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

(11) **EP 3 037 573 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.06.2016 Bulletin 2016/26

(21) Application number: **14837234.5**

(22) Date of filing: **31.07.2014**

(51) Int Cl.:
C25D 17/08 *(2006.01)* ***C23C 18/31*** *(2006.01)*
C25D 21/12 *(2006.01)*

(86) International application number:
PCT/JP2014/070252

(87) International publication number:
WO 2015/025693 (26.02.2015 Gazette 2015/08)

(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

(30) Priority: **19.08.2013 JP 2013169504**

(71) Applicants:
- **Yamamoto-ms Co., Ltd.**
  Tokyo 151-0051 (JP)
- **Waseda University**
  Tokyo 169-8050 (JP)

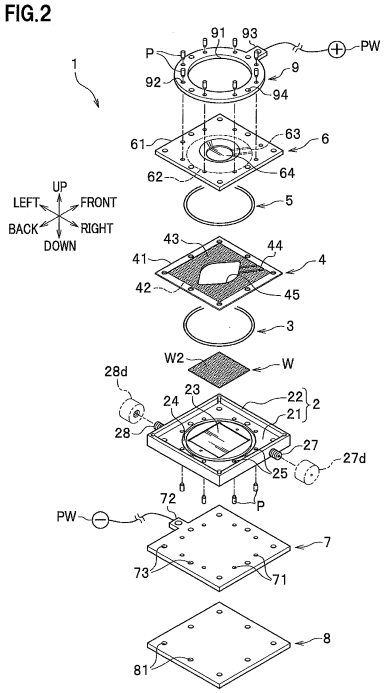
(72) Inventors:
- **YAMAMOTO, Wataru**
  Tokyo 151-0051 (JP)
- **KOIWA, Kimiko**
  Tokyo 151-0051 (JP)
- **HOMMA, Takayuki**
  Tokyo 169-8050 (JP)
- **YANAGISAWA, Masahiro**
  Tokyo 169-8050 (JP)
- **SAITO, Mikiko**
  Tokyo 169-8050 (JP)
- **YAMAMOTO, Tomoyuki**
  Tokyo 169-8050 (JP)

(74) Representative: **Kiwit, Benedikt**
Mitscherlich PartmbB
Patent- und Rechtsanwälte
Sonnenstraße 33
80331 München (DE)

(54) PLATING APPARATUS AND SENSING DEVICE USING SAME

(57) A plating apparatus (1) includes: a holding member (2) that holds a plated object (W); a spacer (4) that is stacked on the holding member (2) via a first seal member (3) in an annular shape surrounding the plated object (W), and has a through portion (45) from which the plated object (W) is exposed and which stores a plating solution; and an anode member (6) that is stacked on the spacer (4) via a second seal member (3) in an annular shape surrounding the through portion (45), and has an anode layer (62) arranged to face the plated object (W) which is exposed from the through portion (45).

FIG.2



EP 3 037 573 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a plating apparatus for applying electrolytic plating or electroless plating on the face of a plated object, and a sensing device using the same.

BACKGROUND ART

[0002] In recent years, a plating technology has been applied to various technical fields such as a semiconductor wiring technique. Further, in order to determine plating conditions at the time of producing plated products, plating tests may be performed before starting the production, such as with a small-sized plating apparatus.

[0003] For example, Patent Document 1 discloses an electroplating testing apparatus including: a tank which has at least a bottom plate and a side plate, and is injected with a plating solution; and a cathode and anode plates which are horizontally placed so as to face each other in the plating solution in the tank, wherein one of the cathode and anode plates as a plated object is placed below the other, an opening is formed in the side plate of the tank for inserting the cathode and anode plates respectively into the tank, and a shield plate is detachably arranged in the tank for shielding the opening. The side plate of the tank includes a plurality of grooves for retaining at least one of the cathode and anode plates in a horizontal state, so as to allow adjusting the gap between the cathode and anode plates.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0004] Patent Document 1: Japanese Patent Application Publication No. 2006-299367 (claims 1-3, Fig. 1)

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] However, the plating apparatus described in Patent Document 1 needs to have the opening and the grooves in the side plate of the tank as well as the tank for accommodating the cathode and anode plates, causing the structure to be larger in size and to be complex, and a manufacturing cost and a material cost to increase accordingly. Therefore, a simpler and more compact plating apparatus has been required.

[0006] Moreover, in the research and development of a plated object in recent years, a plating apparatus has been required that allows for observing production process of a plated object during plating, such as with a high performance microscope (e.g. Raman microscope).

[0007] The present invention has been made in view of the above problems, and provides, as a primary subject, a plating apparatus that is simpler and can be easily made smaller in size than before and a sensing device using the same.

[0008] Further, the present invention provides, as a secondary subject, a plating apparatus that allows for observing a production process of a plated object.

MEANS TO SOLVE THE PROBLEMS

[0009] To solve the problems above, a plating apparatus according to the present invention includes: a holding member (2) that holds a plated object (W) specified as a cathode; a spacer (4) that is stacked on the holding member (2) via a first seal member (3) in an annular shape surrounding the plated object (W), and has a through portion (45) from which the plated object (W) is exposed and which stores a plating solution; and an anode member (6) that is stacked on the spacer (4) via a second seal member (5) in an annular shape surrounding the through portion (45), and has an anode layer (62) arranged to face the plated object (W) which is exposed from the through portion (45).

[0010] According to the structure, a plating apparatus (1) can be easily formed by simply stacking the holding member (2) to hold the plated object (W), the spacer (4) having the through portion (45) to store the plating solution and the anode member (6) having an anode via the first and second seal members (3, 5). Therefore, the plating apparatus (1) can be simpler and smaller in size as compared with the plating apparatus described in Patent Document 1, for example, because the tank having a complex structure is not necessary. Further, in the present invention, a distance between the cathode and the anode can be easily adjusted by exchanging the spacer (4) with one having different thickness.

[0011] Further, the spacer (4) includes a spacer body (41) made of an insulator and an anode-side conductive layer (43) arranged on a face, which faces the anode member (6), of the spacer body (41), the anode member (6) includes an anode member body (61) made of an insulator and an anode layer (62) specified as the anode arranged on a face, which faces the spacer (4), of the anode member body (61), the anode-side conductive layer (43) is connected inside the second seal member (5) to the anode layer (62), and the anode-side conductive layer (43) is connected outside the second seal member (5) to a power supply (PW).

[0012] According to the structure, the anode-side conductive layer 43 is connected inside the second seal member (5) to the anode layer (62), and the anode-side conductive layer (43) is connected outside the second seal member (5) to the power supply (PW), allowing for supplying electricity to the anode layer (62) while maintaining between the spacer (4) and the anode member (6) in watertight.

[0013] Further, the anode member body (61) preferably includes a light transmissive window (64) for observ-

ing the plated object (W) exposed from the through portion (45), and the anode layer (62) is preferably formed around the window (64).

[0014] The structure allows for observing the plating itself produced on the plated object (W), via the window (64) during plating.

[0015] Furthermore, the window (64) preferably has a thickness (t1) smaller than that of other portions of the anode member body (61).

[0016] This structure allows for, for example, arranging a microscope used for observation closer to the cathode. Consequently, the plated object (W) during plating can be suitably observed.

[0017] Moreover, the thickness (t1) of the window (64) is preferably in a range of 0.05 mm $\leq$ t1 $\leq$ 2 mm.

[0018] Since the structure allows for suitably restraining refraction and scattering of light which is transmitted through the window (64), the plated object (W) during plating can be suitably observed in a state where the influence caused by the window (64) is reduced.

[0019] Still moreover, the anode member body (61) preferably has a tapered portion (64a) around the window (W) which declines toward the window (64).

[0020] According to the structure, the anode member body (61) has the tapered portion (64a) around the window (64) that declines toward the window (64), which prevents the microscope (M) from contacting the anode member (6), for example, when the microscope (M) is used for observing the plated object (W).

[0021] Still moreover, the thickness (t2) of the spacer (4) is preferably in a range of 0.05 mm $\leq$ t2 $\leq$ 1 mm.

[0022] According to the structure, the thickness (depth) of the plating solution stored in the through portion (45) is small, to allow for observing the plated object (W) even if the plating solution is colored. Further, by shortening the distance between electrodes remarkably, a steep diffusion gradient of ion concentration can be obtained.

[0023] Still moreover, the spacer (4) preferably includes a cathode-side conductive layer (42) arranged on a face, which faces the holding member (2), of the spacer body (41), the cathode-side conductive layer (42) is connected inside the first seal member (3) to the plated object (W), and the cathode-side conductive layer (42) is connected outside the first seal member (3) to the power supply (PW).

[0024] The structure allows for supplying electricity to the plated object (W) while maintains between the spacer (4) and the holding member (2) in watertight.

[0025] Still moreover, the spacer (4) preferably includes a reference electrode conductive layer (44) insulated from the anode-side conductive layer (43) on a face, which faces the anode member (6), of the spacer body (41), and the anode member (6) preferably includes a reference electrode layer (63) insulated from the anode layer (62) on a face, which faces the spacer (4), of the anode member body (61), the reference electrode conductive layer (44) is connected inside the second seal member (5) to the reference electrode layer (63), and the reference electrode conductive layer (44) is connected outside the second seal member (5) to the measuring device.

[0026] According to the structure, the electric potential of the anode can be measured using the the reference electrode layer (63) while the spacer (4) and the anode member (6) can be maintained in watertight.

[0027] Still moreover, the holding member (2) or the anode member (6) preferably includes a plating solution supply passage (27) through which a plating solution is supplied to the through portion (45), and the holding member (2) or the anode member (6) preferably includes a plating solution discharge passage (28) through which the plating solution is discharged from the through portion (45).

[0028] The structure allows the plating solution in the through portion (45) to be suitably maintained by supplying the solution from the plating solution supply passage (27) to the through portion (45) and discharging it from the through portion (45) to the plating solution discharge passage (28).

[0029] Still moreover, in a case where the plating solution is an electroless plating solution, a measuring device instead of the power supply (PW) is preferably connected to measure the electric potential across the anode and the cathode.

[0030] The structure allows the plating apparatus (1) according to the present invention to apply the electroless plating and to measure the electric potential across the anode and the cathode.

[0031] Still moreover, the present invention provides a sensing device using the above-described plating apparatus (1), wherein the anode-side conductive layer (43) is constituted with a plurality of anode-side conductive layers (43B) insulated from one another, the anode layer (62) is constituted with the same number of anode layers (62B) insulated from one another as the anode-side conductive layers (43B), and portions (62Bb) of anode layers (62B) exposed from the through portion (45) are respectively modified with reaction groups different from one another.

[0032] The structure allows the plating apparatus (1) to be used as a sensing device, for example, by modifying different reaction groups to the plurality of anode layers (62B).

EFFECT OF THE INVENTION

[0033] The present invention can provide a plating apparatus which is simpler and can be easily made smaller in size than before, and a sensing device using the same. Further, the present invention can provide a plating apparatus that allows for observing a production process of a plated object.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

FIG. 1 is a perspective view of a plating apparatus according to a first embodiment;
FIG. 2 is an exploded perspective view of the plating apparatus according to the first embodiment;
FIG. 3 is an exploded cross-sectional view taken along a III-III line in FIG. 1;
FIG. 4 is an exploded cross-sectional view taken along a IV-IV line in FIG. 1;
FIG. 5 is an assembled cross-sectional view taken along the III-III line in Fig. 1;
FIG. 6A is a plan view of a holding member and FIG. 6B is a cross-sectional view taken along a VIb-VIb line in FIG. 6A;
FIG. 7A is a plan view of a spacer and FIG. 7B is a bottom view of the spacer;
FIG. 8A is a plan view of an anode member, FIG. 8B is a cross-sectional view taken along a VIIIb-VIIIb line in FIG. 8B, and FIG. 8C is a bottom view of the anode member;
FIG. 9 is an exploded cross-sectional view of a plating apparatus according to a second embodiment;
FIG. 10 is a plan view of the spacer in a sensing device using the plating apparatus; and
FIG. 11 is a bottom view of an anode member in the sensing device using the plating apparatus.

Embodiments of the Invention

[0035] Next, a first embodiment of the present invention will be described in detail with reference to the accompanying drawings. In the first embodiment, a description will be given of an exemplary case of applying electrolytic plating on a plated object W. It is noted that a direction will be indicated in the description based on the "front-back", "up-down" and "right-left" directions shown by arrows in FIG. 1.

[0036] A plating apparatus 1 according to the first embodiment is a thin plating apparatus formed in a simple stacked structure. The plating apparatus 1 has an advantage to allow for observing a production of a plated object and a reaction at a solid/liquid interface during plating, for example, using a special microscope such as a Raman microscope.

[0037] As shown in FIGS. 1 and 2, the plating apparatus 1 is an apparatus for plating the plated object W, and includes as main components a holding member 2a, a first seal member 3, a spacer 4, a second seal member 5 and an anode member 6, in order from the bottom. Further, the plating apparatus 1 includes a cathode-side conducting member 7 and an insulating member 8 below the holding member 2. Still further, the plating apparatus 1 includes an anode-side conducting member 9 above the anode member 6.

[0038] As shown in FIG. 2, the plated object W is an object on which plating is applied, and is formed of a thin plate member having a square shape, for example, in a plan view. The plated object W is not particularly limited to, and can be various electronic components such as a circuit board, a semiconductor chip and a device package. Also, the plated object W can be a test piece such as made of a mere metal plate. As shown in FIG. 3, in the first embodiment, the plated object W includes an insulating substrate W1 and a plated layer W2 that is stacked on the insulating substrate W1. The plated layer W2 is connected to the negative pole of a power supply PW to function as a cathode.

[0039] As shown in FIGS. 1 to 6B (in particular FIGS. 6A, 6B), the holding member 2 is a member for holding the plated object W. The holding member 2 is formed with, for example, an insulator such as PEEK resin (Poly Ether Ether Ketone). The holding member 2 includes a rectangular bottom wall 21 in a plan view and a sidewall 22 extending upward from four sides of the bottom wall 21. As shown in FIGS. 1 and 2, a space surrounded by the side wall 22 accommodates the plated object W, the first seal member 3, the spacer 4, the second seal member 5, and the anode member 6.

[0040] A recess 23 for mounting the plated object W is formed in the central portion of the upper face of the bottom wall 21. Further, a concave groove 24 in an annular shape for mounting the first seal member 3 is formed on the upper face of the bottom wall 21 so as to surround the recess 23. Further, the bottom wall 21 includes, outside the concave groove 24, a plurality of probe insertion holes 25 (eight in the first embodiment) for inserting probes P described later.

[0041] Still further, the bottom wall 21 includes a plating solution supply passage 27 which supplies the plating solution through a through portion 45 of the spacer 4 described later, and a plating solution discharge passage 28 which discharges the plating solution through the through portion 45. In the first embodiment, an opening 27a at the inlet side of the plating solution supply passage 27 is formed at the distal end of a cylinder 27c protruding from the right side of the bottom wall 21, and an opening 27b at the outlet side of the plating solution supply passage 27 is formed on the upper face of the bottom wall 21 and inside the annular concave groove 24 on the front side of the recess 23. Also, an opening 28a at the inlet side of the plating solution discharge passage 28 is formed on the upper face of the bottom wall 21 and inside the annular concave groove 24 on the back side of the recess 23, and an opening 28b at the outlet side of the plating solution discharge passage 28 is formed at the distal end of a cylinder 28c protruding from the left side of the bottom wall 21. The cylinders 27c, 28c are covered with caps 27d, 28d, respectively. The caps 27d, 28d prevent plating solution flow pipes (not shown) connected to the cylinders 27c, 28c from falling off.

[0042] As shown in FIGS. 2 to 5, the first seal member 3 is an elastic member which seals between the holding member 2 and the spacer 4 and is constituted by an O-ring having an annular shape, for example, in a plan view. The first seal member 3 is mounted in the concave groove 24 of the bottom wall 21. The first seal member 3 is arranged to surround the plated object W. Also, the first

seal member 3 is arranged to surround the through portion 45 of the spacer 4 (described later).

[0043] As shown in FIGS. 2 to 5 and 7A, 7B (in particular FIGS. 7A, 7B), the spacer 4 is a member which maintains the distance between the plated object W and an anode (described later) at a predetermined distance. In the first embodiment, the spacer 4 is formed of a thin plate member having a square shape, for example, in a plan view. The spacer 4 includes a spacer body 41 made of an insulator, a cathode-side conductive layer 42 arranged on the face, which faces the holding member 2, of the spacer body 41, an anode-side conductive layer 43 and a reference electrode conductive layer 44 arranged on the face, which faces the anode member 6, of the spacer body 41, and the through portion 45 formed through at the central portion of the spacer 4.

[0044] The spacer body 41 is a portion which insulates the cathode-side conductive layer 42 from the anode-side conductive layer 43, and is formed of, for example, an insulator such as borosilicate glass.

[0045] The cathode-side conductive layer 42 is a conductive layer which supplies electricity to the plated object W, and is formed of, for example, a metal material such as platinum. The cathode-side conductive layer 42 is formed by the technique such as sputtering or vacuum evaporation. The cathode-side conductive layer 42 is connected inside the first seal member 3 to the plated object W, and is connected outside the first seal member 3 to the negative pole of the power supply PW via the probes P and the cathode-side conducting member 7 (see FIGS. 1 and 5).

[0046] The anode-side conductive layer 43 is a conductive layer which supplies electricity to an anode layer 62 (described later), and is formed of, for example, a metal material such as platinum. The anode-side conductive layer 43 is formed by the technique such as sputtering or vacuum evaporation. The anode-side conductive layer 43 is connected inside the second seal member 5 to the anode layer 62 (described later), and is connected outside the second seal member 5 to the positive pole of the power supply PW via the probes P and the anode-side conducting member 9 (see FIGS 1 and 5).

[0047] The reference electrode conductive layer 44 is a conductive layer which is electrically connected to a reference electrode layer 63 (described later), and is formed of, for example, a metal material such as platinum. The reference electrode conductive layer 44 is formed by the technique such as sputtering or vacuum evaporation. Portions without the conductive layer are provided at both sides of the reference lectrode conductive layer 44 (more specifically, between the the reference electrode conductive layer 44 and the anode-side conductive layer 43) and are insulated from the anode-side conductive layer 43. The reference electrode conductive layer 44 is connected inside the second seal member 5 to the reference electrode layer 63 (described later), and is connected outside the second seal member 5 to a measuring device (not shown) via the probes P (described later).

[0048] The through portion 45 is an opening from which a portion of the plated object W is exposed and which stores the plating solution, and is formed through in the up-down direction substantially at the central portion of the spacer 4. The through portion 45 is formed substantially in an elongated diamond shape in a plan view where the length in the front-back direction is longer than that in the right-left direction. The opening 27b at the outlet side of the plating solution supply passage 27 is exposed in the vicinity of the end portion at the front side of the through portion 45 (see FIG. 2). Also, the opening 28a at the inlet side of the plating solution discharge passage 28 is exposed in the vicinity of the end portion at the back side of the through portion 45 (see FIG. 2). Thus, the plating solution which has flowed from the opening 27b into the through portion 45 flows from the front to the back inside the through portion 45 to finally flow out from the opening 28a.

[0049] The thickness t2 of the spacer 4 is not particularly limited to, but is preferable in the range of 0.05 mm $\leq$ t2 $\leq$ 1 mm, and is more preferable in the range of 0.10 mm $\leq$ t2 $\leq$ 0.20 mm. In the first embodiment, the spacer 4 is formed to have the thickness t2 of approximately 0.10 mm. Making the thickness t2 of the spacer 4 very thin allows for observing the plated object W through a window 64 (described later), even when the plating solution is not so transparent.

[0050] It is noted that a plurality of different spacers 4 having a different thickness t2 may be prepared in advance to be exchanged depending on applications. For example, if the plating solution is very transparent, a spacer 4 having a relatively thicker thickness t2 can be used. In the first embodiment, the spacer 4 having an extremely thin thickness t2 of about 0.10 mm allows for observing the reaction at the solid/liquid interface in more detail.

[0051] As shown in FIGS. 2 to 5, the second seal member 5 is a resilient member for sealing between the spacer 4 and the anode member 6, and is formed of an O-ring having an annular shape, for example, in a plan view. The second seal member 5 is mounted in a concave groove 65 formed in the lower face of the anode member 6. The second seal member 5 is arranged to surround the through portion 45 of the spacer 4. Further, the second seal member 5 is arranged to surround the window 64 of the anode member 6.

[0052] As shown in FIGS. 1 to 5 and 8A to 8C (in particular, 8A to 8C), the anode member 6 mainly includes: an anode member body 61; the anode layer 62 and the reference electrode layer 63 provided on the face, which faces the holding member 2, of the anode member body 61; the window 64 formed in the central portion of the anode member body 61; and the concave groove 65 formed in the face, which faces the holding member 2, of the anode member body 61. The anode member 6 covers the through portion 45 of the spacer 4 from above.

[0053] The anode member body 61 is a plate-like mem-

ber having a rectangular shape in a plan view. The anode member body 61 is made of an insulating material, such as transparent (light transmissive) quartz glass.

[0054] The anode layer 62 is an anode portion which is electrically connected to the positive pole of the power supply PW, and is formed between the window 64 and the concave groove 65 described later on the face, which faces the holding member 2, of the anode member body 61. That is, the anode layer 62 is formed around the window 64. The anode layer 62 is, for example, formed of a metal material such as platinum. The anode layer 62 is formed by the technique such as sputtering or vacuum evaporation. The anode layer 62 is connected inside the second seal member 5 to the anode-side conductive layer 43.

[0055] The reference electrode layer 63 is a portion to be a reference electrode which is electrically connected to the measuring device (not shown). The reference electrode layer 63 is arranged at a position facing the reference electrode conductive layer 44. The reference electrode layer 63 is, for example, formed of a metal material such as platinum. The reference electrode layer 63 is formed by the technique such as sputtering or vacuum evaporation. Portions without the conductive layer are provided at both sides of the reference electrode layer 63 (more specifically, between the reference electrode layer 63 and the anode-side layer 62) and are insulated from the anode-side layer 62. The reference electrode layer 63 is connected inside the second seal member 5 to the reference electrode conductive layer 44. The reference electrode layer 63 allows for measuring electric potential of the anode (anode layer 62) as a working electrode.

[0056] The window 64 is a transparent observation window for observing (or monitoring) the plated object W. The window 64 is arranged at the central portion of the anode member body 61, and formed in a circular shape in a plan view. The window 64 is formed of quartz glass which is the same material as, for instance, the anode member body 61. The thickness t1 of the window 64 is thinner than that of other portions of the anode member body 61 (for example, the outer peripheral portion of the anode member body 61). The thickness t1 of the window 64 is preferably in the range of 0.05 mm $\leq$ t1 $\leq$ 2 mm, and even more preferably in the range of 0.10 mm $\leq$ t1 $\leq$ 0.20 mm. In the first embodiment, the window 64 is formed to have the thickness t1 of approximately 0.13 mm. Making the thickness t1 extremely thin allows for, when the plated object is observed with a microscope, reducing refraction and scattering of light transmitted through the window 64, to allow for observing the plated object precisely.

[0057] A tapered portion 64a in a truncated cone shape is arranged around the window 64, the portion 64a declining toward the window 64. When the microscope is set on the window 64, the tapered portion 64a reduces interference between the microscope and the anode member body 61. In other words, the tapered portion 64a around the window 64 allows a larger microscope in size to be arranged closer to the window 64.

[0058] The concave groove 65 is an annular groove for mounting the second seal member 5 and is formed on the lower face of the anode member body 61. The concave groove 65 is formed to surround the window 64. The concave groove 65 reduces the positional displacement of the second seal member 5 and has a function to facilitate the anode layer 62 to contact the anode-side conductive layer 43.

[0059] Further, the anode member 6 includes a plurality of probe insertion holes 66 (eight in the first embodiment) outside the concave groove 65 for inserting the probes P (described later). One of the probe insertion holes 66A is formed at a position corresponding to the reference electrode conductive layer 44 (see FIG. 7A).

[0060] As shown in FIGS. 1 to 5, the cathode-side conducting member 7 is a member which supplies a current to the plated object W as a cathode. The cathode-side conducting member 7 is made of a metal plate having a rectangular shape in a plan view and is stacked on the lower side of the holding member 2. The cathode-side conducting member 7 has a plurality of probe mount holes 71 through which respective probes P are mounted. Further, the cathode-side conducting member 7 is connected to the negative pole of the power supply PW (not shown) via a protrusion 72 protruding on the left side face. Thus, the negative pole of the power supply PW is electrically connected to the plated object W via the cathode-side conducting member 7, the probes P and the cathode-side conductive layer 42.

[0061] The insulating member 8 is a member which insulates the cathode-side conducting member 7 from a face (for example, the floor) on which the plating apparatus 1 is placed. The insulating member 8 is made of an insulating material such as PEEK resin (Poly Ether Ether Ketone). The insulating member 8 is made of a plate member having a square shape in a plan view and covers the lower face of the cathode-side conducting member 7.

[0062] The anode-side conducting member 9 is a member which supplies a current to the anode layer 62. The anode-side conducting member 9 is made of a metal plate having an annular shape in a plan view and is stacked on the upper side of the anode member 6. The anode-side conducting member 9 has an opening 91 at the center through which the window 64 is exposed. The anode-side conducting member 9 has a plurality of probe mount holes 92 through which the respective probes P are mounted. Further, the anode-side conducting member 9 is connected to the positive pole of the power supply PW (not shown) via a protrusion 93 protruding from the front side face. Thus, the positive pole of the power supply PW is electrically connected to the anode layer 62 via the anode-side conducting member 9, the probes P and the anode-side conductive layer 43.

[0063] The Probes P are metal members which electrically connect the cathode-side conducting member 7 with the cathode-side conductive layer 42, and, the an-

ode-side conducting member 9 with the anode-side conductive layer 43, respectively. As shown in FIG. 3, each probe P includes a cylinder P1 having a bottomed cylindrical shape and a piston P2 which is provided retractably in the cylinder P1. The cylinders P1 are fitted into the probe mount holes 71, 92 and are inserted into the probe insertion holes 25, 66, in a state that the pistons P2 are directed to the cathode-side conductive layer 42 or the anode-side conductive layer 43. The piston P2 is biased in the protruding direction by a spring (not shown) accommodated in the cylinder P1 to be in contact with the cathode-side conductive layer 42 or the anode-side conductive layer 43.

[0064] It is noted that, though not shown, one of the eight probes P on the anode side arranged at a position corresponding to the reference electrode conductive layer 44 has a cylinder P1 surrounded with an insulator to be insulated from the anode-side conducting member 9. The probe P corresponding to the reference electrode conductive layer 44 is connected to the measuring device (not shown), and its piston P2 is in contact with the reference electrode conductive layer 44. The reference electrode conductive layer 44 is connected inside the second seal member 5 to the reference electrode layer 63. Accordingly, electric potential of the reference electrode layer 63 can be measured with the measuring device.

[0065] As shown in FIG. 4, the holding member 2, the spacer 4, the anode member 6, the cathode-side conducting member 7, the insulating member 8 and the anode-side conducting member 9 have a plurality of bolt insertion holes 26, 46, 67, 73, 81, 94 (eight in the first embodiment, except for the anode-side conducting member 9 which has only four holes 94) for inserting bolts B (see FIG. 1) which fasten the respective members in a stacked state. Female screws are formed on the inner peripheral face of the bolt insertion holes 81 in the insulation member 8 for screwing with the bolts B (see FIG. 1).

[0066] The plating apparatus 1 according to the first embodiment is basically formed as described above. Next, usage and advantageous effects of the plating apparatus 1 will be described with reference to FIGS. 1 to 8C (especially FIG. 5).

[0067] As shown in FIG. 5, the plating apparatus 1 according to the first embodiment includes the holding member 2 which holds the plated object W, the spacer 4 having the through portion 45, and the anode member 6 having the anode layer 62, all of which being stacked via the first seal member 3 and the second seal member 5. Thus, while the plated object W faces the anode layer 62 via the through portion 45, the through portion 45 is closed in watertight so that the plating solution can be stored. Therefore, the plating apparatus 1 can be formed easily by simply stacking the respective members. A tank having a complex structure is not necessary compared with, for example, the plating apparatus described in Patent Document 1, and this allows the plating apparatus 1 to be simplified and reduced in size. Further, the plating apparatus 1 according to the first embodiment may have a plurality of spacers 4 having a different thickness t2 prepared in advance, so that the distance between the plated object W and the anode layer 62 can be adjusted easily by exchanging the spacers depending on plating conditions and test conditions.

[0068] Further, the plating apparatus 1 according to the first embodiment includes the anode-side conductive layer 43 connected inside the second seal member 5 to the anode layer 62 and the anode-side conductive layer 43 connected outside the second seal member 5 to the positive pole of the power supply PW via the probes P and the anode-side conducting member 9, allowing for supplying electricity to the anode layer 62 while maintaining between the spacer 4 and the anode member 6 in watertight.

[0069] Further, the anode member body 61 includes the window 64 having a light transmitting property for observing the plated object W which is exposed from the through portion 45, and the anode layer 62 is formed around the window 64. Therefore, as shown in FIG. 5, the plated object W during plating can be observed (or monitored) through the window 64, such as a Raman microscope M.

[0070] Still further, in the first embodiment, the thickness t1 of the window 64 set to be very thin, for example, to 0.13 mm can suitably reduce the refraction and scattering of light transmitted through the window 64 to allow for improving observation accuracy with the Raman microscope M.

[0071] Yet further, the anode member 6 includes a tapered portion 64a and the anode-side conducting member 9 includes the opening 91, to allow the Raman microscope M to be arranged close to the window 64, such as with the anode member 6 and the anode-side conducting member 9 being prevented from interfering with the Raman microscope M.

[0072] In addition, in the first embodiment, the thickness t2 of the spacers 4 is set to be very thin, for example, to 0.10 mm. Therefore, the thickness (depth) of the plating solution stored in the through portion 45 is reduced, to allow for observing the plated object W, even if, for example, the plating solution is colored. Further, in the first embodiment, the thickness t2 of the spacer 4 is set to be extremely thin, approximately 0.10 mm, to allow for observing the reaction at the solid/liquid interface in more detail.

[0073] Besides, the plating apparatus 1 according to the first embodiment includes the cathode-side conductive layer 42 connected inside the first seal member 3 to the plated object W and the cathode-side conductive layer 42 connected outside the first seal member 3 to the power supply PW via the probes B, to allow for supplying electricity to the plated object W while maintaining between the spacer 4 and the holding member 2 in watertight.

[0074] Moreover, since the holding member 2 includes the plating solution supply passage 27 which supplies

the plating solution to the through portion 45 and the plating solution discharge passage 28 which discharges the plating solution from the through portion 45, the plating solution is supplied through the plating solution supply passage 27 to the through portion 45 and is discharged from the through portion 45 through the plating solution discharge passage 28, to allow the plating solution in the through portion 45 to be maintained in a suitable condition.

[0075] Next, a plating apparatus 1A according to a second embodiment will be described with reference to FIG. 9. In the description, the same components as those in the first embodiment are denoted by the same reference numerals, and detailed descriptions thereof will be omitted.

[0076] As shown in FIG. 9, the plating apparatus 1A according to the second embodiment is mainly different from the plating apparatus of the first embodiment described above in that the probes P directly contact the lower face of a plated object WA and a spacer 4A does not have the cathode-side conductive layer 42.

[0077] The plated object WA used in the plating apparatus 1A according to the second embodiment is a member of which lower face (back face), which faces the holding member 2A, is electrically connected to the upper face (front face) which is to be applied with plating, and is formed of a simple metal plate, for example.

[0078] The holding member 2A includes an annular concave groove 23a in the bottom face of the recess 23 on which the plated object WA is mounted. Further, probe insertion holes 23b into which the probes P are inserted are formed through inside the concave groove 23a in the bottom face of the recess 23. It is noted that probe mount holes 74 to be fitted with the probes P are formed through in the cathode-side conducting member 7 at positions corresponding to the probe insertion holes 23b.

[0079] A third seal member 10 is arranged between the holding member 2A and the plated object WA. The third seal member 10 is mounted along the concave groove 23a. The third seal member 10 can maintain between the holding member 2A and the plated object WA in watertight, to prevent the plating solution from leaking through the probe insertion holes 23b and the probe mount holes 74.

[0080] A spacer 4A includes the spacer body 41 and the anode-side conductive layer 43, but does not include the cathode-side conductive layer 42 (see FIG. 3). This is because the probes P are in direct contact with the lower face of the plated object WA.

[0081] In the plating apparatus 1A according to the second embodiment, the probes P are in direct contact with the lower face of the plated object WA and the cathode-side conductive layer 42 of the spacer 4A is eliminated, to allow for simplifying the structure of the plating apparatus 1.

[0082] The present embodiment has been described in detail with reference to the drawings as above, but the present invention is not limited thereto and can be appropriately modified without departing from the spirit of the present invention.

[0083] For example, in the first embodiment, the window 64 is arranged in the anode member 6, but the present invention is not limited thereto, and when the observation is not conducted with the microscope, the window 64 may not be arranged.

[0084] Further, in the first embodiment, the anode member body 61 and the window 64 are made of the same material (for example, quartz glass), but the present invention is not limited thereto, and for example, the anode member 61 may be formed with a material different from that of the window 64. In this case, the window 64 may be formed with a light transmissive material and the anode member body 61 may be formed with an opaque material.

[0085] Still further, in the first embodiment, the reference electrode layer 63 is arranged on the lower face of the anode member body 61 and the reference electrode conductive layer 44 is arranged on the face, which faces the anode member 6 of the spacer 4, but the present invention is not limited thereto, and the reference electrode layer 63 and the reference electrode conductive layer 44 may be omitted.

[0086] Yet further, in the first embodiment, the plating solution supply passage 27 and the plating solution discharge passage 28 are formed in the holding member 2, but the present invention is not limited thereto, and for example, the plating solution supply passage 27 and the plating solution discharge passage 28 may be formed in the anode member 6. In addition, one of the the plating solution supply passage 27 and the plating solution discharge passage 28 may be formed in one of the holding member 2 and the anode member 6, and the other of the plating solution supply passage 27 and the plating liquid discharge passage 28 may be formed in the other of the holding member 2 and the anode member 6. In a case where exchange (circulation) of the plating solution is not necessary, the plating solution supply passage 27 and the plating solution discharge passage 28 may be omitted.

[0087] In addition, in the first embodiment, the electrolytic plating is applied by connecting the cathode-side conducting member 7 and the anode-side conducting member 9 to the power supply PW, respectively, but the present invention is not limited thereto, and the cathode-side conducting member 7 and the anode-side conducting member 9 may be connected to the measuring device (not shown) in place of the power supply PW and an electroless plating solution may be supplied as a plating solution to the through portion 45. This allows the plating apparatus 1 to perform the electroless plating, and allows the measuring device to measure the electric potential of the plated object W and the anode layer 62 during the electroless plating.

[0088] Next, a sensing device using the above-described plating apparatus will be described with reference to FIGS. 10 and 11.

[0089] FIG. 10 is a plan view of a spacer in the sensing device using the plating apparatus. FIG. 11 is a bottom view of an anode member in the sensing device using the plating apparatus.

[0090] Since the sensing device includes the same members as those in the first embodiment except an anode-side conductive layer 43B of a spacer 4B and an anode layer 62B of an anode member 6B, the anode-side conductive layer 43B and the anode layer 62B will be mainly described in the following description, and the other members will not be described.

[0091] As shown in FIG. 10, the spacer 4B includes a plurality of anode-side conductive layers 43B (eight in this modification) which are radially arranged on a face which faces the anode member 6B. Each anode-side conductive layer 43B is insulated from one another. The outer end 43Ba of each anode-side conductive layer 43B is arranged at a position corresponding to the probe insertion hole 66 of the anode member 6. Further, the inner end 43Bb of each anode-side conductive layer 43B is extended to the periphery of the through portion 45.

[0092] As shown in FIG. 11, the anode member 6B includes a plurality of anode layers 62B (eight in this modification) which are radially arranged on a face which faces the spacer 4B. Each anode layer 62B is insulated from one another. Each anode layer 62B is arranged at a position corresponding to the anode-side conductive layer 43B. The outer end 62Ba of each anode layer 62B is extended to the inner periphery of the concave groove 65, and is in contact with the anode-side conductive layer 43B once it is assembled. Further, the inner end 62Bb of each anode layer 62B is extended to the outer peripheray of the window 64 and is exposed from the through portion 45.

[0093] The inner ends 62Bb of anode layers 62B are modified with eight types of reactive groups, respectively, which are different from one another. The Reactive groups are substances which react to potential substances contained in a reagent supplied to the through portion 45 (see FIG. 2) of the sensing device. An example of the reagent includes liquid containing an electrolyte (e.g. blood, etc.). In addition, an example of reactive group includes a self-assembled monolayer (SAM) with a specific binding receptor. For example, the inner end 62Bb of each anode layer 62B is modified with a self-assembled monolayer (SAM) to react with a substance having a metal ion to be sensed or a functional group to be sensed. For example, the inner end 62Bb of each anode layer 62B is modified with aminopropyltriethoxysilane (3-aminopropyltriethoxy silane) to react with Pd ions.

[0094] The probes P are respectively inserted in the probe insertion holes 66 of the anode member 6B. The probes P are insulated from one another and are connected to the measuring device (not shown).

[0095] Such a sensing device can detect a substance contained in the reagent by measuring the change in the electrical potential of the anode layer 62B with the measuring device at the time of reaction between the reactive group modifying the inner end 62Bb of the anode layer 62B and the substances contained in the reagent. For example, the sensing device can be connected to an electrochemical measuring device with the cathode being used as a reference electrode, to allow for checking the variation in the surface electric potential in a two-electrode mode. In addition, it is also possible to measure in a three-electrode mode in which the cathode is set as a counter electrode and one of the eight cathodes is used as the reference electrode.

EXPLANATION OF REFERENCES

[0096]

1: plating apparatus 2: holding member 27: plating solution supply passage 28: plating solution discharge channel 3: first seal member 4: spacer 41: spacer body 42: cathode-side conductive layer 43: anode-side conductive layer 44: reference electrode conductive layer 45: through portion 5: second seal member 6: anode member 61: anode member body 62: anode layer 63: reference electrode layer 64: window 7: cathode-side conducting member 8: insulating member 9: anode-side conducting member P: probe PW: power supply W: plated object

Claims

1. A plating apparatus comprising:

a holding member that holds a plated object specified as a cathode;
a spacer that is stacked on the holding member via a first seal member in an annular shape surrounding the plated object, and has a through portion from which the plated object is exposed and which stores a plating solution; and
an anode member that is stacked on the spacer via a second seal member in an annular shape surrounding the through portion, and has an anode layer arranged to face the plated object which is exposed from the through portion.

2. The plating apparatus according to claim 1, wherein the spacer includes a spacer body made of an insulator and an anode-side conductive layer arranged on a face, which faces the anode member, of the spacer body,
the anode member includes an anode member body made of an insulator and an anode layer specified as the anode arranged on a face, which faces the spacer, of the anode member body,
the anode-side conductive layer is connected inside the second seal member to the anode layer, and
the anode-side conductive layer is connected outside the second seal member to a power supply.

3. The plating apparatus according to claim 2, wherein the anode member body includes a light transmissive window for observing the plated object exposed from the through portion, and
the anode layer is formed around the window.

4. The plating apparatus according to claim 3, wherein the window has a thickness smaller than that of other portions of the anode member body.

5. The plating apparatus according to claim 3, wherein a thickness t1 of the window is in a range of 0.05 mm $\leq$ t1 $\leq$ 2 mm.

6. The plating apparatus according to claim 3, wherein the anode member body has a tapered portion around the window which declines toward the window.

7. The plating apparatus according to any one of claim 1, wherein a thickness t2 of the spacer is in a range of 0.05 mm $\leq$ t2 $\leq$ 1 mm.

8. The plating apparatus according to claim 2, wherein the spacer includes a cathode-side conductive layer arranged on a face, which faces the holding member, of the spacer body,
the cathode-side conductive layer is connected inside the first seal member to the plated object, and
the cathode-side conductive layer is connected outside the first seal member to the power supply.

9. The plating apparatus according to claim 2, wherein the spacer includes a reference electrode conductive layer insulated from the anode-side conductive layer on a face, which faces the anode member, of the spacer body,
the anode member includes a reference electrode layer insulated from the anode layer on a face, which faces the spacer, of the anode member body,
the reference electrode conductive layer is connected inside the second seal member to the reference electrode layer, and
the reference electrode conductive layer is connected outside the second seal member to the measuring device.

10. The plating apparatus according to claim 1, wherein the holding member or the anode member includes a plating solution supply passage through which a plating solution is supplied to the through portion, and
the holding member or the anode member includes a plating solution discharge passage through which the plating solution is discharged from the through portion.

11. The plating apparatus according to claim 8, wherein the plating solution is an electroless plating solution, and a measuring device instead of the power supply is connected to measure the electric potential across the anode and the cathode.

12. A sensing device having the plating apparatus as set forth in any one of claims 2 to 10, wherein the anode-side conductive layer is constituted with a plurality of anode-side conductive layers insulated from one another,
the anode layer is constituted with the same number of anode layers insulated from one another as the anode-side conductive layers, and
portions of anode layer, which is exposed from the through portion are respectively modified with reaction groups different from one another.

FIG.1

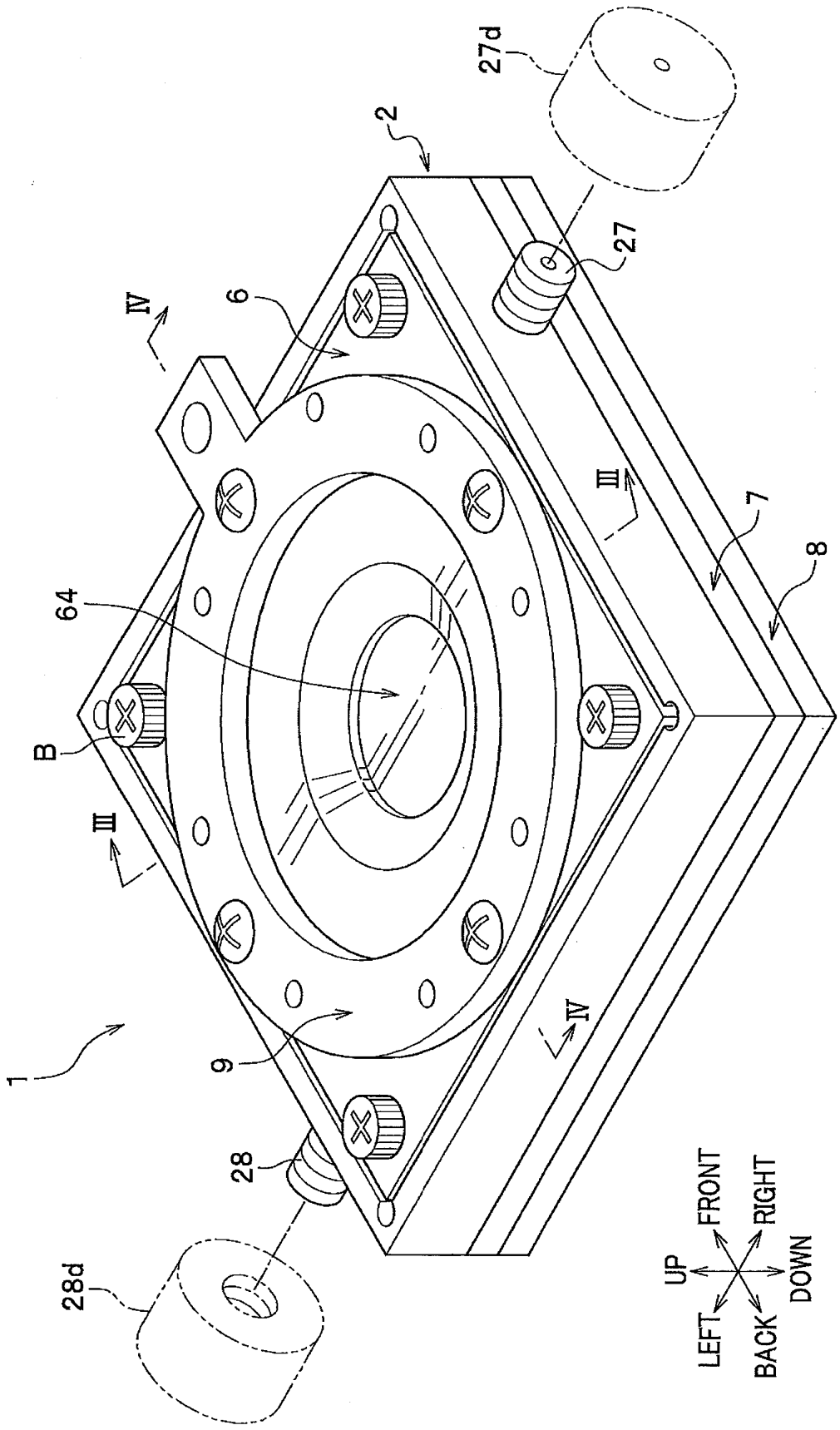
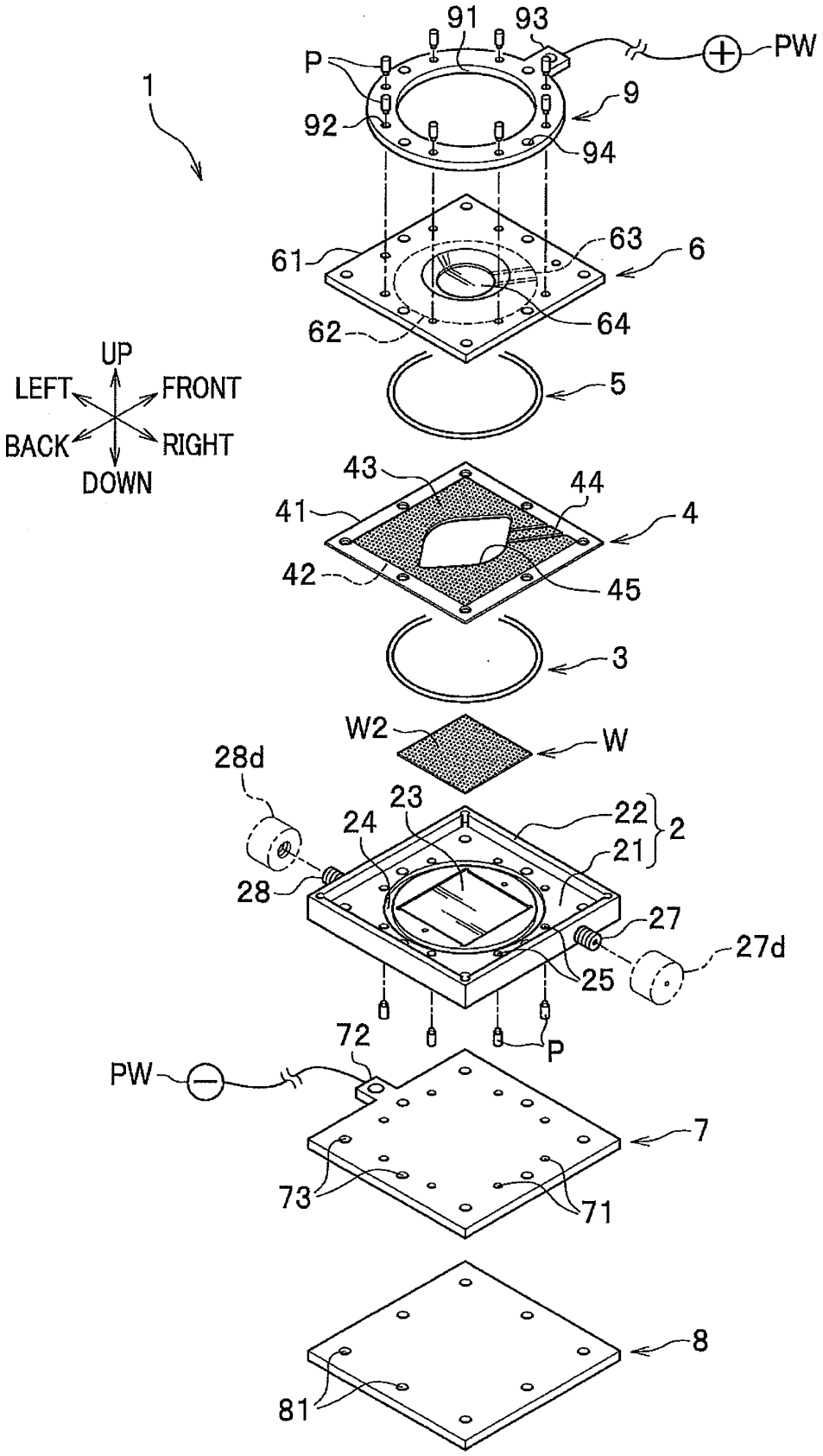

27d
2
27
IV
6
III
7
8
64
B
III
1
9
IV
28
28d
UP
FRONT
RIGHT
LEFT
BACK
DOWN

FIG.2


1
91
93
PW
P
9
92
94
61
63
6
62
64
5
UP
LEFT
FRONT
BACK
RIGHT
DOWN
43
44
41
4
42
45
3
W2
W
28d
23
22
2
24
21
28
27
27d
25
72
P
PW
7
73
71
8
81

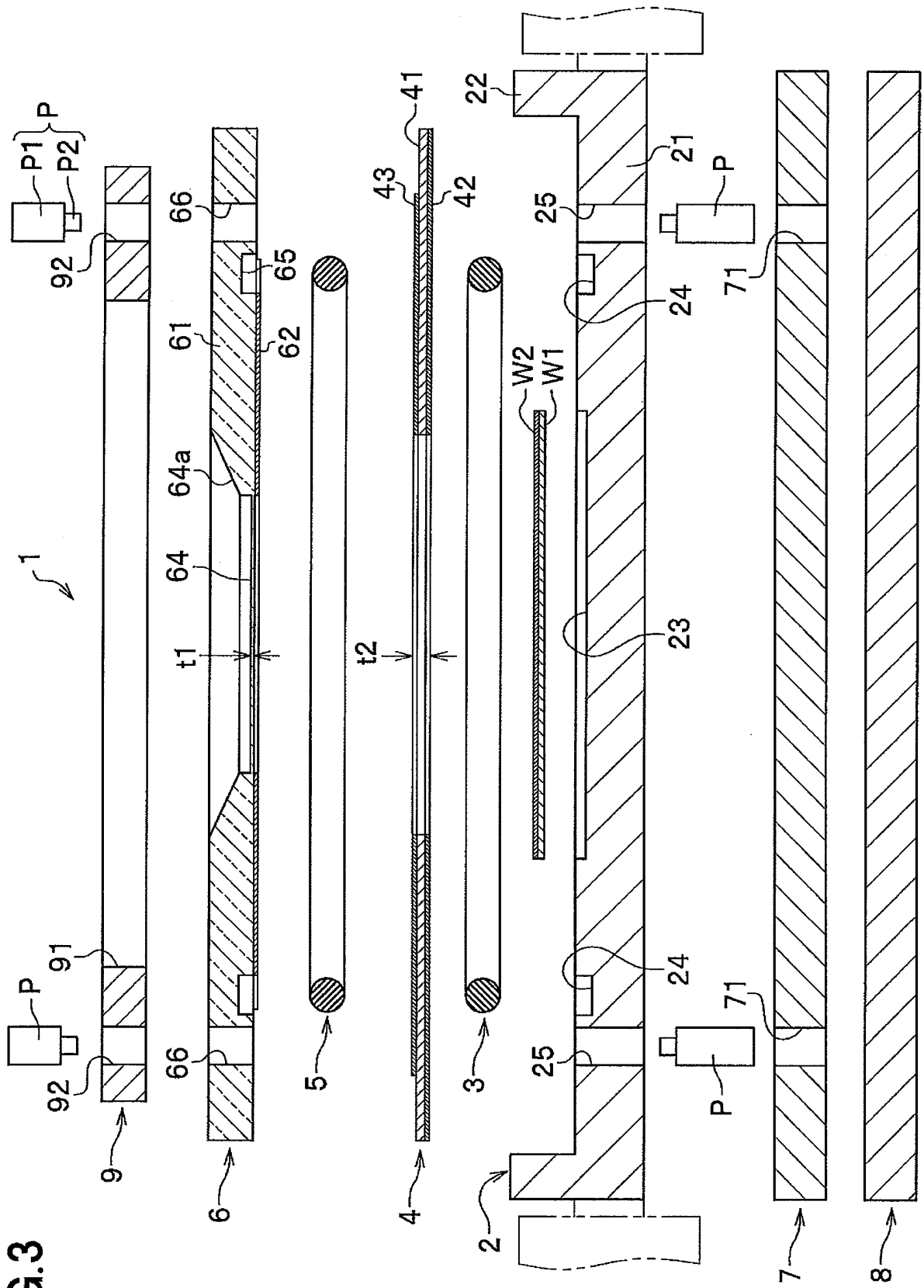

P
P1
P2
92
66
65
61
62
64a
64
t1
1
91
P
92
66
9
6
5
41
43
42
t2
4
3
22
21
25
P
24
W2
W1
23
24
25
P
71
71
2
7
8

FIG.3

FIG.4

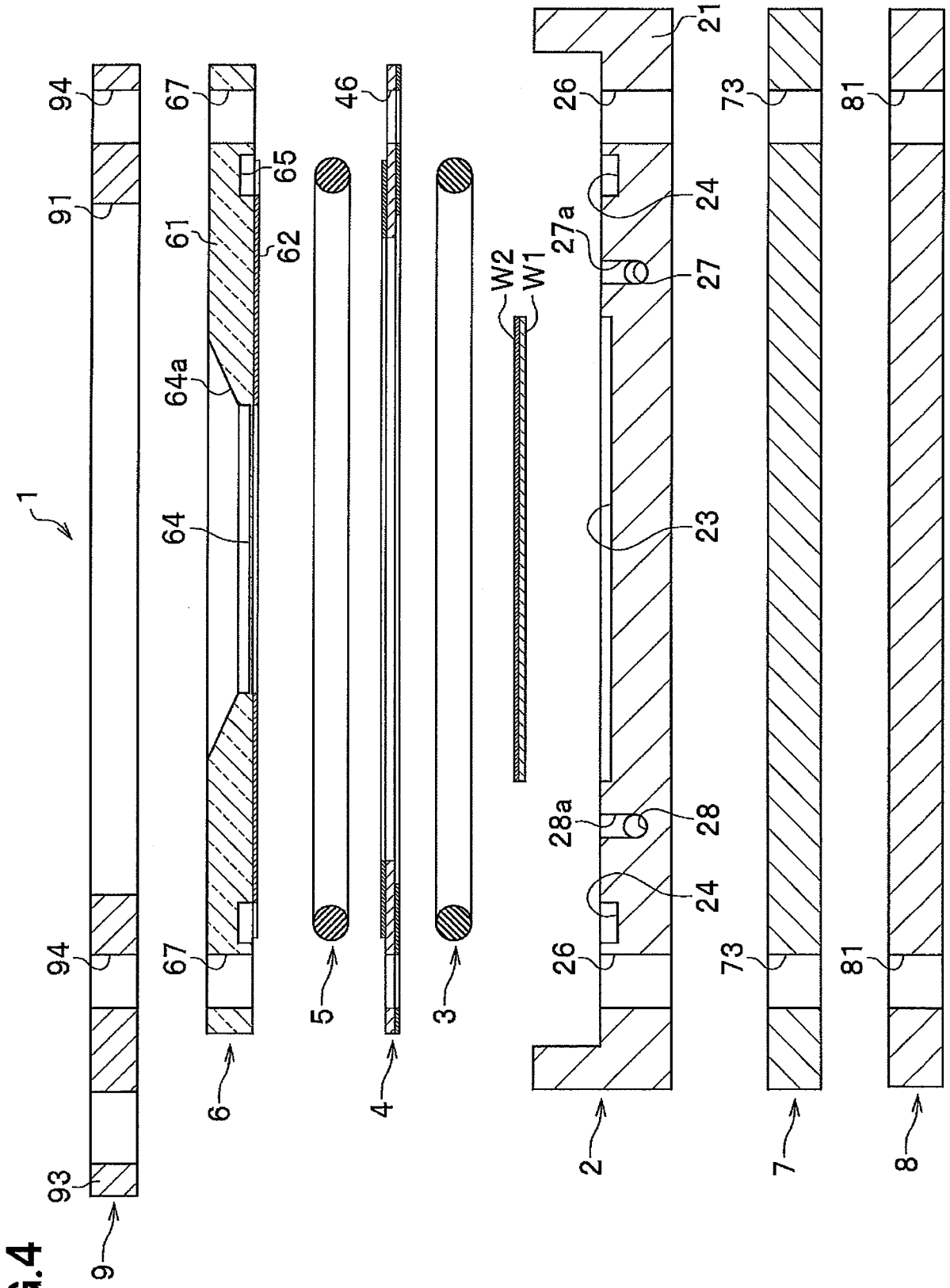

1
9
93
94
91
94
6
67
64a
64
61
62
65
67
5
4
46
3
2
21
26
24
27a
27
W2
W1
23
28a
28
24
26
7
73
73
8
81
81

FIG.5

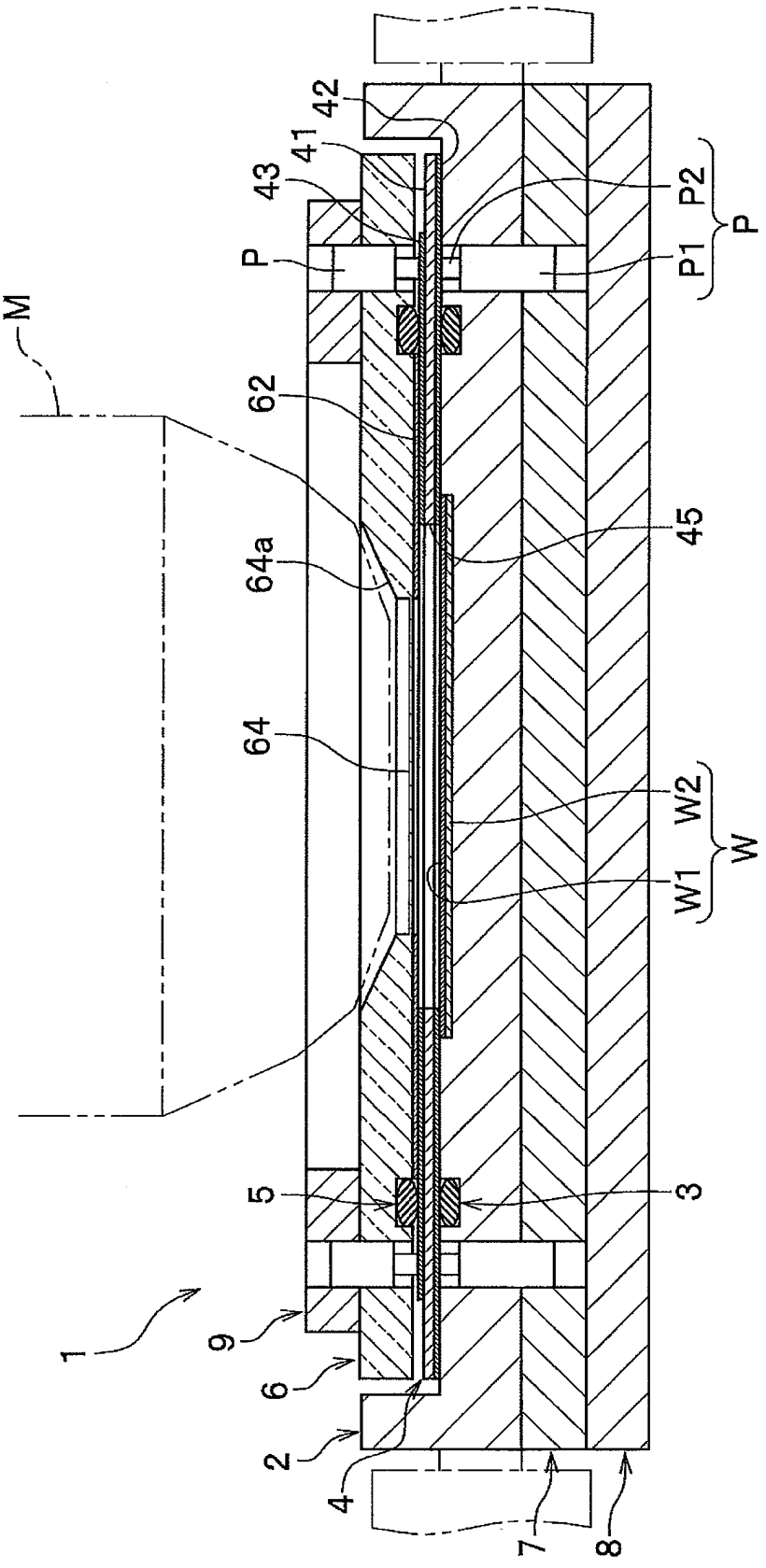


FIG.6A

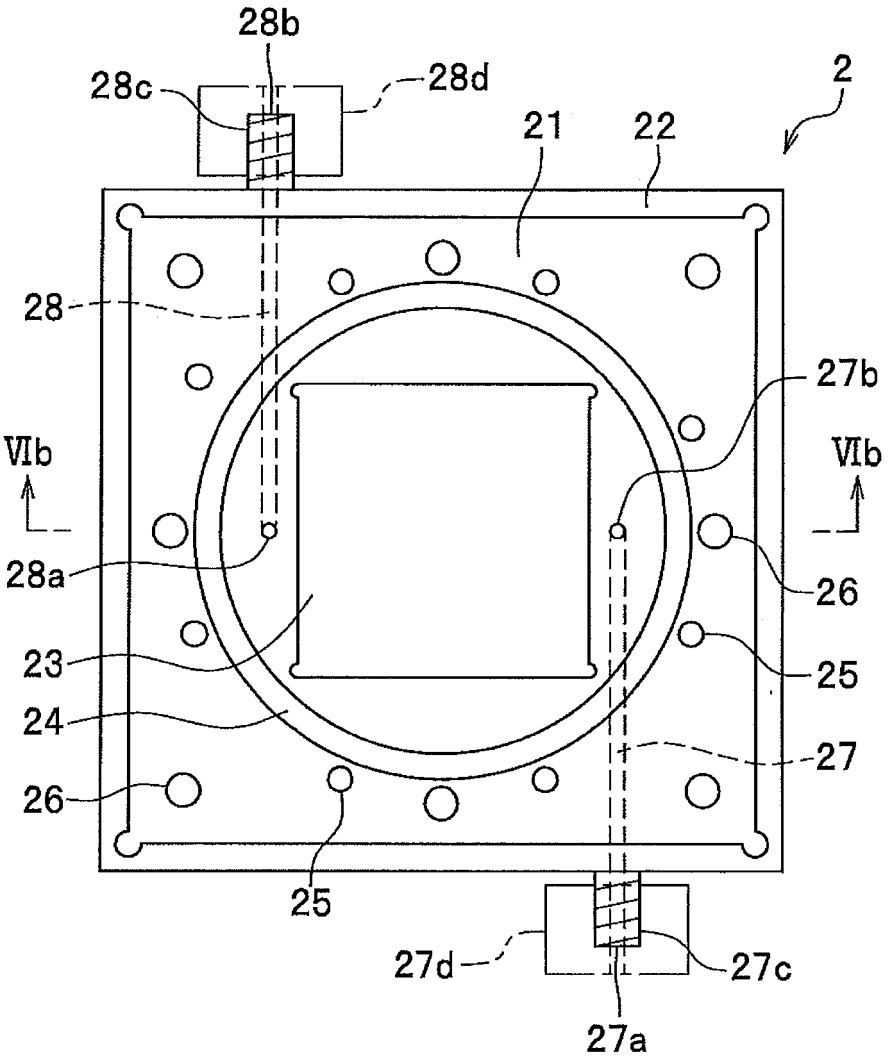

28b
28c
28d
2
21
22
28
27b
VIb
VIb
28a
26
23
25
24
27
26
25
27d
27c
27a

FIG.6B

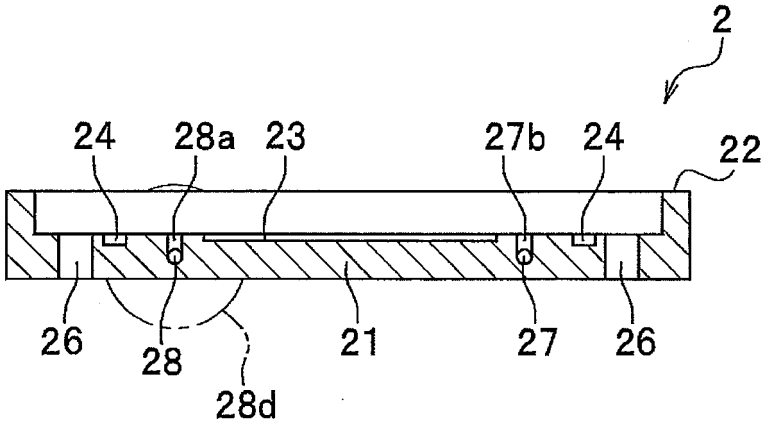

2
24
28a
23
27b
24
22
26
28
21
27
26
28d

FIG.7A

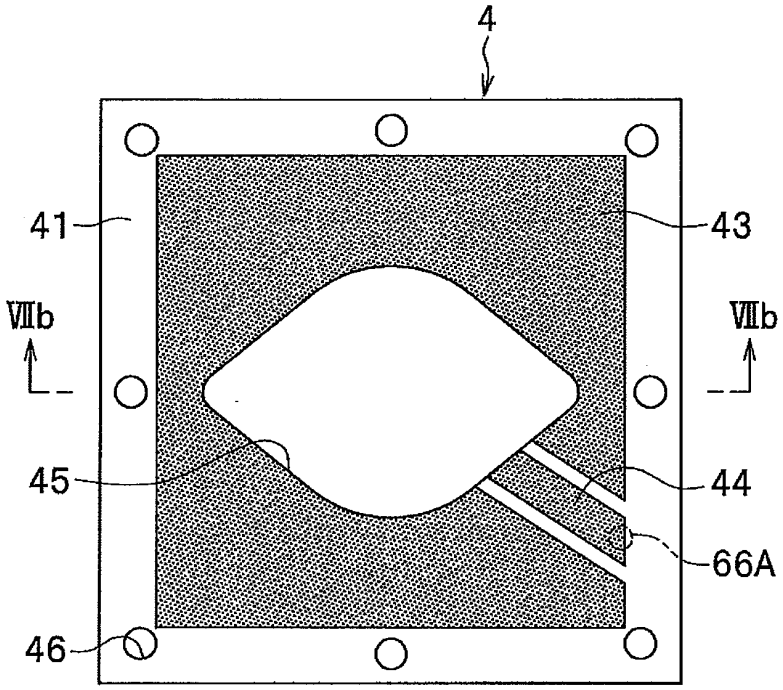


FIG.7B

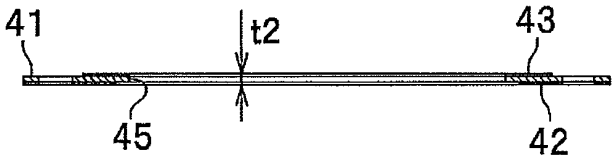


FIG.7C

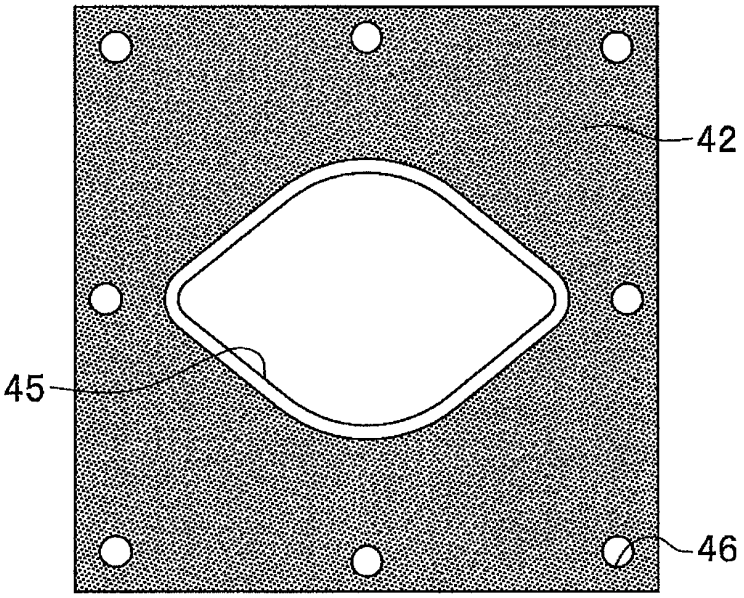


FIG.8A

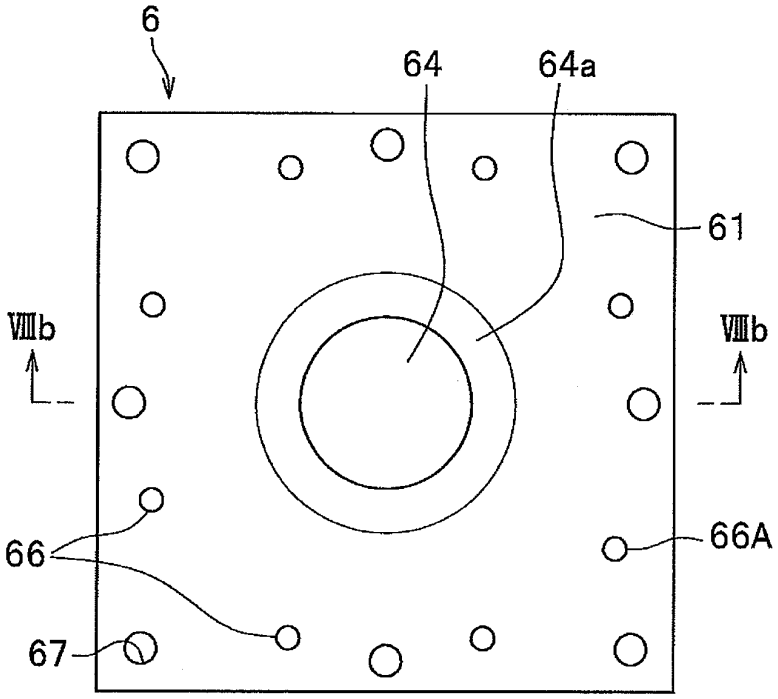


FIG.8B

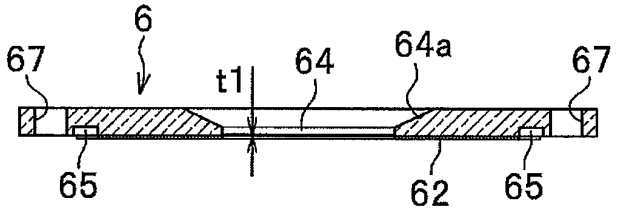


FIG.8C

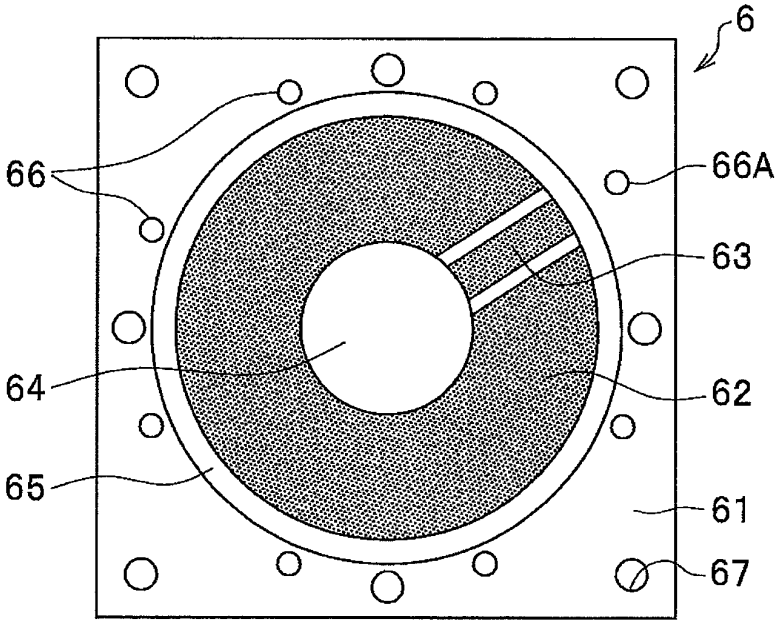


FIG.9

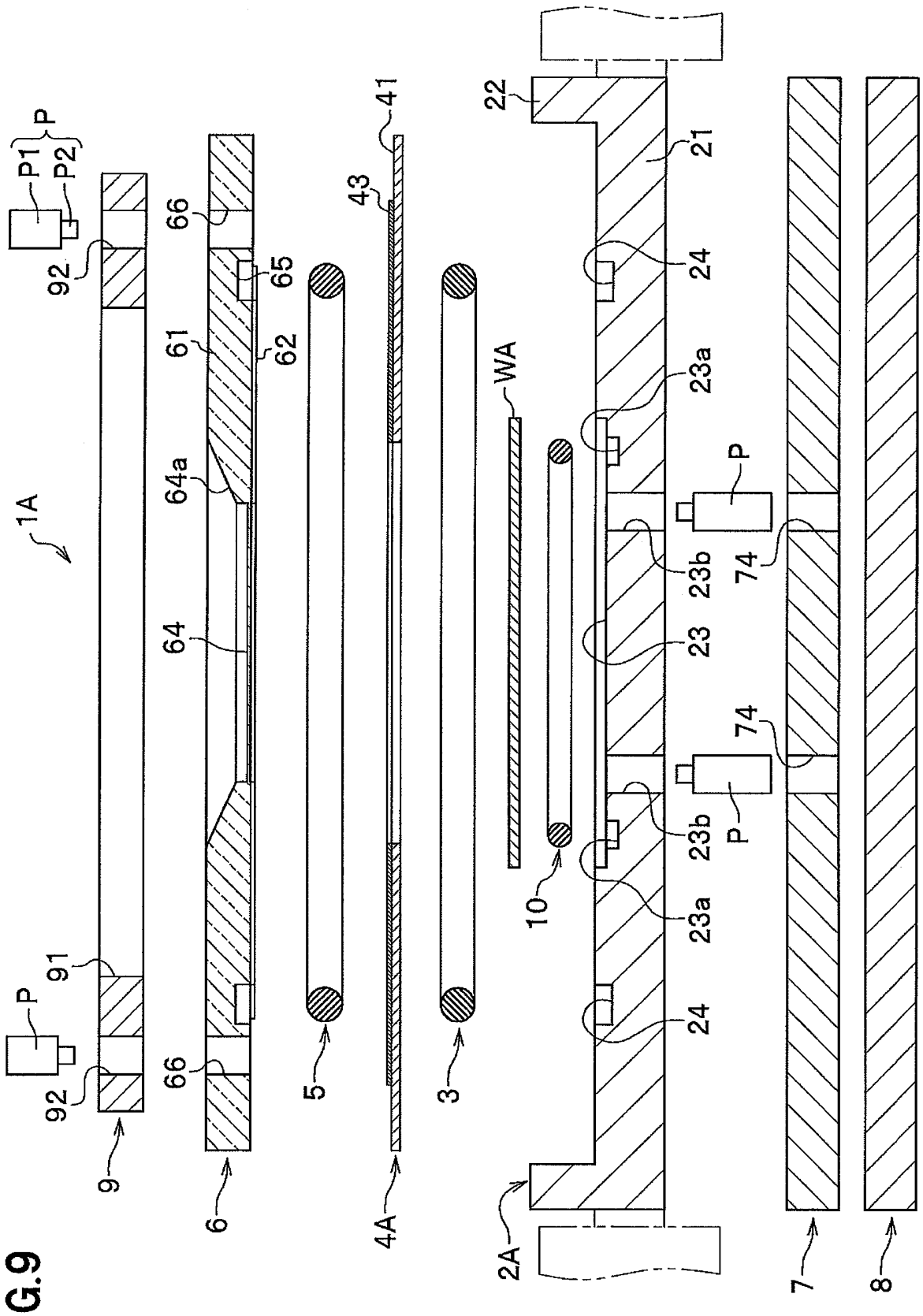

1A
P
P1
P2
92
91
9
66
61
62
65
64a
64
6
5
41
43
4A
3
WA
10
22
21
24
23a
23b
23
74
2A
7
8

FIG.10

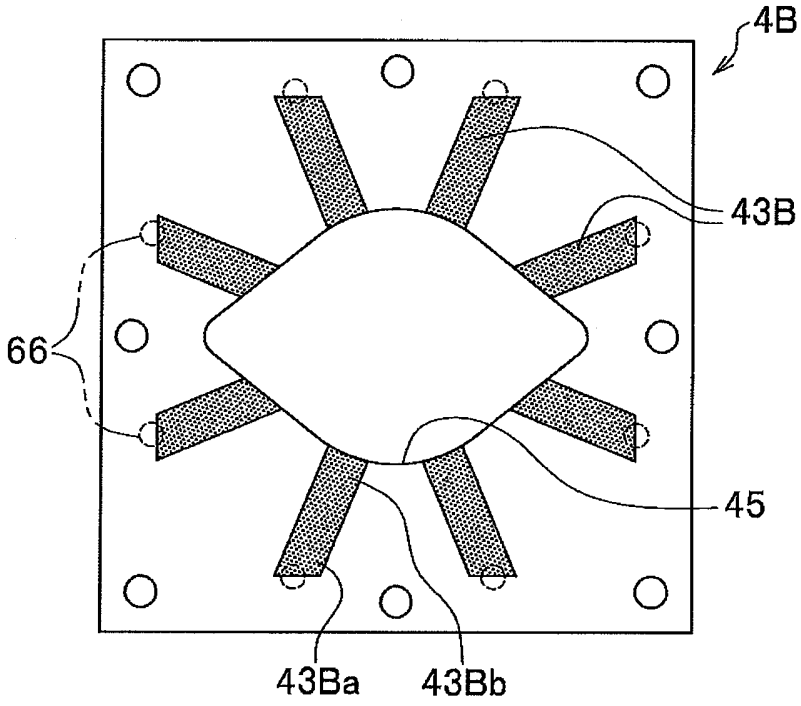
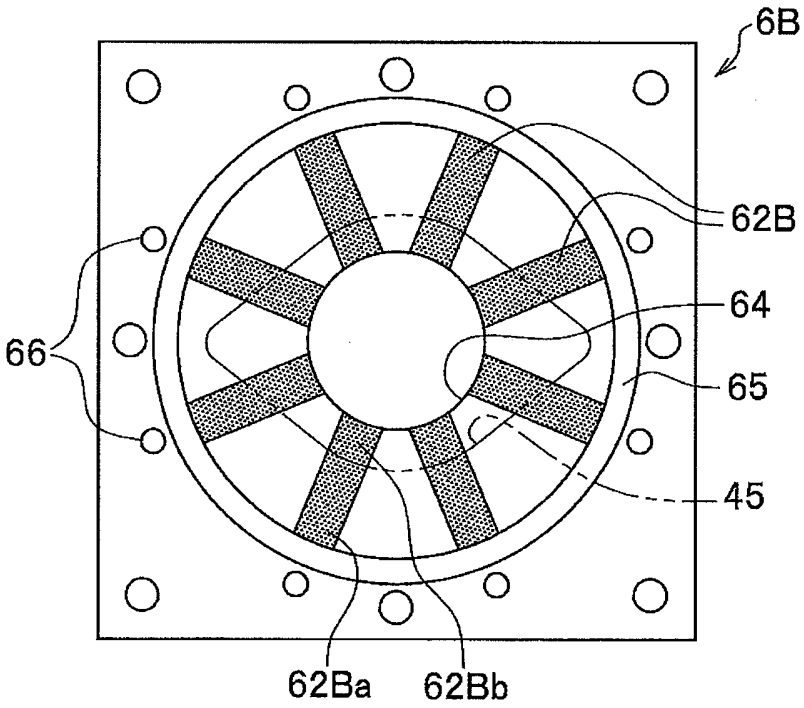


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/070252

A. CLASSIFICATION OF SUBJECT MATTER
C25D17/08(2006.01)i, *C23C18/31*(2006.01)i, *C25D21/12*(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)
C25D17/08-C25D17/12, C23C18/31, C25D21/12

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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	JP 11-195622 A (Ebara Corp.), 21 July 1999 (21.07.1999), paragraphs [0009] to [0012]; fig. 1 to 2 (Family: none)	1-12
A	JP 11-335895 A (Ebara Corp.), 07 December 1999 (07.12.1999), paragraphs [0027] to [0030], [0040]; fig. 1, 6 & US 6582580 B1 & EP 1061157 A1 & WO 1999/045170 A1 & TW 589399 B	1-12
A	JP 2009-287093 A (Yamamoto-MS Co., Ltd.), 10 December 2009 (10.12.2009), paragraphs [0013] to [0017]; fig. 1, 2 (Family: none)	1-12

☒ 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
10 October, 2014 (10.10.14)	21 October, 2014 (21.10.14)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/070252

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-119648 A (Yamamoto-MS Co., Ltd.), 17 June 2013 (17.06.2013), claim 1; paragraphs [0028] to [0047]; fig. 1, 2 (Family: none)	1-12
A	JP 2012-241236 A (Nitto Denko Corp.), 10 December 2012 (10.12.2012), claim 1; paragraphs [0044] to [0050] & US 2012/0295013 A1 & CN 102787307 A	11
A	JP 2008-76143 A (Citizen Holdings Co., Ltd.), 03 April 2008 (03.04.2008), claim 1; paragraph [0046] (Family: none)	12
A	US 4151049 A (IMPERIAL CHEMICAL INDUSTRIES LTD.), 24 April 1979 (24.04.1979), column 5, "APPARATUS" & JP 53-16787 A & DE 2711270 A1	12

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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

- JP 2006299367 A **[0004]**