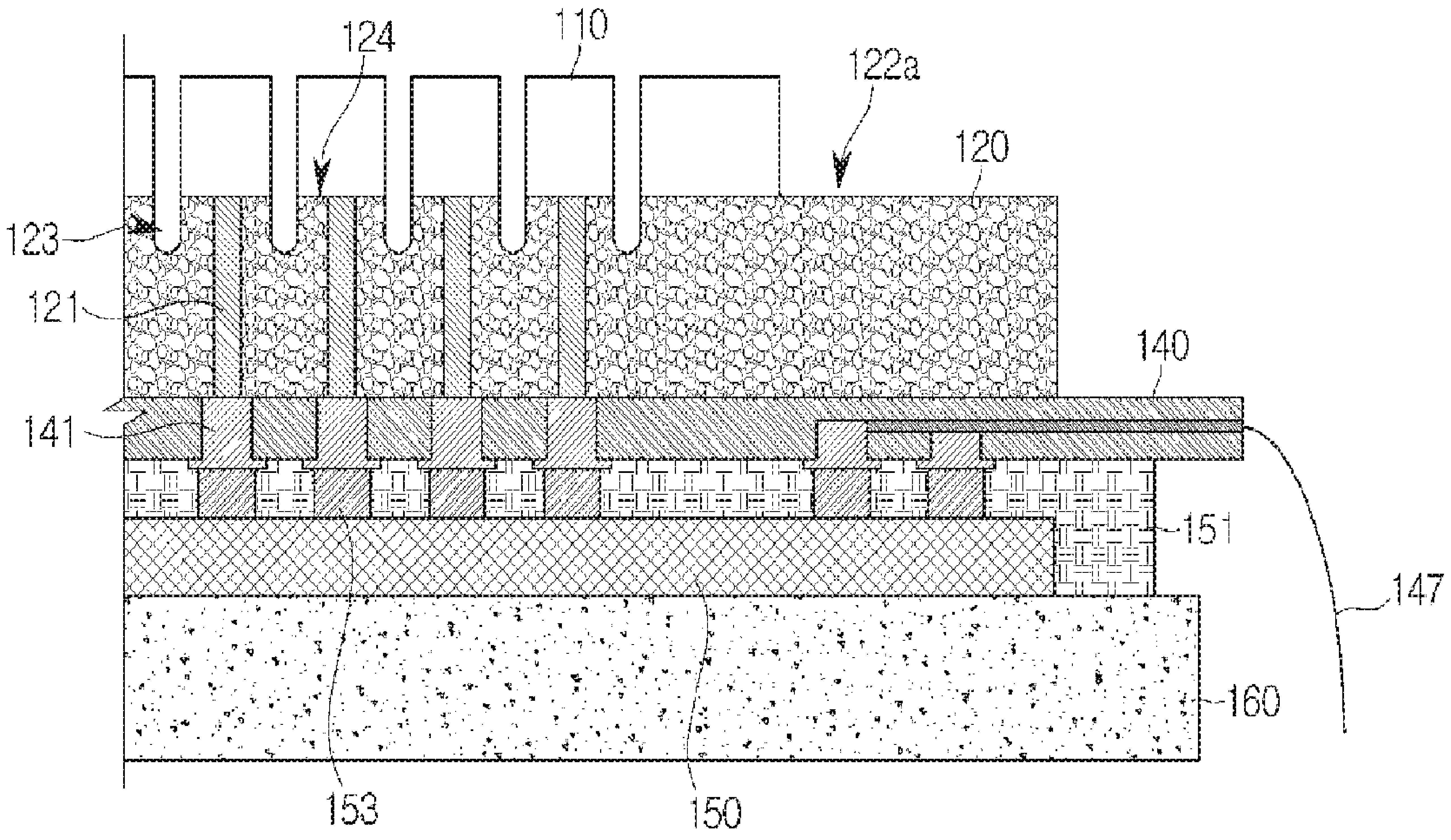


FIG. 10

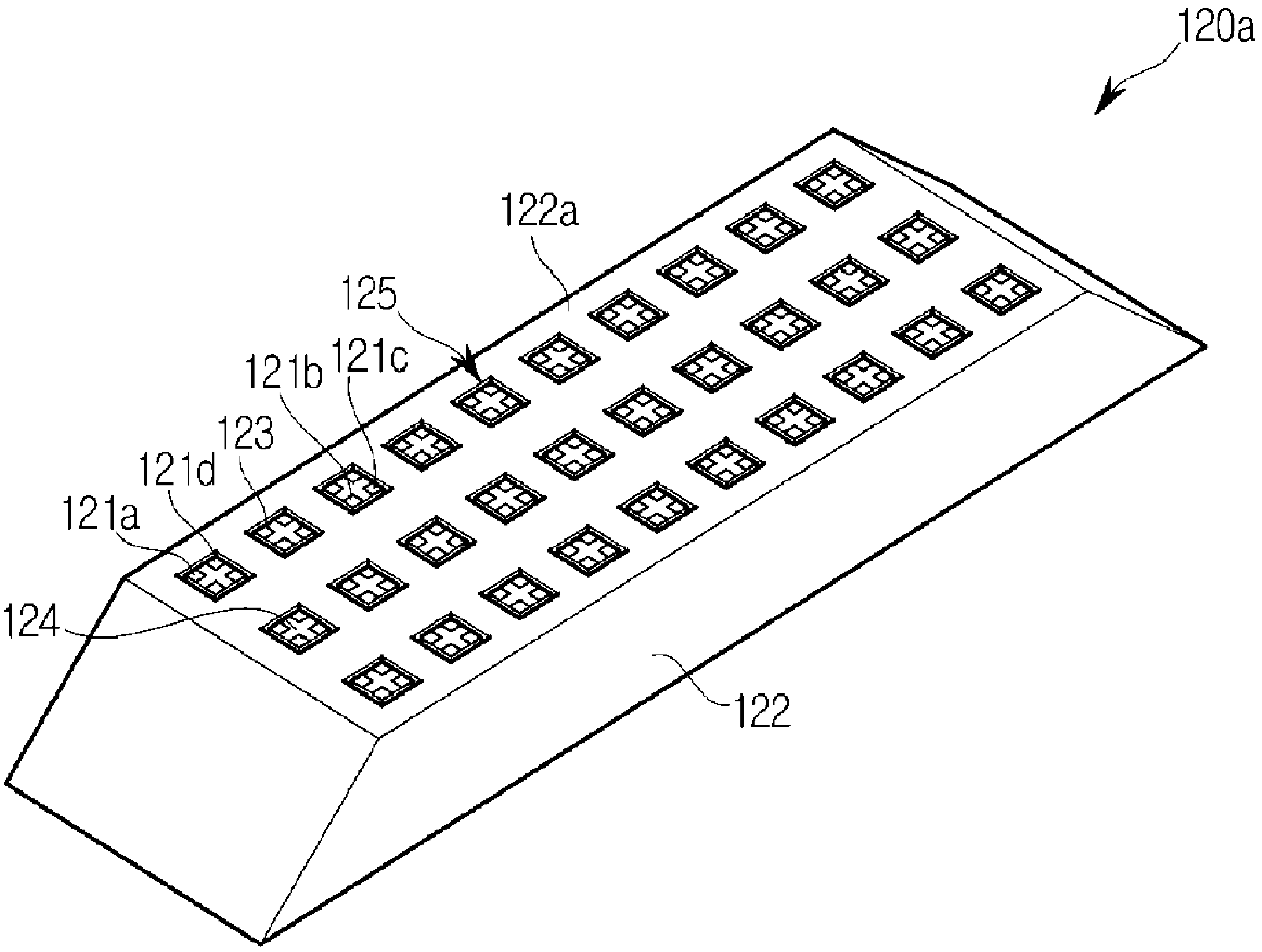


FIG. 11

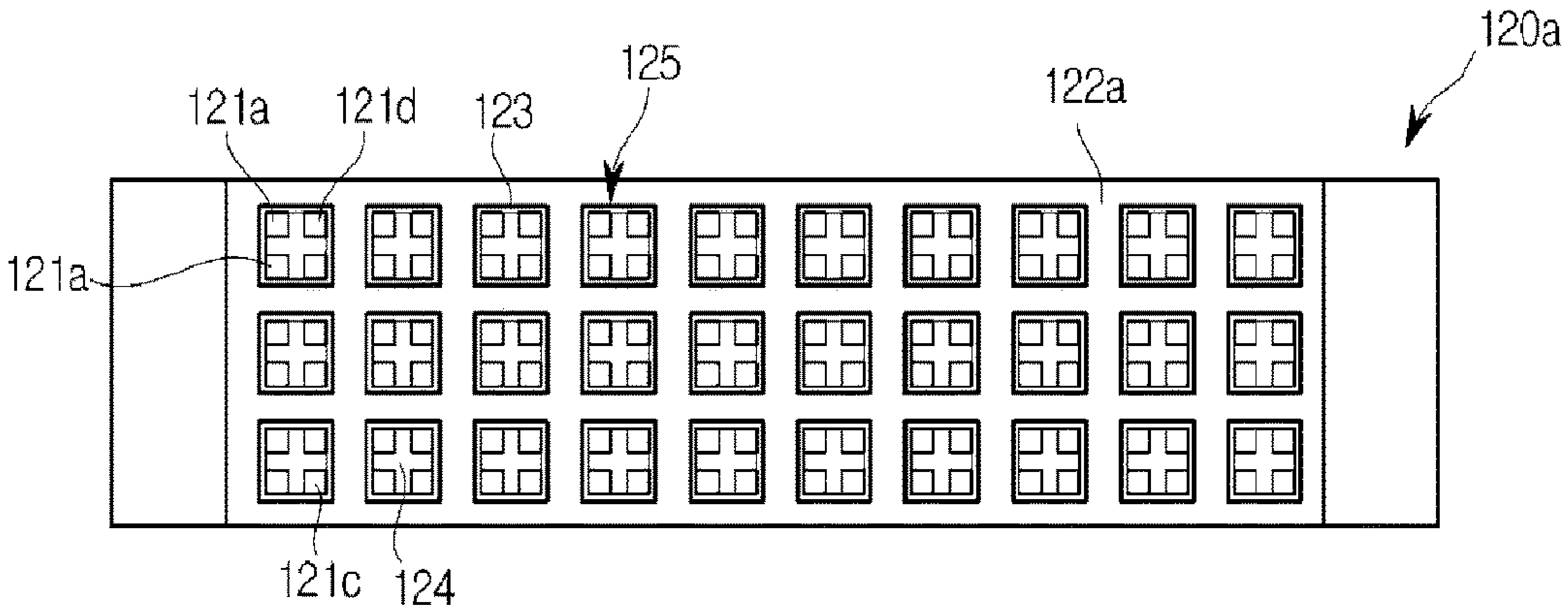


FIG. 12

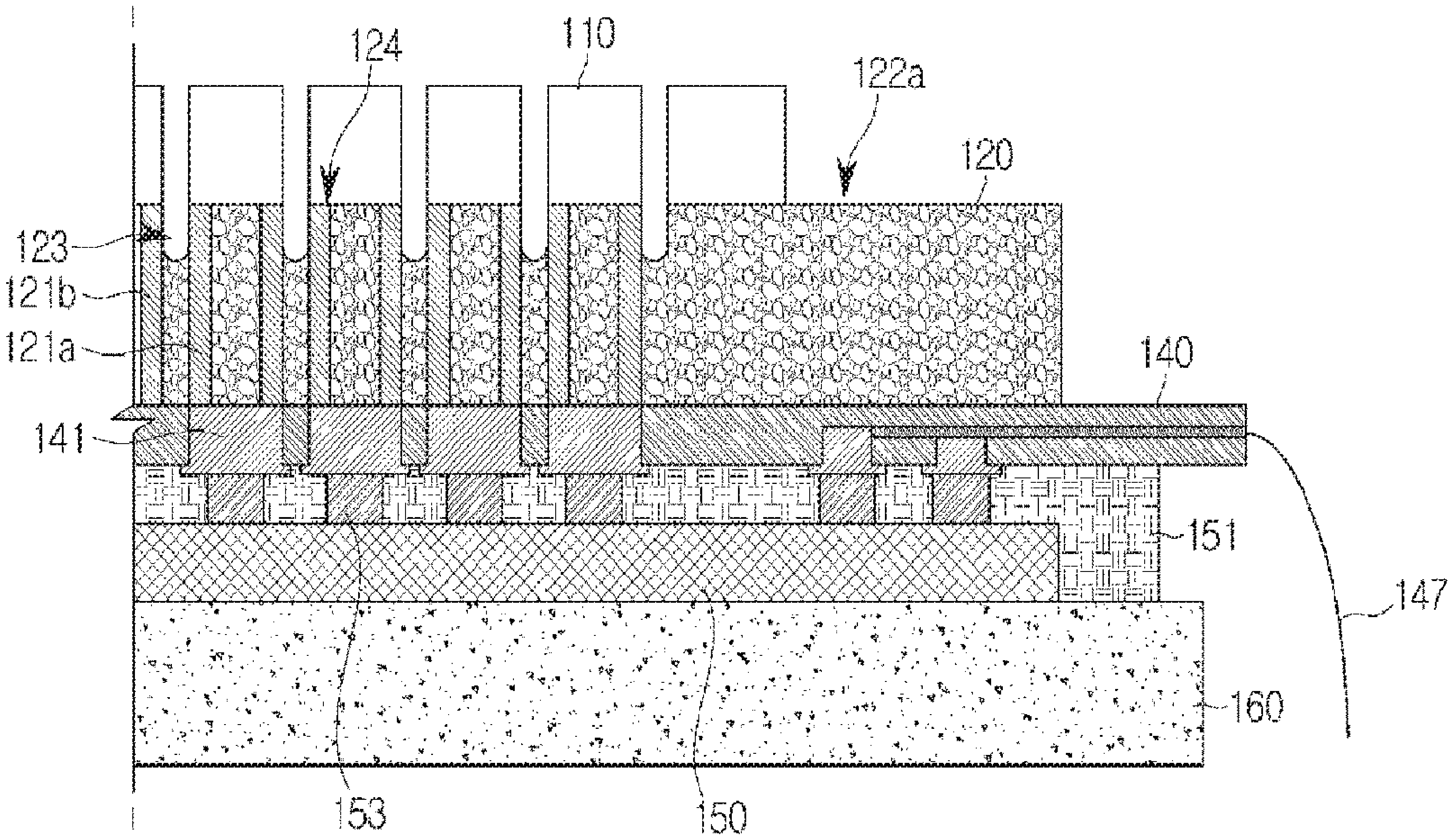


FIG. 13

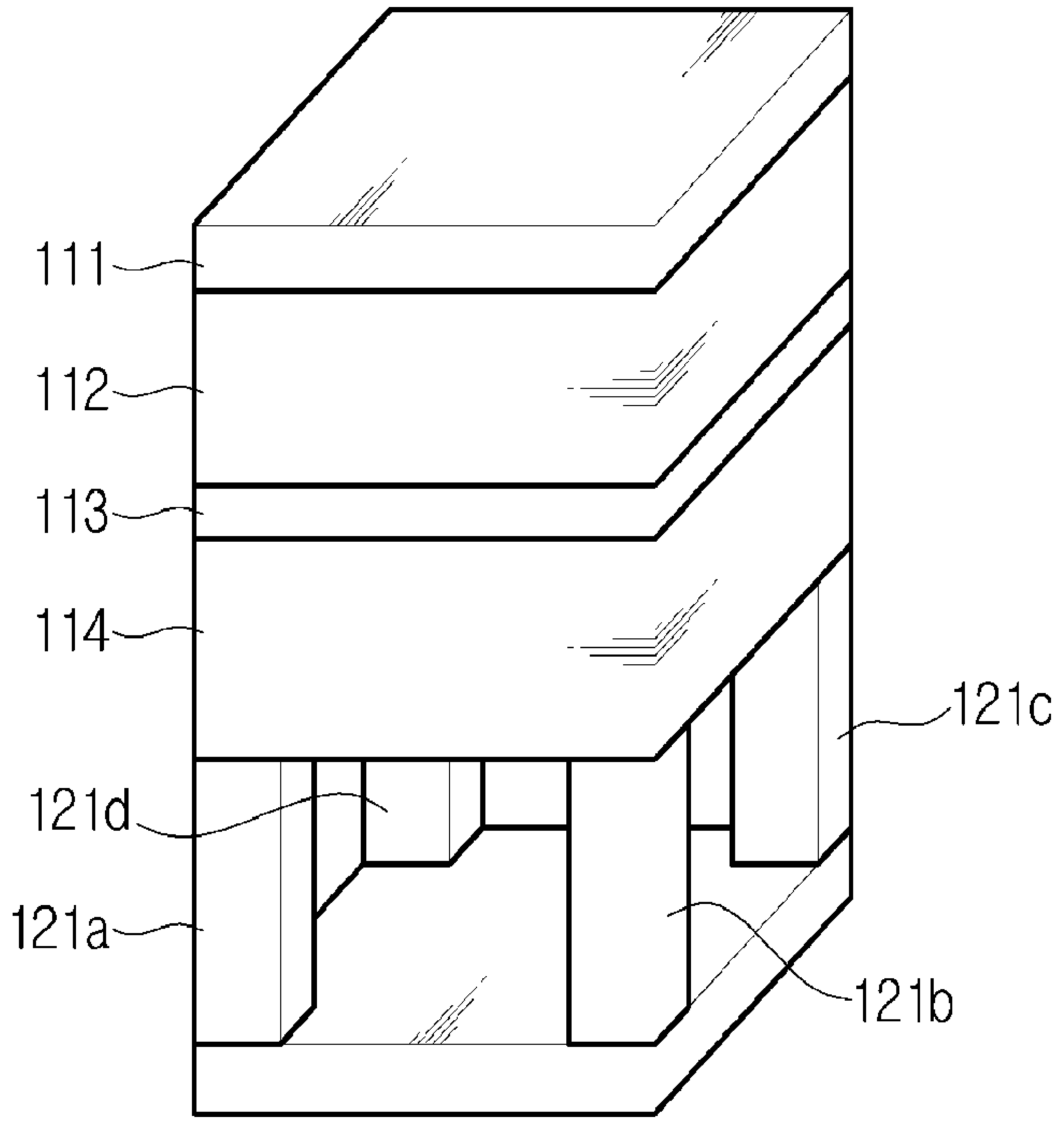


FIG. 14

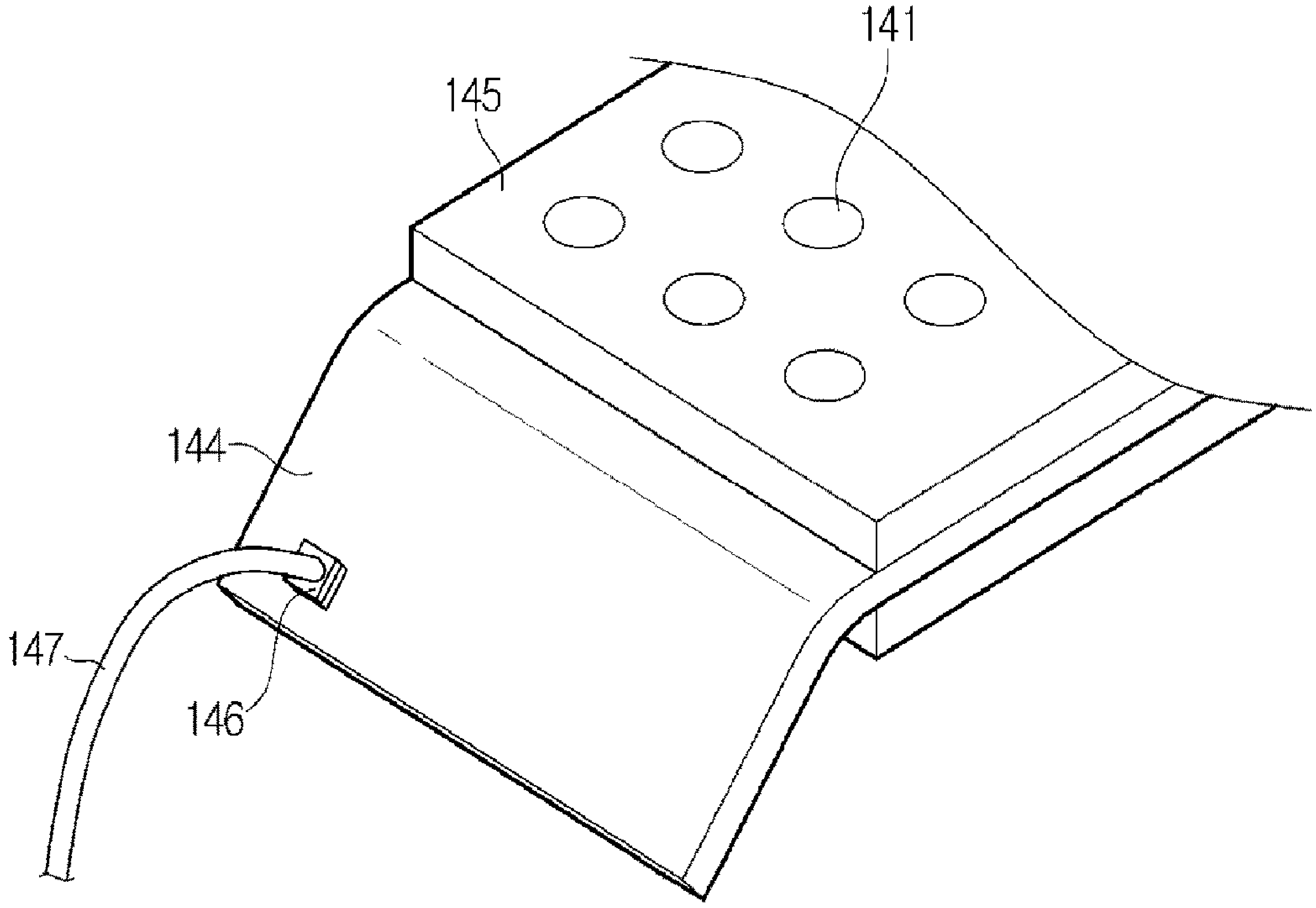


FIG. 15

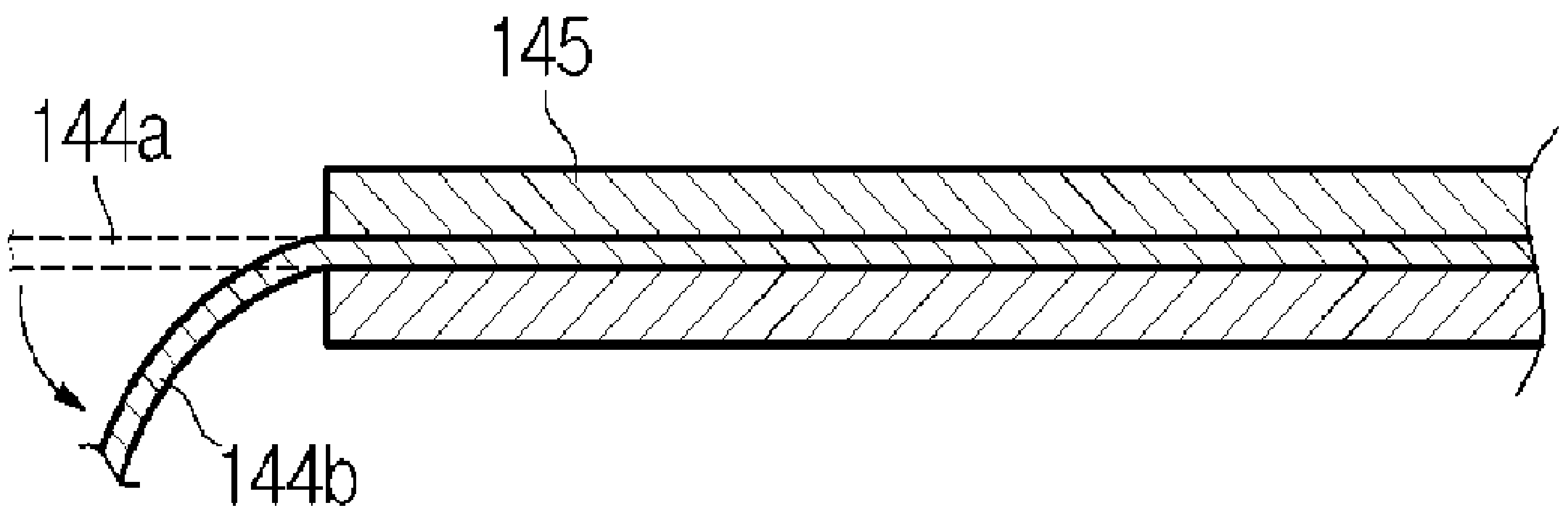


FIG. 16

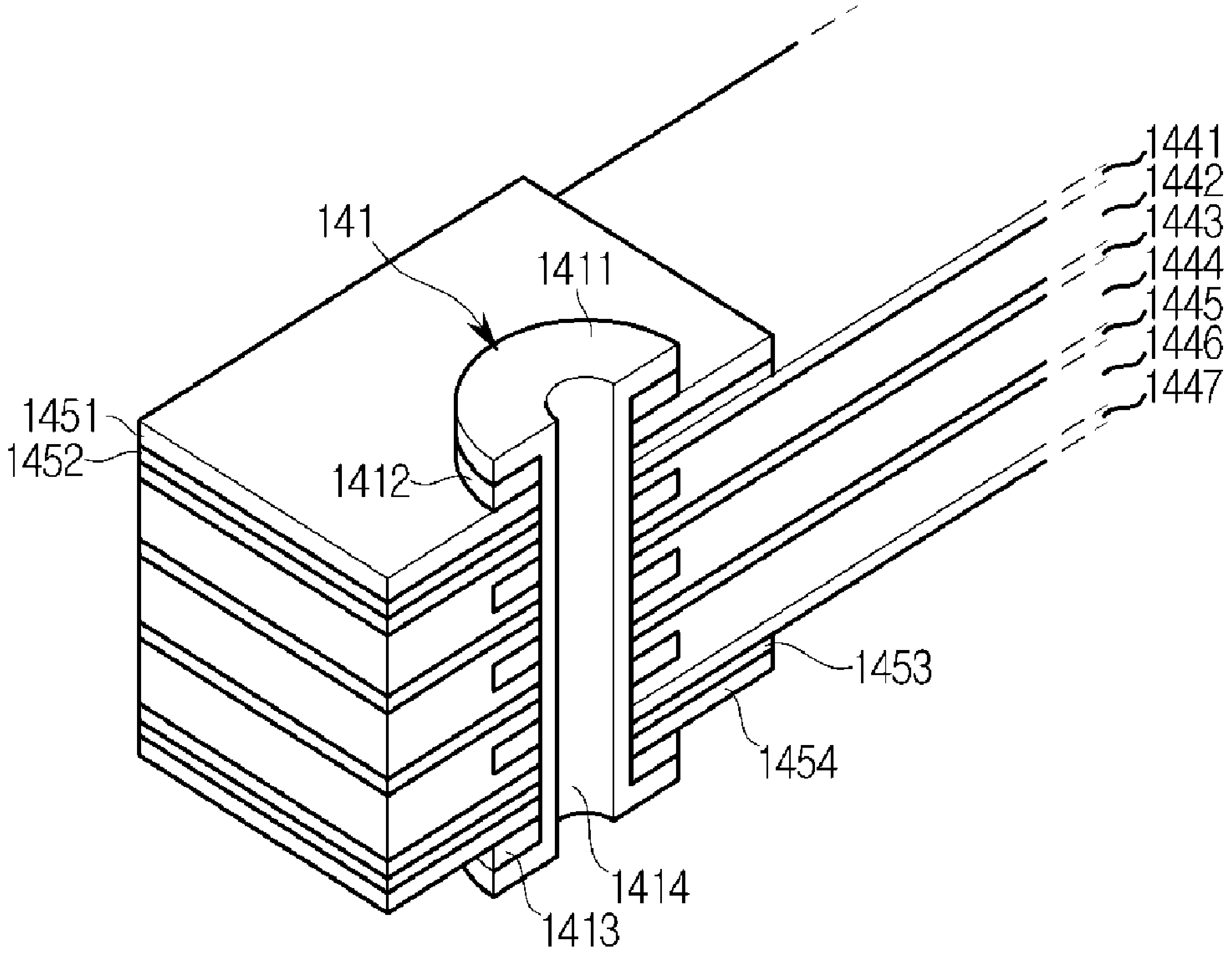

1441
1442
1443
1444
1445
1446
1447
141
1411
1451
1452
1412
1453
1454
1414
1413

FIG. 17A

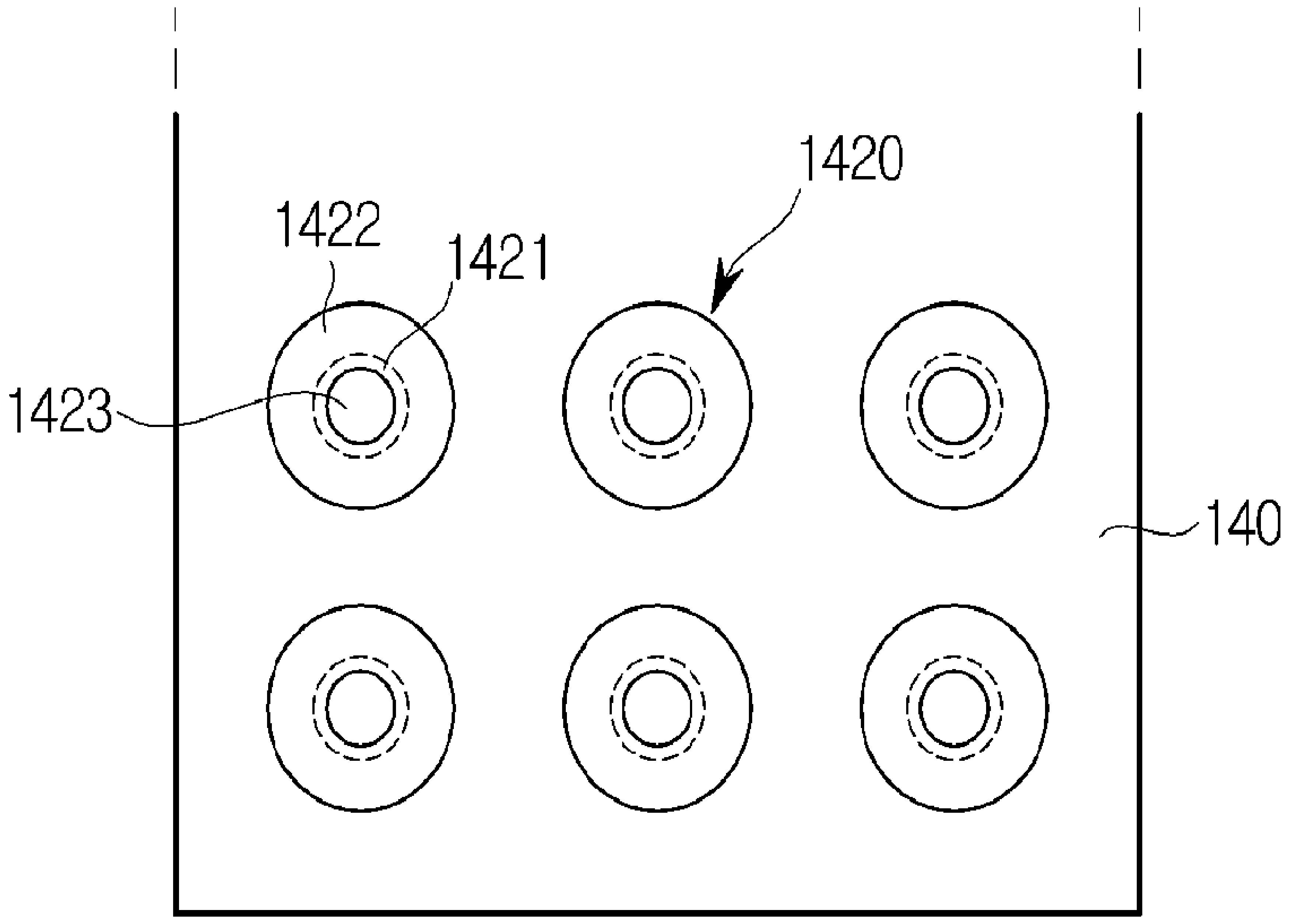


FIG. 17B

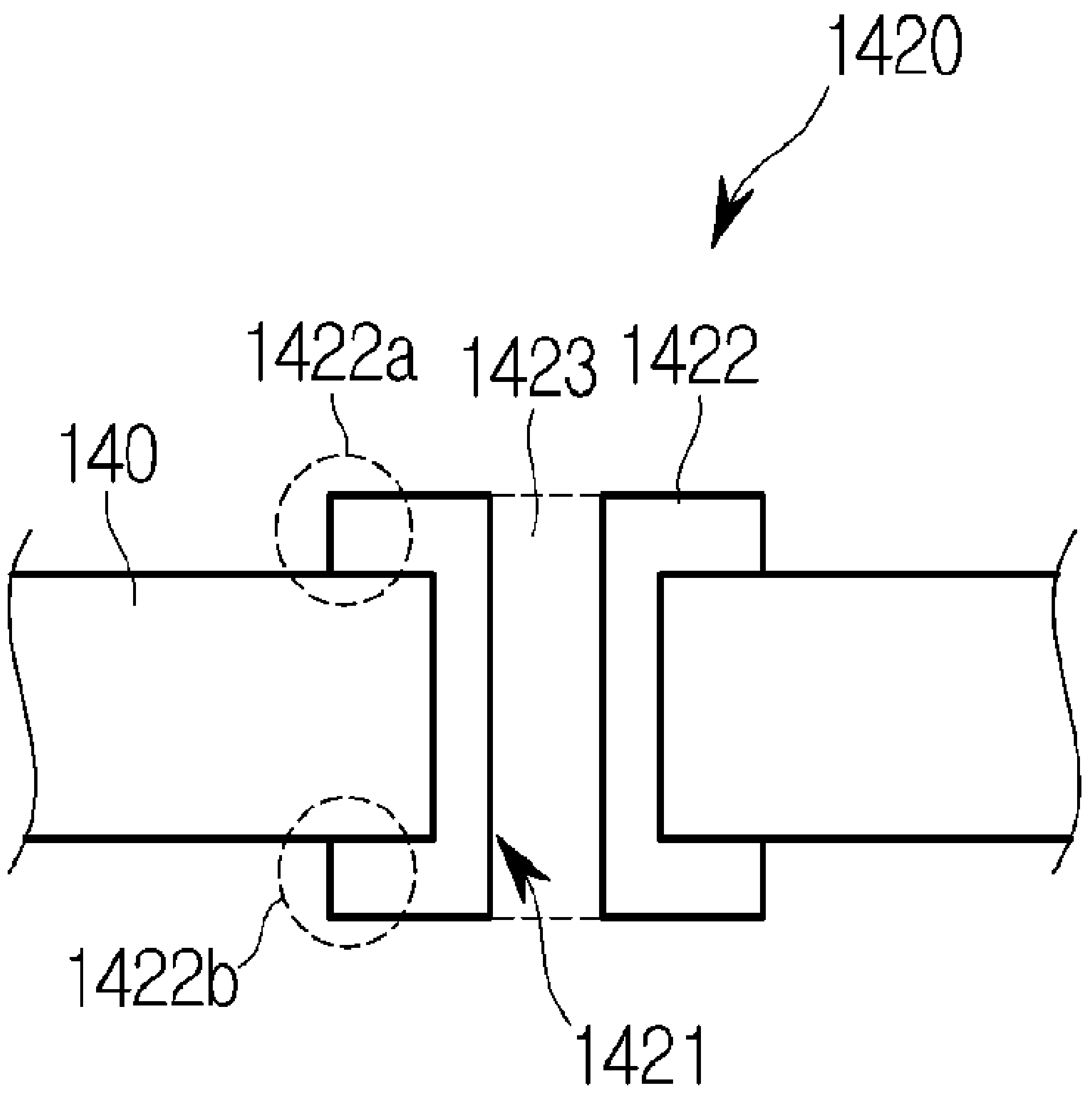


FIG. 18A

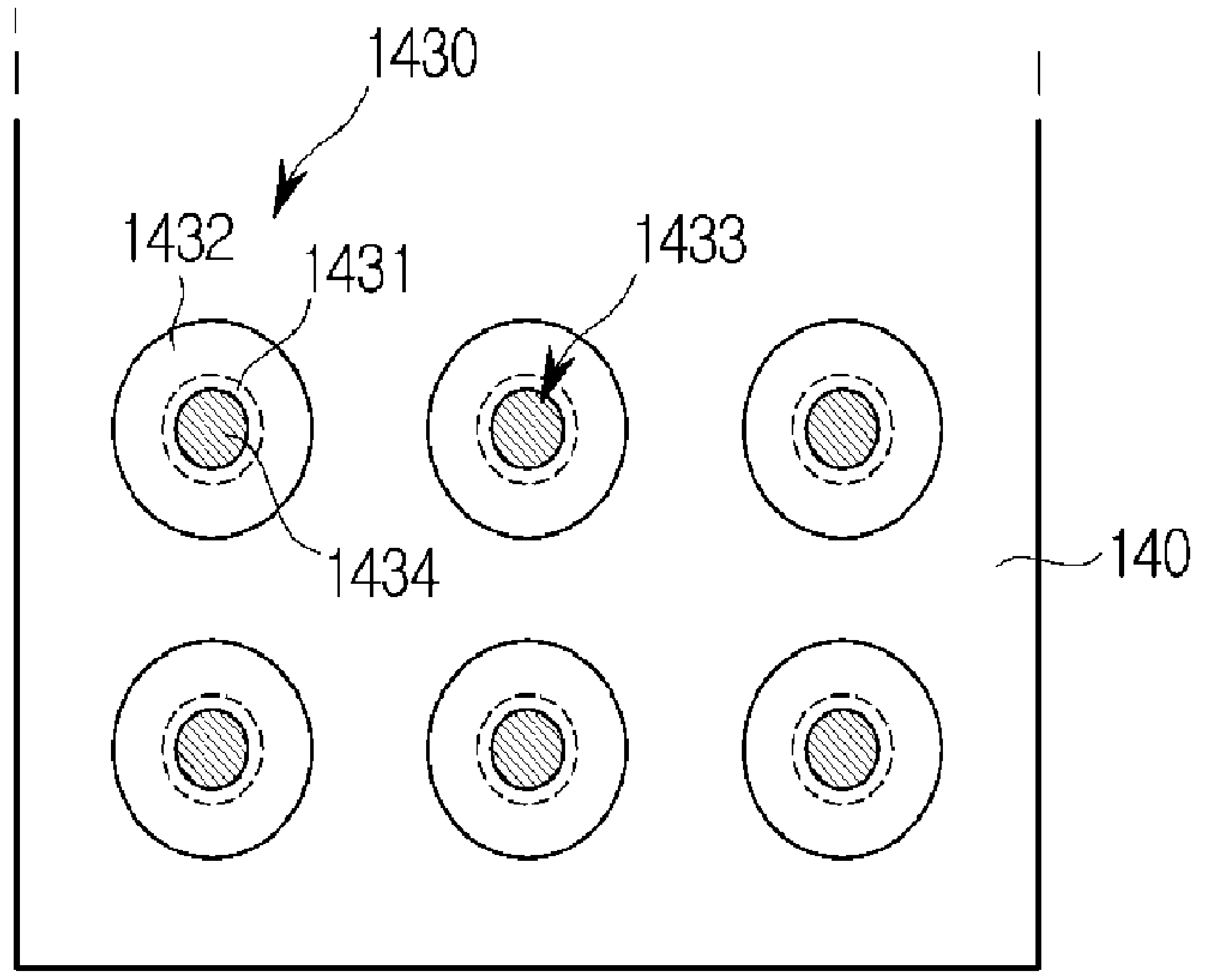


FIG. 18B

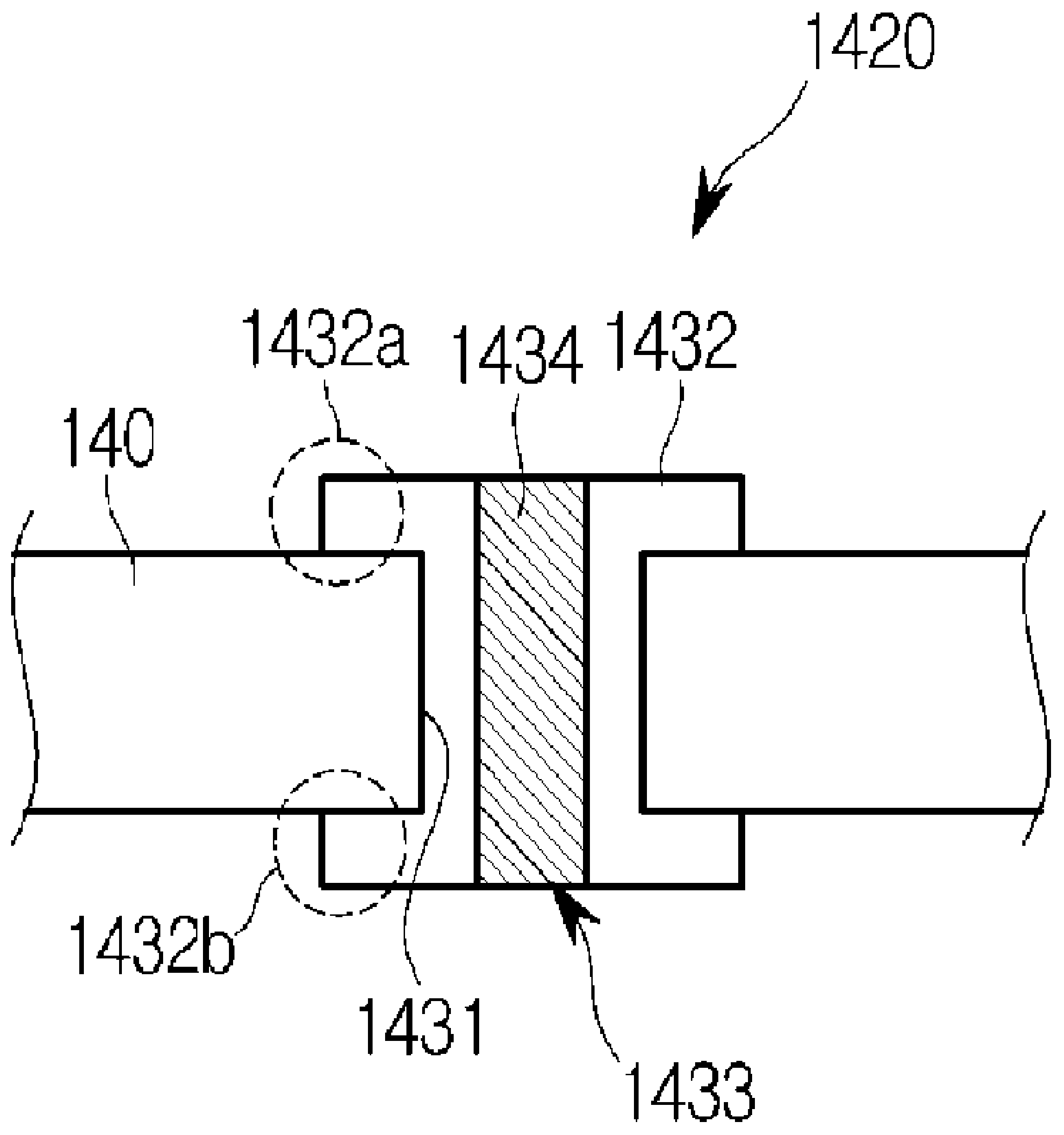


FIG. 19A

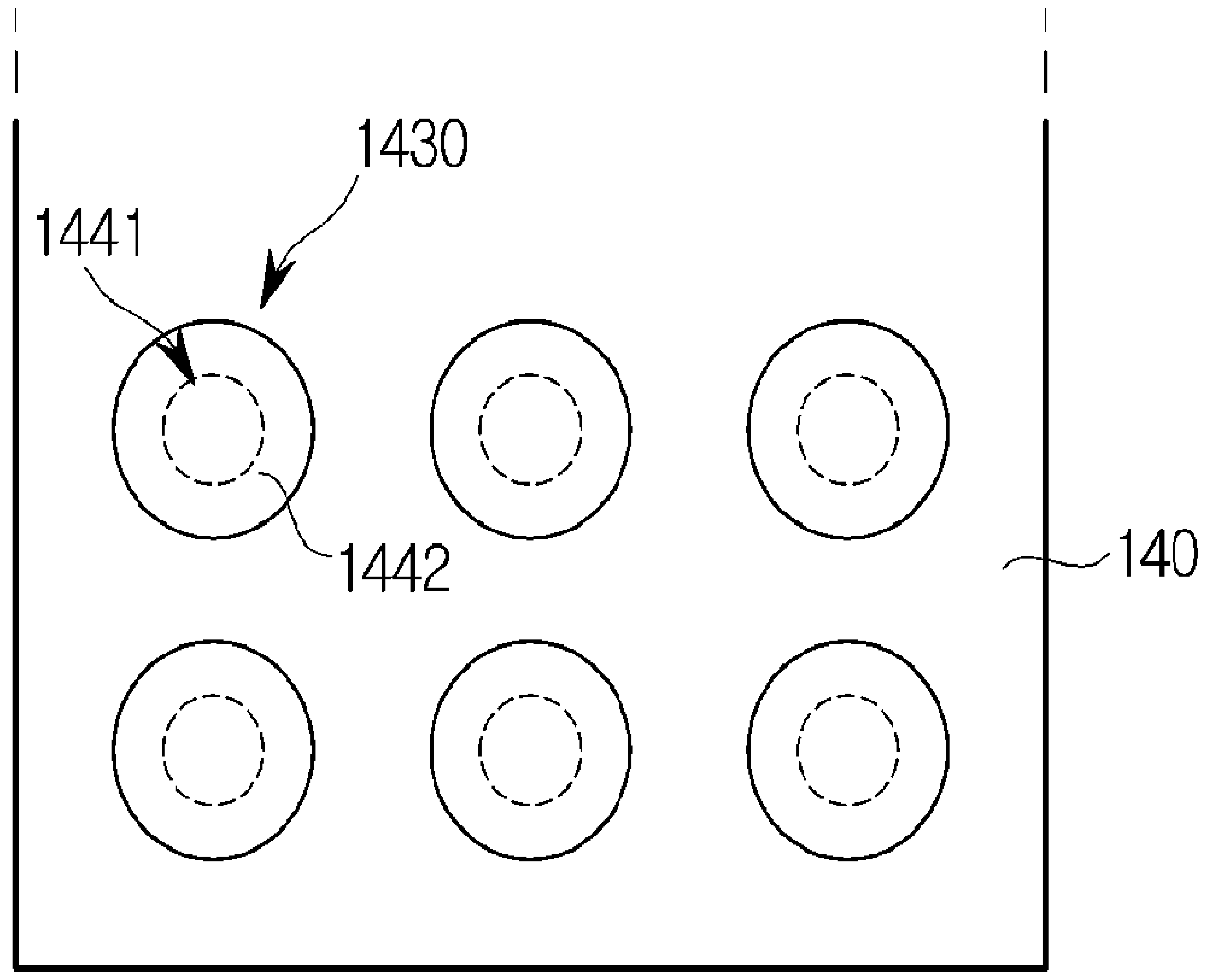


FIG. 19B

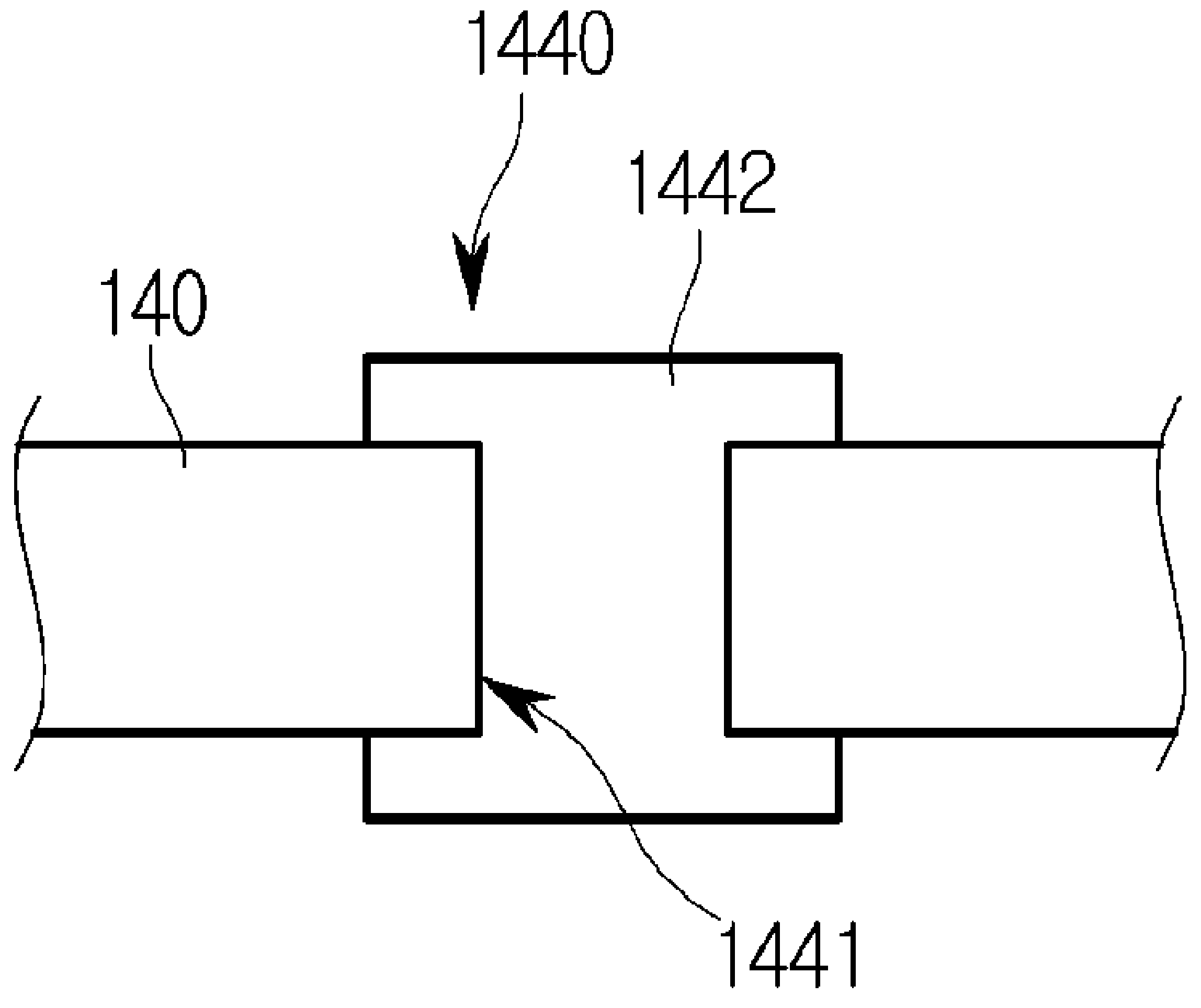


FIG. 20A

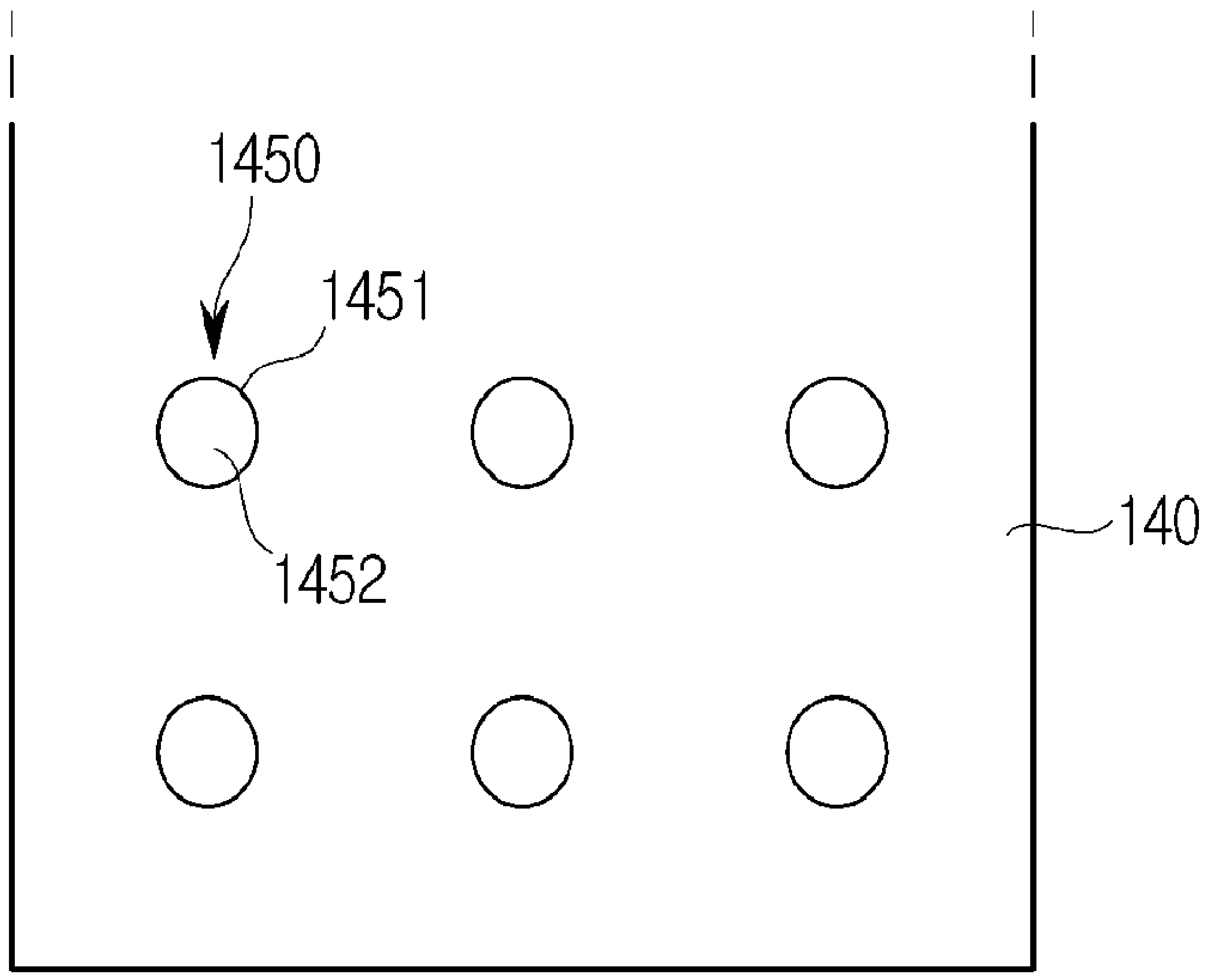


FIG. 20B

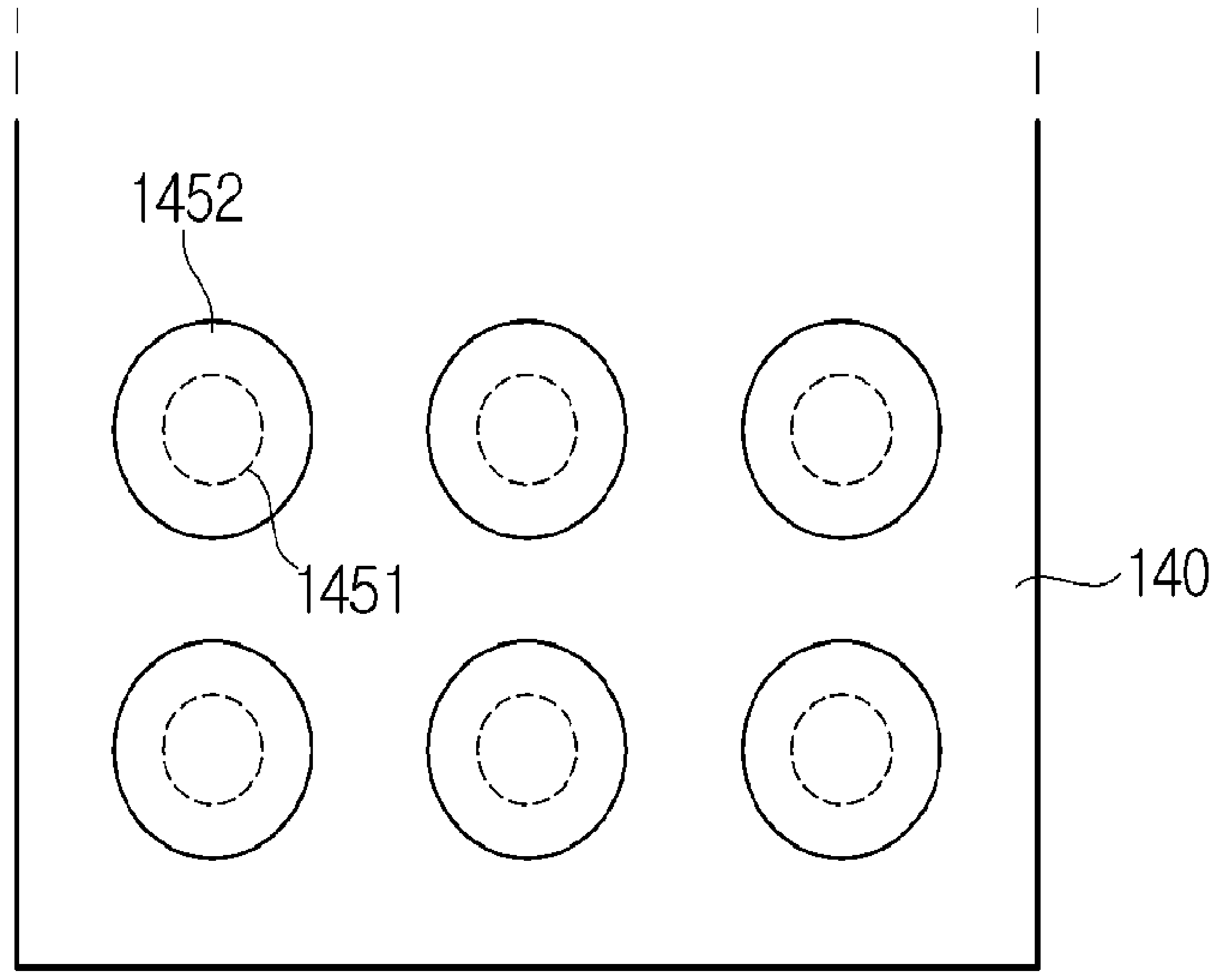


FIG. 20C

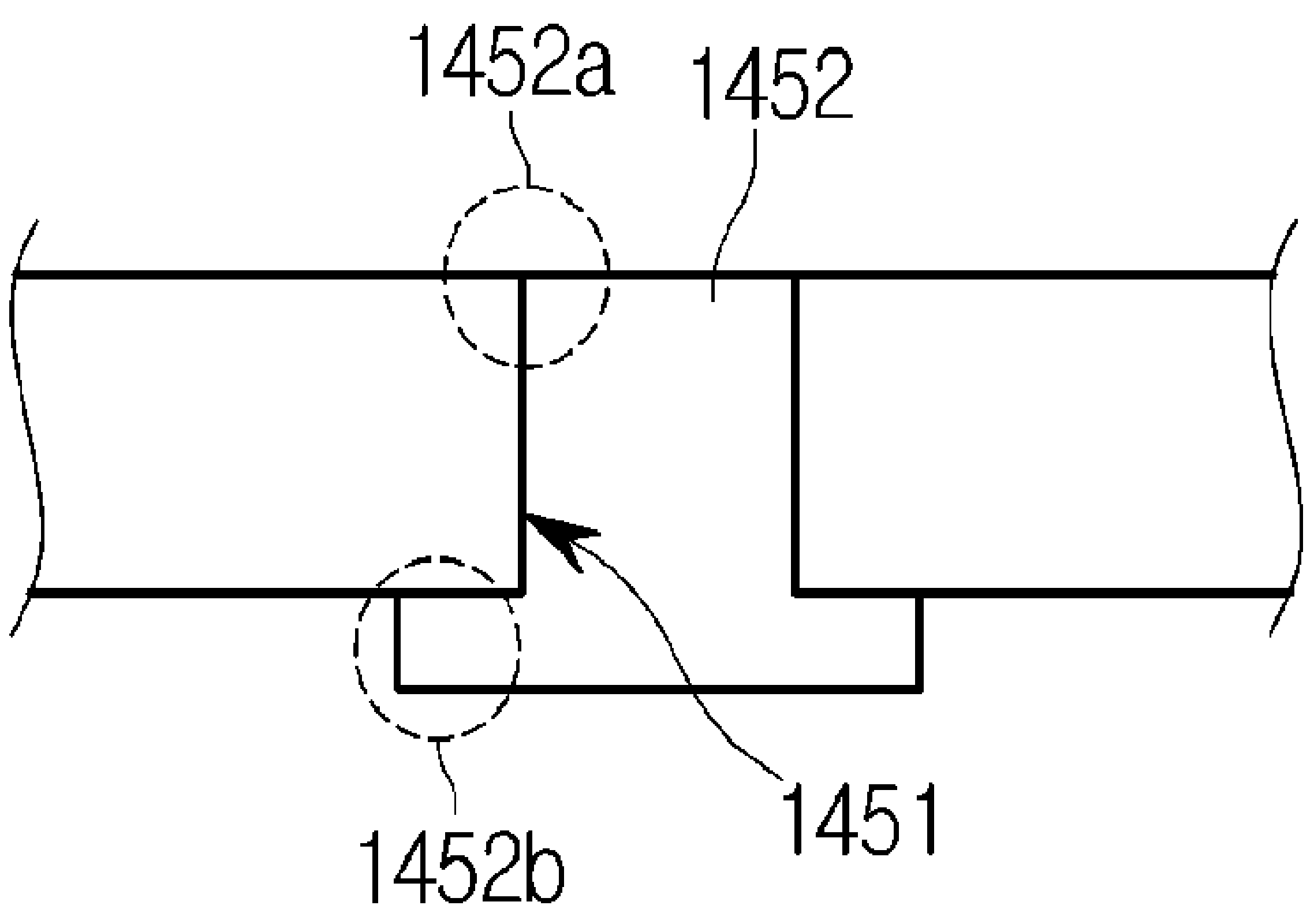


FIG. 21

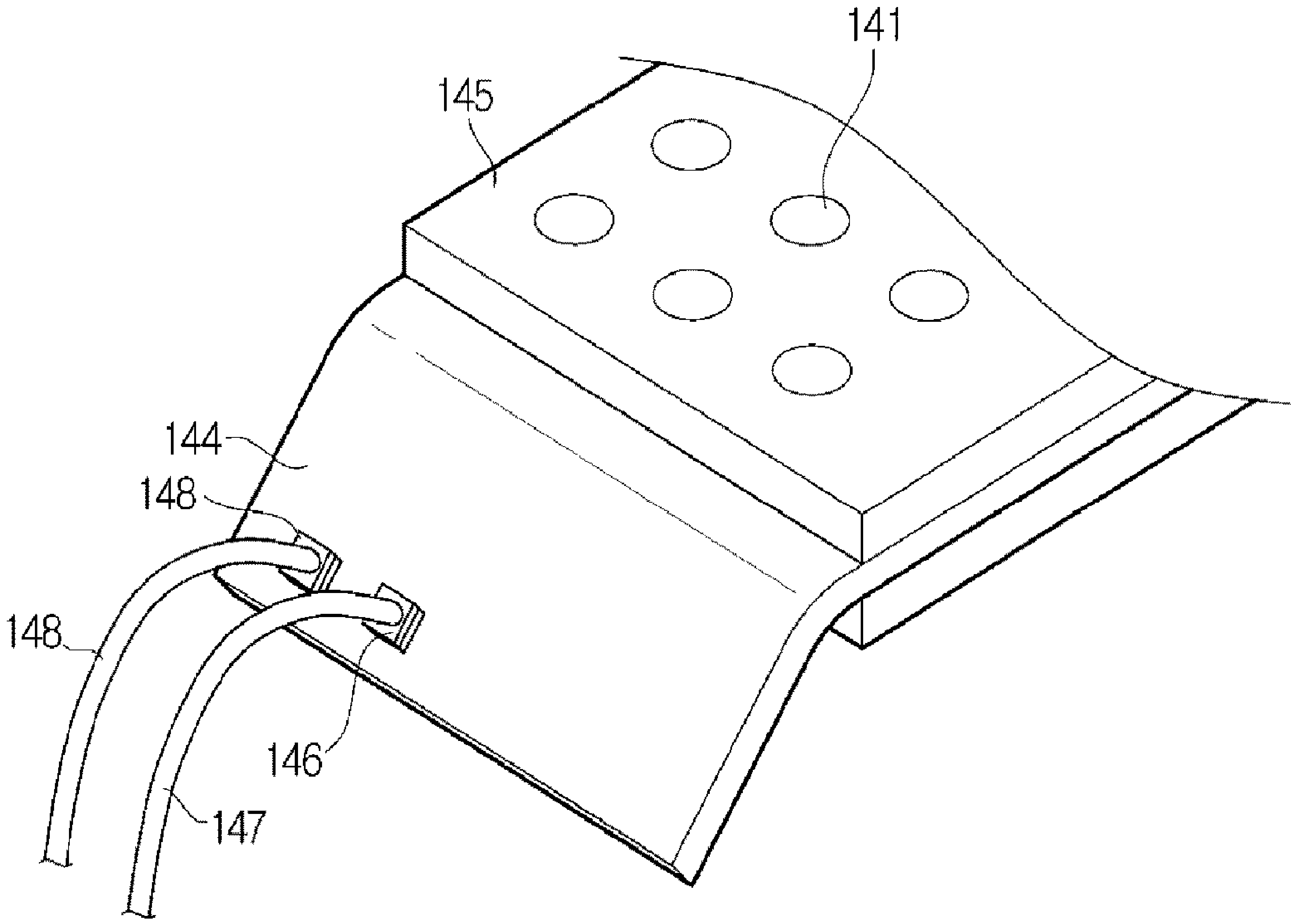


FIG. 22A

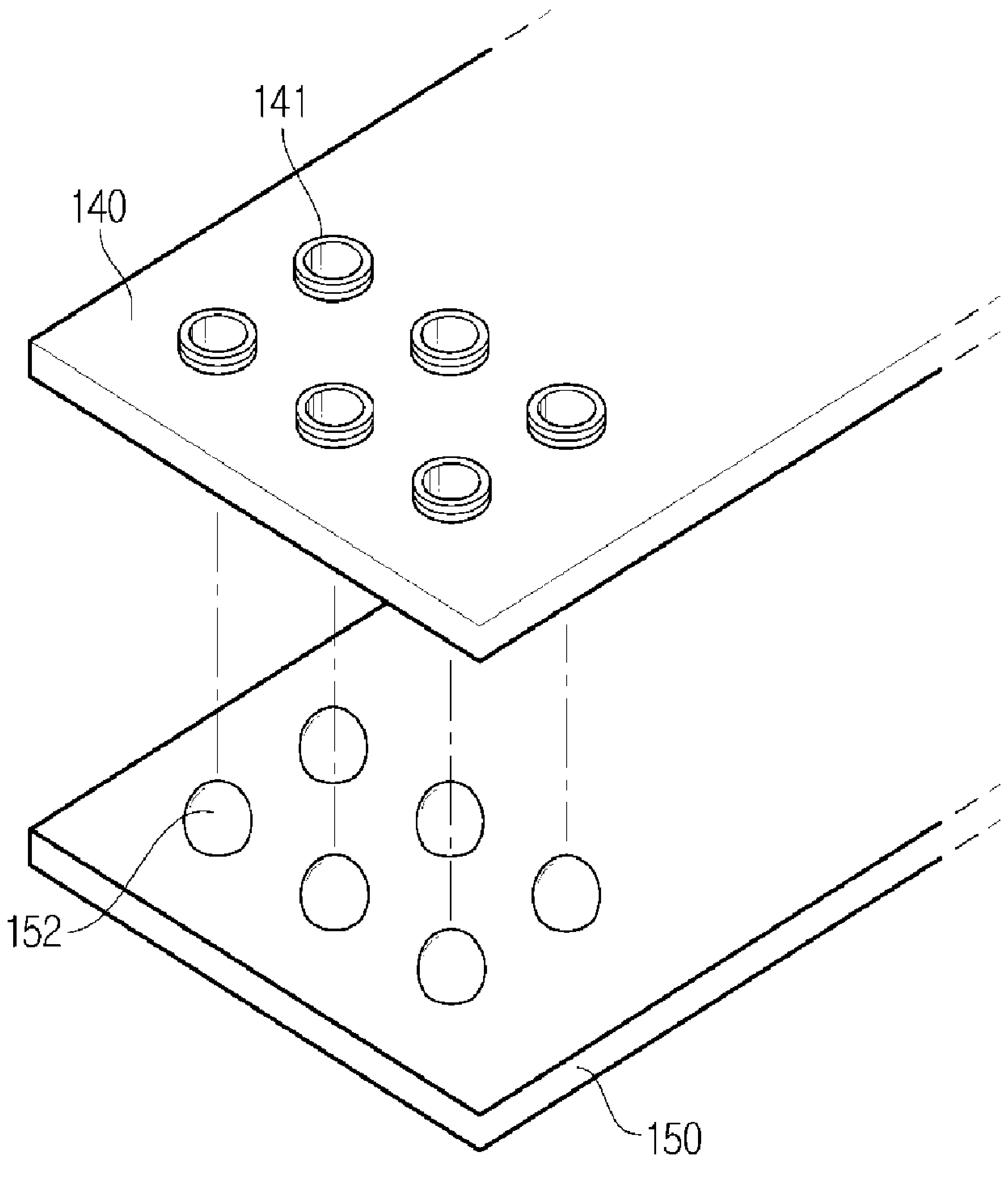


FIG. 22B

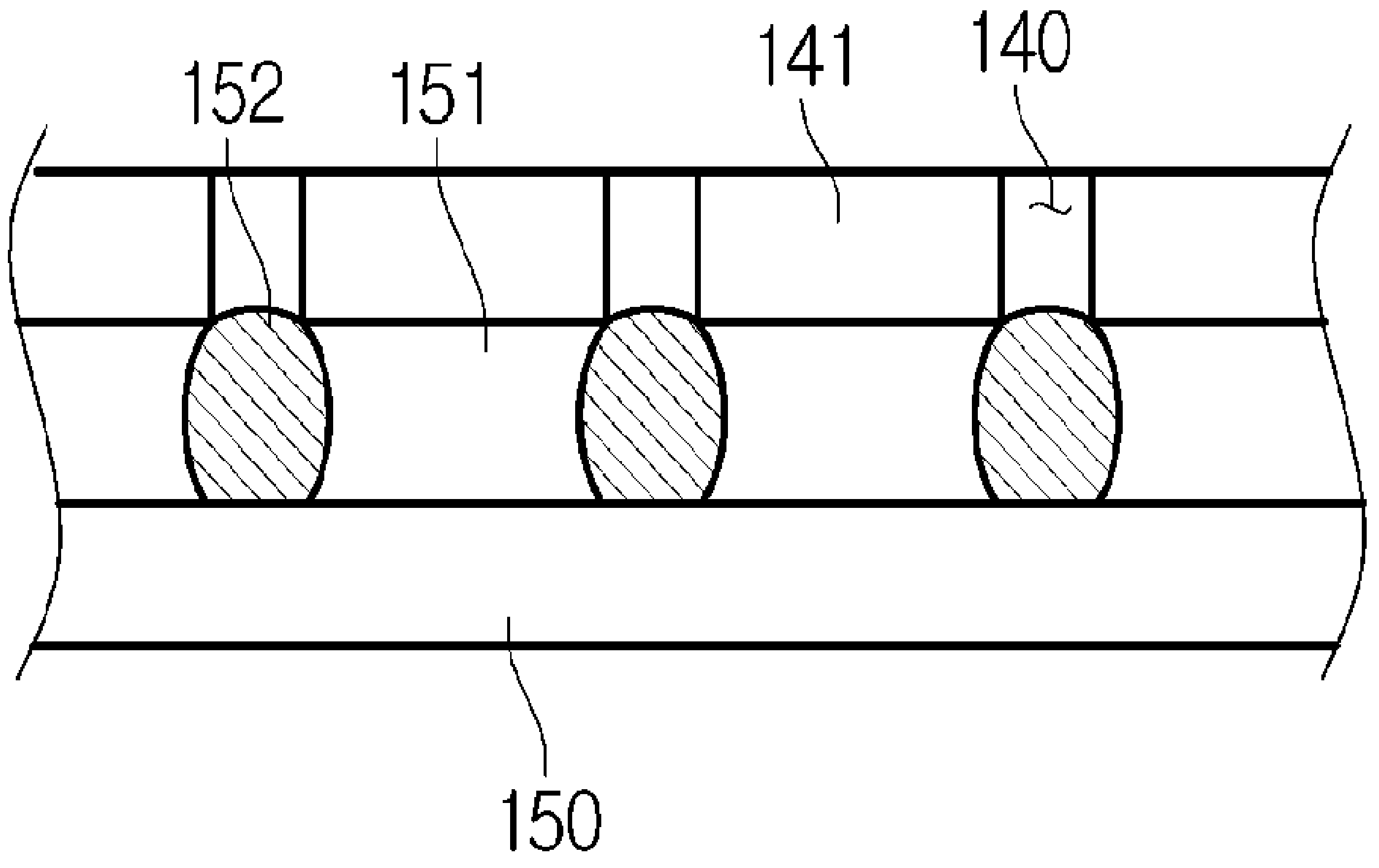


FIG. 22C

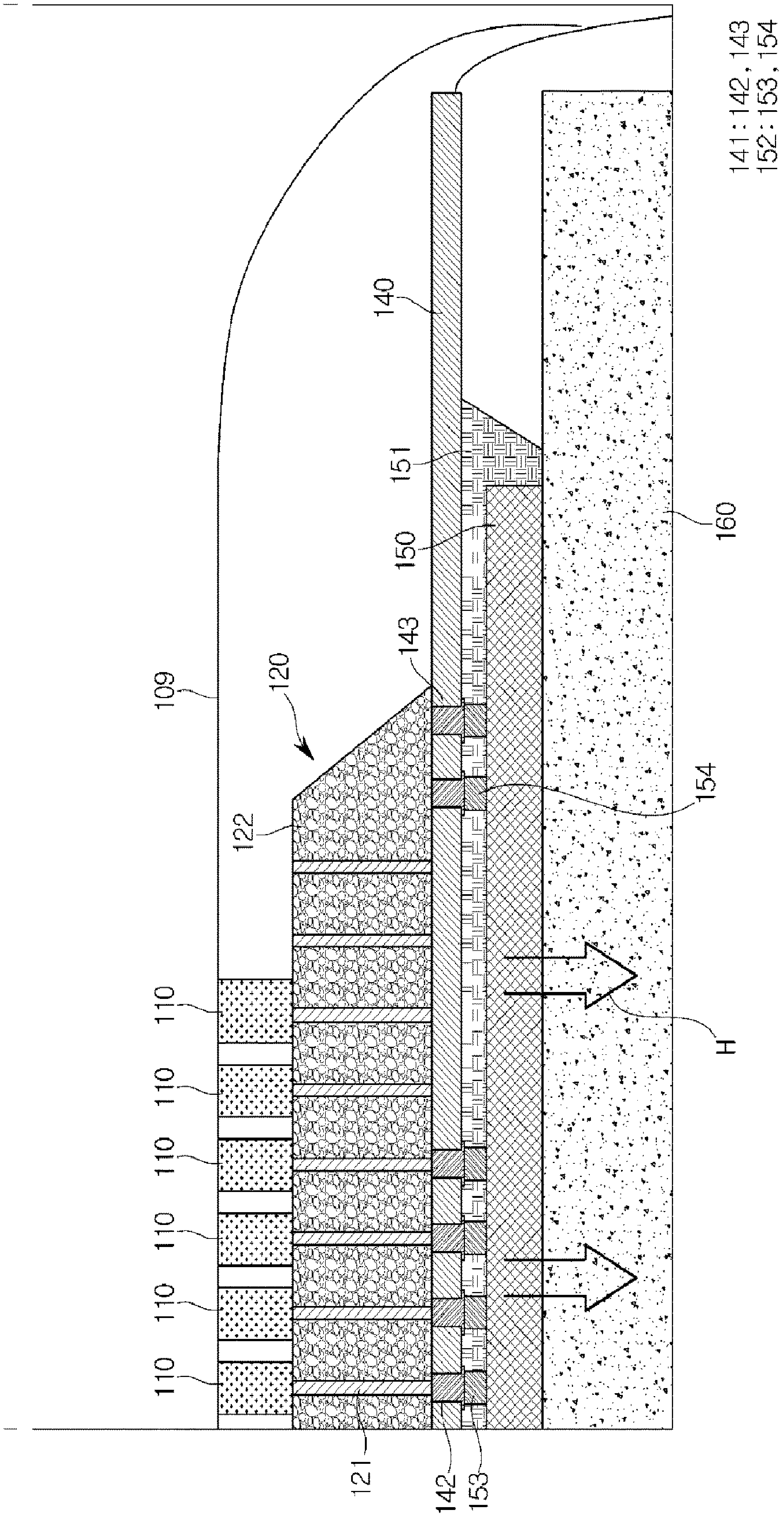

109
120
122
140
143
151
150
160
154
H
110
110
110
110
110
110
121
142
153
141: 142, 143
152: 153, 154

FIG. 23A

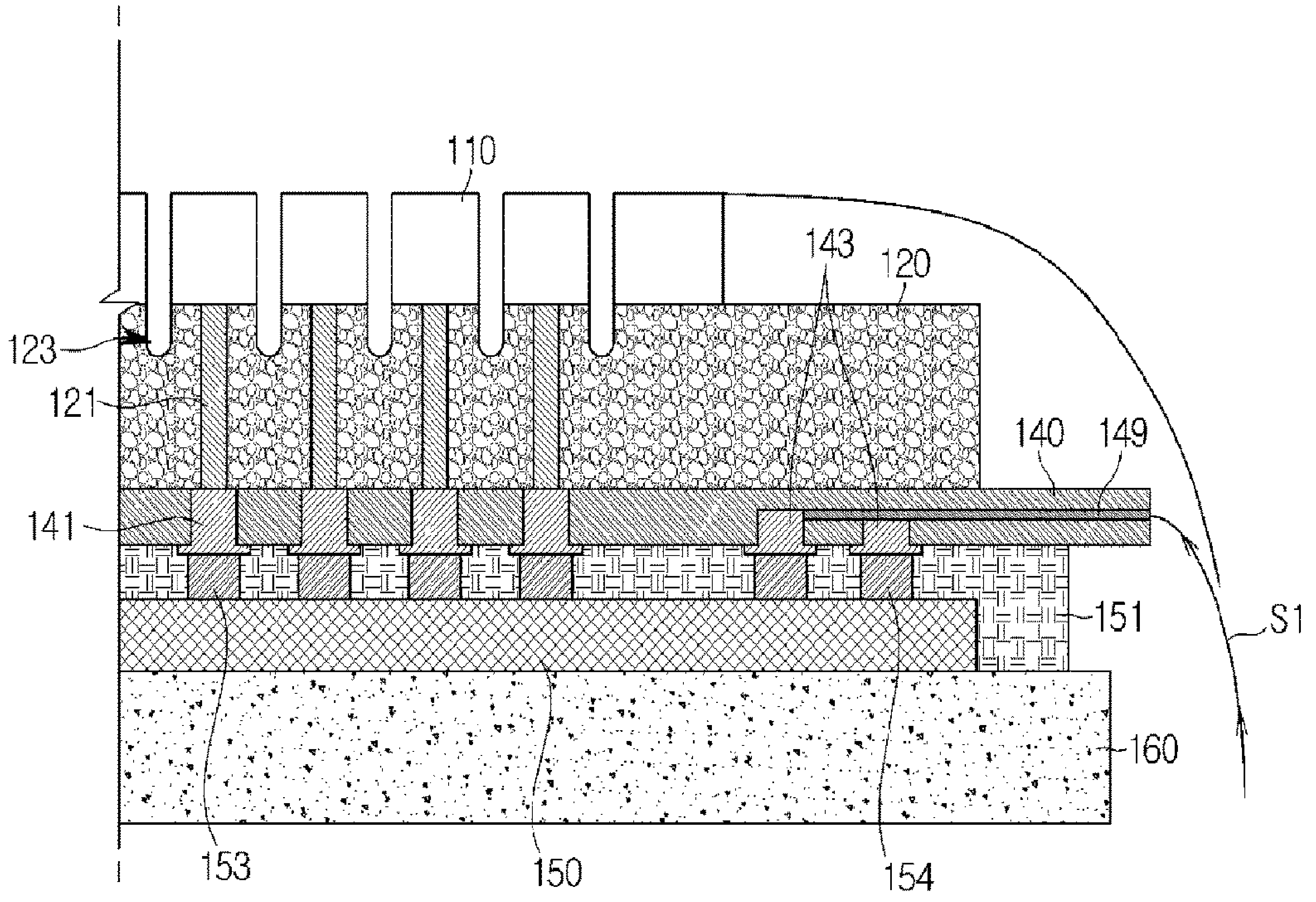


FIG. 23B

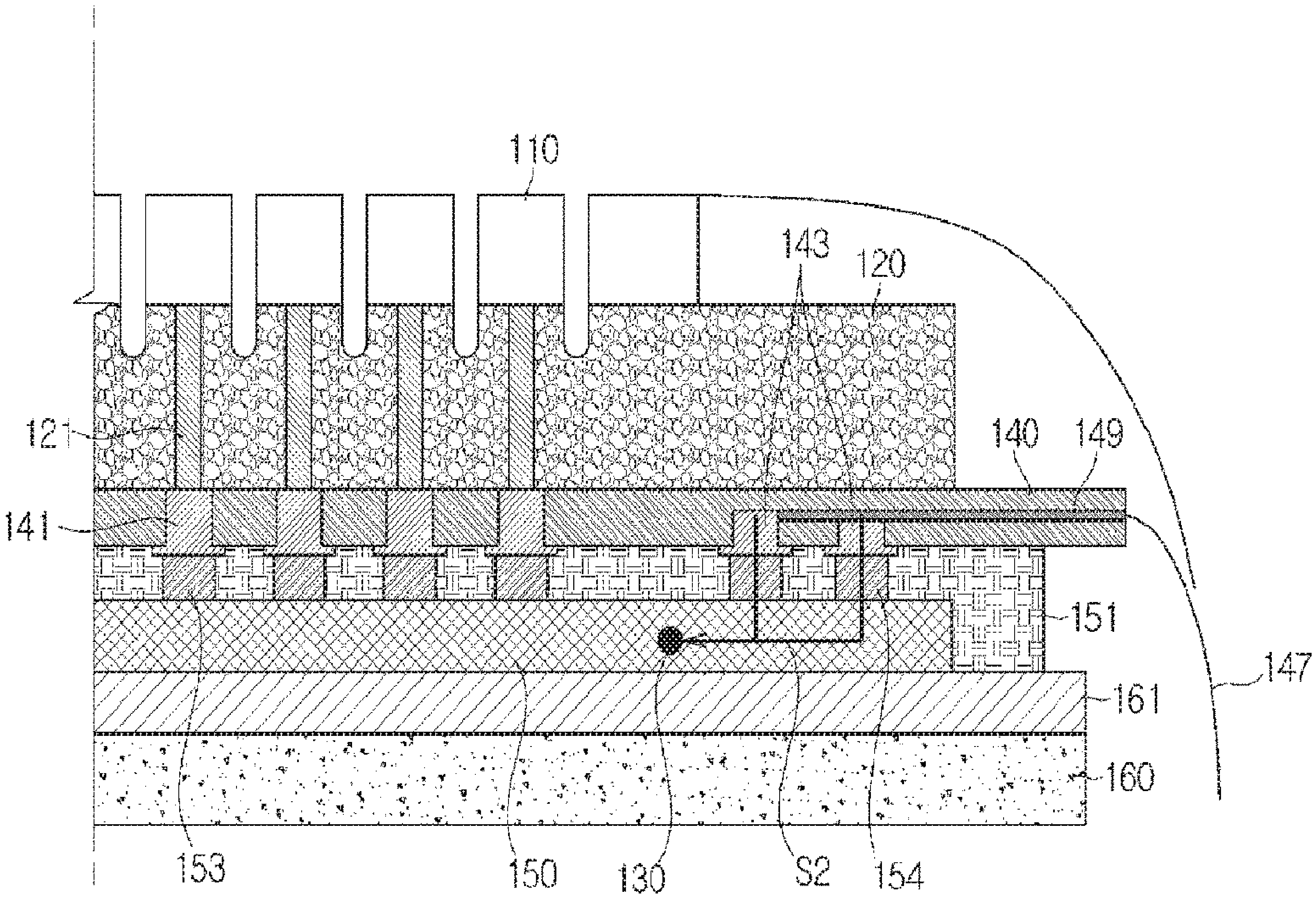


FIG. 23C

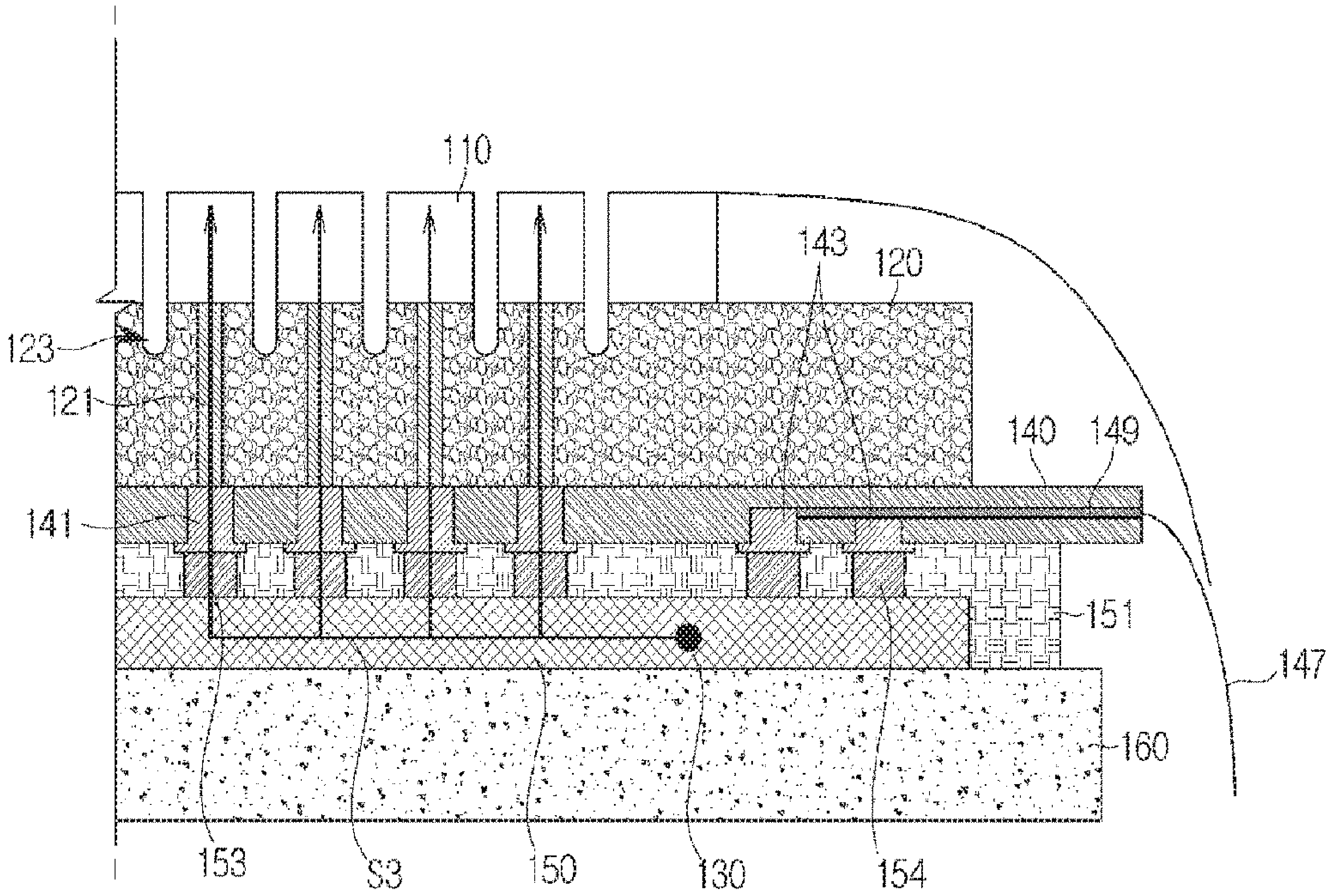


FIG. 24

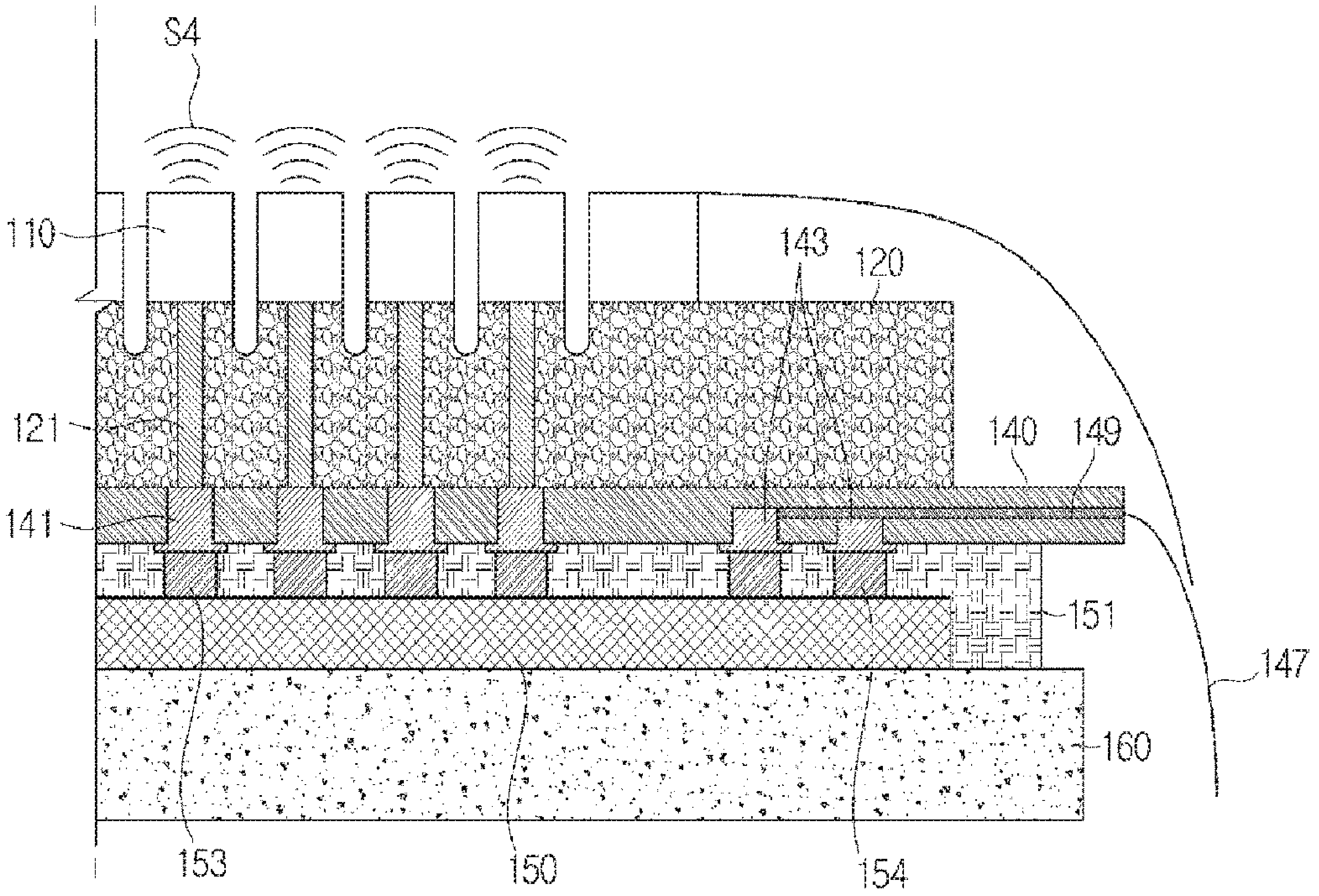


FIG. 25

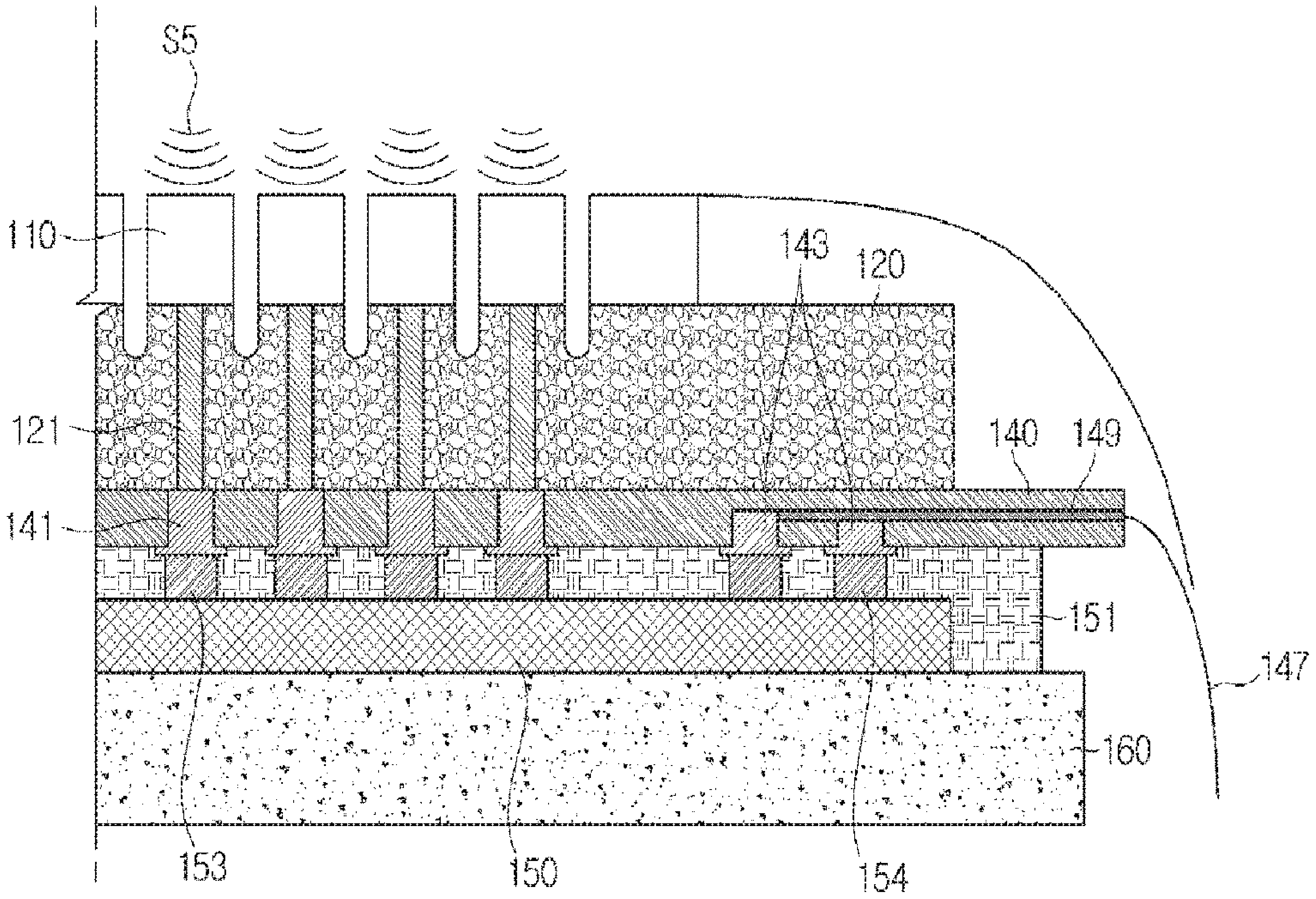


FIG. 26

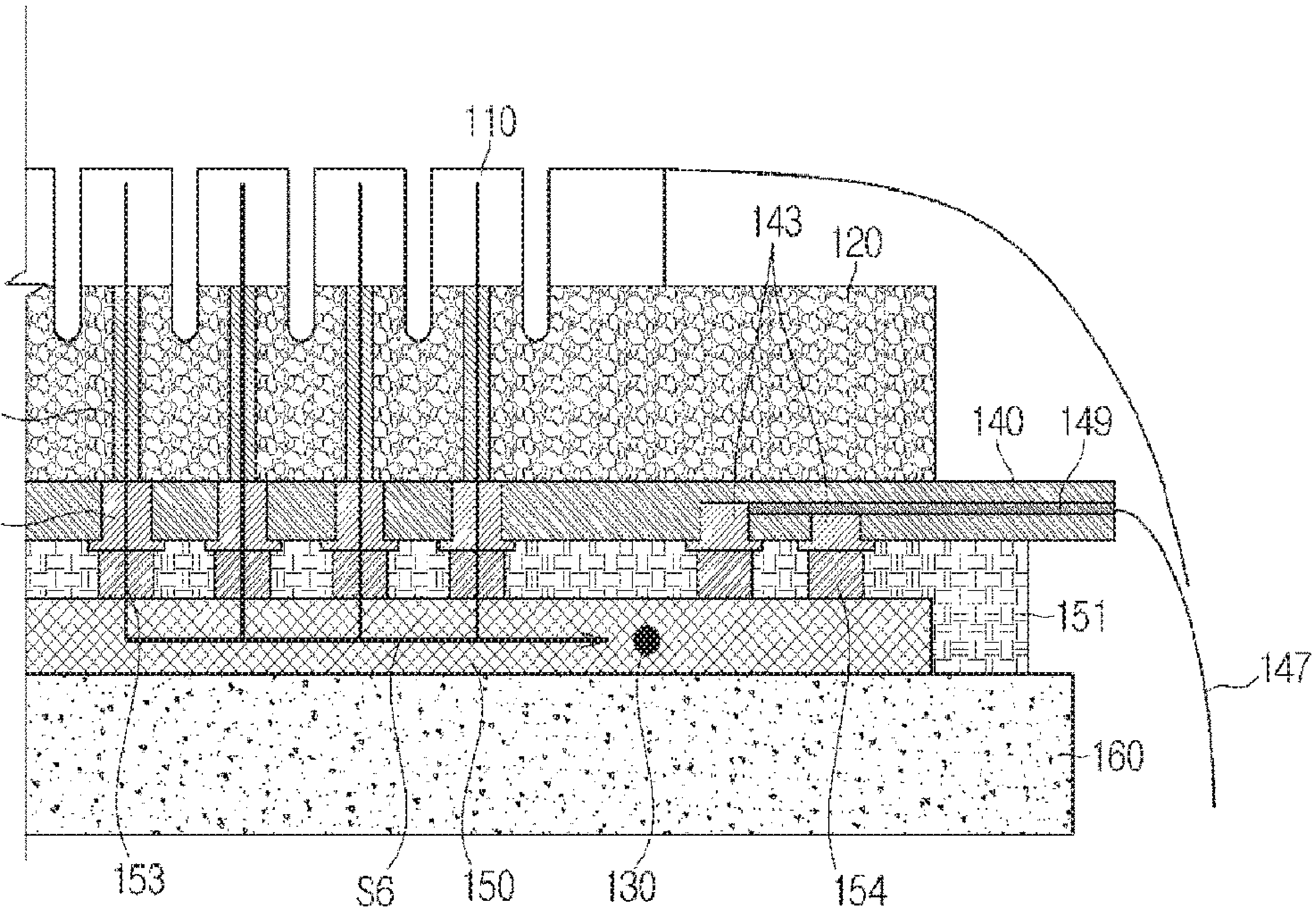


FIG. 27

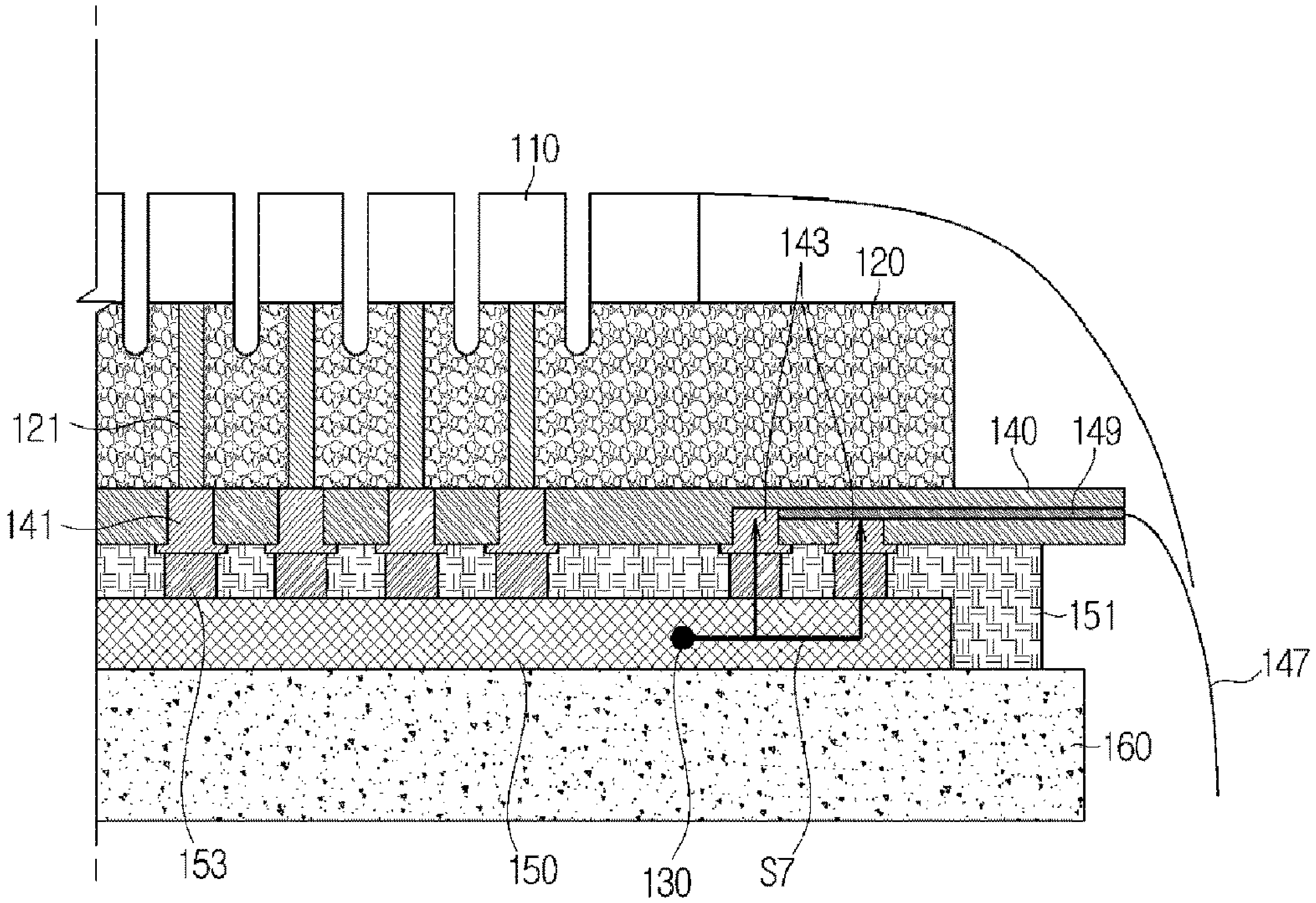


FIG. 28

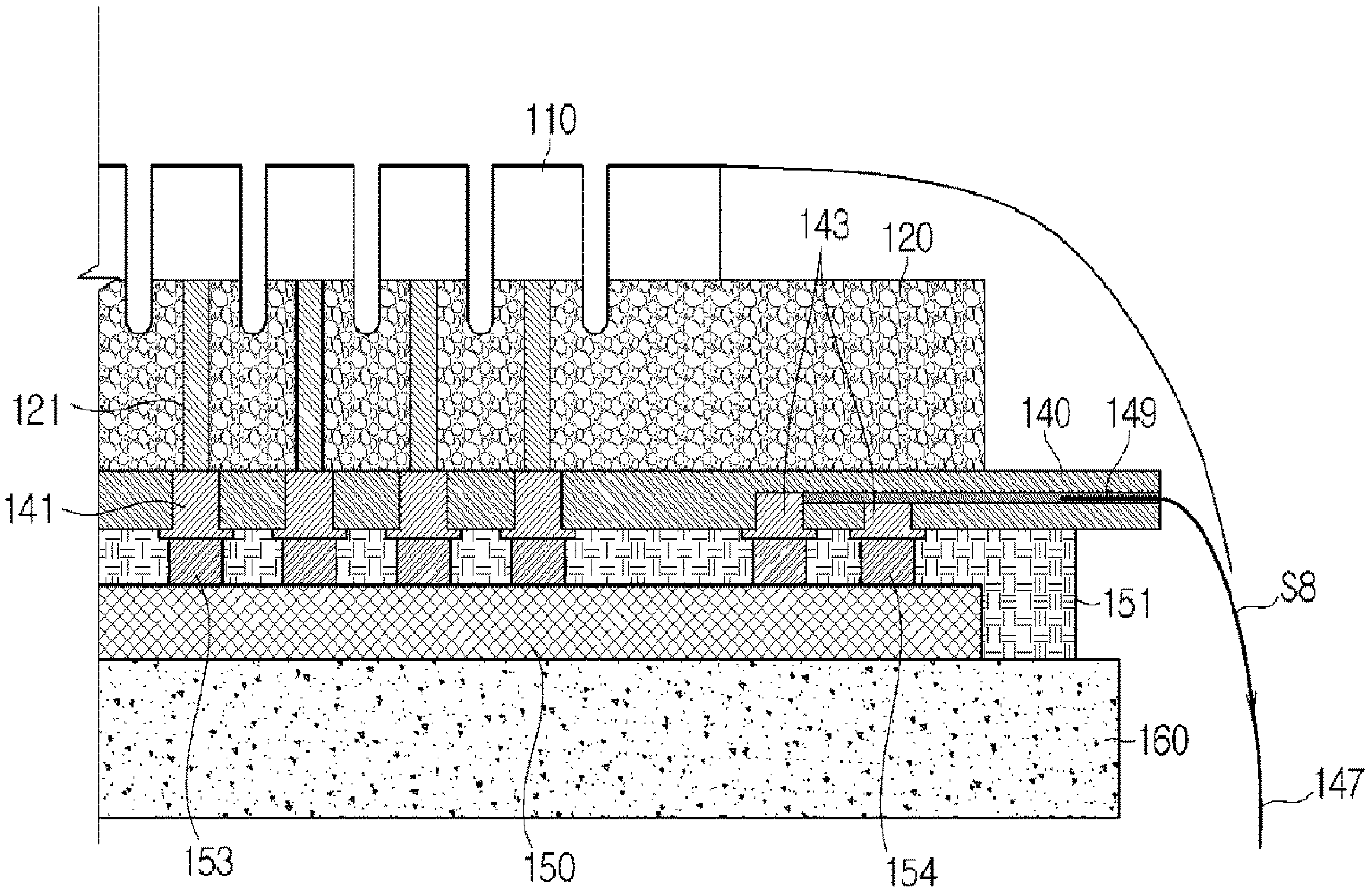


FIG. 29

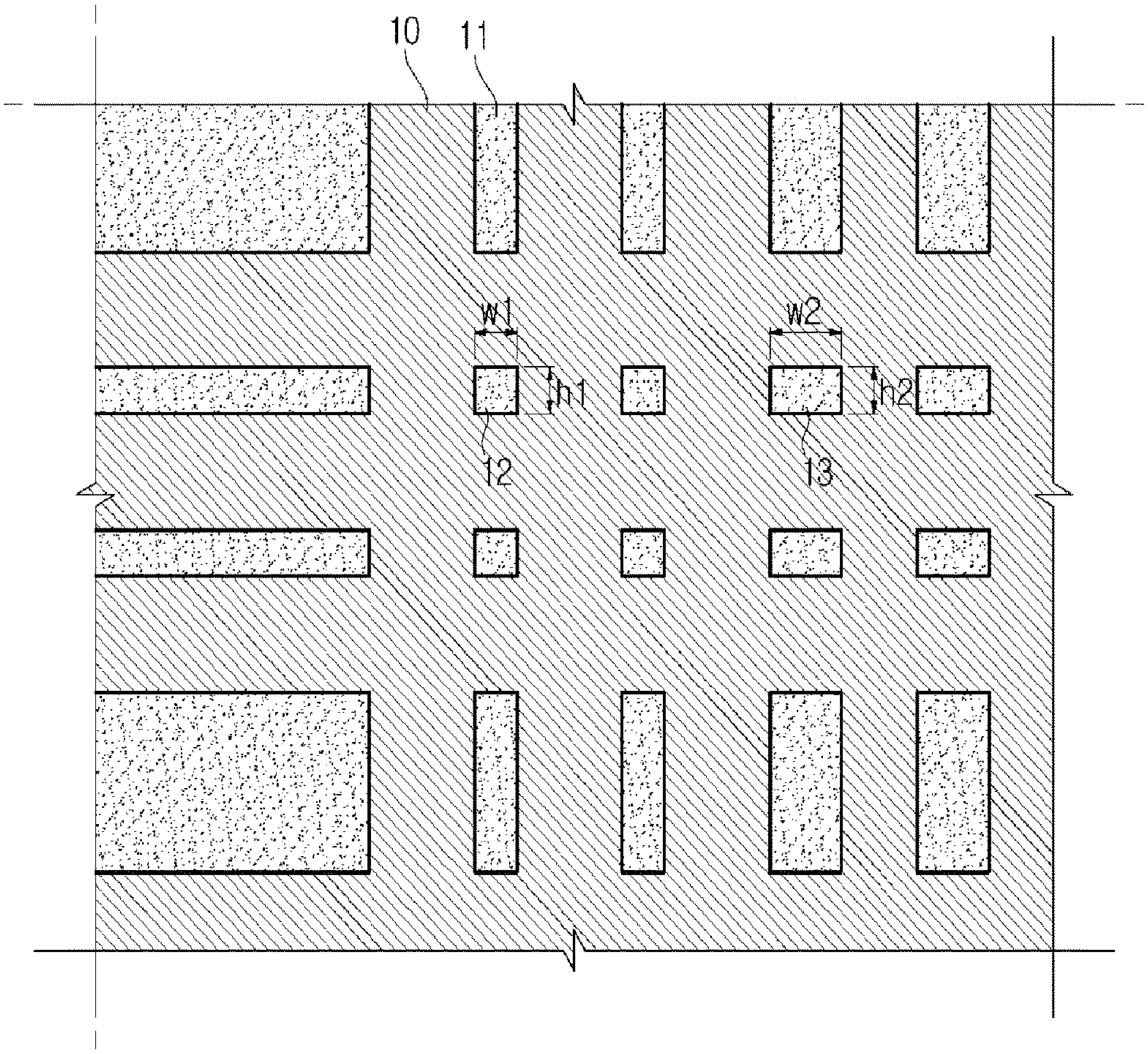
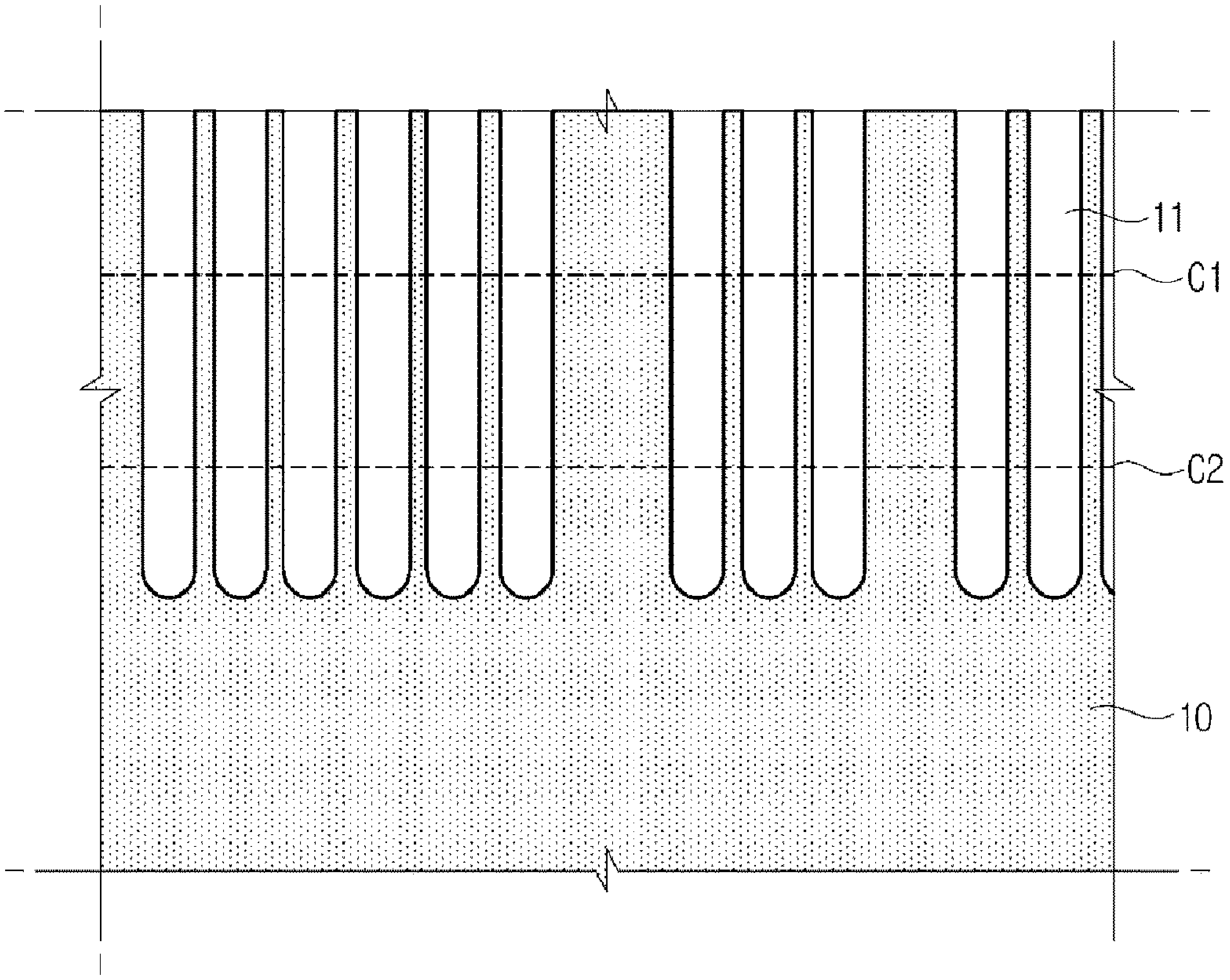


FIG. 30



ULTRASONIC PROBE APPARATUS AND ULTRASONIC IMAGING APPARATUS USING THE SAME

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 10-2014-0190566, filed on Dec. 26, 2014 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field

Examplary embodiments relate to an ultrasonic probe apparatus and an ultrasonic imaging apparatus.

2. Description of the Related Art

An imaging apparatus captures an image of an object using visible light, infrared light, radiation, ultrasonic waves, microwaves, or Free Induction Decay (FID) signals derived from a magnetic resonance phenomenon, and generates an internal or external image of the object. Examples of the imaging apparatus may include a camera, an infrared camera, a radiation imaging apparatus, an ultrasonic imaging apparatus, etc.

The ultrasonic imaging apparatus obtains images by capturing an internal image of the object using ultrasonic waves, and displays the obtained images for user recognition. The ultrasonic imaging apparatus directly irradiates ultrasonic waves to a target site contained in the object, collects the ultrasonic waves reflected from the target site, and thus generates an ultrasound image using the collected ultrasonic waves. The ultrasonic imaging apparatus may collect ultrasonic waves generated from a target site contained in the object using laser beams or the like, and may thus generate an ultrasound image using the collected ultrasonic waves.

The ultrasonic imaging apparatus may irradiate ultrasonic waves to the inside of the object using an ultrasonic probe or may receive ultrasonic waves from the inside of the object using the ultrasonic probe. There are various kinds of ultrasonic probes according to categories of objects and categories of the image-captured parts of the objects or according to categories of target sites contained in the objects.

SUMMARY

Therefore, it is an aspect of the present invention to so provide an ultrasonic probe apparatus and an ultrasonic imaging apparatus, which can efficiently absorb ultrasonic waves emitted in a direction opposite to an object using ultrasonic elements.

Additional aspects of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

In accordance with one aspect of the present invention, an ultrasonic probe apparatus includes: an ultrasonic transducer configured to output an electrical signal upon receiving ultrasonic waves; a sound absorption unit, one surface of which is an installation surface of the ultrasonic transducer and is electrically connected to the ultrasonic transducer; a first electronic circuit electrically connected to the sound absorption unit; and a substrate connection unit disposed between the sound absorption unit and the first electronic circuit, configured to electrically interconnect the first electronic circuit and the sound absorption unit.

The substrate connection unit may include a second electronic circuit configured to electrically interconnect the first electronic circuit and the sound absorption unit.

The second electronic circuit may include a substrate connection unit electrically connected to the first electronic circuit.

The substrate connection unit may include a first substrate connection unit configured to electrically interconnect the sound absorption unit and the first electronic circuit.

The first substrate connection unit may be electrically connected to the ultrasonic transducer.

The sound absorption unit may include at least one first connection unit electrically connected to the ultrasonic transducer, wherein the first substrate connection unit contacts the first connection unit.

The second electronic circuit may include at least one output unit configured to output a signal processed by the first electronic circuit, wherein the substrate connection unit includes a second substrate connection unit configured to electrically interconnect the first electronic circuit and the at least one output unit.

The substrate connection unit may include: a first opening configured to pass through a range from one surface to the other surface of the second electronic circuit; and a conductor installed at an inner lateral surface of the first opening and electrically coupled to the first electronic circuit.

The conductor may be configured to shield the first opening.

The substrate connection unit may further include a second opening formed to pass through the conductor.

The substrate connection unit may further include a filling material configured to shield the second opening.

The conductor may be deposited on an inner lateral surface of the first opening.

The conductor may be installed at one surface of the second electronic circuit located in a vicinity of the first opening.

The second electronic circuit may include a rigid flexible printed circuit board (PCB).

The second electronic circuit may include at least one of a first region that is not curved and a second region that is flexibly curved.

The second electronic circuit may include a substrate connection unit that is electrically connected to the first electronic circuit and is formed in the first region.

A second connection unit (a bump) may be mounted to the first electronic circuit, wherein the second connection unit is attached to the substrate connection unit of the second electronic circuit.

The ultrasonic probe may further include: a separation unit disposed between the second electronic circuit and the first electronic circuit, and formed of a nonconductive material that prevents the second electronic circuit from directly contacting the first electronic circuit.

The second connection unit may be mounted to the first electronic circuit so as to pass through the separation unit.

The ultrasonic probe apparatus may further include: a heat conduction unit mounted to the other surface of the first electronic circuit, and to perform heat transmission of the first electronic circuit.

The sound absorption unit may include: a sound absorption material for absorbing sound; and a first connection unit configured to pass through the sound absorption material so as to electrically interconnect the ultrasonic transducer and the first electronic circuit.

At least one first connection unit may be mounted to a single ultrasonic transducer.

The ultrasonic probe may further include: an acoustic enhancer disposed between the ultrasonic transducer and the sound absorption unit, and configured to amplify the electrical signal generated from the ultrasonic transducer.

The sound absorption unit may be formed of a sound absorption material formed to absorb sound waves or ultrasonic waves.

A seating surface at which the ultrasonic transducer or an acoustic enhancer seated may be formed at one surface of the sound absorption unit, wherein the acoustic enhancer is coupled to the ultrasonic transducer so as to amplify the electrical signal generated from the ultrasonic transducer.

The first electronic circuit may include a processor configured to focus signals generated from the ultrasonic transducer.

The first electronic circuit may include at least one application specific integrated circuit (ASIC).

In accordance with another aspect of the present invention, an ultrasonic imaging apparatus includes: an ultrasonic probe configured to receive ultrasonic waves; and a main body configured to control operations of the ultrasonic probe, and to perform image processing of an ultrasound image corresponding to the received ultrasonic waves. The ultrasonic probe includes: an ultrasonic transducer configured to output an electrical signal upon receiving the ultrasonic waves; a sound absorption unit, one surface of which is an installation surface of the ultrasonic transducer and is electrically connected to the ultrasonic transducer; a first electronic circuit electrically connected to the sound absorption unit; and a substrate connection unit disposed between the sound absorption unit and the first electronic circuit, configured to electrically interconnect the first electronic circuit and the sound absorption unit.

The substrate connection unit may include a second electronic circuit configured to electrically interconnect the first electronic circuit and the sound absorption unit.

The second electronic circuit may include a substrate connection unit electrically connected to the first electronic circuit.

The substrate connection unit may include a first substrate connection unit configured to electrically interconnect the sound absorption unit and the first electronic circuit.

The first substrate connection unit may be electrically connected to the ultrasonic transducer.

The sound absorption unit may include at least one first connection unit electrically connected to the ultrasonic transducer, wherein the first substrate connection unit contacts the first connection unit.

The second electronic circuit may include at least one output unit configured to output a signal processed by the first electronic circuit, wherein the substrate connection unit includes a second substrate connection unit configured to electrically interconnect the first electronic circuit and the at least one output unit.

The second electronic circuit may include a rigid flexible printed circuit board (PCB).

The second electronic circuit may include at least one of a first region that is not curved and a second region that is flexibly curved.

The second electronic circuit may include a substrate connection unit that is electrically connected to the first electronic circuit and is formed in the first region.

A second connection unit may be mounted to the first electronic circuit. The second connection unit may be attached to the substrate connection unit of the second electronic circuit.

The ultrasonic imaging apparatus may further include: a separation unit disposed between the second electronic circuit and the first electronic circuit, and formed of a nonconductive material that prevents the second electronic circuit from directly contacting the first electronic circuit.

The second connection unit may be mounted to the first electronic circuit so as to pass through the separation unit.

The ultrasonic imaging apparatus may further include: a heat conduction unit mounted to the other surface of the first electronic circuit, and to perform heat transmission of the first electronic circuit.

The sound absorption unit may include: a sound absorption material for absorbing sound; and a first connection unit configured to pass through the sound absorption material so as to electrically interconnect the ultrasonic transducer and the first electronic circuit.

At least one first connection unit may be mounted to a single ultrasonic transducer.

The ultrasonic imaging apparatus may further include: an acoustic enhancer disposed between the ultrasonic transducer and the sound absorption unit, and configured to amplify the electrical signal generated from the ultrasonic transducer.

The sound absorption unit may be formed of a sound absorption material configured to absorb sound waves or ultrasonic waves.

A seating surface at which the ultrasonic transducer or an acoustic enhancer seated may be formed at one surface of the sound absorption unit, wherein the acoustic enhancer is coupled to the ultrasonic transducer so as to amplify the electrical signal generated from the ultrasonic transducer.

The first electronic circuit may include a processor configured to focus signals generated from the ultrasonic transducer.

The first electronic circuit may include at least one application specific integrated circuit (ASIC).

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a perspective view illustrating an ultrasonic imaging apparatus according to an embodiment of the present invention.

FIG. **2**A is a block diagram illustrating an ultrasonic imaging apparatus according to an embodiment of the present invention.

FIG. **2**B is a conceptual diagram illustrating a beamforming process according to an embodiment of the present invention.

FIG. **3** illustrates the internal structure of an ultrasonic probe according to an embodiment of the present invention.

FIG. **4** is an exploded perspective view illustrating the internal structure of an ultrasonic probe according to a first embodiment of the present invention.

FIG. **5**A is a conceptual diagram illustrating arrangement of an ultrasonic element unit according to a first embodiment of the present invention.

FIG. **5**B is a conceptual diagram illustrating arrangement of an ultrasonic element unit according to a second embodiment of the present invention.

FIG. **6** is a conceptual diagram illustrating functions of a sound absorption unit.

FIG. **7** is a perspective view illustrating a sound absorption unit according to a first embodiment of the present invention.

FIG. **8** is a plan view illustrating a sound absorption unit according to a first embodiment of the present invention.

FIG. **9** is a lateral perspective view illustrating a sound absorption unit according to a first embodiment of the present invention.

FIG. **10** is a perspective view illustrating a sound absorption unit according to a second embodiment of the present invention.

FIG. **11** is a plan view illustrating a sound absorption unit according to a second embodiment of the present invention.

FIG. **12** is a lateral cross-sectional view illustrating a sound absorption unit according to a second embodiment of the present invention.

FIG. **13** is a view illustrating a sound absorption unit according to a second embodiment of the present invention.

FIG. **14** is a view illustrating a second electronic circuit according to a first embodiment of the present invention.

FIG. **15** illustrates a curved structure of a second electronic circuit.

FIG. **16** is a cross-sectional view illustrating a second electronic circuit.

FIG. **17**A is a plan view illustrating a second electronic circuit including a substrate connection unit according to a first embodiment of the present invention.

FIG. **17**B is an exploded side view illustrating a second electronic circuit including a substrate connection unit according to a first embodiment of the present invention.

FIG. **18**A is a plan view illustrating a second electronic circuit including a substrate connection unit according to a second embodiment of the present invention.

FIG. **18**B is an exploded side view illustrating a second electronic circuit including a substrate connection unit according to a second embodiment of the present invention.

FIG. **19**A is a plan view illustrating a second electronic circuit including a substrate connection unit according to a third embodiment of the present invention.

FIG. **19**B is an exploded side view illustrating a second electronic circuit including a substrate connection unit according to a third embodiment of the present invention.

FIG. **20**A is a plan view illustrating a second electronic circuit including a substrate connection unit according to a fourth embodiment of the present invention.

FIG. **20**B is a bottom view illustrating a second electronic circuit including a substrate connection unit according to a fourth embodiment of the present invention.

FIG. **20**C is an exploded side view illustrating a second electronic circuit including a substrate connection unit according to a fourth embodiment of the present invention.

FIG. **21** is a view illustrating a second electronic circuit according to a second embodiment of the present invention.

FIG. **22**A is a perspective view illustrating a first electronic circuit according to an embodiment of the present invention.

FIG. **22**B is a view illustrating a first electronic circuit according to an embodiment of the present invention.

FIG. **22**C is a view illustrating a heat conduction unit installed at a back surface of the first electronic circuit.

FIG. **23**A is a conceptual diagram illustrating a process for transmitting a control signal to a first processor mounted to an ultrasonic probe.

FIG. **23**B is a conceptual diagram illustrating a process for transmitting a control signal to a first processor mounted to an ultrasonic probe.

FIG. **23**C is a conceptual diagram illustrating a process for transmitting a control signal to an ultrasonic element.

FIG. **24** is a conceptual diagram illustrating a process for irradiating ultrasonic waves using an ultrasonic element.

FIG. **25** is a conceptual diagram illustrating a process for receiving ultrasonic waves using an ultrasonic element.

FIG. **26** is a conceptual diagram illustrating a transmission process of an electrical signal corresponding to ultrasonic waves received by the ultrasonic element

FIG. **27** is a conceptual diagram illustrating a process for transmitting processed signals to a main body.

FIG. **28** is a conceptual diagram illustrating a process for transmitting processed signals to a main body.

FIG. **29** is a conceptual diagram illustrating a process for fabricating a sound absorption unit.

FIG. **30** is a conceptual diagram illustrating a process for fabricating a sound absorption unit.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

FIG. **1** is a perspective view illustrating an ultrasonic imaging apparatus according to an embodiment of the present invention. FIG. **2**A is a block diagram illustrating an ultrasonic imaging apparatus according to an embodiment of the present invention.

Referring to FIGS. **1** and **2**A, the ultrasonic imaging apparatus **1** may include an ultrasonic probe **100** and a main body **200**.

The ultrasonic probe **100** may collect ultrasonic waves, and may transmit an electrical signal corresponding to the collected ultrasonic waves to the main body **200**. In accordance with the embodiment, the ultrasonic probe **100** may perform beamforming of ultrasonic waves of the collected channels, and may also transmit the beamformed signals to the main body **200**.

The main body **200** may control overall operations of the ultrasonic imaging apparatus **1**. In addition, the main body **200** may generate an ultrasound image such as a B-mode image by performing either beamforming or image processing using electrical signals received from the ultrasonic probe **100**, and may display the generated ultrasound image on the display unit **280** for user recognition. In addition, various electronic components for controlling overall operations of either the ultrasonic probe **100** or the main body **200** may be contained in the main body **200**. The main body **200** may receive various commands from the user who uses an input unit **290**, generate a control signal corresponding to the user command, and thus control the ultrasonic imaging apparatus **1**.

The ultrasonic probe **100** may transmit/receive data to/from the main body **200** through a cable **93** or a wireless communication module.

In accordance with one embodiment, the ultrasonic probe **100** and the main body **200** may communicate with each other using the connection cable **93** shown in FIG. **1**. The electrical signal generated from the ultrasonic probe **100** may be transmitted to the main body **200** through the connection cable **93**. In addition, a control command generated from the main body **200** may also be transmitted to the ultrasonic probe **100** through the connection cable **93**.

A connector **94** may be provided at one end of the connection cable **93**. The connector **94** may be detachably coupled to the port **95** provided at the external frame **201** of the main body **200**. If the connector **94** is coupled to the port **95**, the ultrasonic probe **100** and the main body **200** may be interconnected to communicate with each other. In the meantime, according to one embodiment, the ultrasonic probe **100** may be fixed to the other end of the connection cable **93**. That is, the ultrasonic probe **100** and the connection cable may be integrated. In accordance with another embodiment, the connector (not shown) capable of being coupled to or detached from the port contained in the ultrasonic probe **100** may also be provided at the other end of the connection cable **93**.

In accordance with another embodiment, the ultrasonic probe **100** and the main body **200** may transmit electrical signals generated from the ultrasonic probe **100** to the main body **200** over a wireless communication network or may also transmit the electrical signal generated from the main body **200** to the ultrasonic probe **100**. In this case, a wireless communication module including an antenna and a wireless communication chip may be installed in each of the ultrasonic probe and the main body **200**. The wireless communication module may be a short-range wireless communication module based on various short-range communication technologies, for example, Bluetooth, Bluetooth low energy, infrared data association (IrDA), Wireless Fidelity (Wi-Fi), Wi-Fi Direct, Ultra Wideband (UWB), Near Field Communication (NFC), etc. Alternatively, the wireless communication module may be a mobile communication module supporting 3GPP, 3GPP2 or IEEE wireless communication networks defined by the International Telecommunication Union (ITU).

The ultrasonic probe **100** will hereinafter be described in detail.

The ultrasonic probe **100** may receive ultrasonic waves generated from the object, and may convert the received ultrasonic waves into an electrical signal. For convenience of description and better understanding of the present invention, the electrical signal obtained by conversion of the received ultrasonic waves will hereinafter be referred to as an ultrasonic signal.

The ultrasonic probe **100** may include an ultrasonic element unit **110** for generating or receiving ultrasonic waves; and a first processor **130**. The first processor **130** may be electrically connected to the ultrasonic element unit **110**, may control operations of the ultrasonic element unit **110**, or may perform signal processing using the electrical signal generated from the ultrasonic element unit.

The ultrasonic element unit **110** may include an ultrasonic transducer for generating ultrasonic waves or generating an electrical signal corresponding to the ultrasonic waves. The ultrasonic transducer may convert AC (Alternating Current) energy having a predetermined frequency into mechanical vibration having the same frequency, may generate ultrasonic waves, or may convert mechanical vibration having a predetermined frequency based on ultrasound into AC energy. Therefore, the ultrasonic transducer may generate ultrasonic waves or may output electrical signals corresponding to the received ultrasonic waves. In more detail, upon receiving AC power from a battery or the like, a piezoelectric vibrator or a thin film of the ultrasonic transducer vibrates according to the AC power, such that a plurality of ultrasonic waves is generated.

Here, the ultrasonic transducer may be one of, for example, a magnetostrictive ultrasonic transducer using the magnetostrictive effect of a magnetic body, a piezoelectric ultrasonic transducer using the piezoelectric effect of a piezoelectric material, and a capacitive micromachined ultrasonic transducer (cMUT) transmitting/receiving ultrasonic waves using vibration of hundreds or thousands of micromachined thin films. Further, the ultrasonic transducer may be one of other kinds of transducers which may generate ultrasonic waves according to an electrical signal or generate an electrical signal according to ultrasonic waves.

Referring to FIG. **2**A, the ultrasonic element unit **110** may include an ultrasonic transmission element **110**a and an ultrasonic reception element **110**b. The ultrasonic transmission element **110**a may generate ultrasonic waves having a frequency corresponding to a frequency of a pulse signal according to a pulse signal received from the first processor **130** or the second processor **220**. The generated ultrasonic waves may be irradiated to a target site **98** of the object **99**. The generated ultrasonic waves may be focused on at least one target site **98** contained in the object **99**. In this case, the irradiated ultrasonic waves may be focused on a single target site **98** (i.e., single focusing), and may also be focused on a plurality of target sites **98** (i.e., multi-focusing).

The ultrasonic reception element **110**b may receive ultrasonic waves reflected from the target site **98** or may receive ultrasonic waves generated from the target site **98** according to laser or the like, and may convert the received signals into an ultrasonic signal. The ultrasonic reception element **110**b may include a plurality of ultrasonic transducers, each of which outputs an ultrasonic signal, so that the ultrasonic reception element **110**b may output ultrasonic signals of a plurality of channels.

In accordance with the embodiment, the ultrasonic element unit **110** may include ultrasonic transmission/reception (Tx/Rx) elements (not shown) capable of generating and receiving ultrasonic waves. In this case, the ultrasonic transmission element **110**a and the ultrasonic reception element **110**b may be omitted as necessary.

The ultrasonic element unit **110** may be mounted to one surface of the sound absorption unit **120**. A first connection unit **121** corresponding to each ultrasonic element unit **110** may be mounted to the sound absorption unit **120**. In accordance with one embodiment, the first connection unit **121** may be mounted to the sound absorption unit **120** after passing through the sound absorption unit **120**. In this case, the first connection unit **121** may be installed to pass through the range from one surface to the other surface of the sound absorption unit **120**. In this case, one surface may indicate a surface to which the ultrasonic element unit **110** is mounted, and the other surface may indicate a surface to which the substrate connection unit (e.g., a second electronic circuit) is mounted. A detailed description of the sound absorption unit **120** and the first connection unit **121** will be given below.

The first processor **130** may generate and output the electrical signal for controlling the ultrasonic element unit **110**, or may perform various kinds of signal processing using an ultrasonic signal received from the ultrasonic element unit **110**.

The electrical signal generated from the first processor **130** may be transferred to the ultrasonic element unit **110** (e.g., the ultrasonic transmission element **110**a) through the first connection unit **121**. The ultrasonic transmission element **110**a may be driven in response to the received electrical signal. In addition, the first processor **130** may receive the electrical signal corresponding to ultrasonic waves received by the ultrasonic element unit **110** (e.g., the ultrasonic reception element **110**b) through the first connection unit **121**.

The first processor **130** may be implemented by at least one semiconductor chip and associated electronic components. In accordance with the embodiment, the first processor **130** may also be implemented by at least one Application Specific Integrated Circuit (ASIC).

In accordance with the embodiment shown in FIG. **2**A, the first processor **130** may include at least one of a pulser **131**, an amplifier **132**, an analog-to-digital converter (ADC) **133**, and a beamformer **134**.

The pulser **131** may generate a voltage having a predetermined frequency for driving the ultrasonic element unit **110**, and may transmit the generated voltage to the ultrasonic element unit **110**. The ultrasonic element unit **110** may be vibrated according to an amplitude and frequency of the output voltage of the pulser **131**, and thus generate ultrasonic waves. The frequency and intensity of ultrasonic waves generated from the ultrasonic element unit **110** may be determined according to the amplitude and frequency of the voltage generated from the pulser **131**. The output voltage of the pulser **131** may be applied to the ultrasonic element unit **110** at intervals of a predetermined time, so that ultrasonic waves generated from the ultrasonic element unit **110** may be focused on the target site **98** or may be steered in a specific direction.

In accordance with the embodiment, the pulser **131** may be mounted to the second processor **221**. In this case, the first processor **130** may not include the pulser **131**.

The amplifier (AMP) **132** may amplify ultrasonic signals generated from the ultrasonic reception element **110**b of the ultrasonic element unit **110**. A gain of the amplifier **132** may be arbitrarily determined by a system designer or a user. The amplifier **132** may differently amplify multi-channel ultrasonic signals generated from the plurality of ultrasonic element units **110** according to the embodiment, so that a difference in intensity between multi-channel ultrasonic signals can be compensated for.

If the amplified ultrasonic signals are analog signals, the ADC **132** may convert the analog signals into digital signals. The ADC **132** may perform sampling of ultrasonic signals acting as analog signals according to a predetermined sampling rate, so that it may output a digital signal.

A beamformer (B.F) **134** may focus ultrasonic signals input to a plurality of channels. The beamformer **134** may focus signals received from the ultrasonic element unit **110**, the amplifier **132** or the ADC **133**, and thus generate the beamformed signal. The beamformer **134** may perform various functions of multi-channel signals, for example, electronic beam scanning-, steering-, focusing-, apodizing-, and aperture-functions of multi-channel signals.

FIG. **2**B is a conceptual diagram illustrating a beamforming process according to an embodiment of the present invention.

In accordance with the embodiment, the beamformer **134** may include a time-difference correction unit **135** and a receiver focusing unit **136** as shown in FIG. **2**B.

The time-difference correction unit **135** may correct a time difference between multi-channel ultrasonic signals. There may arise a time difference between multi-channel ultrasonic signals generated from several ultrasonic element units **110** according to a distance from the target **98** to each ultrasonic element unit **110** or characteristics of the ultrasonic element unit **110**. The time-difference correction unit **135** may delay transmission of some parts of multi-channel signals, so that it may correct a time difference between multi-channel signals. The time-difference correction unit **135** may be mounted to each channel of ultrasonic signals generated from the ultrasonic element unit **110**.

The receiver focusing unit **136** may synthesize multi-channel ultrasonic signals, a time difference of which is corrected by the time-difference correction unit **135**. The receiver focusing unit **136** may synthesize multi-channel ultrasonic signals by applying a predetermined weight to ultrasonic signals of respective channels. The predetermined weight may be determined irrespective of the ultrasonic signals, and may also be determined according to the ultrasonic signals. According to the synthesizing result of multi-channel ultrasonic signals, the receiver focusing unit **136** may output the beamformed signal. The beamformed signal may be transferred to the main body **200**.

If the beamformer **134** is mounted to the first processor **130**, it is necessary for the ultrasonic probe **100** to transmit only the beamformed signal to the main body **200**. Accordingly, since the ultrasonic probe **100** need not transmit ultrasonic signals of all channels to the main body **200**, system complexity can be reduced whereas system reliability can be increased.

The pulser **131**, the amplifier **132**, the ADC **133**, and the beamformer **134** of the first processor **130** may be logically separated from each other. In this case, the first processor **130** may be implemented by one semiconductor chip and associated electronic components. In accordance with another embodiment, the pulser **131**, the amplifier **132**, and the ADC **133**, and the beamformer **134** of the first processor **130** may also be physically separated from each other. If the pulser **131**, the amplifier **132**, and the ADC **133**, and the beamformer **134** of the first processor **130** are physically separated from each other, each thereof may be implemented by one or at least two semiconductor chips and associated electronic components.

In accordance with the embodiment, at least one of the amplifier **132**, the ADC **134**, and the beamformer **134** of the first processor **130** may also be mounted to the main body **200**. In this case, at least one of the amplifier **132**, the ADC **134**, and the beamformer **134** may be implemented by a Central Processing Unit (CPU) mounted to the main body **200** or a Graphics Processing Unit (GPU). If the amplifier **132**, the ADC **134**, and the beamformer **134** are mounted to the main body **200**, signals generated from the ultrasonic element unit **110** may also be transferred to the main body **200** without conversion.

For example, the ultrasonic probe **100** may be a linear array probe, a convex array probe, or a sector phased array probe. In addition, the ultrasonic probe **100** may be a mechanical sector array probe.

A detailed internal structure of the ultrasonic probe **100** will hereinafter be described in detail.

The main body **200** will hereinafter be described with reference to FIG. **2**A.

Referring to FIG. **2**A, the main body **200** may include a signal processing unit **210**, an image processing unit **211**, a volume data generation unit **212**, a storage unit **213**, and a controller **220**.

The signal processing unit **210** may perform signal processing of the beamformed signal in various ways. For example, the signal processor **210** may perform at least one of a filtering process, a detection process, and a compression process. The filtering process includes applying a filter to the beamformed signal so as to remove signals other than signals of a specific bandwidth. The filtering process may include a harmonic imaging process for removing a basic frequency component and passing harmonic signals. A detection process may convert a radio frequency (RF) format of a voltage of an ultrasonic signal into a video signal format. The compression process may reduce a difference in amplitude between ultrasonic signals. The signal processing unit **210** may be omitted as necessary.

The image processing unit **211** may convert the beamformed signal or signals processed by the signal processing unit **210** into an ultrasound image based on a still image or an ultrasound image based on a moving image. In addition, the image processing unit **211** may perform predetermined image processing of a still image or moving image.

The image processing unit **211** may generate an ultrasound image using scan conversion. The generated ultrasound image may include an A-mode ultrasound image, a B-mode ultrasound image, or an M-mode ultrasound image. The A-mode ultrasound image may indicate an ultrasound image obtained when reflection intensity is amplitude-imaged on the basis of the distance or time from the target site **98** to the ultrasonic probe **100**. The B-mode ultrasound image may indicate an ultrasound image obtained when the ultrasonic intensity is represented using brightness. The M-mode ultrasound image may indicate an ultrasound image obtained when a variation of the operations of the object is imaged. The ultrasound image may include a Doppler image based on the Doppler effect.

The image processing unit **211** may correct the generated ultrasound image. For example, the image processing unit **211** may correct brightness, luminance, sharpness, contrast, or color of all or some regions of the ultrasound image in such a manner that a user can definitely view tissues contained in the ultrasound image. The image processing unit **211** may remove noise from the ultrasound image or may perform pixel interpolation of the ultrasound image.

The image processing unit **211** may transmit the generated or corrected ultrasound image to the storage unit **213** or may display the generated or corrected ultrasound image on the display unit **280**. In addition, the image processing unit **211** may transmit the generated or corrected ultrasound image to the volume data generation unit **212**, so that it can obtain ultrasonic volume data.

The volume data generation unit **212** may obtain ultrasonic volume data that indicates a three-dimensional (3D) volume using a two-dimensional (2D) ultrasound image generated or corrected by the image processing unit **211**.

The signal processing unit **210**, the image processing unit **211**, or the volume data generation unit **212** may be implemented by a CPU or GPU. The CPU or GPU may be implemented by one or at least two semiconductor chips and associated electronic components.

The storage unit **213** may store various programs associated with functions of the controller **200**, data, ultrasound images, and various kinds of information associated with the ultrasound images. The storage unit **213** may be implemented using a semiconductor storage unit, a magnetic disc storage unit, a magnetic tape storage unit, or the like.

The controller **220** may control overall operations of the ultrasonic imaging apparatus **1** according to a user command or a predefined configuration. For example, after the controller **220** generates a predetermined control command according to a frequency of ultrasonic waves to be irradiated, the controller **220** may transmit the generated control command to the pulser **131** of the first processor **130**. The pulser **131** may apply a voltage having a predetermined frequency to the ultrasonic element unit **110** according to a control command. Accordingly, the ultrasonic element unit **110** may generate ultrasonic waves having a predetermined frequency, and thus apply the ultrasonic waves to the target site **98** of the object **99**.

The controller **220** may include a second processor **221**; and a storage unit **222**, such as ROM or RAM, to assist the operations of the second processor **221**. The second processor **221** may be implemented by a CPU. The CPU may be implemented by one or at least two semiconductor chips and associated electronic elements.

The display unit **280** may display an ultrasound image for user recognition. The display unit **280** may use a plasma display panel (PDP), a light emitting diode (LED), a liquid crystal display (LCD), or the like. The LED may include an organic light emitting diode (OLED). In addition, the display unit **280** may use a 3D display configured to represent a 3D image.

The input unit **290** may receive various commands related to control of the ultrasonic imaging apparatus **1** from the user. The input unit **290** may output an electrical signal in response to user manipulation, and may transmit the electrical signal to the second processor **220**.

The input unit **290** may include a manipulation panel **291** to which various input devices are installed. For example, the input devices may include at least one of a keyboard, a mouse, a track ball, a knob, a touchpad, a paddle, various levers, a handle, a joystick, and various input devices.

The input unit **290** may include a touchscreen unit **292**. The user may input various commands by touching a touch panel using a touch tool, such as a finger or a touch pen, of the touchscreen unit **292**.

The touchscreen unit **292** may be implemented by a resistive touchscreen panel or a capacitive touchscreen panel. In addition, the touchscreen unit **292** may also use ultrasonic waves or infrared light.

The internal structure of the ultrasonic probe **100** will hereinafter be described in detail.

FIG. **3** illustrates the internal structure of an ultrasonic probe according to an embodiment of the present invention. FIG. **4** is an exploded perspective view illustrating the internal structure of an ultrasonic probe according to a first embodiment of the present invention.

Referring to FIGS. **3** and **4**, the ultrasonic probe **100** may include an acoustic lens **109** installed at one end of the probe housing **107**; an ultrasonic element unit **110** located close to the acoustic lens **109**; a sound absorption unit **120**, one surface of which contacts the ultrasonic element unit **110** seated therein; a second electronic circuit acting as a substrate connection unit installed at the other surface of the sound absorption unit **120**; a first electrical circuit **150** electrically connected to the second electronic circuit and disposed at the other surface of the second electronic circuit **140**; a heat conduction unit **160** configured to absorb heat generated from the first electronic circuit **150**; and a conductive line (or a conductive wire) **108** configured to transmit the electrical signal generated from the first electronic circuit **150** to the main body **200**.

The ultrasonic element unit **110**, the sound absorption unit **120**, the second electronic circuit **140**, the first electronic circuit **150**, the heat conduction unit **160**, and the conductive line **180** may be installed in the probe housing **107**. A cable **93** may be fixed to the other end of the probe housing **107** or may be detached from the other end of the probe housing **107**.

The housing **107** may allow various electronic components of the ultrasonic probe **100** to be stably fixed, or may protect the electronic components from external impact. The housing **107** may be implemented by various metals or synthetic resins, and may be formed in various shapes according to a use purpose of the ultrasonic probe **100** or according to categories of objects or target sites.

The acoustic lens **109** may focus or emit sound waves or ultrasonic waves. The acoustic lens **109** may focus ultrasonic waves generated from the ultrasonic element unit **110** on the target site **98**. The acoustic lens **109** may be formed of glass or synthetic fibers.

The ultrasonic element unit **110** may be mounted to one surface of the sound absorption unit **120**. The ultrasonic element unit **110** may contact the acoustic lens **109** or may be disposed close to the acoustic lens **109**.

FIG. **5**A is a conceptual diagram illustrating arrangement of an ultrasonic element unit according to a first embodiment of the present invention.

Referring to FIG. **5**A, the ultrasonic element unit **110** may include a matching layer **111** capable of being implemented as one or at least two layers, an ultrasonic transducer **113**, and an acoustic enhancer **114**.

The matching layer **111** may maintain straightness or intensity of the ultrasonic waves generated from the ultrasonic transducer **113**, or may minimize the problem in that the emitted ultrasonic waves do not reach the target site **98** and are reflected from a surface of the object **99** (e.g., the skin of a human being).

The matching layer **111** may include a plurality of matching layers, i.e., a first matching layer **111**a and a second matching layer **111**b. Each of the first matching layer **111**a and the second matching layer **111**b may be formed of a material having medium impedance between impedance of each transducer **113** and tissue impedance. If the matching layer **111** includes a plurality of matching layers (**111**a, **111**b), the respective matching layers (**111**a, **111**b) may contact each other.

One surface of the first matching layer **111**a may contact the acoustic lens **109** or may be disposed close to the acoustic lens **109**. The other surface of the first matching layer **111**a may be attached to one surface of the second matching layer **111**b. The ultrasonic transducer **113** may be attached to the other surface of the second matching layer **111**b. In this case, one ultrasonic element unit **110** may also be attached to the other surface of the second matching layer **111**b, and a plurality of ultrasonic element units may also be attached thereto.

In accordance with the embodiment, the acoustic matching layer **111** may include only one matching layer or may also include three or more matching layers.

As described above, the ultrasonic transducer **113** may convert the ultrasonic waves into electrical signals or vice versa. One surface of the ultrasonic transducer **113** may be attached to the second matching layer **111**b.

The acoustic enhancer **114** may be attached to the other surface of the ultrasonic transducer **113**. The acoustic enhancer **114** may amplify signals received from the first connection unit **121** so that the ultrasonic transducer **113** may generate the amplified ultrasonic waves. The ultrasonic transducer **113** may be attached to one surface of the acoustic enhancer **114**. The other surface facing one surface of the acoustic enhancer **114** may contact the sound absorption unit **120** and the first connection unit **121**. The acoustic enhancer **114** may be formed of a conductive material through which electricity flows.

FIG. **5**B is a conceptual diagram illustrating arrangement of an ultrasonic element unit according to a second embodiment of the present invention.

Referring to FIG. **5**B, the acoustic enhancer **114** may be omitted, and only the matching layer **111** and the ultrasonic transducer **113** may be installed. In this case, the sound absorption unit **120** and the first connection unit **121** may be directly mounted to the ultrasonic transducer **113**. The matching layer **111** and the ultrasonic transducer **113** are identical to those of FIG. **5**A, and as such a detailed description thereof will herein be omitted for convenience of description.

Embodiments of the sound absorption unit **120** in which the ultrasonic element unit **110** is seated will hereinafter be described in detail.

FIG. **6** is a conceptual diagram illustrating functions of the sound absorption unit. FIG. **7** is a perspective view illustrating the sound absorption unit according to a first embodiment of the present invention. FIG. **8** is a plan view illustrating the sound absorption unit according to a first embodiment of the present invention. FIG. **9** is a lateral perspective view illustrating the sound absorption unit according to a first embodiment of the present invention.

As shown in FIG. **4**, the ultrasonic element unit **110** may be attached to one surface of the sound absorption unit **120** according to the first embodiment, and the second electronic circuit **140** acting as the substrate connection unit may be attached to the other surface facing one surface.

Referring to FIG. **6**, if the ultrasonic transducer **113** of the ultrasonic element unit **110** generates ultrasonic waves in response to a reception voltage, the generated ultrasonic waves may be emitted in the direction (u**1**) of the object, and may also be emitted in the direction (u**2**) of the sound absorption unit. As described above, the ultrasonic waves (u**2**) emitted in the direction of the sound absorption unit may cause noise in the ultrasound image. In order to prevent the occurrence of noise, the sound absorption unit **120** may be formed of a sound absorption material **122**. The sound absorption material **122** may be a material capable of absorbing sound waves or ultrasonic waves. The sound absorption material **112** may absorb ultrasonic waves emitted in the direction from the ultrasonic transducer **113** to the sound absorption unit, and may reduce intensity of ultrasonic waves proceeding in an undesired direction. As a result, noise capable of being generated in the ultrasound image can be reduced.

The sound absorption material **122** of the sound absorption unit **120** may be formed of epoxy resin or a hafnium oxide material such as hafnium oxide metal powder. In addition, the sound absorption material **122** may be a mixture of epoxy resins, metals, and various synthetic resins. In addition, various materials capable of providing a function of absorbing sound waves or ultrasonic waves may be used as the sound absorption material **122**.

In accordance with one embodiment, the sound absorption material **122** may be formed in a hexahedral shape as shown in FIGS. **7** to **9**. The sound absorption material **122** may be formed in any of various columns or spheres. The external appearance of the sound absorption material **122** may be arbitrarily determined according to selection of a system designer.

Referring to FIGS. **4** to **9**, at least one first connection unit **121** configured to pass through the range from one surface **122**a to the other surface of the sound absorption material **122** may be mounted to the sound absorption material **122**. Here, the other surface may be a surface facing one surface **122**a of the sound absorption material **120**. The first connection unit **121** may be provided to pass through the sound absorption material **122**, so that the first connection unit **121** may be exposed to the outside at both of one surface **122**a and the other surface of the sound absorption material **122**.

The first connection unit **121** may be formed of a conductive material through which electricity flows. In this case, the conductive material may be any one of various metals through which electricity flows, for example, copper (Cu), gold (Au), or the like. Therefore, the first connection unit **121** may transmit an electrical signal generated from the ultrasonic element unit **110** to either the first electronic circuit **150** or the second electronic circuit **140**, or may transmit an electrical signal generated from the first electronic circuit **150** or the second electronic circuit **140** to the ultrasonic element unit **110**.

The first connection unit **121** may be formed in a hexahedral shape as shown in FIGS. **7** to **9**. However, the shape of the first connection unit **121** is not limited thereto. In accordance with the embodiment, the first connection unit **121** may be formed in a cylindrical shape or various polygonal shapes. The shape of the first connection unit **121** may also be arbitrarily determined according to selection of a system designer.

The ultrasonic element unit **110** may be mounted to one surface **122**a of the sound absorption material **122**. In this case, one surface **122**a of the sound absorption material **122** may also be formed in a planar shape. In addition, one surface **122**a of the sound absorption material **122** may be formed as a curved surface having a predetermined curvature.

Referring to FIGS. **7** and **8**, one or at least two seating units **125** in which the ultrasonic element unit **110** is seated may be mounted to one surface **122**a of the sound absorption material **122**. The seating unit **125** may include a seating surface **124** and a groove **123** formed in the vicinity of the seating surface **124**. The ultrasonic element unit **110** may be disposed on the seating surface **124**. In accordance with the embodiment, the ultrasonic transducer **113** may be disposed on the seating surface **124**, or the acoustic enhancer **124** may be disposed thereon. The groove **123** may separate the seating surface **124** and other parts of one surface **122**a from each other.

One end of the first connection unit **121** may be exposed on the seating surface **124**. As described above, the first connection unit **121** may be formed to pass through the range from one surface **122**a to the other surface of the sound absorption material **120**. In this case, one first connection unit **121** may be exposed on the single seating surface **124**. The first connection unit **121** may be exposed to the outside either at the center part of the seating surface **124** or in the vicinity of the center part of the seating surface **124**. If the ultrasonic element unit **110** is seated on the seating surface **124**, the first connection unit **121** may contact one end of the ultrasonic element unit **110**. Therefore, the first connection unit **121** may be electrically coupled to the ultrasonic element unit **110**.

The second electronic circuit **140** may be mounted to the other surface of the sound absorption material **122**.

FIG. **10** is a perspective view illustrating the sound absorption unit according to a second embodiment of the present invention. FIG. **11** is a plan view illustrating the sound absorption unit according to a second embodiment of the present invention. FIG. **12** is a lateral cross-sectional view illustrating the sound absorption unit according to a second embodiment of the present invention. FIG. **13** is a view illustrating the sound absorption unit according to a second embodiment of the present invention.

Referring to FIGS. **10** to **12**, the sound absorption unit **120**a of the second embodiment may include a sound absorption material **122**, one surface **122**a of which contacts the ultrasonic element unit **110** in the same manner as in the sound absorption unit **120** of the first embodiment. The first connection unit **121** may be configured to pass through the range from one surface **122**a to the other surface of the sound absorption material **122**.

One or at least two seating units **125** may be provided at one surface **122**a of the sound absorption unit **120**a of the second embodiment. The seating unit **125** may include a seating surface **124** and a groove **124** formed in the vicinity of the seating surface **124**.

A plurality of first connection units (**121**a to **121**d) may be exposed on the seating surface **124**. As can be seen from FIGS. **10** to **13**, each of the first connection units (**121**a to **121**d) may be exposed to the outside at the corners of the seating surface **124**. As can be seen from FIG. **13**, if the ultrasonic element unit **110** is seated on the seating surface **124**, the first connection units (**121**a to **121**d) may contact one end of the ultrasonic element unit **110**, and may contact, for example, one surface of the acoustic enhancer **114**. In other words, the first connection units (**121**a to **121**d) may support one ultrasonic element unit **110**. Therefore, the first connection units (**121**a to **121**d) may be electrically connected to the ultrasonic element unit **110**.

The first connection units (**121**a to **121**d) may have various shapes according to embodiments. For example, each of the first connection units (**121**a to **121**d) may be formed in a prismatic or cylindrical shape. Besides, the first connection units (**121**a to **121**d) may be selected by the system designer. An exposed surface of each first connection unit (**121**a to **121**d) of the sound absorption unit **120**a of the second embodiment may be identical in width to or be smaller or larger in width than the first connection unit **121** of the sound absorption unit **120** of the first embodiment.

The second electronic circuit **140** will hereinafter be described as an example of the substrate connection unit.

In accordance with the embodiment, the substrate connection unit may include the second electronic circuit **140**.

FIG. **14** is a view illustrating the second electronic circuit according to a first embodiment of the present invention. FIG. **15** illustrates a curved structure of the second electronic circuit. FIG. **16** is a cross-sectional view illustrating the second electronic circuit.

In accordance with the embodiment, the second electronic circuit **140** may include a substrate, various circuits formed on the substrate, and a semiconductor chip or other electronic components connected to the various circuits. In accordance with the embodiment, at least one of the substrate, the various circuits formed on the substrate, the semiconductor chip or other electronic components connected to the various circuits may be omitted as necessary.

Referring to FIG. **14**, the substrate of the second electrical circuit **140** may be a rigid flexible PCB. The rigid flexible PCB may be a multi-layered substrate composed of a flexible PCB **144** and a rigid PCB **145**. In more detail, the rigid flexible PCB may be implemented by overlapping the rigid substrate **145** with some parts of the flexible substrate **144**.

The flexible substrate **144** may be easily bent, and the rigid substrate **145** may not be easily bent. Therefore, as shown in **144**a and **144**b of FIG. **15**, one region (e.g., a first region) of the second electronic circuit **140** may be flexibly curved in various directions. The other region, for example, the second region, may not be curved. In this case, the statement that the above region is not curved does not indicate that the above region is not curved at all, but indicates that the above region is not generally used as a curved form.

An output unit **146** for communicating with the external part and its associated various circuits and electronic components may be mounted to the flexible substrate **144**. A port coupled to the connector provided at the end of the external conductive line **147** may be included in the output unit **146**.

For example, the flexible substrate **144** may have a multi-layered structure as shown in FIG. **16**. In more detail, the flexible substrate **144** may include a plurality of polyimide cover layers (**1441**, **1447**), a plurality of polyimide substrate layers (**1443**, **1445**), and an adhesive layer to which the polyimide cover layers and the polyimide substrate layers are adhered.

Various electronic components related to control of the ultrasonic probe **100** may be mounted to the rigid substrate **145**. The rigid substrate **145** may be formed of a rigid material **1451**. The rigid material **1451** may be attached to the polyimide cover layers (**1441**, **1447**) of the flexible substrate **144** through an adhesive. The substrate connection unit **141** may be formed on the rigid substrate **145**.

As shown in FIGS. **4** and **16**, the substrate connection unit **141** may pass through the second electronic circuit **140**. In this case, the substrate connection unit **141** may pass through the flexible substrate **144** and the rigid substrate **145**. The substrate connection unit **141** may be electrically coupled to the first electronic circuit **150**.

Referring to FIG. **4**, the substrate connection unit **141** may include a first substrate connection unit **142** configured to electrically interconnect the first connection unit **121** and the first electronic circuit **150**; and a second substrate connection unit **143** configured to electrically interconnect the output unit **146** of the second electronic circuit **140** and the first electronic circuit **150**.

One end of the first substrate connection unit **142** may contact a third connection unit **153** of the first electronic circuit **150**, and the other end thereof may contact the first connection unit **121** of the sound absorption unit **120**. Therefore, the first substrate connection unit **142** may be electrically coupled to the third connection unit **153** and the first connection unit **121**. Therefore, the first substrate connection unit **142** may transmit the electrical signal generated from the third connection unit **153** of the first electronic circuit **150** to the first connection unit **121** of the sound absorption unit **120**. The first substrate connection unit **142** may be provided at a specific part to which the flexible substrate **144** and the rigid substrate **145** are attached. In this case, the first substrate connection unit **142** may pass through both substrates (**144**, **145**). The first substrate connection unit **142** may be concentrated at a specific position (see 'A' of FIG. **4**) in such a manner that the first substrate connection unit **142** can contact the first connection unit **121** of the sound absorption unit **120**.

One end of the second substrate connection unit **143** may be coupled to a fourth connection unit **154** of the first electronic circuit **150**, and the other end or the center part of the second substrate connection unit **143** may be electrically coupled to the output unit **146**. In this case, the second substrate connection unit **143** may be electrically connected to the output unit **146** through the second electronic circuit **140** (e.g., a circuit provided at a flexible substrate **144**). The electrical signal generated from the fourth connection unit **154** of the first electronic circuit **150** may be applied to the output unit **146** through the second substrate connection unit **143**. The second substrate connection unit **143** may pass through both substrates (**144**, **145**) at a specific part to which the flexible substrate **144** and the rigid substrate **145** are attached. The second substrate connection unit **143** may be provided at a specific position (see 'B' of FIG. **4**) at which the second substrate connection unit **143** does not contact the first connection unit **121** of the sound absorption unit **120**. For example, the second substrate connection unit **143** may be installed at a specific position of the rigid substrate **145**, where the specific position corresponds to the outer wall of the sound absorption unit **120**.

Although only the mutual connection parts of the first substrate connection unit **142** and the second substrate connection unit **143** are different from each other, the first substrate connection unit **142** and the second substrate connection unit **143** may be identical in shape. Of course, according to some embodiments, the first substrate connection unit **142** may be different in shape from the second substrate connection unit **143** may be different from each other.

Various embodiments of the substrate connection unit **141** will hereinafter be described in detail.

FIG. **17**A is a plan view illustrating the second electronic circuit including the substrate connection unit according to a first embodiment of the present invention. FIG. **17**B is an exploded side view illustrating the second electronic circuit including the substrate connection unit according to a first embodiment of the present invention.

The substrate connection unit **141** may include a via hole. As shown in FIGS. **17**A and **17**B, the substrate connection unit **1420** of the first embodiment may include a via hole. The via hole may include a first opening (also called a first aperture) **1421** that passes through the range from one surface to the other surface of the second electronic circuit **140**, and a conductive material **1422** mounted to the inner lateral surface of the first opening **1421**.

The first opening **1421** may have a circular shape from the viewpoint of a vertical upward direction of the second electronic circuit **140**. In accordance with the embodiment, the first opening **1421** may have a polygonal shape such as a triangular or rectangular shape. In addition, the first opening **1421** may also have an elliptical shape. The first opening **1421** may be formed in the second electronic circuit **140** by puncturing the second electronic circuit **140** using a puncturing machine such as an electric drill.

The conductor **1422** may be provided at an inner lateral surface of the first opening **1421**. In more detail, a conductive material such as metal is deposited on the inner lateral surface of the first opening **1421**, so that the conductor **1422** may be provided at the inner lateral surface of the first opening **1421**. A second opening **1423** may further be formed at the center part of the conductor **1422**. The second opening **1423** may have a circular or polygonal shape. In addition, the conductor **1422** may protrude in the opposite direction from the center part of the second opening **1423** at both surfaces of the second electronic circuit **140**, and some parts of both surfaces of the second electronic circuit **140** may be deposited as shown in **1422**a and **1422**b.

FIG. **18**A is a plan view illustrating the second electronic circuit including the substrate connection unit according to a second embodiment of the present invention. FIG. **18**B is an exploded side view illustrating the second electronic circuit including the substrate connection unit according to a second embodiment of the present invention.

Referring to FIGS. **18**A and **18**B, the substrate connection unit **1430** of the second embodiment may include a first opening **1431** configured to pass through the range from one surface to the other surface of the second electronic circuit **140**; a conductor **1432** formed at the inner lateral surface of the first opening **1431** and including a second opening **1433** formed at an inner surface; and a filter **1434** configured to shield the second opening **1433**.

In the same manner as described above, the first opening **1431** may have a polygonal shape such as a circular, triangular, or rectangular shape or other shapes such as an elliptical shape from the viewpoint of a vertical upward direction of the second electronic circuit **140**. The first opening **1431** may be formed in the second electronic circuit **140** by puncturing the second electronic circuit **140**.

The conductor **1432** may be provided at the inner lateral surface of the first opening **1431** by depositing a conductive material on the inner lateral surface of the first opening **1431**. The second opening **1433** provided at the conductor **1432** may have a circular or polygonal shape.

The filling material **1434** is inserted into the second opening **1433** so as to shield the second opening **1433**. The filling material **1434** may be formed of a material having no conductivity. The filling material **1434** may also be formed of any of various synthetic resins.

In the case of the substrate connection unit **1430** of the second embodiment, the conductor **1432** protrudes in the opposite direction from the center part of the second opening **1433** at both surfaces of the second electronic circuit **140**, and some parts of both surfaces of the second electronic circuit **140** may be deposited as shown in **1432**a and **1432**b.

FIG. **19**A is a plan view illustrating the second electronic circuit including the substrate connection unit according to a third embodiment of the present invention. FIG. **19**B is an exploded side view illustrating the second electronic circuit including the substrate connection unit according to a third embodiment of the present invention.

Referring to FIGS. **19**A and **19**B, the substrate connection unit **1440** of the third embodiment may include a first opening **1441** configured to pass through the range from one surface to the other surface of the second electronic circuit **140**; and a conductor **1442** provided at the inner surface of the first opening **1441**. The conductor **1442** may completely shield the first opening **1441**. In other words, the conductor **1442** may not form the second openings (**1423**, **1433**) as described above.

In the same manner as described above. the first opening **1441** may have various shapes, and may be formed in the second electronic circuit **140** using a puncturing machine.

FIG. **20**A is a plan view illustrating the second electronic circuit including the substrate connection unit according to a fourth embodiment of the present invention. FIG. **20**B is a bottom view illustrating the second electronic circuit including the substrate connection unit according to a fourth embodiment of the present invention. FIG. **20**C is an exploded side view illustrating the second electronic circuit including the substrate connection unit according to a fourth embodiment of the present invention.

Referring to FIGS. **20**A to **20**C, the substrate connection unit **1450** of the fourth embodiment may include a first opening **1451** configured to pass through the range from one surface to the other surface of the second electronic circuit **140**; and a conductor **1452** installed at the inner lateral surface of the first opening unit **1451**.

In the same manner as described above, the first opening **1451** may have various shapes, and may be formed in the second electronic circuit **140** using the puncturing machine.

The conductor **1452** may be provided at the inner lateral surface of the first opening **1451** by depositing a metal material or the like on the inner lateral surface of the first opening **1451**. The second openings (**1423**, **1433**) may be formed at a center part of the conductor **1452**, or may not be formed at the center part of the conductor **1452**.

Meanwhile, the conductor **1452** may protrude in the opposite direction form the center part of the second opening **1423** at only one surface of the second electronic circuit **140** (see **1452**b). In other words, the conductor **1452** may not be deposited on any one surface of the second electronic circuit **140**, or may be deposited only on the other surface of the second electronic circuit **140**.

FIG. **21** is a view illustrating a second electronic circuit according to a second embodiment of the present invention.

Referring to FIG. **21**, the second electronic circuit **140** may include a plurality of output units (**146**, **148**). The output units (**146**, **148**) may be provided at the flexible substrate **145**. The output units (**146**, **148**) may output different electrical signals, and may transmit the different electrical signals to the main body **200**. The respective output units (**146**, **148**) may be connected to different second substrate connection units **143**. The different second substrate connection units **143** may transmit the electrical signals generated from the first electronic circuit **150** to the respective output units (**146**, **148**).

The first electronic circuit will hereinafter be described in detail.

FIG. **22**A is a perspective view illustrating a first electronic circuit according to an embodiment of the present invention. FIG. **22**B is a view illustrating the first electronic circuit according to an embodiment of the present invention.

In accordance with the embodiment, the first electronic circuit **150** may include a substrate, various circuits formed on the substrate, and a semiconductor chip and various electronic components connected to the various circuits. For example, the first electronic circuit **150** may include at least one Application Specific Integrated Circuit (ASIC). In accordance with the embodiment, at least one of the substrate of the first electronic circuit **150**, various circuits formed on the substrate, and a semiconductor chip and various electronic components connected to the various circuits may be omitted for convenience of description.

Referring to FIGS. **4**, **22**A and **22**B, one surface of the first electronic circuit **150** may contact one surface of the second electronic circuit **140**. In more detail, the first electronic circuit **150** may be mounted to a surface at which a support **120** of the second electronic circuit **140** is not installed.

One or at least two second connection units **152** may be provided at the first electronic circuit **150**. The second connection unit **152** may be formed of a conductive metal material such as gold (Au) or lead (Pb). The second connection unit **152** may be implemented as a bump. The second connection unit **152** implemented as a bump may be, for example, a solder ball. A thin electrode may also be provided at one end of the second connection unit **152**.

The second connection unit **152** may electrically contact the substrate connection unit **141** of the second electronic circuit **140**. In this case, the thin electrode may also contact the substrate connection unit **141**. Since the second connection unit **152** contacts the substrate connection unit **141** of the second electronic circuit **140**, the first electronic circuit **150** and the second electronic circuit **140** may be electrically interconnected by the substrate connection unit **141** and the second connection unit **152**. The second connection unit **152** contained in the first electronic circuit **150** may have a position corresponding to the substrate connection unit **141** of the second electronic circuit **140**, and the number of second connection units **152** contained in the first electronic circuit **150** may correspond to the number of the substrate connection units **141** of the second electronic circuit **140**.

Referring to FIG. **22**B, the first electronic circuit **150** and the second electronic circuit **140** may be adjacent to each other on the basis of a predetermined gap. A separation unit **151** may be disposed between the first electronic circuit **150** and the second electronic circuit **140**. The separation unit **151** may prevent the first electronic circuit **150** from directly contacting the second electronic circuit **140**. The separation unit **151** may be formed of a nonconductive material. For example, the separation unit **151** may also be formed of epoxy resin. The epoxy resin may provide an adhesive function, and the second electronic circuit **140** and the first electronic circuit **150** may be adhered to each other using the separation unit **151** formed of epoxy resin.

Referring to FIG. **22**B, the second connection unit **152** may pass through the separation unit **151** so that it may protrude toward the outside of the separation unit **151**. In other words, the first electronic circuit **150** and various electronic components mounted to the first electronic circuit **150** may be shielded by the separation unit **151** formed of epoxy resin, so that they are not exposed to the outside. However, only the second connection unit **152** may be exposed to the outside of the separation unit **151**. The second connection unit **152** protruding toward the outside may contact the substrate connection unit **141**.

The separation unit **151** may be disposed between the first electronic circuit **150** and the second electronic circuit **140** using various methods.

For example, the first electronic circuit **150** and the second electronic circuit are located close to each other in such a manner that the second connection unit **152** contacts the substrate connection unit **141**, and a gap formed between the first electronic circuit **150** and the second electronic circuit is filled with epoxy resin, so that the separation unit **151** may be disposed between the first electronic circuit **150** and the second electronic circuit.

In another example, after the epoxy resin is deposited on the first electronic circuit **150** having the second connection unit **152** in such a manner that some parts of the second connection unit **152** are exposed to the outside, the second electronic circuit **140** is installed on the epoxy resin, so that the separation unit **151** may be disposed between the first electronic circuit **150** and the second electronic circuit.

The second connection unit **152** may include a third connection unit **153** contacting a first substrate connection unit **142** and a fourth connection unit **154** contacting a second substrate connection unit **143**. The second connection unit **153** may be provided at a specific position at which the second connection unit **153** can contact the first substrate connection unit **142**. The second connection unit **154** may be provided at a specific position at which the second connection unit **154** can contact the second substrate connection unit **143**.

The first electronic circuit **150** may include a semiconductor chip acting as the first processor **130** and electronic components associated with the semiconductor chip. The first processor **130** may be installed at a substrate of the first electronic circuit **150**. The second connection unit **152** may be provided at the first electronic circuit **150**, and may be disposed on the circuit electrically connected to the first processor **130**, so that the second connection unit **152** may be electrically connected to the first processor **130**. The electrical signals generated from not only the semiconductor chip acting as the first processor **130** but also the associated components may be applied to the substrate connection unit **141** or the output unit **146** through the second connection unit **152**. For example, the electrical signals (e.g., ultrasonic signals) transferred through the substrate connection unit **141** may be applied to the first processor **130** through the second connection unit **152**.

FIG. **22**C is a view illustrating a heat conduction unit installed at a back surface of the first electronic circuit.

Referring to FIG. **4**, the second electronic circuit **140** may be attached to one surface of the first electronic circuit **150**, and the heat conduction unit **160** may be installed at the other surface of the first electronic circuit **150**. The heat conduction unit **160** may be attached to the other surface of the first electronic circuit **150** using an adhesive or the like. Referring to FIG. **22**C, if the first processor **130** or the like installed at the first electronic circuit **150** performs data calculation processing, heat may occur in the first electronic circuit **150**. The generated heat may cause malfunction of the first electronic circuit **150** or may cause malfunction of other electronic components (e.g., the second electronic circuit **140**) disposed in the vicinity of the first electronic circuit **150**.

The heat conduction unit **160** may emit the heat generated from the first electronic circuit **150** to the outside. In more detail, after heat generated from the first electronic circuit **150** is transferred to the heat conduction unit **160**, the heat may emit in the air along the heat conduction unit **160**.

The heat conduction unit **160** may be implemented using various heat conductive materials. For example, the heat conduction unit **160** may be formed of graphite, tungsten, tungsten oxide, silicon, aluminum oxide, glass microballoon filling material, or the like.

A process of radiating ultrasonic waves using the above-mentioned ultrasonic probe **100**, a process for receiving ultrasonic waves and converting the received ultrasonic waves into an electrical signal, and a process for transferring the electrical signal to the main body **200** will hereinafter be described in detail.

FIG. **23**A is a conceptual diagram illustrating a process for transmitting a control signal to the first processor mounted to the ultrasonic probe. FIG. **23**B is a conceptual diagram illustrating the process for transmitting a control signal to the first processor mounted to the ultrasonic probe. FIG. **23**C is a conceptual diagram illustrating a process for transmitting a control signal to the ultrasonic element. FIG. **24** is a conceptual diagram illustrating a process of radiating ultrasonic waves using the ultrasonic element.

Referring to FIG. **23**A, if the controller **220** of the main body **200** outputs a control signal, the control signal may be applied to the circuit **149** contained in the second electronic circuit **140** through the cable **93** and the conductive line **147** (S**1**). Referring to FIG. **23**B, the control signal received through the conductive line **147** may be applied to the first processor **130** contained in the first electronic circuit **150** through not only the second substrate connection unit **143** connected to the circuit **149** but also the fourth connection unit electrically connected to the second substrate connection unit **143** (S**2**).

Referring to FIG. **23**C, the first processor **130** contained in the first electronic circuit **150** may output a control command related to ultrasonic irradiation as an electrical signal format. The electrical signal may be a pulse having a predetermined frequency. The output control command may be applied to one or at least two third connection units **153** through the circuit of the first electronic circuit **150**.

Referring to FIG. **23**C, the electrical signals received by the third connection unit **153** may pass through the second electronic circuit **140** through the substrate connection unit **141** attached to the third connection unit **153**, for example, through the first substrate connection unit **142**. After the electrical signal passes through the second electronic circuit **140**, the electrical signal may be applied to the first connection unit **121** provided at the sound absorption unit **120**. The electrical signal applied to the first connection unit **121** may be transmitted to the ultrasonic element unit **110** along the first connection unit **121** (S**3**).

Referring to FIG. **24**, if the electrical signal is applied to the ultrasonic element unit **110**, the ultrasonic transducer **113** (e.g., a piezoelectric element) of the ultrasonic element unit **110** may be vibrated according to the received electrical signal so as to generate ultrasonic waves (S**4**). The generated ultrasonic waves are emitted to the outside. The generated ultrasonic waves may be emitted in the direction of the object **99**. Meanwhile, the generated ultrasonic waves may also be emitted in the direction of the sound absorption unit **120**. In this case, the sound absorption unit **120** may absorb ultrasonic waves emitted in the direction of the sound absorption unit **120**.

FIGS. **25** and **26** are conceptual diagrams illustrating a process for receiving ultrasonic waves using the ultrasonic element.

Referring to FIGS. **25** and **26**, the ultrasonic element unit **110** may receive ultrasonic waves from the external part (S**5**). The ultrasonic waves received from the external part may be obtained when ultrasonic waves generated from the ultrasonic element unit **110** are reflected from the target site **98** contained in the object **99**. In accordance with the embodiment, the ultrasonic waves received from the external part may be generated from the target site **98** by irradiating laser or the like to the target site **98**.

The ultrasonic transducer **113** of the ultrasonic element unit **110** may be vibrated with a frequency corresponding to a frequency of the received ultrasonic waves. so as to output the alternating current (AC) electrical signal. The electrical signal may be transmitted to the processor **130** along an opposite path of the ultrasonic irradiation case (S**6**). In more detail, the electrical signal generated from the ultrasonic element unit **110** may be applied to the first processor **130** through the first connector **121** provided at the sound absorption unit **120**, the first substrate connection unit **142**, the third connection unit **153**, and a circuit contained in the first electronic circuit **150**.

The first processor **130** may amplify the received electrical signal, perform analog-to-digital conversion (ADC) of the amplified signal, and perform beamforming for focusing multi-channel electric signals generated from the respective ultrasonic element units **110**. The beamformed signals may be temporarily stored in a storage unit (e.g., RAM) for assisting the first processor **130**.

FIGS. **27** and **28** are conceptual diagrams illustrating a process for transmitting processed signals to the main body.

The first processor **130** may output the beamformed signal, and the beamformed signal may be applied to the fourth connection unit **143** along the circuit provided in the first electronic circuit **150**. The beamformed signal applied to the fourth connection unit **143** may be transmitted to the second substrate connection unit **143** contacting the fourth connection unit **143** (S**7**). The beamformed signal may be applied to the output unit **146** through the circuit **149** coupled to the second substrate connection unit **143**.

The beamformed signal is output through the output unit **146**, and may be applied to the main body **200** through the conductive line **147** and the cable **93** connected to the output unit **146** (S**8**). The main body **200** may perform signal processing and image processing of the received beamformed signal, may generate an ultrasound image corresponding to the beamformed signal, and may display the ultrasound image on the display unit **280** for user recognition.

A process for fabricating the sound absorption unit will hereinafter be described with reference to FIGS. **29** and **30**.

FIGS. **29** and **30** are conceptual diagrams illustrating the process for fabricating the sound absorption unit. FIG. **29** is a plan view illustrating the sound absorption material **10** in which the conductor **11** is inserted. FIG. **30** is a lateral cross-sectional view illustrating the sound absorption material **10** in which the conductor **11** is inserted. For convenience of description and better understanding of the present invention, an upper part of FIG. **30** will hereinafter be referred to as an upward direction, and a direction from the upper part to the lower part of FIG. **30** will hereinafter be referred to as a vertical direction. In addition, a specific direction orthogonal to the vertical direction will hereinafter be referred to as a horizontal direction.

As can be seen from FIG. **29**, the conductor **11** may be inserted into the sound absorption material **10**, and the conductor **11** may be diced as necessary. The inserted conductor **11** may be used as the above-mentioned support connection unit **121**.

From the viewpoint of the upward direction, the conductor **12** may be diced to have a square shape. The width (w**1**) or the height (h**1**) of the conductor **11** may be designed in various ways according to selection of the system designer. For example, the width (w**1**) of the conductor **11** may be 50 micrometers (μm), and the height (h**1**) of the conductor **11** may be 50 micrometers (μm). In addition, the conductor **13** may be diced to have a rectangular shape. In this case, the conductor **13** may have various widths (w**2**) and heights (h**2**) according to selection of the system designer. For example, the width (w**2**) of the conductor **12** may be 60 micrometers (μm), and the height (h**2**) of the conductor **12** may be 50 micrometers (μm).

If the conductor **11** is inserted into the sound absorption material **10**, the sound absorption material **10** is severed in a horizontal direction so that both ends of the conductor **11** are exposed to the outside, as shown in FIG. **30**. In more detail, the sound absorption material **10** is cut along the first sectional surface (c**1**) and the second sectional surface (c**2**) shown in FIG. **30**. As a result, the sound absorption material **10** formed when the conductor **11** is exposed at the upper and lower parts can be obtained. The obtained sound absorption material **10** may be used as the above-mentioned sound absorption unit **120**.

As is apparent from the above description, the ultrasonic probe apparatus and the ultrasonic imaging apparatus according to the embodiments can efficiently absorb ultrasonic waves emitted in the direction from the ultrasonic elements to the ultrasonic probe, resulting in implementation of improved acoustic throughput.

According to the ultrasonic probe apparatus and the ultrasonic imaging apparatus, a processor of the ultrasonic probe apparatus can be connected to a main body thereof without exposing the conductive lines to the outside, so that product durability, such as mechanical stability, electrical deterioration, corrosiveness, and heat-resistance, can be improved, resulting in increased product reliability.

According to the ultrasonic probe apparatus and the ultrasonic imaging apparatus, the accuracy of impedance matching of signal lines of a low volume dissemination system of semiconductors and a time error between two signals needed for constructing one pair of patterns, resulting in reduction of signal loss.

According to the ultrasonic probe apparatus and the ultrasonic imaging apparatus, heat generated from the processor contained in the ultrasonic probe and a substrate on which the processor is disposed can be easily and quickly emitted to the outside.

According to the ultrasonic probe apparatus and the ultrasonic imaging apparatus, the ultrasonic probe is reduced in weight, resulting in greater convenience.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An ultrasonic probe apparatus comprising:

an ultrasonic transducer configured to output an electrical signal upon receiving ultrasonic waves;

a sound absorption unit, one surface of which is an installation surface of the ultrasonic transducer, and being electrically connected to the ultrasonic transducer;

a first electronic circuit electrically connected to the sound absorption unit; and

a second electronic circuit disposed between the sound absorption unit and the first electronic circuit, configured to electrically interconnect the first electronic circuit and the sound absorption unit,

wherein one surface of the second electronic circuit faces another surface of the sound absorption unit, and another surface of the second electronic circuit faces one surface of the first electronic circuit

wherein the sound absorption unit includes at least one first connection unit electrically connected to the ultrasonic transducer,

wherein the second electronic circuit includes:

a first substrate connection unit provided to pass through from the one surface of the second electronic circuit to the another surface of the second electronic circuit, connected to the at least one first connection unit and configured to electrically connect the sound absorption unit and the first electronic circuit; and

a second substrate connection unit provided at a position not in contact with the at least one first connection unit of the sound absorption unit and configured to electrically connect the first electronic circuit and an output unit of the second electronic circuit.

[**2**. The ultrasonic probe apparatus according to claim **1**, wherein the second electronic circuit includes a substrate connection unit electrically connected to the first electronic circuit.]

[**3**. The ultrasonic probe apparatus according to claim **2**, wherein the substrate connection unit includes a first substrate connection unit configured to electrically interconnect the sound absorption unit and the first electronic circuit.]

[**4**. The ultrasonic probe apparatus according to claim **3**, wherein the first substrate connection unit is electrically connected to the ultrasonic transducer.]

[**5**. The ultrasonic probe apparatus according to claim **4**, wherein the sound absorption unit includes at least one first connection unit electrically connected to the ultrasonic transducer,

wherein the first substrate connection unit contacts the first connection unit.]

6. The ultrasonic probe apparatus according to claim [**2**] *1*, wherein the [second electronic circuit includes at least one] output unit *is* configured to output a signal processed by the first electronic circuit[,

wherein the substrate connection unit includes a second substrate connection unit configured to electrically interconnect the first electronic circuit and the at least one output unit].

7. The ultrasonic probe apparatus according to claim [**2**] *1*, wherein the *first* substrate connection unit [includes] *and the second substrate connection unit include*:

a first opening configured to pass through a range from the one surface to the another surface of the second electronic circuit; and

a conductor installed at an inner lateral surface of the first opening and electrically coupled to the first electronic circuit.

8. The ultrasonic probe apparatus according to claim **7**, wherein the conductor is configured to shield the first opening.

9. The ultrasonic probe apparatus according to claim **7**, wherein the *first* substrate connection unit *and the second substrate connection unit* further [includes] *include* a second opening formed to pass through the conductor.

10. The ultrasonic probe apparatus according to claim **9**, wherein the *first* substrate connection unit *and the second substrate connection unit* further [includes] *include* a filling material configured to shield the second opening.

11. The ultrasonic probe apparatus according to claim **7**, wherein the conductor is deposited on the inner lateral surface of the first opening.

12. The ultrasonic probe apparatus according to claim **7**, wherein the conductor is installed at the one surface of the second electronic circuit located in a vicinity of the first opening.

13. The ultrasonic probe apparatus according to claim **1**, wherein the second electronic circuit includes a rigid flexible printed circuit board (PCB).

14. The ultrasonic probe apparatus according to claim **13**, wherein the second electronic circuit includes at least one of a first region that is not curved and a second region that is flexibly curved.

15. The ultrasonic probe apparatus according to claim **14**, wherein [the second electronic circuit includes a substrate connection unit that is electrically connected to the first electronic circuit and is] *the first substrate connection unit and the second substrate connection unit are* formed in the first region.

16. The ultrasonic probe apparatus according to claim [**2**] *1*, wherein:

a second connection unit is mounted [to] *on* the first electronic circuit *and includes a third connection unit and a fourth connection unit*, the [second] *third* connection unit being attached to the *first* substrate connection unit of the second electronic circuit *and the fourth connection unit, being attached to the second substrate connection unit, of the second electronic circuit.*

17. The ultrasonic probe apparatus according to claim **16**, further comprising:

a separation unit disposed between the second electronic circuit and the first electronic circuit, and formed of a nonconductive material that prevents the second electronic circuit from directly contacting the first electronic circuit.

18. The ultrasonic probe apparatus according to claim **17**, wherein the second connection unit [is mounted to the first electronic circuit so as to pass] *passes* through the separation unit.

19. The ultrasonic probe apparatus according to claim **1**, further comprising:

a heat conduction unit mounted to another surface of the first electronic circuit, and to perform heat transmission of the first electronic circuit.

20. The ultrasonic probe apparatus according to claim **1**, wherein the sound absorption unit includes:

a sound absorption material for absorbing sound; and

[a first] *the at least one first* connection unit configured to pass through the sound absorption material so as to electrically interconnect the ultrasonic transducer and the first electronic circuit.

21. The ultrasonic probe apparatus according to claim **20**, wherein *the* at least one first connection unit is mounted to a single ultrasonic transducer.

[**22**. The ultrasonic probe apparatus according to claim **1**, further comprising:

an acoustic enhancer disposed between the ultrasonic transducer and the sound absorption unit, and configured to amplify the electrical signal generated from the ultrasonic transducer.]

23. The ultrasonic probe apparatus according to claim **1**, wherein the sound absorption unit is formed of a sound absorption material configured to absorb sound waves or ultrasonic waves.

[**24**. The ultrasonic probe apparatus according to claim **1**, wherein:

a seating surface at which the ultrasonic transducer or an acoustic enhancer is seated is formed at the one surface of the sound absorption unit,

wherein the acoustic enhancer is coupled to the ultrasonic transducer so as to amplify the electrical signal generated from the ultrasonic transducer.]

25. The ultrasonic probe apparatus according to claim **1**, wherein the first electronic circuit includes a processor configured to focus signals generated from the ultrasonic transducer.

26. The ultrasonic probe apparatus according to claim **1**, wherein the first electronic circuit includes at least one application specific integrated circuit (ASIC).

27. An ultrasonic imaging apparatus comprising:

an ultrasonic probe configured to receive ultrasonic waves; and

a main body configured to control operations of the ultrasonic probe, and to perform image processing of an ultrasound image corresponding to the received ultrasonic waves,

wherein the ultrasonic probe includes:

an ultrasonic transducer configured to output an electrical signal upon receiving the ultrasonic waves;

a sound absorption unit, one surface of which is an installation surface of the ultrasonic transducer and is electrically connected to the ultrasonic transducer;

a first electronic circuit electrically connected to the sound absorption unit; and a second electronic circuit disposed between the sound absorption unit and the first electronic circuit, configured to electrically interconnect the first electronic circuit and the sound absorption unit,

wherein one surface of the second electronic circuit faces another surface of the sound absorption unit, and another surface of the second electronic circuit faces one surface of the first electronic circuit

wherein the sound absorption unit includes at least one first connection unit electrically connected to the ultrasonic transducer,

wherein the second electronic circuit includes:

a first substrate connection unit provided to pass through from the one surface of the second electronic circuit to the another surface of the second electronic circuit, connected to the at least one first connection unit, and configured to electrically connect the sound absorption unit and the first electronic circuit; and

a second substrate connection unit provided a position not in contact with the at least one first connection unit of the sound absorption unit, and configured to electrically connect the first electronic circuit and an output unit of the second electronic circuit.

[**28**. The ultrasonic imaging apparatus according to claim **27**, wherein the second electronic circuit includes a substrate connection unit electrically connected to the first electronic circuit.]

[**29**. The ultrasonic imaging apparatus according to claim **28**, wherein the substrate connection unit includes a first substrate connection unit configured to electrically interconnect the sound absorption unit and the first electronic circuit.]

[**30**. The ultrasonic imaging apparatus according to claim **29**, wherein the first substrate connection unit is electrically connected to the ultrasonic transducer.]

[**31**. The ultrasonic imaging apparatus according to claim **30**, wherein the sound absorption unit includes at least one first connection unit electrically connected to the ultrasonic transducer,

wherein the first substrate connection unit contacts the first connection unit.]

32. The ultrasonic imaging apparatus according to claim [**28**] *27*, wherein the [second electronic circuit includes at least one] output unit *is* configured to output a signal processed by the first electronic circuit[, wherein the substrate connection unit includes a second substrate connection unit configured to electrically interconnect the first electronic circuit and the at least one output unit].

33. The ultrasonic imaging apparatus according to claim **27**, wherein the second electronic circuit includes a rigid flexible printed circuit board (PCB).

34. The ultrasonic imaging apparatus according to claim **33**, wherein the second electronic circuit includes at least one of a first region that is not curved and a second region that is flexibly curved.

35. The ultrasonic imaging apparatus according to claim **34**, wherein [the second electronic circuit includes a substrate connection unit that is electrically connected to the first electronic circuit and is] *the first substrate connection unit and the second substrate connection unit are* formed in the first region.

36. The ultrasonic imaging apparatus according to claim [**29**] *27*, wherein: a second connection unit is mounted [to] *on* the first electronic circuit *and includes a third connection unit and a fourth connection unit*, the [second] *third* connection unit being attached to the *first* substrate connection unit of the second electronic circuit *and the fourth connection unit being attached to the second substrate connection unit of the second electronic circuit*.

37. The ultrasonic imaging apparatus according to claim **36**, further comprising:

a separation unit disposed between the second electronic circuit and the first electronic circuit, and formed of a nonconductive material that prevents the second electronic circuit from directly contacting the first electronic circuit.

38. The ultrasonic imaging apparatus according to claim **37**, wherein the second connection unit [is mounted to the first electronic circuit so as to pass] *passes* through the separation unit.

39. The ultrasonic imaging apparatus according to claim **27**, further comprising:

a heat conduction unit mounted to another surface of the first electronic circuit, and to perform heat transmission of the first electronic circuit.

40. The ultrasonic imaging apparatus according to claim **27**, wherein the sound absorption unit includes:

a sound absorption material for absorbing sound; and

[a first**]** *the at least one first* connection unit configured to pass through the sound absorption material so as to electrically interconnect the ultrasonic transducer and the first electronic circuit.

41. The ultrasonic imaging apparatus according to claim **40**, wherein *the* at least one first connection unit is mounted to a single ultrasonic transducer.

[42. The ultrasonic imaging apparatus according to claim **27**, further comprising:

an acoustic enhancer disposed between the ultrasonic transducer and the sound absorption unit, and configured to amplify the electrical signal generated from the ultrasonic transducer.**]**

43. The ultrasonic imaging apparatus according to claim **27**, wherein the sound absorption unit is formed of a sound absorption material configured to absorb sound waves or ultrasonic waves.

[44. The ultrasonic imaging apparatus according to claim **27**, wherein:

a seating surface at which the ultrasonic transducer or an acoustic enhancer is seated is formed at the one surface of the sound absorption unit,

wherein the acoustic enhancer is coupled to the ultrasonic transducer so as to amplify the electrical signal generated from the ultrasonic transducer.**]**

45. The ultrasonic imaging apparatus according to claim **27**, wherein the first electronic circuit includes a processor configured to focus signals generated from the ultrasonic transducer.

46. The ultrasonic imaging apparatus according to claim **27**, wherein the first electronic circuit includes at least one application specific integrated circuit (ASIC).

* * * * *