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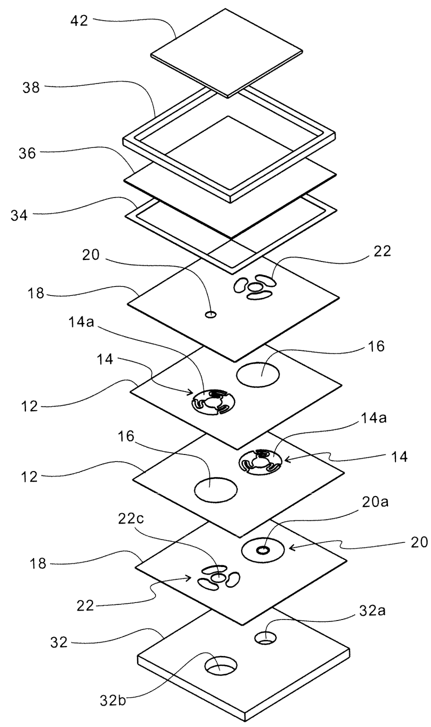
(54) MICRODIAPHRAGM PUMP

(57) A microdiaphragm pump having a diaphragm chamber in contact with one side of an intake valve and one side of a discharge valve. The microdiaphragm includes two valve plate sheets 12, in each of which a valve plate 14 of one of an intake valve 26 and a discharge valve 28 and a flow path aperture 16 that provides a passage of the other valve are formed and which are laminated in directions that are opposite from each other; two valve seat sheets 18, which are laminated to the laminate and in which valve seats 20 and valve stoppers 22 are formed; a base plate 32; a frame 34; a diaphragm 36; and a drive element 42. The microdiaphragm pump has extremely small external dimensions and provides high productivity, high flow control accuracy, a smooth operation, large suction and discharge forces, and high reliability.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to a microdiaphragm pump formed by laminating and joining a plurality of sheet metals in which patterns of valve plates, valve seats, diaphragms and the like have been formed.

Background Art

[0002] In recent years, as the distributed energy plants for houses (detached houses), fuel cell systems have been expected to be spread and commercialized. This type of fuel cell requires a pump for supplying a fuel gas or a liquid fuel and water to a reformer, hydrogen produced in the reformer, and the like to a fuel cell itself. Carbon monoxide (CO) is produced at the time of reforming for taking required hydrogen (H_2) from a fuel. The carbon monoxide adversely affects the performance of a battery catalyst, so that it is also required to control the flow of the air for selective oxidation in order to reduce the concentration of the carbon monoxide. Further, an extremely small quantity of a gas or a liquid is necessary in an analyzing device and a medical field (medication, clinical trials and the like). Further, there is also a need for a pump for cooling by dissipating heat generated as the performance of electronic equipment is enhanced.

[0003] Hitherto, a variety of types of micropumps intended for the applications mentioned above has been proposed. Patent Document 1 discloses a micropump in which an inflow valve and an outflow valve with a valve element held between a metal outer bush (a first columnar portion) and a metal inner bush (a second columnar portion) are disposed to be orthogonal to a flat pressure chamber provided in a pump body. A diaphragm constituting the pressure chamber is disposed to cover inlet port and outlet port of the two valves.

[0004] Patent Documents 2 to 5 disclose a pump in which a pressure chamber (diaphragm chamber) is provided between an intake valve and a discharge valve, and the pressure in the pressure chamber is changed by a piezoelectric element attached to a diaphragm that defines the pressure chamber, thereby discharging a fluid. More specifically, the diaphragm does not cover the intake valve and the discharge valve (is not in contact with surfaces on one side of each of the two valves). Further, partly, a silicon substrate is used.

Prior Art Documents

Patent Documents

[0005]

Patent Document 1: JP-A-2009-236284
Patent Document 2: JP-A-2006-161779
Patent Document 3: JP-A-6-93972
Patent Document 4: JP-A-5-1669
Patent Document 5: JP-A-10-299659

Disclosures of Invention

Problem to be Solved by the Invention

[0006] According to the one disclosed in Patent Document 1, the intake valve and the discharge valve are formed by a combination of two metallic columnar members coaxially fitted, so that the dimension thereof in the direction orthogonal to a diaphragm (the direction of the flow path of the intake valve and the discharge valve) inevitably increases, making it difficult to achieve a reduced size. There is another problem in that machining and assembling the columnar members require many man-hours, resulting in poor productivity. Further, a relatively long fluid flow path is required to be provided between a pressure chamber and the valve element of each valve, the flow path being substantially a part of the pressure chamber. The flow path is a portion, the volume of which remains unchanged and in which a fluid stagnates (unnecessary volume), thus leading to low accuracy of controlling the flow rate of a fluid.

[0007] In every one of Patent Documents 2 to 5, the position of the diaphragm, which forms the pressure chamber, is limited to the space between the intake valve and the discharge valve, so that the area of the diaphragm is small. For this reason, a change in the volume of the pressure chamber caused by the vibration of the diaphragm is small, making it difficult to smoothly operate the intake and the discharge of a fluid, posing a problem in that the control of the discharge rate for each stroke of the diaphragm becomes inaccurate. Thus, it is difficult or impossible to use the pumps with a compressible gas or the like. There is another problem in that the small area of the diaphragm makes it difficult to increase a fluid intake force and a fluid discharge force. There is still another problem in that the silicon substrates used therein are relatively costly.

[0008] The present invention has been made with a view toward solving the problems described above, and it is an object of the invention to provide a highly reliable microdiaphragm pump which permits extremely smaller external dimensions, higher productivity, improved fluid flow rate control accuracy, a smoother fluid intake/discharge operation, increased intake force and discharge force, and a higher degree of freedom in selecting a material to be used rather than being restricted to a silicon substrate.

Means of Solving the Problem

[0009] According to the present invention, a first object is fulfilled by a microdiaphragm pump which has a diaphragm chamber in contact with one side of an intake valve and one side of a discharge valve, including: two valve plate sheets, in each of which a valve plate of one of the intake valve and the discharge valve and a flow path aperture that provides a flow path of the other valve are formed and which are laminated in such directions that the valve plates and the flow path apertures face each other; two valve seat sheets, which are laminated to both surfaces of the laminate and in each of which a valve seat opposing the valve plate of the one valve plate sheet and a valve stopper opposing the valve plate of the other valve plate sheet are formed; a base plate which is superposed on one of the valve seat sheets and which has two flow paths in communication with the intake valve and the discharge valve; a frame which is superposed on the peripheral edge of the other valve seat sheet and which surrounds the intake valve and the discharge valve; a diaphragm which is superposed on the frame to form a diaphragm chamber between the diaphragm and the valve seat sheet on which the frame has been superposed; and a drive element retained on the diaphragm.

[0010] Forming the two valve plate sheets and the two valve seat sheets by sheet metals of stainless steel or the like and laminating and bonding the sheets in layers obviate the need for the use of relatively costly silicon substrates. As a metal to be used, it is preferred to select one that is incorruptible to fluids. There are various methods available to laminate and join many layers of stainless thin sheets. The methods include using a solder with a high Sn (tin) concentration, solder plating of a silver alloy of Sn-Ag or the like, an adhesive agent, and metal diffusion joining from the viewpoint of the wettability, the soldering strength and the like with respect to stainless steel.

[0011] Preferably, the valve plate is configured to be retained by a supporting arm that extends from the inner edge of the valve plate opening formed in the valve plate sheet toward the inside diameter, and the diameters of the flow path aperture formed in the valve plate sheet and the flow path aperture, which is formed in the base plate sheet and which provides the passage of the discharge valve, are the same (including "approximately the same"or "substantially the same" as the inside diameter of the valve plate opening. In this case, it is possible to prevent the valve plate and the supporting arm thereof from being joined to another sheet by being subjected to the pressure required to be applied to the laminated multiple layers, such as the valve plate sheets and the valve seat sheets.

[0012] The valve plate sheets and the valve seat sheets can be processed by various methods, such as etching and press stamping. Especially in the case where many pumps are to be manufactured at the same time, these sheets can be efficiently manufactured by machining many valve plates, flow path apertures, the valve seats, the valve stoppers in the sheets.

[0013] The frame and the diaphragm are made of sheet metals, and the pump can be formed by depositing these on one surface of the laminate (preliminary laminate) formed in claim 2 and by depositing the base plate on the other surface of the laminate and then joining them. Thus, the assembly accuracy and the fabrication efficiency can be improved by stacking and joining the valve plate sheet and the valve seat sheet and stacking and joining the frame, the diaphragm and the base plate in two separate steps.

[0014] Annular protrusions with which the valve plates come in contact are preferably formed on the valve seats to be formed in the two valve seat sheets. The protrusions can be formed by shallowly engraving, by half-etching, an area around the portion to become a valve seat. Alternatively, however, a different method may be used to form the protrusions. In this case, the contact pressure applied to the protrusions of the valve plates increase with resultant improved sealing performance. This means that the sealability of the valves improves.

[0015] In this case, DLC (Diamond Like Carbon) coatings are preferably formed on the annular protrusions. The DLC contains a carbon structure having a highly lubricant molecular structure and a diamond structure having a high degree of hardness, thus having the advantages of both. This allows the protrusions to be hard and smooth, leading to improve wear resistance and durability with resultant sealing performance. In the case where the protrusions are provided with the DLC, the close contact between the valve plate and the valve seat can be further improved by stamping (pushing) the valve plate against the protrusion by making use of the high hardness of the DLC. To enable the stamping, an opening through which a machining tool (such as a punch) for stamping is formed in the valve stopper. More specifically, the valve stopper is provided with an annular portion facing the protrusion, which becomes the valve seat, (also facing the valve plate) and flow paths divided in the circumferential direction around the annular portion are provided, and then a stamping tool is inserted in the annular portion.

[0016] A piezoelectric element is suited for the drive element retained on the diaphragm. For example, a sintered compact made of a piezoelectric material, which contains lead zirconate titanate (PZT) and which is generally referred to as PZT may be attached to the diaphragm and polarized by applying an electric field thereto. Fixing a second frame that surrounds the drive element to the diaphragm makes it possible to secure a movable area (movable space) of the drive element and the diaphragm in the second frame. This prevents the operation of a pump from being interfered with by contact between adjoining components in the case where the pump is mounted on a substrate or the like.

Effect of the Invention

[0017] The present invention allows the area of a diaphragm to be expanded to the outside of an intake valve and a discharge valve, therefore a change in the volume of a diaphragm chamber can be increased to permit a smooth fluid intake/discharge operation. The intake valve and the discharge valve are formed by stacking two valve plate sheets and then superposing the valve seat sheets on both outer sides thereof, so that the entire laminate can be made extremely thin, thus permitting a smaller pump. The valve plate sheets, the valve seat sheets, a base plate, frames and a diaphragm are laminated and joined (multilayer-joined) and a drive element is attached to the diaphragm from outside. Accordingly, higher productivity and a significant reduction in cost can be achieved.

[0018] Regarding the valve plate sheets and the valve seat sheets, forming the combination of the two sheets constituting the intake valve and the combination of the two sheets constituting the discharge valve to have the same shape permits further improved productivity, because the combinations can be stacked, reversing the directions thereof from each other. Especially in the case where sheet-like members, in which the valve plate sheets, the valve seat sheets, the base plates, the frames, and diaphragms have been formed for a plurality of pumps, are prepared, many pumps can be simultaneously produced by laminating and joining the sheet-like members and then cutting and dividing the laminate into separate pumps. In this case, productivity can be further improved.

[0019] The diaphragm chamber (the pressure chamber) and the respective valves will come in contact through the intermediary of one of the valve seat sheets, so that the fluid flow path connecting the diaphragm chamber and the respective valves will be extremely short, making it possible to achieve a sufficiently small volume of the diaphragm chamber at the time of fluid discharge of the diaphragm. In other words, an extremely high ratio of (maximum volume/unnecessary volume) can be obtained. This allows the intake/discharge operation to be securely performed at each stroke of the diaphragm, so that the discharge rate (flow rate) of a fluid is accurately controlled. Further, the larger diaphragm area permits a larger fluid intake/discharge force, leading to the possible applicability for a compressible fluid (a gas or the like) rather than the applicability limited to a non-compressible fluid (a liquid or the like).

Brief Description of the Drawings

[0020]

FIG. 1 is a perspective view of a microdiaphragm pump according to an embodiment of the present invention;

FIG. 2 is an exploded perspective view of the microdiaphragm pump shown in FIG. 1;

FIG. 3 is an enlarged sectional side view of the microdiaphragm pump shown in FIG. 1;

FIG. 4 is an enlarged exploded perspective view of a part of the microdiaphragm pump illustrated in FIG. 1;

FIG. 5 is a top plan view of a valve plate and a flow path aperture in a valve plate sheet;

FIG. 6 is a top plan view of a valve seat and a valve stopper of the valve seat sheet;

FIG. 7 is an enlarged sectional view taken along the line VII-VII in FIG. 6; and

FIG. 8 is a sectional side view of a laminate taken along the line VIII-VIII in FIG. 5.

Mode for Carrying Out of the Invention

First Embodiment

[0021] In FIG. 1 to FIG. 4, reference numeral 10 denotes a microdiaphragm pump according to the present invention. The pump 10 is formed by stacking and joining a plurality of stainless sheet metals and frames in a multilayered manner. More specifically, sheet metals and the like are positioned and laminated, and then joined. The laminate has a rectangular shape, one side of which measuring approximately 7 to 10 mm. Reference numeral 12 denotes a valve plate sheet, which is formed by etching or press stamping a valve plate 14 and a flow path aperture 16 in a stainless sheet metal having a thickness of 0.01 mm (10 microns), as illustrated in FIG. 5. The valve plate 14 is retained by supporting arms 14b which extend, bending toward the inside diameter from a valve plate opening 14a having approximately the same diameter as that of the flow path aperture 16.

[0022] Reference numeral 18 denotes a valve seat sheet, which is formed by etching or press stamping a valve seat 20 and a valve stopper 22 in a stainless sheet metal having a thickness of 0.05 mm, as illustrated in FIG. 6. The valve seat 20 has a circular opening 20a, which provides a flow path, and an annular protrusion 20b along the periphery thereof. As illustrated in FIG. 7, the protrusion 20b can be formed by half-etching an area around the protrusion 20b (by removing the area by etching the area to a predetermined depth) so as to form a shallow recess. In FIG. 7, 20c denotes the area to be subjected to half-etching. The area to be half-etched is the area having substantially the same diameter as the flow path aperture 16 from the center of the opening 20a.

[0023] The valve stopper 22 has an annular portion 22a, which is wider than the protrusion 20b, and three flow paths 22b divided in the circumferential direction around the annular portion 22a. The annular portion 22a opposes the protrusion 20b of the valve seat 20 through the valve plate 14 in a state wherein the pump 10 has been assembled, as will be described hereinafter. The diameter of the circular opening 22c of the annular portion 22a is slightly larger than that of the protrusion 20b, because a stamping tool has to be inserted therethrough, as will be described hereinafter.

[0024] Two valve plate sheets 12 and two valve seat sheets 18 processed as described above are prepared. The valve plate sheet 12 is laid on another valve plate sheet 12, as illustrated in FIG. 2 to FIG. 4, and the valve seat sheets 18 and 18 are placed such that they sandwich the two valve plate sheets 12 therebetween. These multiple layers are joined together by, for example, diffusion joining (joining by heating and pressurizing in a vacuum). At this time, the valve plate sheets 12, 12 are superposed such that they are laterally reversed (rotated 180 degrees relative to each other) or turned over against each other, as is obvious from FIG. 2 and 3. Thus, the valve plate 14 and the flow path aperture 16 of the valve plate sheet 12 are formed in the positions where they are concentric with the valve seat 20 and the valve stopper 22 of the valve seat sheet 18 when the valve plate sheet 12 is laterally reversed or turned over. As a result, an intake valve 26 and a discharge valve 28 shown in FIG. 3 are formed in this laminate (preliminary laminate) 24.

[0025] A DLC coating is formed on the protrusion 20b beforehand. The DLC coating can be formed by, for example, a physical process (PVD), such as vacuum deposition or sputtering, or a chemical process (vapor-phase growth method), such as plasma CVD. At this time, the area except for the protrusion 20b is provided with masking to prevent the coating from being formed thereon. Further, when carrying out the half-etching on the area 20c, the area including the protrusion 20b which should not be etched is provided with masking to protect them from being etched.

[0026] In the preliminary laminate 24, the distal end of a stamping tool (punch or the like) 30 having an annular press surface is inserted from above into the opening 22c provided in the valve stopper 22 of the intake valve 26, as illustrated in FIG. 4, and then the valve plate 14 is pressed (stamped) against the protrusion 20b of the valve seat 20 thereunder. Similarly, the distal end of the stamping tool 30 is inserted from below into the opening 22c provided in the valve stopper 22 of the discharge valve 28, and then the valve plate 14 is pressed against the protrusion 20b of the valve seat 20 thereabove. As a result, the valve plate 14 and the protrusion 20b fit better with each other, permitting improved sealability when the valve is closed.

[0027] In FIG. 2 to FIG. 4, reference numeral 32 denotes a base plate. The base plate 32 is, for example, a stainless plate having a thickness of 0.5 mm, and provided with a passage 32a opposing the valve seat 20 (the opening 20a) of the intake valve 26 and a passage 32b opposing the valve stopper 22 (the passages 22b) of the discharge valve 28. These passages 32a and 32b are formed in the bottom surface of the preliminary laminate 24.

[0028] 34 is a frame having the same external shape as that of the base plate 32. The frame 34 is formed by punching out a square opening 34a in a stainless sheet metal, which has a thickness of 0.02 mm, with a predetermined width from the outer periphery of the sheet metal. The opening 34a surrounds the intake valve 26 and the discharge valve 28. Reference numeral 36 denotes a diaphragm formed of a 0.05 mm-thick stainless sheet metal. This also has the same external shape as that of the base plate 32. Reference numeral 38 denotes a second frame, which is formed of a 0.04 mm-thick stainless sheet metal. The second frame 38 has the same external shape as that of the base plate 32.

[0029] The base plate 32 is deposited on the bottom surface of the preliminary laminate 24. On the top surface of the preliminary laminate 24, the frame 34, the diaphragm 36 and the second frame 38 are deposited in this order. And the resulting multilayer laminate is pressurized to be joined. For example, diffusion joining is used. As a result, a diaphragm chamber (pressure chamber) 40 is formed between the diaphragm 36 and the valve seat sheet 18 located above, facing the diaphragm 36.

[0030] After many sheet metals are formed into the multilayer and joined together as described above, a sheet-shaped PZT 42 is attached to the diaphragm 36 from the upper side of the second frame 38. If the PZT 42 is unpolarized, then the PZT 42 is placed in an electric field to polarize it. The wiring connected to the electrodes of the PZT 42 is led upward and connected to a drive circuit, which is not shown.

[0031] The embodiment is used by connecting the passages 32a and 32b of the base plate 32 to a supply passage and a discharge passage (neither being shown) of a fluid, respectively, and by actuating a drive circuit of the PZT 42. As the PZT 42 is actuated, the diaphragm 36 vertically vibrates, causing the volume of the diaphragm chamber 40 to change due to the vibration. When the vibration causes the diaphragm chamber 40 to develop a negative pressure, then the valve plate 14 of the intake valve 26 moves away from the valve seat 20, thus opening the intake valve 26, while the valve plate 14 of the discharge valve 28 comes in contact with the valve seat 20, thus closing the discharge valve 28. This causes a fluid to be taken in anew from the intake valve 26. As the diaphragm 36 pressurizes the diaphragm chamber 40, the intake valve 26 closes, while the discharge valve 28 opens, causing the fluid to be discharged from the diaphragm chamber 40 through the discharge valve 28.

Description of Reference Numerals

[0032]

10	microdiaphragm pump
12	valve plate sheet
14	valve plate
14a	valve plate opening
14b	supporting arm
16	flow path aperture
18	valve seat sheet
20	valve seat
20a	opening
20b	protrusion
20c	area to be half-etched
22	valve stopper
22a	annular portion
22b	flow path
22c	opening
24	preliminary laminate
26	intake valve

28 discharge valve
30 stamping tool
32 base plate
34 first frame
36 diaphragm
38 second frame
40 diaphragm chamber
42 drive element (piezoelectric element, PZT)

Claims

1. A microdiaphragm pump which has a diaphragm chamber in contact with one side of an intake valve and a discharge valve, comprising:

   two valve plate sheets, in each of which a valve plate of one of the intake valve and the discharge valve and a flow path aperture that provides a flow path of the other valve are formed and which are laminated in such directions that the valve plates and the flow path apertures face each other;
   two valve seat sheets, which are laminated to both surfaces of the laminate and in each of which a valve seat opposing the valve plate of the one valve plate sheet and a valve stopper opposing the valve plate of the other valve plate sheet are formed;
   a base plate which is superposed on one of the valve seat sheets and which has two flow paths in communication with the intake valve and the discharge valve;
   a frame which is superposed on the peripheral edge of the other valve seat sheet and which surrounds the intake valve and the discharge valve;
   a diaphragm which is superposed on the frame to form a diaphragm chamber between the diaphragm and the valve seat sheet on which the frame has been superposed; and
   a drive element retained on the diaphragm.

2. The microdiaphragm pump according to Claim 1, wherein the two valve plate sheets and the two valve seat sheets are formed of sheet metals, the two valve plate sheets are sandwiched by the two valve seat sheets, and the sheets are joined in a multilayered manner thereby to form a laminate.

3. The microdiaphragm pump according to Claim 1, wherein the valve plate is retained by a supporting arm that extends from an inner edge of a valve plate opening formed in the valve plate sheet toward the inside diameter, and opening diameters of the flow path aperture formed in the valve plate sheet and a flow path aperture which is formed in the base plate and which provides a flow path of the discharge valve are equal to an inside diameter of the valve plate opening.

4. The microdiaphragm pump according to Claim 1, wherein the valve plate and the flow path aperture of the valve plate sheet and the valve seat and the valve stopper of the valve seat sheet are processed by either etching or press stamping.

5. The microdiaphragm pump according to Claim 2, wherein the frame and the diaphragm are made of sheet metals and these are laminated to a surface on one side of the laminate formed in Claim 2, and the base plate is laminated to a surface on the other side of the laminate, these layers being joined in a multilayered manner.

6. The microdiaphragm pump according to Claim 1, wherein the valve seats formed on the two valve seat sheets are provided with annular protrusions facing the valve plates to improve sealability relative to the valve plates.

7. The microdiaphragm pump according to Claim 6, wherein the annular protrusions formed on the two valve seat sheets are provided with DLC films to make the protrusions hard and smooth.

8. The microdiaphragm pump according to Claim 7, wherein the valve plates of the two valve plate sheets are subjected to stamping by pressing the valve plates against the annular protrusions of the valve seat sheets to improve close contact with the protrusions.

9. The microdiaphragm pump according to Claim 8, wherein the valve stopper of the valve seat sheet is provided with an annular portion facing the protrusion formed on the valve seat of the other valve seat sheet and a flow path divided in a circumferential direction around the annular portion, and the annular portion allows a stamping tool to be inserted therein.

10. The microdiaphragm pump according to Claim 1, wherein the drive element is a piezoelectric element attached to the diaphragm.

11. The microdiaphragm pump according to Claim 10, wherein a second frame, which surrounds the piezoelectric element, is fixed to the diaphragm.

FIG. 1

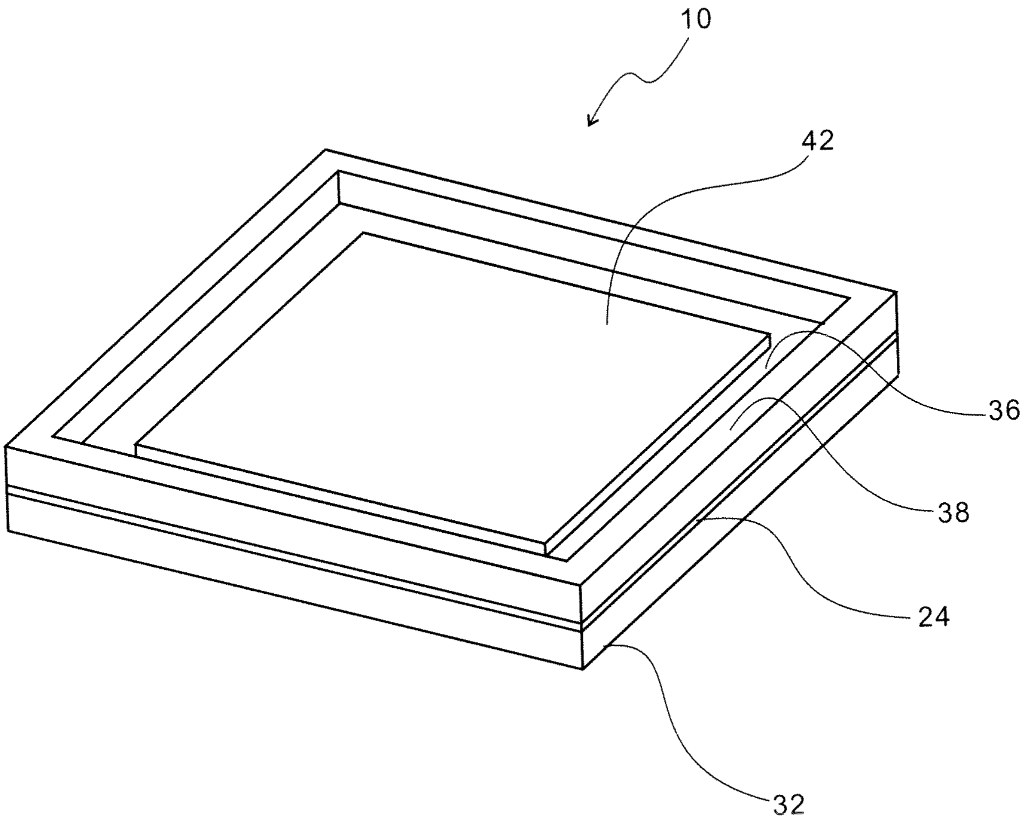

FIG. 2

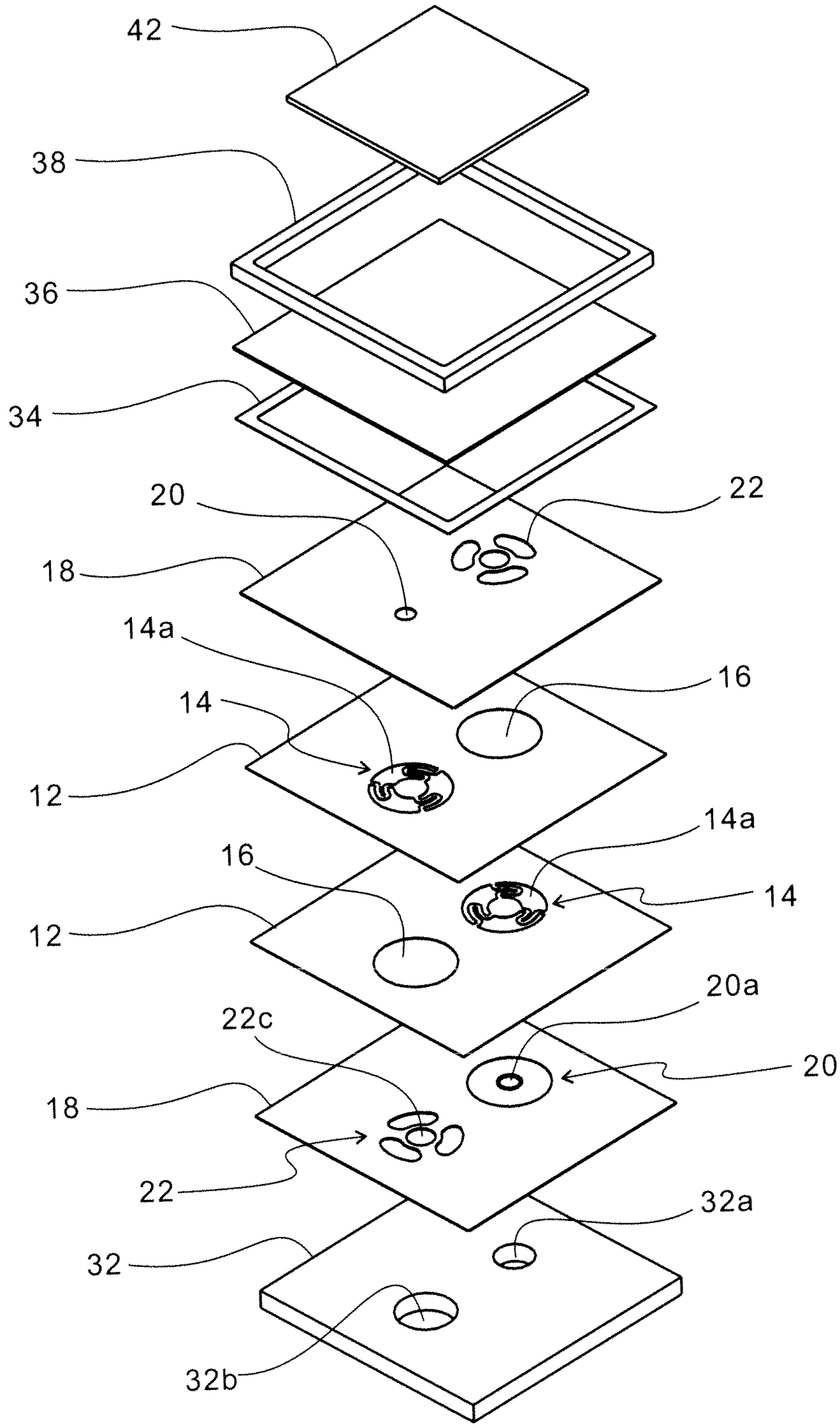
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FIG. 3

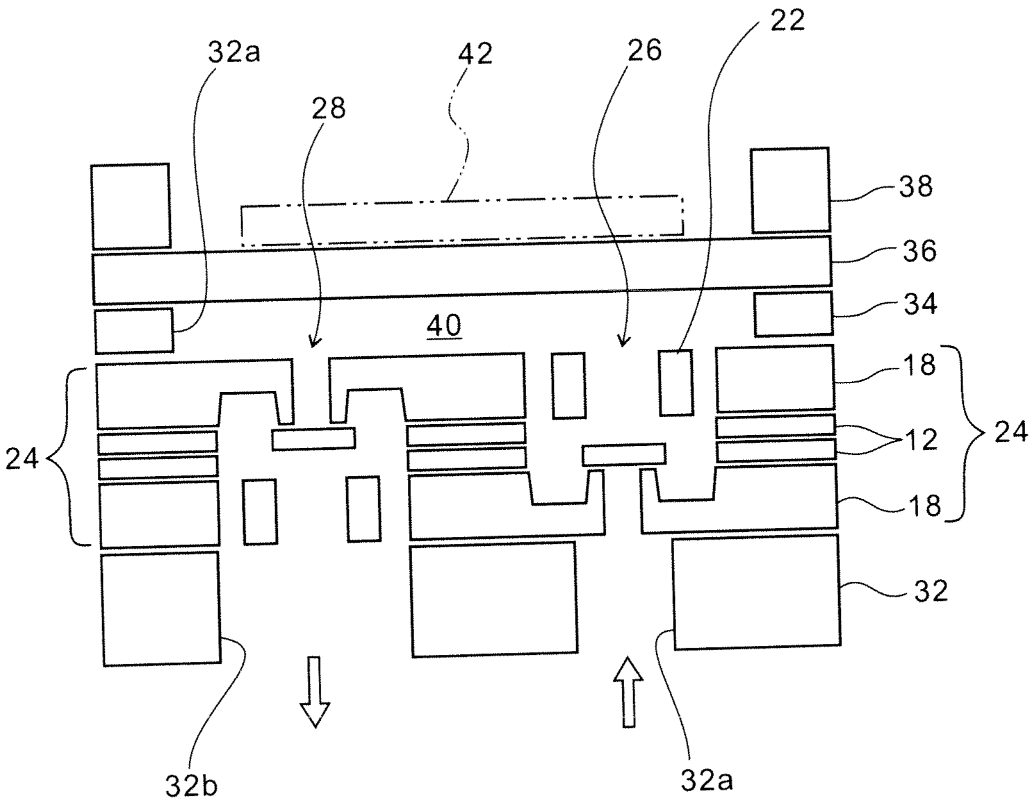
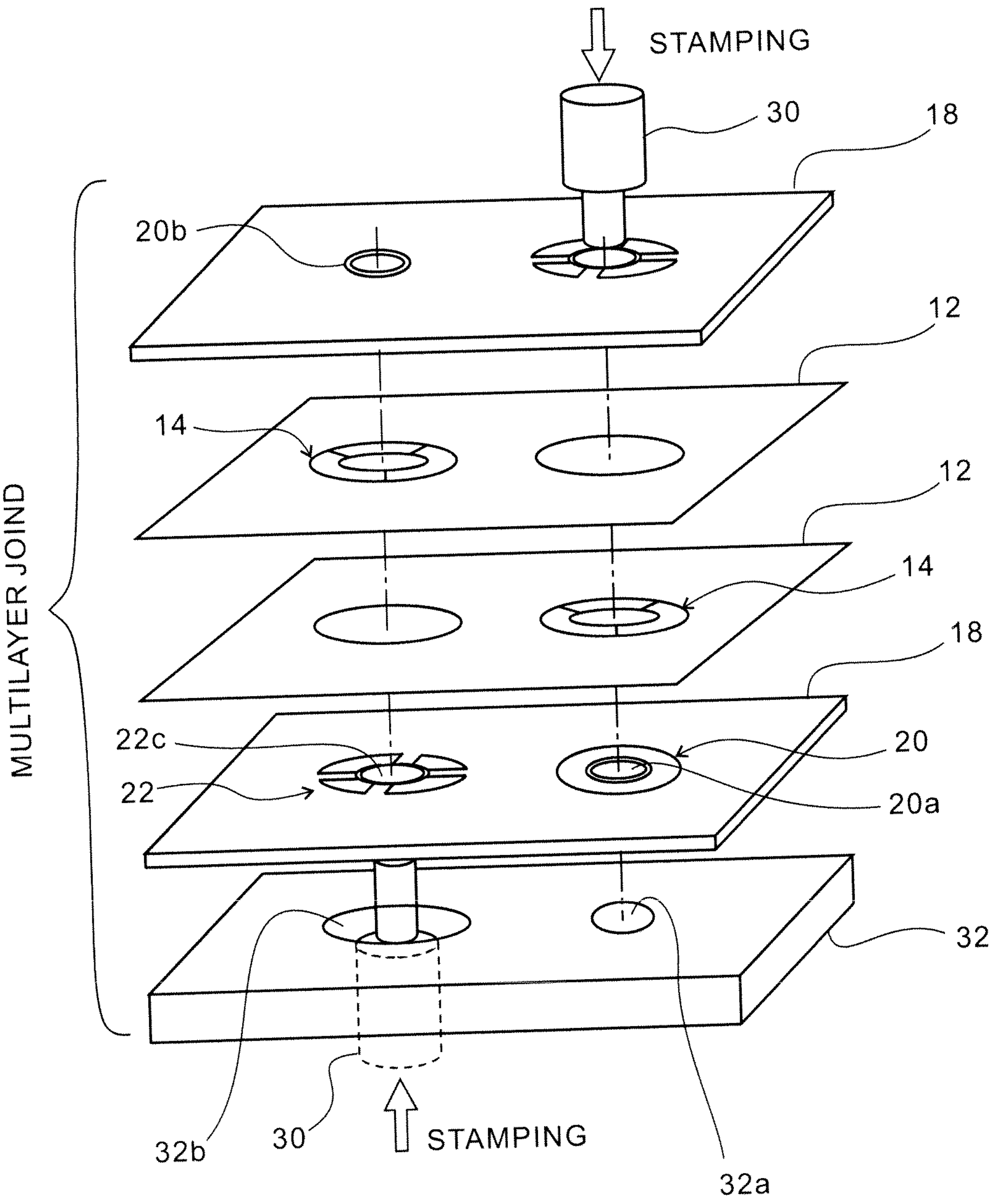


FIG. 4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STAMPING
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FIG. 5

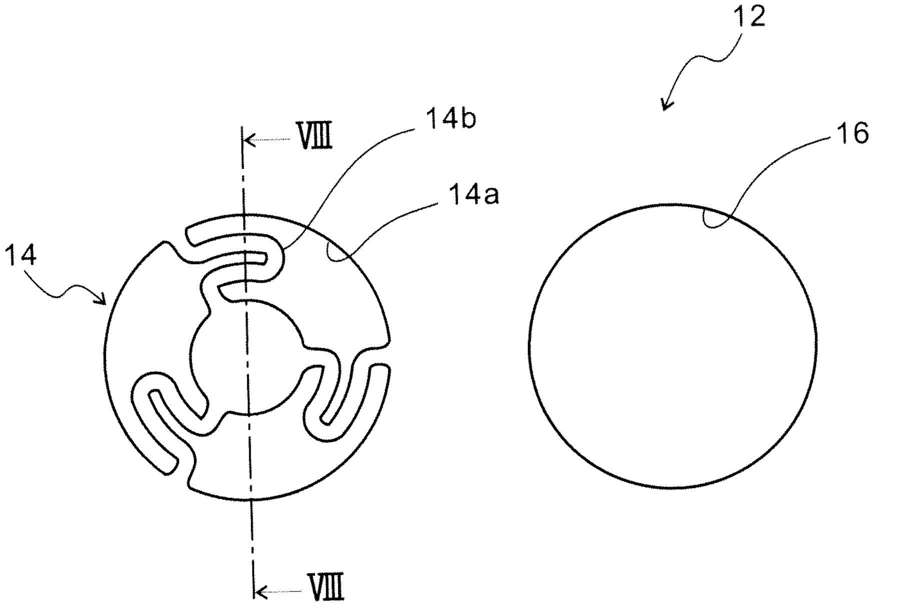
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FIG. 6

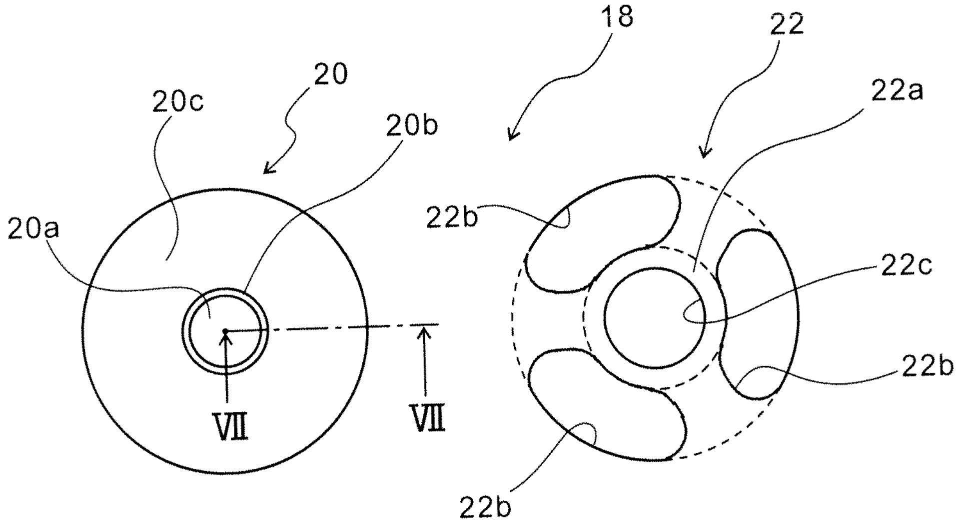
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FIG. 7

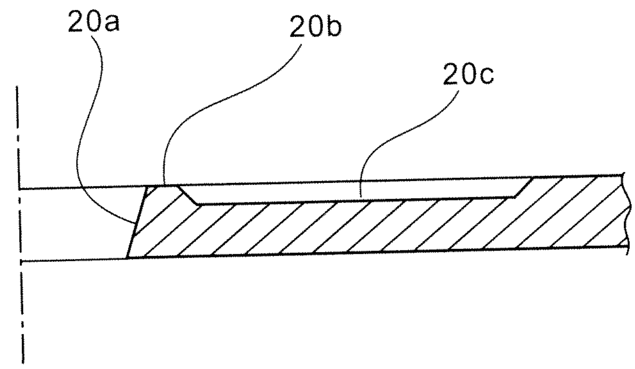
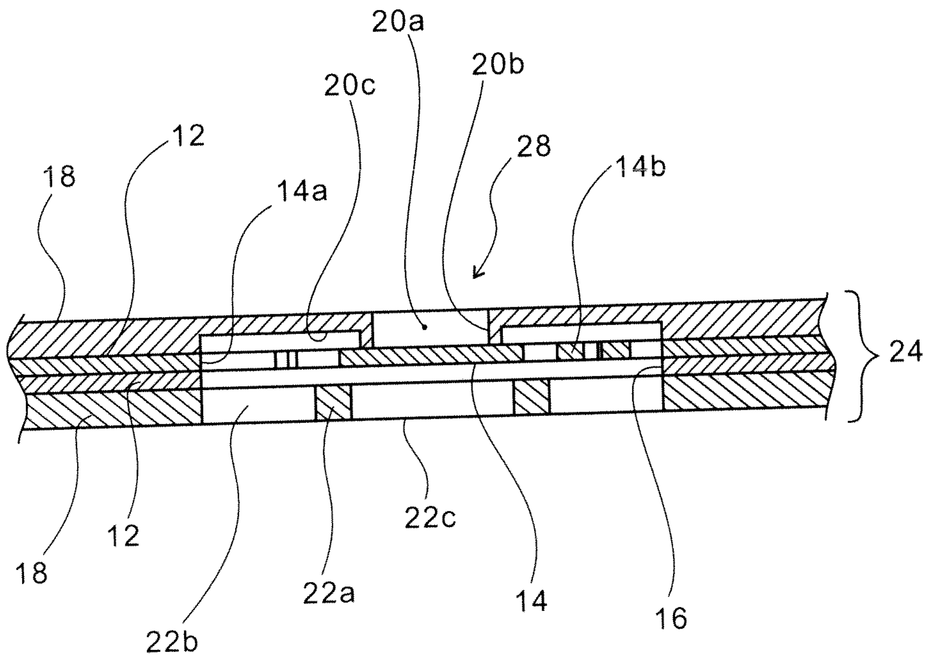


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/072056

A. CLASSIFICATION OF SUBJECT MATTER
F04B43/02(2006.01)i, *F04B43/04*(2006.01)i, *F04B45/04*(2006.01)i, *F04B45/047* (2006.01)i

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)
F04B43/02, F04B43/04, F04B45/04, F04B45/047

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 76874/1990(Laid-open No. 34478/1992) (Mitsubishi Kasei Corp.), 23 March 1992 (23.03.1992), specification, column 4, line 8 to column 8, line 17; fig. 2 to 3 (Family: none)	1-11
A	JP 2005-83212 A (Matsushita Electric Industrial Co., Ltd.), 31 March 2005 (31.03.2005), paragraphs [0021] to [0028]; fig. 1 to 5 & US 2005/0053504 A1	1-11

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
19 December, 2011 (19.12.11)	27 December, 2011 (27.12.11)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/072056

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	JP 2006-242176 A (NEC Corp.), 14 September 2006 (14.09.2006), paragraphs [0044] to [0049]; fig. 14 to 15 & WO 2004/017698 A1	1-11
A	JP 2000-274374 A (Kasei Optonix, Ltd.), 03 October 2000 (03.10.2000), paragraphs [0029] to [0031]; fig. 1, 4, 5 (Family: none)	1
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REFERENCES CITED IN THE DESCRIPTION

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