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(71) Applicant: **HOYA CORPORATION**
Shinjuku-ku,
Tokyo 161-8525 (JP)

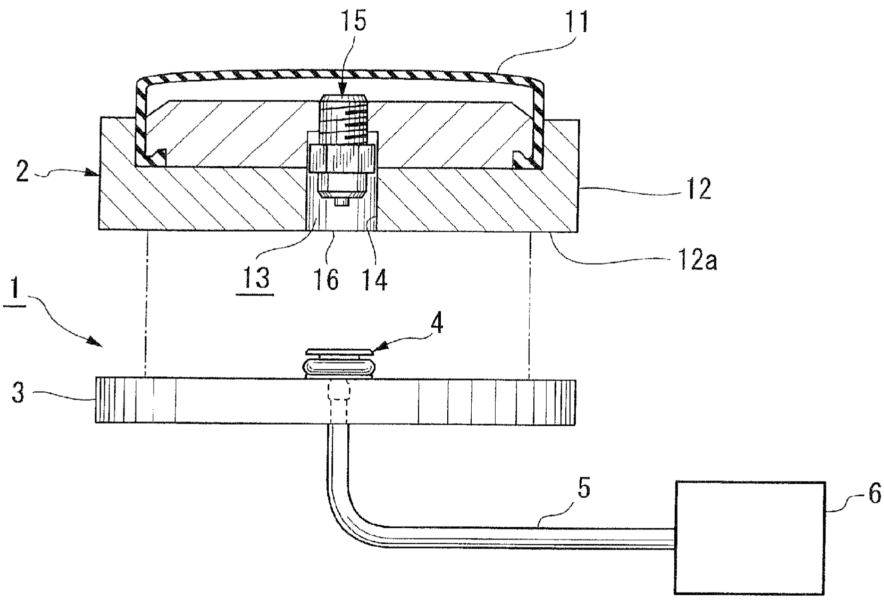
(72) Inventors:
- **Toriumi, Hideo**
  Tokyo 161-8525 (JP)
- **Tajima, Makoto**
  Tokyo 161-8525 (JP)
- **Katagiri, Kazuhiko**
  Tokyo 161-8525 (JP)

(74) Representative: **Betten & Resch**
Patentanwälte
Theatinerstrasse 8
80333 München (DE)

(54) Polishing jig air injection apparatus and method

(57) This invention discloses a polishing jig air injection apparatus (1) including a polishing jig installation base (3) including a surface on which a spectacle lens polishing jig (2) is placed, an injection member (4) which is inserted into an air injection port (16) of the spectacle lens polishing jig, and an air supply device (6) which supplies the air into a balloon member (11) of the spectacle lens polishing jig via the injection member and the air injection port. The injection member includes a main body formed in a pillar shape, and a seal member. The main body includes an air passage, and an annular groove formed in the outer circumferential portion of the main body. The seal member is inserted into the annular groove, is formed in an annular shape, and uses an elastic body. The seal member has an outer diameter larger than the inner diameter of the air injection port (16).

FIG.1



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Description

Background of the Invention

[0001] The present invention relates to a polishing jig air injection apparatus and method for injecting air into a polishing jig provided with a balloon member which inflates by the air pressure.

[0002] As a polishing apparatus for polishing the surface of a spectacle lens, a polishing apparatus which uses a polishing jig provided with a balloon member which inflates by the air pressure is available, as described in, for example, Japanese Patent Laid-Open No. 2004-106117 (literature 1). The polishing jig disclosed in literature 1 includes, for example, a balloon member, a support member which supports the balloon member, and a valve which opens/closes an air passage formed in the support member.

[0003] The air passage is formed to extend from an air injection port which opens on one end surface of the support member into the balloon member. The valve has a structure which opens by the pressure of air supplied into the air injection port.

[0004] The air is injected into the balloon member while the polishing jig is mounted in an air injection apparatus. The air injection apparatus includes, for example, an installation base on which the polishing jig is mounted, an injection member inserted into the air injection port, and an air supply device used to discharge air from the air discharge port of the injection member into the air injection port.

[0005] The injection member is attached to the installation base while projecting from it so as to be inserted into the air injection port by mounting the polishing jig on the installation base. The injection member includes a main body formed in a disk shape, and a seal member used to seal the gap between the main body and the air injection port. The air discharge port opens on the outer circumferential surface of the main body. The seal member is formed using an elastic material to have a cup shape which surrounds the outer circumferential portion of the main body so that it is held on the main body by its self elasticity.

[0006] Upon discharging air from the air discharge port of the main body into the air injection port while the seal member is inserted in the air injection port, together with the main body, the outer circumferential portion of the seal member inflates outwards in the radial direction and comes into tight contact with the wall surface of the air injection port. The seal member thus deforms, thereby sealing the gap between the injection member and the air injection port. The air discharged from the air discharge port flows into the air injection port from the central portion of the seal member upon passing through the gap between the main body and the seal member.

[0007] That is, a polishing jig air injection method related to the present invention is performed by a step of supplying air into the injection member while it is inserted in the air injection port, and a step of inflating the seal member outwards in the radial direction by the air.

[0008] Unfortunately, in the apparatus and method disclosed in literature 1, air needs to be passed through the gap between the seal member and the main body of the injection member, so the shape of the seal member has a given constraint. That is, the seal member must be formed in a shape to cover the main body of the injection member, and therefore inevitably uses a dedicated component with a special shape. This leads to an increase in manufacturing cost of the air injection apparatus used to inject air into the polishing jig.

[0009] Also, when, for example, the seal member deteriorates after it has been used for a long period of time, its force for clamping the main body may weaken. When this happens, the seal member easily falls off the main body of the injection member. When, for example, the polishing jig is detached from the air injection apparatus after completion of air injection, the seal member may fall off the main body of the injection member while it is still attached to the air injection port. If the seal member falls off the main body, an operation of loading the polishing jig into the polishing apparatus is interrupted, thus degrading the polishing efficiency.

[0010] Note that degradation in seal performance of the seal member must be avoided in solving the above-mentioned trouble.

Summary of the Invention

[0011] The present invention has been made to overcome the above-mentioned problem, and has as its object to provide a polishing jig air injection apparatus and method which use a seal member that has high seal performance, and does not easily fall off the main body of an injection member, but nonetheless is inexpensive.

[0012] According to an aspect of the present invention, there is provided a polishing jig air injection apparatus comprising a polishing jig installation base including an installation surface on which a spectacle lens polishing jig including an air injection port and a balloon member which inflates by a pressure of air supplied from the air injection port is placed, an injection member which is supported on the installation surface of the polishing jig installation base while projecting from the installation surface, and inserted into the air injection port of the spectacle lens polishing jig, and an air supply device which is connected to the injection member and supplies the air into the balloon member via the injection member and the air injection port, the injection member including a main body formed in a pillar shape, the main body including an air passage extending through two ends of the main body, and an annular groove formed in an outer circumferential portion of the main body, and a seal member which is inserted into the annular groove, is formed in an annular shape that extends over an entire circumference along the annular groove, and uses an elastic body, the seal member having an outer diameter larger than an inner diameter of the air injection port.

[0013] According to another aspect of the present invention, there is provided a polishing jig air injection method comprising the steps of inserting an injection member into an air injection port of a spectacle lens polishing jig, and discharging air from the injection member into the air injection port to inflate a balloon member connected to the air injection port, the injection member including a main body formed in a pillar shape, the main body including an air passage extending through two ends of the main body, and an annular groove formed in an outer circumferential portion of the main body, and a seal member which is inserted into the annular groove, is formed in an annular shape that extends over an entire circumference along the annular groove, and uses an elastic body, the seal member having an outer diameter larger than an inner diameter of the air injection port.

Brief Description of the Drawings

[0014]

Fig. 1 is a sectional view showing the arrangement of a polishing jig and installation base;
Fig. 2 is an enlarged sectional view showing an air injection port in the polishing jig;
Fig. 3 is a sectional view of an injection member attached to the installation base;
Fig. 4 is a sectional view showing the state in which the injection member is inserted in the air injection port;
Fig. 5 is a sectional view showing another embodiment of an injection member;
Fig. 6 is a sectional view showing the state in which the injection member is inserted in an air injection port;
Fig. 7 is a sectional view showing another embodiment of an injection member;
Fig. 8 is a sectional view showing the state in which the injection member is inserted in an air injection port;
Fig. 9 is a sectional view of an injection member attached to an installation base;
Fig. 10 is a sectional view showing the initial state of a connection step;
Fig. 11 is a sectional view showing the end state of the connection step;
Fig. 12 is a flowchart for explaining a method of injecting air into a polishing jig;
Fig. 13 is a sectional view showing the initial state of a connection step;
Fig. 14 is a sectional view showing the end state of the connection step;
Fig. 15 is a flowchart for explaining a method of injecting air into a polishing jig;
Fig. 16 is a sectional view showing the initial state of a connection step;
Fig. 17 is a sectional view showing the end state of the connection step;
Fig. 18 is a flowchart for explaining a method of injecting air into a polishing jig; and
Fig. 19 is a sectional view showing the size of each portion in an experiment.

Description of the Preferred Embodiments

(First Embodiment)

[0015] An embodiment of a polishing jig air injection apparatus according to the present invention will be described in detail below with reference to Figs. 1 to 4.

[0016] A polishing jig air injection apparatus 1 shown in Fig. 1 includes a polishing jig installation base 3 on which a spectacle lens polishing jig 2 is mounted, an injection member 4 which projects from the installation base 3, and an air supply device 6 connected to the injection member 4 via an air passage 5.

[0017] The polishing jig 2 is equivalent to that described in literature 1, and is loaded into a polishing apparatus (not shown) after air is injected into it by the air injection apparatus 1 according to this embodiment. The polishing jig 2 according to this embodiment includes a rubber balloon member 11 which inflates by the air pressure, and a support member 12 used to support the balloon member 11. The balloon member 11 inflates upon being supplied with air from the air supply device 6 (to be described later), and mounts a polishing pad (not shown) while its surface is inflated to have a predetermined curvature. The predetermined curvature means herein the curvature of the surface of a spectacle lens to be polished.

[0018] An air passage 13 used to inject air into the balloon member 11 or discharge the air from the interior of the balloon member 11 is formed in the support member 12. The air passage 13 includes a circular hole 14 which is formed in the support member 12 and has a circular cross-section, and a valve 15 provided between the circular hole 14 and the balloon member 11. One end of the circular hole 14, which is positioned on the opposite side of the balloon member

11, opens on a flat attachment surface 12a of the support member 12 so as to serve as an air injection port 16. The air injection port 16 is formed to open on the attachment surface 12a in a circular opening shape and extend in a direction perpendicular to the attachment surface 12a.

[0019] The valve 15 includes a check valve 23 including a ball 21 and conical coil spring 22, and an exhaust mechanism 25 including an exhaust pin 24 opposed to the ball 21, as shown in Fig. 2. The check valve 23 adopts a structure which passes air from the air injection port 16 into only the balloon member 11. The exhaust pin 24 is used to press the ball 21 against the spring force of the conical coil spring 22. The exhaust pin 24 is supported by a valve housing 26 to be extendable/retractable between a retraction position shown in Fig. 2 and an exhaust position at which the leading end of the exhaust pin 24 presses the ball 21. Also, the exhaust pin 24 is biased in a direction away from the ball 21 by a conical coil spring 27 provided between it and the valve housing 26.

[0020] The installation base 3 is formed in a plate shape having a flat installation surface 3a on which the polishing jig 2 is mounted, as shown in Fig. 1. Also, the installation base 3 is supported by a moving device (not shown) to be movable between a height measurement position (not shown) and a jig attachment/detachment position at which the polishing jig is attached/detached. The height measurement position is a position at which a height measuring device (not shown) measures the height of the balloon member 11 inflated by the air pressure.

[0021] The balloon member 11 inflates upon being supplied with air from the air supply device 6 (to be described later) while it is mounted on the installation base 3. The curvature of the surface of the balloon member 11 changes in correspondence with the height of the balloon member 11. Therefore, the air is supplied into the balloon member 11 until the height measured by the height measuring device coincides with that corresponding to a target curvature (the curvature of the surface of a spectacle lens to be polished).

[0022] The injection member 4 includes a columnar-shaped main body 33 and seal member 34, as shown in Fig. 3. The main body 33 projects from the installation surface 3a, and includes a threaded portion 32 which is threadably mounted in a screw hole 31 in the installation base 3. The seal member 34 is formed from an elastic body and mounted on the outer circumferential portion of the main body 33.

[0023] The threaded portion 32 is connected to the air supply device 6 via the air passage 5. The air supply device 6 uses an air compressor (not shown) as an air supply source.

[0024] The columnar-shaped main body 33 is formed to have an outer diameter A smaller than an inner diameter B (see Fig. 2) of the air injection port 16 of the polishing jig 2. A through hole (air passage) 35 extending through the two ends of the main body 33 is formed at the axis center of the main body 33. The through hole 35 has its one end which opens on the projection-side end face of the main body 33 as an air discharge port 36. The through hole 35 has its other end connected to the air passage 5.

[0025] An annular groove 41 used to hold the seal member 34 (to be described later) is formed in the outer circumferential portion of the main body 33 to extend circumferentially. The annular groove 41 according to this embodiment is formed from a circumferential wall 42 parallel to an outer circumferential surface 33a of the main body 33, and a first side wall 43 and second side wall 44 which extend from the circumferential wall 42 outwards in the radial direction. The first side wall 43 and second side wall 44 are formed parallel to the installation surface 3a of the installation base 3.

[0026] The seal member 34 is formed from an elastic body and inserted in the annular groove 41. The seal member 34 has an annular shape which extends over the entire circumference along the annular groove 41. The seal member 34 used in this embodiment is a ready-made O-ring.

[0027] The seal member 34 is formed to have an inner diameter d1 equal to an outer diameter D of the circumferential wall 42. Also, the seal member 34 is formed to have a thickness W smaller than a groove width (an interval between the first side wall 43 and the second side wall 44) G of the annular groove 41. That is, while the seal member 34 is inserted in the annular groove 41, a gap g is formed between the seal member 34 and at least one of the first side wall 43 and second side wall 44 defining the annular groove 41. Moreover, the seal member 34 is formed to have an outer diameter d2 larger than the inner diameter B of the air injection port 16.

[0028] That is, the seal member 34 is inserted into the air injection port 16 of the polishing jig 2, together with the main body 33 of the injection member 4, thereby pressing it inwards in the radial direction by a wall surface 16a of the air injection port 16, as shown in Fig. 4. At this time, the inner circumferential portion of the seal member 34 is kept in contact with the circumferential wall 42 to prevent the seal member 34 from deforming inwards in the radial direction, so the seal member 34 elastically deforms toward the gap g. As a result, the gap g is sealed by the elastically deformed seal member 34. In other words, the gap g is formed so as to be sealed by the seal member 34 elastically deformed upon inserting the injection member 4 into the air injection port 16.

[0029] Note that the seal member 34 is not limited to an O-ring, and can take any form as long as it serves as an elastic body having a shape which extends over the entire circumference along the annular groove 41. For example, the seal member 34 can use an elastic body formed in a ring shape, or an elastic body having a shape obtained by cutting a ring in one circumferential portion. When the seal member 34 uses an elastic body having a ring shape obtained by cutting a ring in one circumferential portion in this manner, it can be opened in a C shape, thus making it possible to easily perform an operation of inserting it into the annular groove 41 and an operation of removing it from the annular groove 41.

[0030] The elastic body which forms the seal member 34 can be made of a material such as fluororubber (FPM). Fluororubber has self-lubricity and therefore has a resistance which reduces upon inserting/removing the seal member 34 into/from the air injection port 16 of the polishing jig 2. This not only facilitates attachment/detachment of the polishing jig 2 but also makes it hard for the seal member 34 to wear out.

[0031] To inject air into the balloon member 11 of the polishing jig 2 using the polishing jig air injection apparatus 1 configured as described above, first, the polishing jig 2 is mounted on the installation base 3 set at the jig attachment/detachment position, and the injection member 4 is inserted into the air injection port 16, as shown in Fig. 4. At this time, the attachment surface 12a of the polishing jig 2 faces the installation surface 3a of the installation base 3. Upon inserting the injection member 4 into the air injection port 16, the seal member 34 is compressed and elastically deforms so as to enter the gap g. Even while the seal member 34 is compressed in the annular groove 41, its elasticity does not degrade. Therefore, the seal member 34 comes into tight contact with the circumferential wall 42 and first and second side walls 43 and 44 defining the annular groove 41, and the wall surface 16a of the air injection port 16, with an appropriate elastic repulsive force, thereby sealing the gap between the injection member 4 and the air injection port 16.

[0032] Next, the installation base 3 is moved to the height measurement position, and the air supply device 6 is operated to discharge air into the air passage 5. The air in the air passage 5 flows into the air injection port 16 upon passing through the through hole 35 in the injection member 4. At this time, the seal member 34 remains in tight contact with the walls 42 to 44 defining the annular groove 41 and the wall surface 16a of the air injection port 16, so the air does not leak upon passing through the gap between the air injection port 16 and the injection member 4.

[0033] The air supplied into the air injection port 16 flows into the balloon member 11 upon passing through the valve 15 when the pressure in the air injection port 16 rises to the degree that the valve 15 opens. The balloon member 11 inflates upon injecting air into it. The air is injected into the balloon member 11 until the height of the balloon member 11 measured by the height measuring device reaches a target height. The target height means herein the height corresponding to the curvature of the surface of a spectacle lens to be polished.

[0034] The installation base 3 is returned to the jig attachment/detachment position after completion of air injection into the balloon member 11, as described above. After the installation base 3 moves to the jig attachment/detachment position, the polishing jig 2 is detached from the installation base 3 and loaded into the polishing apparatus. When the polishing jig 2 is detached from the installation base 3, a force acts on the seal member 34 so as to pull it away from the injection member 4. In fact, however, the seal member 34 does not fall off the injection member 4 because it is inserted and held in the annular groove 41.

[0035] Hence, since the polishing jig air injection apparatus 1 according to this embodiment uses a ready-made O-ring as the seal member 34, its manufacturing cost can be kept low. Also, since the polishing jig air injection apparatus 1 according to this embodiment does not degrade in elasticity even while the seal member 34 is compressed in the annular groove 41, it is possible not only to achieve high seal performance but also to prevent the seal member 34 from wearing out upon attaching/detaching the polishing jig 2.

[0036] Note that high seal performance can be achieved because the seal member 34 is pressed against the walls 42 to 44 defining the annular groove 41 and the wall surface 16a of the air injection port 16, with an appropriate elastic repulsive force. That is, the seal performance improves because the seal member 34 can deform to follow minute projections and recesses formed on and in the surfaces of the walls 42 to 44.

[0037] The reason why the seal member 34 can be prevented from wearing out is that it is not pressed against the wall surface 16a of the air injection port 16 with too much force, so its frictional resistance relatively decreases upon sliding it on the wall surface 16a.

[0038] Moreover, since the seal member 34 is inserted in the annular groove 41 and does not fall off the injection member 4 in the polishing jig air injection apparatus 1 according to this embodiment, an operation of loading the polishing jig 2 from the installation base 3 into the polishing apparatus after air injection is not interrupted. Therefore, the use of the polishing jig air injection apparatus 1 allows efficient polishing of the spectacle lens.

(Second Embodiment)

[0039] An injection member and a seal member can be formed, as shown in Figs. 5 and 6. Referring to Figs. 5 and 6, the same reference numerals denote the same or equivalent members as or to those described with reference to Figs. 1 to 4, and a detailed description thereof will not be given as needed.

[0040] A seal member 34 shown in Fig. 5 is formed to have an outer diameter d2 larger than an inner diameter B of an air injection port 16, like the seal member 34 shown in Figs. 3 and 4. However, the seal member 34 is formed to have a thickness W equal to a groove width (an interval between a first side wall 43 and a second side wall 44) G of an annular groove 41. Also, the seal member 34 is formed to have an inner diameter d1 larger than an outer diameter D of a circumferential wall 42 defining the annular groove 41.

[0041] That is, in this embodiment, a gap g is formed between the circumferential wall 42 defining the annular groove

41 and the inner circumferential portion of the seal member 34. Upon inserting the seal member 34 according to this embodiment into the air injection port 16, it elastically deforms inwards in the radial direction so as to enter the gap g, as shown in Fig. 6. The seal member 34 thus elastically deforms, thereby sealing the gap g.

[0042] In the second embodiment as well, because the seal member 34 does not degrade in elasticity, an effect equivalent to that in the above-described embodiments can be produced.

(Third Embodiment)

[0043] An injection member and a seal member can be formed, as shown in Figs. 7 and 8. Referring to Figs. 7 and 8, the same reference numerals denote the same or equivalent members as or to those described with reference to Figs. 1 to 4, and a detailed description thereof will not be given as needed.

[0044] A seal member 34 shown in Fig. 7 is formed to have an outer diameter d2 larger than an inner diameter B of an air injection port 16, like the seal member 34 shown in Figs. 3 and 4. Also, the seal member 34 is formed to have a thickness W smaller than a groove width (an interval between a first side wall 43 and a second side wall 44) G of an annular groove 41. Moreover, the seal member 34 is formed to have an inner diameter d1 larger than an outer diameter D of a circumferential wall 42 defining the annular groove 41.

[0045] That is, in this embodiment, a gap g1 is formed between the seal member 34 and at least one of the first and second side walls 43 and 44 defining the annular groove 41, and a gap g2 is formed between the circumferential wall 42 and the inner circumferential portion of the seal member 34. Upon inserting the seal member 34 according to this embodiment into the air injection port 16, it comes into contact with a wall surface 16a of the air injection port 16 and is pressed not only toward the second side wall 44 but also inwards in the radial direction.

[0046] As a result, the seal member 34 elastically deforms not only inwards in the radial direction so as to enter the gap g2 positioned inside in the radial direction, but also in the axial direction so as to enter the other gap g1, as shown in Fig. 8. The seal member 34 thus elastically deforms, thereby sealing the gaps g1 and g2.

[0047] In the third embodiment as well, because the seal member 34 does not degrade in elasticity although it is compressed in the annular groove 41, an effect equivalent to that in the above-described embodiments can be produced.

(Fourth Embodiment)

[0048] An embodiment of a polishing jig air injection method according to the present invention will be described in detail next with reference to Figs. 9 to 12.

[0049] The air injection method according to this embodiment is performed by a polishing jig air injection apparatus 1 having almost the same arrangement as that according to the first embodiment. However, a seal member 34 uses a seal member which does not come into contact with a first side wall 43 defining an annular groove 41 even when it elastically deforms upon inserting an injection member 4 into an air injection port 16 of a polishing jig 2. Note that in this embodiment, a gap g1 is formed between the seal member 34 and at least one of the first side wall 43 and a second side wall 44 defining the annular groove 41 while the seal member 34 is inserted in the annular groove 41, as shown in Fig. 9.

[0050] The polishing jig air injection method according to this embodiment is performed by connection step S1, air supply step S2, and height adjustment step S3, as shown in Fig. 12.

[0051] Connection step S1 is executed by mounting the polishing jig 2 on an installation base 3 set at the jig attachment/ detachment position, and inserting the injection member 4 into the air injection port 16, as shown in Figs. 10 and 11.

[0052] In connection step S1 when the injection member 4 is inserted into the air injection port 16, the seal member 34 is pressed toward the second side wall 44 by friction with a wall surface 16a of the air injection port 16 first, as shown in Fig. 10 (axial direction pressing step S4). The seal member 34 is brought into contact with the second side wall 44 by the pressing, as shown in Fig. 10.

[0053] The wall surface 16a further extends while the seal member 34 is kept in contact with the second side wall 44 in this way (it moves downwards in Fig. 10). The wall surface 16a thus further extends, thereby pressing the outer circumferential portion of the seal member 34 in the direction, in which the wall surface 16a travels, by friction with the wall surface 16a, so the portion of the seal member 34, which is opposed to the first side wall 43, is displaced outwards in the radial direction, as indicated by arrows in Fig. 11 (radial direction deformation step S5).

[0054] After completion of connection step S1, the apparatus assumes a state shown in Fig. 11. That is, in this state, the seal member 34 comes into contact with the second side wall 44. Also, a gap g1 is formed between the seal member 34 and the first side wall 43 inserted into the air injection port 16 first of the pair of side walls 43 and 44. Moreover, a gap g2 is formed between a circumferential wall 42 and the inner circumferential portion of the seal member 34.

[0055] After connection step S1 is thus completed, the process advances to air supply step S2. Air supply step S2 is executed while a pressurizing air passage 51 (see Fig. 11) extending from an air discharge port 36 of the injection member 4 to the inner circumferential portion of the seal member 34 is ensured, after completion of connection step S1

The pressurizing air passage 51 is defined by the gaps g1 and g2, a gap between the injection member 4 and a valve 15, and a gap g3 (see Fig. 11) between the air injection port 16 and the distal end of the injection member 4.

[0056] In air supply step S2, the installation base 3 is moved to the height measurement position, and an air supply device 6 is operated to discharge air into an air passage 5. The air in the air passage 5 flows into the air injection port 16 upon passing through a through hole 35 in the injection member 4. The air supplied into the air injection port 16 flows into a balloon member 11 upon passing through the valve 15 as the pressure in the air injection port 16 rises to the degree that the valve 15 opens. The balloon member 11 inflates upon injecting air into it in this way.

[0057] On the other hand, the pressure of the air discharged from the air discharge port 36 propagates to the inner circumferential portion of the seal member 34 as well via the pressurizing air passage 51. Upon applying the air pressure to the inner circumferential portion of the seal member 34 in this way, the seal member 34 is pressed outwards in the radial direction, so the force acting to press the wall surface 16a of the air injection port 16 increases (pressurization step S6). That is, according to this embodiment, the gap between the injection member 4 and the air injection port 16 can be sealed by biasing the seal member 34 using the air pressure.

[0058] The air is injected into the balloon member 11 until the height of the balloon member 11 measured by a height measuring device reaches a target height in height adjustment step S3. The target height means herein the height corresponding to the curvature of the surface of a spectacle lens to be polished.

[0059] The installation base 3 is returned to the jig attachment/detachment position after completion of air injection into the balloon member 11. After the installation base 3 moves to the jig attachment/detachment position, the polishing jig 2 is detached from the installation base 3 and loaded into the polishing apparatus.

[0060] Hence, according to this embodiment, since the pressurizing air passage 51 is ensured before the start of air supply step S2, the air pressure can reliably be applied to the inner circumferential portion of the seal member 34 so that the seal member 34 can be biased by the air pressure to perform sealing, despite the use of the inexpensive ready-made seal member 34.

[0061] Therefore, according to this embodiment, it is possible to provide an air supply method for the polishing jig 2, which can keep the manufacturing cost of the polishing jig air injection apparatus 1 low while sustaining high seal performance.

[0062] Connection step S1 according to this embodiment includes axial direction pressing step S4 and radial direction deformation step S5. In axial direction pressing step S4, the seal member 34 is pressed toward the second side wall 44 by friction with the wall surface 16a of the air injection port 16. In radial direction deformation step S5, the seal member 34 elastically deforms so that the gap g2 is formed between it and the circumferential wall 42 by friction with the wall surface 16a of the air injection port 16.

[0063] Hence, according to this embodiment, the pressurizing air passage 51 can forcibly be formed by elastically deforming the seal member 34 outwards in the radial direction using an operation of inserting the injection member 4 into the air injection port 16. Therefore, again according to this embodiment, since the seal member 34 can more reliably expand outwards in the radial direction, high seal reliability can be attained.

(Fifth Embodiment)

[0064] A pressurizing air passage can be ensured by a method to be described with reference to Figs. 13 to 15.

[0065] Referring to Figs. 13 to 15, the same reference numerals denote the same or equivalent members as or to those described with reference to Figs. 9 to 12, and a detailed description thereof will not be given as needed.

[0066] A seal member 34 shown in Fig. 13 is formed to have an outer diameter d2 larger than an inner diameter B of an air injection port 16, like the seal member 34 shown in Figs. 9 to 11. However, the seal member 34 is formed to have a thickness W equal to a groove width (an interval between a first side wall 43 and a second side wall 44) G of an annular groove 41. Also, the seal member 34 is formed to have an inner diameter d1 larger than an outer diameter D of a circumferential wall 42 defining the annular groove 41.

[0067] That is, the seal member 34 according to this embodiment comes into contact with the two side walls 43 and 44 defining the annular groove 41, and is formed in a shape in which a gap g2 is formed between it and the circumferential wall 42. Upon inserting the seal member 34 according to this embodiment into the air injection port 16, it is pressed toward an installation base 3 in the axial direction by friction with a wall surface 16a of the air injection port 16, as indicated by arrows in Fig. 14.

[0068] Hence, the seal member 34 according to this embodiment elastically deforms so as to form a gap g1 between it and the first side wall 43 in connection step S1 in which it is inserted into the air injection port 16. That is, connection step S1 according to this embodiment includes axial direction deformation step S7 (see Fig. 15) in which the seal member 34 elastically deforms upon being pressed in the axial direction, as described above. In this embodiment as well, upon completion of connection step S1, a pressurizing air passage 51 is formed to extend from an air discharge port 36 of an injection member 4 to the inner circumferential portion of the seal member 34, as shown in Fig. 14.

[0069] Hence, the air injection method for a polishing jig 2 according to this embodiment can forcibly form the pressurizing air passage 51 by elastically deforming the seal member 34 in the axial direction using an operation of inserting the injection member 4 into the air injection port 16. Therefore, according to this embodiment, since the seal member 34 can more reliably expand outwards in the radial direction, high seal reliability can be attained.

(Sixth Embodiment)

[0070] A pressurizing air passage can be ensured by a method shown in Figs. 16 to 18.

[0071] Referring to Figs. 16 to 18, the same reference numerals denote the same or equivalent members as or to those described with reference to Figs. 9 to 12, and a detailed description thereof will not be given as needed.

[0072] A seal member 34 shown in Fig. 16 is formed to have an outer diameter d2 large enough to bring it into contact with a wall surface 16a of an air injection port 16. That is, the outer diameter d2 is set equal to or slightly larger than an inner diameter B of the air injection port 16. Also, the seal member 34 is formed to have a thickness W smaller than a groove width (an interval between a first side wall 43 and a second side wall 44) G of an annular groove 41. Moreover, the seal member 34 is formed to have an inner diameter d1 larger than an outer diameter D of a circumferential wall 42 defining the annular groove 41.

[0073] That is, the seal member 34 according to this embodiment is formed in a shape in which a gap g1 is formed between it and at least one of the side walls 43 and 44 defining the annular groove 41, and a gap g2 is formed between it and the circumferential wall 42.

[0074] Upon inserting the seal member 34 according to this embodiment into the air injection port 16, it is pressed toward an installation base 3 in the axial direction by friction with the wall surface 16a of the air injection port 16, as indicated by arrows in Fig. 17.

[0075] Hence, the seal member 34 according to this embodiment comes into contact with the second side wall 44 upon being pressed in the above-mentioned way in connection step S1 in which it is inserted into the air injection port 16. That is, connection step S1 according to this embodiment includes axial direction pressing step S4 (see Fig. 18) in which the seal member 34 is pressed in the axial direction, as described above. In this embodiment as well, upon completion of connection step S1, a pressurizing air passage 51 is formed to extend from an air discharge port 36 of an injection member 4 to the inner circumferential portion of the seal member 34.

[0076] The air injection method for a polishing jig 2 according to this embodiment can form the pressurizing air passage 51 without considerably elastically deforming the seal member 34. Therefore, according to this embodiment, since air supply step S2 starts while the seal member 34 has elastically deformed by a relatively small amount, the seal member 34 can be sufficiently elastically deformed using the air pressure. As a result, the adoption of the air injection method according to this embodiment allows a further improvement in seal performance.

[0077] When a prototype was manufactured for the injection member 4 shown in this embodiment to have dimensions shown in Fig. 19, and air was injected into the polishing jig 2 in practice, the injection member 4 could be repeatedly used without leakage of the air or fall of the seal member 34. A main body 33 of the injection member 4 used in this experiment has an outer diameter A of 12.6 mm, the circumferential wall 42 defining the annular groove 41 has an outer diameter D of 7.2 mm, and the annular groove 41 has a groove width G is 3.7 mm. The seal member 34 has an inner diameter d1 of 7.5 mm and a thickness W of 3.55 mm. Accordingly, the seal member 34 has an outer diameter of 14.6 mm. An O-ring named AS568-203 was used as the seal member 34. This O-ring is made of fluororubber (FPM).

[0078] This experiment was conducted using a plurality of polishing jigs 2 to be used for polishing in practice by repeating attachment/detachment of each polishing jig 2 100 times and air injection 100 times. During the experiment, it was checked whether the seal member 34 had fallen upon attaching/detaching each polishing jig 2, and it was checked whether air had leaked upon injecting air into the polishing jig 2. The experimental results were evaluated upon determining that attachment/detachment is satisfactory when each polishing jig 2 could be attached/detached 95 or more times without fall of the seal member 34, and that air injection is satisfactory when air could be injected into the polishing jig 2 95 or more times without leakage of the air.

[0079] As the experimental results, satisfactory was determined for all the polishing jigs 2 with regard to both polishing jig attachment/detachment and air injection, as shown in Table 1. In Table 1, "good" indicates satisfactory results for each polishing jig 2. Sizes A and B of each polishing jig 2 shown in Table 1 have values obtained by measuring the inner diameter B of the air injection port 16 in two orthogonal directions. The air injection ports 16 of the polishing jigs 2 used in this experiment have inner diameters B of 14.0 to 14.32 mm, as can be seen from Table 1. The size of the air injection port 16 varies in each individual polishing jig 2 because it has a given tolerance.

Table 1

	Size A (mm)	Size B (mm)	Polishing Jig Attachment/Detachment	Air Injection
1	14.04	14.01	Good	Good

(continued)

	Size A (mm)	Size B (mm)	Polishing Jig Attachment/Detachment	Air Injection
2	14.11	14.32	Good	Good
3	14.07	14.14	Good	Good
4	14.02	14.01	Good	Good
5	14.09	14.08	Good	Good
6	14.04	14.03	Good	Good
7	14.10	14.07	Good	Good
8	14.05	14.07	Good	Good
9	14.06	14.06	Good	Good
10	14.06	14.05	Good	Good
11	14.07	14.08	Good	Good
12	14.10	14.12	Good	Good
13	14.08	14.03	Good	Good
14	14.03	14.00	Good	Good
15	14.04	14.03	Good	Good
16	14.15	14.07	Good	Good
17	14.08	14.07	Good	Good
18	14.04	14.10	Good	Good

[0080] The effects of the embodiments described above are compared with the prior art. The prior art used an apparatus including a seal member having a special shape, as indicated in literature 1. Table 2 summarizes the results obtained when air injections were repeated 100 times/day (3,000 times/month) for the prior art and the embodiments described above.

[0081] Since the seal member of the prior art was of a cover type, it was often removed from the injection member when the polishing jig was attached or detached. When the air injections were repeated 100 times/day, the seal member was removed about 5 times/day. To the contrary, since each of the embodiments employs a fitting type seal member, it cannot be easily removed. The removal frequency of the seal member 34 was about once/day depending on the shape and type of the polishing jig 2 when air injections were repeated for the embodiments under the same conditions as in the prior art. The operation error frequency of about 5% in the prior art was reduced to about 1% in the embodiments described above. The air injection can thus be improved by the embodiments described above.

[0082] The prior art required seal member replacement every time the air injections were repeated 1,500 times. To the contrary, in each embodiment described above, the seal member 34 can stand repeated injections as many as 6,000 times. The prior art required seal member replacement of twice/month, and each embodiment required seal member replacement of 0.5 times/month when the air injections were repeated 3,000 times per month.

[0083] The seal member used in the prior art was a dedicated component having a special shape, which was expensive. To the contrary, each embodiment described above can use a general-purpose O-ring as the seal member 34, thereby reducing the cost of the seal member. In consideration of the replacement frequency of the seal members, the running cost can be greatly reduced in each embodiment.

[0084] The seal member 34 of each embodiment described above could maintain the same durability as in the prior art.

Table 2

Item	Prior Art	Embodiments
Frequency of Injection Error	about 5%	about 1%
Operability	unsatisfactory	good
Replacement Frequency	about 2 times/month	about 0.5 times/month
Durability	good	good

(continued)

Item	Prior Art	Embodiments
Cost (unit cost)	¥3,590/pcs	¥200/pcs
Running Cost (estimated)	¥7,180/month	¥100/month
Others	finished product	general-purpose O-ring

[0085] Although an example in which an O-ring having a circular cross-section is used as the seal member 34 has been given in each of the above-described embodiments, the cross-sectional shape of the seal member 34 can appropriately be changed to, for example, an elliptical or oval shape.

[0086] According to the first to third embodiments mentioned above, the seal member 34 is compressed so as to enter the gap g formed between it and the annular groove 41 by inserting it into the air injection port 16, together with the main body 33 of the injection member 4. Since the seal member 34 does not degrade in elasticity even while it is compressed in the annular groove 41, it reliably seals the gap between the annular groove 41 and the air injection port 16. Also, since the seal member 34 is inserted in the annular groove 41 in the injection member 4, it does not easily fall off the injection member 4. Moreover, the seal member 34 can use an inexpensive ready-made product. Therefore, it is possible to provide the polishing jig air injection apparatus 1 including the seal member 34 which has high seal performance, and does not easily fall off the injection member 4, but nonetheless is inexpensive.

[0087] According to the fourth to sixth embodiments mentioned above, the air directly flows into the air injection port 16 from the air discharge port 36 of the injection member 4. Since the seal member 34 is formed from an annular elastic body extending along the annular groove 41, it can use an inexpensive ready-made product. Also, according to the air injection method, after completion of connection step S1, that is, before the start of air supply step S2, the pressurizing air passage 51 extending from the air discharge port 36 of the injection member 4 to the inner circumferential portion of the seal member 34 can be ensured. Therefore, the air pressure can reliably be applied to the inner circumferential portion of the seal member 34 so that the seal member 34 can be biased by the air pressure to perform sealing, despite the use of the inexpensive ready-made seal member 34. Therefore, it is possible to provide an air supply method for a polishing jig, which can keep the manufacturing cost of a polishing jig air injection apparatus low while sustaining high seal performance.

Claims

1. A polishing jig air injection apparatus **characterized by** comprising:

a polishing jig installation base (3) including an installation surface (3a) on which a spectacle lens polishing jig (2) including an air injection port (16) and a balloon member (11) which inflates by a pressure of air supplied from the air injection port (16) is placed;
an injection member (4) which is supported on said installation surface (3a) of said polishing jig installation base (3) while projecting from said installation surface (3a), and inserted into the air injection port (16) of the spectacle lens polishing jig (2); and
an air supply device (6) which is connected to said injection member (4) and supplies the air into the balloon member (11) via said injection member (4) and the air injection port (16),
said injection member (4) including
a main body (33) formed in a pillar shape, said main body (33) including an air passage (35) extending through two ends of said main body (33), and an annular groove (41) formed in an outer circumferential portion of said main body (33), and
a seal member (34) which is inserted into said annular groove (41), is formed in an annular shape that extends over an entire circumference along said annular groove (41), and uses an elastic body, said seal member (34) having an outer diameter (d2) larger than an inner diameter (B) of the air injection port (16).

2. An apparatus according to claim 1, wherein
said seal member (34) is formed from an O-ring.

3. An apparatus according to claim 1 or 2, wherein
the air injection port (16) opens on an attachment surface (12a) of the spectacle lens polishing jig (2), which is opposed to said installation surface (3a) of said polishing jig installation base (3), and has a circular shape defined

in the attachment surface (12a), said main body (33) of said injection member (4) has a columnar shape, and said seal member (34) of said injection member (4) has an annular shape.

4. An apparatus according to claim 1, 2 or 3 wherein a gap (g, g1, g2) to be sealed by said seal member elastically deformed upon inserting said injection member (4) into the air injection port (16) is present between said seal member (34) and said annular groove (41).

5. An apparatus according to claim 4, wherein said annular groove (41) includes a circumferential wall (42) parallel to an outer circumferential surface (33a) of said main body (33), and a pair of side walls (43, 44) extending outwards in a radial direction from said circumferential wall (42), and the gap (g, g1) is present between said seal member (34) and at least one of said pair of side walls (43, 44).

6. An apparatus according to claim 4, wherein said annular groove (41) includes a circumferential wall (42) parallel to an outer circumferential surface (33a) of said main body (33), and a pair of side walls (43, 44) extending outwards in a radial direction from said circumferential wall (42), and the gap (g, g2) is present between said seal member (34) and said circumferential wall (42).

7. A polishing jig air injection method **characterized by** comprising the steps of:

inserting an injection member (4) into an air injection port (16) of a spectacle lens polishing jig (2) (S1) ; and discharging air from the injection member (4) into the air injection port (16) to inflate a balloon member (11) connected to the air injection port (16) (S2), the injection member (4) including a main body (33) formed in a pillar shape, the main body (33) including an air passage (35) extending through two ends of the main body (33), and an annular groove (41) formed in an outer circumferential portion of the main body (33), and a seal member (34) which is inserted into the annular groove (41), is formed in an annular shape that extends over an entire circumferential region along the annular groove (41), and uses an elastic body, the seal member (34) having an outer diameter (d2) larger than an inner diameter (B) of the air injection port (16).

8. A method according to claim 7, wherein the annular groove (41) includes a circumferential wall (42) parallel to an outer circumferential surface (33a) of the main body (33), and a pair of side walls (43, 44) extending outwards in a radial direction from the circumferential wall (42), the inserting step (S1) includes the step of forming a gap (g2) between the seal member (34) and the circumferential wall (42), forming a gap (g1) between the seal member (34) and one side wall (43) inserted into the air injection port (16) first of the pair of side walls (43, 44), and bringing the seal member (34) into contact with the other side wall (44) of the pair of side walls (43, 44), and the discharging step (S2) includes the step of biasing the seal member (34) outwards in a radial direction by a pressure of air to press an outer circumferential portion of the seal member (34) against a wall surface of the air injection port (16).

9. A method according to claim 8, wherein the seal member (34) is formed in a shape, in which the seal member (34) comes into contact with the circumferential wall (42) defining the annular groove (41), and the gap (g1) is formed between the seal member (34) and at least one of the pair of side walls (43, 44) defining the annular groove (41), and the inserting step (S1) includes the steps of pressing the seal member (34) toward said other side wall (44) by friction between the seal member (34) and the wall surface of the air injection port (16) (S4), and elastically deforming the seal member (34) so that the gap (g2) is formed between the seal member (34) and the circumferential wall (42) by friction between the seal member (34) and the wall surface of the air injection port (16) (S5).

10. A method according to claim 8, wherein the seal member (34) is formed in a shape, in which the seal member (34) comes into contact with both the pair of side walls (43, 44) defining the annular groove (41), and the gap (g2) is formed between the seal member (34) and

the circumferential wall (42) defining the annular groove (41), and
the inserting step (S1) includes the step of elastically deforming the seal member (34) so that the gap (g1) is formed between the seal member (34) and said one side wall (43) by friction between the seal member (34) and the wall surface of the air injection port (16) (S7).

11. A method according to claim 8, wherein
the seal member (34) is formed in a shape in which the gaps (g1, g2) are formed between the seal member (34) and at least one of the pair of side walls (43, 44) defining the annular groove (41), and between the seal member (34) and the circumferential wall (42) defining the annular groove (41), and
the inserting step (Sl) includes the step of pressing the seal member (34) toward said other side wall (44) by friction between the seal member (34) and the wall surface of the air injection port (16) (S4).

FIG.1

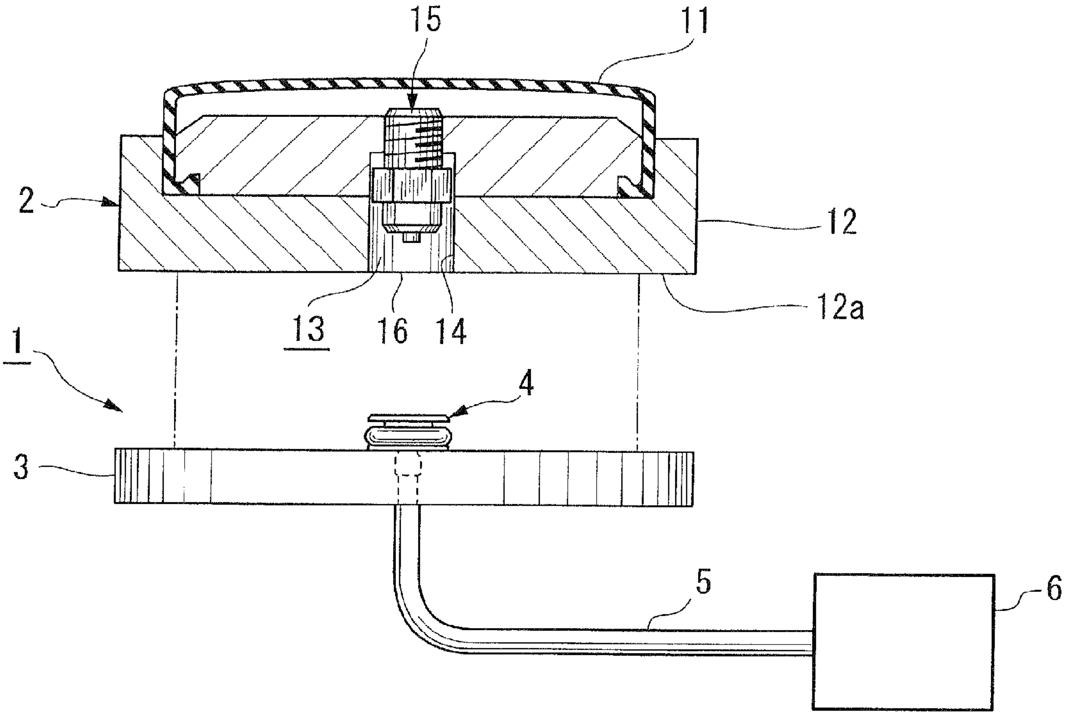

15
11
2
12
12a
13
16
14
1
4
3
5
6

FIG.2

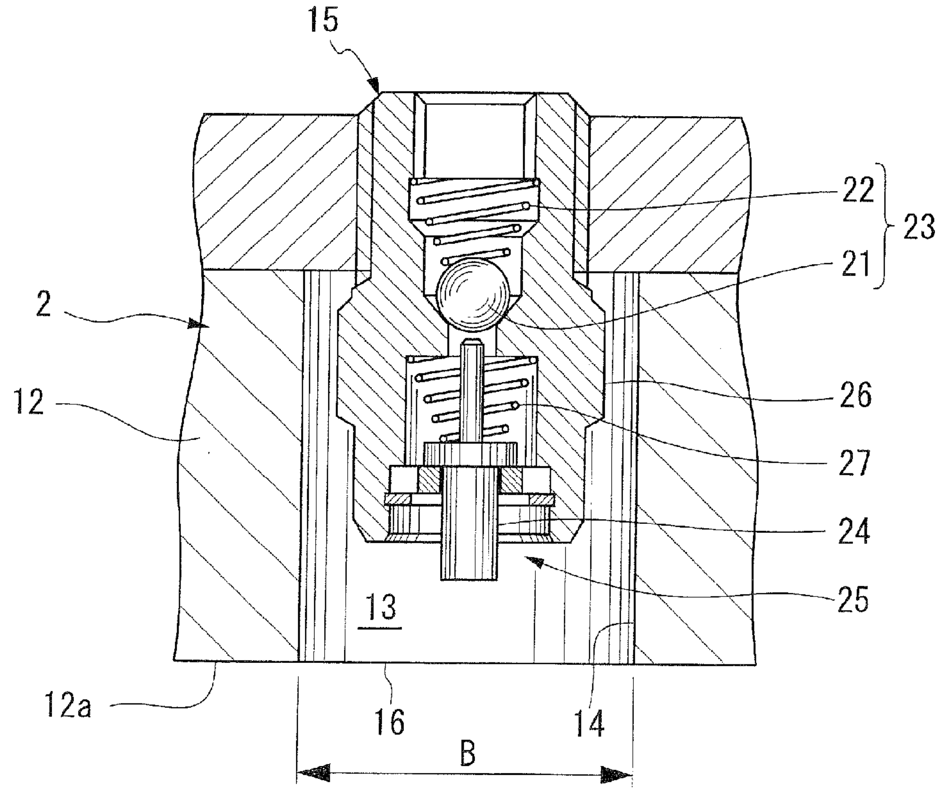

15
22
23
21
2
26
12
27
24
25
13
12a
16
14
B

FIG.3

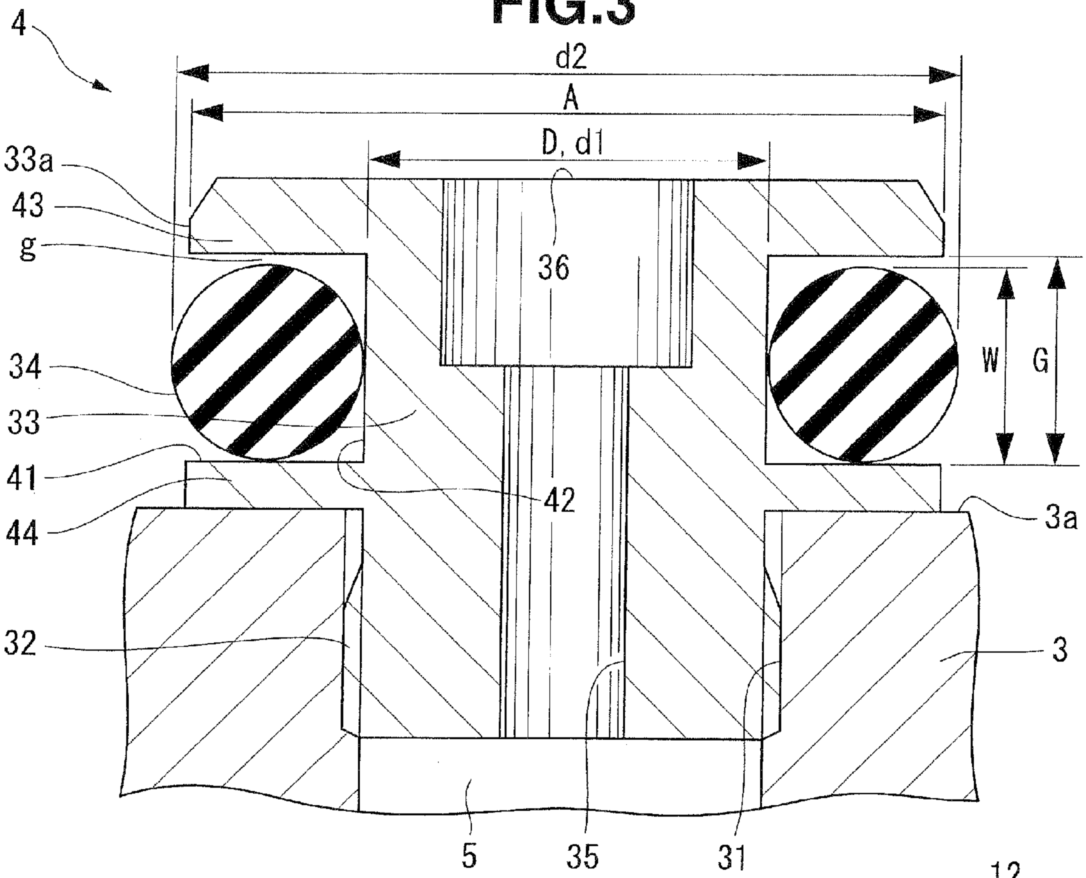

4
d2
A
D, d1
33a
43
g
36
W
G
34
33
41
42
44
3a
32
3
5
35
31

FIG.4

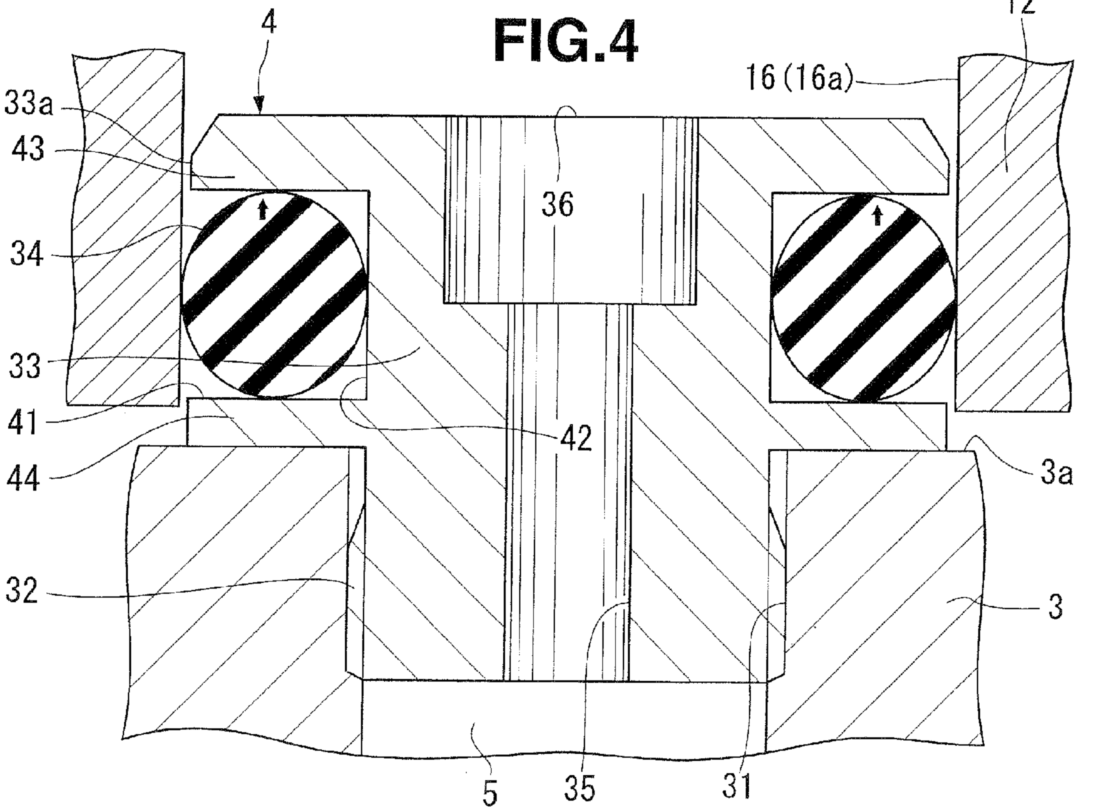

4
12
16 (16a)
33a
43
36
34
33
41
42
44
3a
32
3
5
35
31

FIG.5

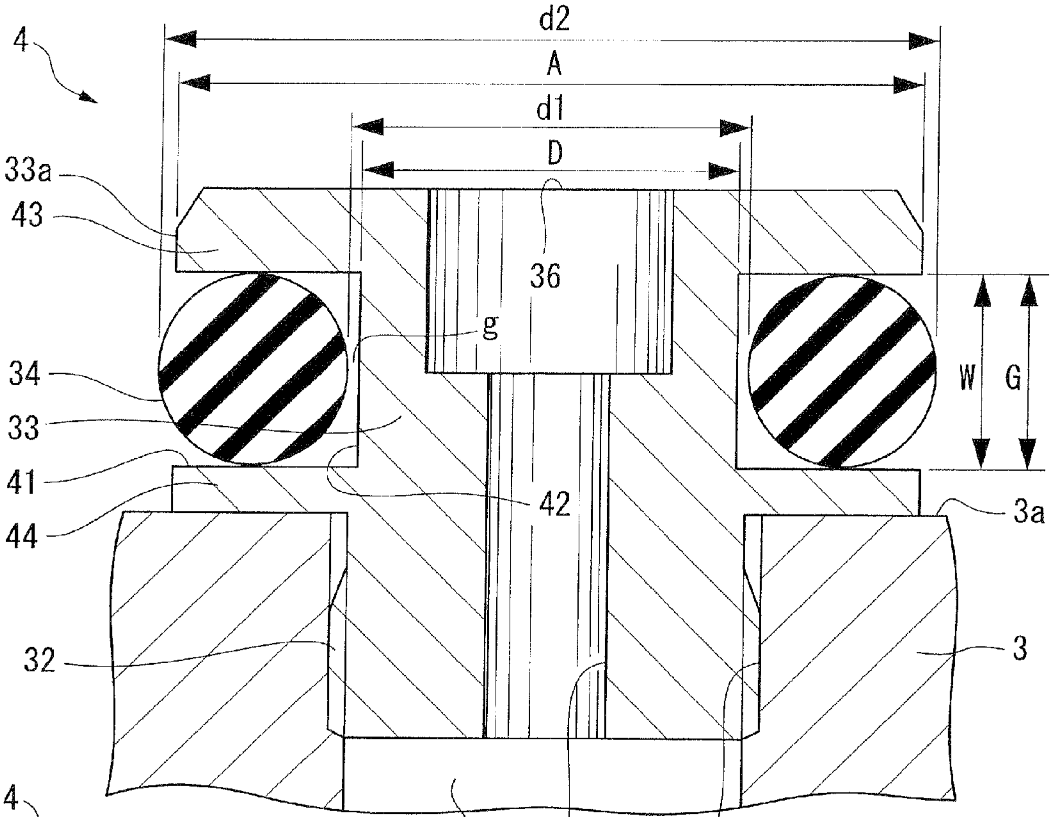

4
d2
A
d1
D
33a
43
36
g
34
33
41
44
42
3a
W
G
32
3
5
35
31

FIG.6

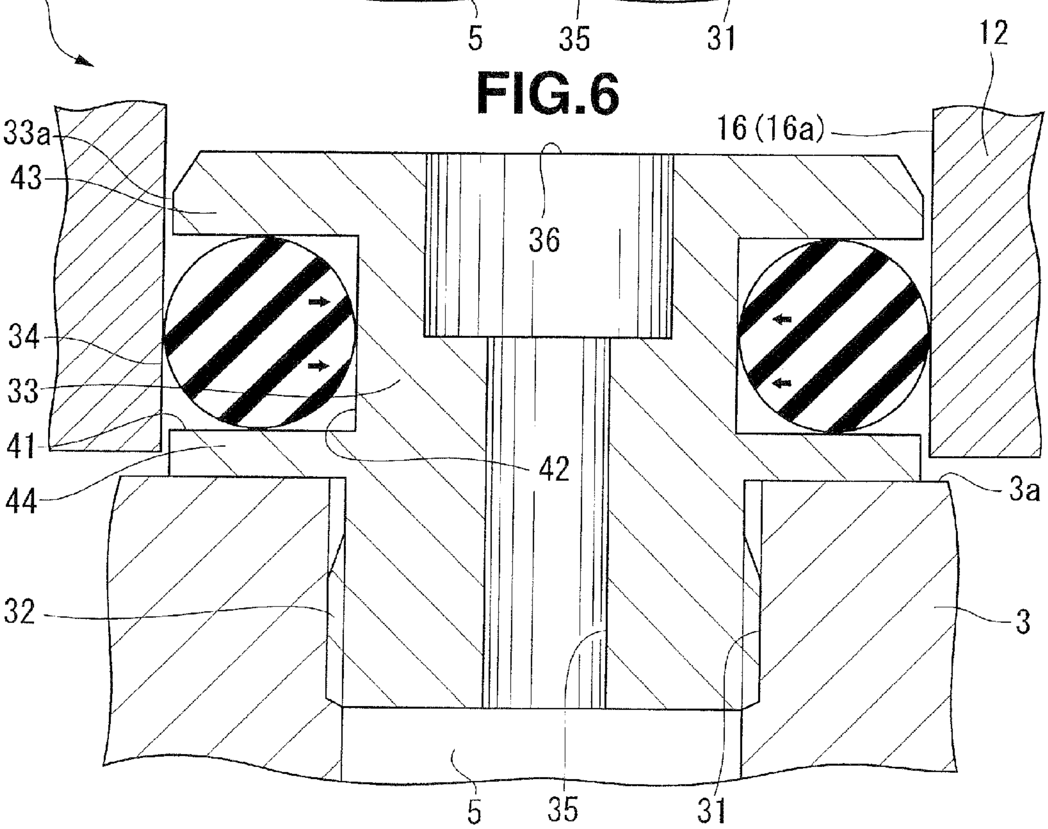

4
12
16(16a)
33a
43
36
34
33
41
44
42
3a
32
3
5
35
31

FIG.7

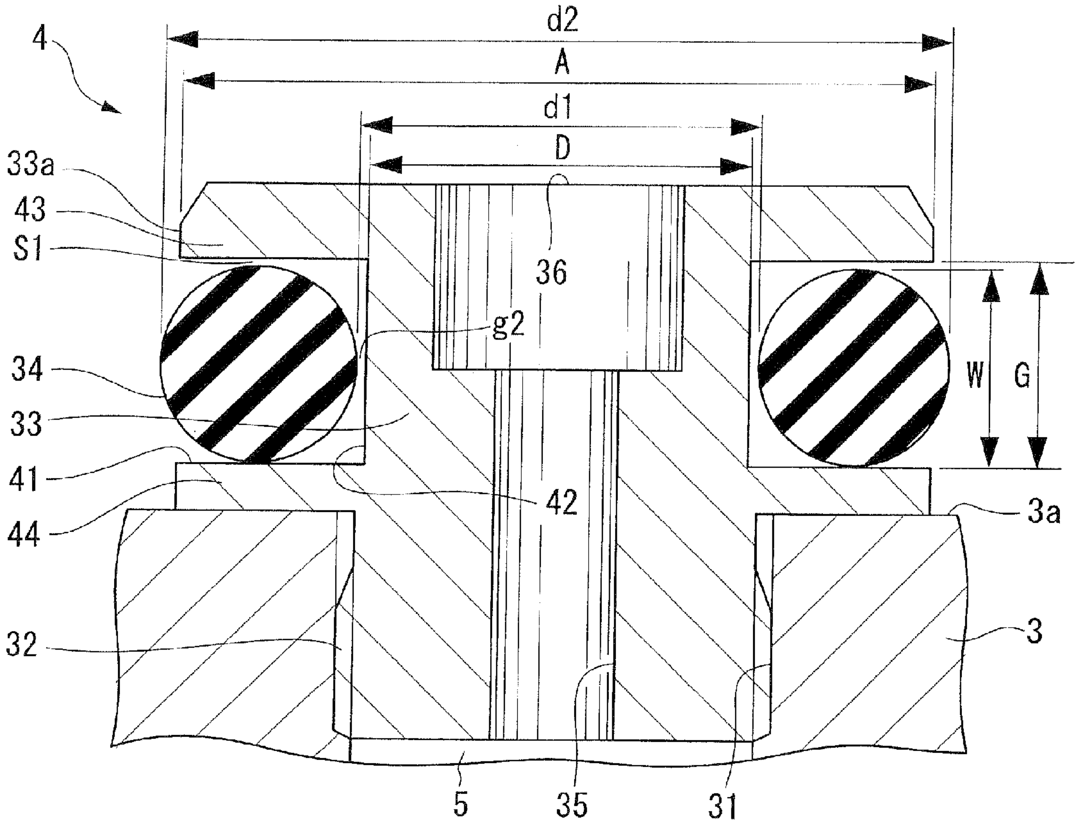

4
d2
A
d1
D
33a
43
S1
36
g2
34
W
G
33
41
42
3a
44
32
3
5
35
31

FIG.8

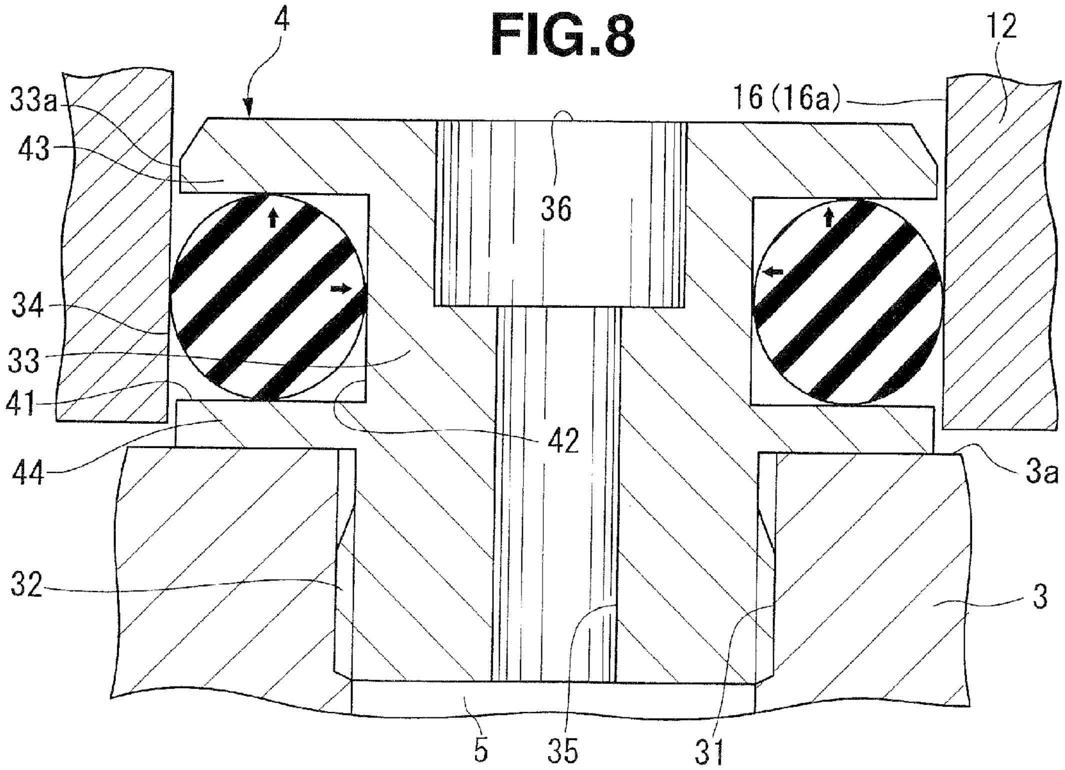

4
12
16 (16a)
33a
43
36
34
33
41
42
44
3a
32
3
5
35
31

FIG.9

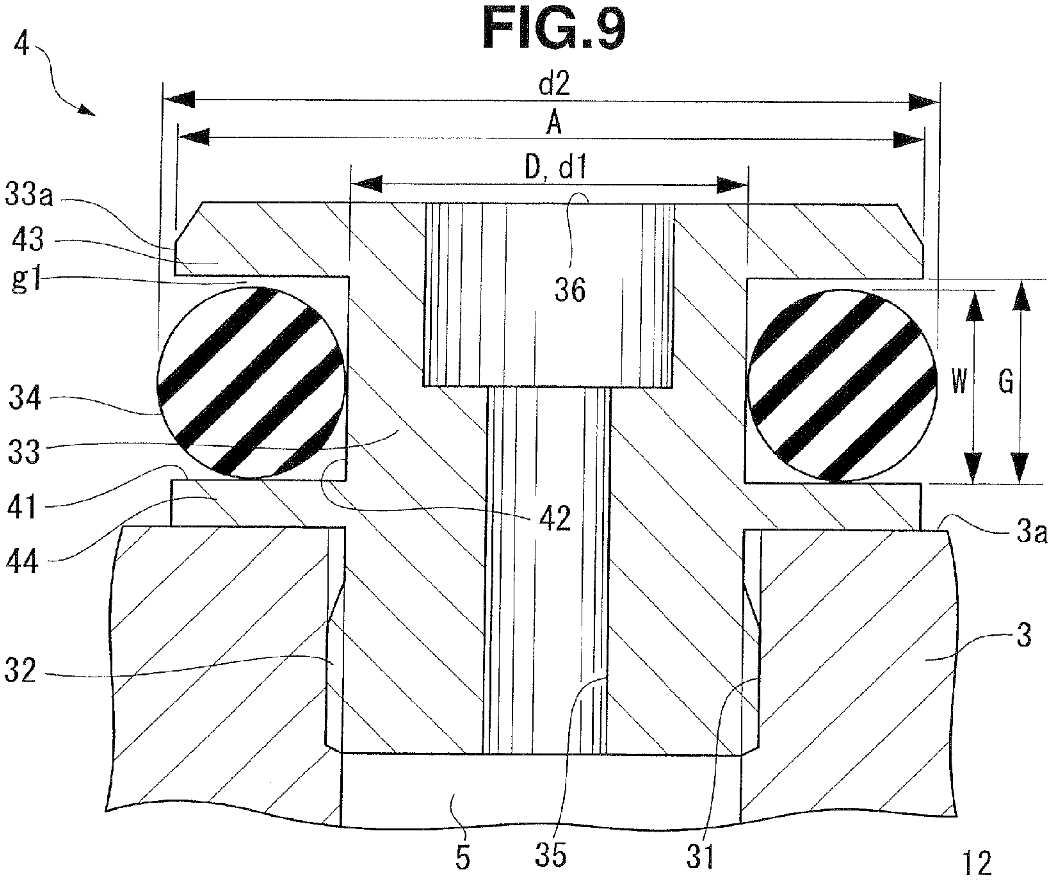

4
d2
A
D, d1
33a
43
g1
36
W
G
34
33
41
42
3a
44
3
32
5
35
31

FIG.10

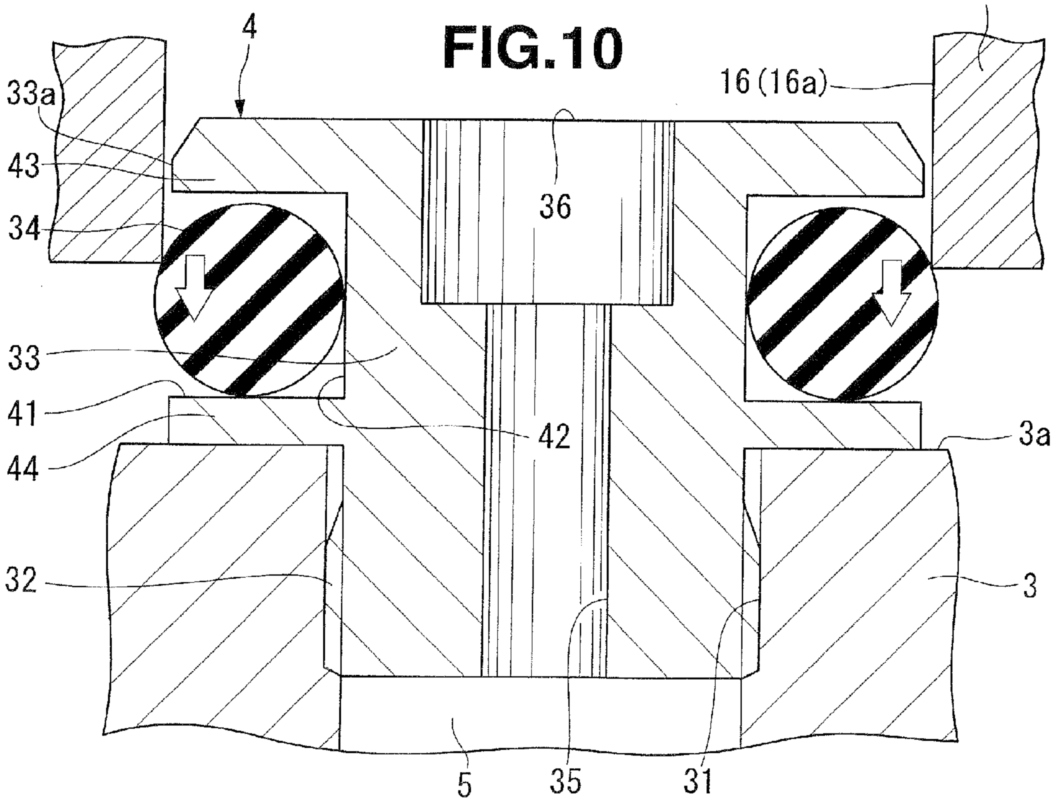

12
4
16 (16a)
33a
43
36
34
33
41
42
3a
44
32
3
5
35
31

FIG.11

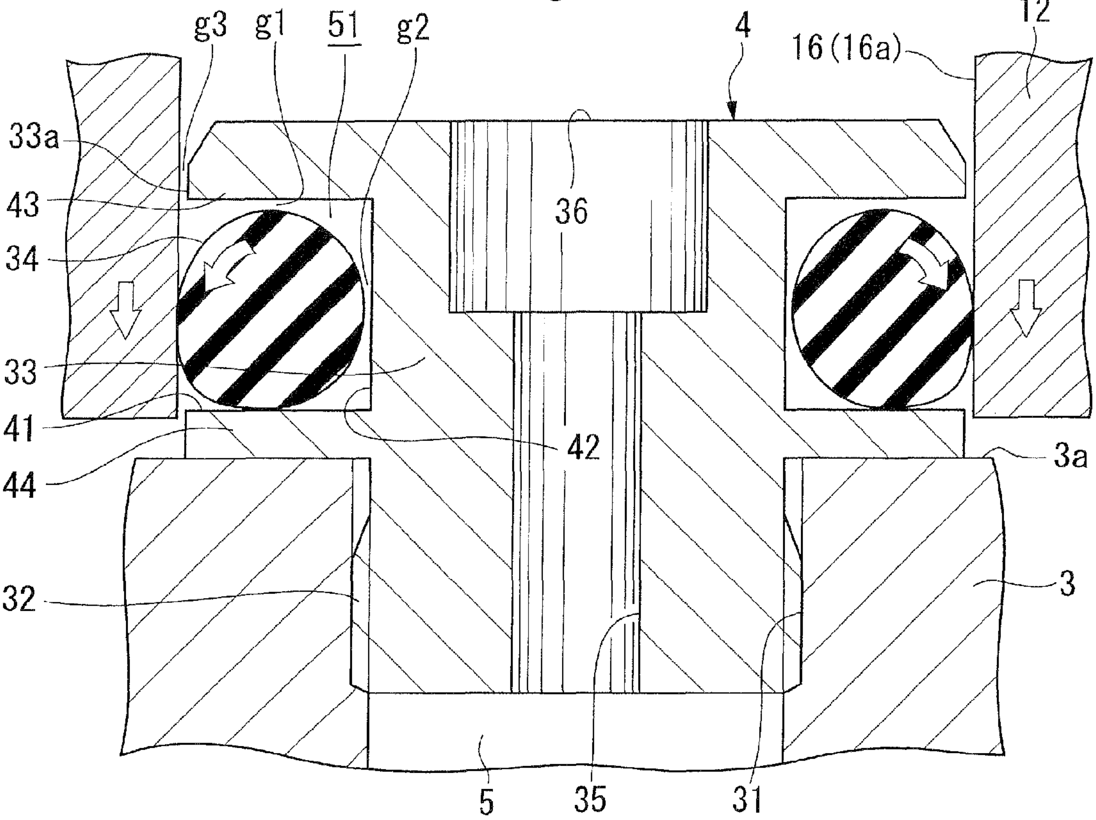

g3
g1
51
g2
4
12
16 (16a)
33a
43
36
34
33
41
42
3a
44
32
3
5
35
31

FIG.12

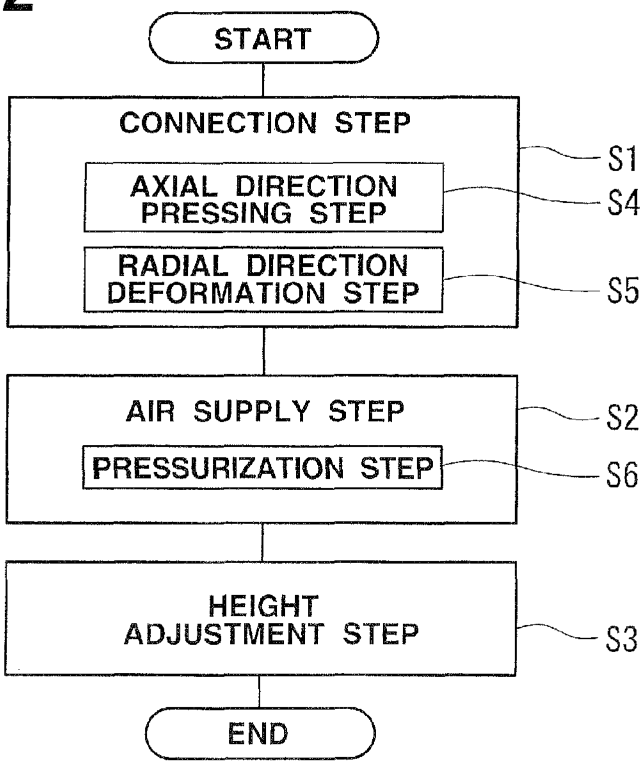

START
CONNECTION STEP
S1
AXIAL DIRECTION PRESSING STEP
S4
RADIAL DIRECTION DEFORMATION STEP
S5
AIR SUPPLY STEP
S2
PRESSURIZATION STEP
S6
HEIGHT ADJUSTMENT STEP
S3
END

FIG.13

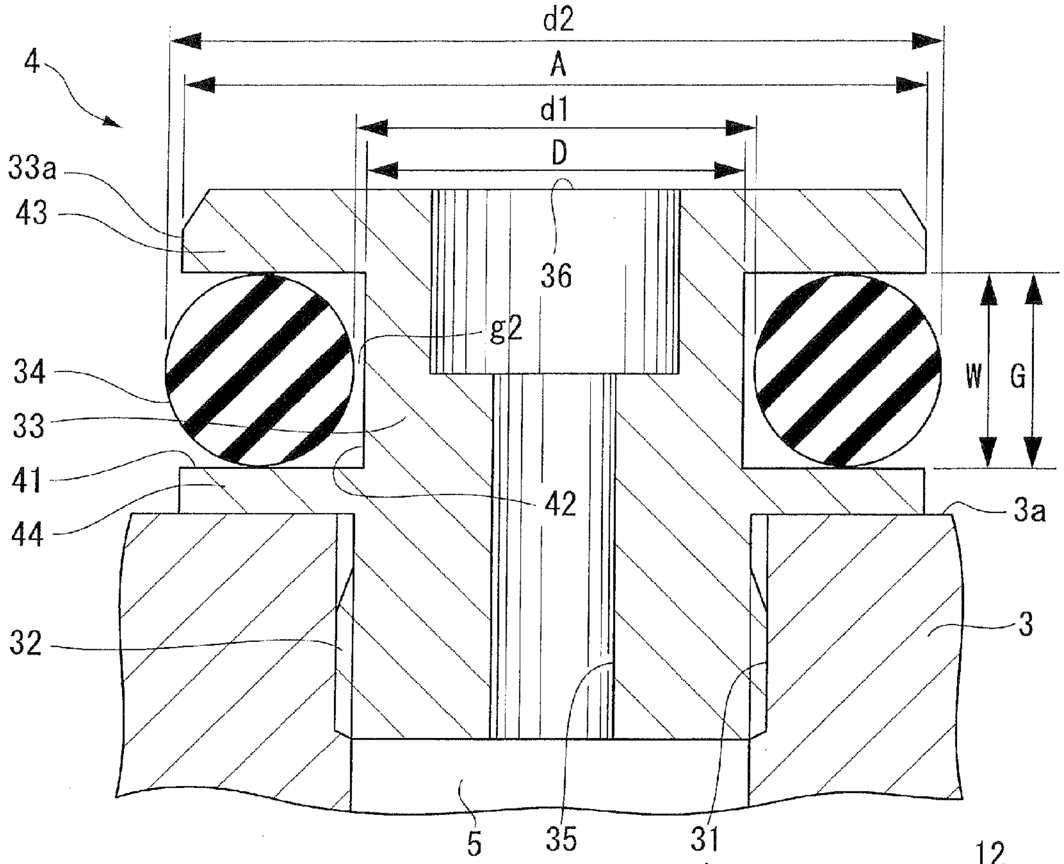

d2
A
d1
D
4
33a
43
36
g2
34
33
41
44
42
W
G
3a
3
32
35
31
5

FIG.14

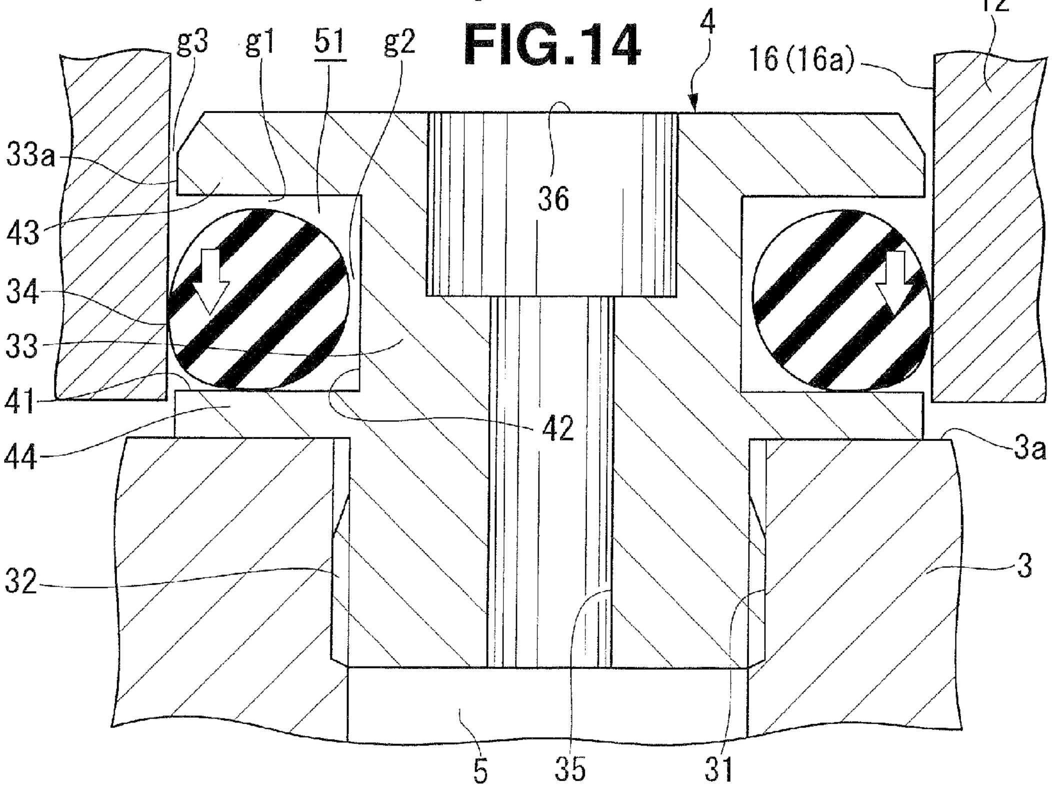

g3
g1
51
g2
4
16(16a)
12
33a
43
36
34
33
41
44
42
3a
32
3
5
35
31

FIG.15

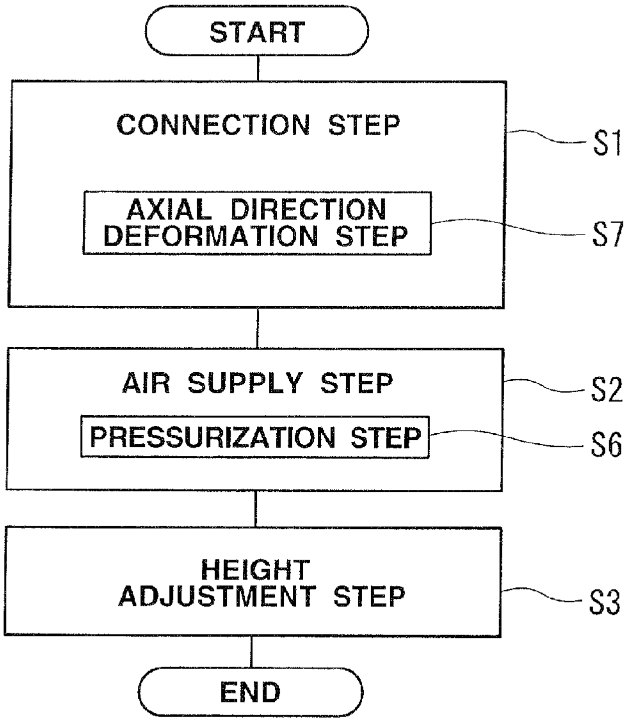

START
CONNECTION STEP
AXIAL DIRECTION DEFORMATION STEP
AIR SUPPLY STEP
PRESSURIZATION STEP
HEIGHT ADJUSTMENT STEP
END
S1
S7
S2
S6
S3

FIG.16

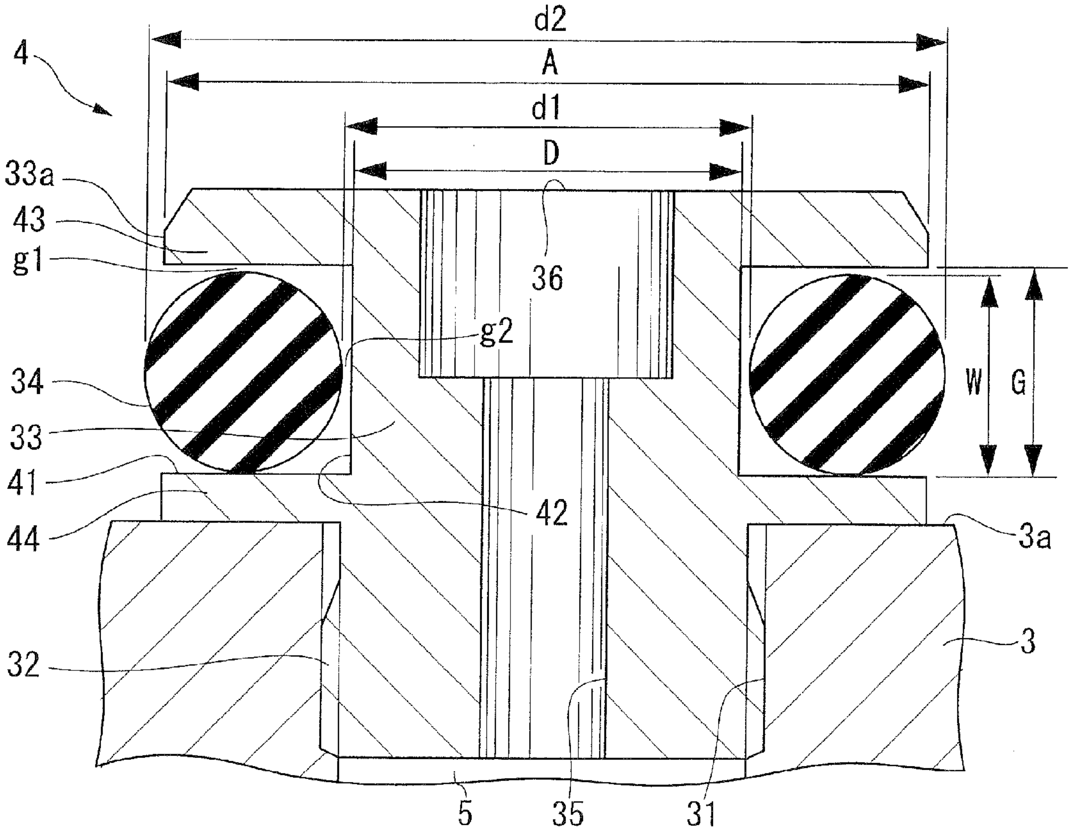

d2
A
d1
D
4
33a
43
g1
34
33
41
44
32
36
g2
42
W
G
3a
3
5
35
31

FIG.17

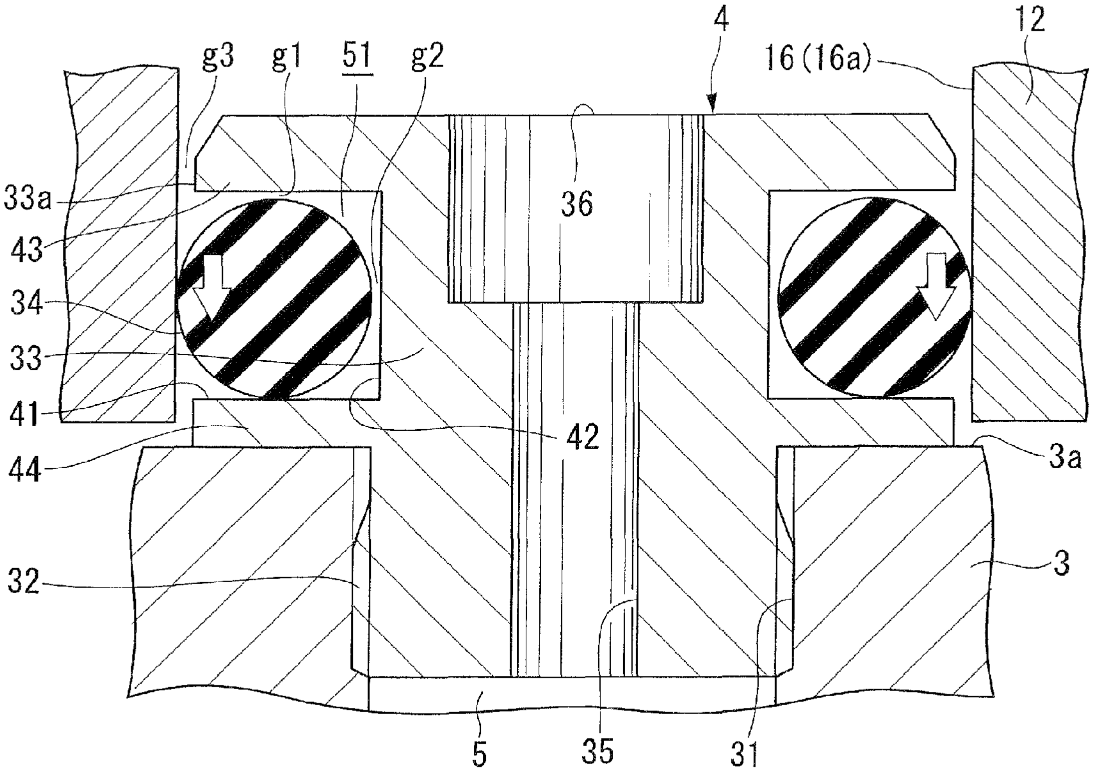

g3
g1
51
g2
4
16(16a)
12
33a
43
34
33
41
44
36
42
3a
3
32
5
35
31

FIG.18

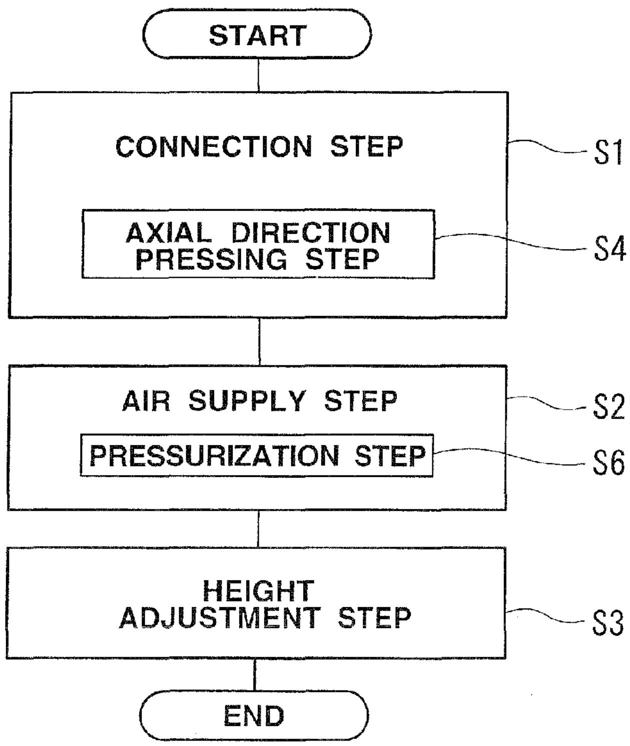
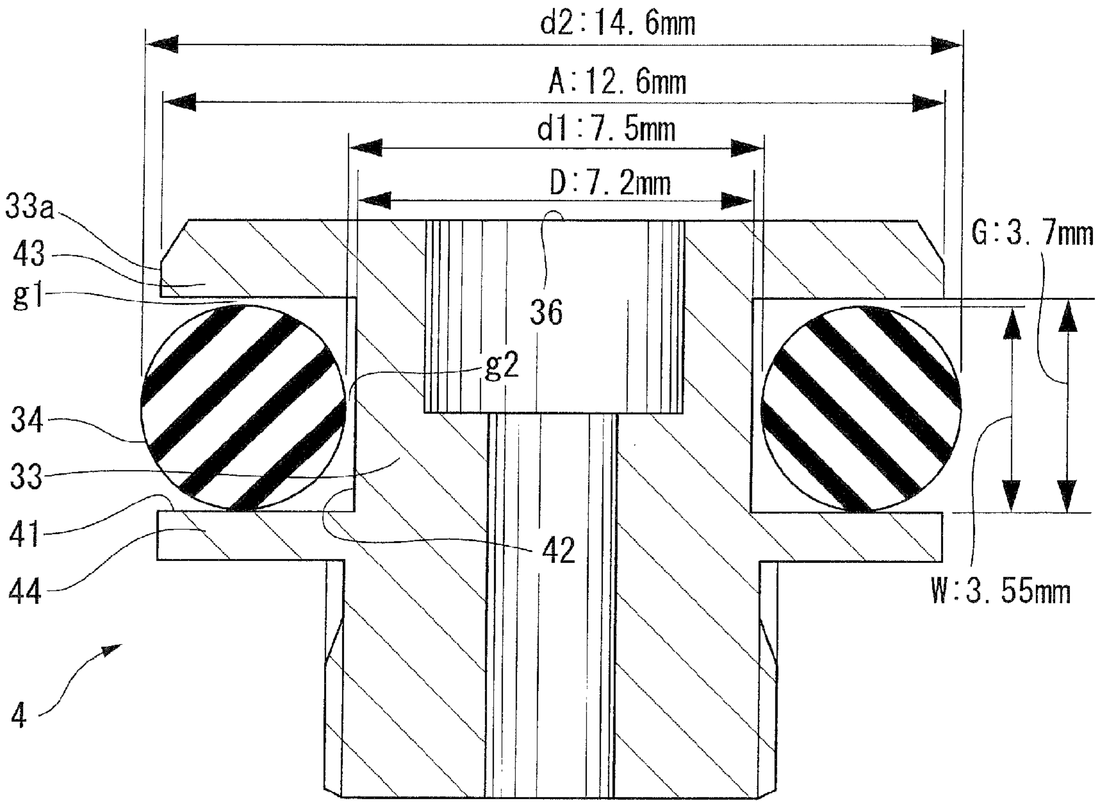

START
CONNECTION STEP
S1
AXIAL DIRECTION PRESSING STEP
S4
AIR SUPPLY STEP
S2
PRESSURIZATION STEP
S6
HEIGHT ADJUSTMENT STEP
S3
END

FIG.19


d2:14.6mm
A:12.6mm
d1:7.5mm
D:7.2mm
33a
43
g1
36
g2
G:3.7mm
34
33
41
44
42
W:3.55mm
4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004106117 A **[0002]**