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(54) Title: ECCENTRIC ROUNDEL STRUCTURE FOR COMPRESSING DIAPHRAGM PUMP WITH MULTIPLE EFFECTS

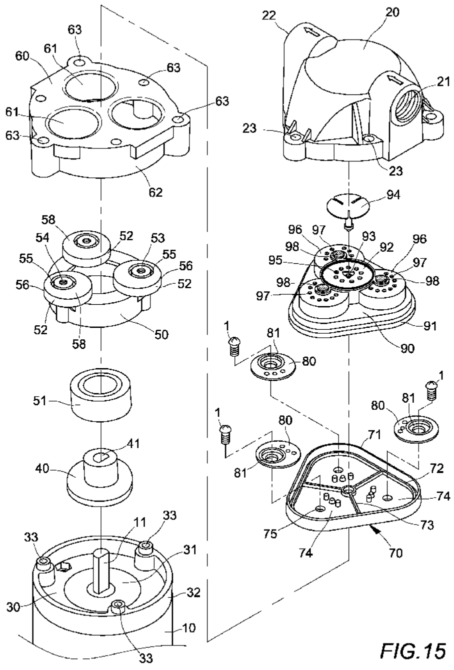

FIG.15

(57) Abstract: A cylindrical or inverted frustoconical eccentric roundel structure for a compressing diaphragm pump includes an annular positioning groove, a vertical or frustoconical flank and a sloped top ring extending between the annular positioning groove and the vertical or inverted frustoconical flank. By providing the sloped top ring, the oblique high frequency pulling and squeezing phenomenon that occurs in a conventional tubular eccentric roundel is completely eliminated.

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Title

Eccentric roundel structure for compressing diaphragm pump with multiple effects

This application claims the benefit of provisional U.S. Patent Application number 62/000,630, filed May 20, 2014, and incorporated herein by reference.

Field Of The Present Invention

The present invention relates to an eccentric roundel structure for a compressing diaphragm pump used in a reverse osmosis (RO) purification system, and particularly to a compressing diaphragm pump with a sloped top ring that can eliminate the oblique pulling and squeezing phenomena of the pump so that the service lifespan of the compressing diaphragm pump and the durability of key components therein are prolonged.

Background Of The Invention

Conventional compressing diaphragm pumps of the type commonly used with reverse osmosis (RO) purifier or RO water purification systems are disclosed in U.S. Patent Nos. 4396357, 4610605, 5476367, 5571000, 5615597, 5649812, 5706715, 5791882 and 5816133. An example of such a conventional compressing diaphragm pump is shown in **FIGS. 1** through **10**, and includes a brushed motor **10** with an output shaft **11**, a motor upper chassis **30**, a wobble plate with an integral protruding cam-lobed shaft **40**, 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 a bearing **31** through which an output shaft **11** of the motor **10** extends. The motor upper chassis **30** also includes an upper annular rib ring **32** with several fastening bores **33** evenly and circumferentially disposed in a rim of the upper annular rib ring **32**

The wobble plate **40** includes a shaft coupling hole **41** through which the corresponding motor output shaft **11** of the motor **10** extends.

The eccentric roundel mount **50** includes a central bearing **51** at the bottom thereof for receiving the corresponding wobble plate **40**. Three tubular eccentric roundels **52** are evenly and circumferentially disposed on the eccentric roundel mount **50**. Each tubular eccentric roundel **52** has a horizontal top face **53**, a female-threaded bore **54** and an annular positioning groove **55** formed in the top face thereof, as well as a rounded shoulder **57** created at the intersection of the horizontal top face **53** and a vertical flank 56.

The pump head body **60** covers the upper annular rib ring **32** of the motor upper chassis **30** to encompass the wobble plate **40** and eccentric roundel mount **50** therein, and includes three operating holes **61** evenly and circumferentially disposed therein. Each operating hole **61** has an inner diameter that is slightly bigger than the outer diameter of the corresponding tubular eccentric roundel **52** in the eccentric roundel mount **50** for receiving each corresponding tubular eccentric roundel **52** respectively, a lower annular flange **62** formed thereunder for mating with corresponding upper annular rib ring **32** of the motor upper chassis **30**, and several fastening bores **63** evenly disposed around a circumference of the pump head body **60**.

The diaphragm membrane **70**, which is extrusion-molded from a semi-rigid elastic material and placed on the pump head body **60**, includes a pair of parallel rims, including outer raised rim **71** and inner raised rim **72**, as well as three evenly spaced radial raised partition ribs **73** arranged such that each end of the radial raised partition ribs **73** connects with the inner raised rim **72**, thereby forming three equivalent piston acting zones **74** partitioned by the radial raised partition ribs **73**. Each piston acting zone **74** has an acting zone hole **75** created therein in correspondence with a respective female-threaded bore **54** in the tubular eccentric roundel **52** of the eccentric roundel mount **50**, and an annular positioning protrusion **76** for each acting zone hole **75** is formed at the bottom side of the diaphragm membrane **70** (as shown in **FIGS. 8** and **9**).

Each pumping piston **80** is respectively disposed in a respective one of the corresponding piston acting zones **74** of the diaphragm membrane **70** and has a tiered hole **81** extending therethrough. After each of the annular positioning protrusions **76** in the diaphragm membrane **70** has been inserted into a corresponding annular positioning groove **55** in the tubular eccentric roundel **52** of the eccentric roundel mount **50**, respective fastening screws **1** are inserted through the tiered hole **81** of each pumping piston **80** and the acting zone hole **75** of each corresponding piston acting zone **74** in the diaphragm membrane **70**, so that the diaphragm membrane **70** and three pumping pistons **80** can be securely screwed into female-threaded bores **54** of the corresponding three tubular eccentric roundels **52** on the eccentric roundel mount **50** (as can be seen in the enlarged portion of **FIG. 10**).

Piston valvular assembly **90** covers the diaphragm membrane **70** and includes a downwardly extending raised rim **91** for insertion between the outer raised rim **71** and inner raised rim **72** in the diaphragm membrane **70**, and a central dish-shaped round outlet mount **92** having a central positioning bore **93** with three equivalent sectors, each of which contains multiple evenly circumferentially-located outlet ports **95**. The piston valvular assembly **90** also includes a T-shaped plastic anti-backflow valve **94** with a central positioning shank, and three circumferentially-adjacent inlet mounts **96**. Each of the circumferentially-adjacent inlet mounts **96** includes multiple evenly circumferentially-located inlet ports **97** and an inverted central piston disk **98** respectively so that each piston disk **98** serves as a valve for each corresponding group of multiple inlet ports **97**. The central positioning shank of the plastic anti-backflow valve **94** mates with the central positioning bore **93** of the central outlet mount **92** such that multiple outlet ports **95** in the central round outlet mount **92** are in communication with the three inlet mounts **96**. Finally, a hermetically sealed preliminary-compression chamber **26** is formed between each inlet mount **96** and a corresponding piston acting zone **74** in the diaphragm membrane **70** upon insertion of the downwardly extending raised rim **91** into the gap ring between the outer raised rim **71** and inner raised rim **72** of diaphragm membrane **70**, such that one end of each preliminary-compressing chamber **26** is in communication with each of the corresponding inlet ports **97** (as shown in the enlarged portion of **FIG. 10**).

The pump head cover **20**, which covers the pump head body **60** to encompass the piston valvular assembly **90**, pumping piston **80** and diaphragm membrane **70** therein, includes a water inlet orifice **21**, a water outlet orifice **22**, and several fastening bores **23**. A tiered rim **24** and an annular rib ring **25** are disposed in the bottom inside of the pump head cover **20** such that the outer rim for the assembly of diaphragm membrane **70** and piston valvular assembly **90** can be hermetically attached to the tiered rim **24** (as shown in the enlarged portion of **FIG. 11**). A high-compression chamber **27** is formed between the cavity formed by the inside wall of the annular rib ring **25** and the central outlet mount **92** of the piston valvular assembly **90** when the bottom of the annular rib ring **25** closely covers the rim of the central outlet mount **92** (as shown in **FIG. 10**).

By running each fastening bolt **2** through a corresponding fastening bore **23** of pump head cover **20** and a corresponding fastening bore **63** in the pump head body **60**, and then putting a nut **3** onto each fastening bolt **2** to securely screw the pump head cover **20** to the pump head body **60** via the corresponding fastening bores **33** in the motor upper chassis **30**, the whole assembly of the compressing diaphragm pump is finished (as shown in **FIGS. 1** and **10**).

Please refer to **FIGS. 11** and **12**, which are illustrative figures for the operation of the conventional compressing diaphragm pump of Figs. 1-10.

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 tubular eccentric roundels **52** on the eccentric roundel mount **50** constantly move in a sequential up-and-down reciprocal stroke.

Secondly, in the meantime, the three pumping pistons **80** and three piston acting zones **74** in the diaphragm membrane **70** are sequentially driven by the up-and-down reciprocal stroke of the three tubular eccentric roundels **52** to move in an up-and-down displacement.

Thirdly, when the tubular eccentric roundel **52** moves in a down stroke, causing pumping piston **80** and piston acting zone **74** to be displaced downwardly, the piston disk **98** in the piston valvular assembly **90** is pushed into an open status so that tap water **W** can flow into the preliminary-compression chamber **26** via water inlet orifice **21** in the pump head cover **20** and inlet ports **97** in the piston valvular assembly **90** (as indicated by the arrowhead extending from **W** in the enlarged view of **FIG. 11**);

Fourthly, when the tubular eccentric roundel **52** moves in an up stroke, causing pumping piston **80** and piston acting zone **74** to be 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 preliminary-compression chamber **26** and increase the water pressure therein up to a range of 80psi-100psi. The resulting pressurized water **Wp** causes the plastic anti-backflow valve **94** in the piston valvular assembly **90** to be pushed to an open status.

Fifthly, when the plastic anti-backflow valve **94** in the piston valvular assembly **90** is pushed to an open status, the pressurized water **Wp** in the preliminary-compression chamber **26** is directed into high-compression chamber **27** via the group of outlet ports **95** for the corresponding sector in the central outlet mount **92**, and then expelled out of the water outlet orifice **22** in the pump head cover **20** (as indicated by arrowhead **W** in the enlarged portion of **FIG. 12**).

Finally, the sequential iterative action for each group of outlet ports **95** for the three sectors in central outlet mount **92** causes the pressurized water **Wp** to be 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.

Referring to **FIGS. 13** and **14**, a serious vibration-related drawback has long existed in the 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 tubular eccentric roundels **52** on the eccentric roundel mount **50** constantly move in a sequential up-and-down reciprocal stroke, and the three piston acting zones **74** in the diaphragm membrane **70** are sequentially driven by the up-and-down reciprocal stroke of the three tubular eccentric roundels **52** to move in up-and-down displacement so that a force **F** constantly acts on the bottom side of each piston acting zone **74**.

Meanwhile a corresponding plurality of rebounding forces **Fs** are created in reaction to the acting force **F** exerted on the bottom side of diaphragm membrane **70**, with different components distributed over the entire bottom area of each corresponding piston acting zone **74** in the diaphragm membrane **70**, as shown in **FIG. 14**, so that a squeezing phenomenon caused by the rebounding force **Fs** occurs on a section of the diaphragm membrane **70**.

The squeezing phenomenon occurs because, among all of the distributed components of the rebounding force **Fs**, the maximum component force is exerted at the contacting bottom position **P** of the diaphragm membrane **70** with the rounded shoulder **57** of the horizontal top face **53** in the tubular eccentric roundel **52** so that the squeezing phenomenon at the bottom position **P** is also maximum, as shown in **FIG. 18**.

With the rotational speed for the motor output shaft **11** of the motor **10** reaching a range of 700-1200 rpm, each bottom position **P** of the piston acting zone **74** of the diaphragm membrane **70** suffers from the squeezing phenomenon at a frequency of four times per second. Under such circumstances, the bottom position **P** of the diaphragm membrane **70** is always the first broken place for the entire conventional compressing diaphragm pump, which is an essential cause of not only shortening the service lifespan but also terminating the normal function of the conventional compressing diaphragm pump.

Therefore, how to substantially reduce the drawbacks associated with the squeezing phenomenon caused by the constant application of force **F** to the bottom side of each piston acting zone **74** of the diaphragm membrane **70** as a result of the movement of the tubular eccentric roundel **52** has also become an urgent and critical issue.

Summary Of The Invention

An objective of the present invention is to provide a compressing diaphragm pump, in which the eccentric roundel structure is a cylindrical or inverted frustoconical eccentric roundel disposed in an eccentric roundel mount, the cylindrical or inverted frustoconical eccentric roundel including an annular positioning groove, a vertical or frustoconical flank, and an annular top surface portion that is inclined relative to horizontal to form a sloped top ring between the annular positioning groove and the vertical flank.

By means of the sloped top ring, the high-frequency oblique pulling and squeezing phenomena that occurs in a conventional tubular eccentric roundel are completely eliminated because the sloped top ring flatly attaches to the bottom area of a corresponding piston acting zone of the diaphragm membrane.

Thus, not only is the durability of the diaphragm membrane enhanced to better withstand the sustained high-frequency pumping action of the eccentric roundels, but the service lifespan of the diaphragm membrane is also greatly prolonged.

Yet another objective of the present invention is to provide an eccentric roundel for a compressing diaphragm pump, in which the eccentric roundel structure is a cylindrical or inverted frustoconical eccentric roundel disposed on an eccentric roundel mount, the eccentric roundel including an annular positioning groove, a vertical or frustoconical flank, and a sloped top ring formed between the annular positioning groove and the vertical or frustoconical flank.

Again, by means of the sloped top ring, all distributed components of the rebounding force for the cylindrical eccentric roundels that are generated in reaction to the acting force caused by the pumping action are substantially reduced because the sloped top ring flatly attaches to the bottom area of the corresponding piston acting zone for the diaphragm membrane.

In achieving the above-described objectives, which are not intended to limit the scope of the invention, at least the following benefits are obtained:

1. The durability of the diaphragm membrane for sustaining the high-frequency pumping action of the cylindrical or inverted frustoconical eccentric roundels is substantially enhanced.

2. The power consumption of the compressing diaphragm pump is tremendously diminished due to less current being wasted as a result of the above-described high-frequency squeezing phenomena.

3. The working temperature of the compressing diaphragm pump is tremendously reduced due to less power consumption.

4. The annoying noise of the bearings that results from aged lubricant in the compressing diaphragm pump, which is expeditiously accelerated by the high working temperature, is mostly eliminated.

Brief Description Of The Drawings

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

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

FIG. 3 is a perspective view of an eccentric roundel mount for the conventional compressing diaphragm pump.

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

FIG. 5 is a top view of a pump head body for the conventional compressing diaphragm pump.

FIG. 6 is a cross sectional view taken against the section line 6-6 from previous **FIG. 5**.

FIG. 7 is a perspective view of a diaphragm membrane for the conventional compressing diaphragm pump.

FIG. 8 is a cross sectional view taken against the section line 8-8 from previous **FIG. 7**.

FIG. 9 is a bottom view of a diaphragm membrane for the conventional compressing diaphragm pump.

FIG. 10 is a cross sectional view taken against the section line 10-10 from previous **FIG. 1**.

FIG. 11 is a first operation illustrative view of a conventional compressing diaphragm pump.

FIG. 12 is a second operation illustrative view of a conventional compressing diaphragm pump.

FIG. 13 is a third operation illustrative view of a conventional compressing diaphragm pump.

FIG. 14 is a partially enlarged view taken from circled-portion-a of previous **FIG. 13**.

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

FIG. 16 is a perspective view of an eccentric roundel mount in the first exemplary embodiment of the present invention.

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

FIG. 18 is an assembled cross sectional view of the first exemplary embodiment of the present invention.

FIG. 19 is an operation illustrative view of the first exemplary embodiment of the present invention.

FIG. 20 is a partially enlarged view taken from circled-portion-a of previous **FIG. 19.**

FIG. 21 is an illustrative view showing a comparison between the eccentric cylindrical roundel acting on the diaphragm membrane of the conventional compressing diaphragm pump and that of the first exemplary embodiment of the present invention.

FIG. 22 is a perspective view for eccentric roundel mount in the second exemplary embodiment of the present invention.

FIG. 23 is a cross sectional view taken against the section line 23-23 from previous **FIG. 22**.

FIG. 24 is an assembled cross sectional view for the second exemplary embodiment of the present invention.

FIG. 25 is an operation illustrative view of the second exemplary embodiment of the present invention.

FIG. 26 is a partially enlarged view taken from circled-portion-a of previous **FIG. 25**.

FIG. 27 is an illustrative view showing a comparison between the eccentric cylindrical roundel acting on the diaphragm membrane for the conventional compressing diaphragm pump and for the present invention in the second exemplary embodiment of the present invention.

FIG. 28 is a perspective exploded view for the third exemplary embodiment of the present invention.

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

FIG. 30 is a perspective assembled view for the third exemplary embodiment of the present invention.

FIG. 31 is a cross sectional view taken against the section line 31-31 from previous **FIG. 30**.

FIG. 32 is an assembled cross sectional view for the third exemplary embodiment of the present invention.

FIG. 33 is an operation illustrative view for the third exemplary embodiment of the present invention.

FIG. 34 is a partially enlarged view taken from circled-portion-a of previous **FIG. 33**.

FIG. 35 is an illustrative view showing a comparison between the eccentric cylindrical roundel acting on the diaphragm membrane for the conventional compressing diaphragm pump and for the present invention in the third exemplary embodiment of the present invention.

Detailed Description Of The Preferred Embodiments

FIGS. 15 through **18** are illustrative figures of an eccentric roundel structure for compressing diaphragm pump according to a first exemplary embodiment of the present invention.

The eccentric roundel structure is a cylindrical eccentric roundel **52** that is mounted on the eccentric roundel mount **50**. The cylindrical eccentric roundel includes an annular top surface portion that is inclined relative to horizontal to form a sloped top ring **58** between the annular positioning groove **55** and a vertical flank **56,** the sloped top ring **58** replacing the conventional rounded shoulder **57** in each tubular eccentric roundel **52** of the eccentric roundel mount **50**.

FIGS. 19 through **21** are illustrative figures for the operation of the eccentric roundel structure for compressing diaphragm pump" in the first exemplary embodiment of the present invention.

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 cylindrical eccentric roundels **52** on the eccentric roundel mount **50** constantly move in a sequential up-and-down reciprocal stroke.

Secondly, the three piston acting zones **74** in the diaphragm membrane **70** are sequentially driven by the up-and-down reciprocal stroke of three cylindrical eccentric roundels **52** to move in up-and-down displacement.

Thirdly, when the tubular eccentric roundel or cylindrical eccentric roundel **52** moves in an up stroke with the piston acting zone **74** in an upward displacement, an acting force **F** will obliquely pull on the partial portion between the corresponding annular positioning protrusion **76** and outer raised rim **71** of the diaphragm membrane **70**.

1420 By comparing the operation of the conventional tubular eccentric roundels **52** shown in **FIG. 14** and the cylindrical eccentric roundels **52** of the present invention, as illustrated in **FIG. 20,** at least the following two differences are evident:

In the case of conventional tubular eccentric roundel **52** shown in **FIG. 14**, the maximum among all of the distributed components **Fs** of the rebounding force is the component force exerted at the contacting bottom position **P** of the diaphragm membrane 70, which is located at an edge of the rounded shoulder **57** on a horizontal top face **53** of tubular eccentric roundel **52**, so that the "squeezing phenomenon" at point **P** is also maximum**4**. With such nonlinear distribution of the "squeezing phenomena," the obliquely pulling action becomes severe. In contrast, in the case of cylindrical eccentric roundels **52** as illustrated in **FIG. 20**, the distribution of components of the rebounding force **Fs** is more linear because the sloped top ring **58** therein flatly attaches to the bottom area of the piston acting zone **74** for the diaphragm membrane **70**, so that the oblique pulling action is almost eliminated due to reduction in the squeezing phenomenon**1920**.

Moreover, under the same acting force **F**, the rebounding force **Fs** is inversely proportional to the contact area so that the magnitudes of the distributed components of the rebounding force **Fs** for the cylindrical eccentric roundels **52** of the present invention, as shown in **FIG. 20**, are substantially less than the magnitudes of the distributed components of the rebounding force **Fs** for the conventional tubular eccentric roundel **52** shown in **FIG. 14**.

The improved distribution linearity and decreased magnitudes of the rebounding force components **Fs** are the result of forming the sloped top ring **58** between the annular positioning groove **55** and the vertical flank **56** in the eccentric roundel mount **50**, and in turn provides at least the following advantages. First, the improved force component distribution eliminates susceptibility to breakage of the diaphragm membrane **70** caused by the high frequency squeezing phenomena, that occurs in the conventional arrangement as a result of the rounded shoulder **57** in the otherwise horizontal top face **53** of the tubular eccentric roundel**52**. Second, because of decrease in magnitude of the rebounding force components, the overall rebounding force **Fs** of the diaphragm membrane **70** caused by the acting force **F** during sequential up-and-down displacement of the three piston acting zones **74** in the diaphragm membrane **70** driven by the up-and-down reciprocal stroke of the three tubular eccentric roundels or cylindrical eccentric roundels **52** is tremendously reduced.

These advantages result in the following practical benefits:

1. The durability of the diaphragm membrane **70** for sustaining the high frequency pumping action of the cylindrical eccentric roundels **52** is substantially enhanced.

2. The power consumption of the compressing diaphragm pump is tremendously diminished due to less current being wasted as a result of the squeezing phenomena at high frequencies.

3. The working temperature of the compressing diaphragm pump is tremendously reduced due to the decrease in power consumption.

4. The undesirable bearing noise caused by aging of the lubricant in the compressing diaphragm pump, which is normally accelerated by the high working temperature, is mostly eliminated.

Test results carried out on a prototype of the present invention are as follows.

A. The service lifespan of the tested diaphragm membrane **70** was more than doubled.

B. The reduction in electric current consumption exceeded 1 ampere.

C. The working temperature was reduced by over 15 degrees Celsius.

D. The smoothness of the bearing was improved.

Please refer to **FIGS. 22** through **24**, which are illustrative figures of an eccentric roundel structure for compressing diaphragm pump in the second exemplary embodiment of the present invention, The eccentric roundel structure is an inverted frustoconical eccentric roundel **502,** again provided on an eccentric roundel mount **500**.

The frustoconical eccentric roundel **502** includes an integral inverted frustoconical flank **506** and a sloped top ring **508** such that the outer diameter of the frustoconical eccentric roundel **502** is enlarged but still smaller than the inner diameter of the operating hole **61** in the pump head body **60**, the sloped top ring **508** extending between an annular positioning groove **505** and the inverted frustoconical flank **506**.

FIGS. 25 through **27** are illustrative figures showing the modified operation of the eccentric roundel structure for compressing diaphragm pump in the second exemplary embodiment of the present invention.

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 frustoconical eccentric roundels **502** on the eccentric roundel mount **500** constantly move in a sequential up-and-down reciprocal stroke.

Secondly, the three piston acting zones **74** in the diaphragm membrane **70** are sequentially driven by the up-and-down reciprocal stroke of the three frustoconical eccentric roundels 502 to move in up-and-down displacement.

Thirdly, when one of the frustoconical eccentric roundels **502** in the present invention moves in an up stroke so that the corresponding piston acting zone **74** is displaced upwardly, the acting force **F** will obliquely pull the partial portion between the corresponding annular positioning protrusion **76** and outer raised rim **71** of the diaphragm membrane **70**.

Consequently, the inclusion of the sloped top ring **508** in the eccentric roundel mount **500** eliminates breakage of the diaphragm membrane **70** caused by the high frequency squeezing phenomena and also causes the rebounding force **Fs** of the diaphragm membrane **70** caused by the acting force **F** to be tremendously reduced. Meanwhile, by means of the inverted frustoconical flank **506**, the possibility of collision between the frustoconical eccentric roundel **502** and the operating hole **61** in the pump head body **60** is eliminated even though the outer diameter of the frustoconical eccentric roundel **502** is enlarged.

Moreover, under the same acting force **F**, the rebounding force **Fs** is inversely proportional to the contact area. By means of the enlarged outer diameter of the inverted frustoconical eccentric roundel **502**, the contact area of the sloped top ring **508** with the bottom side of the diaphragm membrane **70** is increased (as indicated by ring A shown in **FIG. 27**) so that all distributed components of the rebounding force **Fs** for the inverted frustoconical eccentric roundels **502** of the present invention are further reduced.

The inverted frustoconical eccentric roundel **502** of this embodiment of the present invention therefore provides at least some of the following benefits:

1. The durability of the diaphragm membrane **70** for sustaining the high frequency pumping action is substantially increased as a result of the inverted frustoconical eccentric roundel **502**.

2. The power consumption of the compressing diaphragm pump is tremendously diminished due to less current being wasted as a result of the high frequency squeezing phenomena.

3. The working temperature of the compressing diaphragm pump is tremendously reduced due to less power consumption.

4. The undesirable bearing noise resulting from aged lubricant in the compressing diaphragm pump, which is exacerbated by accelerated aging due to a high working temperature, is mostly eliminated.

5. The service lifespan of the compressing diaphragm pump is further prolonged because all distributed components of the rebounding force **Fs** for the inverted frustoconical eccentric roundels **502** of the present invention are reduced.

FIGS. 28 through **31** are illustrative figures of eccentric roundel structure for compressing diaphragm pump in the third exemplary embodiment of the present invention, in which the eccentric roundel structure is a combinational eccentric roundel **502** in an eccentric roundel mount **500**. The combinational eccentric roundel **502** includes a roundel mount **511** and an inverted frustoconical roundel yoke **521** in detachable separation such that the outer diameter of the frustoconical roundel yoke **521** is enlarged but still smaller than the inner diameter of the operating hole **61** in the pump head body **60**. In this embodiment, the roundel mount **511** has two layers that include a bottom-layer base with a positioning crescent surface **512** facing inwardly and a top-layer protruding cylinder **513** with a central female-threaded bore **514**. The inverted frustoconical roundel yoke **521** is sleeved over the corresponding roundel mount **511** and includes an upper bore **523**, a middle bore **524** and a lower bore **525** stacked as a three-layered integral hollow structure, as well as an inverted frustoconical flank **522** and a sloped top ring **526** extending from the upper bore **523** to the inverted frustoconical flank **522** such that the bore diameter of the upper bore **523** is bigger than the outer diameter of the protruding cylinder **513.** The bore diameter of the middle bore **524** is approximately equal to the outer diameter of the protruding cylinder **513**, such that the bore diameter of the lower bore **525** is approximately equal to the outer diameter of the bottom-layer base in the roundel mount **511**, and such that the crescent engages a corresponding surface of the lower bore to prevent relative rotation of the roundel yoke **521** and the corresponding roundel mount **511**. A positioning annular groove **515** is formed between the protruding cylinder **513** and the inside wall of the upper bore **523** when the frustoconical roundel yoke **521** is sleeved over the roundel mounts **511** (as shown in **FIGS. 30** and **31**).

FIGS. 32 and **35** illustrate the manner in which the eccentric roundel structure for compressing diaphragm pump third exemplary embodiment of the present invention is assembled.

Firstly, the frustoconical roundel yoke **521** is fitted over the roundel mounts **511**.

Secondly, all three annular positioning protrusions **76** of the diaphragm membrane **70** are inserted into three corresponding positioning annular grooves **515** in the three combinational eccentric roundels **502** of the eccentric roundel mount **500.**

Finally, each fastening screw **1** is inserted through a corresponding tiered hole **81** of the pumping piston **80** and each corresponding acting zone hole **75** in the piston acting zones **74** of the diaphragm membrane **70**, and then the fastening screw **1** is securely screwed into the three corresponding female-threaded bores **514** in the three roundel mounts **511** of the eccentric roundel mount **500** to firmly assembly the diaphragm membrane **70** and three pumping pistons **80** (as shown in **FIG. 32**).

FIGS. 33 and **34** illustrate the operation of the eccentric roundel structure for compressing diaphragm pump of the third exemplary embodiment of the present invention.

Firstly, when the motor **10** is powered on, the wobble plate **40** is driven to rotate by the motor output shaft **11** so that three combinational eccentric roundels **502** on the eccentric roundel mount **50** constantly move in a sequential up-and-down reciprocal stroke.

Secondly, the three piston acting zones **74** in the diaphragm membrane **70** are sequentially driven by the up-and-down reciprocal stroke of the three combinational eccentric roundels **502** to move in up-and-down displacement.

Thirdly, when the combinational eccentric roundel **502** in the present invention moves in an up stroke to displace the piston acting zone **74** upwardly, the acting force **F** will obliquely pull the partial portion between the corresponding annular positioning protrusion **76** and the outer raised rim **71** of the diaphragm membrane **70**.

Consequently, the inclusion of the sloped top ring **526** in the inverted frustoconical roundel yoke **521** of the eccentric roundel mount **500** eliminates susceptibility to breakage of the diaphragm membrane **70** caused by the high frequency squeezing phenomena (as shown in **FIGS. 33** and **34**) and also causes the rebounding force **Fs** of the diaphragm membrane **70** caused by the acting force **F** to be tremendously reduced (as shown in **FIG. 34**).

Moreover, under the same acting force **F**, the rebounding force **Fs** is inversely proportional to the contact area. By means of the enlarged outer diameter of the inverted frustoconical roundel yoke **521**, the contact area of the sloped top ring **508** with the bottom side of the diaphragm membrane **70** is increased (as indicated by ring A shown in **FIG. 35**) so that all distributed components of the rebounding force **Fs** for the inverted frustoconical roundel yoke **521** of the present invention are further reduced.

The fabrication of the eccentric roundel structure for compressing diaphragm pump of the third exemplary embodiment of the present invention is as follows:

Firstly, the roundel mount **511** and eccentric roundel mount **500** are fabricated together as an integral body.

Secondly, the frustoconical roundel yoke **521** is independently fabricated as a separate entity.

Finally, the frustoconical roundel yoke **521** and the integral body of the roundel mount **511** are assembled with eccentric roundel mount **500** to become a united entity and form the assembled eccentric roundel **502** best shown in **FIGS. 108** and **109**.

Thereby, the contrivance of the combinational eccentric roundel **502** not only meets the requirement of mass production but also reduces the overall manufacturing cost.

The eccentric roundel **502** with frustoconical roundel yoke **521** of the present invention provides at least some of the following benefits:

1. The durability of the diaphragm membrane **70** for sustaining the high frequency pumping action is substantially increased by including the inverted frustoconical roundel yoke **521**.

2. The power consumption of the compressing diaphragm pump is tremendously reduced due to less current being wasted as a result of the high frequency squeezing phenomena.

3. The working temperature of the compressing diaphragm pump is tremendously reduced due to the reduction in power consumption.

4. The undesired bearing noise resulting from temperature-accelerated aging of the lubricant in the compressing diaphragm pump is mostly eliminated.

5. The service lifespan of the compressing diaphragm pump is further prolonged because all distributed components of the rebounding force **Fs** for the inverted frustoconical roundel yoke **521** of the present invention are further reduced.

6. The manufacturing cost of the compressing diaphragm pump is reduced because the present invention is suitable for mass production.

The illustrated embodiments of the invention provide a cylindrical eccentric roundel **52**, an inverted frustoconical eccentric roundel **502**, or combinational eccentric roundel **502** that, among other advantages, increases the service lifespan of the diaphragm membrane **70** so that the service lifespan of the compressing diaphragm pump can be doubled.

What Is Claimed Is:

1. An eccentric roundel structure for a compressing diaphragm pump, said roundel structure including a roundel mount situated on a lower side of a pump head body and a plurality of eccentric roundels mounted on the roundel mount to extend through a corresponding plurality of operating holes in the pump head body, said compressing diaphragm pump having a motor with a motor housing to which the pump head body is fixed, 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 pumping pistons arranged to be moved in a pumping action upon movement of the diaphragm membrane, the roundel mount engaging a wobble plate such that rotation of the wobble plate by the motor causes the roundel mount to wobble, resulting in sequential up and down movement of the eccentric roundels, the sequential up and down movement of the eccentric roundels causing sequential, reciprocating movement the plurality of pumping pistons and of a plurality of piston acting zones in the diaphragm member, and the diaphragm membrane further including a plurality of annular downwardly-projecting positioning protrusions each arranged to be inserted into a respective annular positioning groove in a top surface of each of said eccentric roundels, wherein:

a section of the top surface of each eccentric roundel is inclined relative to horizontal to form a sloped top ring between a respective said annular positioning groove and a vertical or inverted frustoconical flank of the respective eccentric roundel.

2. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 1, wherein said eccentric roundel mount includes a central bearing for receiving an integral cam-lobed shaft of the wobble plate to enable said sequential up and down

movement of the eccentric roundels in response to rotation of the wobble plate by the motor.

3. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 1, wherein:

said pump head body is secured to the motor housing to encompass the wobble plate and eccentric roundel mount therein;

said diaphragm membrane is made of a semi-rigid elastic material and placed on the pump head body, said diaphragm membrane including at least one raised rim as well as a plurality of evenly spaced radial raised partition ribs connected with the at least one raised brim to form said piston acting zones, and

each piston acting zone has an acting zone hole formed therein at a position corresponding to a position of a fastening bore in a respective one of the eccentric roundels, and each pumping piston has a tiered hole such that a fastening member extends through the tiered hole, through the acting zone hole of each corresponding piston acting zone in the diaphragm membrane, and into a respective fastening hole in a respective one of the eccentric roundels to secure the diaphragm membrane and each of the pumping pistons to the corresponding eccentric roundels in the eccentric roundel mount.

4 An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 3, wherein said compressing diaphragm pump further includes:

a piston valvular assembly that covers the diaphragm membrane and is peripherally secured to the diaphragm membrane by sealing engagement, the piston valvular assembly including a central outlet mount having a central positioning bore and a plurality of equivalent sectors, each of which contains multiple evenly circumferentially-located outlet ports, a T-shaped plastic anti-backflow valve with a central positioning shank, and a plurality of circumferential inlet mounts, each of each of the inlet mounts including multiple evenly circumferentially-located inlet ports and an inverted central piston disk mounted to the respective inlet mount so that each piston disk serves as a valve for each corresponding group of multiple inlet ports, wherein the central positioning shank of the plastic anti-backflow valve mates with the central positioning bore of the central outlet mount such that said multiple outlet ports in the central round outlet mount communicate with the plurality of inlet mounts, and a hermetic preliminary water-pressurizing chamber is formed in each inlet mount and corresponding piston acting zone in the diaphragm membrane upon the diaphragm membrane being peripherally secured to the piston valvular assembly such that one end of each of the preliminary water-pressuring chamber is communicable with each corresponding one of said inlet ports; and

a pump head cover, which covers the pump head body to encompass the piston valvular assembly, pumping pistons and diaphragm membrane therein, includes a water inlet orifice, and a water outlet orifice, said pump head cover being hermetically attached to the assembly of diaphragm membrane and piston valvular assembly to form a high-pressured water chamber between a cavity formed by an inside wall of an annular rib ring and the central outlet mount of the piston valvular assembly.

5. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 1, wherein each said eccentric roundel is a cylindrical eccentric roundel.

6. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 1, wherein each said eccentric roundel is an inverted frustoconical eccentric roundel,

and wherein a largest diameter of the inverted frustoconical eccentric roundel is smaller than an inner diameter of a corresponding one of said operating holes in the pump head body.

7. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 6, wherein said inverted frustoconical eccentric roundels each includes a mounting portion fixed to the roundel mount and a separable inverted frustoconical roundel yoke mounted on the roundel mount to form a two-layered eccentric roundel structure.

8. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 7, wherein the mounting portion of each of the inverted frustoconical eccentric roundels is integrally fabricated with the roundel mount, and the inverted frustoconical roundel yokes are separately fabricated.

9. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 6, wherein a mounting portion of each of the inverted frustoconical eccentric roundels includes a base with an inwardly-facing positioning surface and a cylinder with a central female-threaded bore extending upwardly from the base, and wherein each of the inverted frustoconical yokes includes an upper bore, a middle bore, and a lower bore, wherein a diameter of the middle bore is approximately equal to a diameter of the mounting portion cylinder, a diameter of the upper bore is larger than the diameter of the mounting portion cylinder, and a diameter of the lower bore is approximately equal to a diameter of the mounting portion base, said lower bore being fitted over the base, said middle bore being sleeved over the cylinder, and said annular positioning groove being defined by a space between said cylinder and an inner wall of said upper bore.

10. An eccentric roundel structure for a compressing diaphragm pump as claimed

in claim 1, 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.

11. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 1, wherein said motor is a brushed motor.

12. An eccentric roundel structure for a compressing diaphragm pump as claimed in claim 1, wherein said motor is a brushless motor.

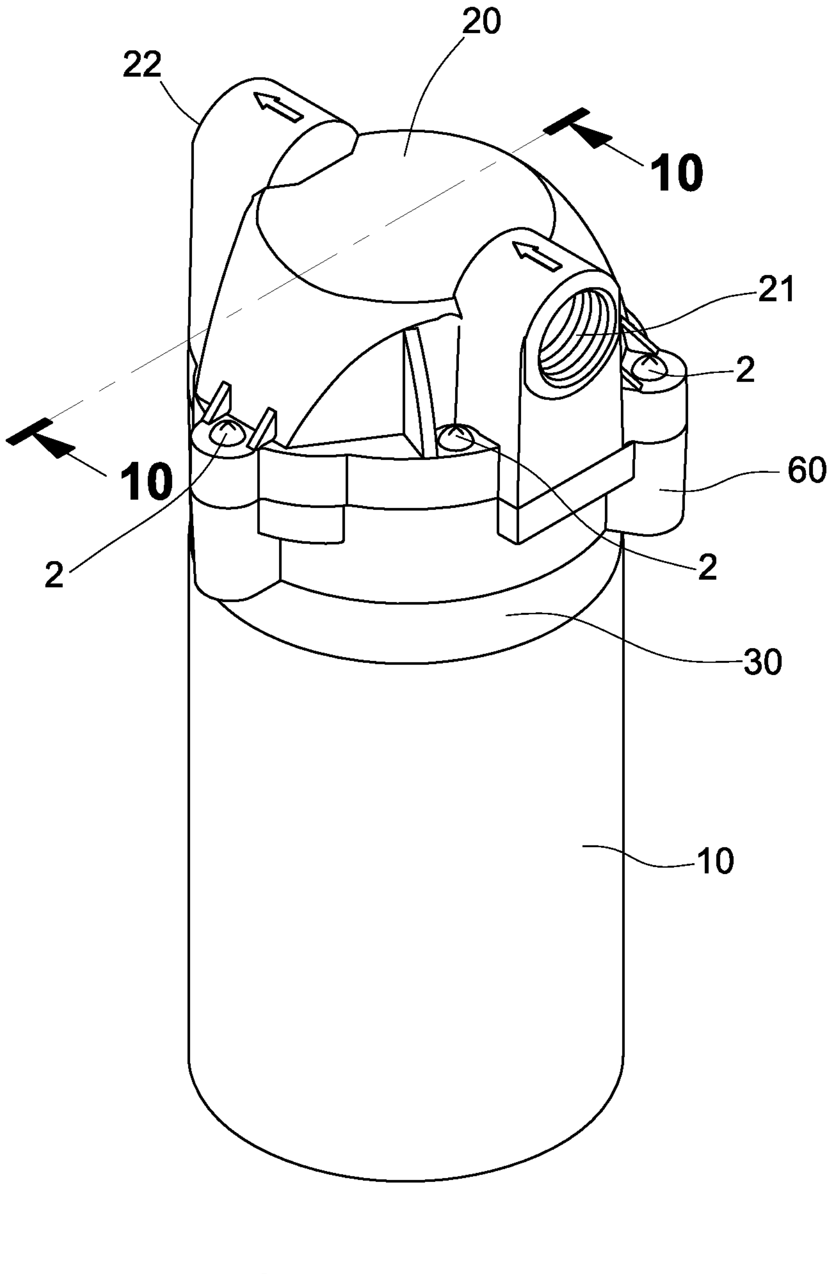

FIG.1 (PRIOR ART)

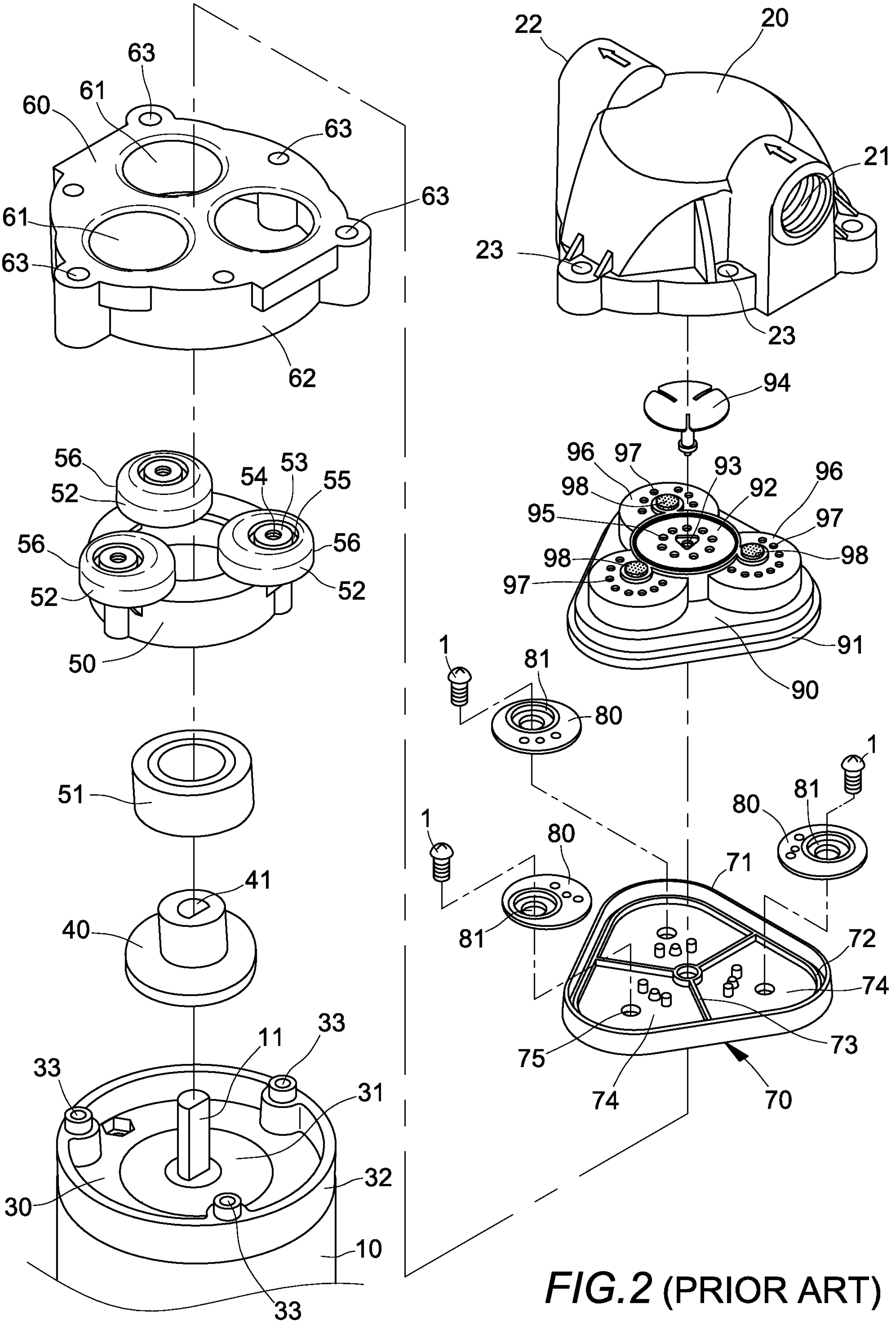

FIG.2 (PRIOR ART)

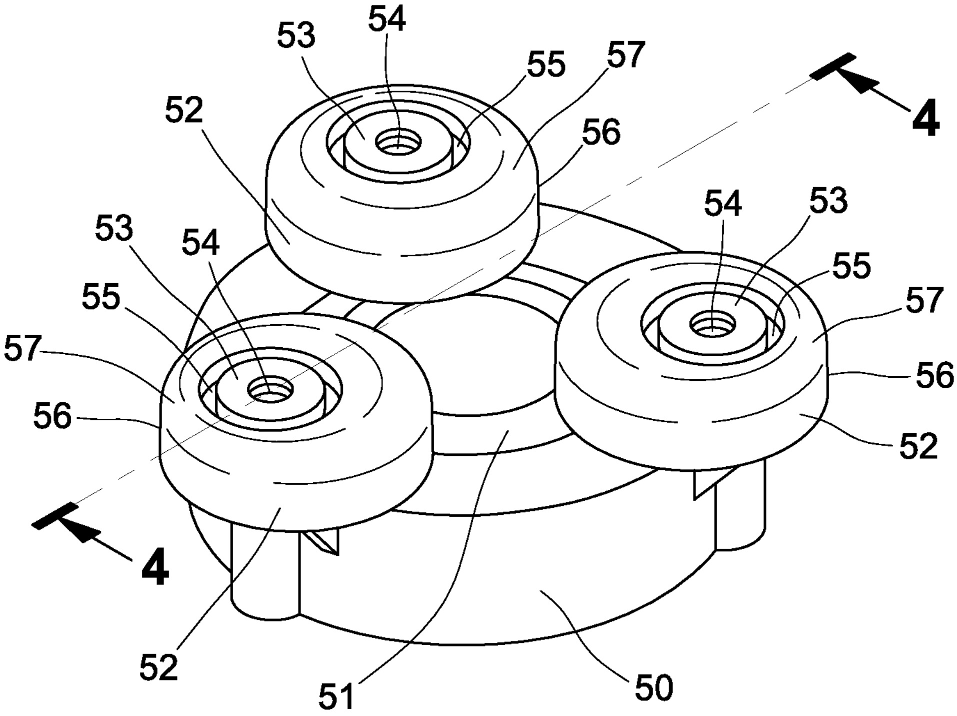

FIG.3 (PRIOR ART)

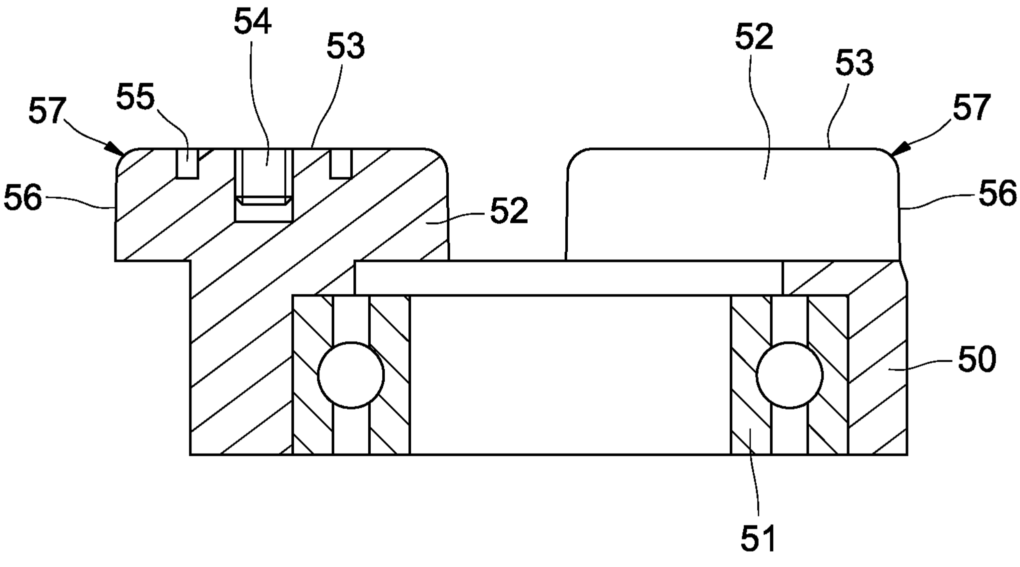

FIG.4 (PRIOR ART)

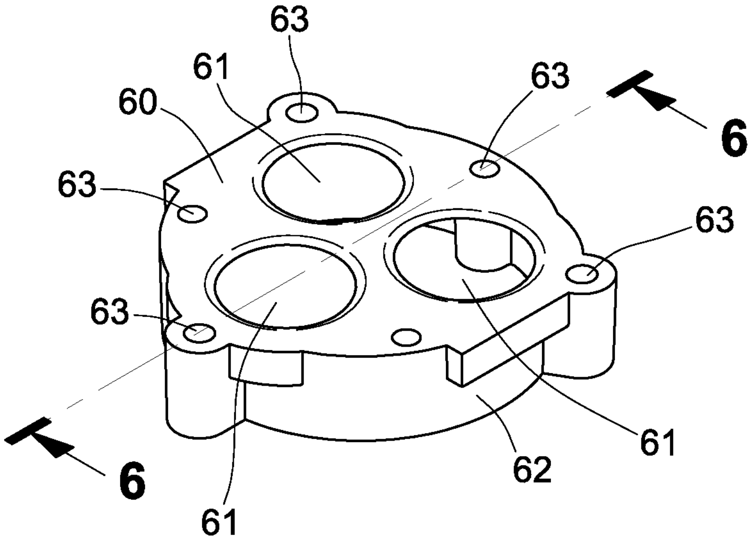

FIG.5 (PRIOR ART)

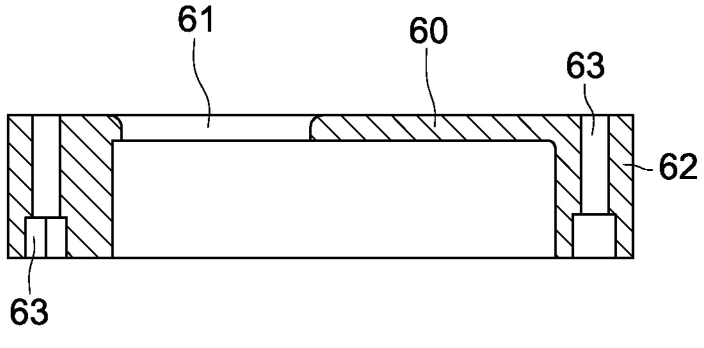

FIG.6 (PRIOR ART)

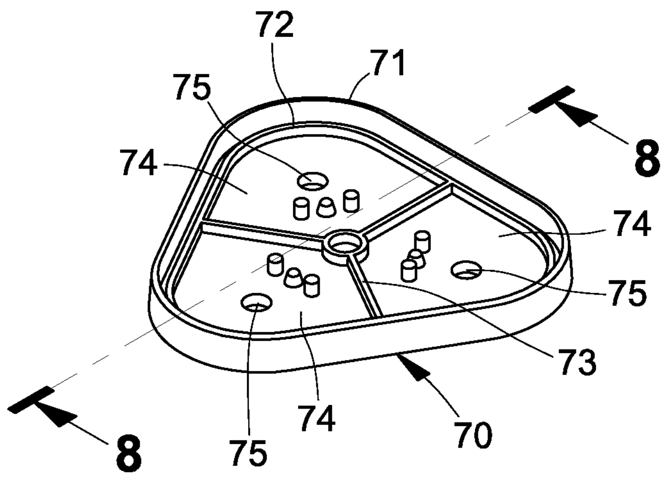

FIG.7 (PRIOR ART)

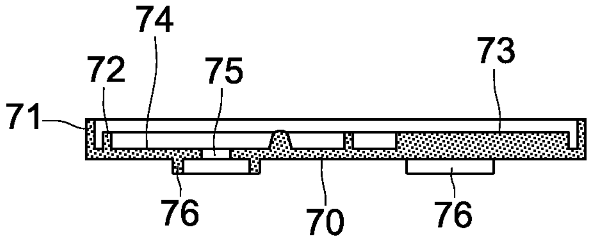

FIG.8 (PRIOR ART)

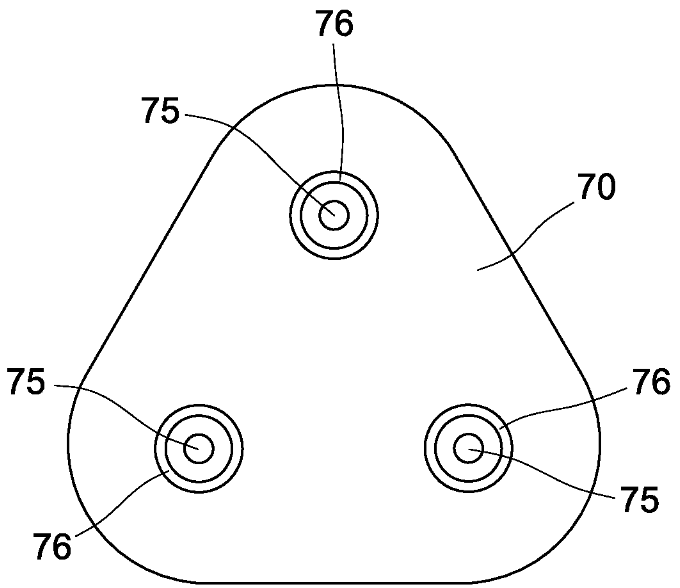

FIG.9 (PRIOR ART)

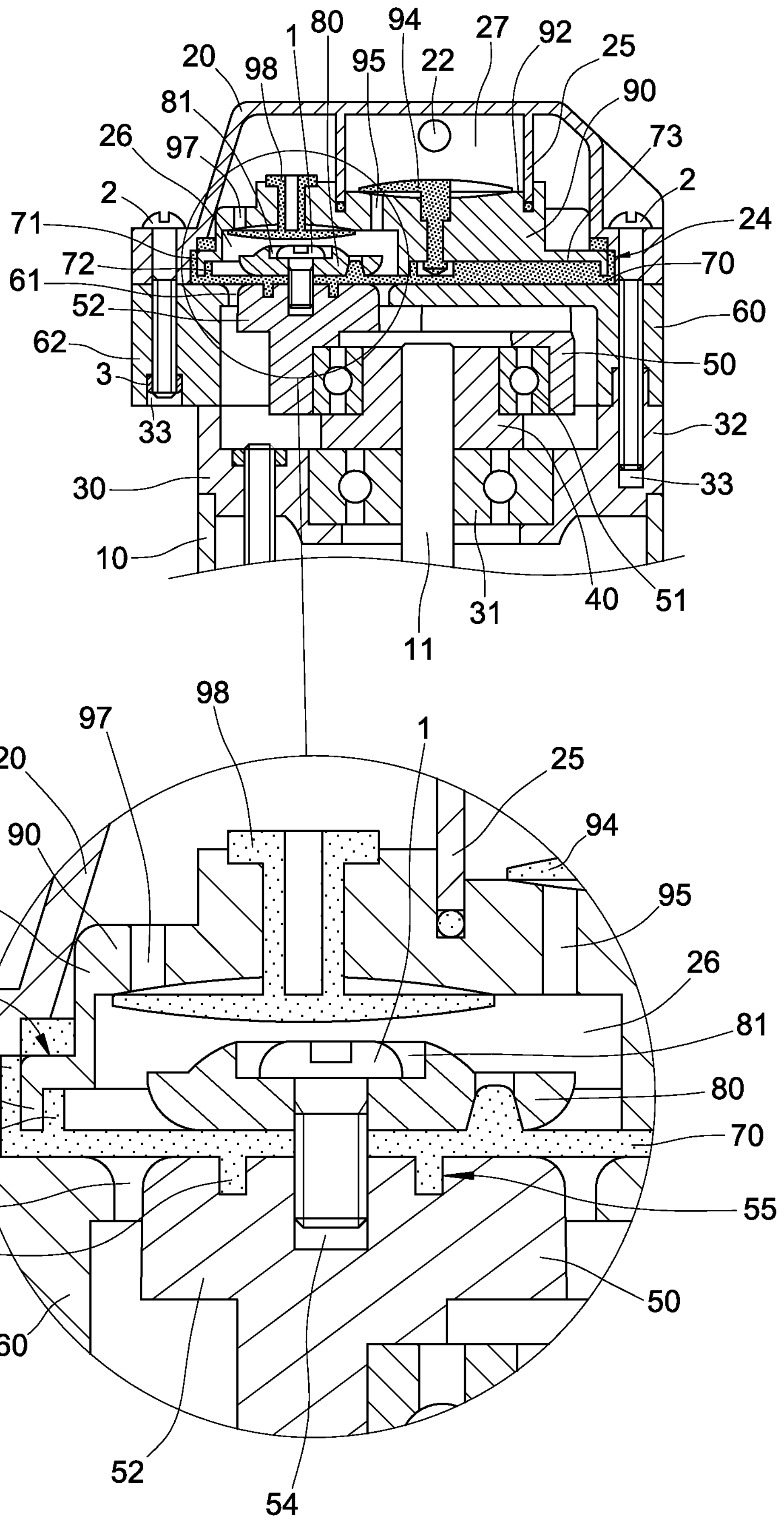

FIG.10 (PRIOR ART)

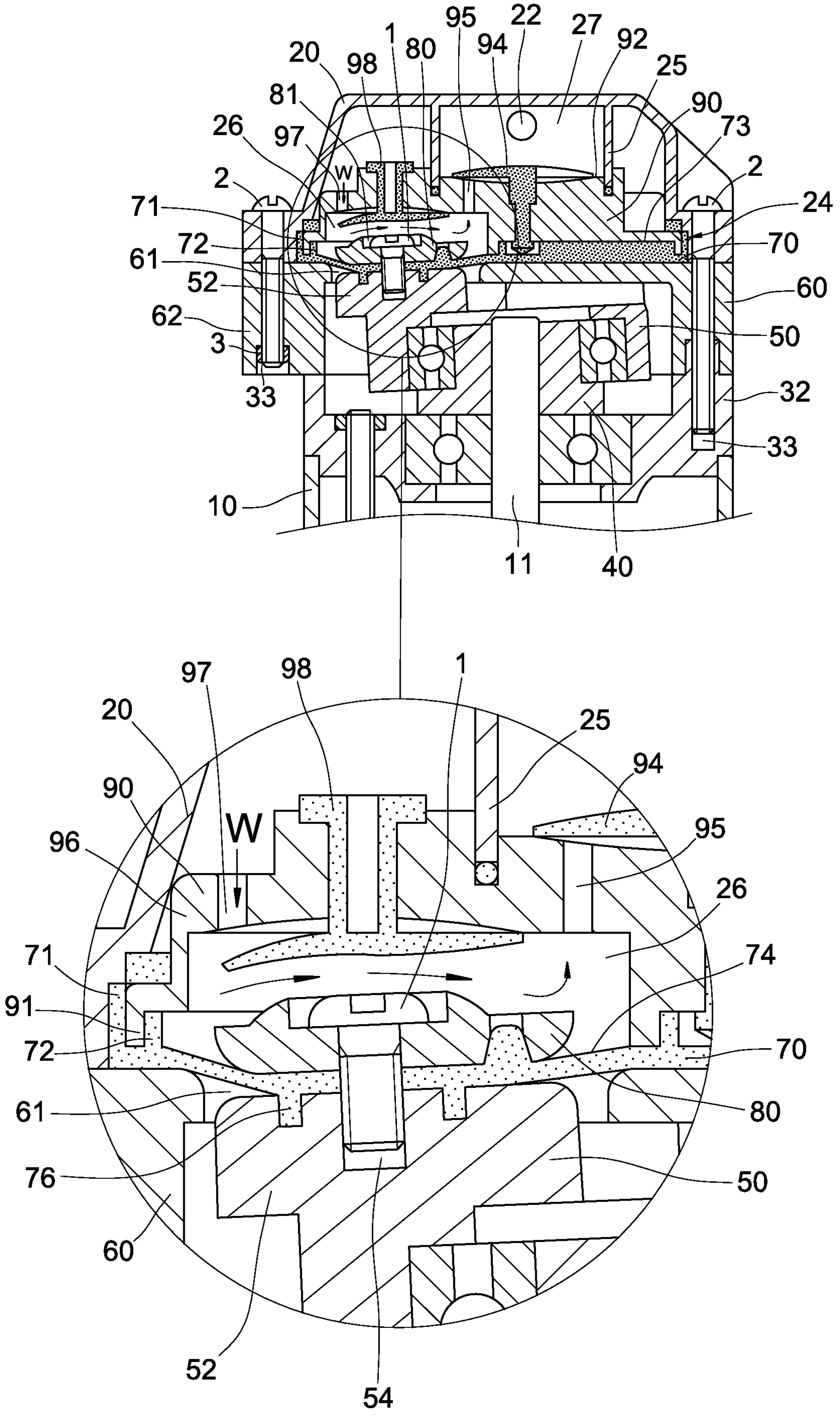

FIG.11 (PRIOR ART)

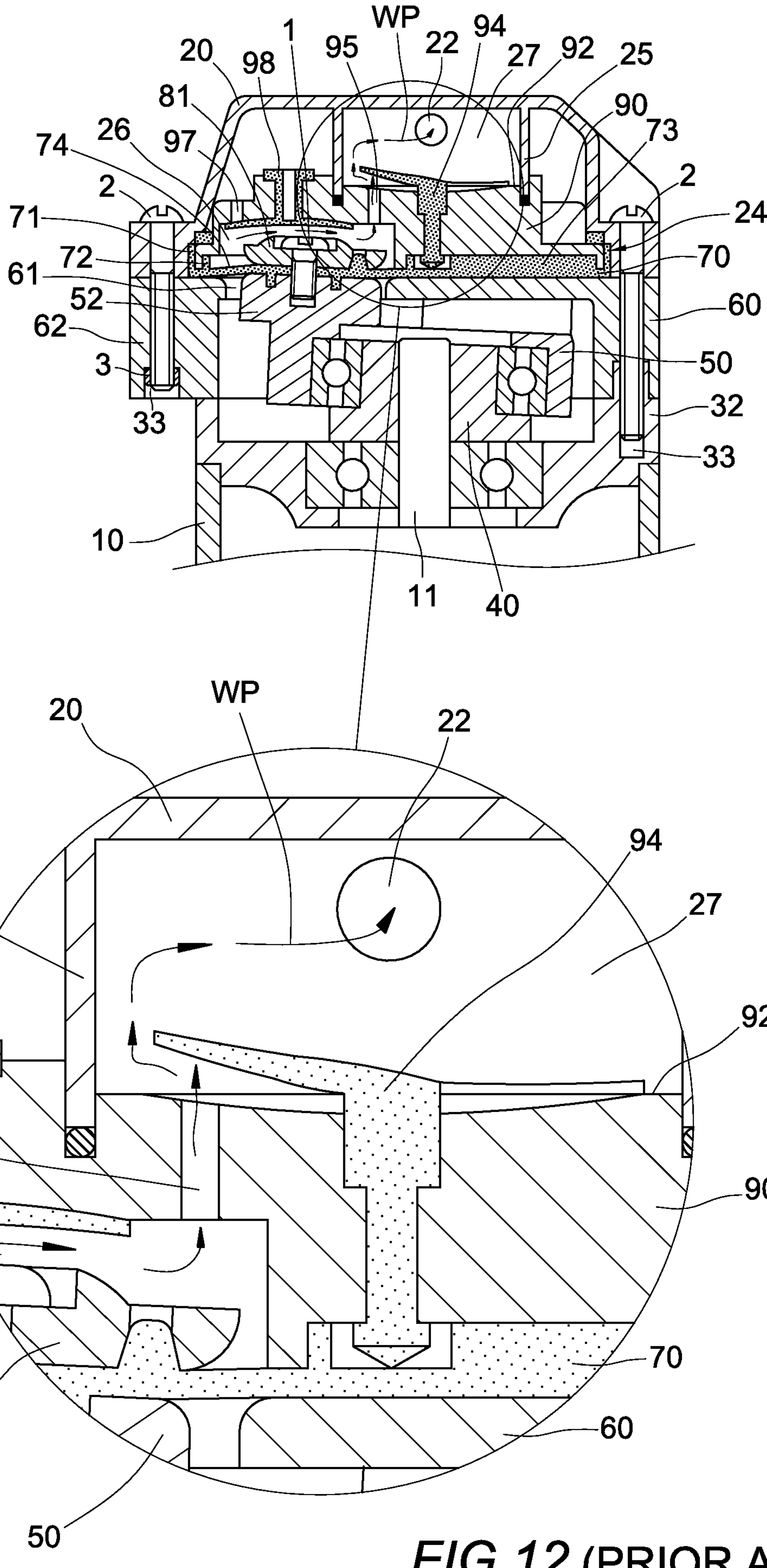

FIG.12 (PRIOR ART)

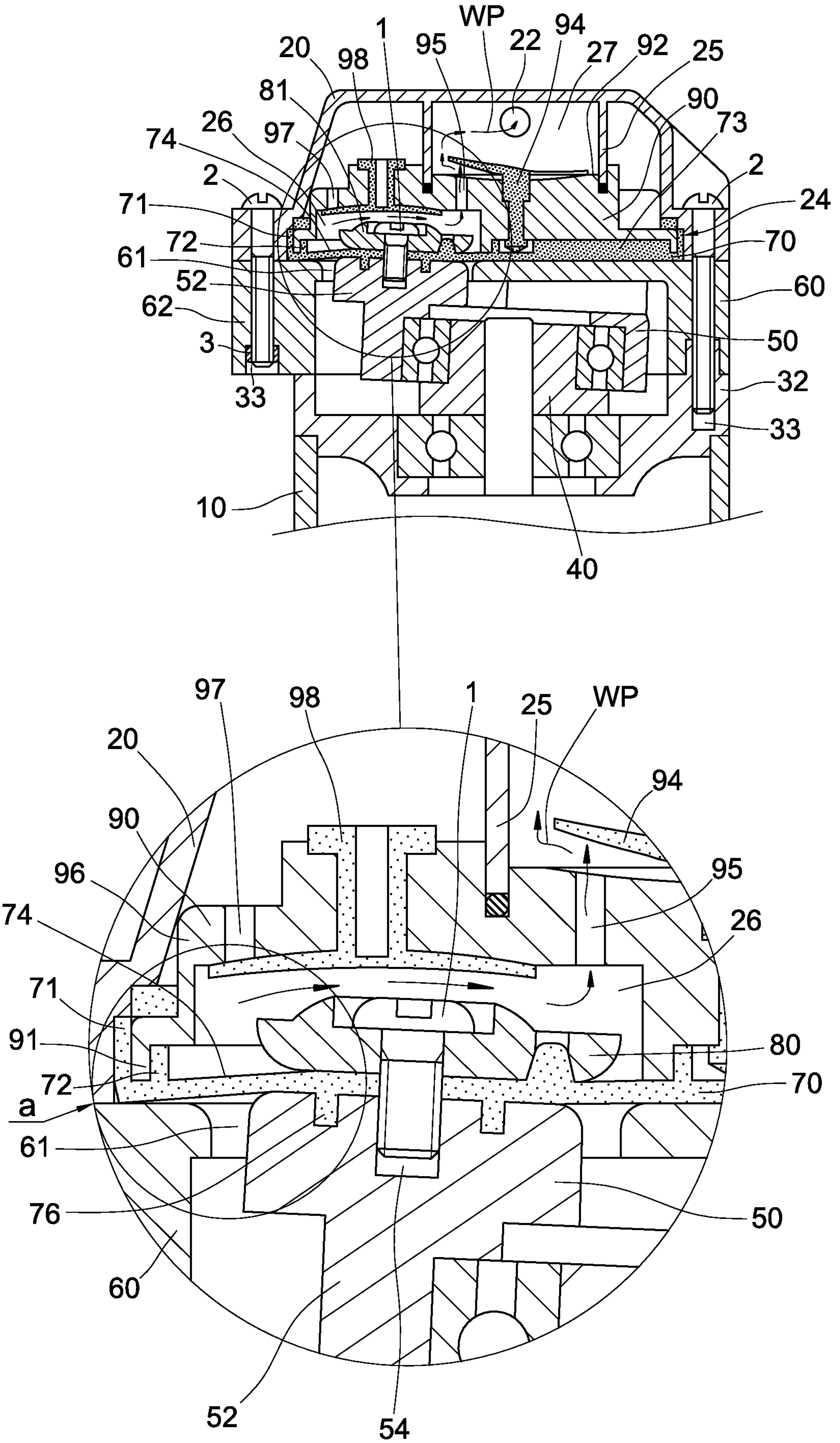

FIG.13 (PRIOR ART)

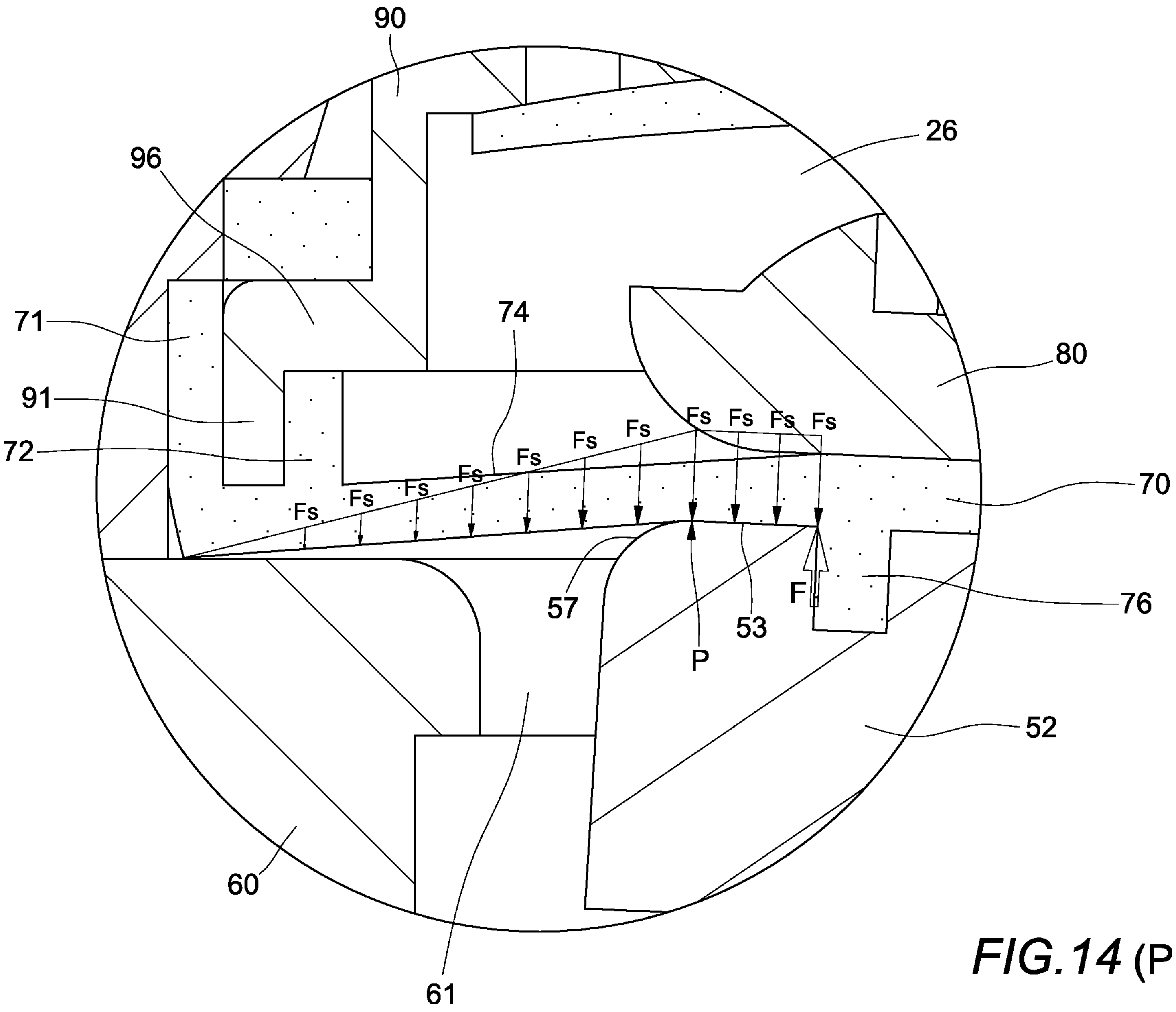

FIG.14 (PRIOR ART)

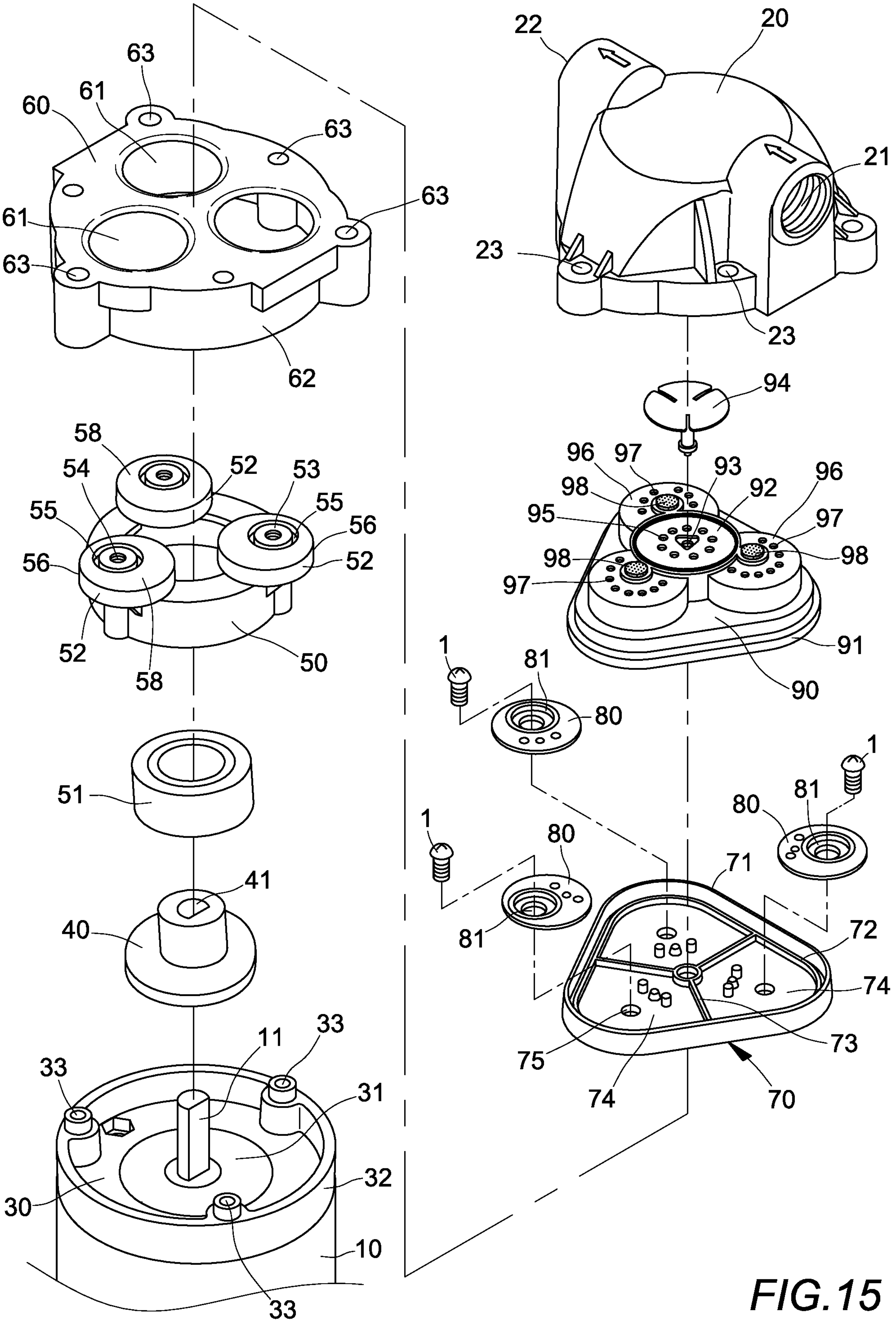
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FIG.15

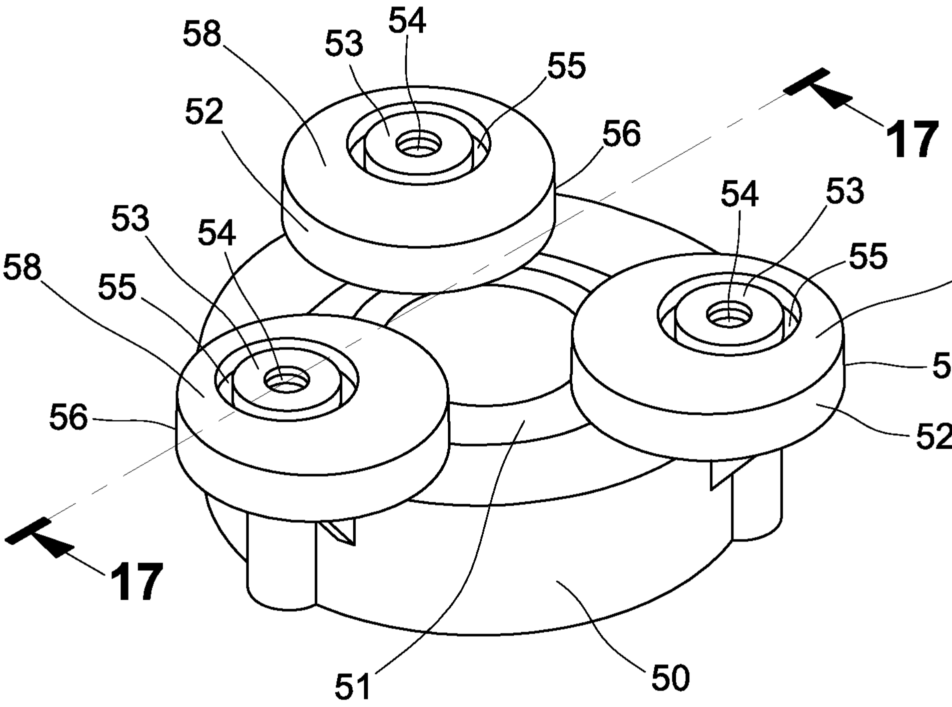
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FIG.16

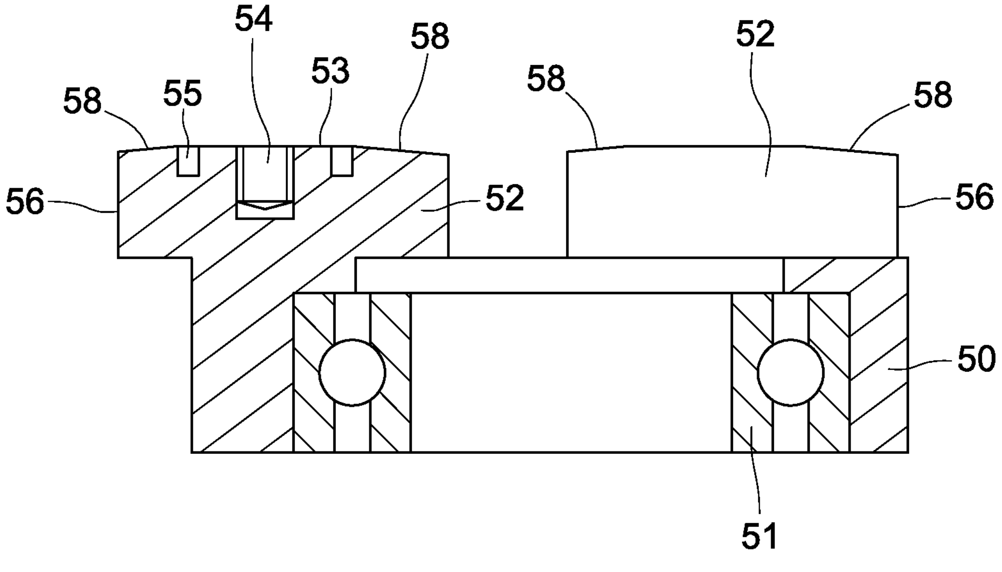
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FIG.17

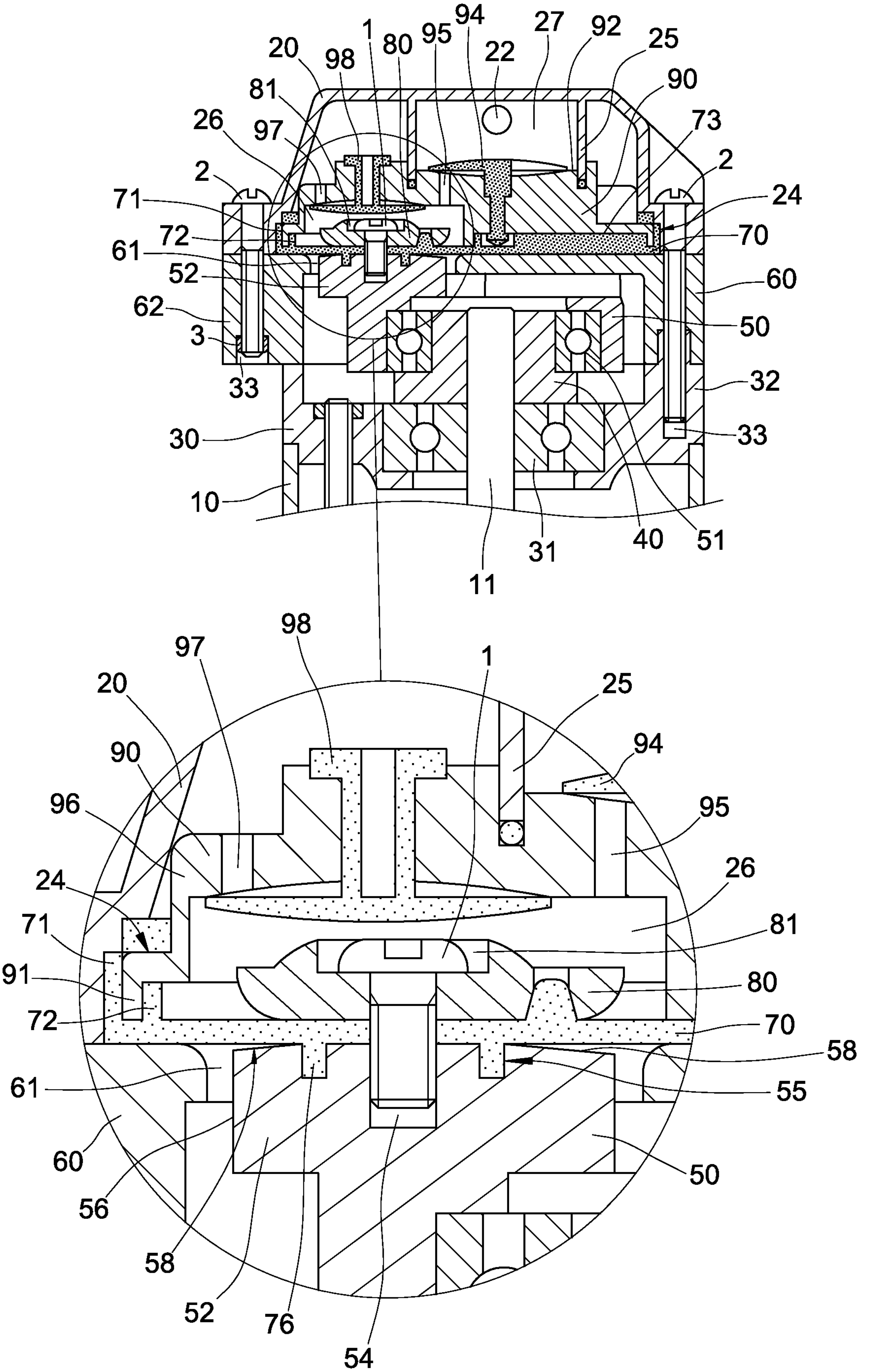
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FIG.18

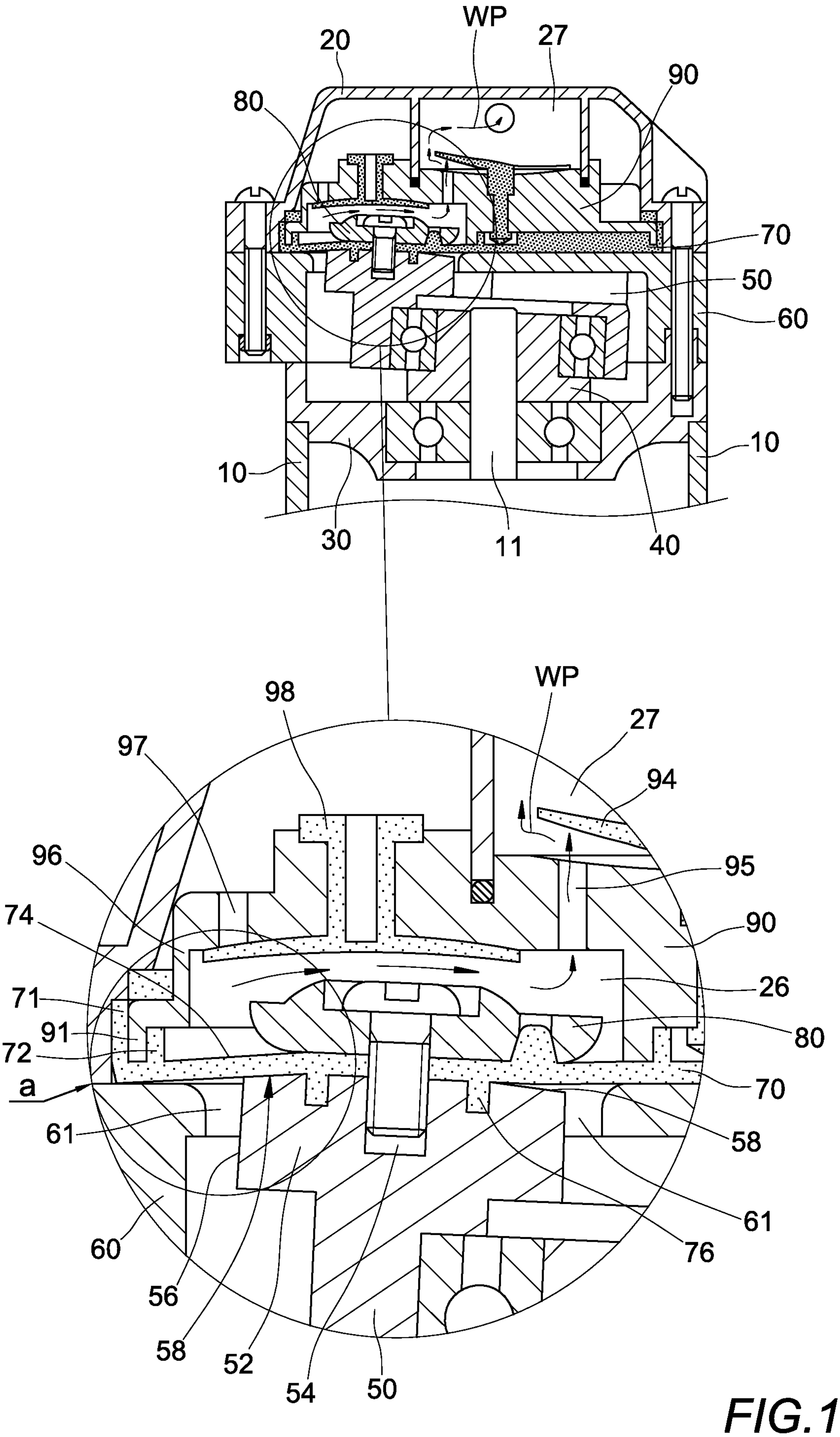
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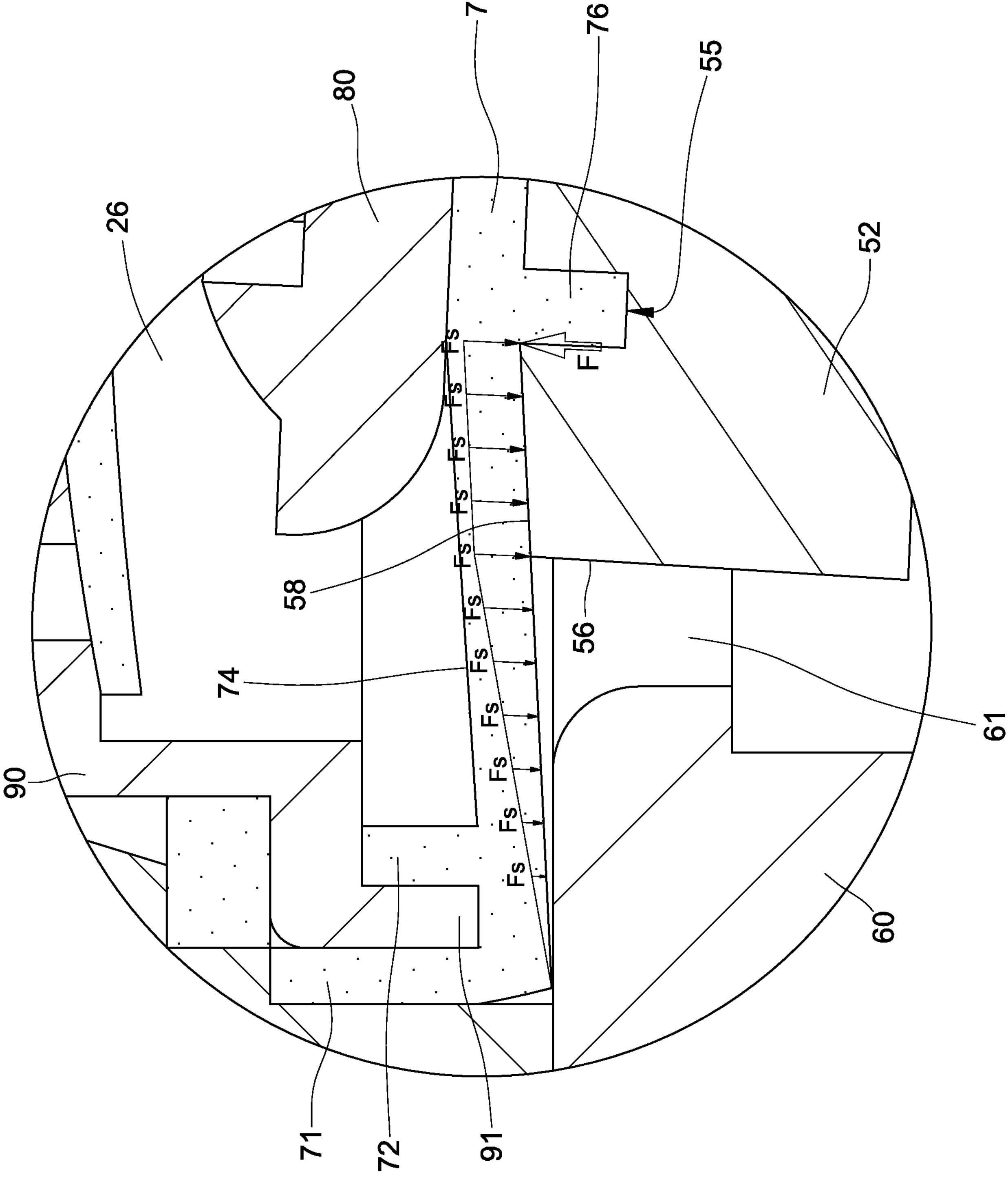
FIG.19

FIG.20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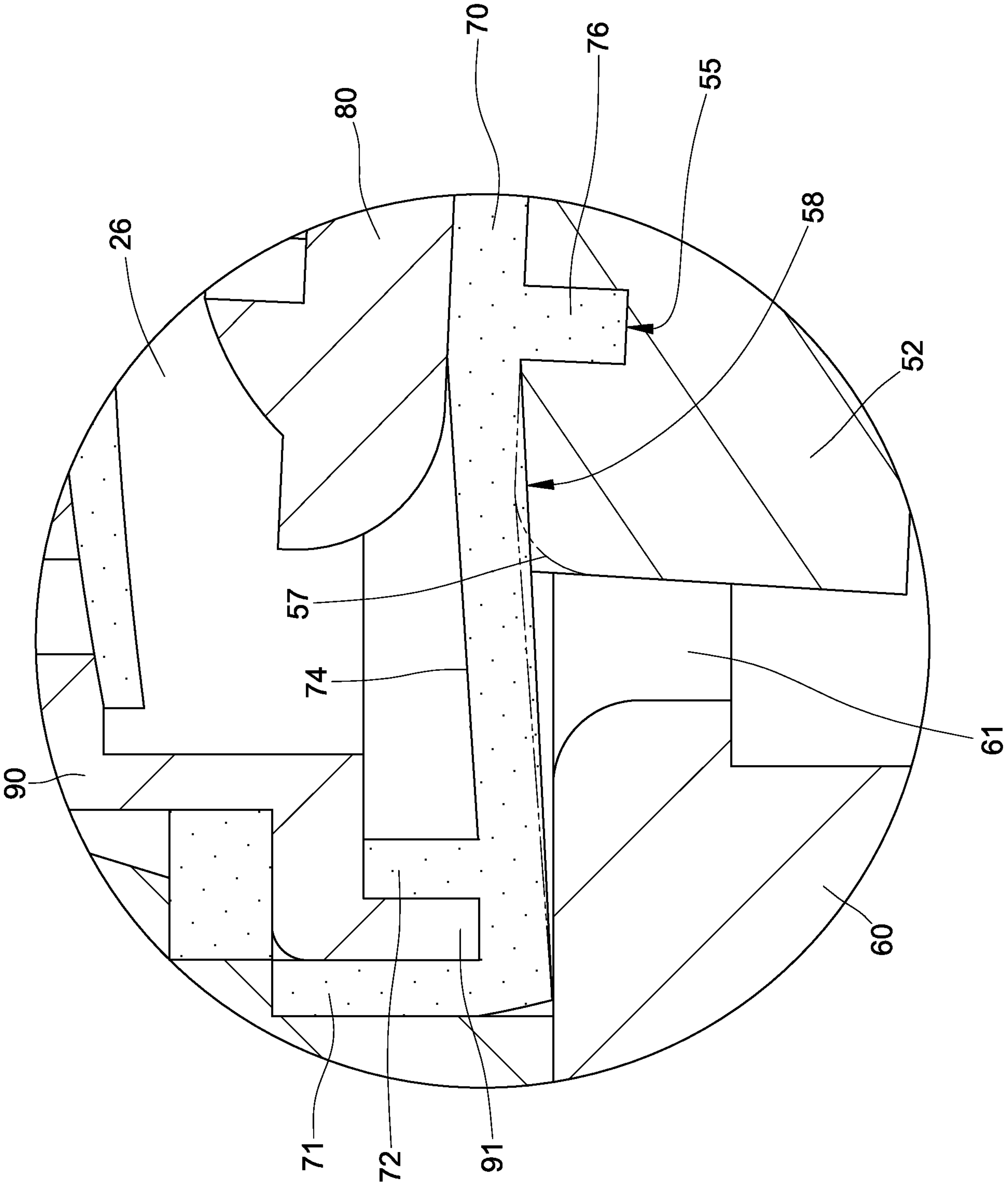

FIG.21

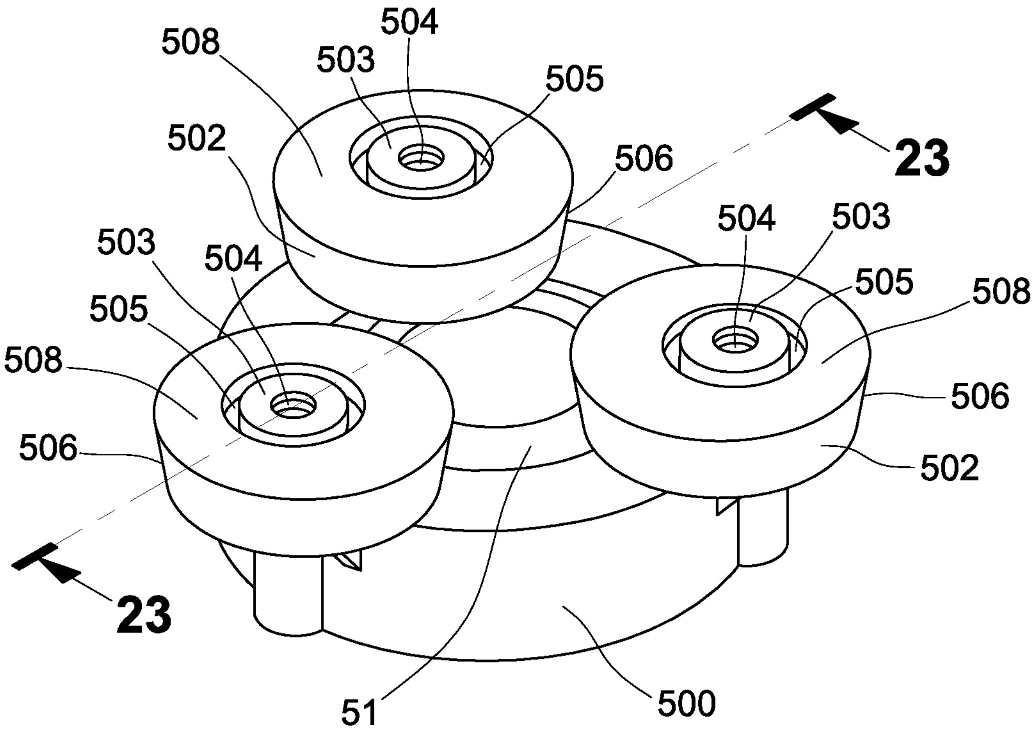
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FIG.22

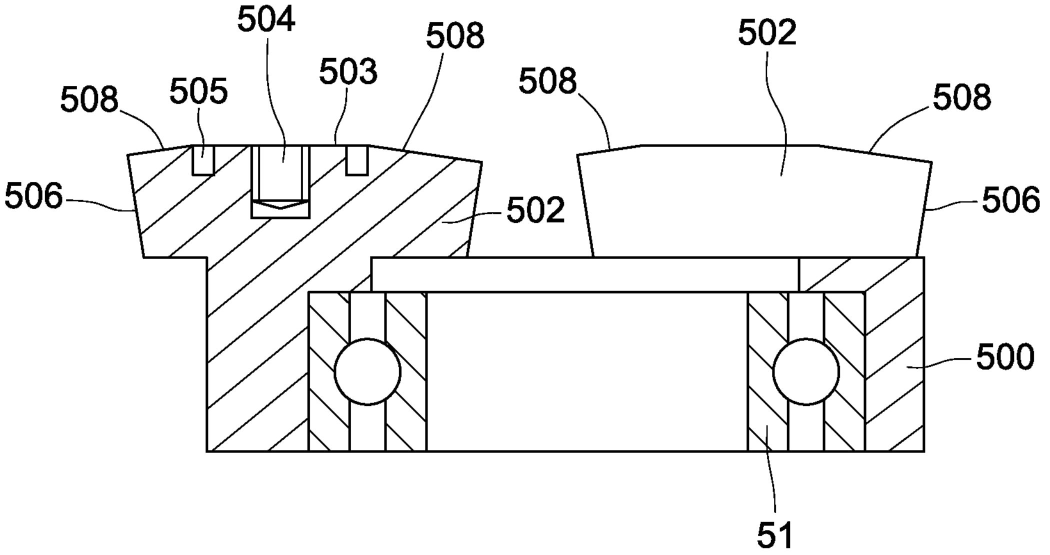
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FIG.23

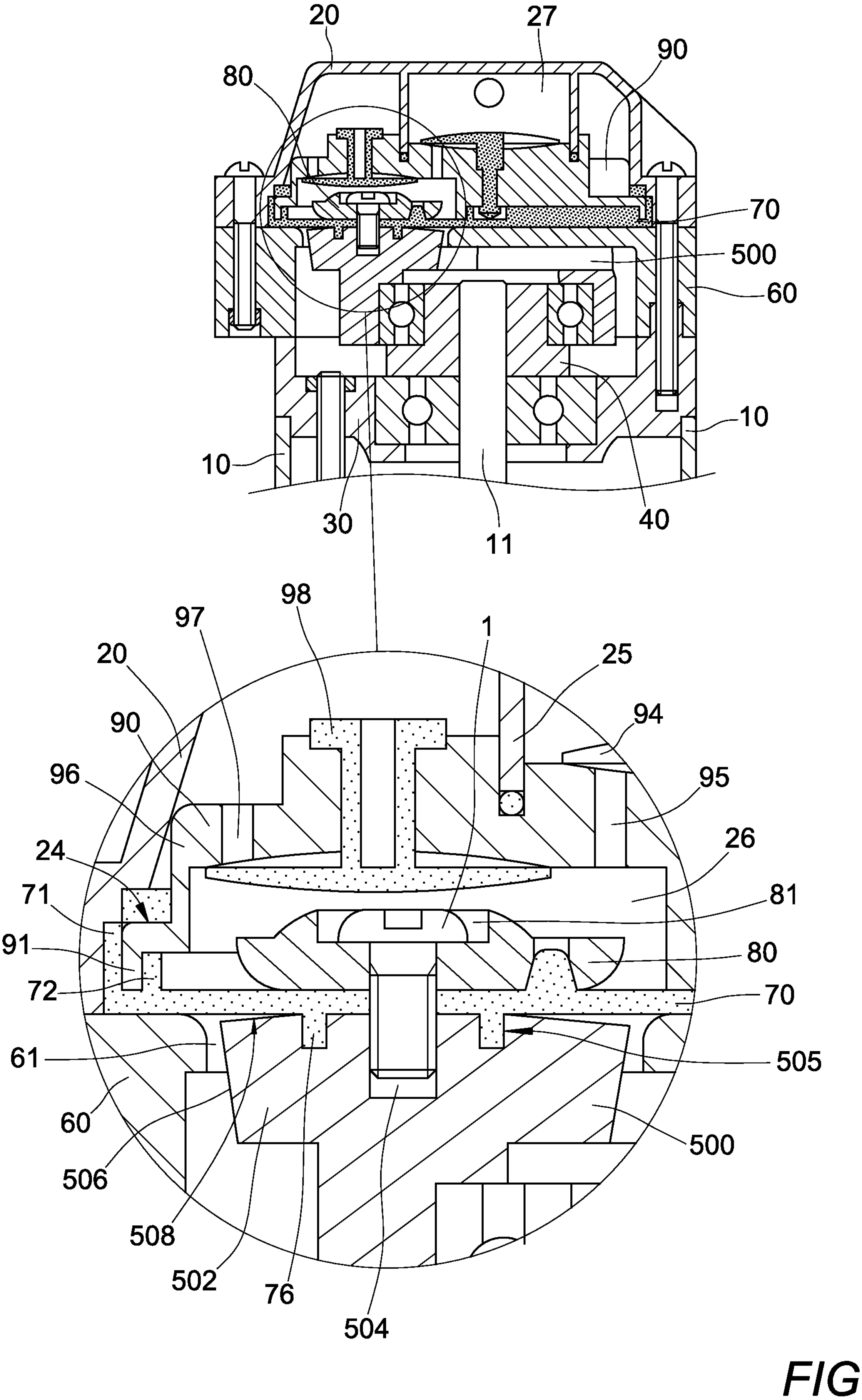
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FIG.24

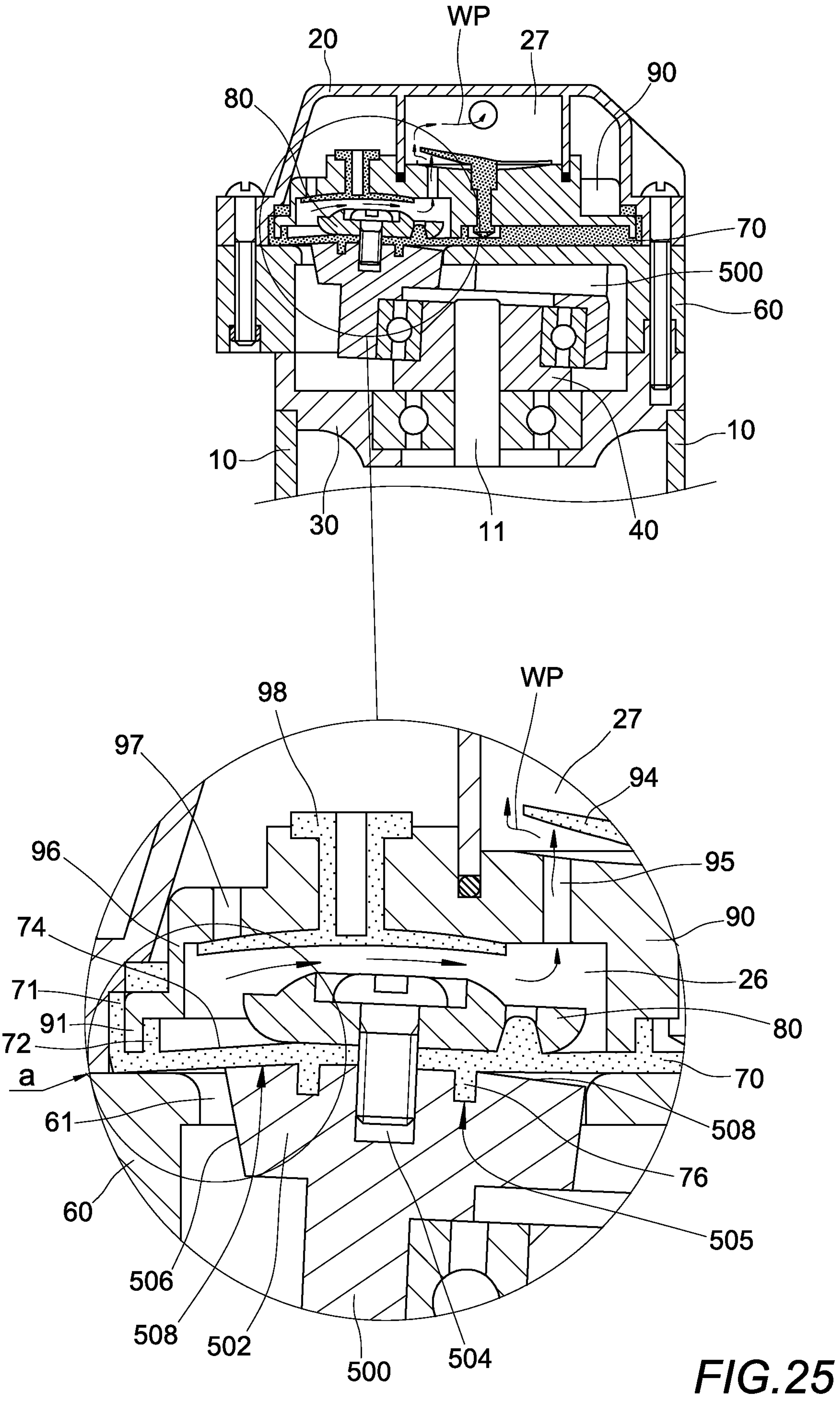
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FIG.25

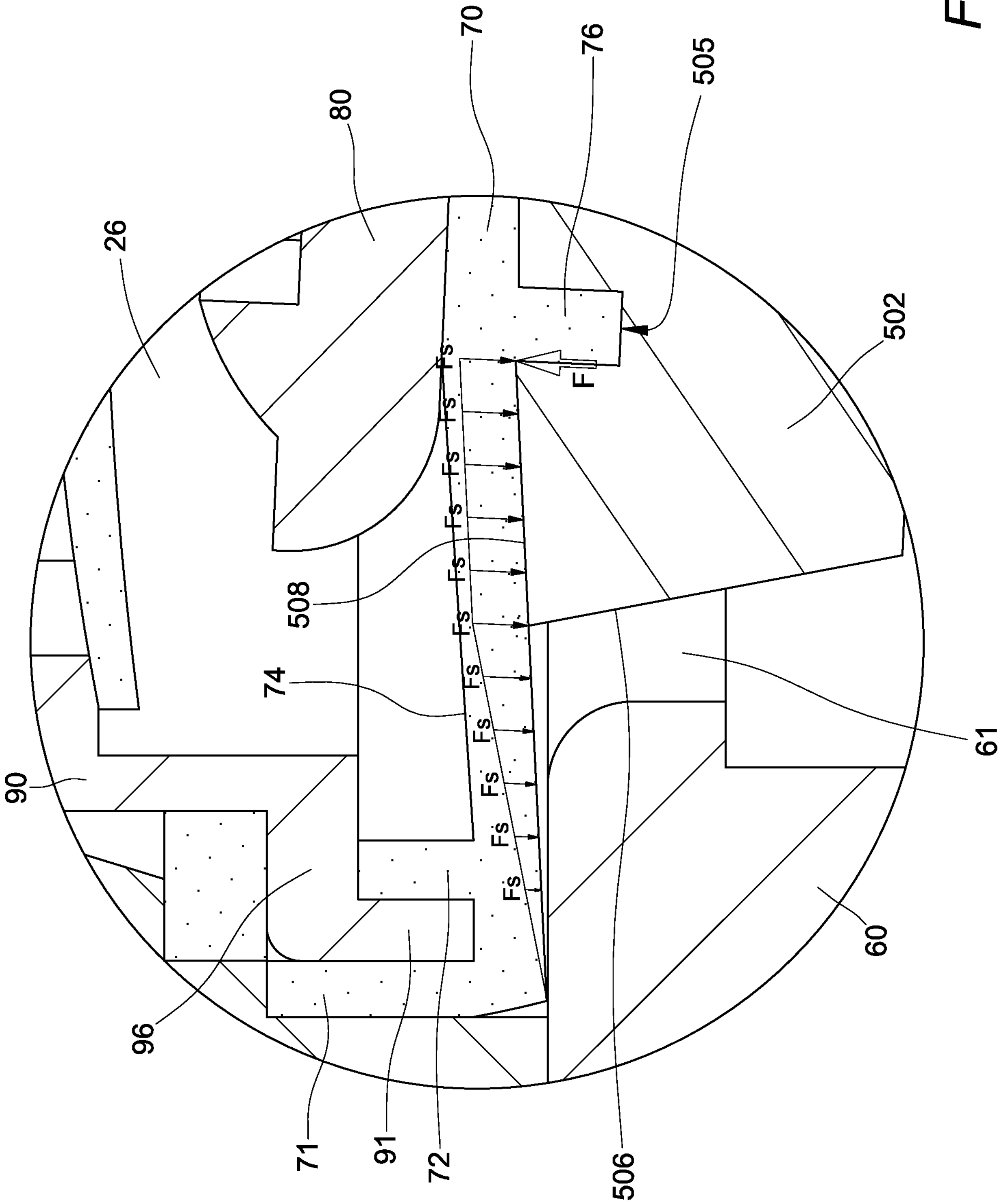
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FIG.26

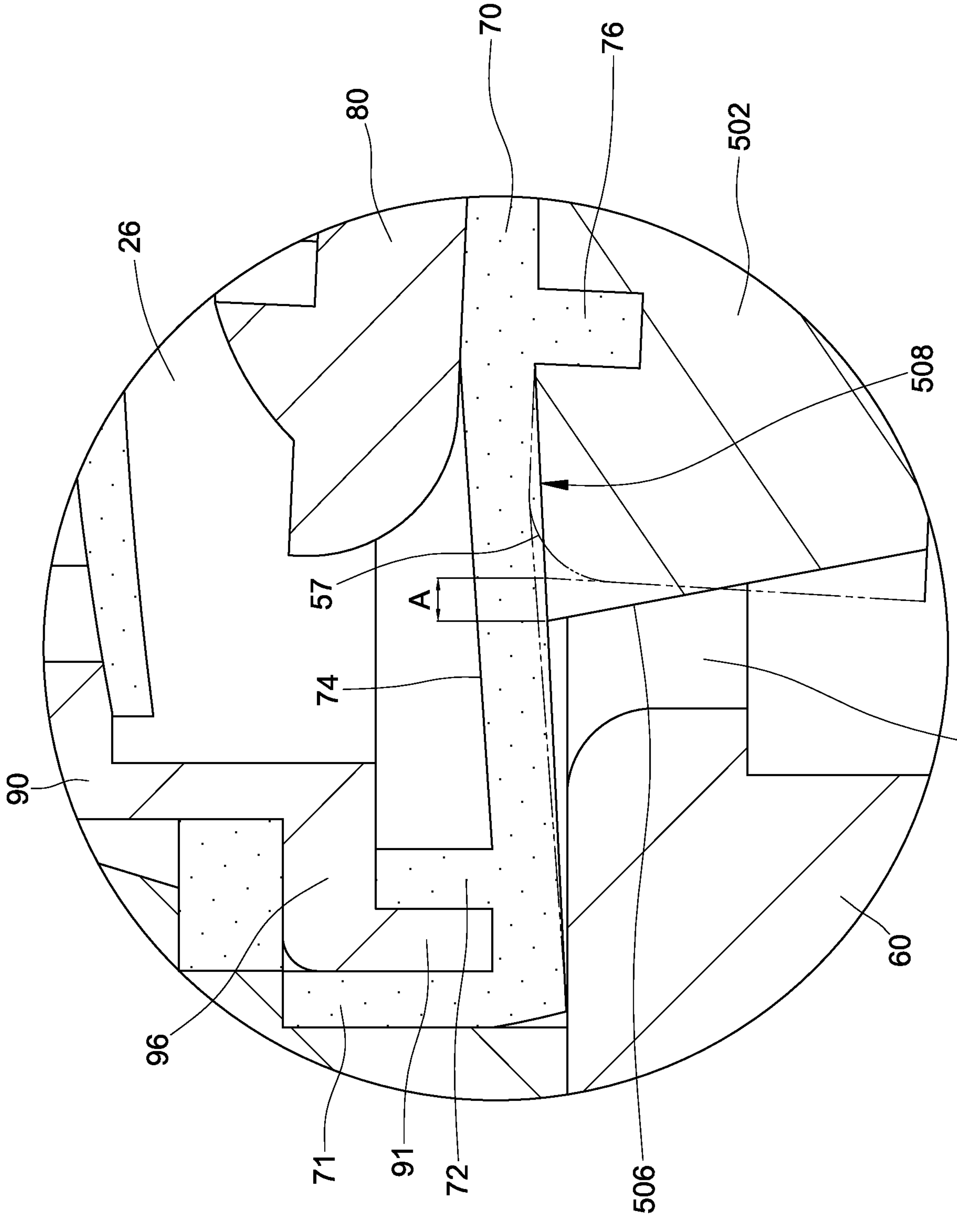

FIG.27

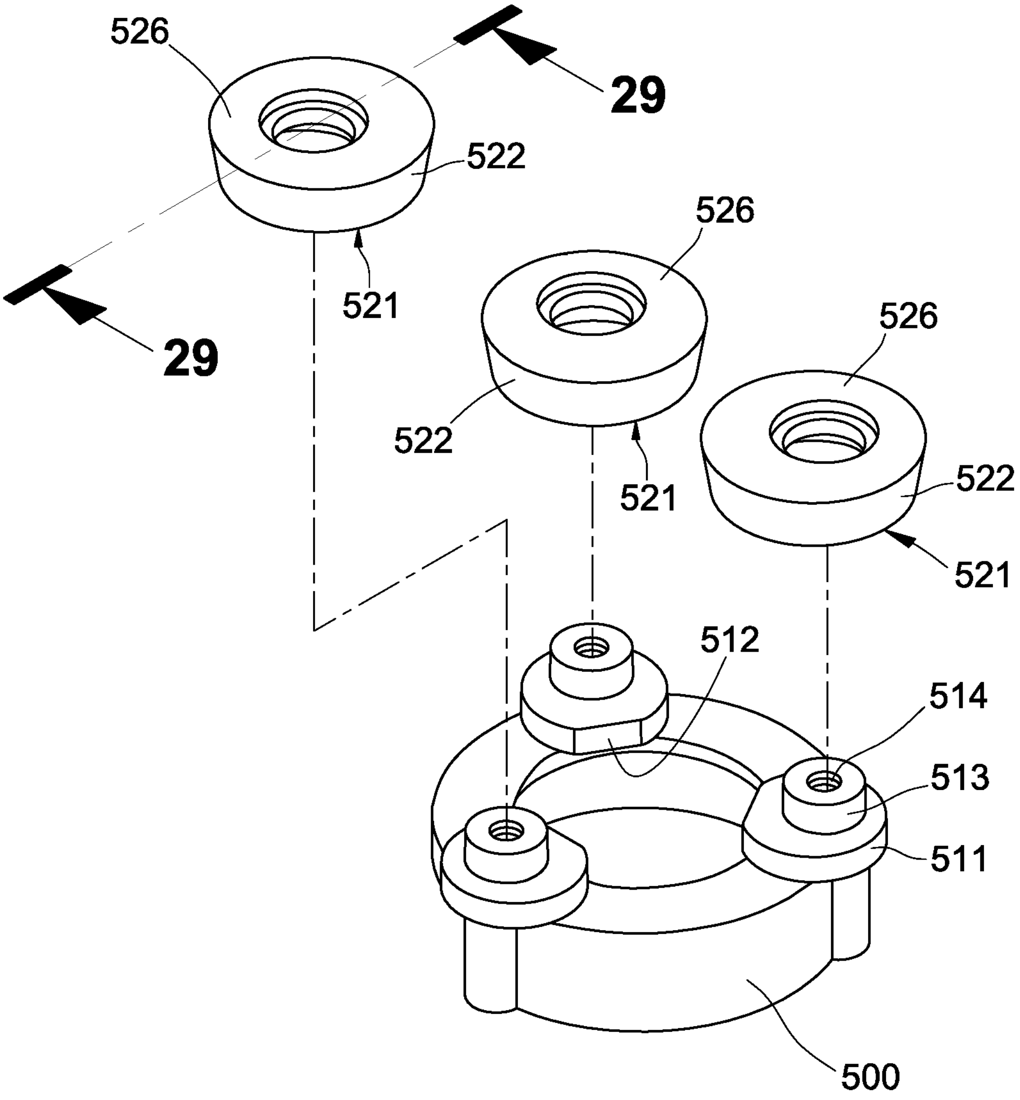
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FIG.28

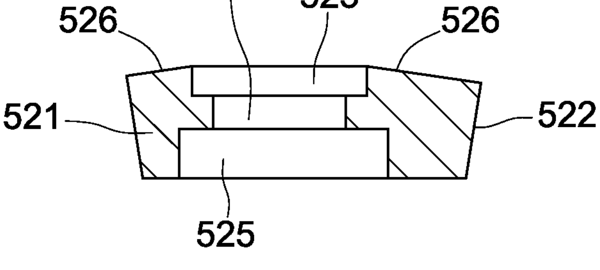
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FIG.29

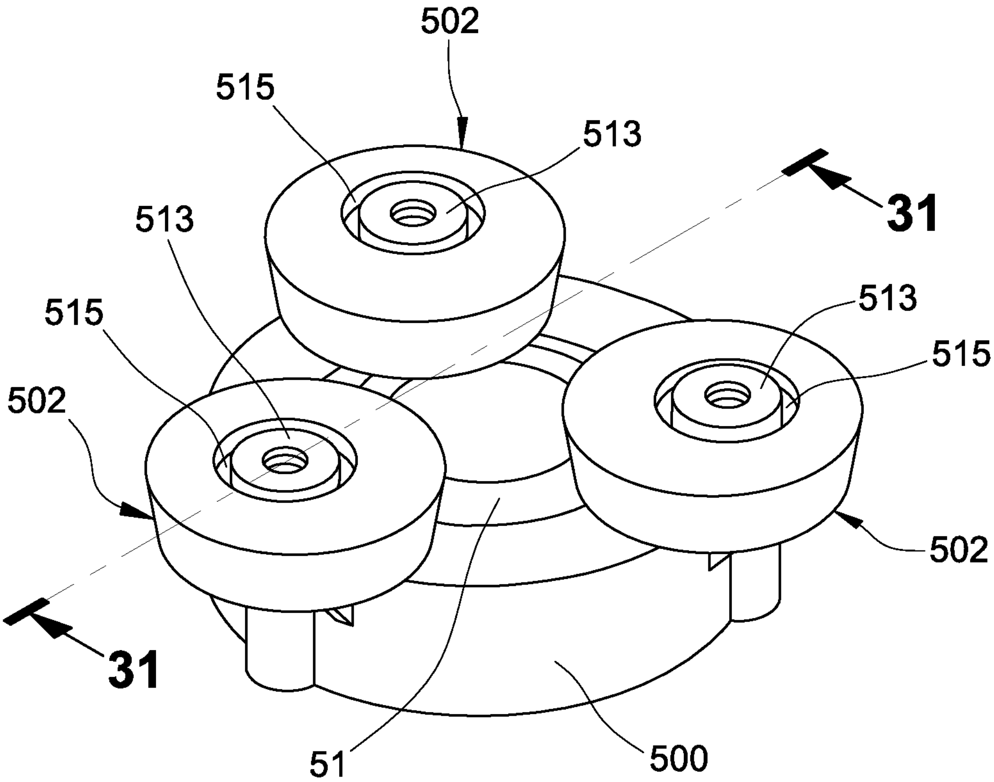
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FIG.30

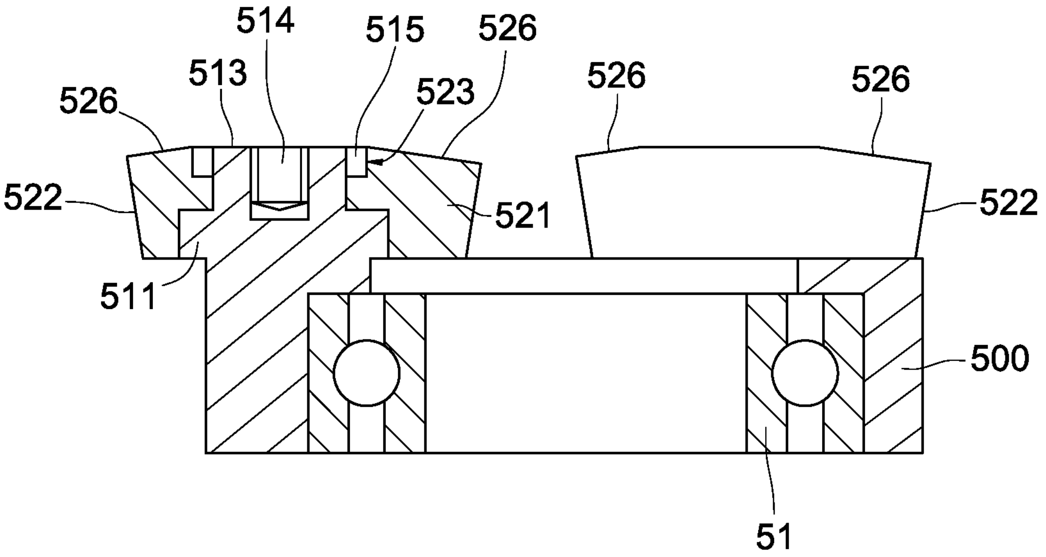
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FIG.31

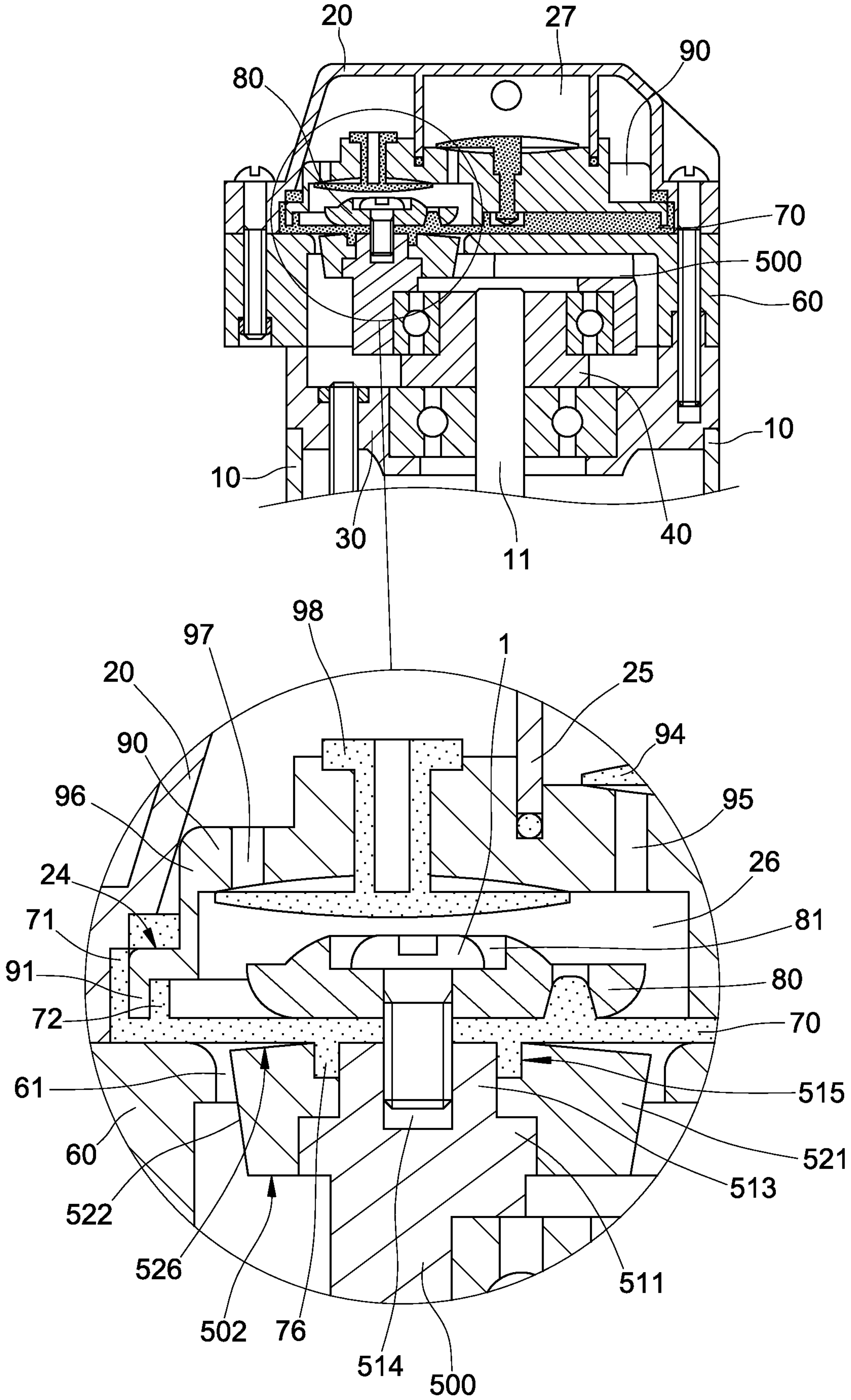
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FIG.32

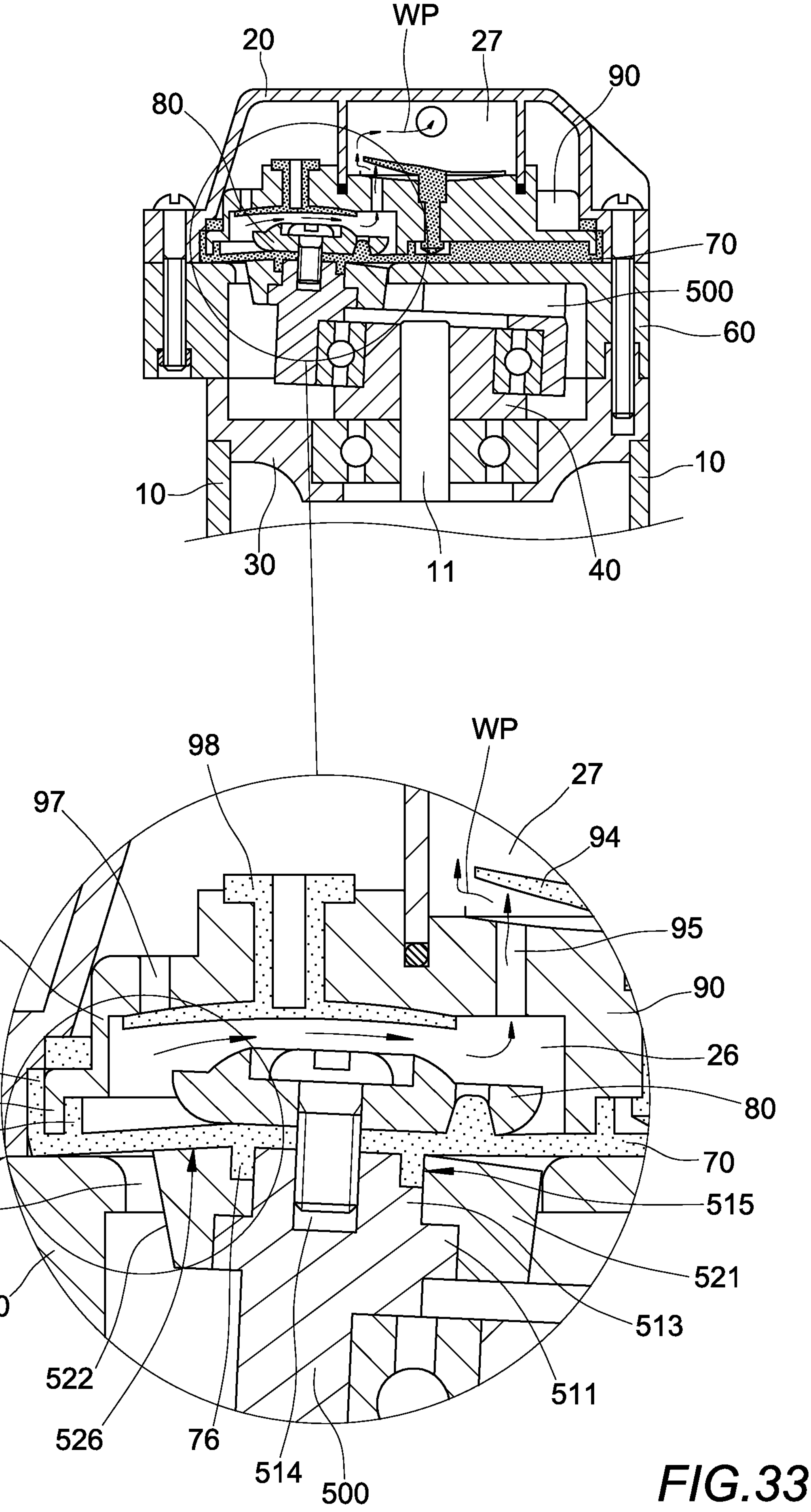
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FIG.33

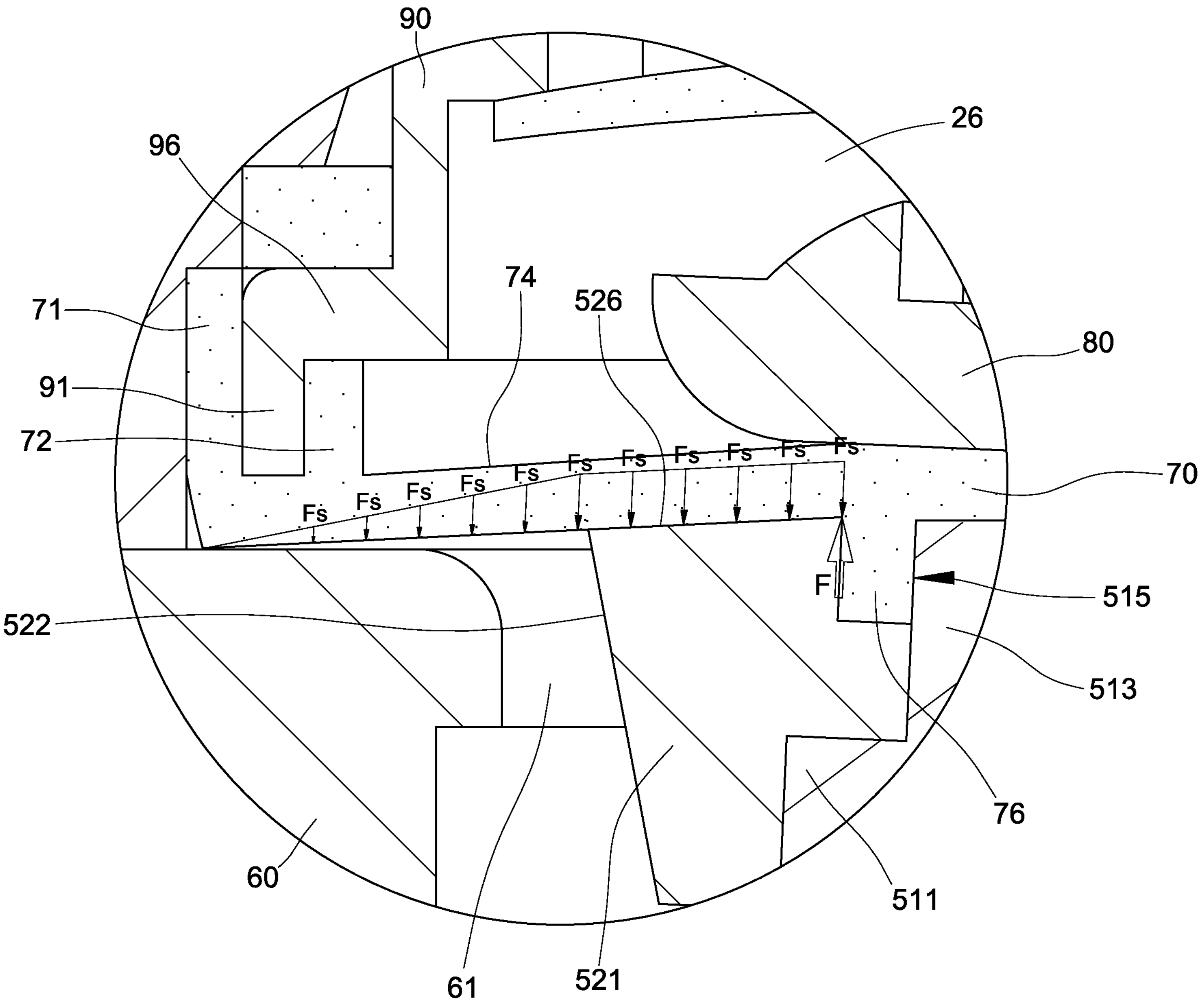
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FIG.34

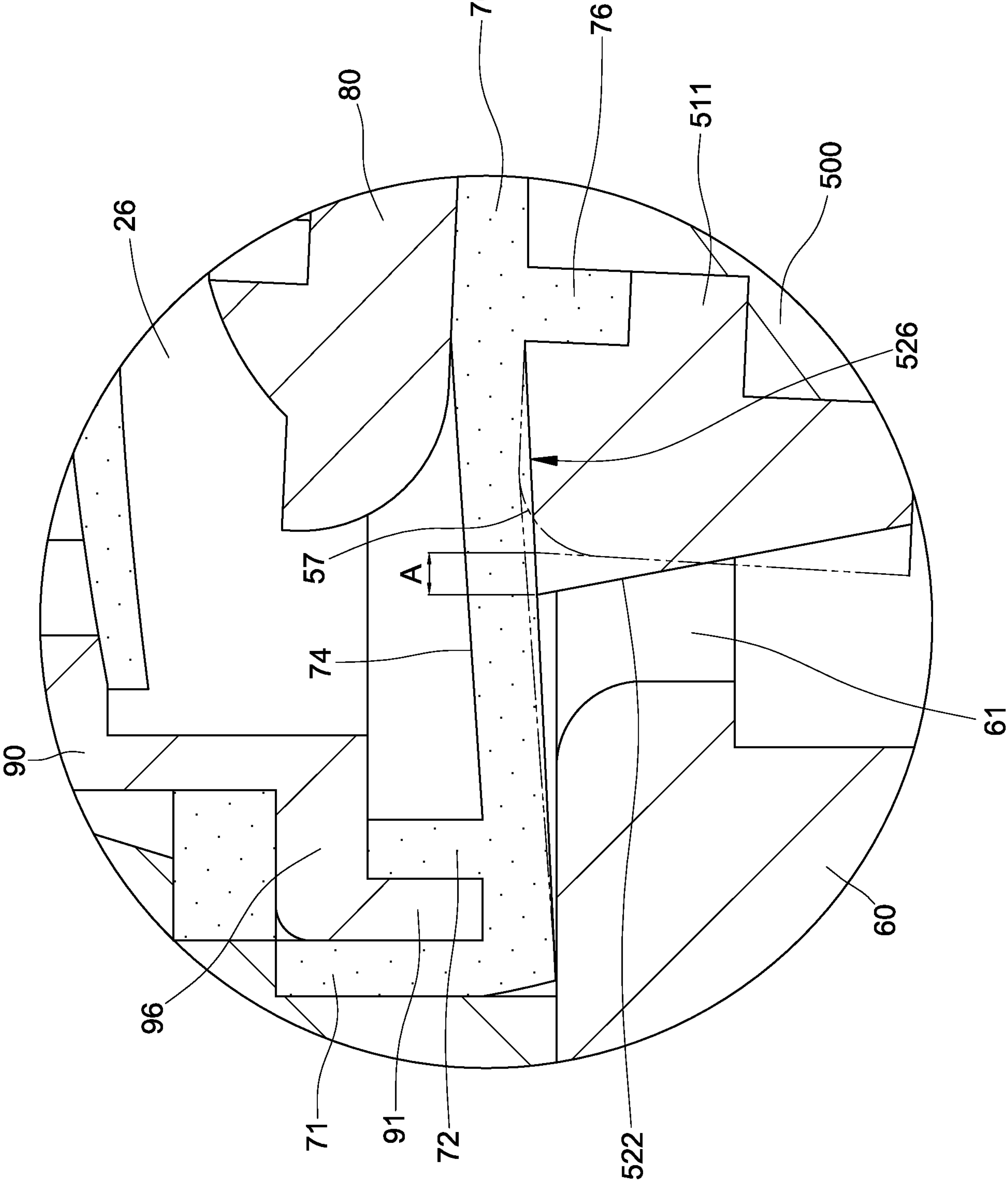

FIG.35

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/028137

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F04B 43/067 (2015.01)
CPC - F04B 43/067 (2015.07)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - E03B 5/00; F04B 43/02, 43/06, 43/067; G05D 16/02 (2015.01)
CPC - F04B 43/026, 43/067, 53/001, 53/003, 53/16; G05D 16/02 (2015.07) (keyword delimited)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 92/190; 137/510, 565.11; 417/244, 270, 321, 387, 388, 441

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patent, Google Scholar
diaphragm, membrane, pump, piston, sloped, positioning, groove, annular, eccentric, roundel, compressing, reciprocating, wobble, mount, reverse, osmosis, water, project, force, top

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/0068082 A1 (CAI et al) 18 March 2010 (18.03.2010) entire document	1-12
A	US 2007/0041845 A1 (FREUDENBERGER) 22 February 2007 (22.02.2007) entire document	1-12
A	US 5,306,122 A (GEBAUER et al) 26 April 1994 (26.04.1994) entire document	1-12
A	US 5,554,014 A (BECKER) 10 September 1996 (10.09.1996) entire document	1-12
A	US 6,276,907 B1 (COOPER et al) 21 August 2001 (21.08.2001) entire document	1-12

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 07 July 2015	Date of mailing of the international search report 22 JUL 2015
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774