(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 723 390 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.10.2020 Bulletin 2020/42

(51) Int Cl.:
H04R 19/00 *(2006.01)* ***B81B 3/00*** *(2006.01)*
G10K 9/12 *(2006.01)*

(21) Application number: **19211048.4**

(22) Date of filing: **22.11.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **09.04.2019 US 201916379746**

(71) Applicant: **Xmems Labs, Inc.**
Los Altos, CA 94022 (US)

(72) Inventors:
- **Hong, David**
  Los Altos, CA California 94024 (US)
- **Lo, Chiung C.**
  San Jose, CA California 95124 (US)
- **Liang, Jemm Yue**
  Sunnyvale, CA California 94086 (US)

(74) Representative: **Straus, Alexander et al**
2K Patent- und Rechtsanwälte - München
Keltenring 9
82041 Oberhaching (DE)

(54) AIR PULSE GENERATING ELEMENT AND SOUND PRODUCING DEVICE

(57) An air pulse generating element (60) includes a membrane (605), disposed within a chamber; a first valve (601), controlled by a first valve control signal (G'), configured to seal a first opening (611) of the chamber at a first time and to seal a second opening (612) of the chamber at a second time; a second valve (602), controlled by a second valve control signal (H'), configured to seal a third opening (613) of the chamber at a third time and to seal a fourth opening (614) of the chamber at a fourth time; wherein the membrane (605), the first valve (601) and the second valve (602) are coplanar and all disposed at a first layer.

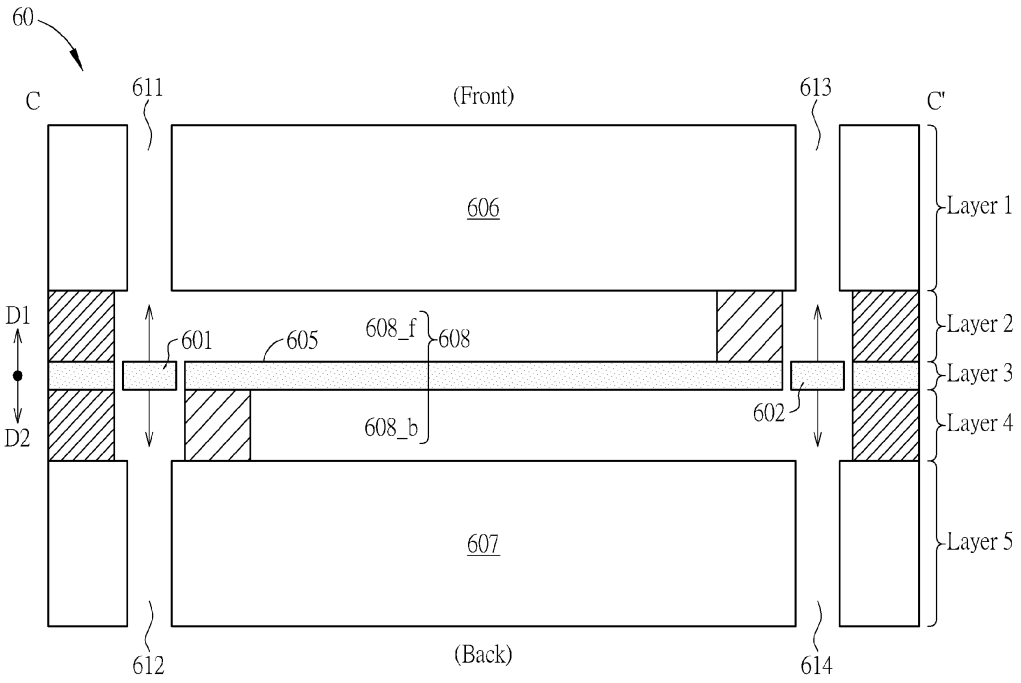


FIG. 7

EP 3 723 390 A1

Description

Field of the Invention

[0001] The present application relates to an air pulse generating element and a sound producing device, and more particularly, to an air pulse generating element and a sound producing device with low manufacturing complexity and low yield loss rate.

Background of the Invention

[0002] Speaker driver and back enclosure are two major design challenges in the speaker industry. It is difficult for a conventional speaker driver to cover an entire audio frequency band, e.g., from 20 Hz to 20 KHz, due to a membrane displacement D is proportional to $1/f^2$, i.e., $D \propto 1/f^2$. On the other hand, to produce sound with high fidelity, a volume/size of back enclosure for the conventional speaker is required to be sufficiently large.

[0003] To combat against the design challenges in the above, applicant has proposed an air pulse generating element and a sound producing device in U.S. Application No. 16/125,761, which produce sound using a plurality of pulses at a pulse rate, where the pulse rate is higher than a maximum audible frequency and the plurality of pulses is regarded as being amplitude modulated according to an input audio signal. By exploiting a low pass effect caused by ambient environment and human ear structure, a sound corresponding to the input audio signal is perceived. The sound producing device in U.S. Application No. 16/125,761 is able to cover the entire audio frequency band, and an enclosure volume/size of which is significantly reduced.

[0004] However, the air pulse generating element in U.S. Application No. 16/125,761 is complicated to be manufactured, because it requires 3 different layers to manufacture the valves and the membrane thereof, suffering from high yield loss rate. Specifically, FIG. 1 is a sectional view of an air pulse generating element 10 in U.S. Application No. 16/125,761. The air pulse generating element 10 comprises valves 101-104, a membrane 105, a front faceplate 106 and a back faceplate 107. The membrane 105 partitions a chamber 108 into a front sub-chamber 108_f and a back sub-chamber 108_b. The air pulse generating element 10 is a MEMS (micro electrical mechanical system) device. The valves 101 and 103 are fabricated at a layer 1, the membrane 105 is fabricated at a layer 3, and the valves 102 and 104 are fabricated at a layer 5. Manufacturing the valves 101-104 and the membrane 105 at the layers 1, 3, 5 require high wafer cost. In addition, one yield loss of one single layer among the layers 1, 3, 5 would lead to a failure of the entire air pulse generating element 10. Thus, the yield loss rate of the 3-layered air pulse generating element 10 is high.

[0005] Therefore, it is necessary to lower the manufacturing complexity of the air pulse generating element.

Summary of the Invention

[0006] It is therefore a primary objective of the present application to provide an air pulse generating element and a sound producing device with low manufacturing complexity and low yield loss rate.

[0007] An embodiment of the present invention discloses an air pulse generating element disposed in a sound producing device. The air pulse generating element comprises a membrane, disposed within a chamber; and a plurality of valves, disposed by the membrane within the chamber, configured to seal a plurality of openings of the chamber in response to a plurality of valve control signals; wherein the membrane and the plurality of valves are all fabricated at a first layer.

[0008] An embodiment of the present invention discloses a sound producing device. The sound producing device comprises a plurality of air pulse generating elements, wherein an air pulse generating element comprises a membrane, disposed within a chamber; and a plurality of valves, disposed by the membrane within the chamber, configured to seal a plurality of openings of the chamber in response to a plurality of valve control signals; wherein the membrane and the plurality of valves are all fabricated at a first layer; and a control unit, configured to generate the plurality of valve control signals.

Brief Description of the Drawings

[0009]

FIG. 1 is a schematic diagram of an air pulse generating element in the art.
FIG. 2 is a top view of an air pulse generating element according to an embodiment of the present invention.
FIG. 3 is a first sectional view of the air pulse generating element of FIG. 2.
FIG. 4 is a second sectional view of the air pulse generating element of FIG. 2.
FIG. 5 is a timing diagram of valve control signals and a membrane driving voltage according to an embodiment of the present invention.

FIG. 6 is a top view of an air pulse generating element according to an embodiment of the present invention.
FIG. 7 is a first sectional view diagram of the air pulse generating element of FIG. 6.
FIG. 8 is a schematic diagram of valve movement according to an embodiment of the present invention.
FIG. 9 is a schematic diagram of a valve according to an embodiment of the present invention.
FIG. 10 is a schematic diagram of a valve according to an embodiment of the present invention.
FIG. 11 is a schematic diagram of a sound producing device according to an embodiment of the present invention.

Detailed Description

[0010] FIG. 2 is a top view of an air pulse generating element 20 according to an embodiment of the present invention. FIG. 3 is a sectional view of the air pulse generating element 20 through an A-A' line shown in FIG. 2. FIG. 4 is a sectional view of the air pulse generating element 20 through a B-B' line shown in FIG. 2. The air pulse generating element 20 comprises valves 201-204, a membrane 205, a front faceplate 206 and a back faceplate 207. The valves 201-204 are disposed by four sides s1-s4 of the membrane 205, respectively, within a chamber 208. The membrane 205 partitions the chamber 208 into a front sub-chamber 208_f and a back sub-chamber 208_b. The valves 201-204 may be controlled by a plurality of valve control signals, respectively. The air pulse generating element 20 is a MEMS (micro electrical mechanical system) device. In an embodiment shown in FIGs. 2-4, the front faceplate 206 is disposed at a layer 1, the valves 201-204 and the membrane 205 are all fabricated at a layer 3, and the back faceplate 207 is disposed at a layer 5. Supporting elements 223, 224 are fabricated at a layer 2, and supporting elements 221, 222 are fabricated at a layer 4.

[0011] Openings 211 and 213 are formed within the front faceplate 206, and openings 212 and 214 are formed within the back faceplate 207. In an embodiment, the valve 201 is controlled in response to a valve control signal G to move upward to seal the openings 211, the valve 202 is controlled in response to a valve control signal H to move downward to seal the openings 212, the valve 203 is controlled in response to the valve control signal H to move upward to seal the openings 211, and the valve 204 is controlled in response to the valve control signal G to move downward to seal the openings 214.

[0012] In the embodiment stated in the above, the valve control signals G and H are configured to control the valves 201-204 to perform an open-and-close movement. When the valve control signal G controls the valves 201, 204 to be opened, denoted as "G=1", the opening 211, 214 are not sealed and air flows through the opening 211, 214. When the valve control signal G controls the valves 201, 204 to be closed, denoted as "G=0", the opening 211, 214 are sealed and air is not able to flow through the opening 211, 214. When the valve control signal H controls the valves 202, 203 to be opened, denoted as "H=1", the opening 212, 213 are not sealed and air flows through the opening 212, 213. When the valve control signal H controls the valves 202, 203 to be closed, denoted as "H=0", the opening 212, 213 are sealed and air is not able to flow through the opening 212, 213.

[0013] In addition, the membrane 205 is controlled in response to a membrane driving voltage V_{MBN} to either move upward (i.e., from back to front) or move downward (i.e., from front to back). In other words, the valve control signals G and H are configured to control the valves 201-204 to perform an open-and-close movement, and the membrane driving voltage V_{MBN} is configured to drive the membrane to perform an up-and-down movement. When the membrane 205 moves upward, an instantaneous front air pressure of the front sub-chamber 208_f is increased and an instantaneous back air pressure of back sub-chamber 208_b is decreased. When the membrane 205 moves downward, the instantaneous front air pressure of the front sub-chamber 208_f is decreased and the instantaneous back air pressure of the back sub-chamber 208_b is increased.

[0014] FIG. 5 is a timing diagram of the valve control signals G, H and the membrane driving voltage V_{MBN} according to an embodiment of the present invention. In FIG. 5, hexagons within the timing diagram of the valve control signals G, H represents that the corresponding valve(s) is opened, i.e., G=1 or H=1, and straight lines within the timing diagram of the valve control signals G, H represents that the corresponding valve(s) is closed, i.e., G=0 or H=0. The valve control signals G, H and the membrane driving voltage V_{MBN} are mutually synchronized.

[0015] A pulse cycle 114a begins at a status of G=1 and H=0. If the membrane driving voltage V_{MBN} drives the membrane 205 to move upward (i.e., from back to front) during the pulse cycle 114a, the air is pushed from the front sub-chamber 208_f to a front environment through the opening 211 and pulled from a back environment to the back sub-chamber 208_b through the opening 214, and therefore a positive air pulse (in a back-to-front direction) is generated. If the membrane driving voltage V_{MBN} drives the membrane 205 to move downward (i.e., from front to back) during the pulse cycle 114a, the air is pulled from the front environment to the front sub-chamber 208_f through the opening 211 and pushed from the back sub-chamber 208_b to the back environment through the opening 214, and therefore a negative air pulse (in a front-to-back direction) is generated.

[0016] In other words, during the pulse cycle 114a beginning at the status of G=1 and H=0, i.e., the valves 201, 204 being opened and the 202, 203 being closed, the membrane movement direction corresponding of the membrane 205 would be substantially the same as the air pulse direction.

[0017] A pulse cycle 114b begins at a status of G=0 and H=1. If the membrane driving voltage V_{MBN} drives the

membrane 205 to move upward during the pulse cycle 114b, the air is pushed from the front sub-chamber 208_f to the back environment through the opening 212 and pulled from the front environment to the back sub-chamber 208_b through the opening 213, and therefore a negative air pulse is generated. If the membrane driving voltage V_{MBN} drives the membrane 205 to move downward during the pulse cycle 114b, the air is pulled from the back environment to the front sub-chamber 208_f through the opening 212 and pushed from the back sub-chamber 208_b to the front environment through the opening 213, and therefore a positive air pulse is generated.

[0018] In other words, during the pulse cycle 114b beginning at the status of G=0 and H=1, i.e., the valves 201, 204 being closed and the 202, 203 being opened, the membrane movement direction corresponding of the membrane 205 would be substantially opposite to the air pulse direction.

[0019] Operations of the air pulse generating element 20 are tabulated in Table I.

Table I

Up-and-Down Movement of Membrane	Status of Valves at Beginning of Pulse Cycle	
	G=1, H=0	G=0, H=1
Downward	Front-to-Back	Back-to-Front
Upward	Back-to-Front	Front-to-Back

[0020] In addition, during the pulse cycle 114a or 114b, if the membrane driving voltage V_{MBN} is constant and the membrane 205 remains static, moving neither upward nor downward, a null pulse is generated.

[0021] Note that, an air flow direction within the front sub-chamber 208_f is along the A-A' direction between the valve 201 and the valve 202, and an air flow direction within the back sub-chamber 208_b is along the B-B' direction between the valve 203 and the valve 204.

[0022] Therefore, the air pulse generating element 20 is able to perform the same function of the air pulse generating element 10 disclosed in U.S. Application No. 16/125,761. Similar to the air pulse generating element 10, the air pulse generating element 20 is able to generate a plurality of air pulses in response to the valve control signals G, H and the membrane driving voltage V_{MBN} at a pulse rate, where the pulse rate of the plurality of air pulses is higher than a maximum audible frequency. Different from the air pulse generating element 10, the valves 201-204 and the membrane 205 are coplanar, which means that the valves 201-204 and the membrane 205 are fabricated at the same layer. Thereby, a manufacturing cost is reduced and a yield rate is improved.

[0023] Note that, the air pulse generating element 20 has four valves disposed by four sides of the membrane, which is not limited thereto. The air pulse generating element of the present invention may comprise two valves disposed by two sides of the membrane.

[0024] FIG. 6 is a top view of an air pulse generating element 60 according to an embodiment of the present invention. FIG. 7 is a sectional view diagram of the air pulse generating element 60 through a C- C' line shown in FIG. 6. The air pulse generating element 60 is also a MEMS device.

[0025] Similar to the air pulse generating element 20, the air pulse generating element 60 comprises valves 601, 602, a membrane 605, a front faceplate 606 and a back faceplate 607. The valves 601, 602 are fabricated at the same layer (e.g., Layer 3) as the membrane 605. The membrane 605 partitions the chamber 608 into a front sub-chamber 608_f and a back sub-chamber 608_b. In an embodiment shown in FIGs. 6-1, the front faceplate 606 is disposed at the layer 1, the valves 601-604 and the membrane 605 are all fabricated at the layer 3, and the back faceplate 607 is disposed at the layer 5. Openings 611 and 613 are formed within the front faceplate 606, and openings 612 and 614 are formed within the back faceplate 607. The valve 601 is controlled by a valve control signal G' to alternatively seal the openings 611 and 612, which means that the valve 601 may be controlled by the signal G' to seal the opening 611 at a first time and to seal the opening 612 at a second time. Similarly, the valve 602 is controlled by the valve control signal H' to alternatively seal the openings 612 and 613, which means that the valve 601 may be controlled by the signal H' to seal the opening 613 at a third time and to seal the opening 614 at a fourth time.

[0026] In the embodiment illustrated in FIG. 6, the valve 601 is disposed by the side s1 of the membrane 605, and the valve 602 is disposed by the side s2 of the membrane 605, where the side s1 and the side s2 are opposite to each other.

[0027] In the embodiment illustrated in FIG. 7, the opening 611/613 is at a first direction D1 in related to the valve 601, and the opening 612/614 is at a second direction D2 in related to the valve 602, where the first direction D1 is opposite to the second direction D2. Different from the valves 201-204, the valves 601 and 602 are bi-directional valves, or 2-way valves, which means that the valves 601 and 602 are able to move toward the first direction D1 and also move toward the second direction D2.

[0028] Details of the (dynamic) movement of the valves 601, 602 sealing the openings 611-614 are not limited. In an

embodiment, the valves 601, 602 may seal the openings 611-614 by a translational movement or a rotational movement, which are illustrated in FIG. 8. In the sub-figure 8a, an embodiment of the translational movement is illustrated. The valve 601/602 may be controlled to move upward to seal the opening 611/613 (at the first/third time) and be controlled to move downward to seal the opening 612/614 (at the second/fourth time). In the sub-figure 8b, an embodiment of the rotational movement is illustrated. The valve 601/602 may comprise caps 62, lever arms 64 and anchors 66. The valve 601/602 may be controlled to rotate clockwise to seal the opening 611/613 (at the first/third time) and be controlled to rotate clockwise to seal the opening 612/614 (at the second/fourth time). In this case, the first/third time may, but not necessarily, be different from the second/fourth time.

[0029] Details of the (static) structure of the valve 601/602 are not limited. For example, FIG. 9 illustrates a schematic diagram of a valve 90 according to an embodiment of the present invention. The valve 90 can be used to realize the valve 601 or 602. The valve 90 comprises a cap 92 and actuators 94, 96. The actuators 94, 96 may be disposed on, either a top surface or a bottom surface, or both surfaces, of the valve 90. When the valve 90 is controlled to be move upward, the actuators 94 deform in a concave manner and the actuators 96 deform in a convex manner, as the sub-figure 9a illustrates. When the valve 90 is controlled to be move downward, the actuators 94 deform in a convex manner and the actuators 96 deform in a concave manner, as the sub-figure 9b illustrates.

[0030] Furthermore, to shorten the transition period or response time of the valve, the valve may be light weighted. FIG. 9 illustrates a schematic diagram of a valve A0 according to an embodiment of the present invention. The valve A0 can be used to realize the valve 601 or 602. Different from the valve 90, holes may be formed on the valve A0. The holes may be formed by etching. In this case, the response time of the valve A0, in response to the valve signal G'/H', to move either upward or downward, would be shortened, compared to the valve 90.

[0031] The air pulse generating element 20/60 may be applied/disposed in a sound producing device. FIG. 11 is a schematic diagram of a sound producing device B0 according to an embodiment of the present invention. The sound producing device B0 comprises a plurality of air pulse generating elements B4 and a control unit B2. The plurality of air pulse generating elements B4 are grouped into air pulse generating groups labeled as P0, P1, P2, and F1-F5. The control unit B2 is configured to generate the valve control signals G/G', H/H' and the membrane driving voltage V_{MBN}. Details of the sound producing device B0 may be referred to U.S. Application No. 16/125,761, which is not narrated herein for brevity.

[0032] In summary, in the air pulse generating element of the present invention, the valves and the membrane are coplanar or fabricated at the same layer, which reduces manufacturing cost and lower the yield rate.

Claims

1. An air pulse generating element, **characterized by,** comprising:

a membrane (605); and
a plurality of valves (601, 602), disposed by the membrane (605), configured to seal a plurality of openings of a chamber in which the membrane (605) is disposed, in response to a plurality of valve control signals;
wherein the membrane (605) and the plurality of valves (601, 602) are coplanar and all disposed at a first layer;
wherein the plurality of valves comprises:

a first valve (601), controlled by a first valve control signal (G'), configured to seal a first opening (611) of the chamber at a first time and to seal a second opening (612) of the chamber at a second time;
a second valve (602), controlled by a second valve control signal (H'), configured to seal a third opening (613) of the chamber at a third time and to seal a fourth opening (614) of the chamber at a fourth time;
wherein the first opening (611) is formed on a first faceplate (606) of the air pulse generating element, and the first faceplate is disposed at a second layer;
wherein the second opening (612) is formed on a second faceplate (607) of the air pulse generating element, and the second faceplate is disposed at a third layer;
wherein the third opening (613) is formed on the first faceplate (606) of the air pulse generating element;
wherein the fourth opening (614) is formed on the second faceplate (607) of the air pulse generating element.

2. The air pulse generating element of claim 1, **characterized in that,**
the first valve (601) is disposed by a first side of the membrane (605); and
the second valve (602) is disposed by a second side of the membrane (605).

3. The air pulse generating element of claim 2, **characterized in that,** the first side is opposite to the second side.

4. The air pulse generating element of claim 1, **characterized in that,**
the first opening (611) is at a first direction (D1) in related to the first valve (601);
the second opening (612) is at a second direction (D2) in related to the first valve (601); and
the first direction is opposite to the second direction.

5. The air pulse generating element of claim 1, **characterized in that,** the first valve (601) is controlled to seal the first opening (611) or the second opening (612) by a translational movement or a rotational movement.

6. The air pulse generating element of claim 1, **characterized in that,** the first valve (90) comprises
a cap (92), configured to seal one of the first opening and the second opening;
a first actuator (94), configured to deform in a concave manner; and
a second actuator (96), configured to deform in a convex manner.

7. The air pulse generating element of claim 1, **characterized in that,** a plurality of holes (A2) is formed on the first valve (A0).

8. The air pulse generating element of claim 1, **characterized in that,** the air pulse generating element generates a plurality of air pulses in response to the plurality of valve control signals at a pulse rate, and the pulse rate of the plurality of air pulses is higher than a maximum audible frequency.

9. A sound producing device (B0), **characterized by**, comprising:

a plurality of air pulse generating elements (B4), wherein each air pulse generating element is the air pulse generating element of claims 1-8; and
a control unit (B2), configured to generate the first valve control signal and the second valve control signal.

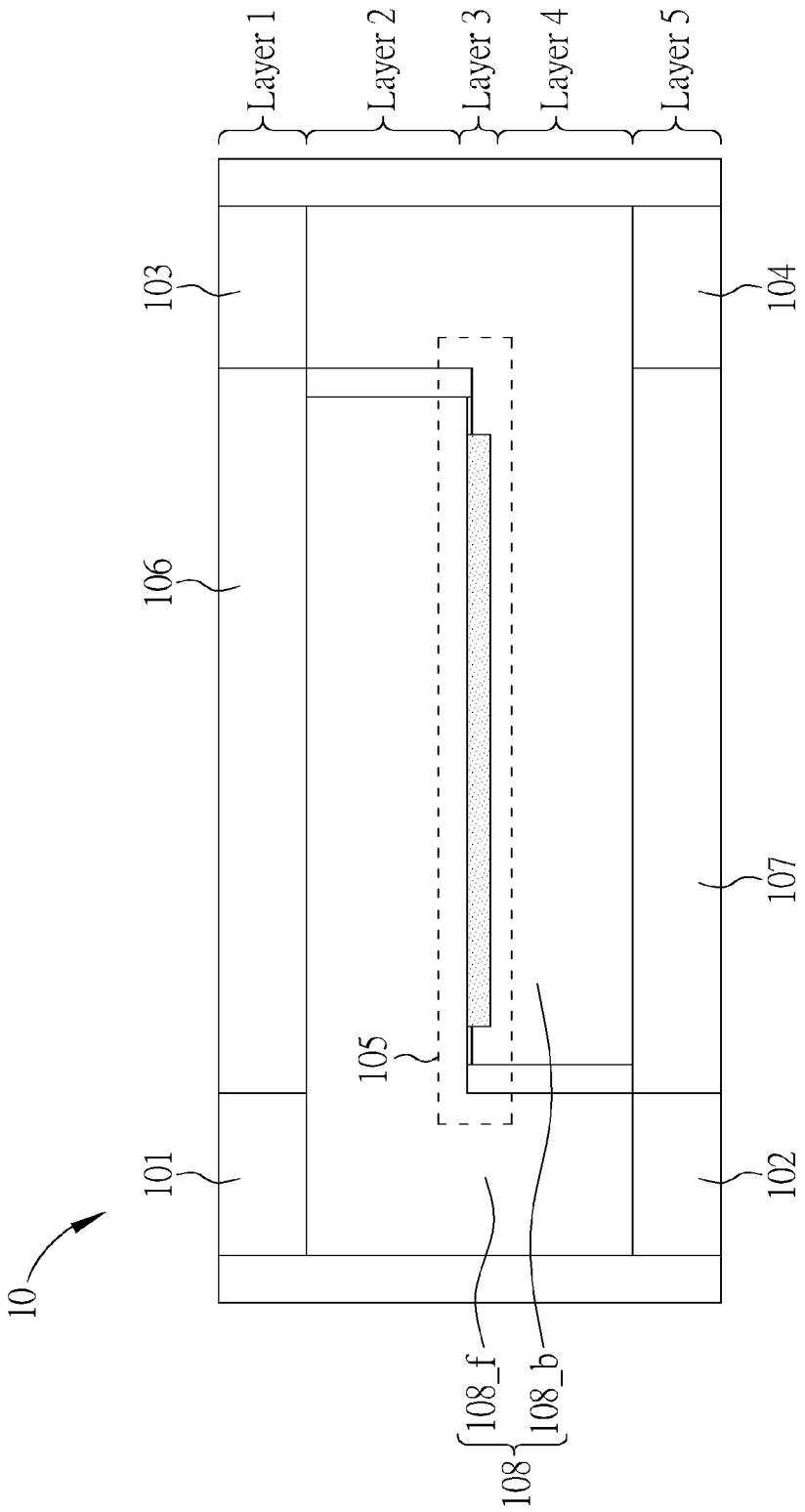


FIG. 1 PRIOR ART

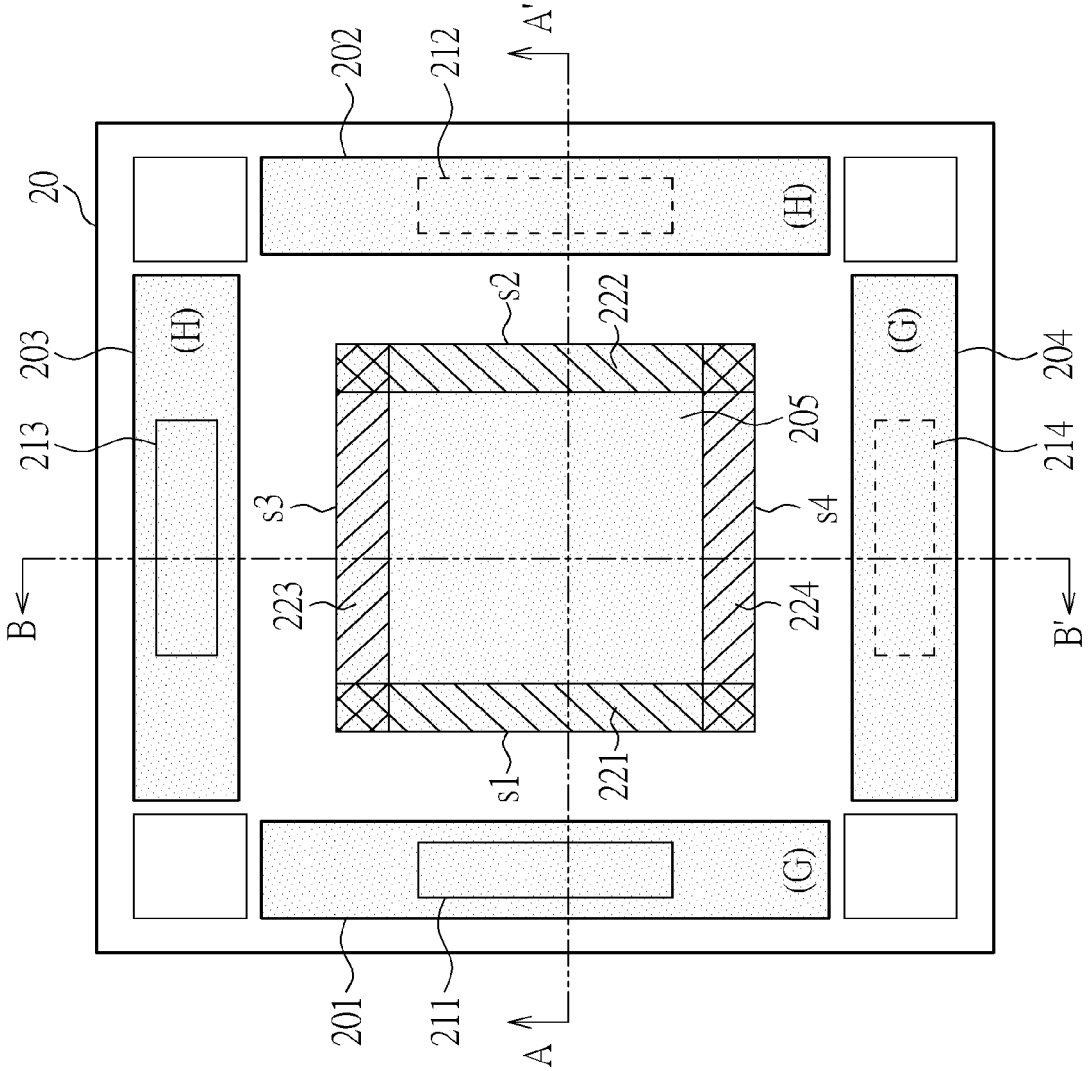

A'
202
212
20
(H)
s2
222
203
(H)
(G)
204
213
205
214
s3
s4
B
223
224
B'
s1
221
(G)
201
211
A

FIG. 2

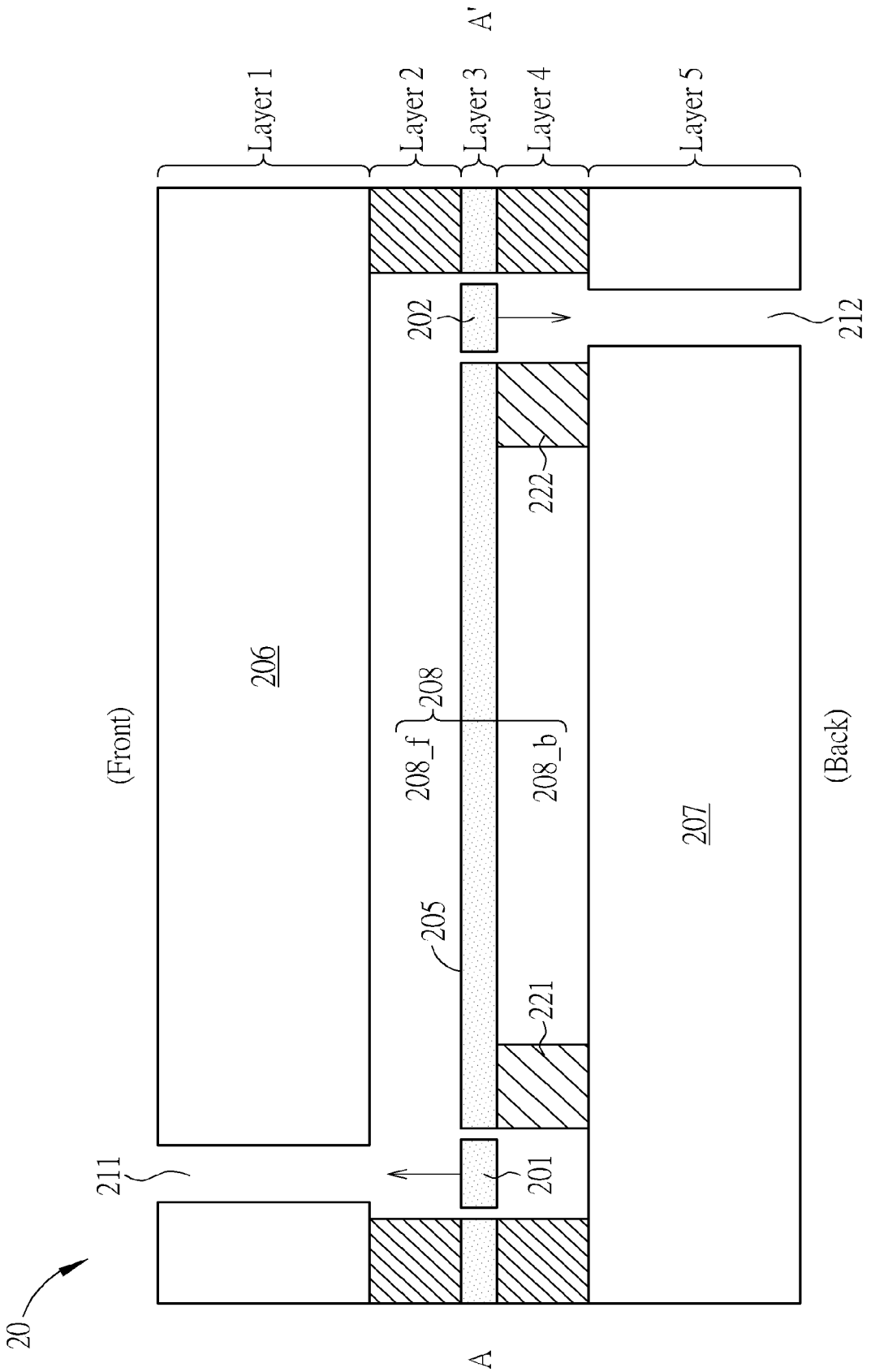

Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
A'
A
20
211
201
202
212
206
207
205
208
208_f
208_b
221
222
(Front)
(Back)

FIG. 3

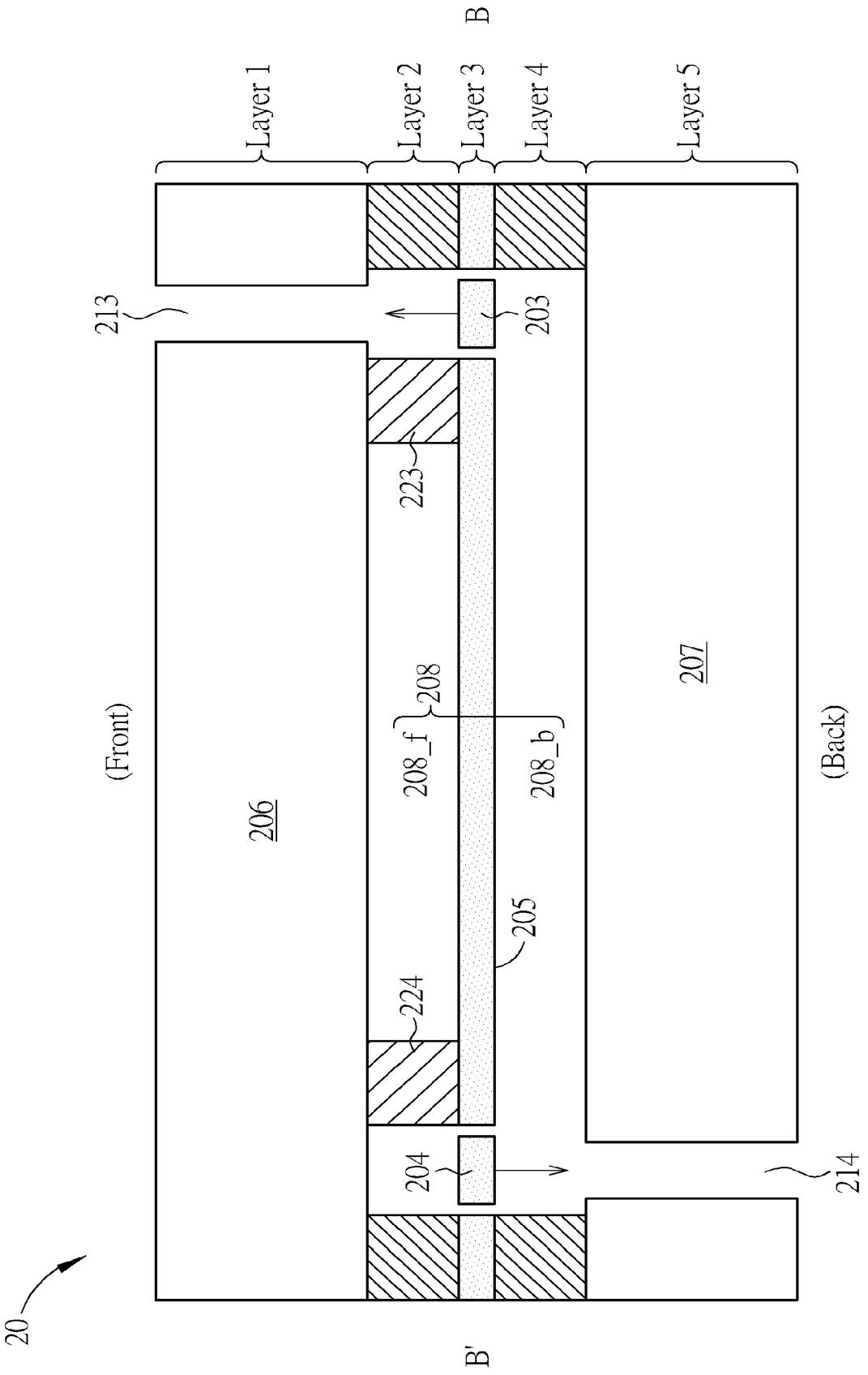

B
Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
213
203
223
208
208_f
208_b
(Front)
206
207
(Back)
205
224
204
214
20
B'

FIG. 4

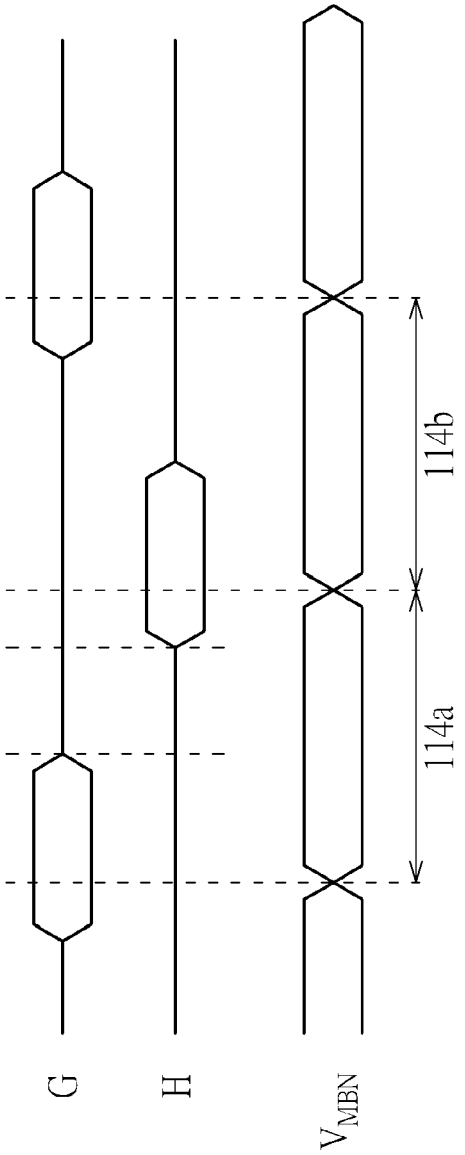


FIG. 5

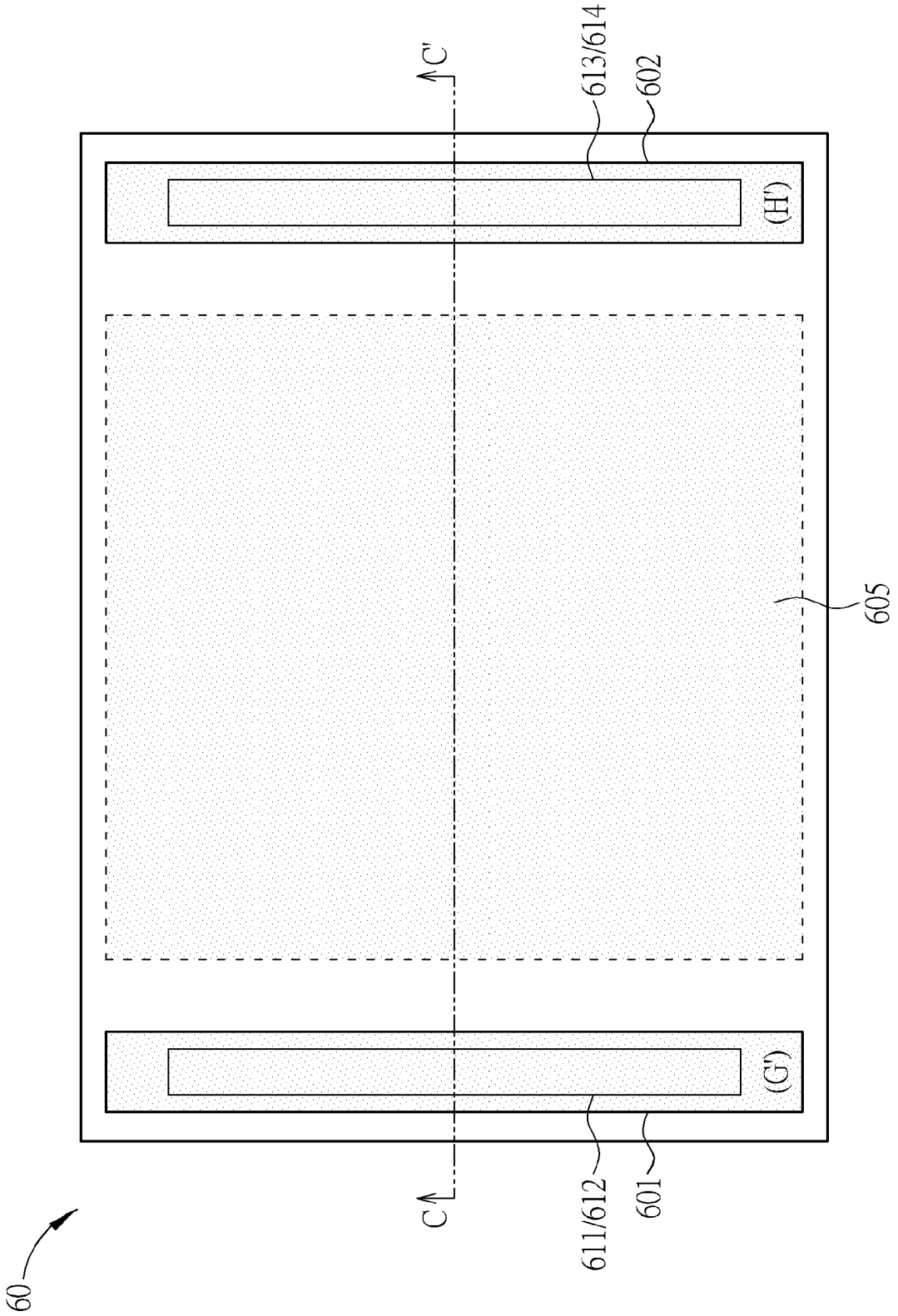


FIG. 6

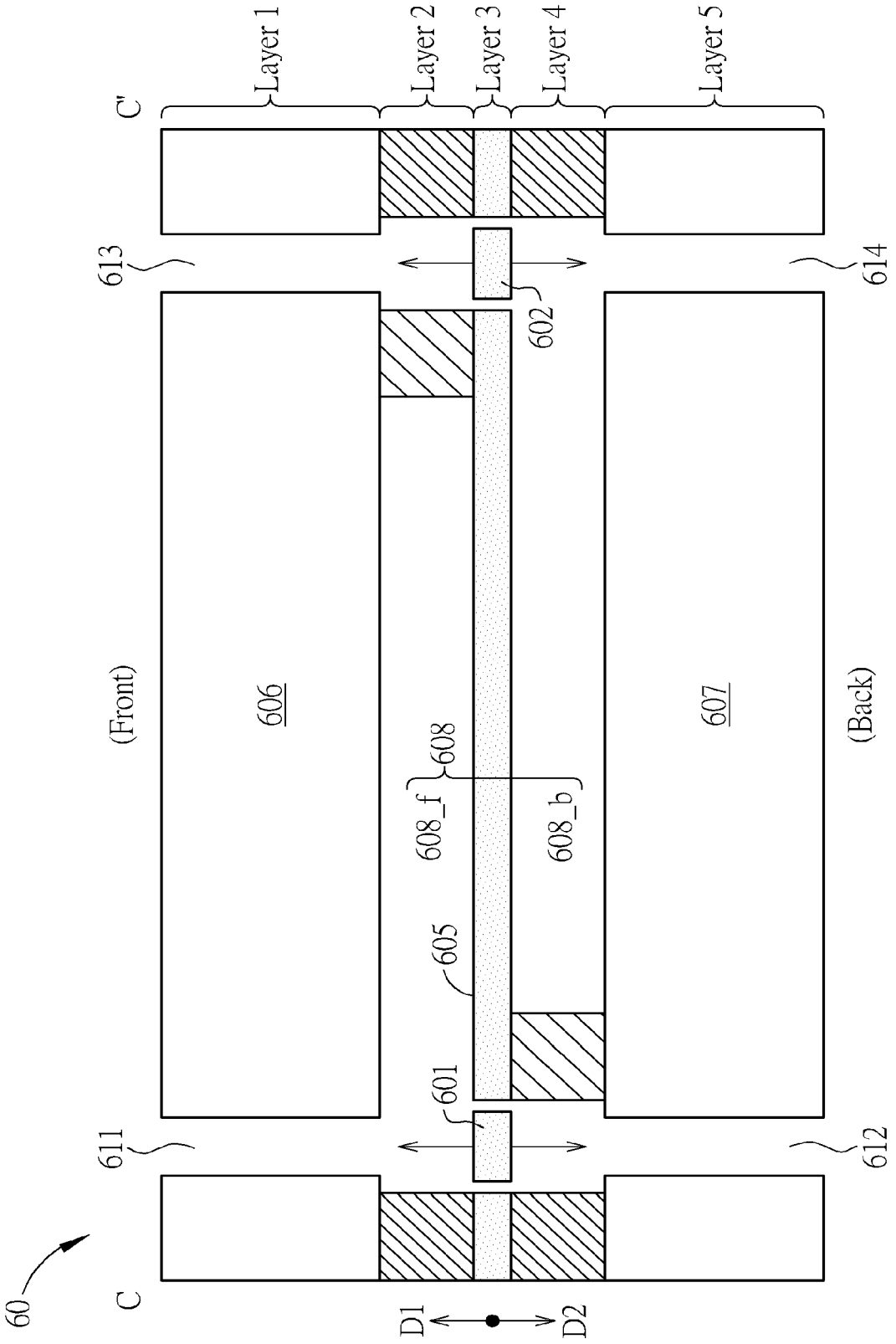
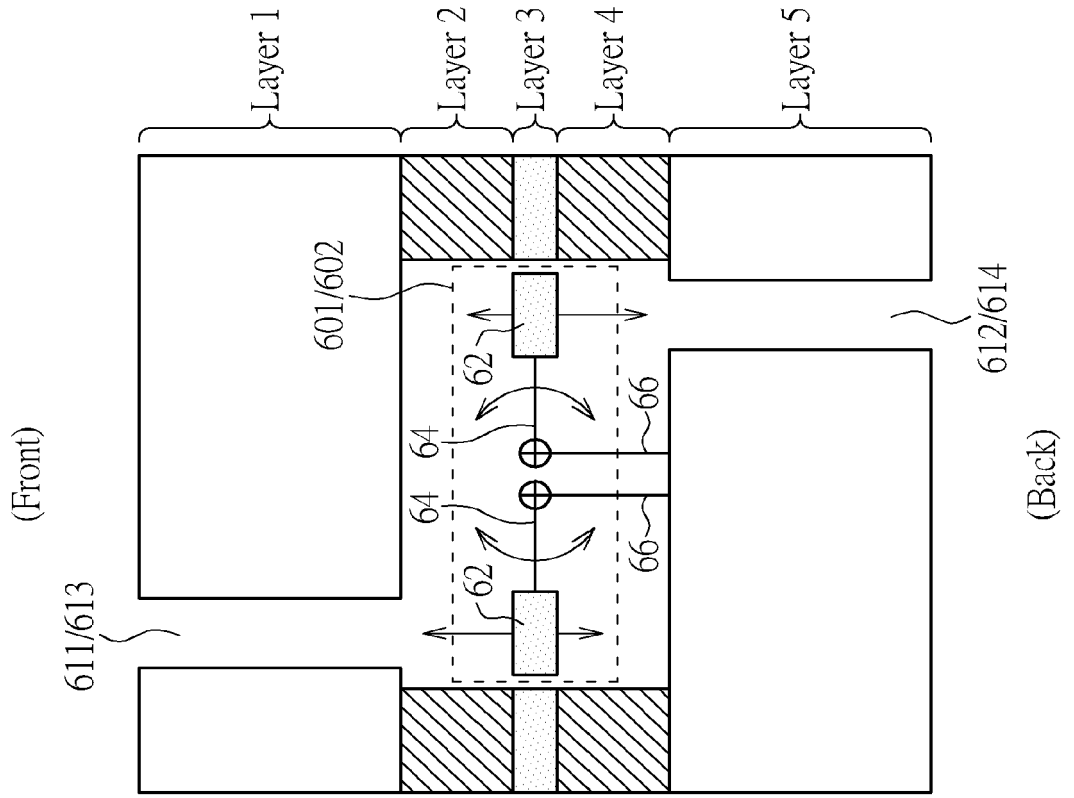

Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
C'
613
614
602
(Front)
606
608
608_f
608_b
607
(Back)
605
601
611
612
60
C
D1
D2

FIG. 7


Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
601/602
612/614
62
66
64
64
66
62
(Front)
611/613
(Back)
(8b)

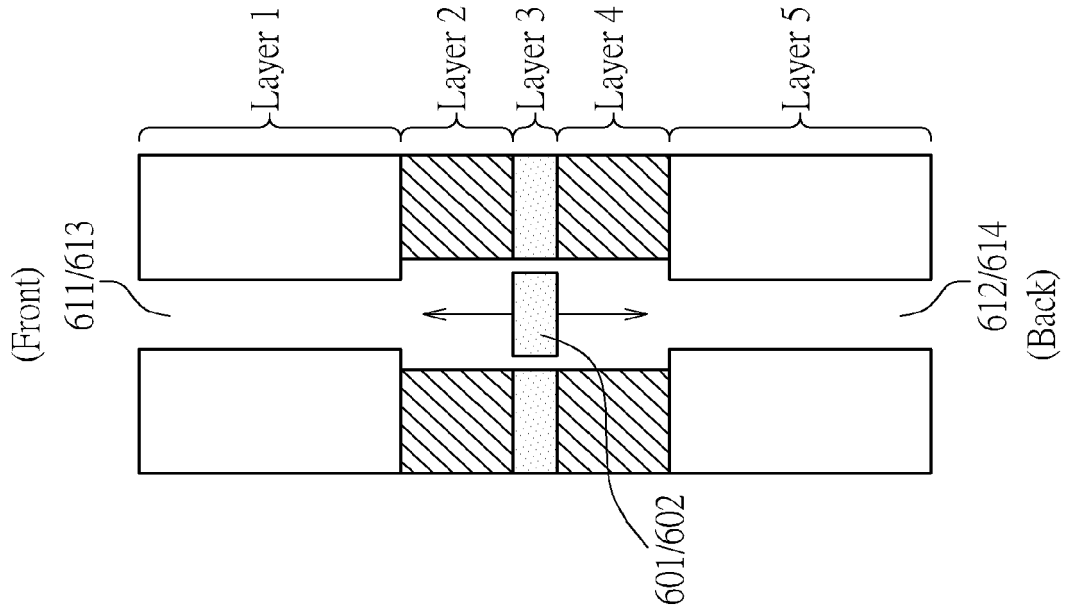

Layer 1
Layer 2
Layer 3
Layer 4
Layer 5
(Front)
611/613
612/614
(Back)
601/602
(8a)

FIG. 8

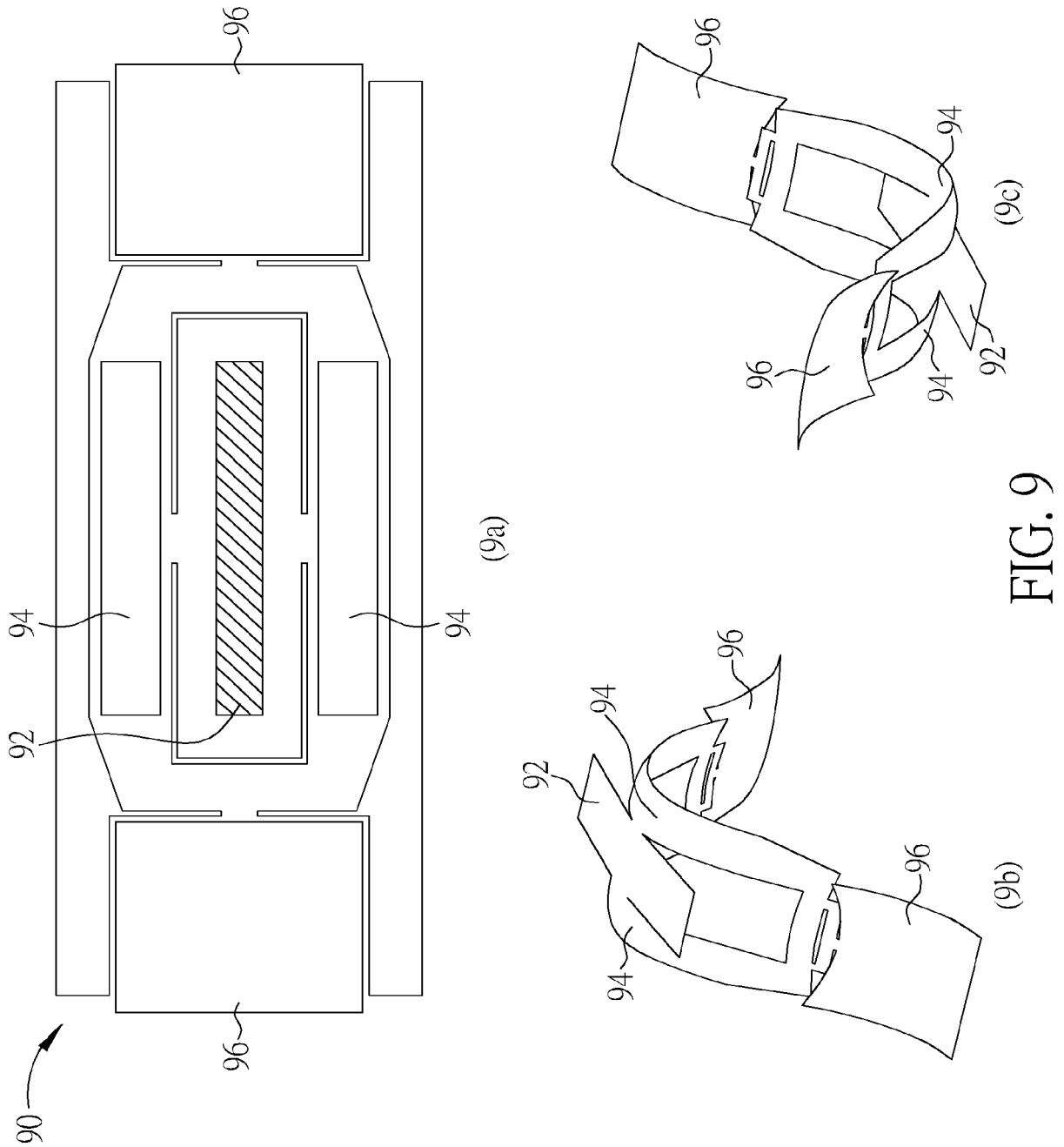


FIG. 9

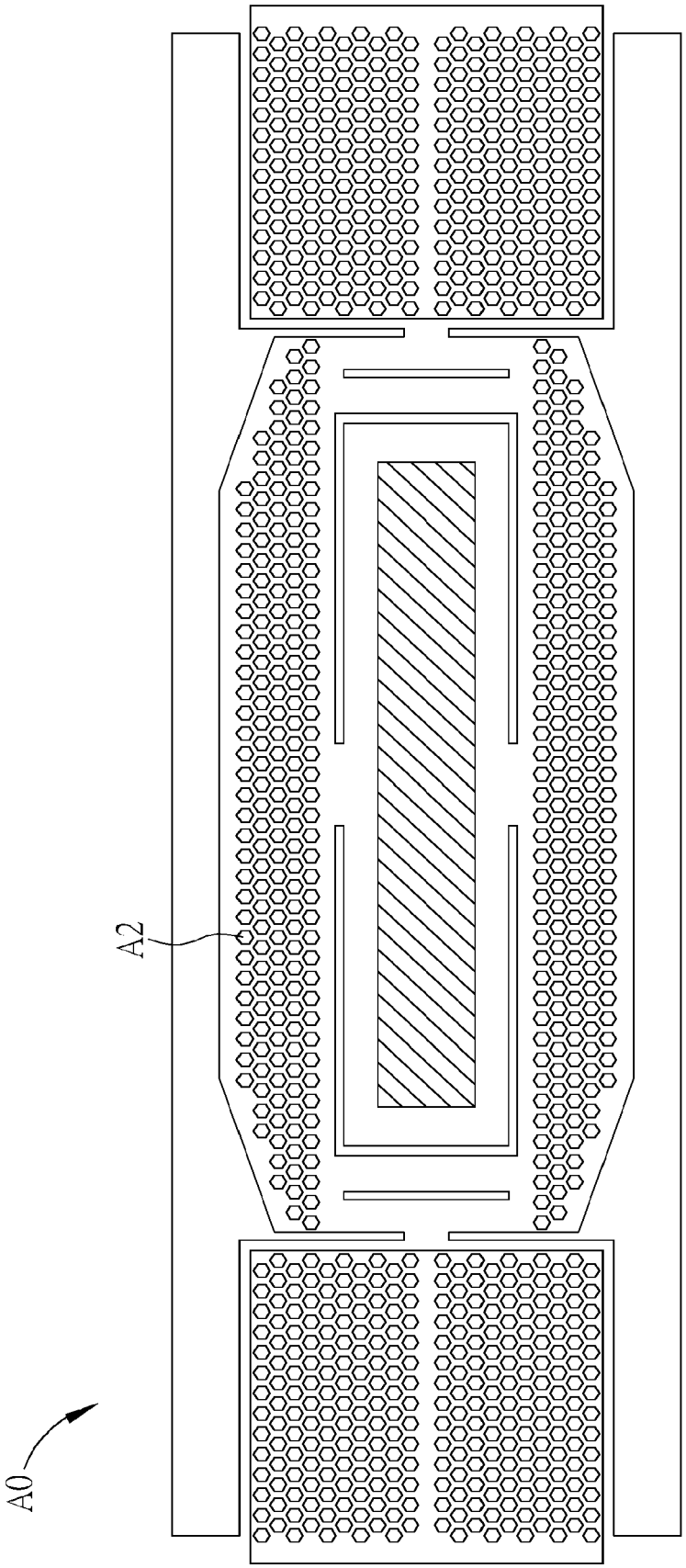


FIG. 10

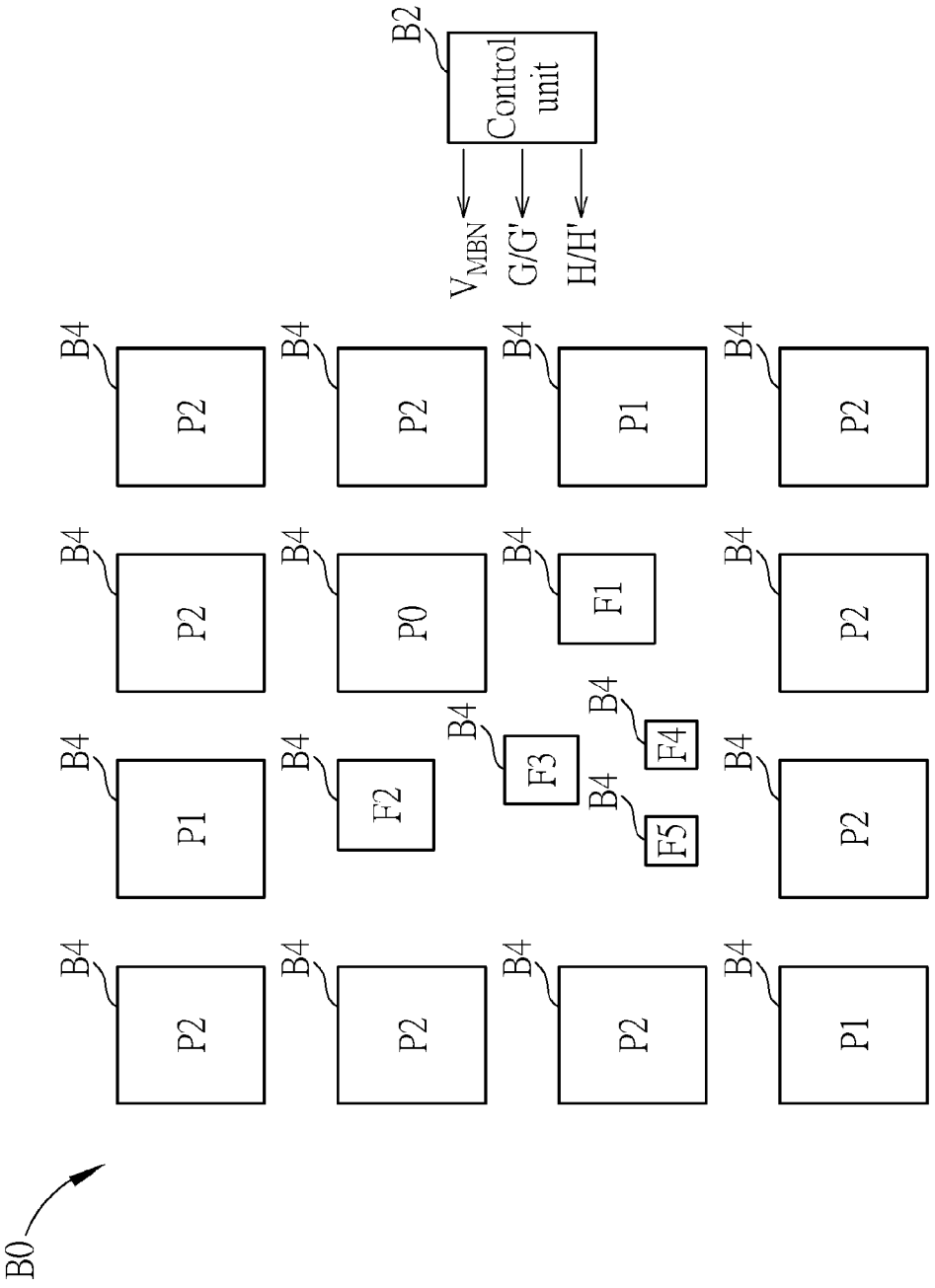


FIG. 11

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 21 1048

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2016/381464 A1 (ELYADA ORI [IL]) 29 December 2016 (2016-12-29) * paragraphs [0040] - [0042], [0065] - [0067]; figures 1,3,4,7 * -----	1-9 5	INV. H04R19/00 B81B3/00 ADD. G10K9/12
Y	WO 2015/119626 A1 (EMPIRE TECHNOLOGY DEV LLC [US]) 13 August 2015 (2015-08-13) * paragraphs [0029] - [0040]; figures 4,8 * -----	5	
A	US 2018/179048 A1 (SCHENK HARALD [DE] ET AL) 28 June 2018 (2018-06-28) * paragraphs [0020], [0022], [0029], [0180] - [0191]; figure 12 * -----	1-9	

TECHNICAL FIELDS SEARCHED (IPC)
H04R B82B B81B G10K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 May 2020	Navarri, Massimo

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 21 1048

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-05-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016381464 A1	29-12-2016	NONE	
WO 2015119626 A1	13-08-2015	US 2016360321 A1	08-12-2016
		WO 2015119626 A1	13-08-2015
US 2018179048 A1	28-06-2018	CN 107925825 A	17-04-2018
		DE 102015210919 A1	15-12-2016
		EP 3308555 A2	18-04-2018
		JP 6668385 B2	18-03-2020
		JP 2018521576 A	02-08-2018
		JP 2020051428 A	02-04-2020
		KR 20180030784 A	26-03-2018
		US 2018179048 A1	28-06-2018
		WO 2016202790 A2	22-12-2016

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 125761 **[0003] [0004] [0022] [0031]**