(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 June 2017 (08.06.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/095531 A1

(51) **International Patent Classification**:
H01L 23/04 (2006.01) ***H01L 23/24*** (2006.01)

(21) **International Application Number**:
PCT/US2016/056591

(22) **International Filing Date**:
12 October 2016 (12.10.2016)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
14/959,345 4 December 2015 (04.12.2015) US

(71) **Applicant**: **CONTINENTAL AUTOMOTIVE SYSTEMS, INC.** [US/US]; One Continental Drive, Auburn Hills, Michigan 48326 (US).

(72) **Inventors**: **CHIOU, Jen-huang Albert**; 5350 West River Bend, Libertyville, Illinois 60048 (US). **MANFREDI, David**; 432 S Forrest Ave., Arlington Heights, Illinois 60004 (US). **BRATEK, Daniel J.**; 233 N. Norman Drive, Palatine, Illinois 60067 (US).

(74) **Agents**: **KLEIN, William** et al.; 21440 W Lake Cook Rd, 7th floor, Deer Park, Illinois 60010 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2017/095531 A1

(54) **Title**: AUTOMOTIVE ELECTRONIC DEVICE HAVING A COVER WITH FINS TO REDUCE GEL VIBRATION

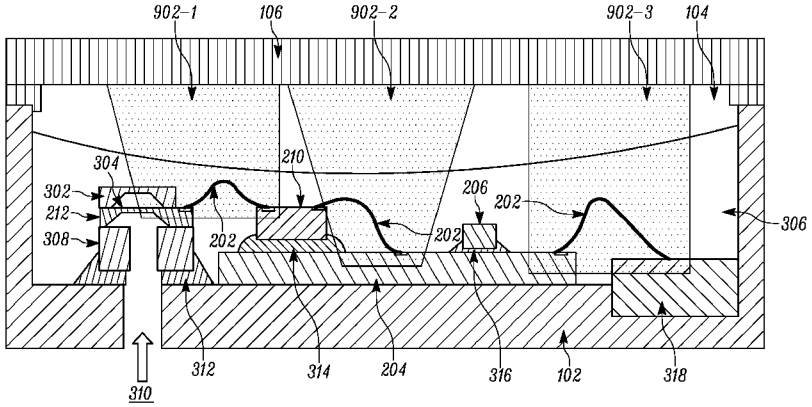

Figure 9

(57) **Abstract**: An automotive electronic device includes a pocket, which houses electronic components, bond wires connecting the electronic components, and a protective gel to encapsulate the electronic components and bond wires. A pocket cover has fins that protrude into the gel to reduce vibration of the gel and reduce vibration fatigue failure of the bond wires. The fins may: divide the gel into a plurality of cells; reduce the width of cells perpendicular to the bond wires; protrude deeper into the gel than the bond wires; and/or have differing shapes and/or depths.

AUTOMOTIVE ELECTRONIC DEVICE HAVING A COVER WITH FINS TO REDUCE GEL VIBRATION

BACKGROUND

[0001] Bond wire vibration fatigue failure is a problem for certain automotive electronic devices, including, but not limited to, various types of sensors, such as pressure sensors.

[0002] For example, Figure 1 depicts a transmission-fluid pressure sensor 100 in accordance with the prior art. The transmission-fluid pressure sensor includes a housing 102. The bond wires for electrical connections are located in a pocket 104 with a high density protection gel encapsulating them. During operation of an automobile, bond wires of this type may encounter vibration fatigue failure.

[0003] Figure 1 also depicts a cover 106 for the pocket 104. The cover includes a rim 108.

[0004] Figure 2 is a top view of the pocket 104. Eighteen bond wires 202 are shown in Figure 2. Also in the pocket are printed circuit board (PCB) 204, application-specific integrated circuits (ASICs) 208 and 210, chip capacitors 206, and pressure sensing elements 212.

[0005] Figure 3 is a cross-sectional view, along sectional view line I – I of Figure 2, of the housing pocket 104 and the cover 106. The pressure sensing element 212 is electrically coupled to the ASIC 210 by bond wires 202-1, which are attached to bond pads on the pressure sensing element 212 and on the ASIC 210. Similarly, the ASIC 210 is electrically coupled to the PCB 204 by bond wires 202-2, which are attached to bond pads on the ASIC 210 and the PCB 204. And the PCB 204 is electrically coupled to a lead frame 318 by bond wires 202-3, which are attached to bond pads on the PCB 204 and to the lead frame 318. Chip capacitors 206 are used for electromagnetic compatibility (EMC) by coupling electrical signals between

the wires 202-2 and 202-3 through metal traces (not shown) in the PCB 204 and electrically conductive adhesive (ECA) or solder 316 on the PCB 204.

[0006] Other components shown in Figure 3 include: a glass cap 302, a vacuum cavity 304, a glass pedestal 308, gel 306, transmission-fluid pressure 310, ambient pressure 311, epoxy 312, and adhesive 314.

[0007] Figure 4 is a log-log-scaled graphical depiction of the power spectral density impressed on a bond wire of a transmission-fluid pressure sensor by random vibration as a function of the frequency of wave fronts. Figure 4 shows a random vibration example in a log-log scale. As the frequency increases above a critical value F_1, the power spectral density on a bond wire increases linearly to a second frequency F_2. At frequencies above F_2, random-vibration-induced power spectral density gradually decreases linearly.

[0008] Figures 5A and 5B depict pressure or forces on bond wires from vibration-induced wave fronts. Figures 5A and 5B are graphical depictions of the forces exerted on a "long" bond wire and a "short" bond wire. Lateral forces from the wave fronts are distributed over the length of the wire and represented in the figures by the arrows identified by "F." While the wave fronts can strike the wires at any angle, the force that is orthogonal to the wire's axial length is the force that tends to break the wire and/or its bond due to the lateral displacements D_1 and D_2 that a force normal to the wire's axis tends to cause.

[0009] As is well known, the total force F exerted on a surface of area A, by a pressure of magnitude P acting uniformly over the entire area, is the product of P and A. In other words,

$$F = P * A$$

[0010] where F is the force on an area A under a uniform pressure P.

[0011] In the pocket 104, since the gel edge is considered herein to be essentially "anchored" to the sidewall, the wave front pressure P in the horizontal direction is proportional to the gel acceleration a multiplied by the gel density ρ times the "width" of the gel W, which is the width of the pocket 104. Stated another way,

$$P \propto \rho \times a \times W$$

[0012] where ρ is the density of the gel 306, a is the acceleration of the gel and W is the "width" of the gel, perpendicular to the wire inside the pocket 104.

[0013] Figures 5A and 5B show that for a given wave-front pressure, the total force exerted on a "long" bond wire will be greater than the total force exerted on a "short" bond wire. The wave fronts that strike long bond wires thus tend to cause such wires and/or their connections to fail.

[0014] A method and/or apparatus to reduce vibration-induced wave fronts in a pocket 104 containing the gel 306 would be an improvement over the prior art in that reducing wave fronts would tend to reduce bond wire failure as well as reduce bond wire connection failure.

BRIEF SUMMARY

[0015] Embodiments of the invention are directed to an automotive electronic device that includes a pocket that houses: electronic components, bond wires connecting the electronic components, and a protective gel. A pocket cover has fins that protrude into the gel to reduce vibration of the gel and vibration fatigue failure of the bond wires. The fins may: divide the gel into a plurality of cells; reduce the width of cells perpendicular to the bond wires; protrude deeper into the gel than the bond wires; and/or have differing shapes and/or depths. Embodiments of the invention are also directed to associated methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Figure 1 depicts a transmission-fluid pressure sensor in accordance with the prior art.

[0017] Figure 2 is a top view of the pocket shown Figure 1.

[0018] Figure 3 is a cross-sectional view of the housing pocket and cover.

[0019] Figure 4 is a graphical depiction of the power spectral density impressed on a bond wire of the transmission-fluid pressure sensor by random vibration.

[0020] Figures 5A and 5B depict forces on bond wires from vibration-induced wave fronts.

[0021] Figures 6A and 6B show pressure waves moving perpendicular, and parallel to a bond wire.

[0022] Figure 7 depicts a cover with fins in accordance with embodiments of the invention.

[0023] Figure 8 is a top sectional view through the cover shown in Figure 7 showing fins that form cells to reduce the width of the pocket in which pressure waves can travel.

[0024] Figure 9 is a sectional side view of the cavity showing fins in accordance with embodiments of the invention.

DETAILED DESCRIPTION

[0025] An embodiment of the invention is directed to a medium pressure sensor (e.g., approximately 1 MPa to approximately 5 MPa) such as a transmission-fluid pressure sensor. Other embodiments may be directed to various other types of automotive electronic devices that contain bond wires and protective gel; e.g., a transmission control module.

[0026] Figures 6A and 6B show pressure waves moving perpendicular, and parallel, respectively, to a bond wire. Pressure waves moving

perpendicular to the wire produce a much higher risk of wire failure than do pressure waves moving parallel to the wire.

[0027] Pressure P on a bond wire is proportional to the gel density ρ multiplied by the gel acceleration a times the width of gel W, which is the width of the pocket perpendicular to the bond wire.

[0028] The bending stress acting on a bond wire is proportional to the bond wire length squared.

[0029] In order to reduce gel vibration and prevent bond wire fatigue failures, a cover with fins may be used to divide the gel into a plurality of cells. The cover may be made of plastic or any other suitable material.

[0030] Figure 7 depicts a cover 702 with fins 704 in accordance with embodiments of the invention. Figure 7 is perspective view of the bottom of the cover from which a rim 108 and several rectangular fins 704 protrude.

[0031] Figure 8 is a top sectional view through the cover 702 showing fins 704 that form cells 802-1 through 802-5 to reduce the width of the pocket in which pressure waves can travel perpendicularly to the bond wires. Fins 802-1 through 802-3 are formed above the horizontal fin 704 in Figure 8 and are divided by the two fins that run vertically up from the horizontal fin in Figure 8 to the rim 108 of the cover 702. Cells 802-4 and 802-5 are formed below the horizontal fin 704 in Figure 8 and are divided by the single fin that runs vertically down in Figure 8 from the horizontal fin to the rim 108.

[0032] Figure 9 is a sectional side view of the cavity showing fins in accordance with embodiments of the invention. Fins 902-1, 902-2, and 902-3 are shown in various shapes, such as rectangular 902-3 and trapezoidal 902-1 and 902-2, and having varying depths, such as shallow 902-1 and deep 902-2 and 902-3. The fins are configured to protect the bond wires 202 from perpendicular pressure waves, which would otherwise travel in

directions that can be referred to as "into or out of the page" with reference to the view shown in Figure 9.

[0033] In the embodiment of Figure 9, there is no short wall between the PCB 204 and lead frame 318. Also, a slightly wider pocket (or slightly narrower PCB) is used with a slot between the PCB and housing side wall. The deep fins, 902-2 and 902-3, therefore, can be more deeply inserted into the gel. For example, deep fin 902-2 extends deeper into the gel than the top surface of the PCB, and deep fin 902-3 extends deeper into the gel than the top surfaces of the PCB and the lead frame.

[0034] In accordance with embodiments of the invention, fins protrude from the pocket cover into the gel thereby dividing the gel into a plurality of cells and reducing the gel mass and gel movement in each cell during vibration. Further, gel movement is reduced by increasing friction between the gel and fin walls as compared to the amount of gel movement in the absence of fins.

[0035] By using fins protruding downwardly from the bottom of the cover 106, as opposed to breakwaters, of the type disclosed by U.S. Patent 8,245,575 to Chiou et al., that protrude from within the pocket 104, increased flexibility is provided with respect to placement of both the components within the pocket and also with respect to placement of the fins in response to placement of the components within the pocket. For example, use of the PCB as depicted in Figure 8 would preclude use of breakwaters to protect the bond wires shown in Figure 8.

[0036] While the present invention has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the

specific details, representative apparatus and method, and illustrative example shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept.

CLAIMS

1. An automotive electronic device comprising:

a pocket having therein a plurality of electronic components, a plurality of bond wires connecting the electronic components, and a gel encapsulating the electronic components and the plurality of bond wires; and

a pocket cover having a plurality of fins that protrude into the gel to reduce vibration of the gel and to reduce vibration fatigue failure of the bond wires.

2. The automotive electronic device of claim 1, wherein the fins divide the gel into a plurality of cells.

3. The automotive electronic device of claim 2, wherein the plurality of fins protrude from the pocket cover such that the fins reduce the width of the cells perpendicular to the bond wires.

4. The automotive electronic device of claim 1, wherein the plurality of fins protrude deeper into the gel than the plurality of bond wires.

5. The automotive electronic device of claim 1, wherein a first fin of the plurality of fins has a first depth, and a second fin of the plurality of fins has a second depth that is different from the first depth.

6. The automotive electronic device of claim 1, wherein at least one of the fins is generally rectangular.

7. The automotive electronic device of claim 1, wherein at least one of the fins is generally trapezoidal.

8. The automotive electronic device of claim 1, wherein the automotive electronic device is a pressure sensor.

9. The automotive electronic device of claim 1, further comprising a printed circuit board in the pocket.

10. A method comprising:

using a plurality of fins protruding from a pocket cover to divide a gel, within a pocket of an automotive electronic device, to reduce vibration of the gel and to reduce vibration fatigue failure of bond wires within the pocket.

11. The method of claim 10, wherein the fins divide the gel into a plurality of cells.

12. The method of claim 11, wherein the plurality of fins protrude from the pocket cover such that the fins reduce the width of the cells perpendicular to the bond wires.

13. The method of claim 10, wherein the plurality of fins protrude deeper into the gel than the plurality of bond wires.

14. The method of claim 10, wherein a first fin of the plurality of fins has a first depth, and a second fin of the plurality of fins has a second depth that is different from the first depth.

15. The method of claim 10, wherein at least one of the fins is generally rectangular.

16. The method of claim 10, wherein at least one of the fins is generally trapezoidal.

17. The method of claim 10, wherein the automotive electronic device is a pressure sensor.

18. The method of claim 10, wherein there is a printed circuit board in the pocket.

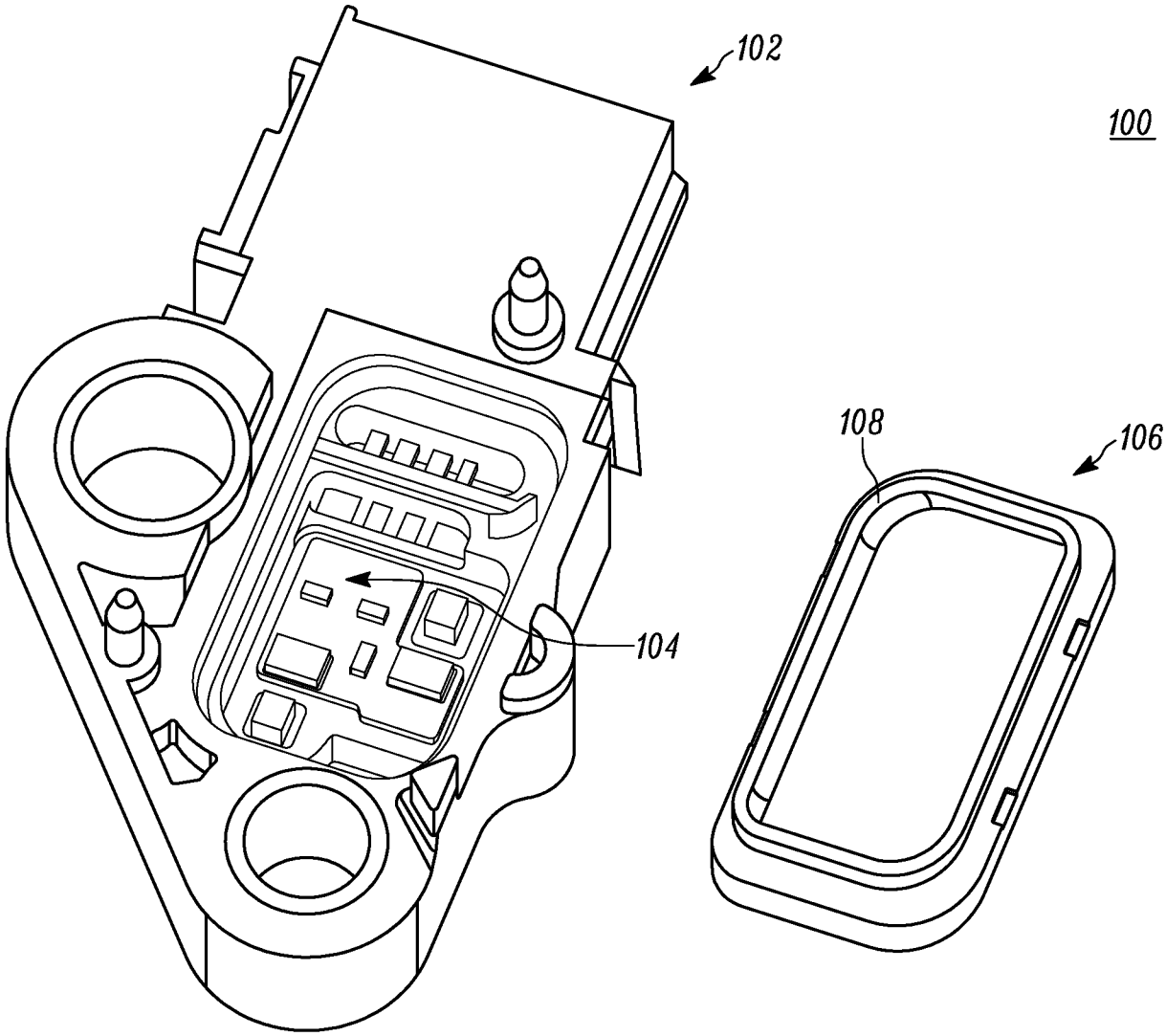

Figure 1

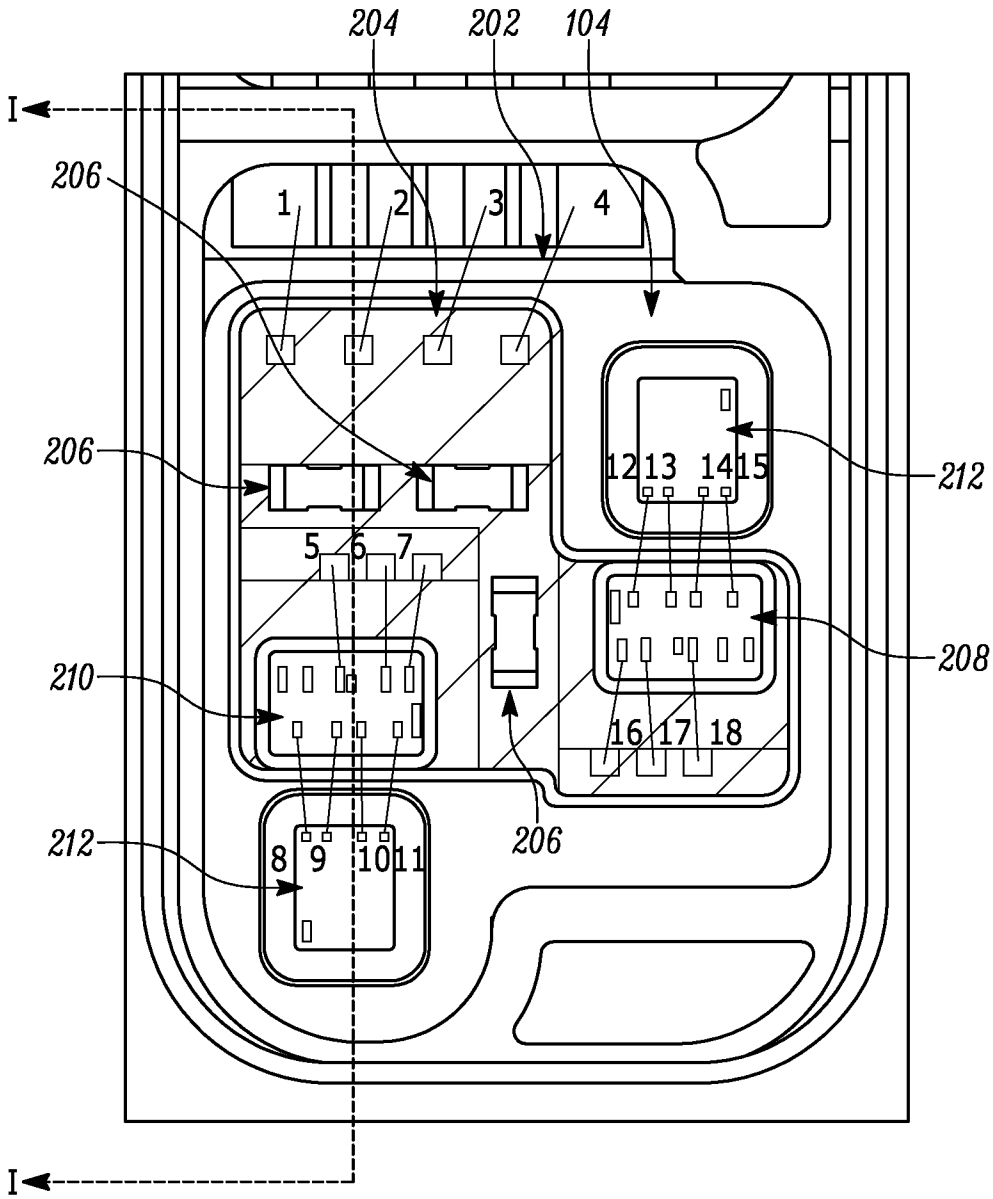
204
202
104
I
206
1
2
3
4
206
12 13 14 15
212
5 6 7
208
210
16 17 18
212
8 9 10 11
206
I

Figure 2

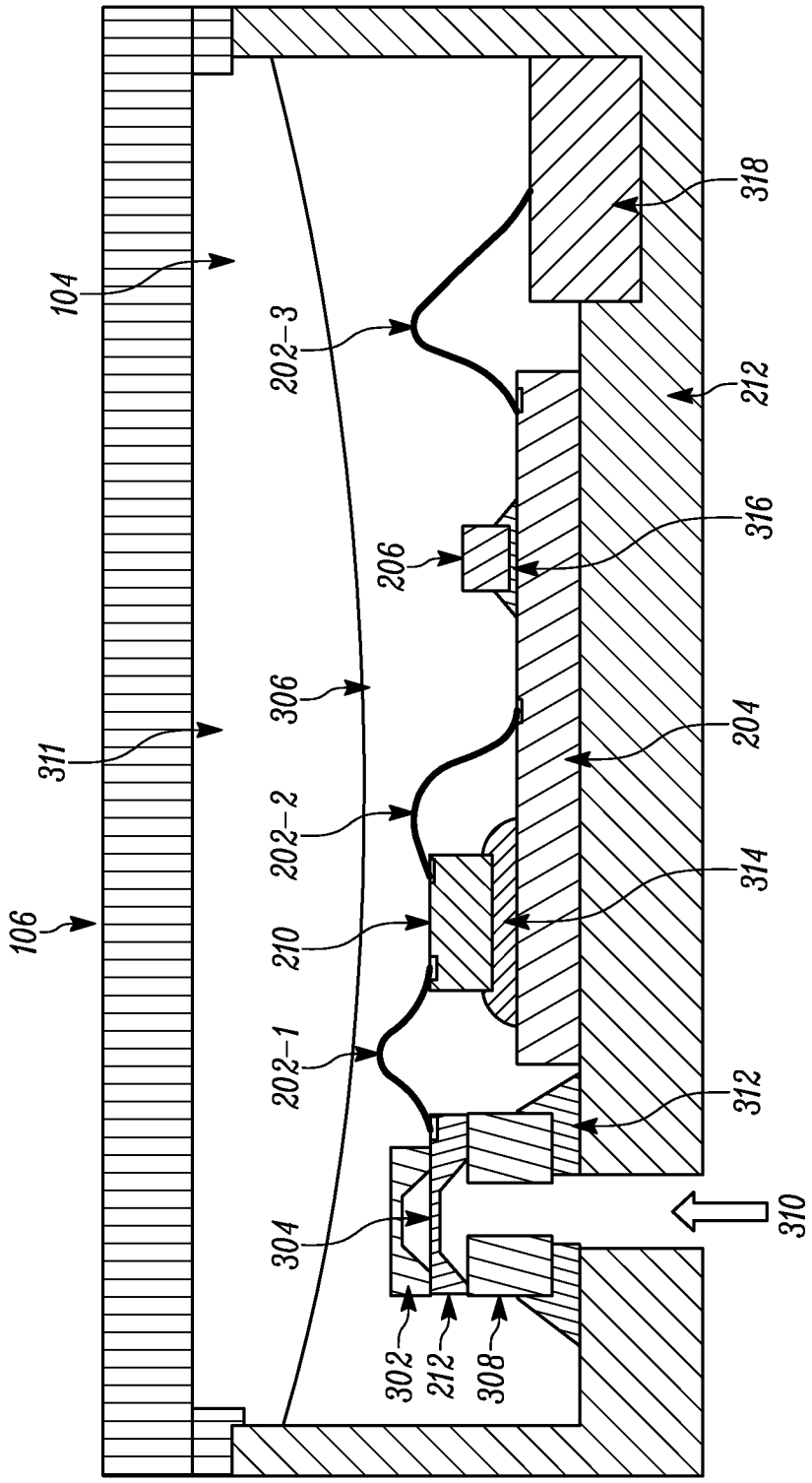
104
202-3
318
212
206
316
306
311
204
202-2
106
210
314
202-1
312
304
310
302
212
308

Figure 3

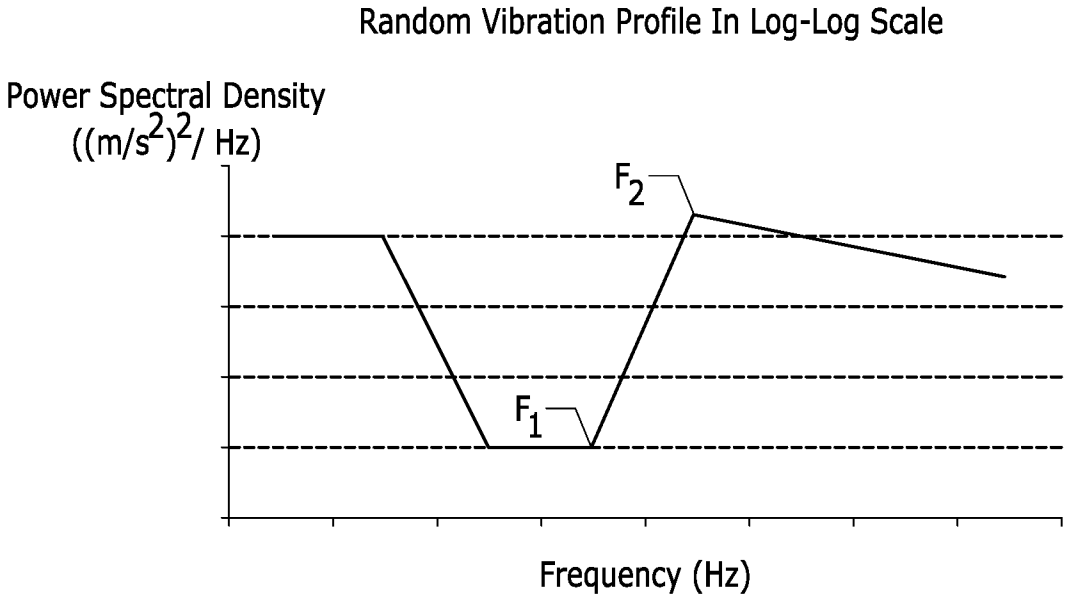

Figure 4

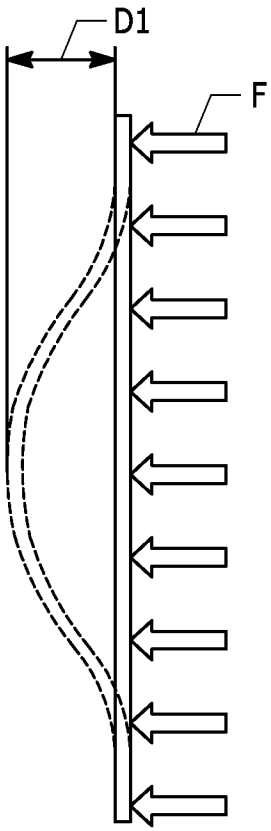

Figure 5A

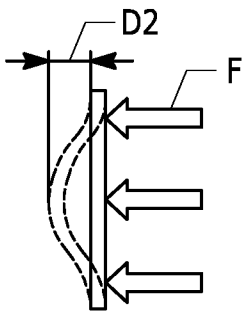

Figure 5B

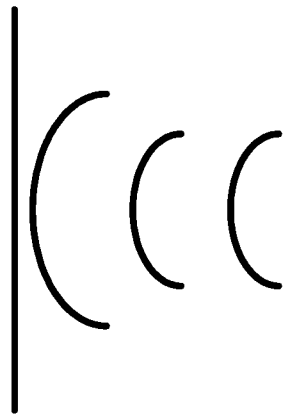

Figure 6A

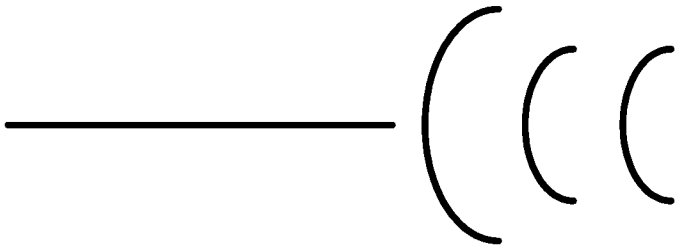

Figure 6B

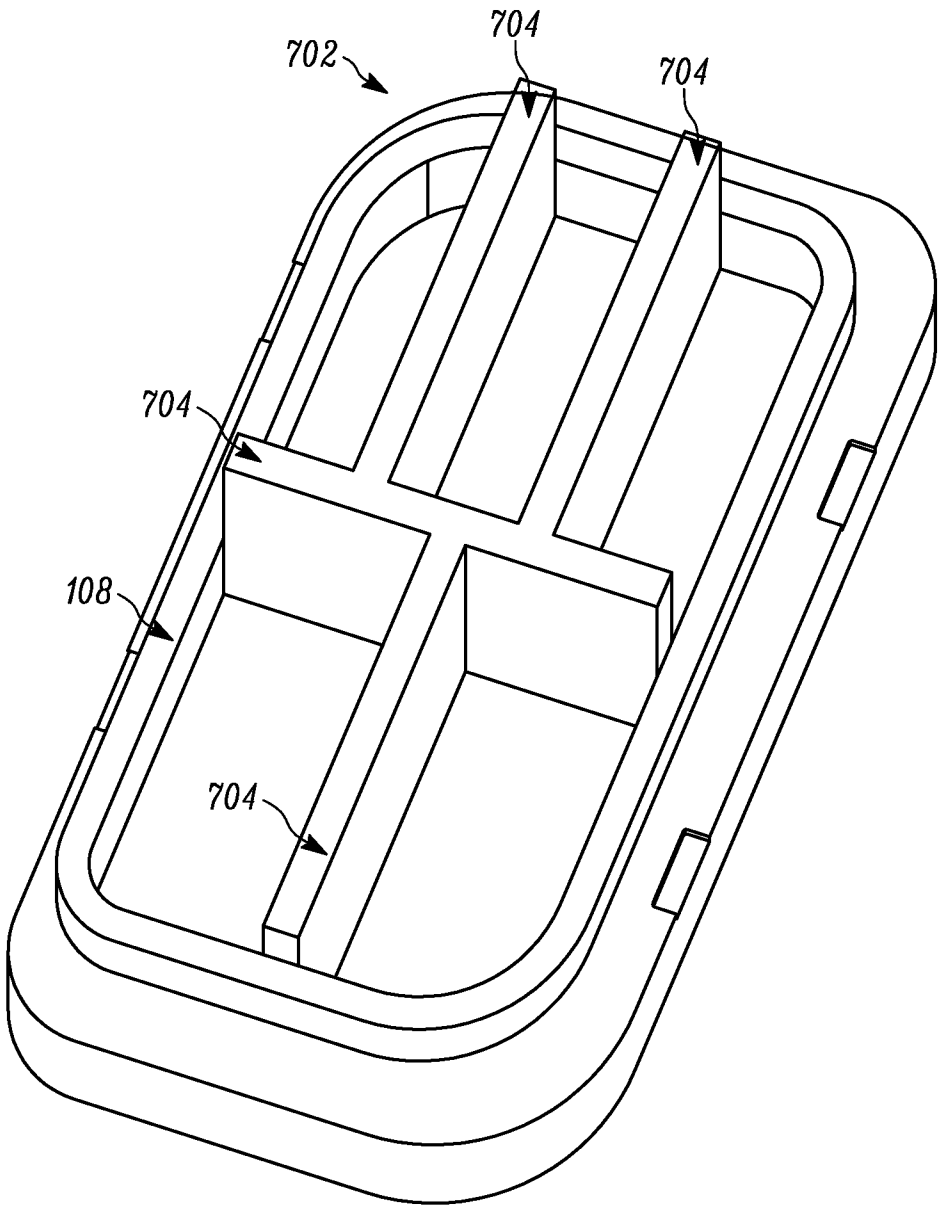

Figure 7

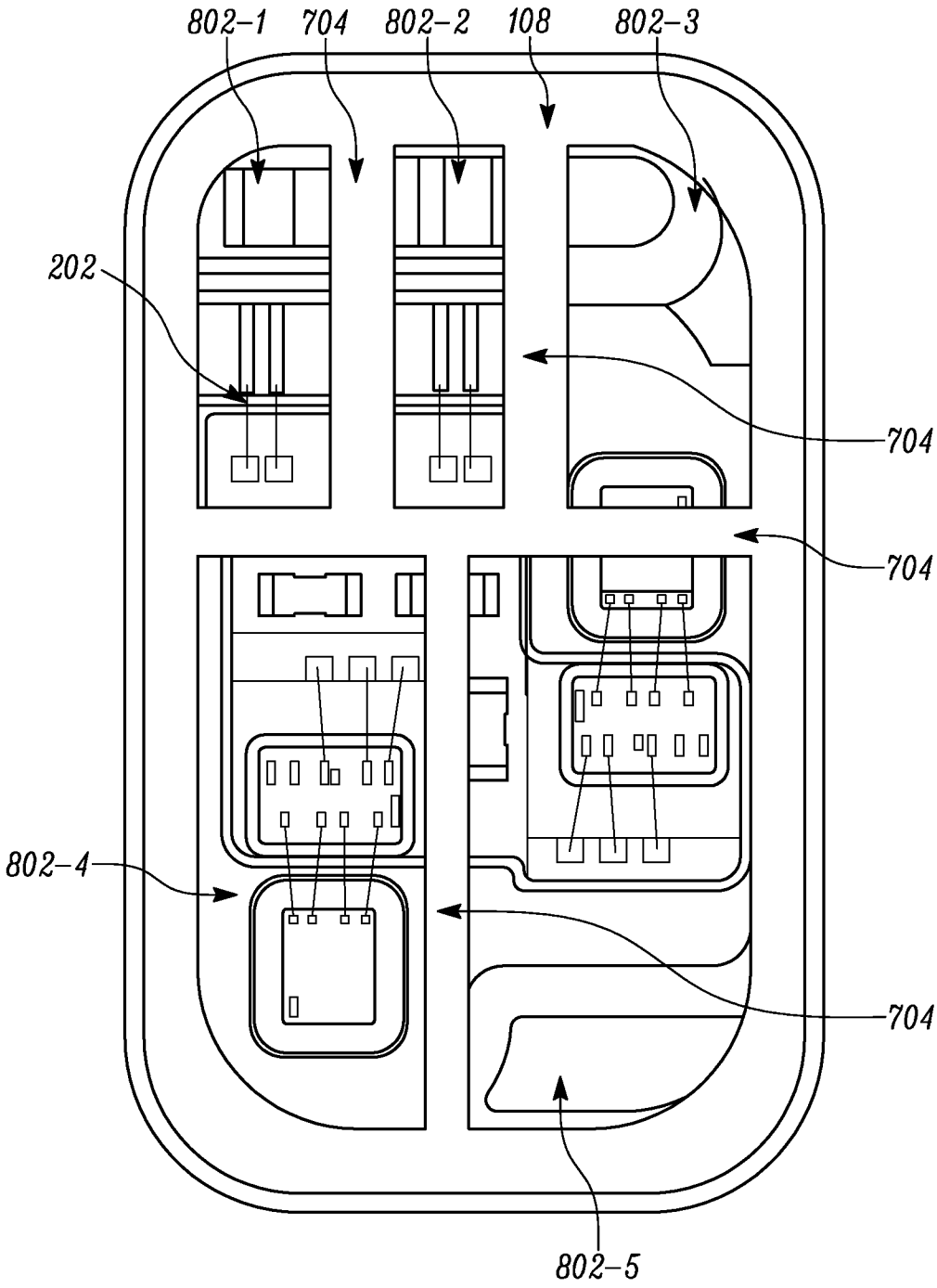

Figure 8

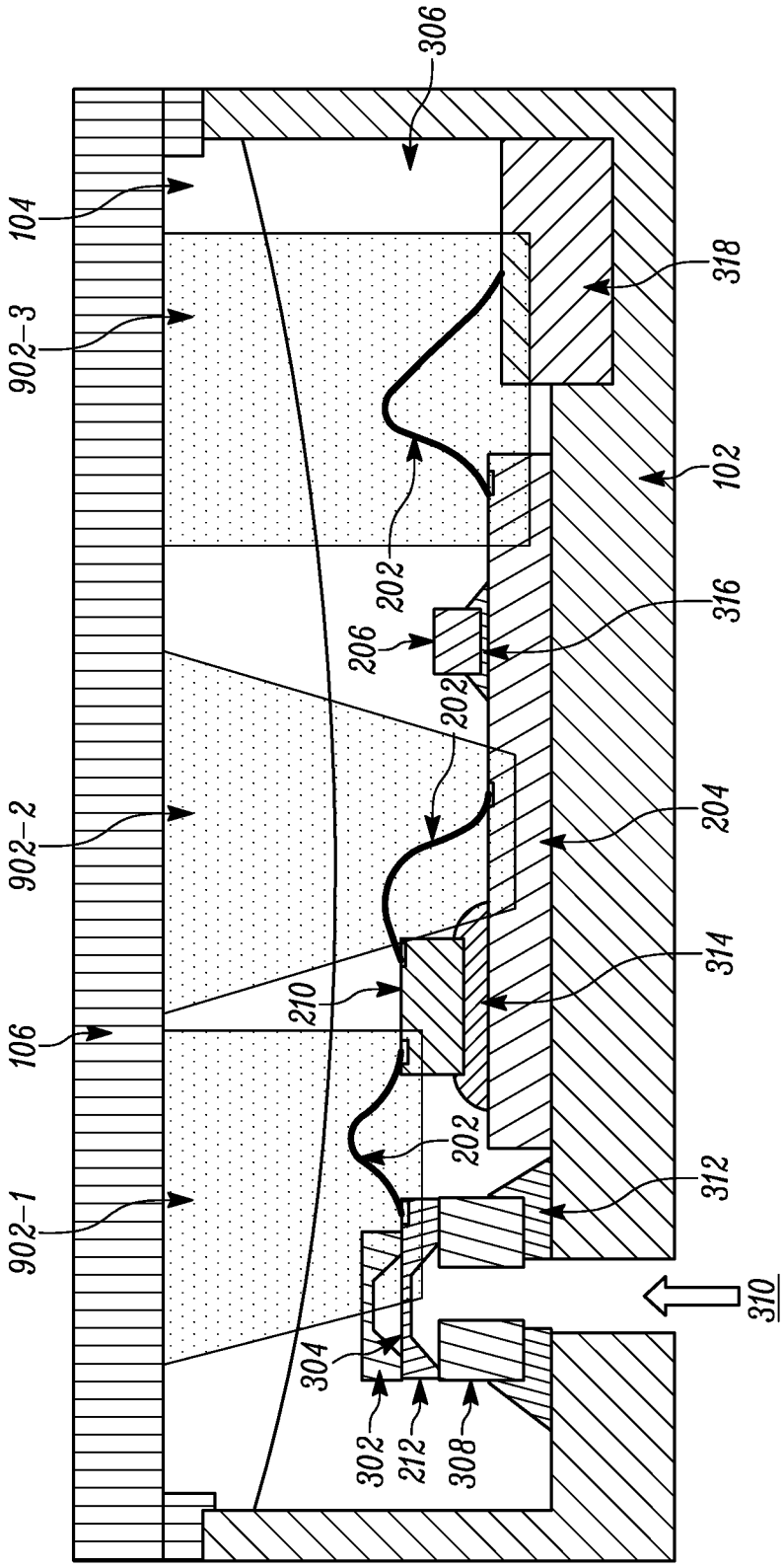
306
104
902-3
318
102
202
206
316
202
204
902-2
210
314
106
202
312
902-1
310
304
302
212
308

Figure 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/056591

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L23/04 H01L23/24
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/110801 A1 (HIGGINS III LEO M [US]) 24 April 2014 (2014-04-24) paragraph [0027]; figures 7, 8 -----	1-18
X	US 2010/230805 A1 (REFAI-AHMED GAMAL [CA]) 16 September 2010 (2010-09-16) figure 1 -----	1-18

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 December 2016	05/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kenevey, Kester

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/056591

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014110801 A1	24-04-2014	CN 103776580 A	07-05-2014
		EP 2722660 A2	23-04-2014
		JP 2014085337 A	12-05-2014
		US 2014110801 A1	24-04-2014
US 2010230805 A1	16-09-2010	CN 102414815 A	11-04-2012
		EP 2409328 A1	25-01-2012
		JP 5661095 B2	28-01-2015
		JP 2012520575 A	06-09-2012
		KR 20110139265 A	28-12-2011
		US 2010230805 A1	16-09-2010
		WO 2010105346 A1	23-09-2010