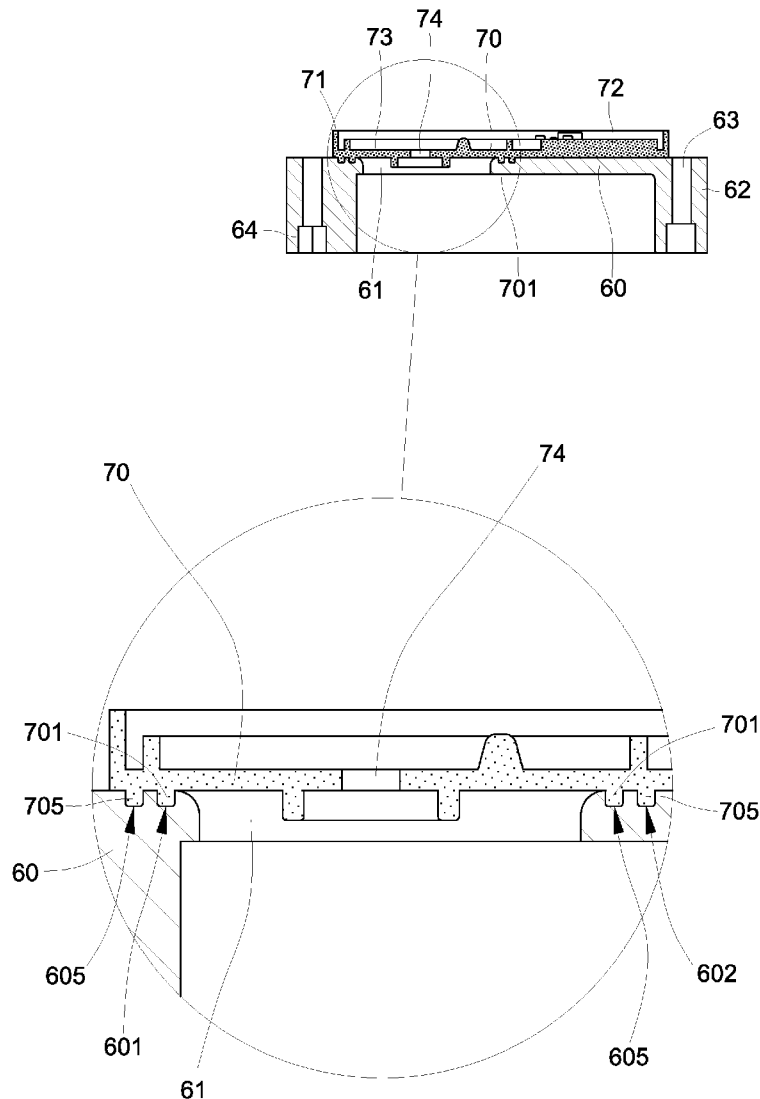




US 20150198154A1

(19) **United States**(12) **Patent Application Publication**
CAI et al.(10) **Pub. No.: US 2015/0198154 A1**(43) **Pub. Date: Jul. 16, 2015**(54) **VIBRATION-REDUCING STRUCTURE FOR
COMPRESSING DIAPHRAGM PUMP****Publication Classification**(71) Applicants: **Ying Lin CAI**, Guangdong (CN); **Chao
Fou HSU**, Kaohsiung City (TW)(51) **Int. Cl.**
F04B 45/047 (2006.01)(72) Inventors: **Ying Lin CAI**, Guangdong (CN); **Chao
Fou HSU**, Kaohsiung City (TW)(52) **U.S. Cl.**
CPC **F04B 45/047** (2013.01)(21) Appl. No.: **14/580,639**(22) Filed: **Dec. 23, 2014****Related U.S. Application Data**(60) Provisional application No. 61/928,162, filed on Jan.
16, 2014.(57) **ABSTRACT**

A vibration-reducing method for reducing vibrations and vibration noise in a compressing diaphragm pump includes the step of disposing a vibration-reducing unit between the pump head body and a diaphragm membrane to reduce a length of the moment arm, and therefore of the torque, generated upon up and down movement of the diaphragm membrane during pumping.



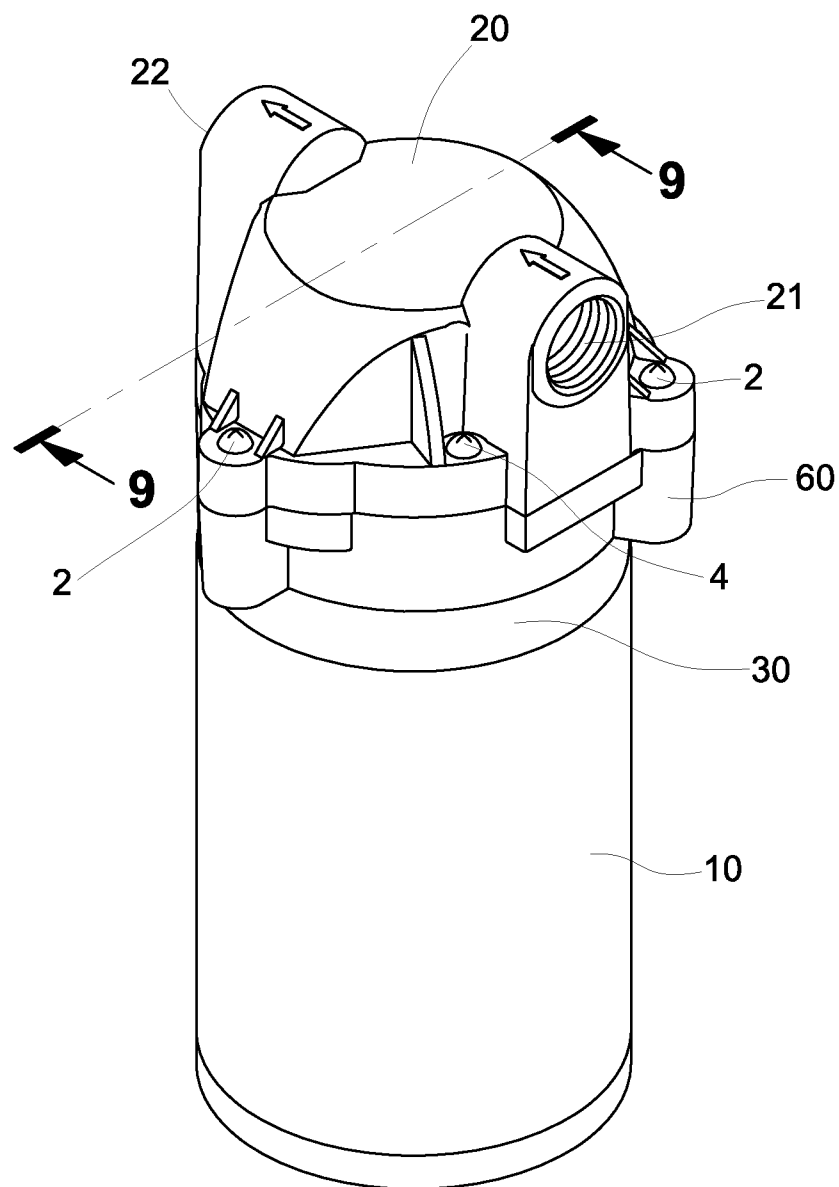
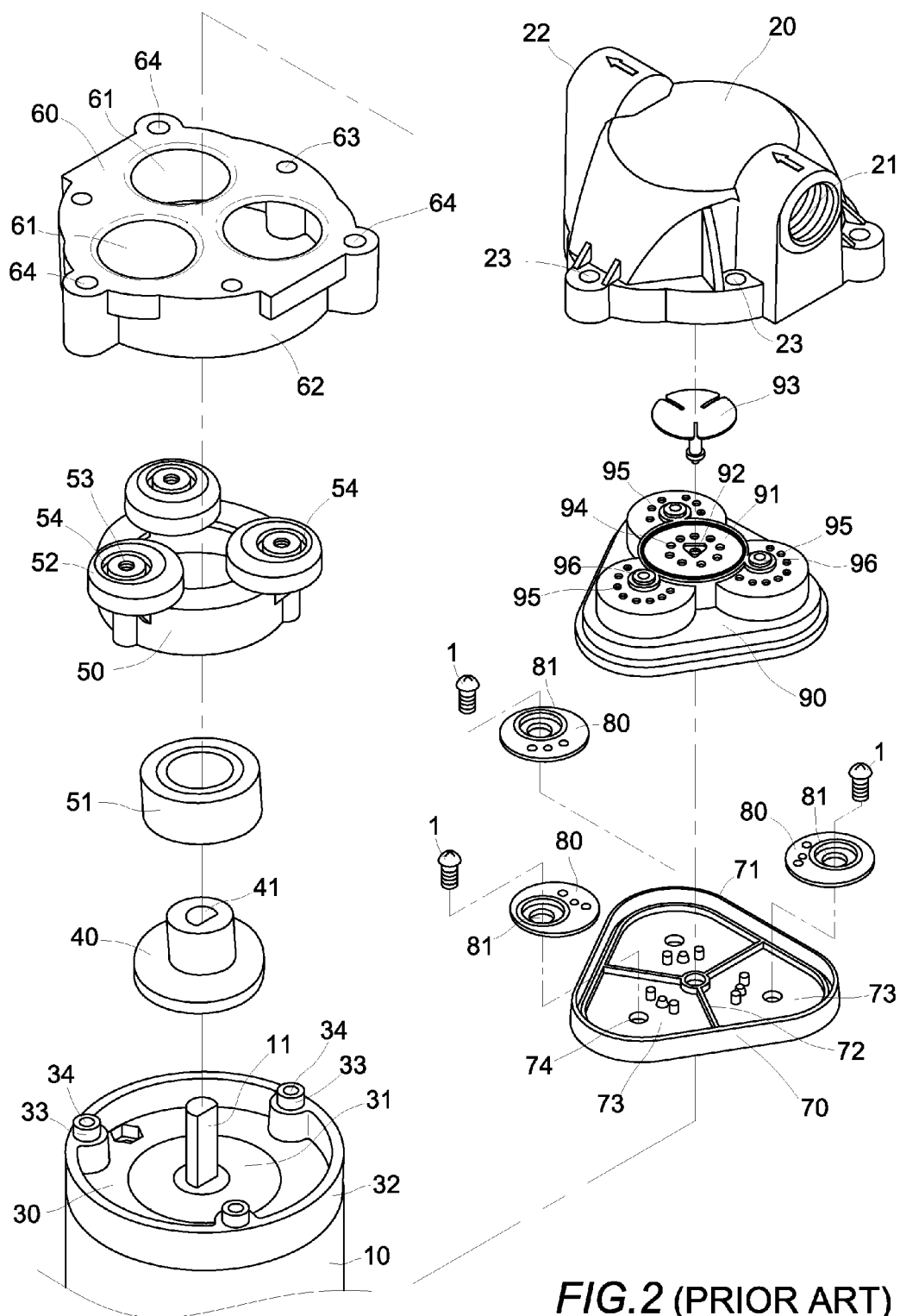
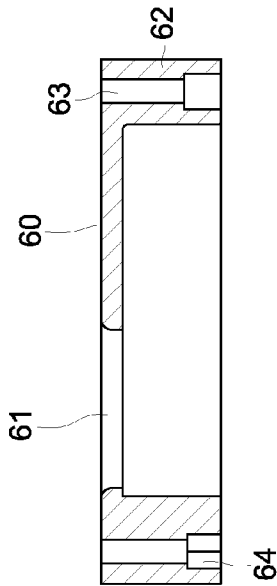
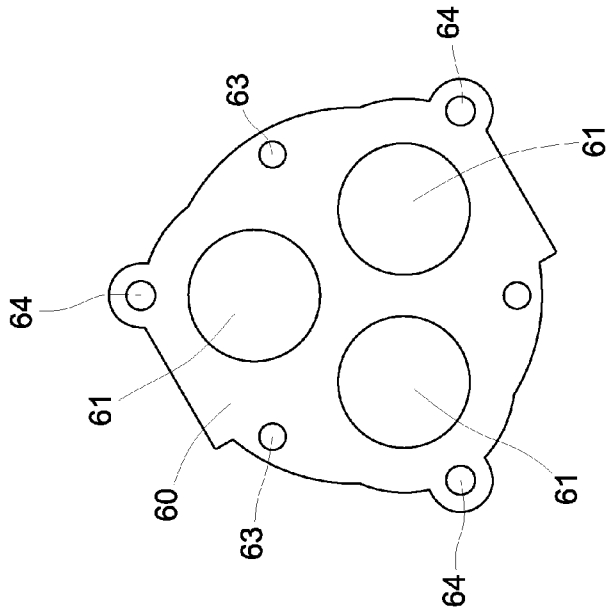
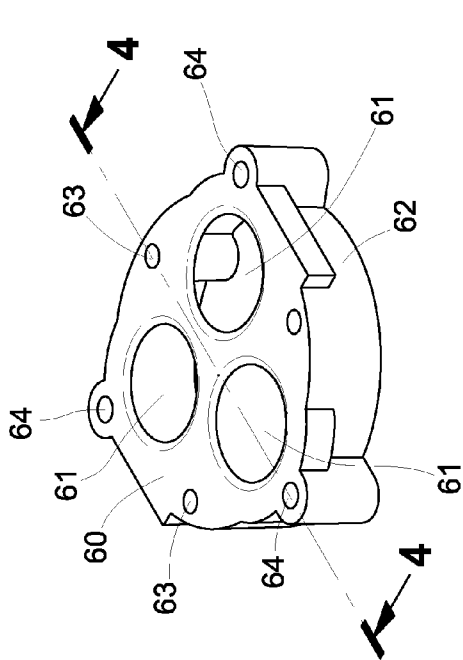


FIG. 1 (PRIOR ART)





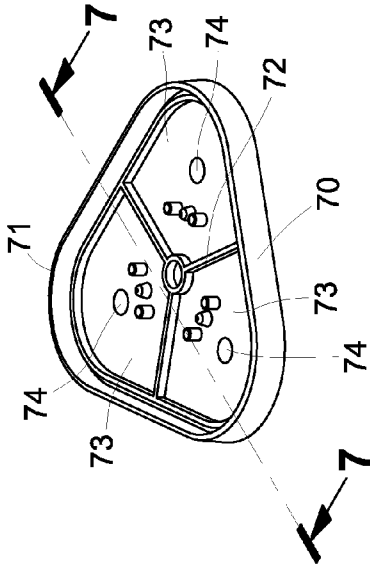


FIG. 6 (PRIOR ART)

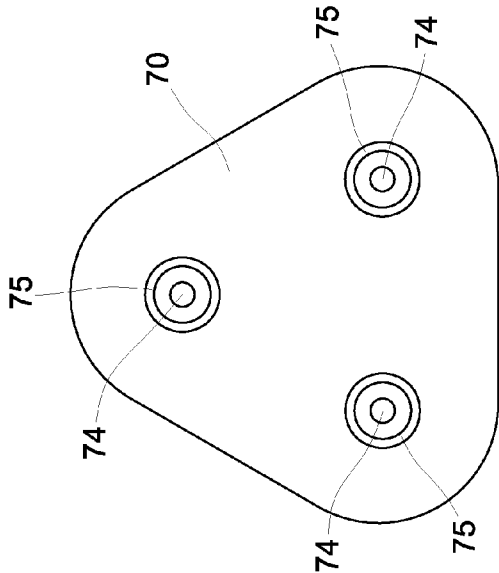


FIG. 8 (PRIOR ART)

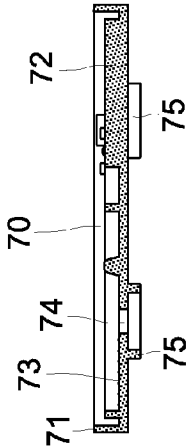


FIG. 7 (PRIOR ART)

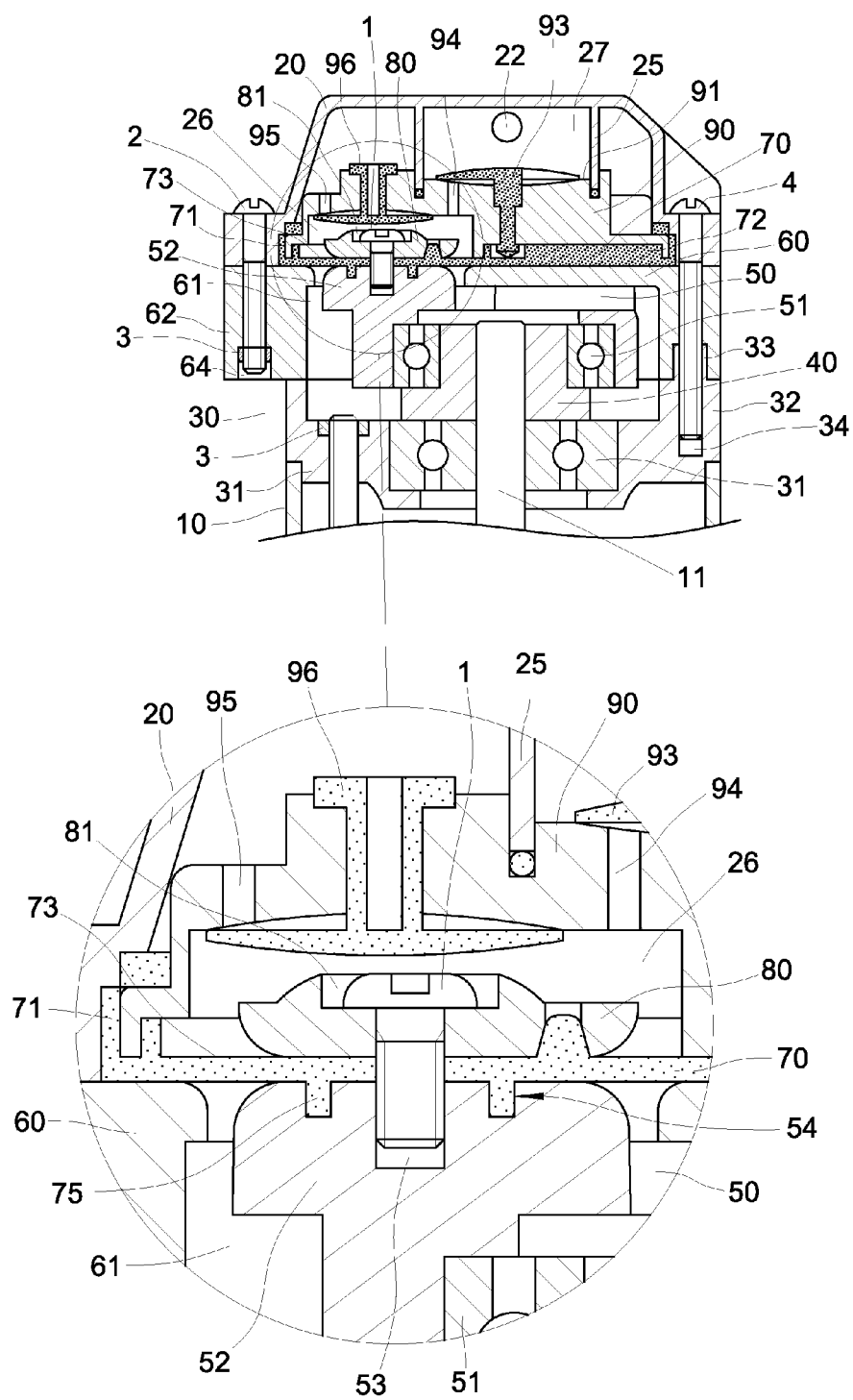


FIG.9 (PRIOR ART)

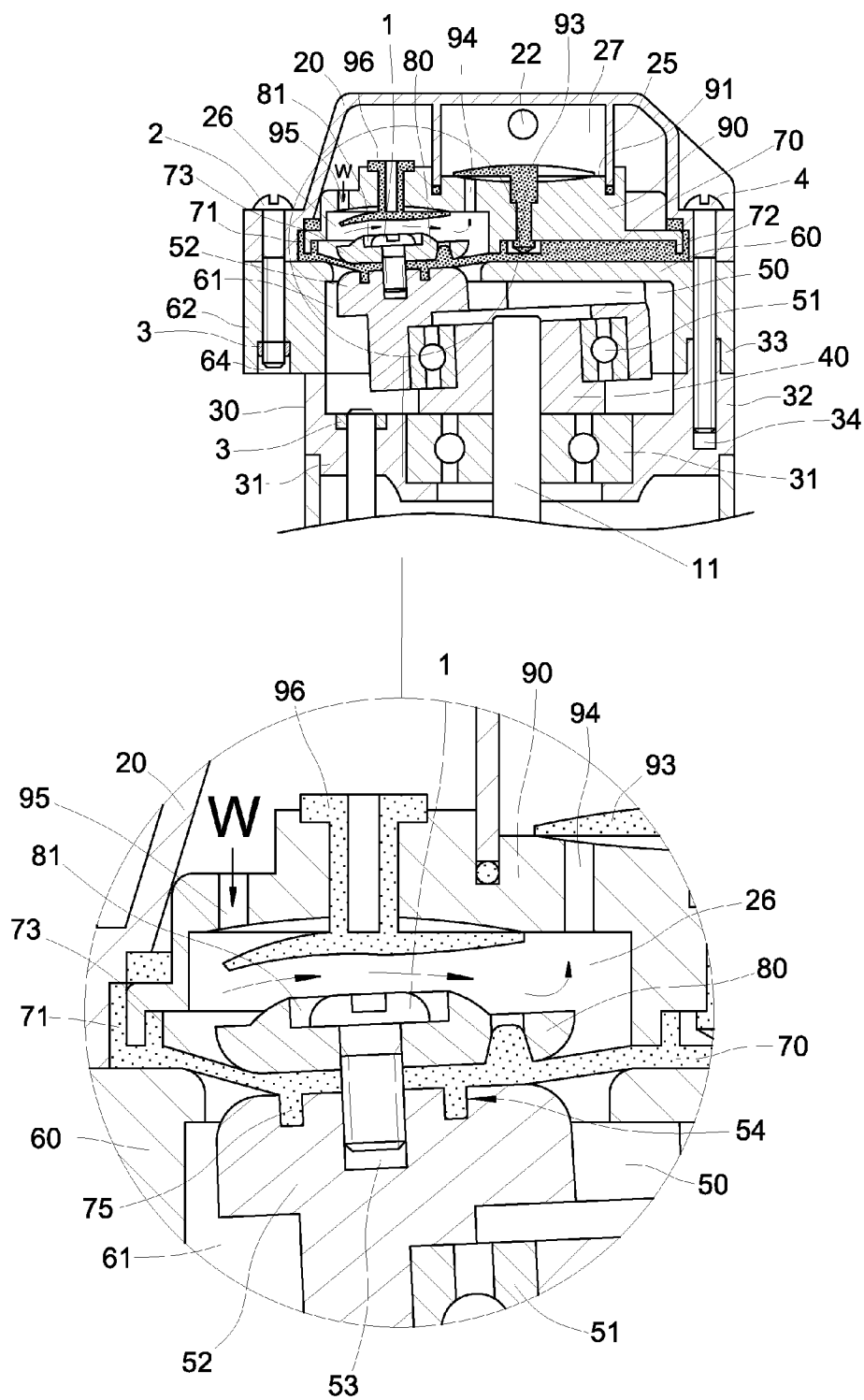


FIG. 10 (PRIOR ART)

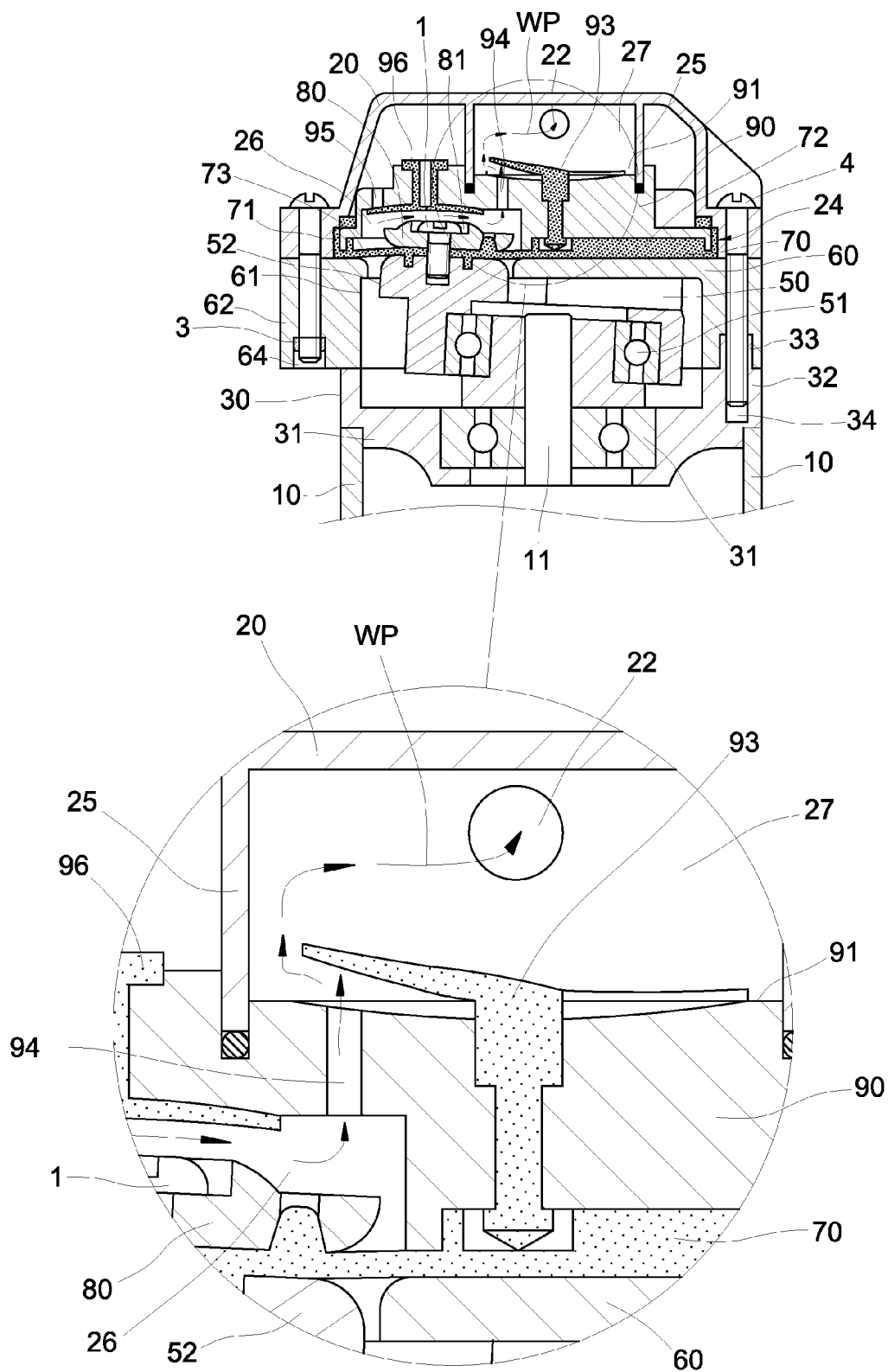
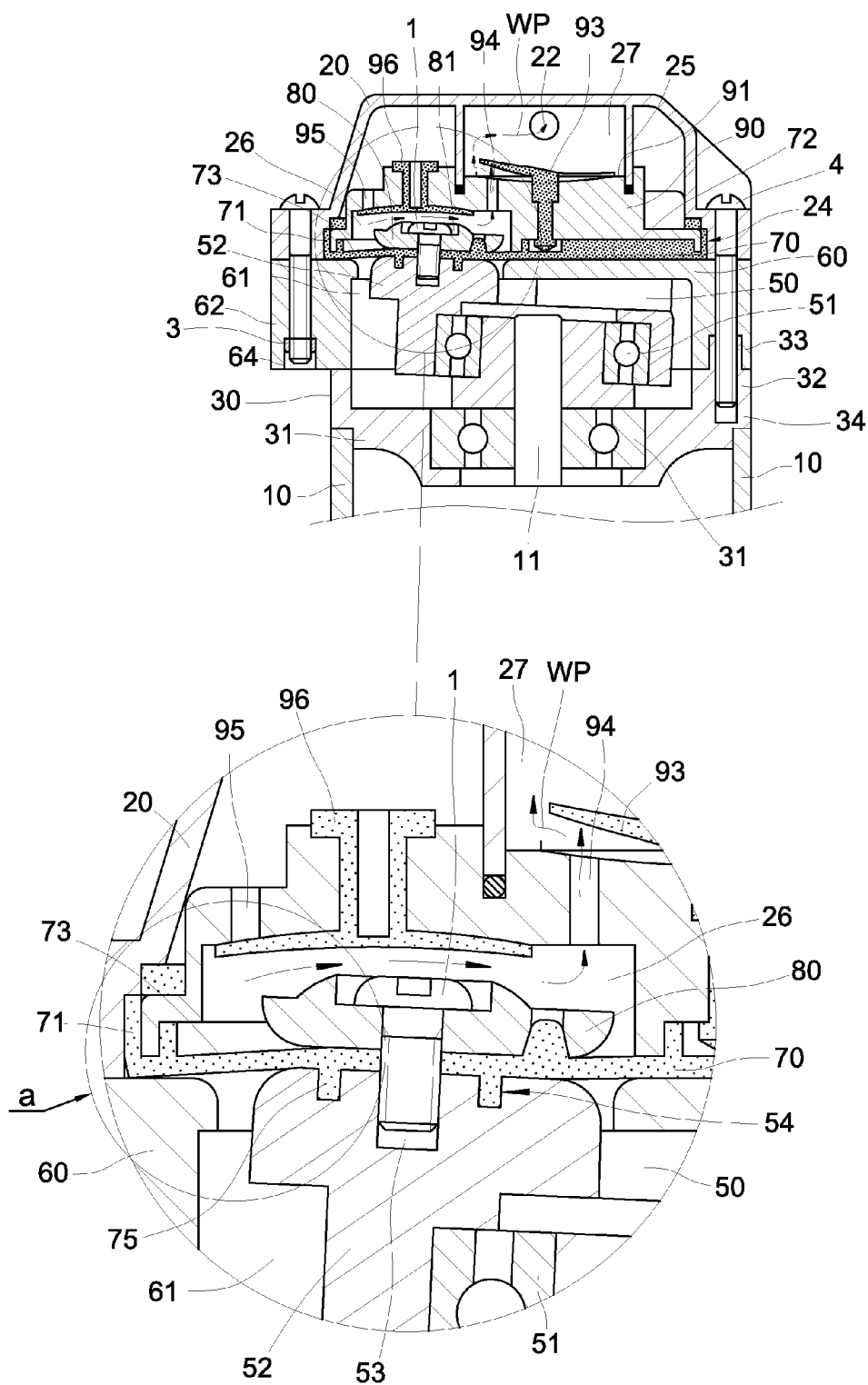


FIG. 11 (PRIOR ART)



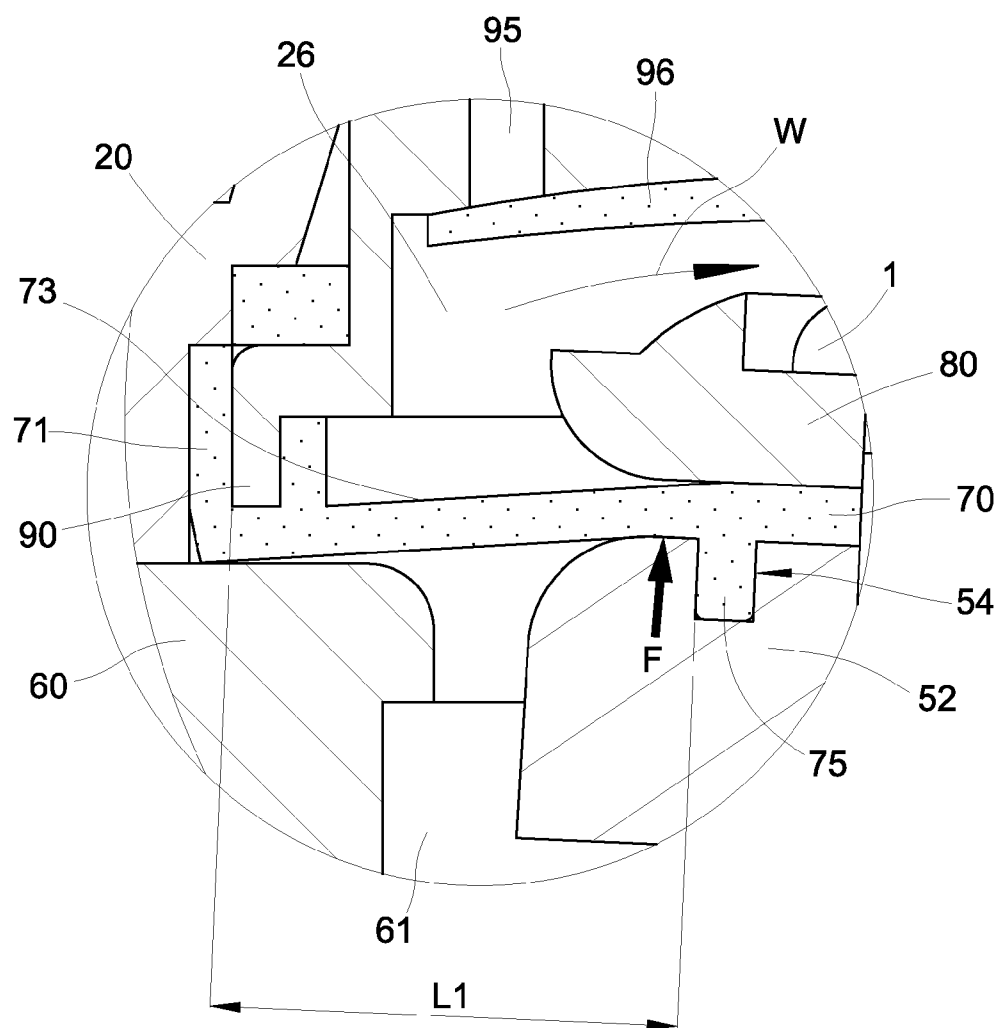


FIG. 13 (PRIOR ART)

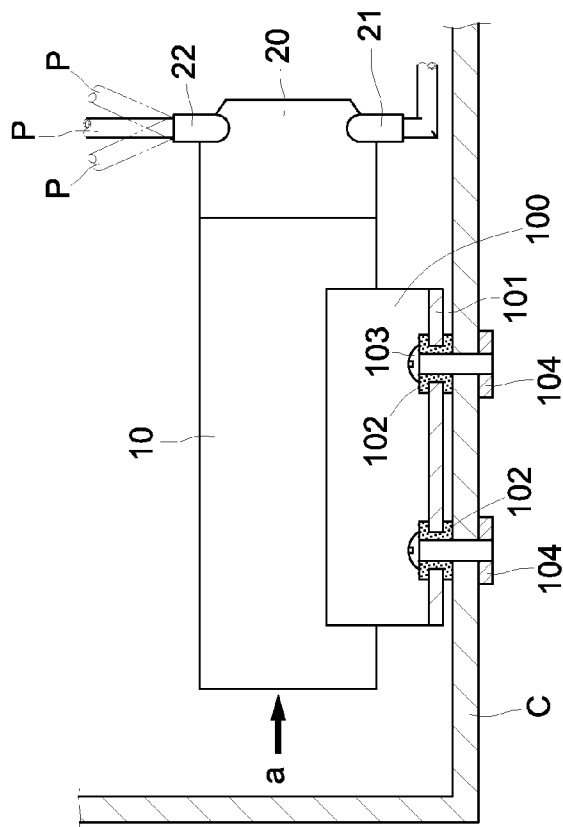


FIG. 14 (PRIOR ART)

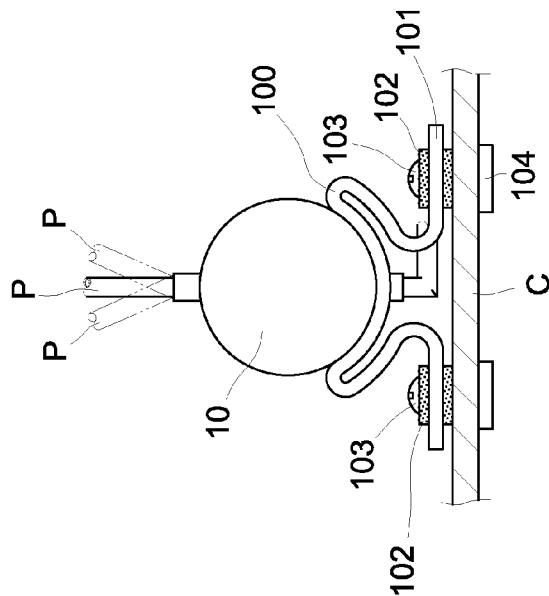


FIG. 14(a) (PRIOR ART)

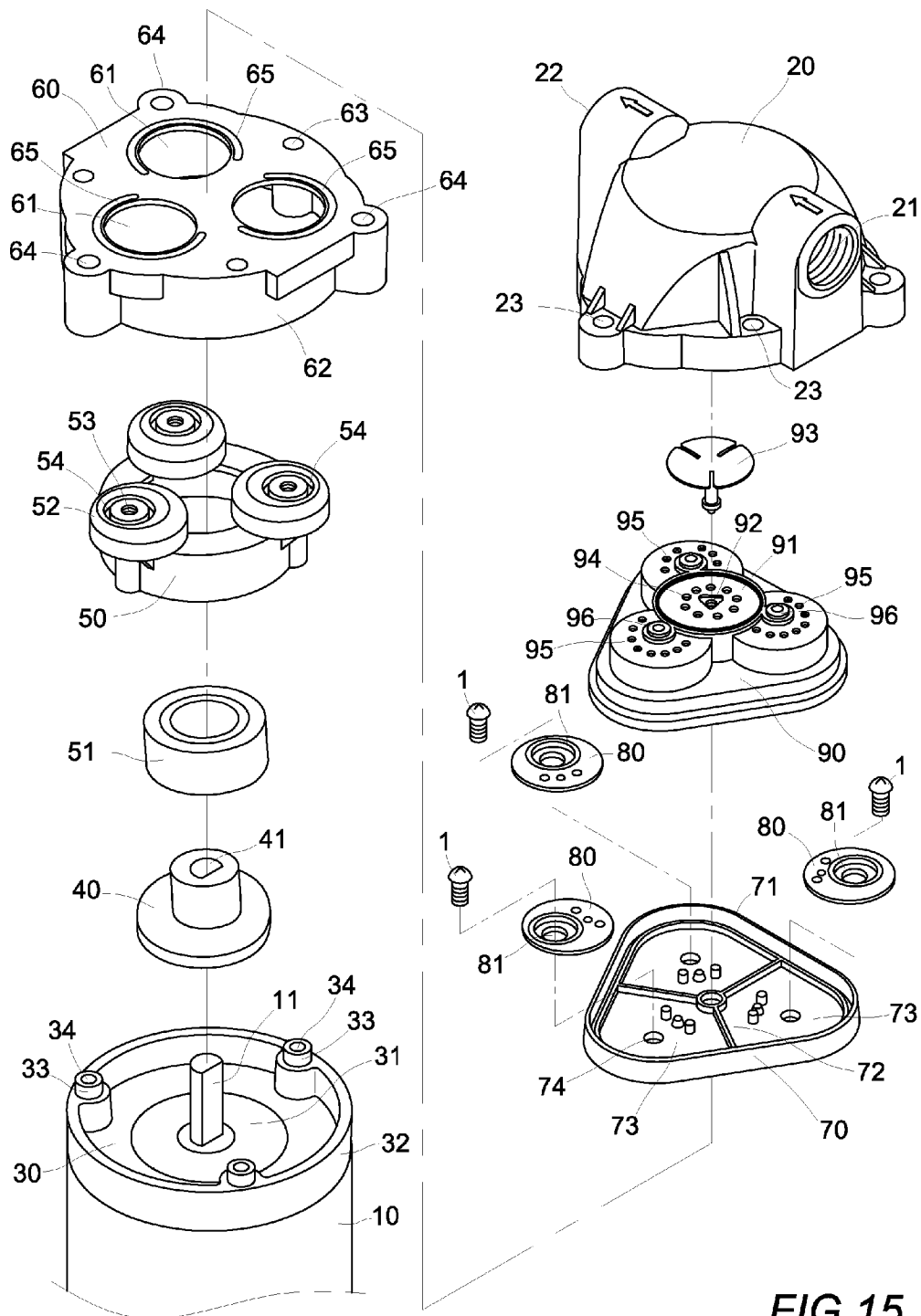


FIG. 15

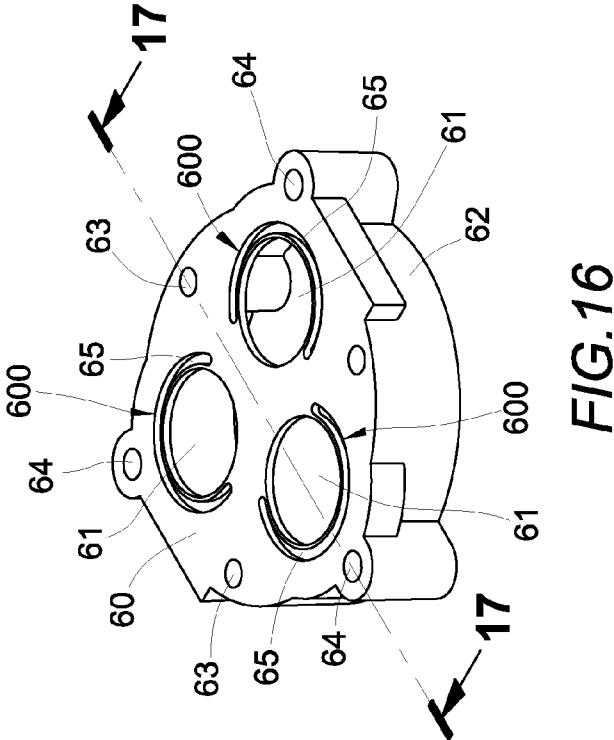


FIG. 16

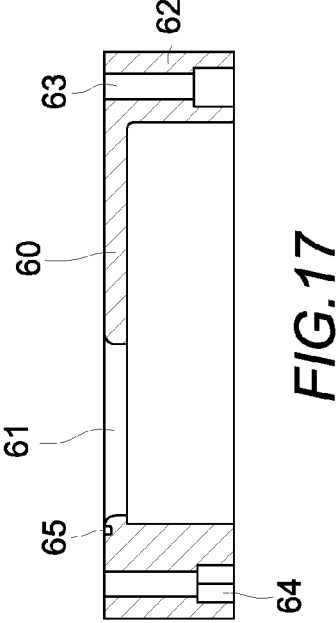


FIG. 17

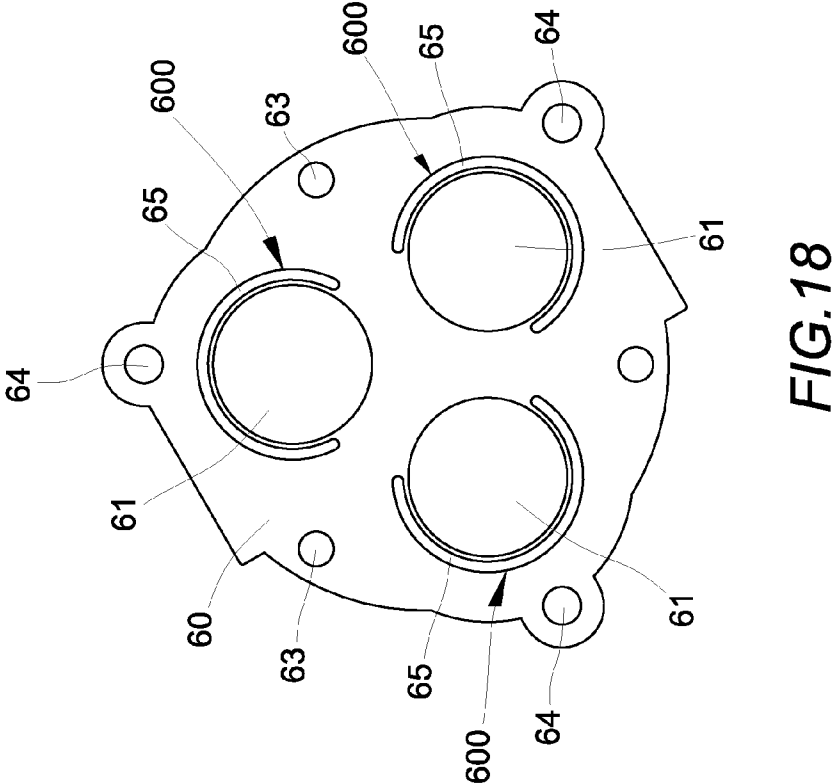


FIG. 18

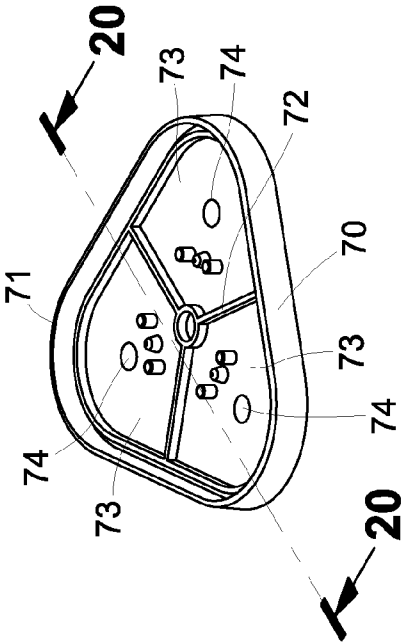


FIG. 19

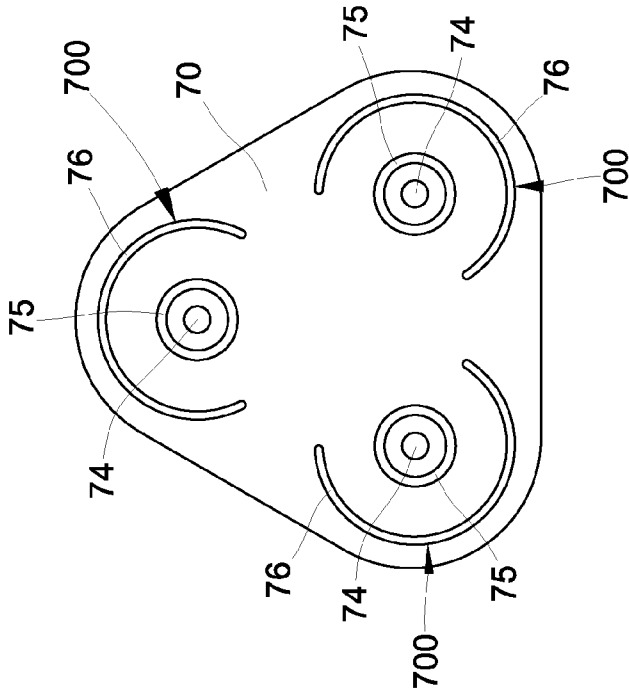


FIG. 21

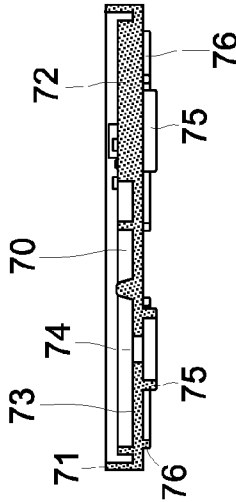


FIG. 20

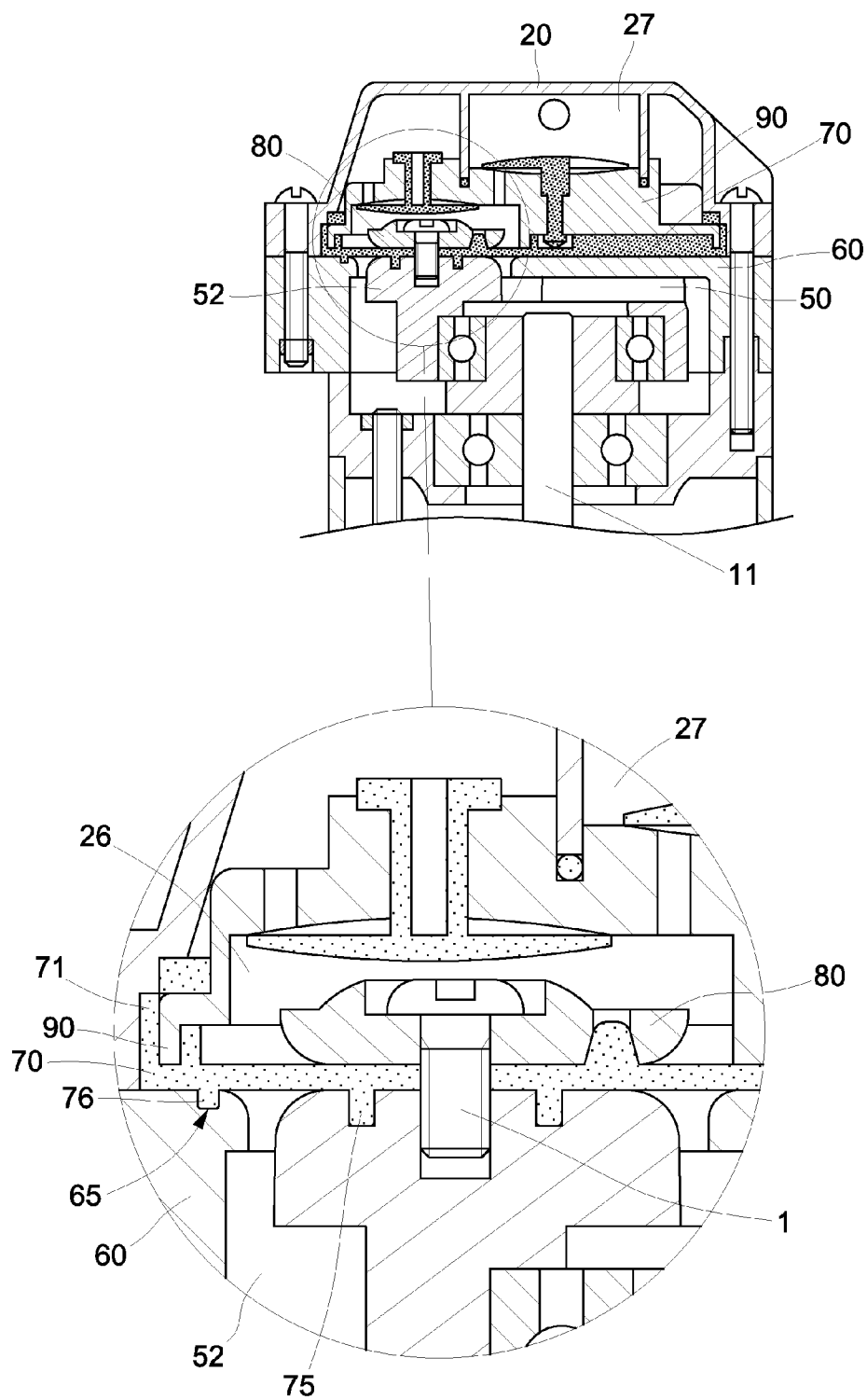


FIG.22

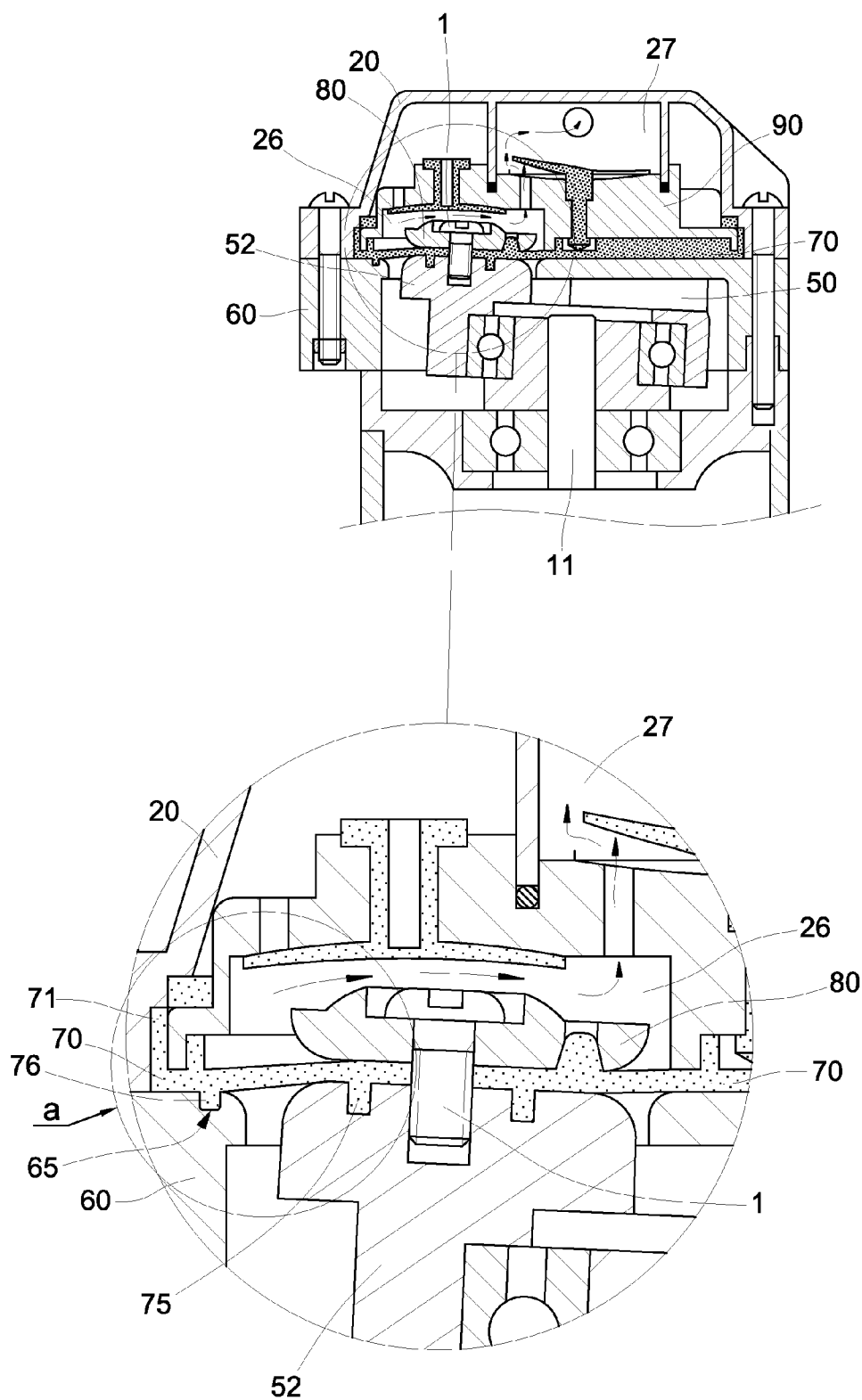


FIG. 23

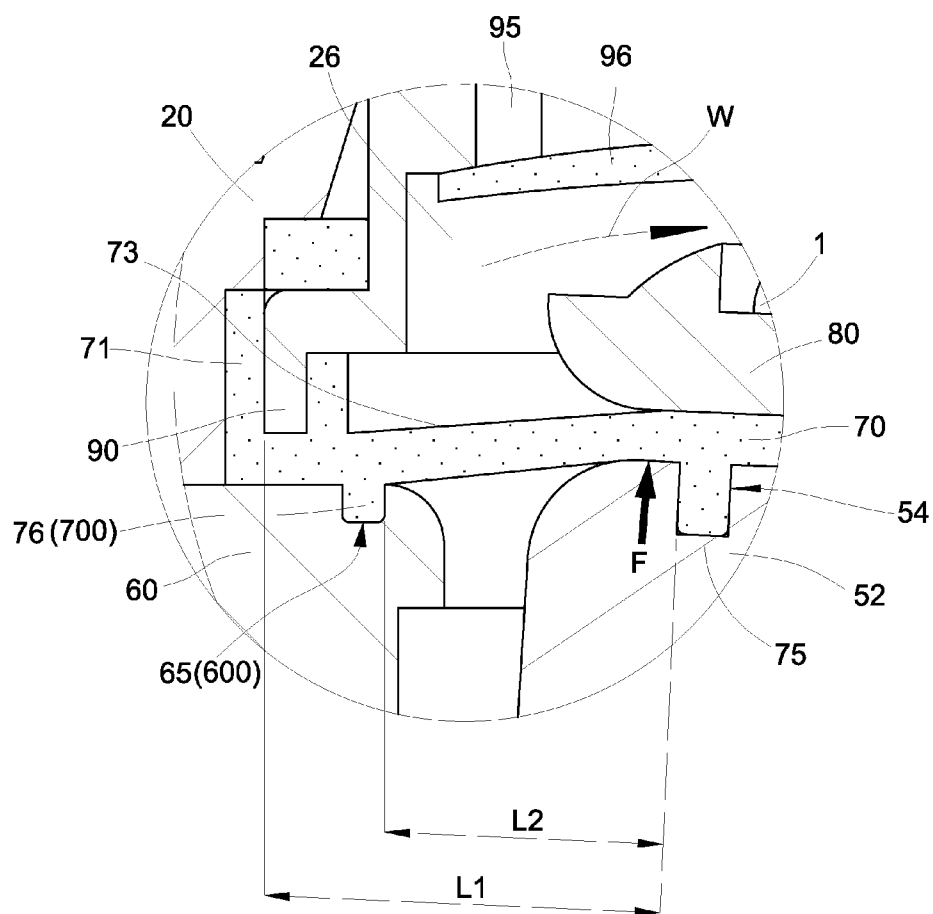


FIG. 24

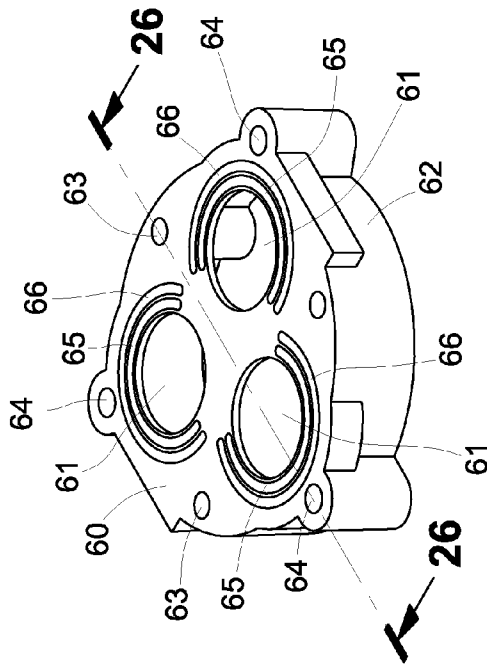


FIG. 25

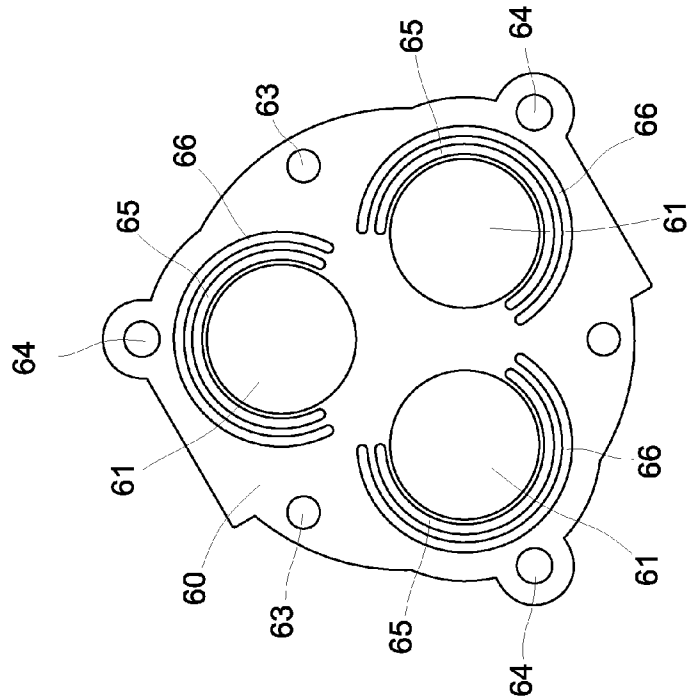


FIG. 27

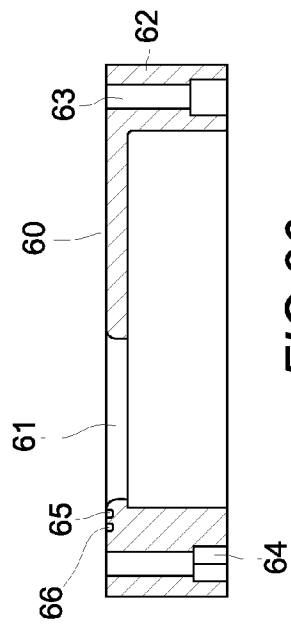


FIG. 26

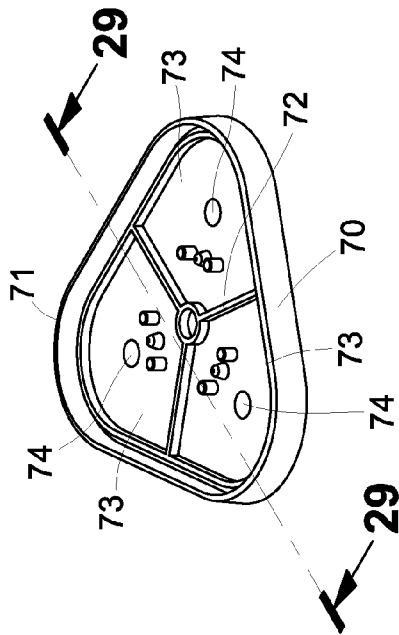


FIG. 28

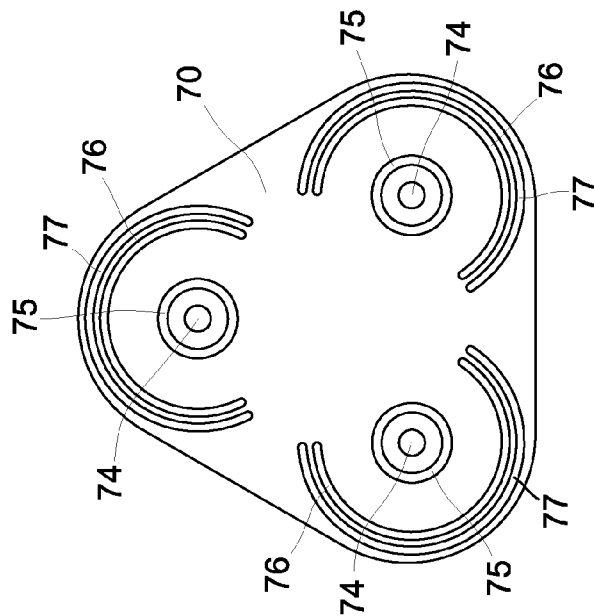


FIG. 30

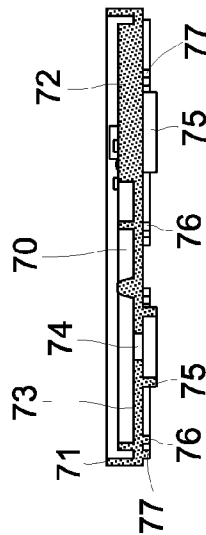
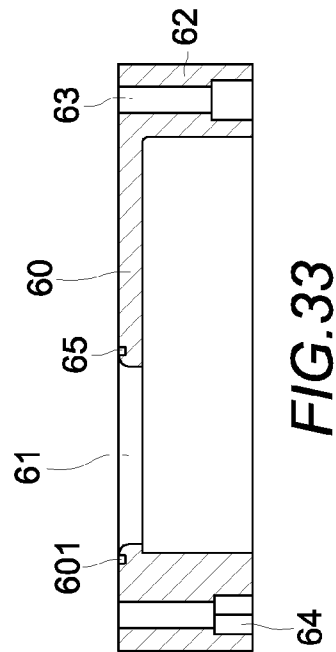
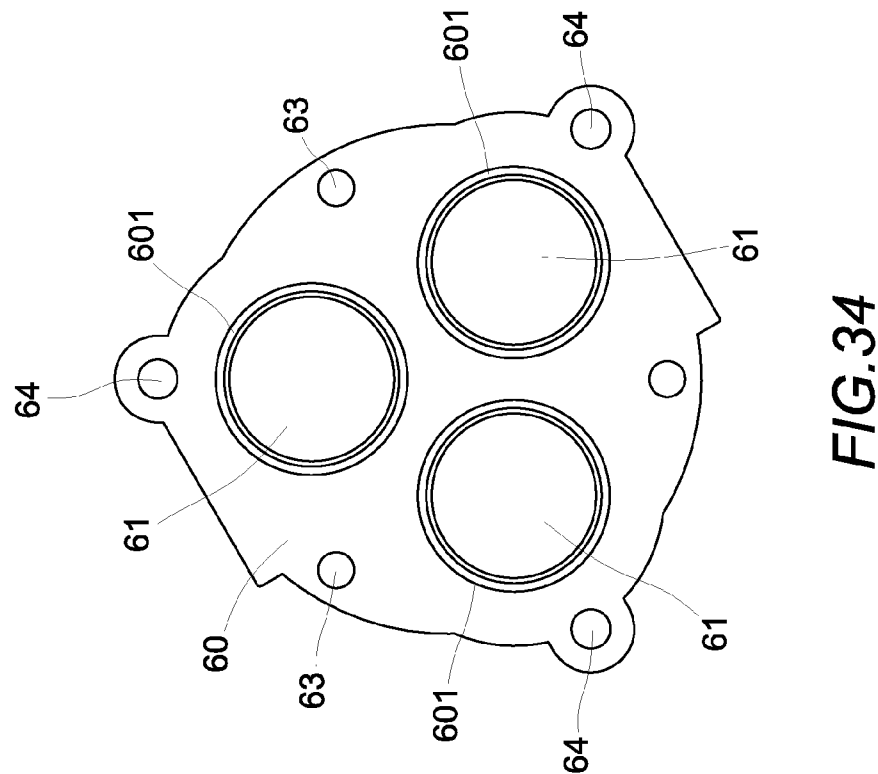
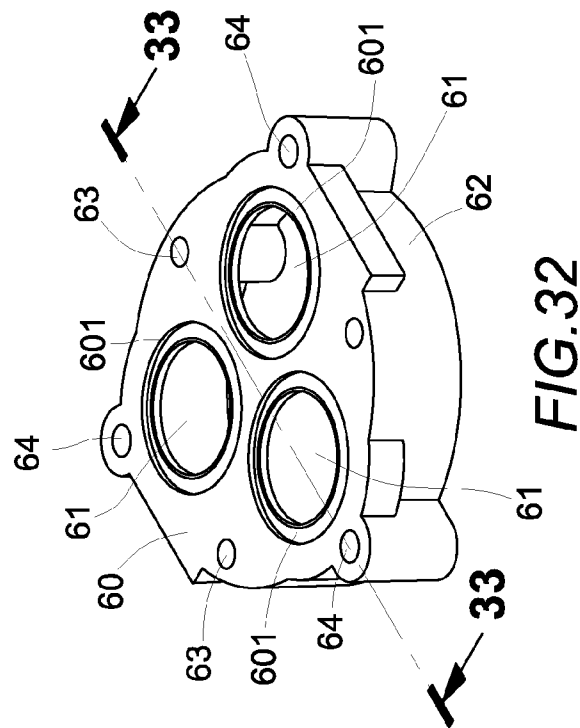


FIG. 29

FIG.31



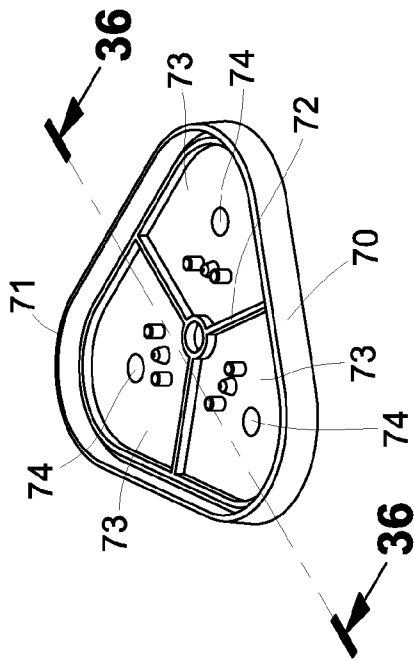


FIG. 35

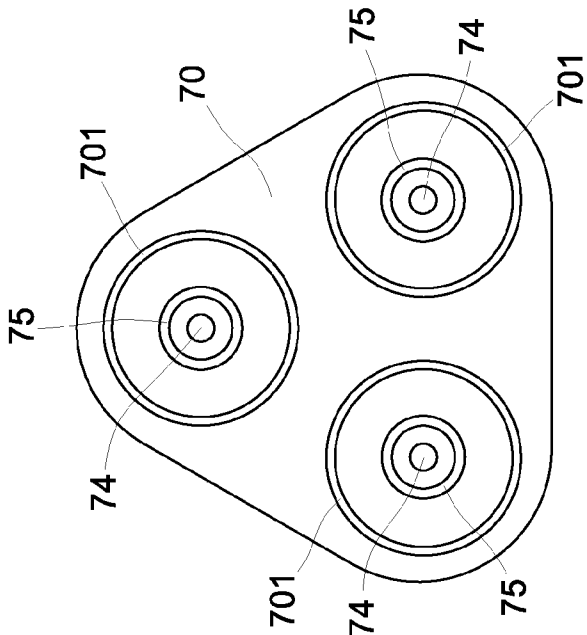


FIG. 37

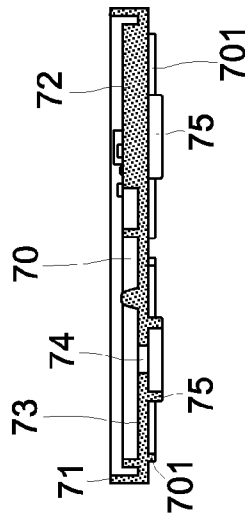


FIG. 36

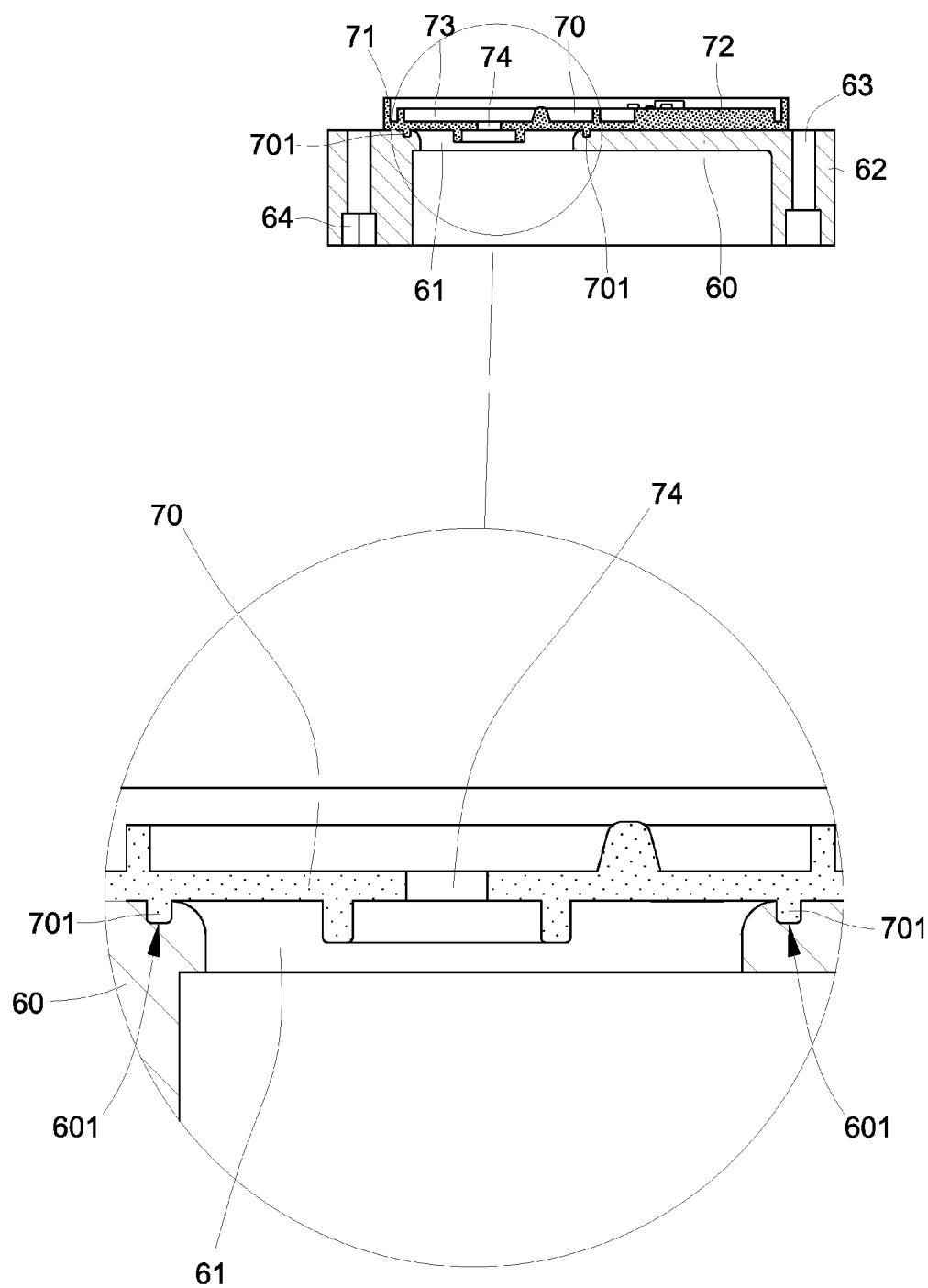
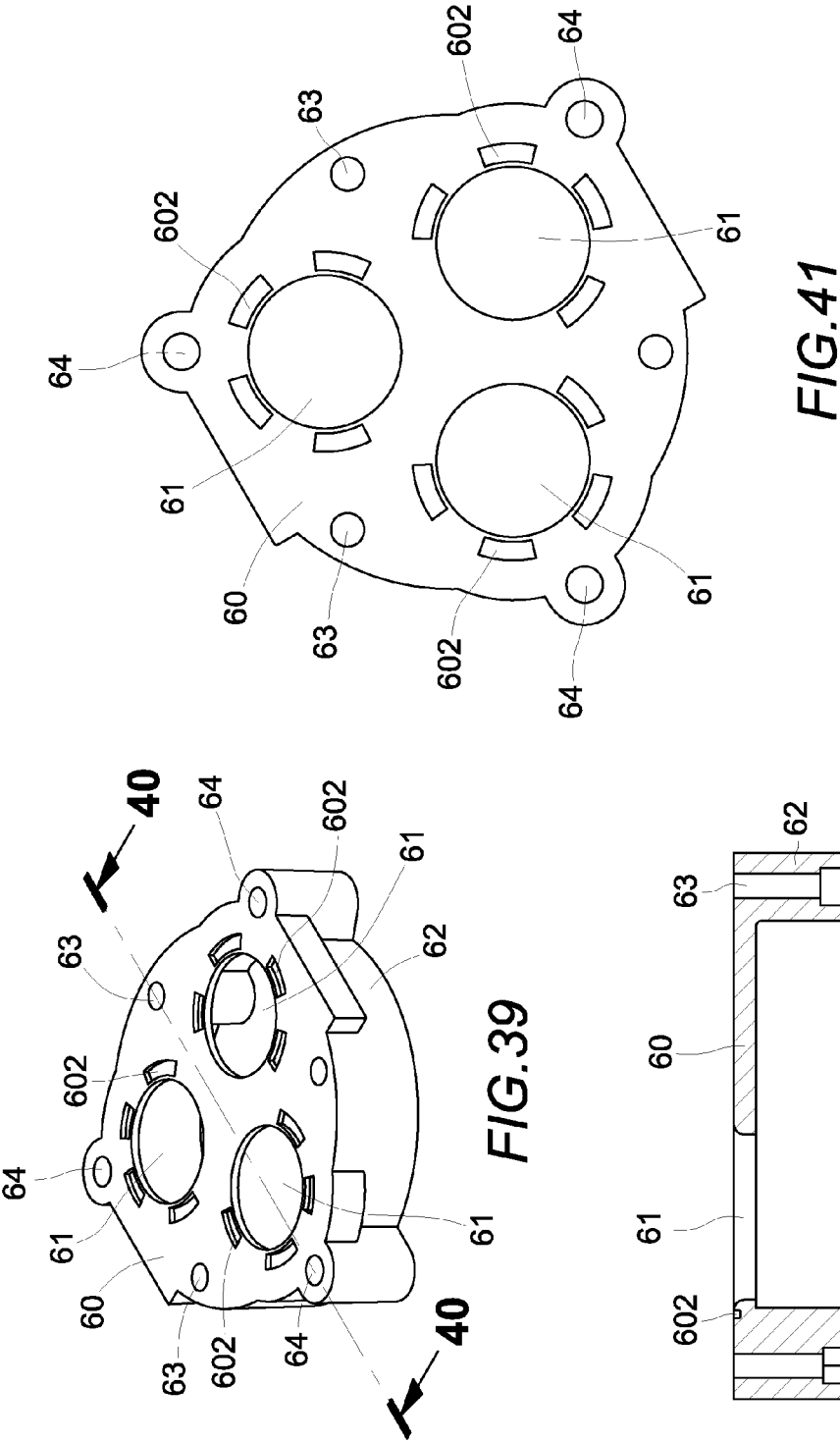


FIG.38



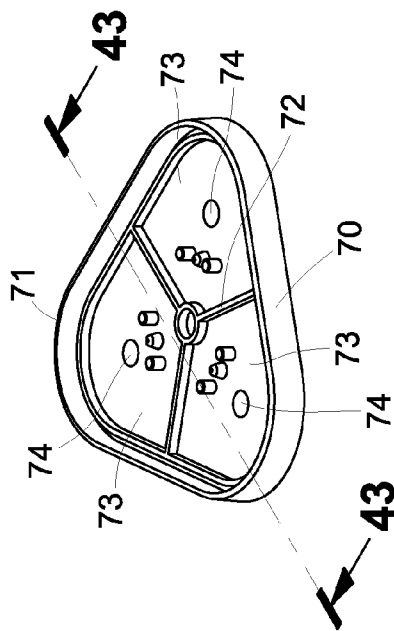


FIG. 42

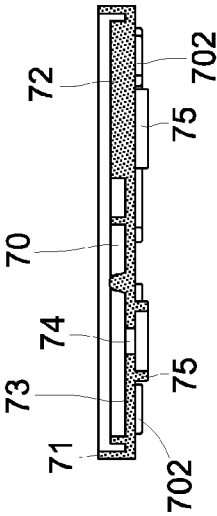


FIG. 43

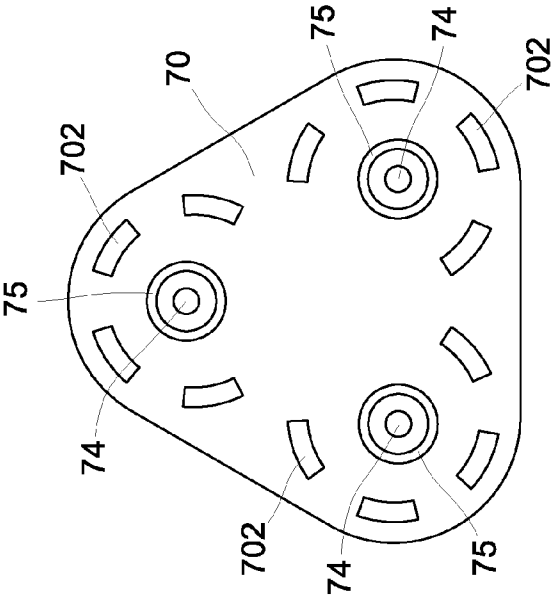


FIG. 44

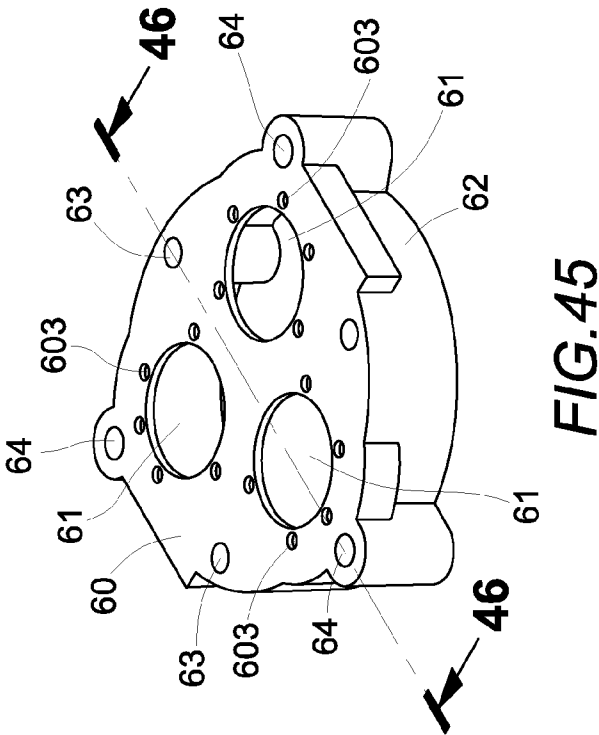


FIG. 45

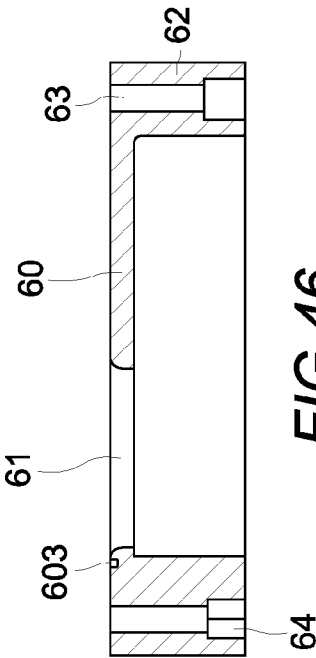


FIG. 46

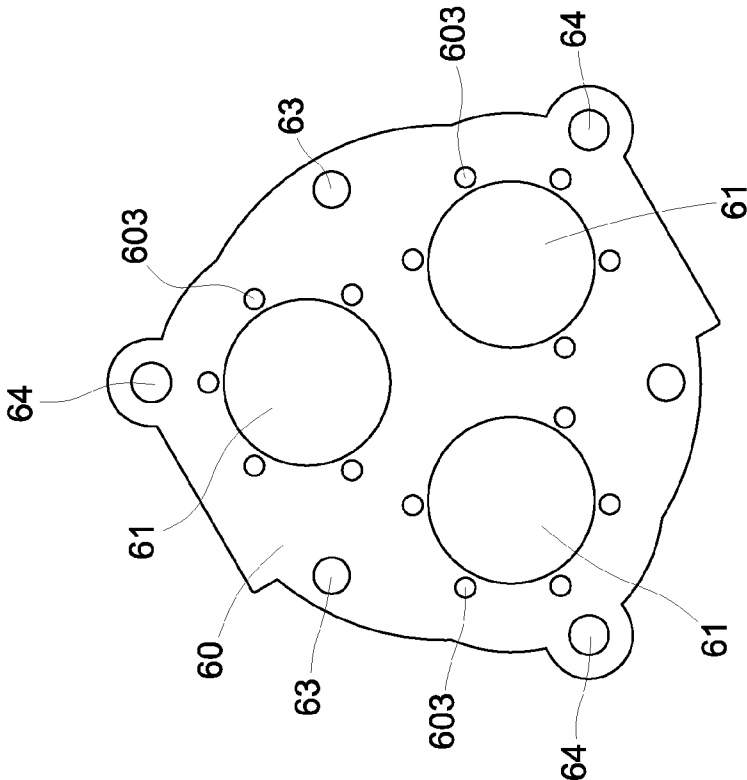


FIG. 47

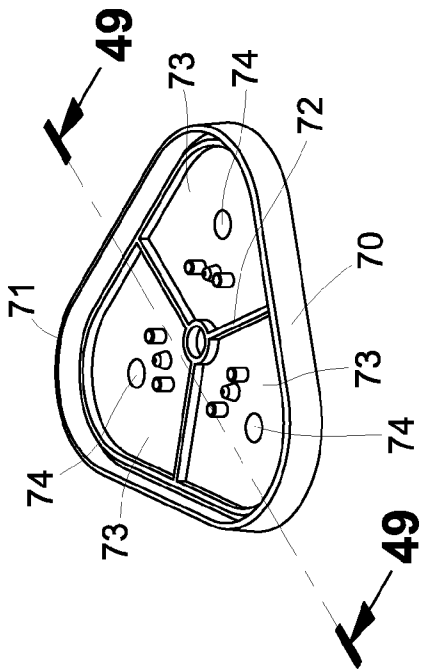


FIG. 48

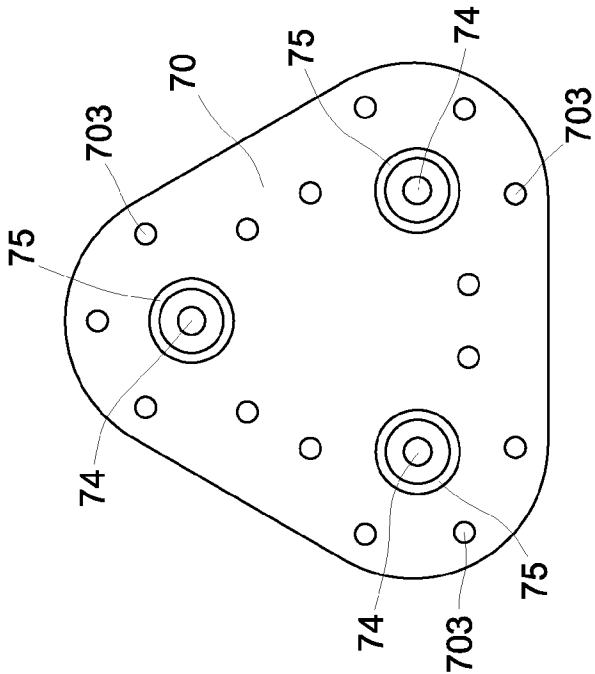


FIG. 50

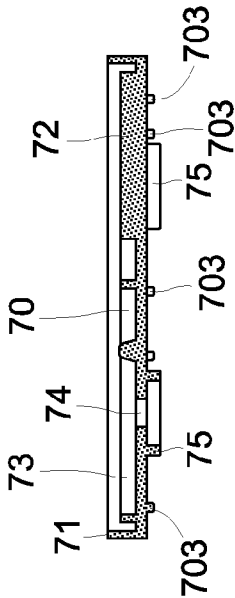
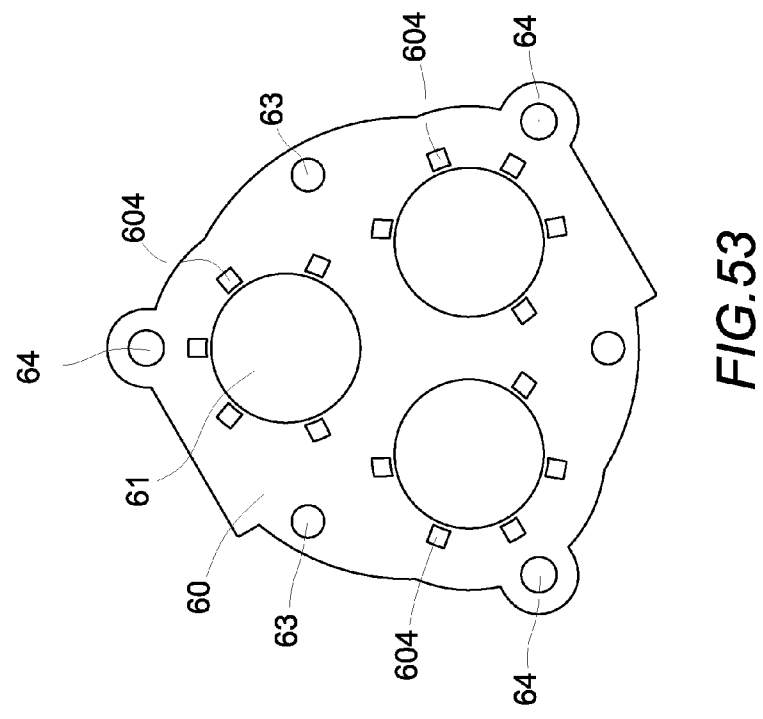
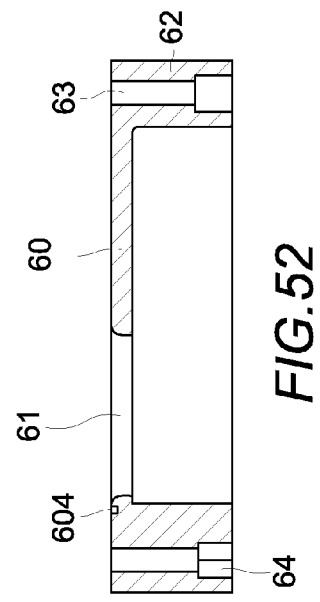
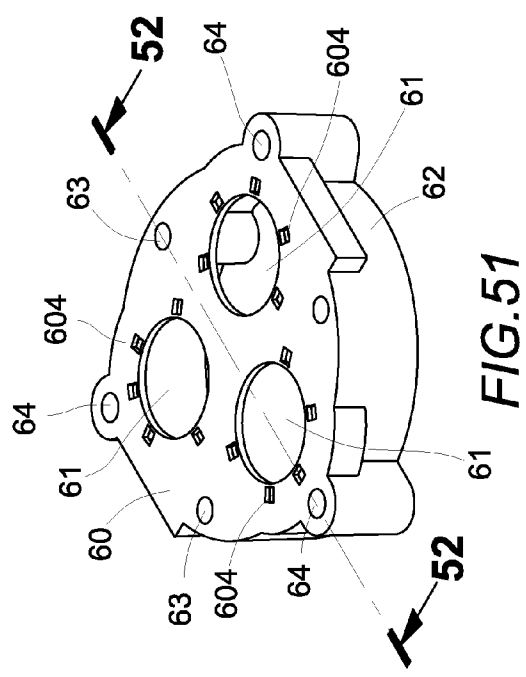


FIG. 49



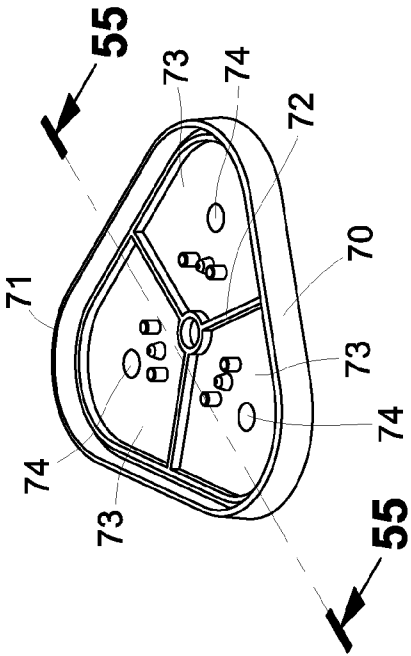


FIG. 54

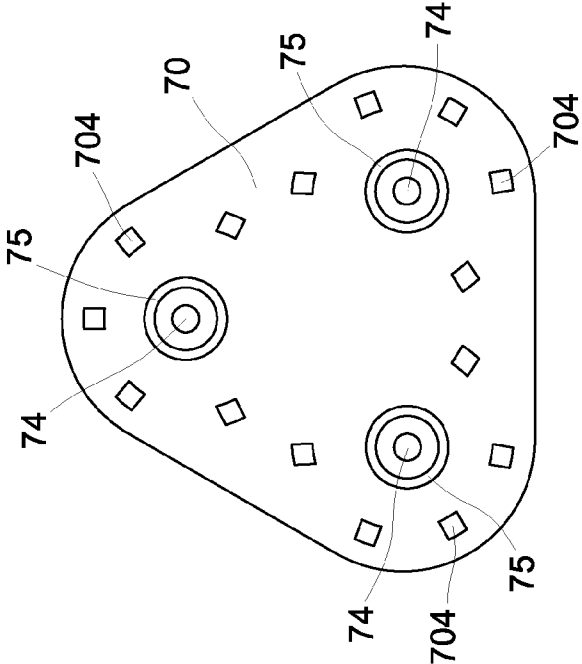


FIG. 56

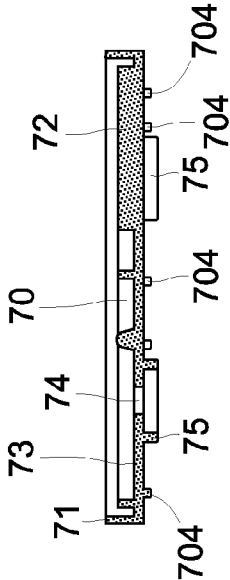


FIG. 55

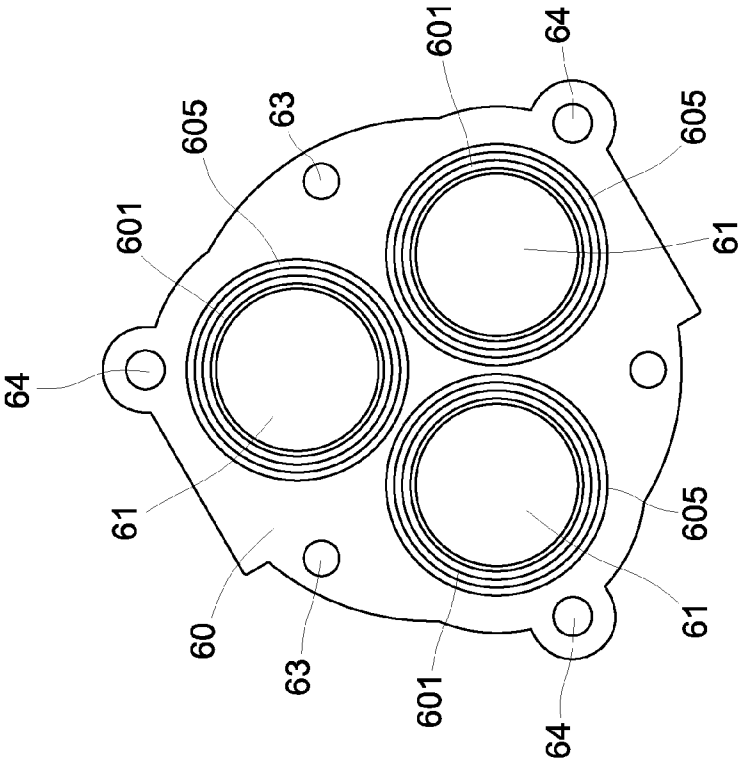


FIG. 57

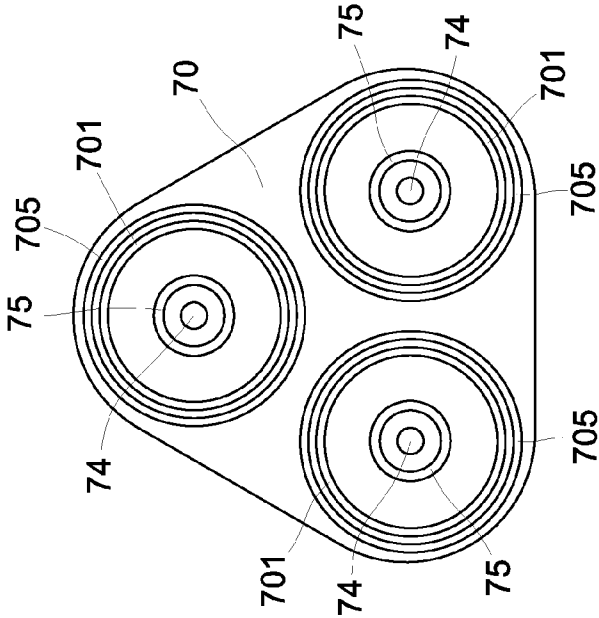


FIG. 58

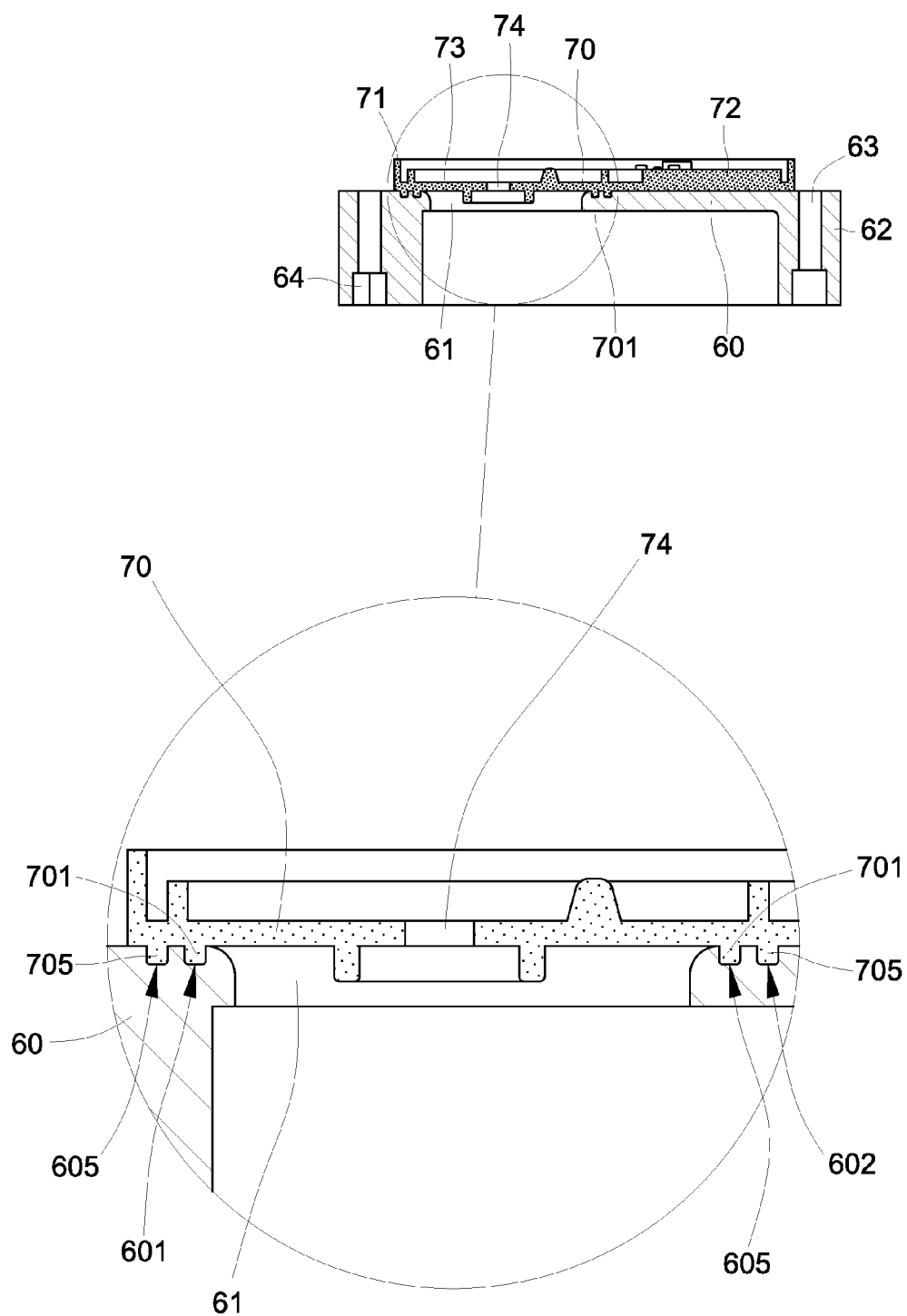


FIG. 59

VIBRATION-REDUCING STRUCTURE FOR COMPRESSING DIAPHRAGM PUMP

[0001] This application claims the benefit of provisional U.S. Patent Application No. 61/928,162, filed Jan. 16, 2014, and incorporated herein by reference.

FIELD OF THE PRESENT INVENTION

[0002] The present invention relates to a vibration-reducing method for compressing diaphragm pump used in a reverse osmosis purification system, and particularly to a method that utilizes a vibration-reducing unit to reduce the vibration strength of the pump so that the annoying noise incurred by consonance with the housing of the reverse osmosis purification system is eliminated when the vibration-reducing unit is installed thereon.

BACKGROUND OF THE INVENTION

[0003] Conventional compressing diaphragm pumps, which have been exclusively used with RO (Reverse Osmosis) purifier or RO water purification systems, are disclosed in U.S. Pat. Nos. 4,396,357, 4,610,605, 5,476,367, 5,571,000, 5,615,597, 5,626,464, 5,649,812, 5,706,715, 5,791,882, 5,816,133, 6,048,183, 6,089,838, 6,299,414, 6,604,909, 6,840,745 and 6,892,624.

[0004] The conventional compressing diaphragm pump, as shown in FIGS. 1 through 9, essentially comprises a brushed or brushless motor 10 with an output shaft 11, a motor upper chassis 30, a wobble plate 40 with integral protruding cam-lobed shaft, an eccentric roundel mount 50, a pump head body 60, a diaphragm membrane 70, three pumping pistons 80, a piston valvular assembly 90 and a pump head cover 20. The motor upper chassis 30 includes components of a bearing 31 through which an output shaft 11 of the motor 10 extends, an upper annular rib ring 32 with three positioning seats 33 disposed therein in an even and circumferentially-located manner. Each positioning seat 33 has a respective screw-threaded bore 34 created therein. The wobble plate 40 with integral protruding cam-lobed shaft includes a shaft coupling hole 41 through which the corresponding motor output shaft 11 of the motor 10 extends, and the eccentric roundel mount 50 includes bearing 51 for the corresponding wobble plate 40, and three eccentric roundels 52 disposed thereon in an even and circumferentially-located manner such that each eccentric roundel 52 has a screw-threaded bore 53 and an annular positioning dent 54 formed therein respectively. The pump head body 60 covers the upper annular rib ring 32 of the motor upper chassis 30 and encompasses the wobble plate 40 and eccentric roundel mount 50 therein. Pump head body 60 includes three through holes 61 evenly disposed therein in a circumferentially-located manner, and arranged such that each through hole 61 has an inner diameter slightly bigger than an outer diameter of the eccentric roundel 52 in the eccentric roundel mount 50 for respectively receiving each corresponding eccentric roundel 52. The pump head body 60 further includes a lower annular flange 62 formed thereunder for mating with corresponding motor upper chassis 30 in a peripherally flush manner, three inner peripheral fastening through bores 63 and three outer peripheral fastening through bores 64 evenly disposed in a circumferentially-located manner such that each inner peripheral fastening through bore 63 mates with the positioning seat 33 in the motor upper chassis 30. The diaphragm membrane 70, which is plastic extrusion molded and placed on the pump head body 60, includes a

sealing raised rim 71 and three evenly spaced radial raised partition ribs 72, such that each sealing raised rim 71 ends and connects with the sealing raised rim 71. Three equivalent piston acting zones 73 are formed and partitioned by the radial raised partition ribs 72 such that each piston acting zone 73 has a central through hole 74 created therein in correspondence with respective screw-threaded bores 53 in the eccentric roundel mount 50, and an annular positioning protrusion 75 for each central through hole 74 is formed at the bottom side thereof (as shown in FIGS. 7 and 8). The pumping pistons 80 are respectively disposed in each corresponding piston acting zones 73 of the diaphragm membrane 70, and each pumping piston 80 includes a tiered hole 81 running there-through. By running fastening screw 1 through the tiered hole 81 of each pumping piston 80 and the central through hole 74 of each corresponding piston acting zone 73 in the diaphragm membrane 70, the diaphragm membrane 70 and three pumping pistons 80 can be securely screwed into each screw-threaded bore 53 of the corresponding three annular positioning indents 54 in the eccentric roundel mount 50 (as shown in FIG. 9). The piston valvular assembly 90 includes a central outlet mount 91 having a central positioning bore 92 with three equivalent sectors, each of which contains multiple evenly circumferentially-located outlet ports 94, a plastic anti-backflow valve 93 with a central positioning shank, and three circumjacent inlet mounts with multiple evenly circumferentially-located inlet ports 95 and a respective inverted central piston disk 96. The central positioning shank of the plastic anti-backflow valve 93 mates with the central positioning bore 92 of the central outlet mount 91, and each piston disk 96 serves as a valve for each corresponding group of multiple evenly circumferentially-located inlet ports 95. The pump head cover 20 includes a water inlet orifice 21, a water outlet orifice 22, three outer peripheral fastening through bores 23 and three inner peripheral fastening through bores 23 disposed on the outside thereof as well as a tiered rim 24 and an annular rib ring 25 disposed in the bottom inside thereof such that the outer rim for the assembly of diaphragm membrane 70 and piston valvular assembly 90 can be attached to tiered rim 24 in a water tight manner. A water inlet chamber 26 is configured between each pumping piston 80 of the diaphragm membrane 70 and a corresponding group of outlet ports 94 in each corresponding sector of the central outlet mount 91, such that passage of water at one end of the water inlet chamber 26 is controlled by the plastic anti-backflow valve 93 while the other end communicates with corresponding inlet port 95 (as shown in FIG. 9), and a high-pressure water chamber 27 is configured between the cavity formed by the inside wall of the annular rib ring 25 and the central outlet mount 91 of the piston valvular assembly 90 by pressing the bottom of the annular rib ring 25 onto the rim for the central outlet mount 91 of the piston valvular assembly 90 (as shown in FIG. 9).

[0005] FIGS. 1 and 9 illustrate the manner in which the conventional compressing diaphragm pump is assembled. Firstly, the three annular positioning protrusions 75 are inserted at the bottom side of the diaphragm membrane 70 into the corresponding three annular positioning indents 54 in the eccentric roundels 52 of the eccentric roundel mount 50. Secondly, fastening screw 1 is inserted through the tiered hole 81 of each pumping piston 80 and the central through hole 74 of each corresponding piston acting zone 73 in the diaphragm membrane 70. Thirdly, each fastening screw 1 is driven until tight to securely screw the diaphragm membrane 70 and three

pumping pistons **80** into each screw-threaded bore **53** of corresponding the three annular positioning indents **54** in the eccentric roundel mount **50** (as shown in FIG. 9); Fourthly, three fastening bolts **2** are inserted through the three outer peripheral fastening through bores **23** of pump head cover **20** and each corresponding outer peripheral fastening through bore **64** in the pump head body **60**.

[0006] Fifthly, a nut **3** (shown in FIG. 9) is placed onto each fastening bolt **2** to securely screw the pump head cover **20** and the pump head body **60** (as shown in FIG. 1); Sixthly, three self-threading screws or self-drilling screws **4** are inserted through the other three inner peripheral fastening through bores **23** of pump head cover **20** and each corresponding inner peripheral fastening through bore **63** in the pump head body **60**. Finally, each self-threading screw or self-drilling screw **4** is driven until tight to securely screw the pump head cover **20** and the pump head body **60** so that the whole assembly of the conventional compressing diaphragm pump is finished (as shown in FIGS. 1 and 9).

[0007] FIGS. 10 and 11 are illustrative figures for the practical operation mode of the conventional compressing diaphragm pump.

[0008] Firstly, when the motor **10** is powered on, the wobble plate **40** is driven to rotate by the motor output shaft **11** so that the three eccentric roundels **52** on the eccentric roundel mount **50** move sequentially up-and-down in a constant reciprocal stroke. Secondly, in the meantime, the three pumping pistons **80** and three piston acting zones **73** in the diaphragm membrane **70** are driven by the up-and-down reciprocal stroke of the three eccentric roundels **52** to move in a sequential up-and-down displacement. Thirdly, when the eccentric roundel **52** moves in a down stroke with pumping piston **80** and piston acting zone **73** being downwardly displaced, the piston disk **96** in the piston valvular assembly **90** is pushed into an open status so that the tap water **W** can flow into the water inlet chamber **26** via water inlet orifice **21** in the pump head cover **20** and sequentially via inlet ports **95** in the piston valvular assembly **90** (as indicated by the arrow in the enlarged portion of FIG. 10). Fourthly, when the eccentric roundel **52** moves in up stroke with pumping piston **80** and piston acting zone **73** being displaced upwardly, the piston disk **96** in the piston valvular assembly **90** is pulled into a closed status to compress the tap water **W** in the water inlet chamber **26** and increase the water pressure therein up to range of 80 psi-100 psi to obtain pressurized water **Wp**, with the result that the plastic anti-backflow valve **93** in the piston valvular assembly **90** is pushed to open status. Fifthly, when the plastic anti-backflow valve **93** in the piston valvular assembly **90** is pushed to open status, the pressurized water **Wp** in the water inlet chamber **26** is directed into high-pressure water chamber **27** via a group of outlet ports **94** for the corresponding sector in central outlet mount **91**, and then expelled out of the water outlet orifice **22** in the pump head cover **20** (as indicated by the arrows in the enlarged portion of FIG. 11). Finally, as a result of iterative sequential action for each group of outlet ports **94** of the three sectors in central outlet mount **91**, the pressurized water **Wp** is constantly discharged out of the conventional compressing diaphragm pump to be further RO-filtered by the RO-cartridge so that the final filtered pressurized water **Wp** can be used in the reverse osmosis water purification system.

[0009] Referring to FIGS. 12 through 14, a primary serious drawback has long existed in the foregoing conventional compressing diaphragm pump. As described previously,

when the motor **10** is powered on, the wobble plate **40** is driven to rotate by the motor output shaft **11** so that the three eccentric roundels **52** on the eccentric roundel mount **50** sequentially move in a constant up-and-down reciprocal stroke, while the three pumping pistons **80** and three piston acting zones **73** in the diaphragm membrane **70** are driven by the sequential up-and-down reciprocal stroke of the three eccentric roundels **52** to move in up-and-down displacement so that a corresponding acting force **F** constantly acts on the three piston acting zones **73** with a length of moment arm **L1** measured from the sealing raised rim **71** to the periphery of the annular positioning protrusion **75** (as shown in FIG. 13). Thereby, a resultant torque is created by the acting force **F** multiplying the length of moment arm **L1** according to the formula "torque=acting force **F**×length of moment arm **L1**". However, the resultant torque causes the whole conventional compressing diaphragm pump to vibrate directly. With a high rotational speed of the motor output shaft **11** in the motor **10** of up to 700-1200 rpm, the vibrating strength caused by alternately acting of three eccentric roundels **52** can reach a persistently unacceptable level. Furthermore, in addition to the primary direct vibration drawback, the water pipe **P** connected on the water outlet orifice **22** of the pump head cover **20** will also synchronously shake in resonance with the vibration of the pump (as indicated by arrow "a" in FIG. 14(a)). This synchronous shaking" of the water pipe **P** will further cause other parts of the conventional compressing diaphragm pump to also simultaneously shake. Consequently, the overall resonant shaking aforesaid will cause vibration of the housing **C** of the reverse osmosis purification unit to become stronger, increasing vibration noise and, after a certain period, causing water leakage of the conventional compressing diaphragm pump due to a gradually loosened connection between water pipe **P** and water outlet orifice **22**, as well as gradual loosening of other parts affected by the shaking.

[0010] To address the above-described drawbacks of the conventional compressing diaphragm pump, a cushion base **100** with a pair of wing plates **101** is added to provide supplementary support for the pump (as shown in FIG. 14) such that each wing plate **101** is further sleeved by a rubber shock absorber **102** for vibration suppressing enhancement. Upon installation of the conventional compressing diaphragm pump, the cushion base **100** is firmly screwed onto the housing **C** of the reverse osmosis purification unit by means of suitable fastening screws **103** and corresponding nuts **104**.

[0011] However, the practical vibration suppression efficiency of using foregoing cushion base **100** with wing plates **101** and rubber shock absorber **102** only affects the primary vibrating drawback to a limited degree, and does not solve the drawbacks of overall resonant shaking or water leakage for the conventional compressing diaphragm pump. The problem of substantially reducing all of the drawbacks associated with the operating vibration of the compressing diaphragm pump has become an urgent and critical issue.

SUMMARY OF THE INVENTION

[0012] An objective is to provide a vibration-reducing method for a compressing diaphragm pump that features of a vibration-reducing unit. The compressing diaphragm pump includes a brushed or brushless motor with an output shaft, a pump head cover, a motor upper chassis, a wobble plate with integral protruding cam-lobed shaft, an eccentric roundel mount with three eccentric roundels, a pump head body, a diaphragm membrane with three piston acting zones, three

pumping pistons and a piston valvular assembly. The vibration-reducing unit is disposed between the pump head body and diaphragm membrane. The vibration-reducing unit functions for diminishing torque by shortening the length of the moment arm for the circumnutating action of the eccentric roundel mount in each piston acting zone. Since the torque is the equal to the length of moment arm multiplied by a constant acting force, a lower torque is generated by the shortened length of moment arm. Consequently, with less torque for the compressing diaphragm pump, the strength of vibration is substantially reduced, with a consequent lowering of annoying vibration noise.

[0013] Another objective is to provide a vibration-reducing method for a compressing diaphragm pump that features a vibration-reducing unit disposed between a pump head body with three basic curved indents and a diaphragm membrane with three basic curved protrusions, in which the three basic curved protrusions are completely inserted into the corresponding three basic curved indents. The vibration-reducing unit functions to diminish torque by shortening the length of the moment arm for each piston acting zone upon circumnutating action of the eccentric roundel mount. Because the torque is obtained by multiplying the length of the moment arm by a constant acting force, is reduced due to the shortened length of moment arm, the strength of vibration and the resulting vibration noise is also substantially reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a perspective assembled view of a conventional compressing diaphragm pump.

[0015] FIG. 2 is a perspective exploded view of a conventional compressing diaphragm pump.

[0016] FIG. 3 is a perspective view of a pump head body for the conventional compressing diaphragm pump.

[0017] FIG. 4 is a cross sectional view taken against the section line 3-3 from previous FIG. 3.

[0018] FIG. 5 is a top view of a pump head body of the conventional compressing diaphragm pump.

[0019] FIG. 6 is a perspective view of a diaphragm membrane of the conventional compressing diaphragm pump.

[0020] FIG. 7 is a cross sectional view taken against the section line 7-7 from previous FIG. 6.

[0021] FIG. 8 is a bottom view of a diaphragm membrane of conventional compressing diaphragm pump.

[0022] FIG. 9 is a cross sectional view taken against the section line 9-9 from previous FIG. 1.

[0023] FIG. 10 is the first operation illustrative view of a conventional compressing diaphragm pump.

[0024] FIG. 11 is the second operation illustrative view of a conventional compressing diaphragm pump.

[0025] FIG. 12 is the third operation illustrative view of the conventional compressing diaphragm pump with a partially enlarged view of a circled-portion.

[0026] FIG. 13 is a partially enlarged view taken from the circled-portion "a" in the enlarged view of previous FIG. 12.

[0027] FIG. 14 is a schematic side view showing a conventional compressing diaphragm pump installed on a mounting base in a reverse osmosis purification system.

[0028] FIG. 14(a) is a schematic end view of the conventional compressing diaphragm pump installed on a mounting base, as illustrated in FIG. 14.

[0029] FIG. 15 is a perspective exploded view of the first exemplary embodiment of the present invention.

[0030] FIG. 16 is a perspective view of a pump head body in the first exemplary embodiment of the present invention.

[0031] FIG. 17 is a cross sectional view taken against the section line 17-17 from previous FIG. 16.

[0032] FIG. 18 is a top view of a pump head body in the first exemplary embodiment of the present invention.

[0033] FIG. 19 is a perspective view of a diaphragm membrane in the first exemplary embodiment of the present invention.

[0034] FIG. 20 is a cross sectional view taken against the section line 20-20 from previous FIG. 19.

[0035] FIG. 21 is a bottom view of a diaphragm membrane in the first exemplary embodiment of the present invention.

[0036] FIG. 22 is an assembled cross sectional view for the first exemplary embodiment of the present invention.

[0037] FIG. 23 is an operation illustrative view for the first exemplary embodiment of the present invention with a partially enlarged view of the circled-portion.

[0038] FIG. 24 is a partially enlarged view taken from the circled-portion "a" of previous FIG. 23.

[0039] FIG. 25 is a perspective view of a pump head body in the second exemplary embodiment of the present invention.

[0040] FIG. 26 is a cross sectional view taken against the section line 26-26 from previous FIG. 25.

[0041] FIG. 27 is a top view of a pump head body in the second exemplary embodiment of the present invention.

[0042] FIG. 28 is a perspective view of a diaphragm membrane in the second exemplary embodiment of the present invention.

[0043] FIG. 29 is a cross sectional view taken against the section line 29-29 from previous FIG. 28.

[0044] FIG. 30 is a perspective view of a diaphragm membrane in the second exemplary embodiment of the present invention.

[0045] FIG. 31 is a cross section assembled view of a diaphragm membrane and a pump head body in the second exemplary embodiment of the present invention.

[0046] FIG. 32 is a perspective view of a pump head body in the third exemplary embodiment of the present invention.

[0047] FIG. 33 is a cross sectional view taken against the section line 33-33 from previous FIG. 32.

[0048] FIG. 34 is a top view of a pump head body in the third exemplary embodiment of the present invention.

[0049] FIG. 35 is a perspective view of a diaphragm membrane in the third exemplary embodiment of the present invention.

[0050] FIG. 36 is a cross sectional view taken against the section line 36-36 from previous FIG. 35.

[0051] FIG. 37 is a bottom view of a pump head body in the third exemplary embodiment of the present invention.

[0052] FIG. 38 is a cross section assembled view for a diaphragm membrane and a pump head body in the third exemplary embodiment of the present invention.

[0053] FIG. 39 is a perspective view for pump head body in the fourth exemplary embodiment of the present invention.

[0054] FIG. 40 is a cross sectional view taken against the section line 40-40 from previous FIG. 39.

[0055] FIG. 41 is a top view of a pump head body in the fourth exemplary embodiment of the present invention.

[0056] FIG. 42 is a perspective view of a diaphragm membrane in the fourth exemplary embodiment of the present invention.

[0057] FIG. 43 is a cross sectional view taken against the section line 43-43 from previous FIG. 42.

[0058] FIG. 44 is a bottom view of a diaphragm membrane in the fourth exemplary embodiment of the present invention.

[0059] FIG. 45 is a perspective view of a pump head body in a variation of the fourth exemplary embodiment of the present invention.

[0060] FIG. 46 is a cross sectional view taken against the section line 45-45 from previous FIG. 45.

[0061] FIG. 47 is a top view of a pump head body in the variation of the fourth exemplary embodiment of the present invention.

[0062] FIG. 48 is a perspective view of a diaphragm membrane in the variation of the fourth exemplary embodiment of the present invention.

[0063] FIG. 49 is a cross sectional view taken against the section line 49-49 from previous FIG. 48.

[0064] FIG. 50 is a bottom view of a diaphragm membrane in the variation of the fourth exemplary embodiment of the present invention.

[0065] FIG. 51 is a perspective view of a pump head body in the variation of the fourth exemplary embodiment of the present invention.

[0066] FIG. 52 is a cross sectional view taken against the section line 52-52 from previous FIG. 51.

[0067] FIG. 53 is a top view of a pump head body in the variation of the fourth exemplary embodiment of the present invention.

[0068] FIG. 54 is a perspective view of a pump head body in the variation of the fourth exemplary embodiment of the present invention.

[0069] FIG. 55 is a cross sectional view taken against the section line 55-55 from previous FIG. 54.

[0070] FIG. 56 is a bottom view of a diaphragm membrane in the variation of the fourth exemplary embodiment of the present invention.

[0071] FIG. 57 is a top view of a pump head body in the fifth exemplary embodiment of the present invention.

[0072] FIG. 58 is a bottom view of a diaphragm membrane in the fifth exemplary embodiment of the present invention.

[0073] FIG. 59 is a cross section assembled view for a diaphragm membrane and a pump head body in the fifth exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0074] FIGS. 15 through 59 are illustrative figures for the vibration-reducing method for compressing diaphragm pump of the present invention. The compressing diaphragm pump comprises a motor 10 with an output shaft 11, a pump head cover 20, a motor upper chassis 30, a wobble plate 40 with integral protruding cam-lobed shaft, an eccentric roundel mount 50, a pump head body 60, a diaphragm membrane 70, three pumping pistons 80 and a piston valvular assembly 90, wherein, except as described below, components included in each part may be the same as those in the conventional compressing diaphragm pump as described above.

[0075] The basic operation mode of the compressing diaphragm pump is as follows: When the motor 10 is powered on, the wobble plate 40 is driven to rotate by the motor output shaft 11 so that three eccentric roundels 52 on the eccentric roundel mount 50 sequentially and constantly move in up-and-down reciprocal stroke. Meanwhile, three pumping pistons 80 and three piston acting zones 73 in the diaphragm

membrane 70 are driven by the sequential up-and-down reciprocal stroke of the three eccentric roundels 52 to move in an up-and-down displacement. Thereby, the tap water W, which flows into the piston valvular assembly 90, is compressed to obtain pressurized water Wp, which is constantly discharged out of the compressing diaphragm pump for being further RO-filtered by the RO-cartridge and used in the reverse osmosis water purification system.

[0076] A vibration-reducing unit is further disposed between the pump head body 60 and diaphragm membrane 70 to reduce the torque of each piston acting zone 73 in the diaphragm membrane 70 by shortening the length of the moment arm that occurs upon the circumnutating action of each eccentric roundels 52 in the eccentric roundel mount 50, so that the vibration strength of the compressing diaphragm pump is effectively reduced. The vibration-reducing unit includes a pair of mated acting fasteners, which are composed of a pump head body acting fastener 600 (as indicated by the reference number 600 shown in FIGS. 16 and 18) and a mating diaphragm membrane acting fastener 700 (as indicated by the reference number 700 shown in FIG. 21). The pump head body acting fastener 600 is disposed on the upper side of the pump head body 60 while the diaphragm membrane acting fastener 700 is disposed on the bottom side of the diaphragm membrane 70 at a position corresponding to a position of the pump head body acting fastener 600 on the pump head body 60. By means of the vibration-reducing unit, a length of moment arm L1 from the sealing raised rim 71 to the periphery of the annular positioning protrusion 75 of the conventional compressing diaphragm pump is shortened into a new length of moment arm L2 from the basic curved protrusions 76 to the periphery of the annular positioning protrusion 75 for the circumnutating action of each eccentric roundels 52 in the eccentric roundel mount 50 (as indicated by the length of moment arms L1 and L2 shown in FIG. 24).

[0077] FIGS. 15 through 22 are illustrative figures for the first exemplary embodiment of the vibration-reducing method for a compressing diaphragm pump utilizing the newly devised vibration-reducing unit in the present invention, wherein the pump head body acting fastener 600 and mating diaphragm membrane acting fastener 700 of the vibration-reducing unit include three basic curved indents 65 (as indicated by the reference number 65 corresponding to reference number 600 shown in FIGS. 16 and 18) and three corresponding basic curved protrusions 76 (as indicated by the reference number 76 corresponding to reference number 700 shown in FIG. 21) respectively. Each basic curved groove 65 is circumferentially disposed around the upper side of each through hole 61 in the pump head body 60 while each basic curved protrusion 76 is circumferentially disposed around each concentric annular positioning protrusion 75 at the bottom side of the mating diaphragm membrane 70 at a position corresponding to a position of each mating basic curved groove 65 in the pump head body 60. The three basic curved protrusions 76 at the bottom side of the mating diaphragm membrane 70 are completely insert into the corresponding three basic curved grooves 65 at the upper side of the pump head body 60 upon assembly of the pump head body 60 and the mating diaphragm membrane 70 (as shown in FIG. 22).

[0078] FIGS. 23, 24 and 13 are illustrative figures for the practical operation result in the first exemplary embodiment of the vibration-reducing method for compressing diaphragm pump with a newly devised vibration-reducing unit according to the present invention. Compared to the operation of con-

ventional compressing diaphragm pump, in which the moment arm L1 extends from the sealing raised rim 71 to the periphery of the annular positioning protrusion 75 (as shown in FIGS. 13 and 24), the moment arm L2 of the illustrated embodiment extends from the basic curved protrusions 76 to the periphery of the annular positioning protrusion 75 (as shown in FIG. 24). As a result, the length of moment arm L2 is shorter than the length of moment arm L1, and the resultant torque, calculated by multiplying the acting force F by the length of moment arm, is less than that of the conventional compressing diaphragm pump. As a result of the reduced torque of the present invention, the vibration strength is substantially reduced. According to a pilot test on a sample of the present invention, the vibration strength was only one tenth (10%) of the vibration strength in the conventional compressing diaphragm pump. If the present invention is installed on the housing C of the reverse osmosis purification unit pil- lowed by a conventional cushion base 100 with a rubber shock absorber 102 (as shown in FIG. 14), the annoying noise caused by resonant shaking in the conventional compressing diaphragm pump can be completely eliminated.

[0079] Each basic curved groove 65 in the first exemplary embodiment can be replaced by a curved slot (not shown in figures). Moreover, the basic curved groove 65 in the pump head body 60 and corresponding basic curved protrusion 76 in the diaphragm membrane 70 can also be exchanged with a basic curved protrusion 65 in the pump head body 60 and corresponding basic curved groove 76 in the diaphragm membrane 70 without affecting their mating condition.

[0080] FIGS. 25 through 31 are illustrative figures for the second exemplary embodiment of the vibration-reducing method for a compressing diaphragm pump with the newly devised vibration-reducing unit of the present invention, wherein the pump head body acting fastener 600 and mating diaphragm membrane acting fastener 700 of the vibration-reducing unit include the basic curved groove 65 paired with an outer second curved groove 66 and corresponding basic curved protrusion 76 paired with an outer second curved protrusion 77 respectively. The outer second curved groove 66 is further circumferentially disposed around each existing basic curved groove 65 in the pump head body 60 (as shown in FIGS. 25 through 27) while the outer second curved protrusion 77 is further circumferentially disposed around each existing curved protrusion 76 in the mating diaphragm membrane 70 at a position corresponding to a position of each mating outer second curved groove 66 in the pump head body 60 (as shown in FIGS. 29 and 30). The paired basic curved protrusions 76 and outer second curved protrusions 77 at the bottom side of the mating diaphragm membrane 70 are completely inserted into corresponding the paired basic curved grooves 65 and outer second curved grooves 66 at the upper side of the pump head body 60 upon assembly of the pump head body 60 and the mating diaphragm membrane 70 (as shown in FIG. 31). The newly devised vibration-reducing unit not only has significant effect in reducing vibration but also enhances the resistance of the eccentric roundel 52 against displacement by the acting force F.

[0081] Each basic curved groove 65 and outer second curved groove 66 in the second exemplary embodiment can also be replaced by curved slots (not shown in figures). Moreover, the paired basic curved groove 65 with outer second curved groove 66 in the pump head body 60 and corresponding paired basic curved protrusion 76 with outer second curved protrusion 77 in the mating diaphragm membrane 70

can be exchanged for a paired basic curved protrusion 65 with outer second curved protrusion 66 in the pump head body 60 and corresponding paired basic curved groove 76 with outer second curved groove 77 in the mating diaphragm membrane 70 without affecting their mating condition.

[0082] FIGS. 32 through 38 are illustrative figures for the third exemplary embodiment of the vibration-reducing method for a compressing diaphragm pump with newly devised vibration-reducing unit according to the present invention, wherein the pump head body acting fastener 600 and mating diaphragm membrane acting fastener 700 of the vibration-reducing unit are a basic indented ring 601 and a corresponding basic protruding ring 701, respectively. The basic indented ring 601 is circumferentially disposed around the upper side of each through hole 61 in the pump head body 60 (as shown in FIGS. 32 and 34) while the basic protruding ring 701 is circumferentially disposed at the bottom side of each concentric annular positioning protrusion 75 in the mating diaphragm membrane 70 at a position corresponding to a position of each mating basic indented ring 601 in the pump head body 60 (as shown in FIGS. 36 and 37). The three basic protruded rings 701 at the bottom side of the mating diaphragm membrane 70 are completely inserted into the corresponding three basic indented rings 601 at the upper side of the pump head body 60 (as shown in FIG. 38) upon assembly of the pump head body 60 and the mating diaphragm membrane 70. By means of the vibration-reducing unit in reinforcing steadiness between the basic indented ring 601 and mating basic protruded ring 701, the effect in reducing vibration is substantially enhanced.

[0083] Each basic indented ring 601 in the third exemplary embodiment can be replaced by a slot ring (not shown in figures). Moreover, the basic indented ring 601 in the pump head body 60 and corresponding basic protruded ring 701 in the mating diaphragm membrane 70 can be exchanged with a basic protruded ring 601 in the pump head body 60 and corresponding basic indented ring 701 in the mating diaphragm membrane 70 without affecting their mating condition.

[0084] FIGS. 39 through 44 are illustrative figures for the fourth exemplary embodiment of the vibration-reducing method for a compressing diaphragm pump with newly devised vibration-reducing unit according to the present invention, wherein the pump head body acting fastener 600 and mating diaphragm membrane acting fastener 700 of the vibration-reducing unit are a plurality of circumferentially located curved indented segments 602 and a plurality of circumferentially located curved protruding segments 702. The plural circumferentially located curved indented segments 602 are circumferentially disposed around the upper side of each through hole 61 in the pump head body 60 (as shown in FIGS. 39 and 41) while the plural circumferentially located curved protruding segments 702 are circumferentially disposed at the bottom side of each concentric annular positioning protrusion 75 in the mating diaphragm membrane 70 at a position corresponding to a position of each of the mating plural circumferentially located curved indented segments 602 in the pump head body 60 (as shown in FIGS. 43 and 44). The circumferentially located curved protruding segments 702 at the bottom side of the mating diaphragm membrane 70 are completely inserted into the corresponding circumferentially located curved indented segments 602 at the upper side of the pump head body 60 upon assembly of the pump head body 60 and the mating diaphragm membrane 70 so that the

effect in reducing vibration is substantially enhanced. The circumferentially located curved indented segments **602** can be replaced by circumferentially located round holes **603** (as shown in FIGS. **45** and **47**) or circumferentially located square holes **604** (as shown in FIGS. **51** and **53**) while corresponding circumferentially located curved protruding segments **702** can be adapted into circumferentially located round protrusions **703** (as shown in FIG. **50**) or circumferentially located square protrusions **704** (as shown in FIG. **56**) such that all these foregoing counterparts have the same effect in reducing vibration.

[0085] Besides, each group of circumferentially located curved indented segments **602** in the fourth exemplary embodiment can be replaced by a group of circumferentially located curved slot segments (not shown in figures). Moreover, the curved indented segments **602** in the pump head body **60** and corresponding curved protruding segments **702** in the mating diaphragm membrane **70** can be exchanged with curved protruding segments **602** in the pump head body **60** and corresponding curved indented segments **702** in the mating diaphragm membrane **70** without affecting their mating condition. Similarly, each group of circumferentially located round holes **603** and square holes **604** can also be replaced by a group of circumferentially located round holes and square holes (not shown in figures). Moreover, the round holes **603** in the pump head body **60** and corresponding round protrusions **703** in the mating diaphragm membrane **70** can be exchanged with the round protrusions **603** in the pump head body **60** and corresponding round holes **703** in the mating diaphragm membrane **70** without affecting their mating condition, while the square holes **604** in the pump head body **60** and corresponding square protrusions **704** in the mating diaphragm membrane **70** can also be exchanged with square protrusions **604** in the pump head body **60** and corresponding square holes **704** in the mating diaphragm membrane **70** without affecting their mating condition as well.

[0086] FIGS. **57** through **59** are illustrative figures for the fifth exemplary embodiment of the vibration-reducing method for a compressing diaphragm pump with newly devised vibration-reducing unit according to the present invention, wherein the pump head body acting fastener **600** and mating diaphragm membrane acting fastener **700** of the vibration-reducing unit are a basic indented ring **601** paired with an outer second indented ring **605** and a corresponding basic protruding ring **701** paired with an outer second protruding ring **705**, respectively. The outer second indented ring **605** is circumferentially disposed around each basic indented ring **601** in the pump head body **60** (as shown in FIG. **57**) while the outer second protruding ring **705** is circumferentially disposed around each basic protruding ring **701** in the mating diaphragm membrane **70** at a position corresponding to a position of each mating outer second indented ring **605** in the pump head body **60** (as shown in FIG. **58**). The paired basic protruding ring **701** and outer second protruding ring **705** at the bottom side of the mating diaphragm membrane **70** are completely inserted into the corresponding paired basic indented ring **601** and outer second indented ring **605** at the upper side of the pump head body **60** upon assembly of the pump head body **60** and the mating diaphragm membrane **70** (as shown in FIG. **59**). The newly devised vibration-reducing unit not only has a significant effect in reducing vibration but also enhances the resistance of the eccentric roundel **52** against displacement by the acting force F.

[0087] Each basic indented ring **601** and outer second indented ring **605** in the fifth exemplary embodiment can also be replaced by slot rings (not shown in figures). Moreover, the paired basic indented ring **601** with outer second indented ring **605** in the pump head body **60** and corresponding paired basic protruding ring **701** with outer second protruding ring **705** in the mating diaphragm membrane **70** can be exchanged with pair of basic protruding ring **601** with outer second protruding ring **605** in the pump head body **60** and corresponding paired basic indented ring **701** with outer second indented ring **705** in the mating diaphragm membrane **70** without affecting their mating condition.

[0088] Basing on the foregoing disclosure, it is apparent that the present invention substantially achieves a vibration reducing effect in compressing diaphragm pump by means of simple vibration-reducing unit without increasing overall cost. The present invention surely solves all issues of annoying noise and resonant shaking resulting from vibration in the conventional compressing diaphragm pump, thereby providing valuable industrial applicability.

What is claimed is:

1. A vibration-reducing method for a compressing diaphragm pump having a motor, a pump head body fixed to a motor housing, a roundel mount situated on a lower side of the pump head body and a plurality of eccentric roundels that extend through operating holes in the pump head body, a diaphragm membrane fixed to the eccentric roundels through the operating holes and situated on an upper side of the pump head body, and a plurality of pumping pistons arranged to be moved in a pumping action upon movement of the diaphragm membrane, comprising the step of:

disposing a vibration-reducing unit between the pump head body and diaphragm membrane to lessen the torque of each piston acting zone in the diaphragm membrane by shortening a length of a moment arm generated as a result of circumnutating action of the eccentric roundels in the eccentric roundel mount, so that the vibration strength of the compressing diaphragm pump is effectively reduced, the vibration-reducing unit including a pair of mated vibration-reducing structures, said pair of mated vibration-reducing structures including a pump head body vibration-reducing structure, which is disposed on the upper side of the pump head body, and a mating diaphragm membrane vibration-reducing structure, which is disposed on the bottom side of the diaphragm membrane at a position corresponding to a position of the pump head body vibration-reducing structure on the pump head body, said pump head body vibration-reducing structure and said diaphragm membrane vibration-reducing structure being mated to each other to establish a position of one end of the moment arm at the position of said mating vibration-reducing structures.

2. A vibration-reducing method for a compressing diaphragm pump with a vibration-reducing structure as claimed in claim 1, wherein the motor includes an output shaft, a wobble plate with an integral protruding cam-lobed shaft, and a piston valvular assembly, wherein said eccentric roundel mount includes a bearing for rotatably receiving the integral protruding cam-lobed shaft of the wobble plate, a plurality of eccentric roundels are evenly and circumferentially located on each eccentric roundel, the plurality of eccentric roundels each including a fastening bore formed therein respectively; said pump head body includes a plurality of evenly and cir-

cumferentially located through holes, each through hole having an inner diameter slightly bigger than an outer diameter of a respective eccentric roundel on the eccentric roundel mount for receiving the respective eccentric roundel, and said diaphragm membrane includes a plurality of evenly spaced radial raised partition ribs such that when the diaphragm membrane is peripherally attached in a sealing manner to the piston valvular assembly, a plurality of equivalent piston acting zones are formed and partitioned by the radial raised partition ribs such that each piston acting zone has a central through hole therein at a position corresponding to a position of each fastening bore in the eccentric roundel mount respectively; wherein when the motor is powered on, the wobble plate is driven to rotate by the motor output shaft so that the plurality of eccentric roundels on the eccentric roundel mount sequentially move in a constant up-and-down reciprocal stroke while the plurality of pumping pistons and piston acting zones in the diaphragm membrane are driven by the up-and-down reciprocal stroke of the eccentric roundels to move in up-and-down displacement to thereby cause tap water, which flows into the piston valvular assembly, to be compressed to become pressurized water, the pressurized water being constantly discharged out of the compressing diaphragm pump to be further reverse osmosis (RO)-filtered by an RO-cartridge and used in the reverse osmosis water purification system.

3. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a curved groove in the pump head body and each said diaphragm membrane vibration-reducing structure is a curved protrusion extending from the diaphragm membrane.

4. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a curved slot in the pump head body and each said diaphragm membrane vibration-reducing structure is a curved protrusion extending from the diaphragm membrane.

5. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a curved set of openings in the pump head body and each said diaphragm membrane vibration-reducing structure is a curved set of protrusions extending from the diaphragm membrane.

6. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a curved protrusion extending from the pump head body and each said diaphragm membrane vibration-reducing structure is a curved groove in the diaphragm membrane.

7. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a curved protrusion extending from the pump head body and each said diaphragm membrane vibration-reducing structure is a curved slot in the diaphragm membrane.

8. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a curved set of protrusions extending from the pump head body and each said diaphragm membrane vibration-reducing structure is a curved set of openings in the diaphragm membrane.

9. The vibration-reducing method as claimed in claim 8, wherein said protrusions are round protrusions.

10. The vibration-reducing method as claimed in claim 8, wherein said protrusions are square protrusions.

11. The vibration-reducing method as claimed in claim 1, wherein each said pump head body vibration-reducing structure is a pair of curved grooves or slots in the pump head body and each said diaphragm membrane vibration-reducing structure is a pair of curved protrusions extending from the diaphragm membrane.

12. The vibration-reducing method as claimed in claim 1, wherein each said pump head body vibration-reducing structure is a curved protrusions extending from the pump head body and each said diaphragm membrane vibration-reducing structure is a pair of curved grooves or slots in the diaphragm membrane.

13. The vibration-reducing method as claimed in claim 12, wherein said protrusions are round protrusions.

14. The vibration-reducing method as claimed in claim 12, wherein said protrusions are round protrusions.

15. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is an indented ring in the pump head body and each said diaphragm membrane vibration-reducing structure is a ring structure projecting from the diaphragm membrane.

16. The vibration-reducing method as claimed in claim 2, wherein each said pump head body vibration-reducing structure is a pair of indented rings in the pump head body and each said diaphragm membrane vibration-reducing structure is a pair of ring structures projecting from the diaphragm membrane.

17. The vibration-reducing method as claimed in claim 2, wherein each said eccentric roundel further includes an annular groove extending around said fastening bore, and said pump head body further includes a plurality of lower annular flanges extending into respective said annular grooves when said pump head body is fastened to said eccentric roundel.

18. The vibration-reducing method as claimed in claim 2, wherein said at least one raised rim of said diaphragm membrane is an inner raised rim, said diaphragm membrane includes a parallel outer raised rim, said piston valvular assembly includes a downwardly extending raised rim, and said to downwardly extending raised rim of said piston valvular assembly extends between said inner and outer raised rims of said diaphragm membrane to provide a peripheral seal when said diaphragm membrane is peripherally secured to said piston valvular assembly.

19. The vibration-reducing method as claimed in claim 2, wherein a respective number of said eccentric roundels, said operating holes in said pump head body, said piston acting zones, and said pumping pistons is three.

20. The vibration-reducing method as claimed in claim 2, wherein a number of said circumferential inlet mounts is three.

21. The vibration-reducing method as claimed in claim 2, wherein said fastening bores in said eccentric roundels are threaded bores and said fastening members are screws.

22. The vibration-reducing method as claimed in claim 2, wherein said cavity is formed by a bottom of an annular rib ring of the pump head cover being pressed onto a rim of the central outlet mount of the piston valvular assembly.

23. The vibration-reducing method as claimed in claim 1, wherein said motor is a brushed motor.

24. The vibration-reducing method as claimed in claim 1, wherein said motor is a brushless motor.