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Forest

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(54) **PRESSURE ENHANCER VALUE SYSTEM**

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(22) Filed: **Jun. 4, 2003**

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(51) **Int. Cl.**
F04B 17/00 (2006.01)

(52) **U.S. Cl.** **417/225**; 417/226; 417/393; 417/401; 417/534

(58) **Field of Classification Search** 417/225, 417/226, 393, 401, 534
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,386,888 A * 6/1983 Verley 417/393
4,515,516 A * 5/1985 Perrine et al. 417/38
4,627,794 A * 12/1986 Silva 417/225
4,674,958 A * 6/1987 Igarashi et al. 417/225
4,927,335 A * 5/1990 Pensa 417/393
5,462,414 A * 10/1995 Permar 417/313

* cited by examiner

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(57) **ABSTRACT**

A system to intensify pressure supplied by a conventional pump where a piston assembly having two piston members at opposite ends is positioned in a pressure cylinder. The laterally outer subchambers are defined by the piston members and the cylinder and are adapted to receive fluid at an operating pressure provided by the pump and produce intensified pressure at the opposite outer subchamber. A pressure distributing system alternates returning fluid at intensified pressure to the inner subchamber near the outer subchamber creating the intensified pressure.

8 Claims, 19 Drawing Sheets

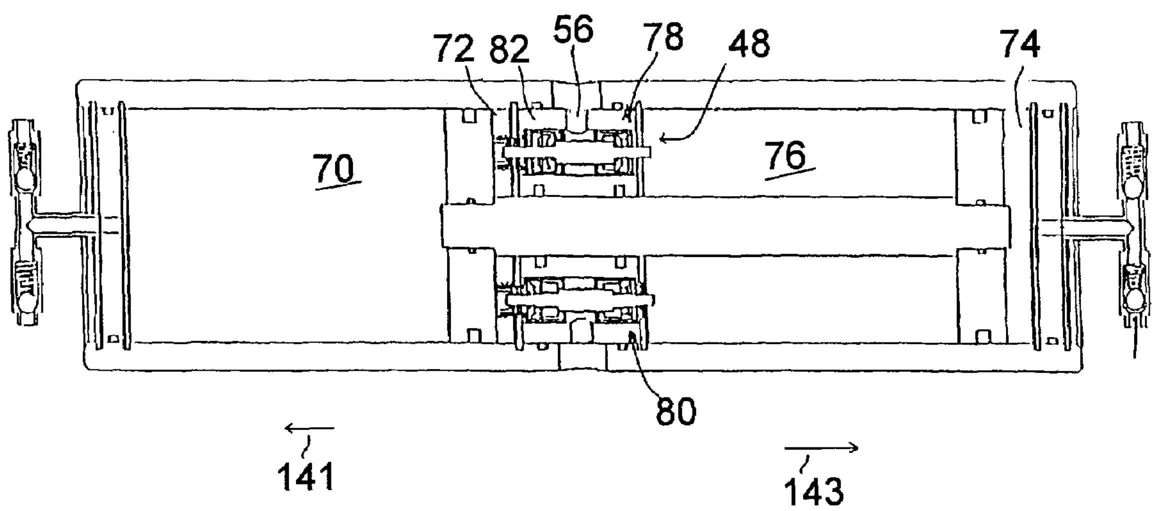

Fig. 1

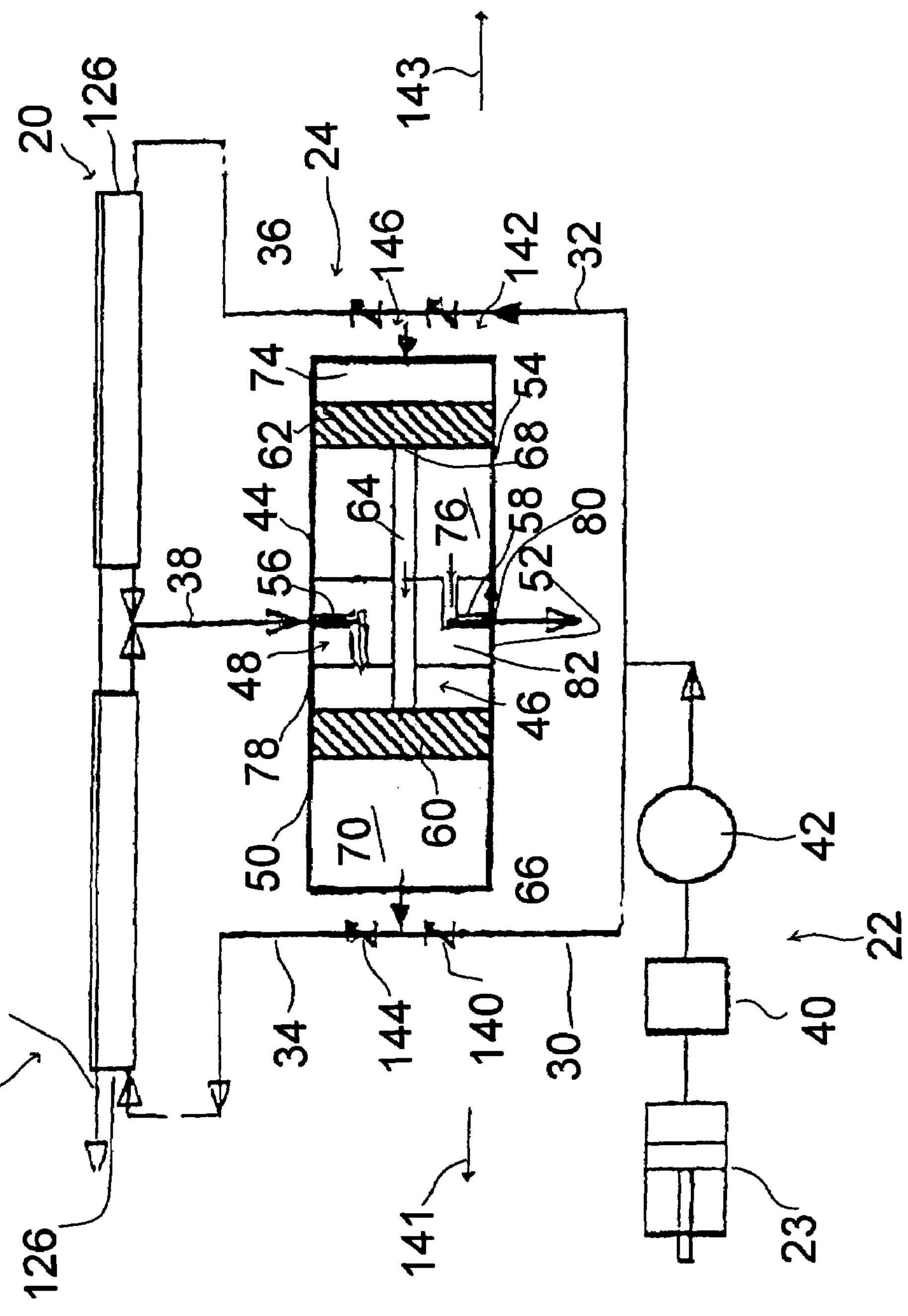
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Fig. 2

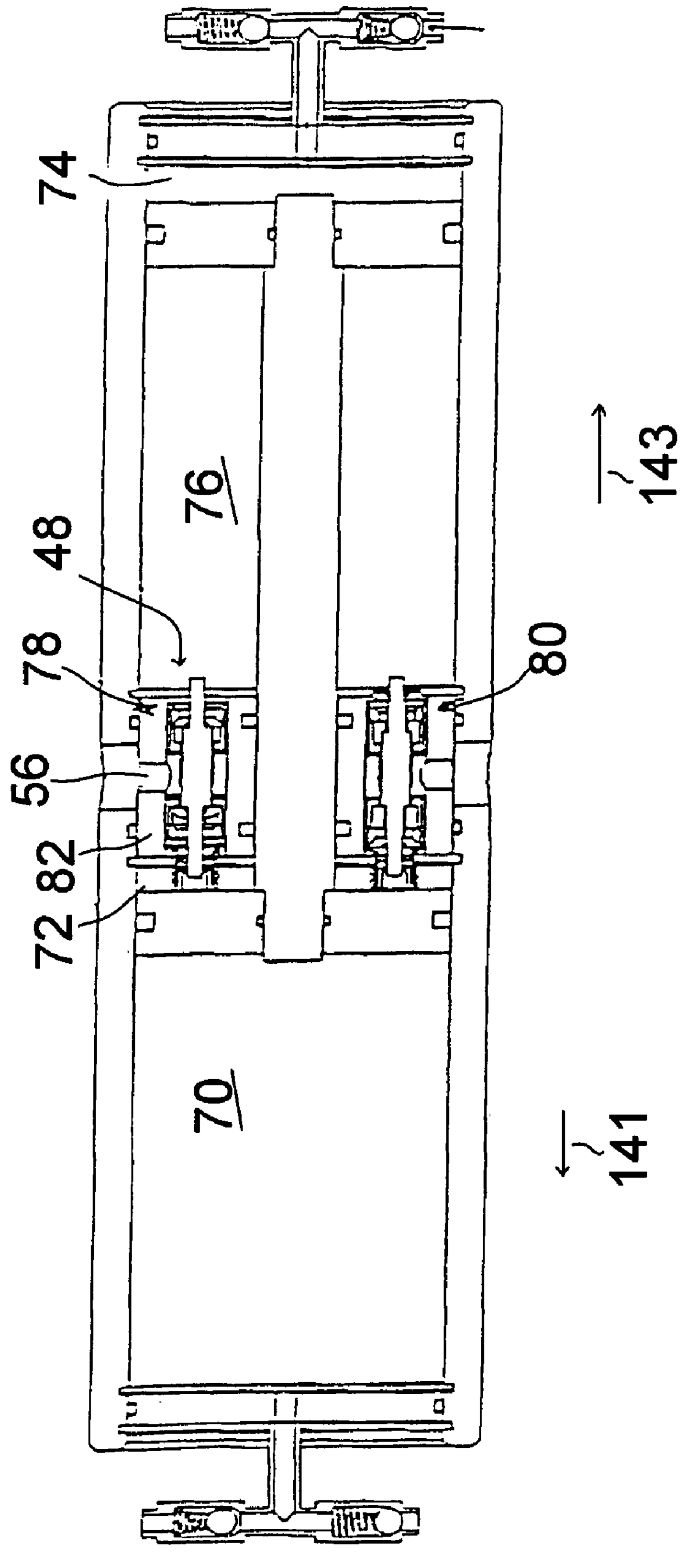

Fig. 3

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Fig. 4

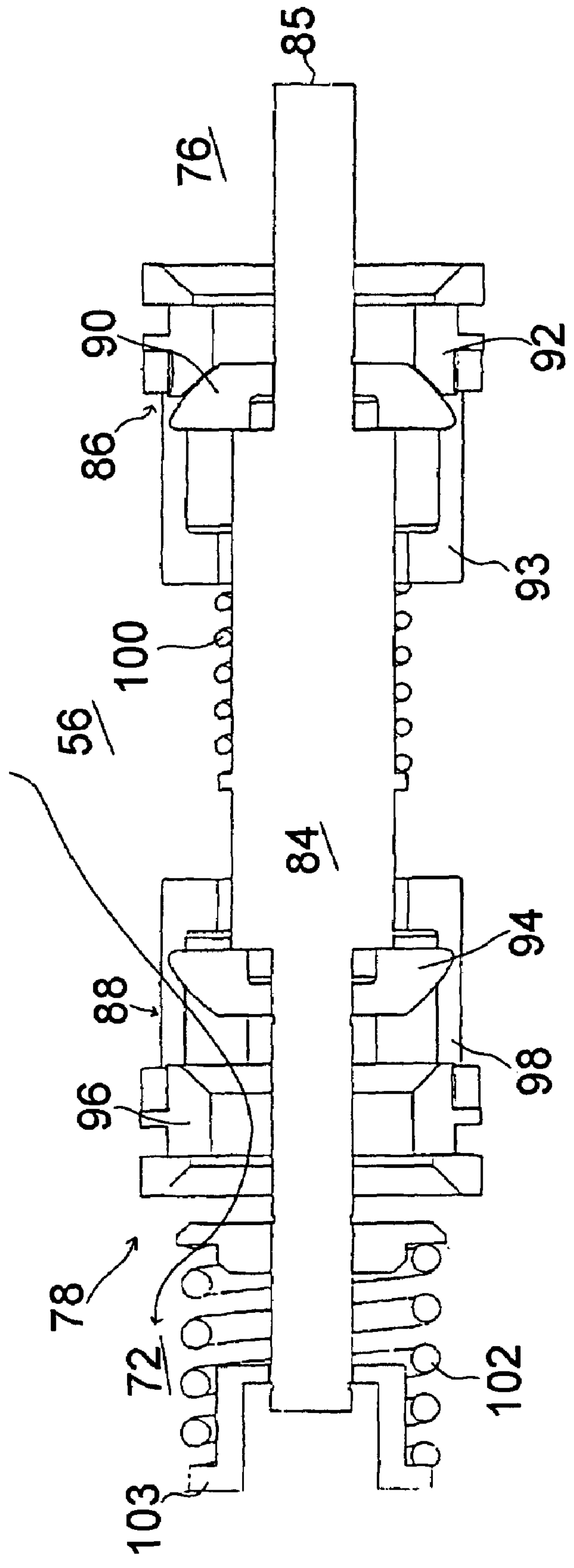


Fig. 5

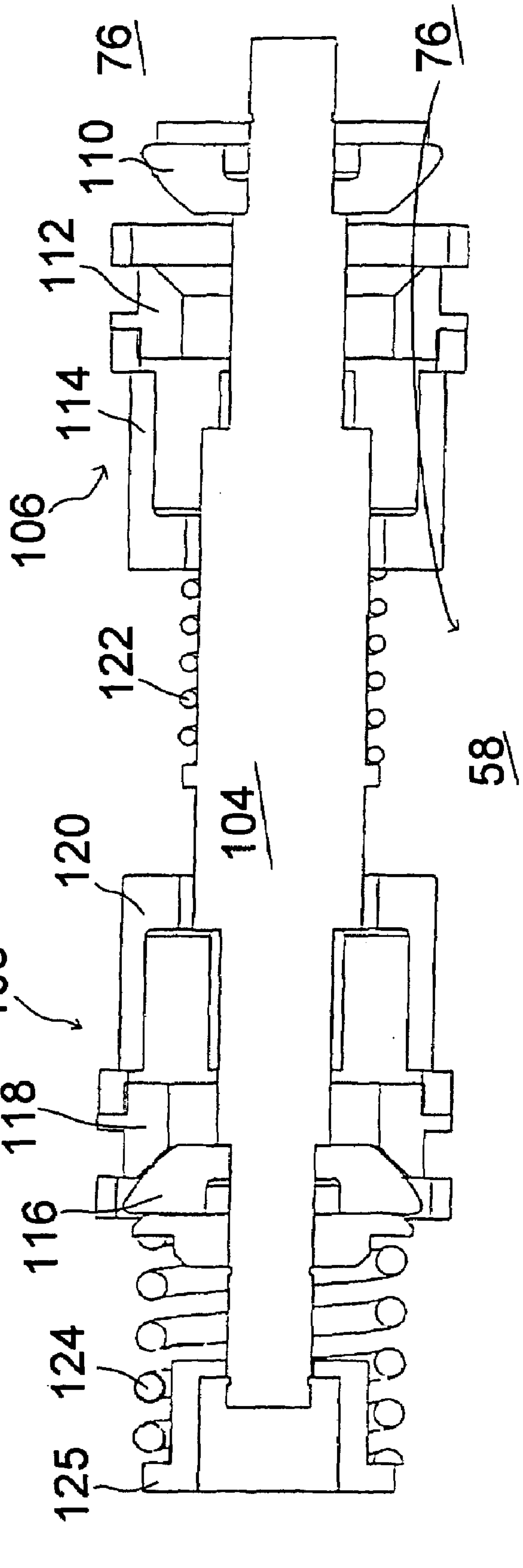
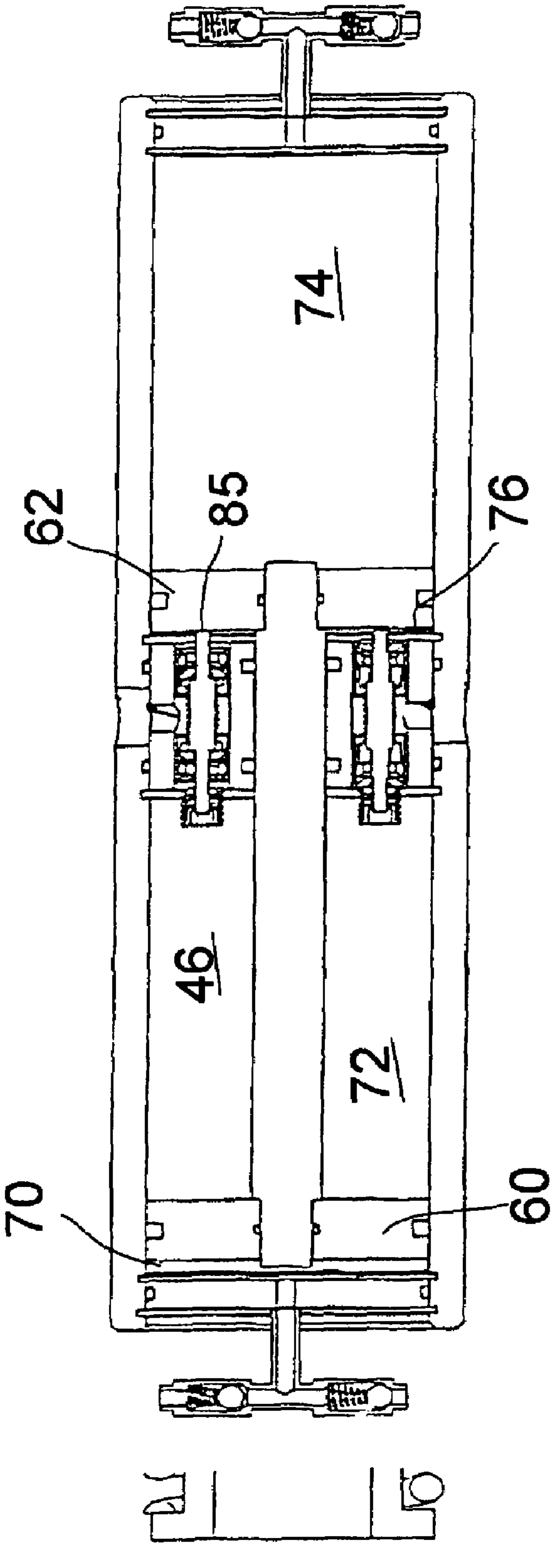


Fig. 6



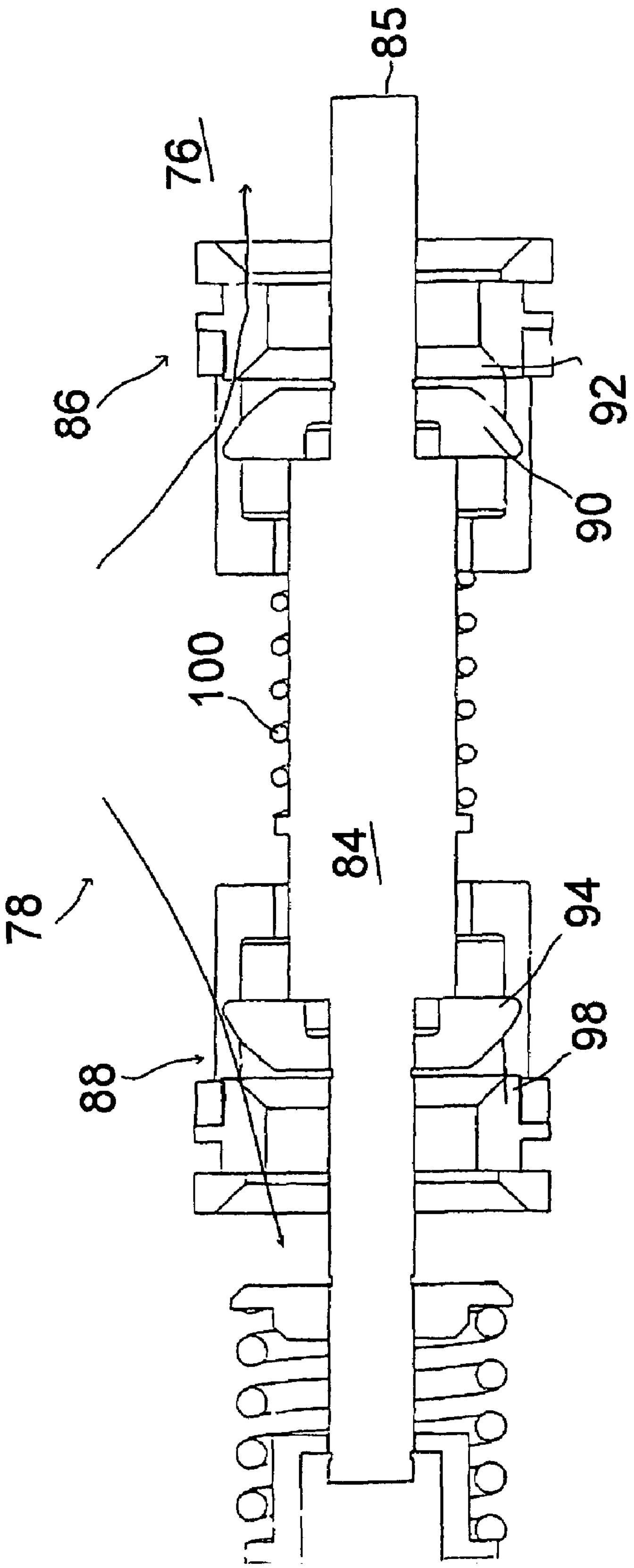
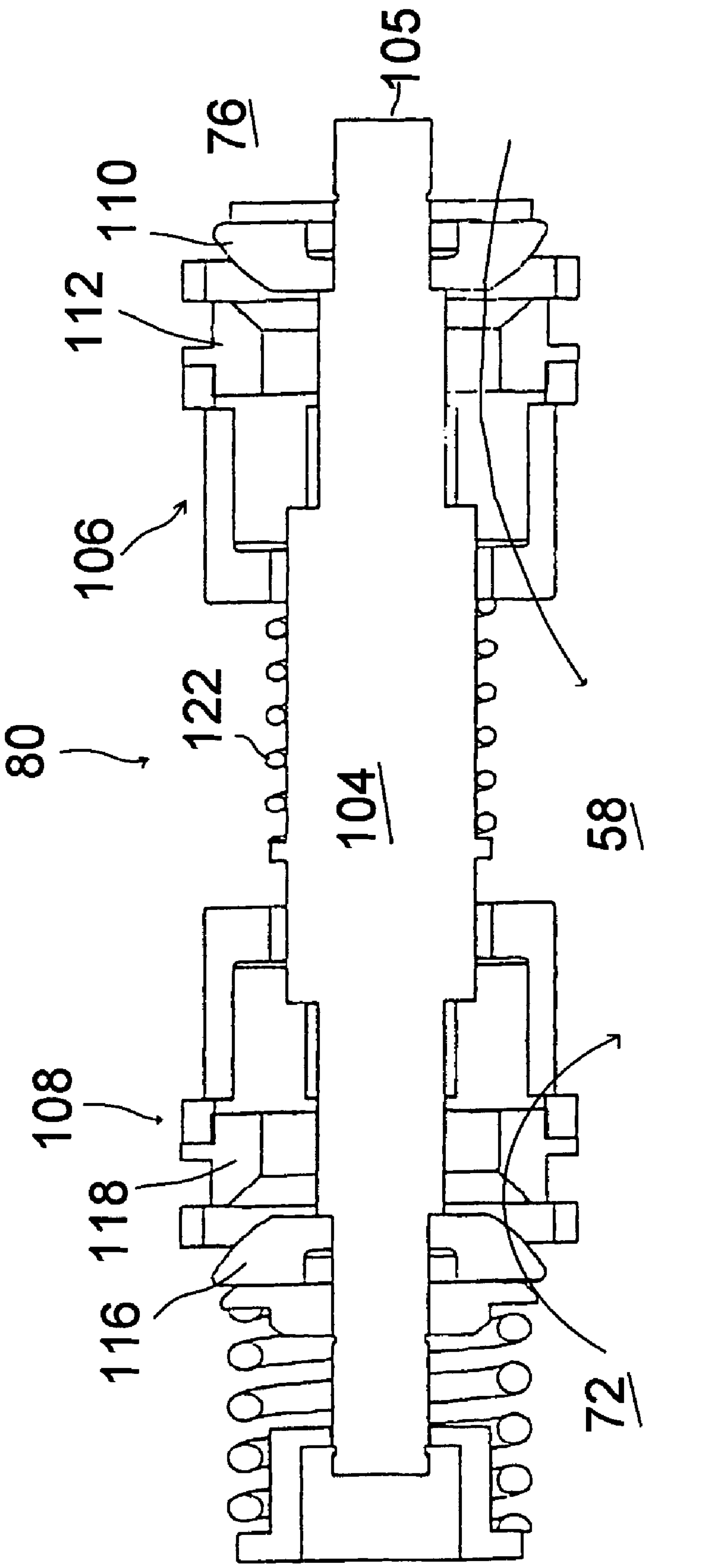


Fig. 7

Fig. 8



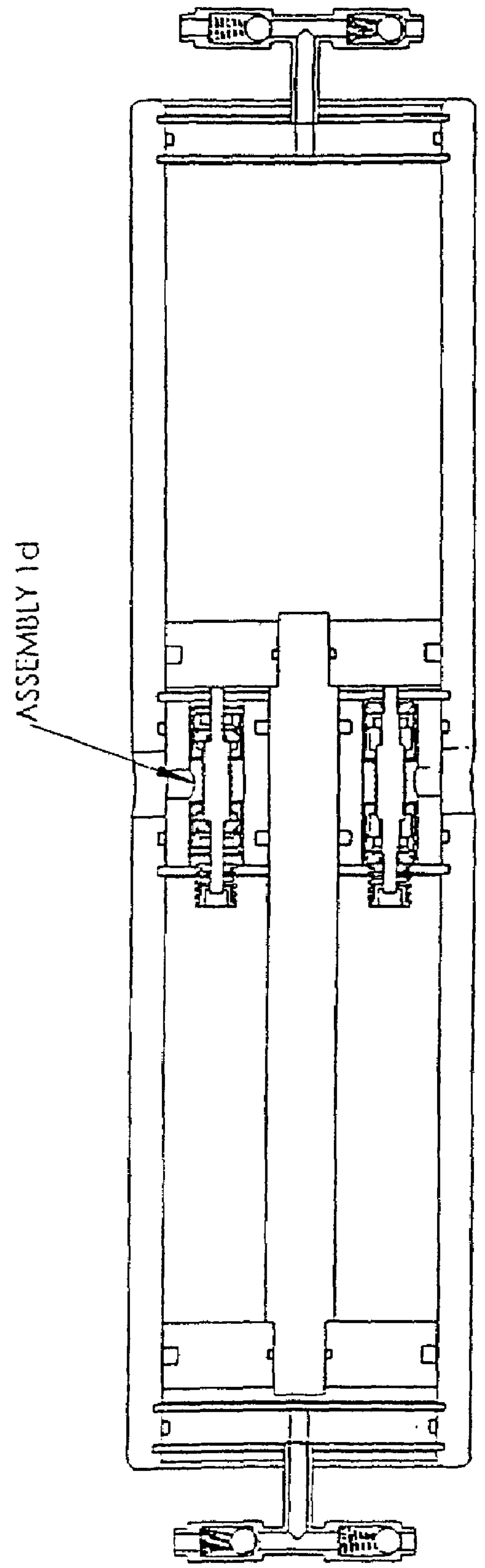


Fig. 9

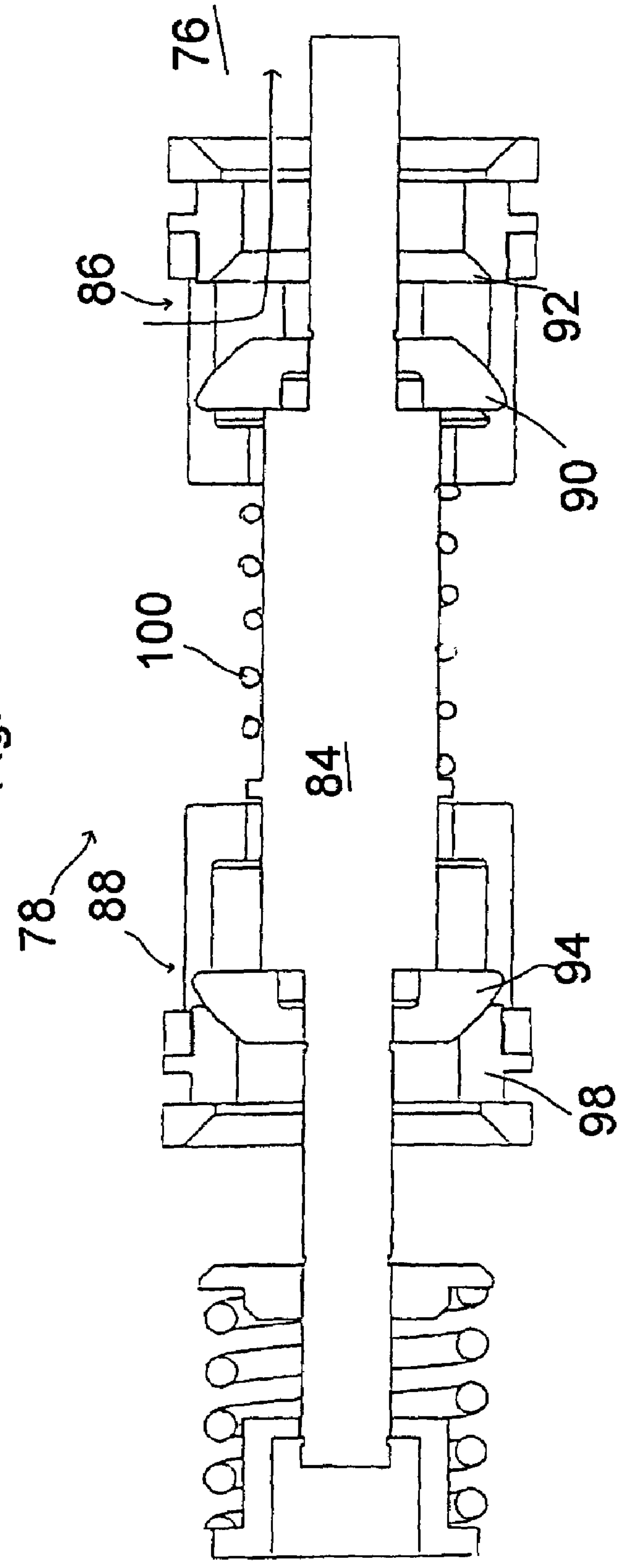


Fig. 10

Fig. 11

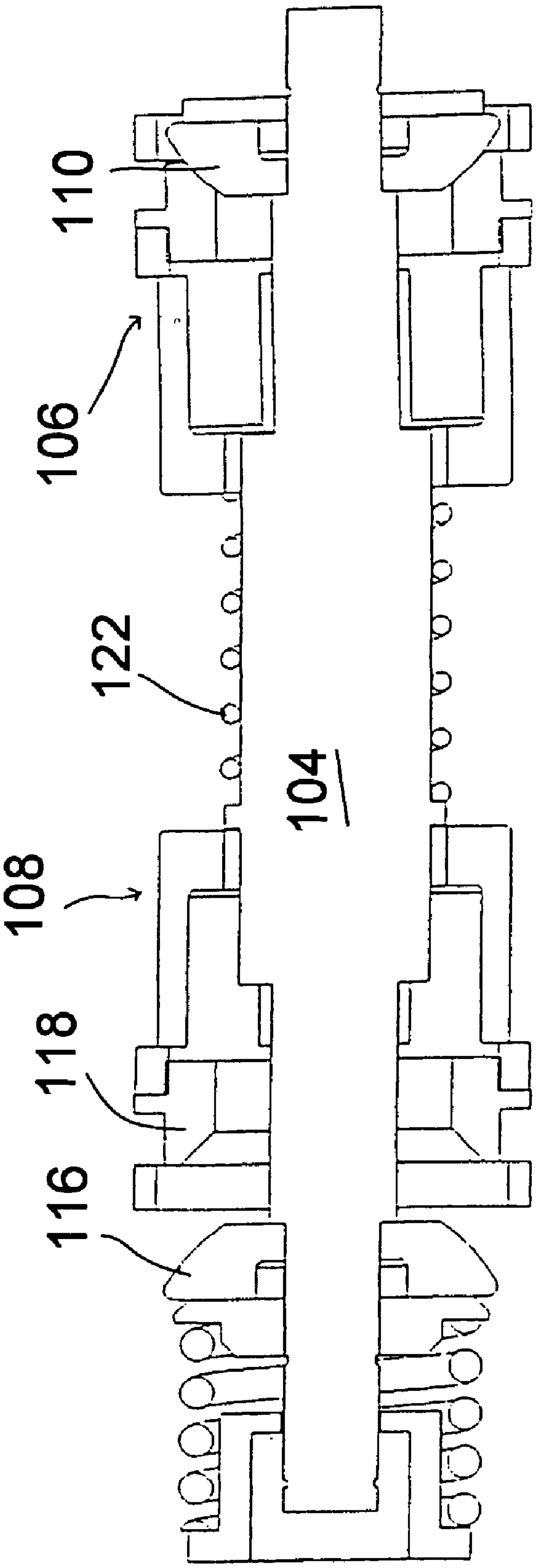
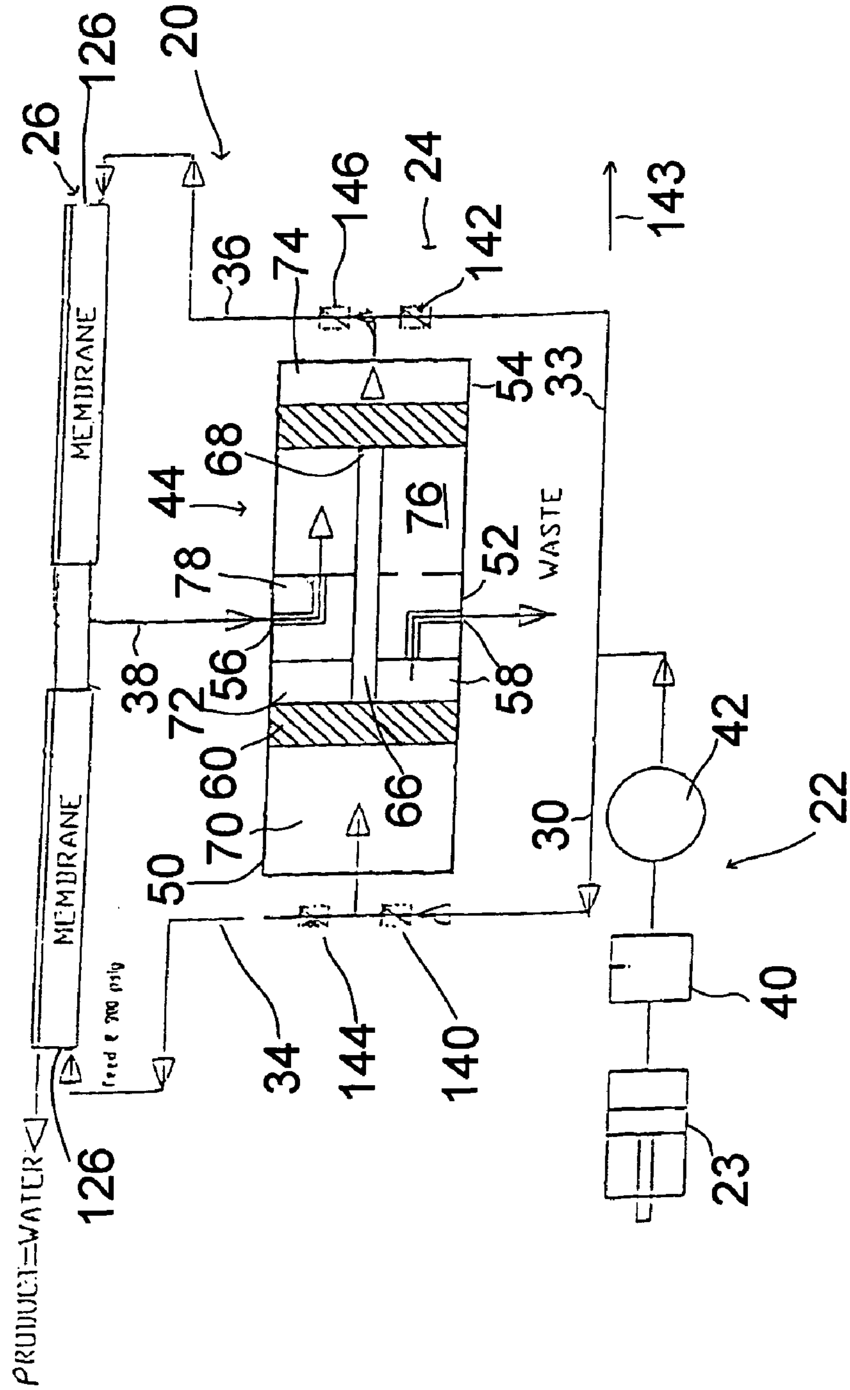


Fig. 12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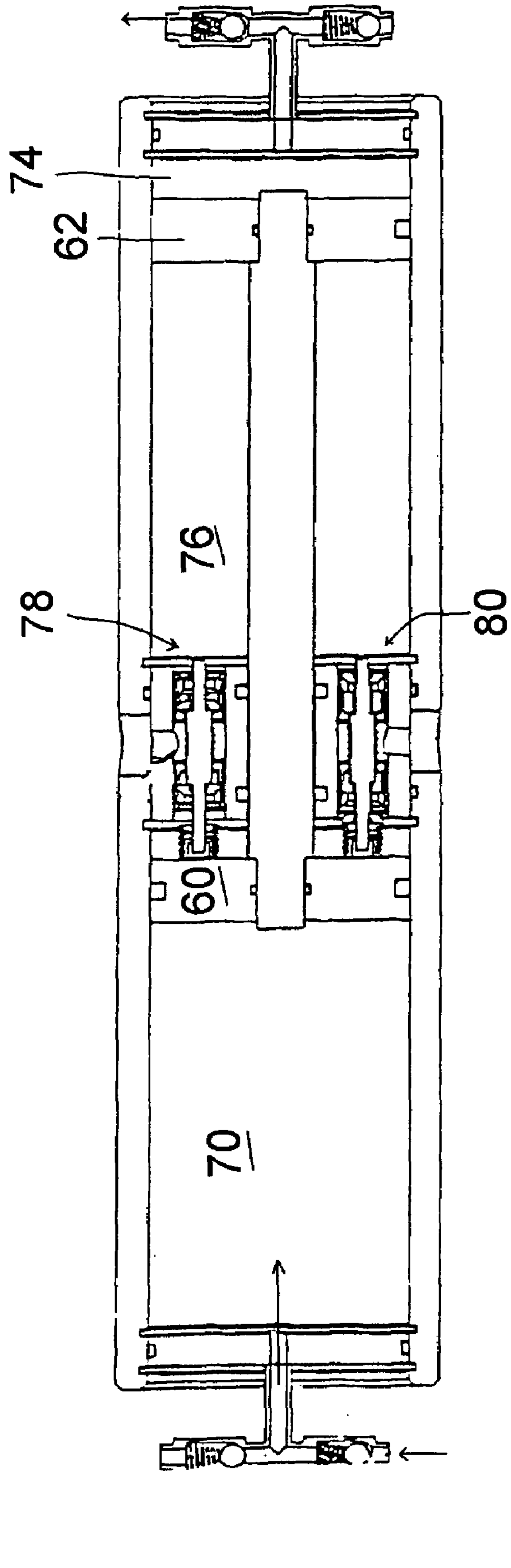
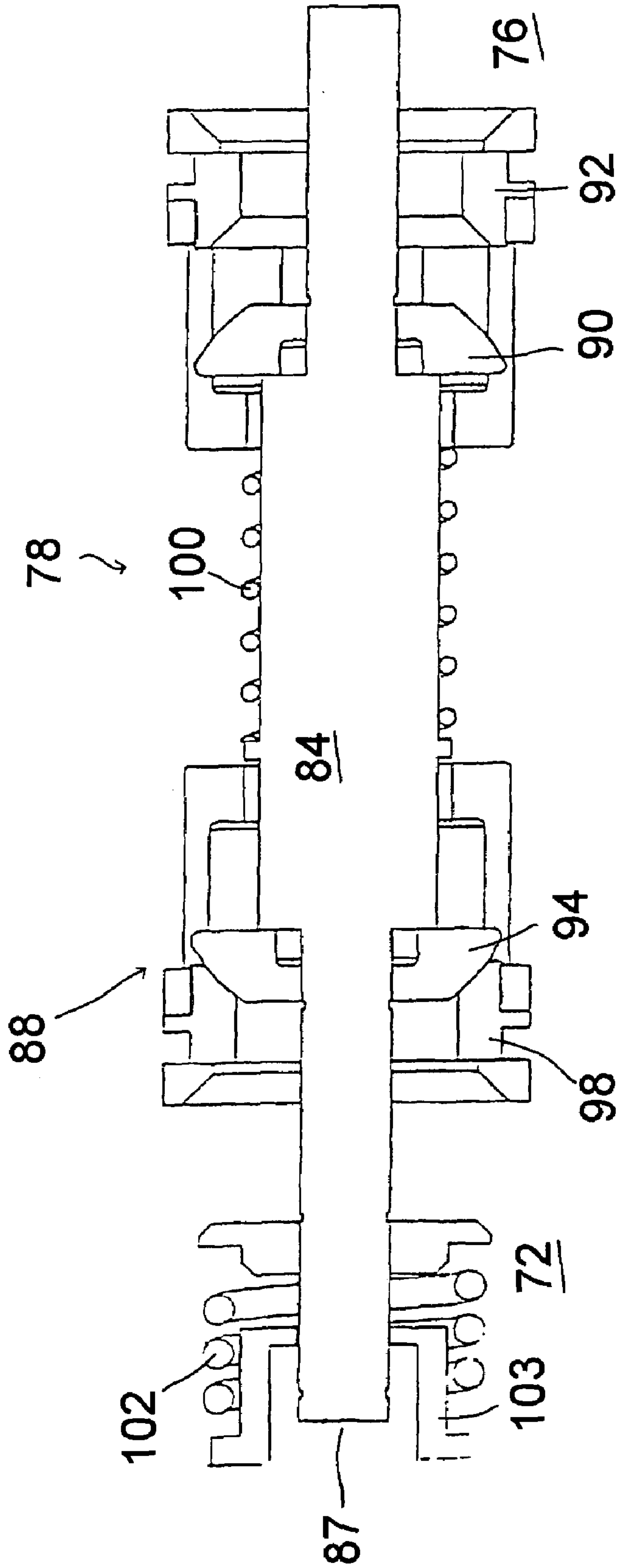


Fig. 13

Fig. 14



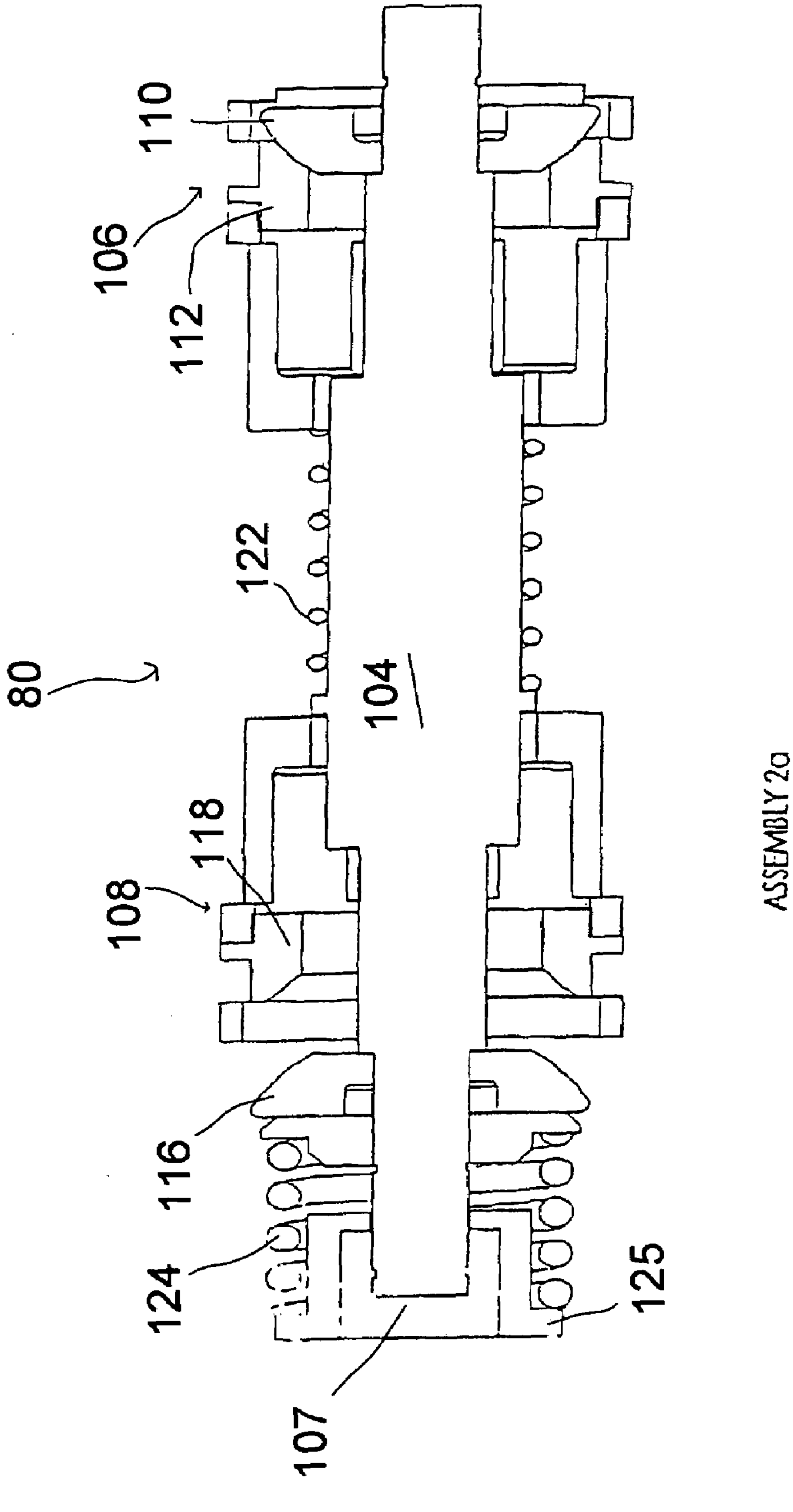


Fig. 15

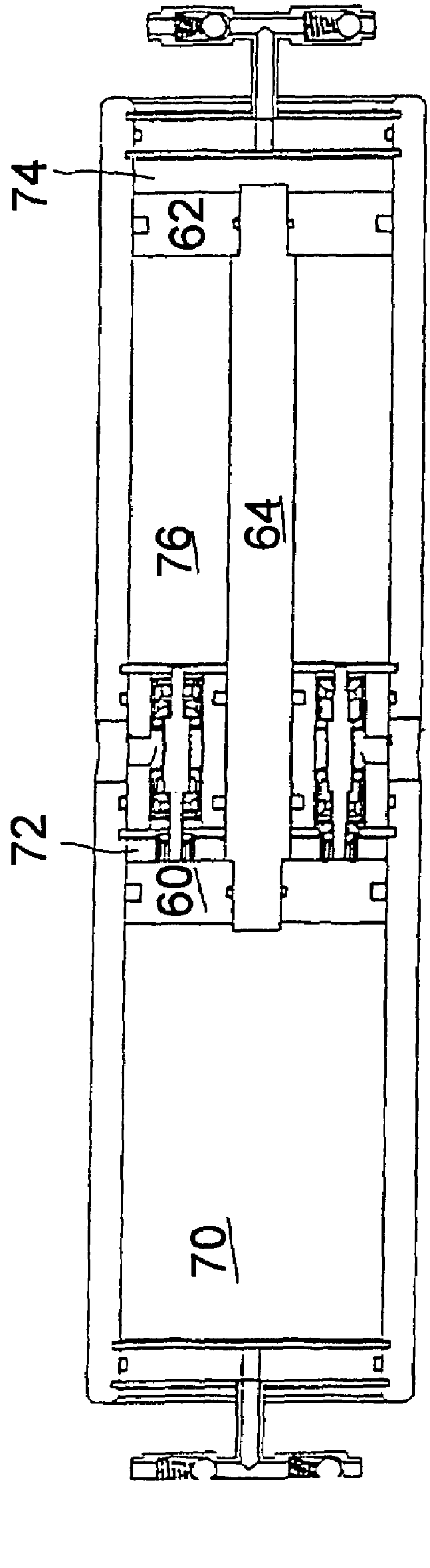


Fig. 16

Fig. 17

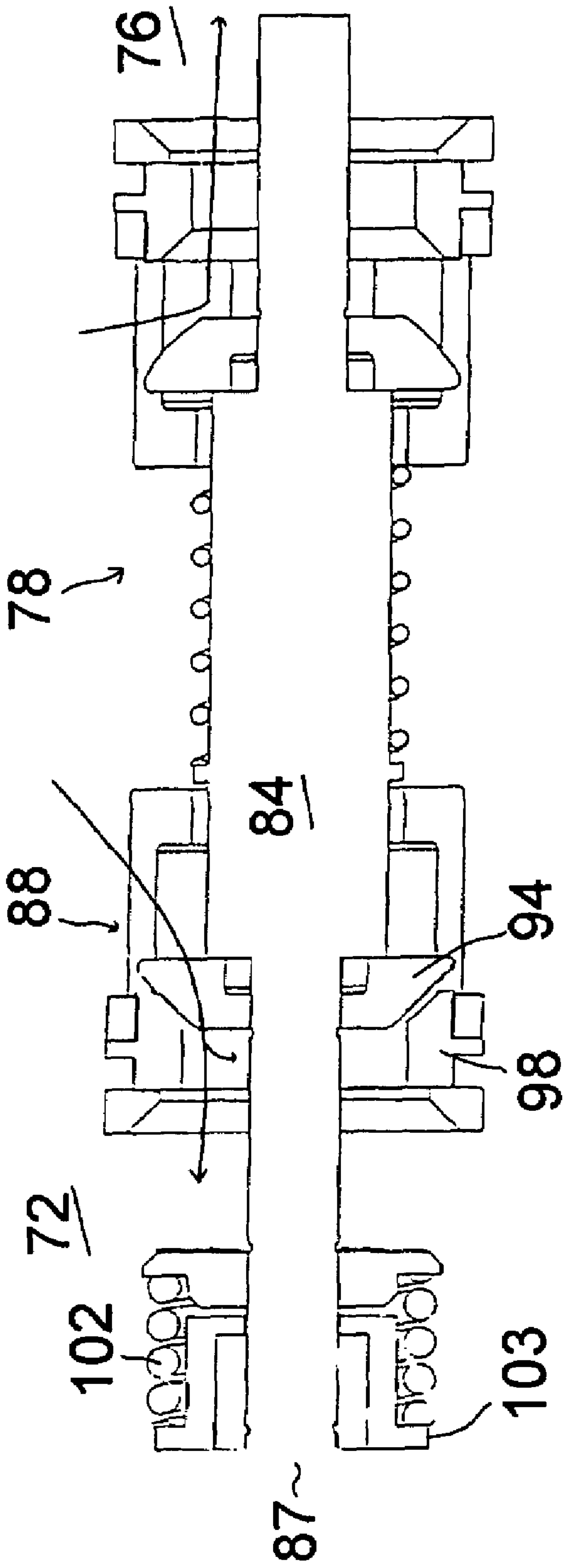
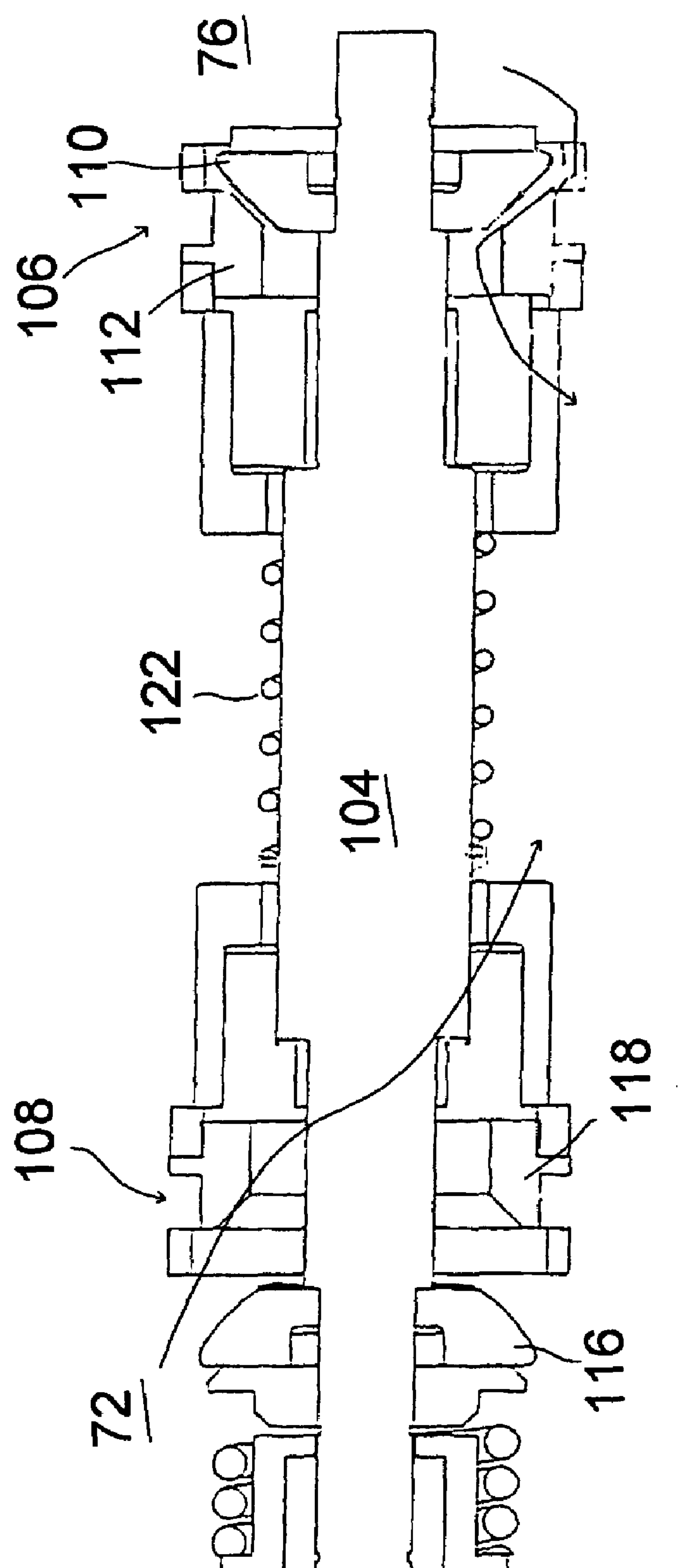


Fig. 18



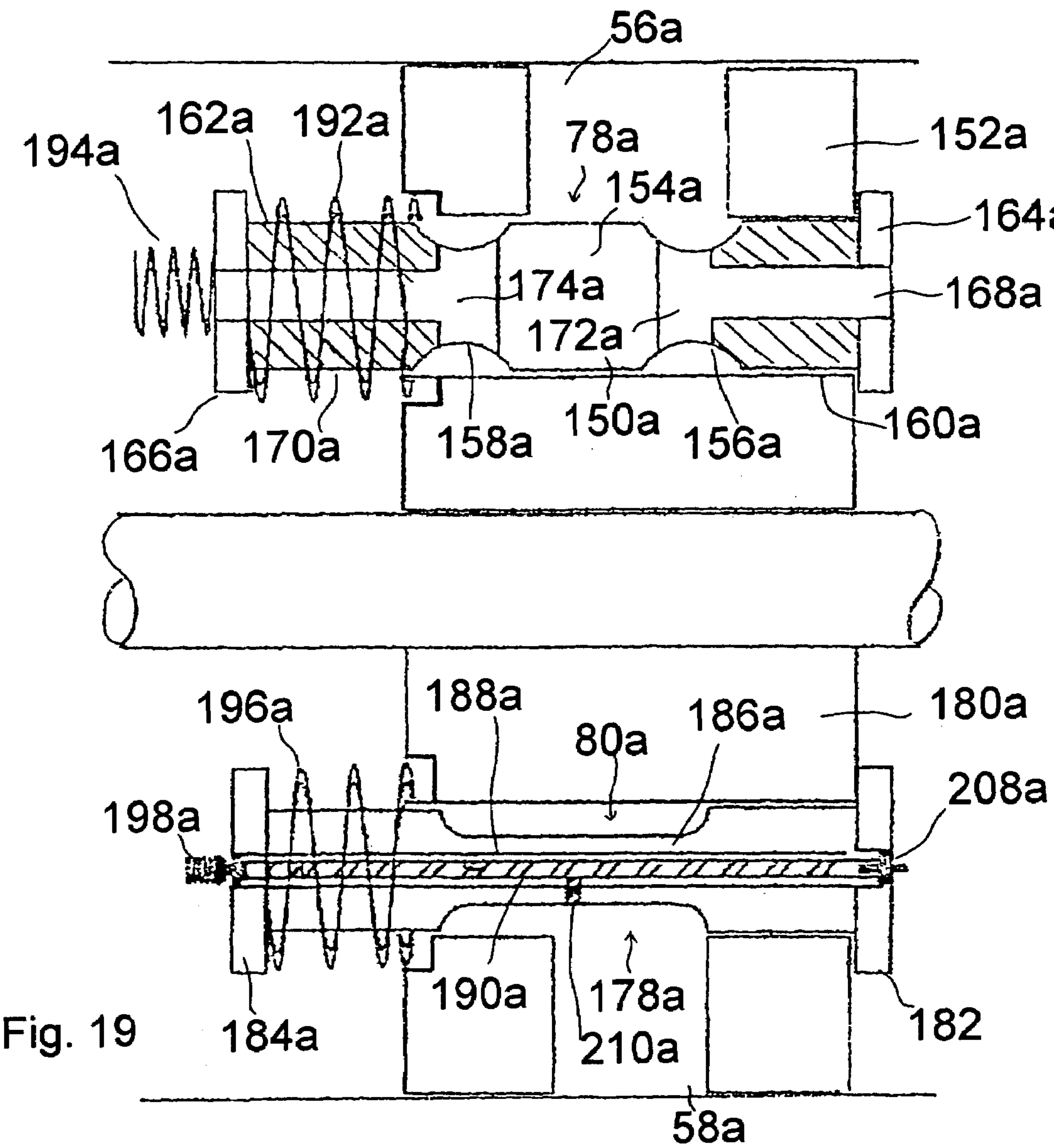


Fig. 19

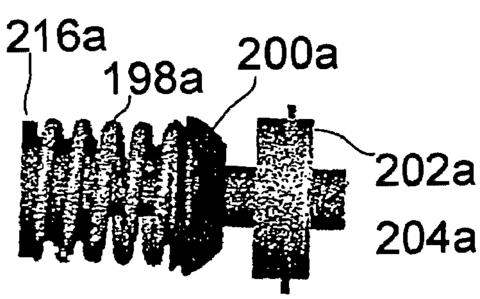


Fig. 21

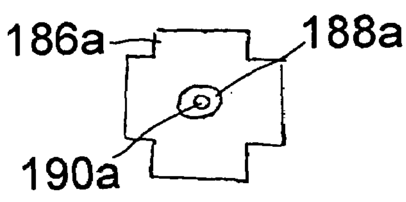


Fig. 20

PRESSURE ENHANCER VALUE SYSTEM

RELATED APPLICATIONS

This application claims priority benefit of Provisional U.S. Ser. No. 60/386,458, filed Jun. 4, 2002.

FIELD OF THE INVENTION

The present invention relates to apparatus for creating pressurized fluid at an intensified pressure by using a conventional pumping device providing a lower operating pressure. One application of the intensified pressure is used in a reverse osmosis filter for purification of seawater.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically shows the pressure intensifier system in a first position where the return operating fluid under intensified pressure is in communication with the first laterally inner subchamber;

FIG. **2** shows the pressure multiplier where the pressure distributor system is in a first position;

FIG. **3** shows the piston assembly moving in the first direction (to the left) with respect to the position as shown in FIG. **2**;

FIG. **4** shows the first valve in a first position where the returning fluid from the high pressure receiving member is in communication with the first laterally inner subchamber;

FIG. **5** shows the second valve also in the first position where the second laterally inner subchamber is in communication with the exit passage;

FIG. **6** shows the pressure multiplier where the piston assembly is at an extreme left location and the first and second valves are in a transition state from the first position to the second position;

FIG. **7** shows the first valve in the dynamic state as shown in FIG. **6** where the central shaft member of the first valve is shifted to the left causing equal hydrostatic pressure upon first and second stop members whereby the first biasing member is shifting the central shaft to the left (the first direction);

FIG. **8** shows the second valve in the dynamic state as shown in FIG. **6** where the central shaft member of the second valve is shifted to the left causing equal hydrostatic pressure upon third and fourth stop members whereby the third biasing member is shifting the central shaft to the left (the first direction);

FIG. **9** shows the first and second valves in the second assembly whereby the piston assembly is moving to the right (the second direction);

FIG. **10** shows the first valve in a the second position as shown in FIG. **9** where the operating fluid under intensified pressure is in communication with the second laterally inner subchamber;

FIG. **11** is a view of the second valve in the second position as shown in FIG. **9** where the first laterally inner subchamber is in communication with the exit passage;

FIG. **12** schematically shows the pressure intensifier system in the second position where the returning operating fluid under intensified pressure is in communication with the second laterally inner subchamber;

FIG. **13** shows the piston assembly to the rightward portion of the pressure cylinder where the second and fourth biasing members (springs) are partially compressed by the first piston member;

FIG. **14** shows the first valve in the position shown in FIG. **13** where the second biasing member is under partial compression and the valve remains in the second position;

FIG. **15** shows the second valve in the position as shown in FIG. **13** where the fourth biasing member is under partial compression and still in the second position;

FIG. **16** shows the pressure multiplier where the first piston member is engaging the central shafts of the first and second valves and the second and third valve elements are beginning to unseat;

FIG. **17** shows the first valve in the position as shown in FIG. **16** where the second valve element is beginning to unseat thereby causing equal hydrostatic pressure on either side of the second stop member allowing the second biasing member to relinquish its stored energy and biasing the central shaft to the right;

FIG. **18** shows the second valve in the position as shown in FIG. **16** where the third valve element is beginning to unseat thereby causing equal hydrostatic pressure on either side of the third stop member allowing the fourth biasing member to relinquish its stored energy and biasing the central shaft to the right;

FIG. **19** is a view of the pressure distributor system of a second embodiment of the present invention;

FIG. **20** is a sectional view taken along line **20**—**20** of FIG. **19**; and

FIG. **21** is a drawing made to an enlarged scale showing that portion of FIG. **19** which is in a broken line circle designated "**21**".

DESCRIPTION OF THE EMBODIMENTS

The invention relates to a pressure intensifier system adapted to increase the pressure of an operating fluid. The pressure intensifier comprises a pressure cylinder, a piston assembly, a pressure distributor system, a fluid distributor system and a high pressure receiving section.

The pressure cylinder has a first region, a central region and a second region. The pressure distributor system is located in the central region to separate the first and second regions from one another. The lateral direction from the central region to the first region indicates a first direction and the opposing lateral direction from the central region to the second region indicates a second direction. The pressure cylinder has an interior surface, a high pressure passage, and an exit passage.

The piston assembly comprises a first piston member positioned in the first region of the pressure cylinder. The first piston member is in sealing engagement with the inner wall of the pressure cylinder thereby defining a first laterally outer subchamber and a first laterally inner subchamber. A second piston member is positioned in the second region of the pressure cylinder in sealing engagement with the inner wall of the pressure cylinder, thereby defining a second laterally outer subchamber and a second laterally inner subchamber. The piston assembly has a connecting rod having first and second lateral ends that are each fixedly having first and second lateral ends that are each fixedly connected to the first and second piston members respectively.

The fluid distributor system directs lower pressure fluid alternately to the first and second laterally outward subchambers, and receives higher pressure fluid alternately from said second and first laterally outer subchambers and delivers higher pressure fluid.

The high pressure receiving section comprises a high pressure inlet portion to receive the higher pressure fluid and direct a first portion of the higher pressure fluid to the high pressure passage of the pressure cylinder, and direct a second portion of the higher pressure fluid to a second location.

In one embodiment, the pressure distributor system comprises a first valve which is located in the central region of the pressure cylinder and enables communication alternately between the high pressure passage and either the first laterally inner subchamber or the second laterally inner subchamber. The first valve has a first biasing member that biases the first valve to a second position that provides communication between the second laterally inner subchamber and the high pressure passage. The first valve also has a second biasing member adapted to change the first valve to a first position that provides communication between the first laterally inner subchamber and the high pressure passage.

The pressure distributor system also has a second valve that is located in the central region of the pressure cylinder and enables communication between an exit passage and either the first laterally inner subchamber or the second laterally inner subchamber. The second valve has a first biasing member that biases the first valve to a first position that provides communication between the second laterally inner subchamber and the exit passage, and a second biasing member adapted to change the second valve to a second position that provides communication between the first laterally inner subchamber and the exit passage.

The system has a pressurizing system having a first line that is in communication with the first laterally outer subchamber and the second laterally outer subchamber along with a check valve system allows unidirectional flow to the first or second laterally outer subchambers.

The high pressure receiving section has a high pressure inlet port connected to the first and second laterally outer subchambers, along with a check valve system allows unidirectional flow to the inlet port. A return line provides communication to the high pressure inlet port and the high pressure passage of the pressure cylinder. The high pressure receiving member has a high pressure operating device (e.g. a reverse osmosis filter) in communication with the high pressure inlet port.

The piston assembly is adapted to oscillate to alternately displace operating fluid contained in the first laterally outer subchamber and the second laterally outer subchamber to deliver a portion of the pressurized fluid to the high pressure receiving member and another portion of this fluid to the high pressure passage of the pressure cylinder.

The biasing members function in a manner to prevent a stall position where the piston assembly is not able to move in the first or second direction.

A first embodiment is disclosed in FIG. **1** where the pressure intensifier system **20** comprises generally a pressurizing system **22** having a pump **23**, a pressure intensifier, hereinafter referred to as a pressure multiplier **24**, and high pressure receiving section **26**. Generally speaking, the pressurizing system **22** provides an input pressure that in one form is produced by a conventional incompressible fluid pump.

The pressure multiplier **24** comprises a pressure cylinder **44** in which is a piston assembly **46** that has a dual piston arrangement with a feedback route through a pressure distributor system **48** to inner chambers to provide a balancing pressure acting in the inner surface wall of the pressure output piston in the direction of piston travel to assist in the increase of pressure. The high pressure receiving member **26** is adapted to receive the intensified pressure fluid from the pressure multiplier **24** and use the intensified pressure for a desired operation. One use for the intensified pressure is with a reverse osmosis membrane used for the purification of seawater.

The high pressure receiving member **26** has a return passage **38** that provides the intensified pressurized fluid to the pressure distributor system **48** of the pressure multiplier **24**, which distributes the pressure intensified fluid to the active laterally inner chamber to assist in the piston movement. The above method for intensifying pressure is further described later herein more specifically with reference numerals to designate specific components and assemblies. Although the disclosed embodiment shows a method of intensifying pressure for one particular use, equivalent assemblies that serve the same or a similar function can be substituted without departing from the scope of the invention as defined in the claims.

The major assemblies, the pressurizing system **22**, the pressure multiplier **24** and the high pressure receiving member **26** direct the operating fluid through various fluid conduits or fluid lines. The lines **30** and **32** allow the operating fluid to pass from the pressurizing system **22** to the pressure multiplier **24**. Further, the output lines **34** and **36** provide hydraulic communication between the laterally outward pressure subchambers (to be described later herein) of the pressure multiplier **24** and the high pressure receiving member **26**. These various lines along with their associated check valves are generally designated the "fluid distributor system **35**". The return line **38** allows a return path of the fluid that is under intensified pressure back to the pressure distributor system **48** of the pressure multiplier **24**. The communication lines can be constructed of any conventional manner. These lines **30**–**36** allow the operating fluid to flow between the various assemblies and preferably with minimal flow resistance to reduce unnecessary fluid head loss. Also, it should be understood that the pressure distributor system is shown only schematically in FIG. **1**, to show a flow pattern in one part of an operating cycle.

The pressurizing system **22** comprises the aforementioned pump **23** and in the preferred form includes a pre-filter **40** and an accumulator **42**. The pressurized fluid may be supplied by a conventional electric pump or hand pump, preferably a positive displacement pump such as a piston pump to create sufficiently high pressures; however, other forms of pumps could be employed. The ranges of operating pressures may be 20–200 pounds per square inch. The pre-filter **40** is employed to filter out small particulate matter (e.g. >5 microns) and the accumulator **42** is employed to store the fluid at the operating pressure to be supplied through lines **30** and **32**. These components schematically shown in FIG. **1** can be integrated into a singe device for purposes of portability.

The pressure multiplier **24** comprises the aforementioned pressure cylinder **44**, the piston assembly **46** and the pressure distributor system **48**. The pressure cylinder **44** is adapted to withstand the internal pressures produced by the system, which can be up to 900 psi and higher. The pressure cylinder **44** has an inner wall surface that is in a sealing engagement with the pistons **60** and **62**. The pressure cylinder **44** has a longitudinal axis extending along its lengthwise region and it further has a first end region **50**, a central region **52** and a second end region **54**. The regions are arranged to house the aforementioned main components. Specifically, the first piston member **60** is located in the first region **50**, the pressure distributor system **48** is located in the central region **52** and the second piston member **62** is located in the second region **54**. The pressure distributor system **48** is stationary in the central region **52** into first and second sub-regions on opposite sides of the pressure distributor system **48**.

The cylinder further has a high pressure passage **56** and an exit passage **58**, both of which are adapted to communicate with the pressure distributor system **48** discussed in further detail later herein. The pressure cylinder is preferably cylindrical in shape; however, any cross-sectional shape that permits the oscillatory motion of the piston assembly **46** and can withstand the intensified pressure is suitable for operation.

As indicated above, the piston assembly **46** comprises a first piston member **60** and a second piston member **62**, and the two pistons **60** and **62** are connected by a connecting rod **64** (also referred to as a central shaft). The central shaft **64** has a diameter d and is preferably cylindrical in shape. The cross-sectional area of the shaft **64** is constant to allow passage through a central opening of the pressure distributor system **48**. The central shaft **64** has a first end portion **66** and a second end portion **68**. The first piston member **60** is attached to the first end portion **66** of the central shaft **64**. The first piston member **60** in conjunction with the first region **50** of the pressure cylinder **44** defines two subchambers, a first laterally outer subchamber **70** and a first laterally inner subchamber **72**, defined by the first piston member **60** and the pressure distributor system **48**. In a similar fashion, the second piston member **62** in conjunction with the second region **54** of the pressure cylinder **44** defines two subchambers, a second laterally outer subchamber **74** and a second laterally inner subchamber **76** defined by the second cylinder **62** and the pressure distributor system **48**. Each of the subchambers is substantially sealed from the adjacent subchamber(s) and to the environment outside of the pressure cylinder **44**.

The inner subchambers **72** and **76** communicate with the operating fluid through the pressure distributor system **48** to alternate between ambient pressure and intensified pressure (the process is described in detail following the discussion of the pressure distributor system infra). The pistons **60** and **62** have a diameter "d" and a cross-sectional area. In a preferred form, cross-sectional areas of the pistons **60** and **64** (and corresponding cylinder **44** sections) are the same; however if they are not the same (particularly in cross-sectional area) then the intensified pressure will change with respect to the piston assembly's direction of travel. The ratio of the piston cross-sectional area with respect to the central shaft's **64** cross-sectional area determines the maximum pressure multiple of the system. The maximum pressure multiple is the piston cross-sectional area divided by the central shaft's **64** cross-sectional area and this number is multiplied by the operating pressure to give a number that is slightly higher than the maximum possible theoretical pressure output of the pressure intensifier system **20**. Further, the cross-sectional area of the central shaft **64** multiplied by the distance the shaft is displaced longitudinally, determines the amount of operating fluid ejected from the system through the exit port **128** of the high pressure receiving member **26**. This is further described herein following a discussion of the pressure distributor system **48**.

The pressure distributor system **48** is responsible for alternating the communication of the intensified pressure between the first and second laterally inner subchambers **72** and **76**. The pressure distributor system **48** further alternates the communication of the opposing laterally inner subchamber (the one not exposed to the intensified pressure) to the exit passage **58** of the cylinder to atmospheric pressure. As will become apparent later herein, the pressure distributor system has a set of internal biasing members which operate in a manner that the piston assembly will not be in a stall position at which the piston assembly **46** would remain motionless.

The pressure distributor system **48** comprises a first valve **78**, a second valve **80** and a valve housing **82**. As shown in FIG. **2** and FIG. **3**, the pressure distributor system **48** is in a state where the communication paths have the same basic flow pattern as the ones schematically shown in FIG. **1**, except that the flow pattern reverses on every half cycle. The first laterally inner subchamber **72** is in communication with the high pressure passage **56** and the second laterally inner subchamber **76** is in communication with the exit passage **58** of the pressure cylinder **44**, and this flow pattern reverses on every half cycle.

As shown in FIG. **4**, the first valve **78** comprises a central shaft **84**, a first valve element **86**, and a second valve element **88**. The first valve element **86** comprises a first stop member **90** and a first stop seat **92**. The first stop member **90** is attached to the central shaft **84** and is adapted to engage the stop seat **92** to provide a seal between the second laterally inner subchamber **76** and the high pressure passage **56**. The first stop seat **92** is attached to the valve housing **82** which is in turn attached to the pressure cylinder **44**. In the preferred form an encasement **93** is employed to position the central shaft **84** and to provide a base for the first biasing member **100**. In a preferred method of assembly, annular retention rings are cut in the valve housing **82** and a retention ring (not shown) is used to hold the encasement **93** in place (and the other encasements are held in a similar manner).

Also shown in FIG. **4**, the second valve element **88** is comprised of similar components as the first valve element **86** where a second stop member **94** is attached to the central shaft **84** and the second stop seat **96** is attached to the valve housing **82** (see FIG. **3**). The operation of the second valve element is similar to that of the first valve element **86** where if the second stop member **94** is in engagement with the second stop seat **96**, the first laterally inner subchamber **72** is not in communication with the high pressure passage **56**. An encasement **98** assists in positioning the shaft **84** and supporting the second stop seat **96**.

The first valve **78** also comprises a first biasing member **100** and a second biasing member **102**. The first biasing member biases the central shaft **84** in the second direction with respect to the pressure cylinder **44**. The second biasing member **102** has a first end attached to the central shaft **84** and a second end that is adapted to engage the second piston member **62**. The second biasing member **102** will not begin to compress or not substantially compress until the first stop member **90** engages the first stop seat **92**. Therefore, the second biasing member **102** has an effectively higher spring constant than the first biasing member **100**. In general, the biasing members **100** and **102** are adapted to position the central shaft **84** with respect to various positions of the piston assembly **46** where the first valve will "snap" from one locked position to another. Further, the biasing members **100** and **102** are such that these operate in conjunction with the check valves **140** and **142** so that a stall position will not occur in start up mode, regardless of the location of the piston assembly **46**. A complete discussion of the operation will follow the detailed discussion of the second valve **80** given below.

As shown in detail in FIG. **5**, there is a valve **80** which comprises a central shaft **104**, a third valve element **106**, and a fourth valve element **108**. The second valve **80** is somewhat similar to the first valve **78**; however, the third and fourth valve elements **106** and **108** are adapted to control passage between the operating fluid of the first and second laterally inner subchamber **72** and **76** and the exit passage **58**.

The second valve element comprises a third stop member **110** and a third stop seat **112**. The third stop member **110** is attached to the central shaft **104** and is adapted to engage the third stop seat **112** to control the flow from the second laterally inner subchamber **76** and the exit passage **58**. An encasement **114** assists in positioning the central shaft **104** and fixing the third stop seat to the valve housing **82** (see FIG. **3**). Because the pressure in the second laterally inner subchamber **76** will be greater than ambient pressure at the exit passage **58**, when the third valve element is in a sealing position, the third valve element **106** is in an opposite operational position (open/closed) with respect to the first valve element **86**. As shown in FIG. **3**, the operating fluid under intensified pressurize at pressure passage **56** will be greater than the second laterally inner subchamber **76** which will be atmospheric pressure (zero gage pressure). As seen in FIG. **4**., the first valve element **86** is in a sealing position so that the slope of the first stop member **90** must be pointed conically laterally outward to react to the pressure differential between passage **56** and the chamber **76** to maintain the seal. This is also the case for the second and fourth valve elements **88** and **108** as well.

Now referring back to FIG. **5**, the fourth valve element **108** comprises a fourth stop member **116** attached to the central shaft **104** and a fourth stop seat **118** effectively attached to the valve housing **82** (see FIG. **3**). An encasement **120** assists in positioning the central shaft **104**. The second valve **80** further has two biasing members, a third biasing member **122** and a fourth biasing member **124**. The third biasing member is adapted to bias the central shaft **104** to the left in FIG. **5** so the third stop member **110** will seat against the third stop seat **112** and cut off communication between the second laterally inner subchamber **76** and the exit passage **58**. The fourth biasing member **124** has one end that is attached to the central shaft **104** and the opposite end is adapted to engage the first piston member **60**. In a preferred form the biasing members are springs; however, any form of delivering a force to reposition the central shafts **84** and **104** could be employed (e.g. magnetic members, leaf springs, pressure pistons, etc.).

Now referring back to FIG. **1**, there will be a description of the high pressure receiving member **26**. In general, the high pressure receiving member **26** requires a relatively high pressure to function effectively. As previously mentioned, a preferred use of the high pressure receiving member **26** is for a reverse osmosis seawater filter to produce substantially fresh/unsalted potable water. The high pressure receiving member **26** has two inlet ports **126** to receive the sea water and an exit port **128** to discharge the filtered water. The member **26** essentially receives operating fluid (i.e., salt water) from lines **34** and **36** and a portion of this fluid is directed to a reverse osmosis membrane (not shown) and another portion of the operating fluid (e.g. sea water) is directed to the return line **38** as high pressure.

With the foregoing foundation of elements presented there will now be a detailed discussion of the operation of this first embodiment of the present invention with attention directed to the particular features of this embodiment.

To begin the operation, the fluid enters in to the pump **23** and is pressurized to an operating pressure. The operating pressure can be in the preferred range of 10–100 psig or in some instances beyond this range. The operating fluid then passes through the pre-filter **40** that assists in removing small particulate matter. A filter that removes matter larger than 5 microns is preferred. Next, the operating fluid passes to the accumulator **42**. The accumulator **42** functions as a capacitor in the fluid circuit and maintains a supply of the operating fluid which is maintained to a nearly constant pressure and which is then drawn in through either line **30** or **32**.

Referring to FIG. **1**, this figure schematically shows the first valve **78** providing communication with the first laterally inner subchamber **72** and the high pressure return line **38**. The second valve **80** (shown schematically) is providing communication between the second laterally inner subchamber **76** and the exit passage **58** which is at atmospheric pressure. Therefore, as will become more apparent later herein, the piston assembly **46** is moving to the left in FIG. **1**. The operating fluid at the operating pressure passes through a check valve **142** and enters into the second laterally outer subchamber **74**. The operating fluid in the second laterally inner subchamber **76** is simultaneously venting to atmospheric pressure and is at zero gage pressure. Therefore, the cross-sectional surface area of the piston member **62** multiplied by the operating pressure results in the force value in the first longitudinal direction indicated by arrow **141**. If there were a back pressure in the subchamber **76**, the area of the cross-sectional surface area of the piston **62** minus the cross-sectional area of the shaft multiplied by the gage pressure in the subchamber **76**, would result in a force in the second longitudinal direction indicated by arrow **143**. However, the gage pressure is at zero since the exit passage **58** is in communication with the second inner subchamber **76**.

The discussion of the operation will now focus on the operating fluid contained in the second laterally outer subchamber **74**. As will become more apparent shortly, the piston **60** is biased to the left (the first direction) in FIG. **1** and hence the operating fluid is positively displaced through the check valve **144** to the high pressure receiving member **26**. For reasons that will be described shortly, the operating fluid in line **34** is in this portion of the cycle now at the intensified pressure which is several times higher than the operating pressure produced by the pump **23**. The operating fluid passes through line **34** and enters the inlet port **126** of the high pressure receiving member **26**. Thereafter, it is split into two flow paths. One flow path is for a functional purpose such as a reverse osmosis filter. A second flow path is to the high pressure line **38**, so that the operating fluid at the intensified pressure passes through the first valve **78** and flows into the first laterally inner subchamber **72**. Now the pressure in the first laterally inner and outer subchambers **70** and **72** both are substantially at intensified pressure.

However, the cross-sectional surface area of the first laterally inner subchamber **72** is less than the first laterally outer subchamber **70** by the amount of the cross-sectional area of the shaft **64**. Therefore, the net force acting on the piston assembly in the first laterally inner chamber **72** is the cross-sectional area of the shaft multiplied by the intensified pressure, and the direction of this force is in the second longitudinal direction (indicated by arrow **141** in FIG. **1**). As mentioned previously, the force in the first direction (indicated by arrow **141**) is created by the operating pressure of the fluid multiplied by the cross-sectional area of the first piston member **60**. Although the operating pressure is several times less than the intensified pressure of the system, the operating pressure in chamber **74** is acting on a large surface area and hence biases the piston assembly **46** to the left as shown in FIG. **1**.

The high pressure receiving member **26** has an internal flow resistance that creates a pressure drop between the inlet ports **126** and the exit port **128** which is presumably atmospheric, or at least at a lower pressure. Further, this flow resistance is a function of the velocity of the operating fluid that is a square of the velocity of the fluid flow.

To illustrate how the pressure of the operating fluid is intensified, let us assume that the operating pressure is 100 psig and the ratio of the area of each of the pistons **60** and **62** to the area of the shaft **64** is 15 to 1. If the membrane in the high pressure receiving chamber **26** were clogged and fluid was not permitted to exit the system and the input operating pressure was a constant 100 psig, then the static fluid circuit would produce an intensified pressure of 1500 psig (15/1*100 psig) in the subchambers **72** and **74**. This intensified pressure would be necessary to keep the piston assembly from moving to the left. In other words as the pressure is building up in subchamber **74** it will initially reposition to the left in FIG. **1**. As the piston assembly **46** moves to the left, the pressure in subchamber **70** will build up causing the pressure in subchamber **72** to increase at the same time. The fluid in laterally inner subchamber **72** is essentially pushing the piston assembly **46** to the left as well. Whatever the value of the pressure in the first laterally outer subchamber **70** the pressure in the second laterally outer subchamber must be, in this example, 15/1 which is 15 times the pressure to keep the pistons static (the ratio of the cross-sectional area of the piston member over the cross-sectional area of the shaft **64**). It should be noted that the gage pressure in subchamber **76** is zero and hence has no effect on the force on the piston.

Now let us assume the high pressure receiving member **26** becomes unclogged and the operating fluid is permitted to pass and pass through the exit port **128**. Now the piston assembly **46** will move to the left in FIG. **1** and the volume which is equal to the cross-sectional area of the shaft **64** multiplied the lateral displacement distance is equal to the output of fluid from the exit port **128**. Because the pressure multiplier **24** is a positive displacement device and the operating fluid is incompressible (substantially incompressible for all practical measurable engineering purposes), the amount of operating fluid exiting the second laterally outer subchamber **74** must equal the amount of operating fluid entering the second laterally inner subchamber plus the amount exiting the high pressure receiving member **26**.

As the piston assembly **46** moves to the left, the pressure in the subchambers **70** and **72** will slightly lower while the fluid accelerates through the a pressure multiplier **24**. Then, as the fluid velocity increases and the internal flow resistance also increases, the piston assembly **46** will cease to accelerate and the intensified pressure in the subchambers **70** and **72** will be back to max intensified pressure and the piston will essentially be static (not accelerating) and the lateral forces acting thereon are balanced.

Now with the underlying principles of the pressure intensifying system **20** having been explained, focus will now be directed to the pressure distributor system **48**.

As shown in FIG. **2** the first and second valves **78** and **80** are positioned in a manner that provides a fluid circuit flow that is schematically shown in FIG. **1**. The intensified pressure from the high pressure passage **56** is in communication with the first laterally inner subchamber **72** and the second laterally inner subchamber **76** is in communication with the exit passage **58**. The position of the piston assembly **46** is such that the first and second valves **78** and **80** just switched from a second position to a first position and this change was induced by the force of the first piston member **60** acting on the caps **103** and **125** (see FIGS. **4** and **5**). As soon as the valves **78** and **80** are in the first position as shown in FIG. **2** the piston assembly **46** begins to move towards the first direction **141** (to the left in FIG. **2**). As described above, the intensified pressure of the operating fluid in the first laterally inner subchamber **72** will create a force that substantially balances the laterally inner surface of the piston **60** against the opposing force upon the laterally outer surface of piston **60** by the pressure in the first laterally outer subchamber **70** (the lateral inner surface of piston **60** is less by the cross-sectional area of the shaft **64**). The operating pressure provided by the pump **23** is fed into the second laterally outer subchamber **74**, and the second laterally inner subchamber **76** is at zero gage pressure so the piston assembly **46** moves to the left as shown in FIG. **3**. FIG. **4** illustrates the intensified pressure passing through the first valve element **88** into the first laterally inner subchamber **72**. Further, FIG. **5** shows the operating fluid in the second laterally inner subchamber **76** passing through the third valve element **106** to the exit passage **58**. The piston assembly **46** will continue to travel towards the first direction **141** (to the left in FIG. **3**) until it reaches the position as shown in FIG. **6**.

FIG. **6** shows the embodiment at a dynamic state where there the valves **78** and **80** are in rapid transition. It should be noted that this transition occurs rather quickly due to the stored energy in the biasing members **100** and **122** and therefore FIG. **6** illustratively shows how the valves **78** and **80** change quickly where hydro-pressure forces acting thereon are substantially equalized.

The laterally inner surface of the second piston member **62** of the piston assembly **46** in FIG. **6** is in contact with the engagement surface **85** at the right end of the shaft **84** of the first valve **78**. The first piston member **60** repositions the central shaft **84** towards the first direction **141** (to the left in FIG. **6**). As soon as the first stop member **90** is unseated from the first stop seat **92** the operating fluid entering in through the high pressure passage **56** is allowed now to pass through not only the second valve element **88** but now also through the first valve element **86**. Prior to the repositioning of the central shaft **84** the first stop member **90** was maintained in forceful engagement with the first stop seat **92** because of the pressure differential between the first laterally inner subchamber **72** and the high pressure passage **56** (see FIG. **2**). Now that the seal is broken as shown in FIGS. **6** and **7**, the pressures acting upon either side of the first stop member **90** (as well as the second stop member **96**) are substantially equal and hence the only element that is providing a force to act upon the central shaft **84** is the first biasing member **100** which is compressed and has stored energy therein. Therefore the central shaft **84** is “snapped” to the left to a position as shown in FIGS. **9** and **10**.

Now referring to FIG. **8**, the second valve **80** is in a transition where the laterally inner surface of piston **62** has placed a force upon the engagement surface **105** of the central shaft **104**. This moves the central shaft **104** toward the first direction (to the left in FIGS. **8** and **9**) and unseats the fourth stop member **116** from the fourth stop seat **118**. This allows the intensified pressure in first laterally inner subchamber **72** to leak around the fourth stop member **116** thereby now creating substantially equal pressure on either side of the fourth stop member **116**. The third biasing member **122** now does not have an opposing force therefore it biases the central shaft towards the first direction and “snaps” in the second position as shown in FIGS. **9** and **11**.

FIGS. **9** and **12** show the pressure distributor system **48** in a second position where the second laterally inner subchamber **76** is in communication with the high pressure passage **56** and the first laterally inner subchamber **72** is in communication with the exit passage **58**. The piston assembly **46** is now traveling towards the second direction **143** (to the right in FIG. **9**) and operating fluid contained in the second laterally outer subchamber **74** is under intensified pressure. This intensified pressurized fluid now exits past the check valve **146** and the operating fluid in subchamber **72** now exits through the exit passage **58**. Operating fluid at the operating pressure passes through the check valve **140** to apply a pressure-force upon the first piston member **60**. It should be noted that the intensified pressure in line **34** is greater than the pressure of the line **30** by the maximum pressure multiple. Therefore line **34** is not in communication with line **30** because of the check valve **144**. Likewise the intensified pressure in the second laterally outer subchamber **74** is much greater than the operating pressure in line **32**. Therefore the check valve **142** prevents fluid to flow therethrough. The operation of the pressure intensifier system **20** is in the second operating position that is the opposite of the first operating position as shown in FIG. **1** (due to the pressure distributor system **48** valve orientation). The piston will continue to travel in the second direction and will reach a position as shown in FIG. **13**.

FIG. **13** shows the pressure distributor system **48** still in the second position; however, the first piston member **60** is traveling to the right (the second direction) and has begun compressing the second biasing member **102** and the fourth biasing member **124** (see FIGS. **14** and **15**). As shown in the preferred FIGS. **13**–**15**, force in the spring members **102** and **124** is not great enough to unseat the second valve element **88** and the third valve element **106**. However, energy is being stored in the biasing members **102** and **124** as the first piston member **60** moves to the right. As the piston assembly **46** continues to move to the right to the position as shown in FIGS. **16**–**18**, the engagement surface **87** of the central shaft **84** and the engagement surface **107** of central shaft **104** contact the first piston member **60**.

As soon as piston member forces the central shafts **84** and **104** to be repositioned to the right, the valve elements **88** and **106** become unseated as shown in FIGS. **17** and **18**. As shown in FIG. **17**, the second stop member **94** has the same pressure acting on each lateral side and hence creating balanced fluid pressure-forces about the first valve **78**. Now the stored energy in the second biasing member **102** comes into play and dynamically snapping the central shaft **84** and the components attached thereto to the right (second direction) to a position back where the discussion began with FIGS. **4** and **5**. It should be noted that the first biasing member **100** does not produce as much force per unit of distance of travel than the second biasing member **102**. Therefore when the second biasing member **102** expands the first biasing member **100** is compressed and the energy is stored there in until the first piston member **60** releases the pressure forces acting upon the first valve **78** as shown in FIG. **6**.

The second valve **80** as shown in FIG. **18** performs in a similar manner to that of the first valve **78**. As the central shaft **104** is repositioned to the right, the third stop member **110** is unseated from the third stop seat **112** whereby allowing the operating fluid at intensified pressure in second laterally outer subchamber **76** pass therearound. The fluid pressure is now the substantially same on both lateral sides of the third stop member **110** and the stored energy in the fourth biasing member **124** is released where by the central shaft **104** is snapped to the right (the second direction) and the second valve **80** is in the first position as shown in FIG. **5**.

Referring back to FIG. **2** the pressure multiplier **24** is in what is referred to as the first position where the operating fluid in the first laterally outer subchamber **70** is now under intensified pressure and the fluid is exiting through check valve **144** and traveling to the high pressure receiving member **26**.

The process will continue as long as the pressurizing system **22** supplies on operating pressure that is sufficient that when multiplied by the maximum pressure multiple to produce the intensified pressure, that value is great enough to pass through the high pressure receiving member **26**.

With the foregoing in mind, there will now be a discussion regarding the operation of the pressure distributor system **48** in various non-continuous circumstances. The pressure distributor system **48** will not allow the pressure intensifier system **20** to enter a "stall" state where the fluid circuit allows a steady stream of operating fluid from the return line **38** to both of the laterally inner subchambers **72** and **76**. As shown in FIGS. **7** and **8** and in FIGS. **17** and **18**, the first and second valves **78** and **80** are in dynamic state of transition from a second position to a first position. The biasing members **100**, **102**, **122** and **124** ensure that the alternating transition from the first and second positions is dynamic and employs stored energy. The stored energy is derived from the movement of the piston assembly **46**; however, the valve transition is only accomplished by the biasing members and not predicated upon the relatively slow moving piston assembly **46**. In other words, once the seal between a stop member and stop seat is "cracked" and the hydrostatic pressure on either side of the seal member is equalized, the valve transition is accomplished by the stored energy in the biasing members and is independent of the position of the piston assembly.

It should be noted that the first and second valves **78** and **80** do not remain in the intermediate zone where communication between the return line **38** or the exit passage **58** and the first and second laterally inner subchambers **72** and **76**.

For example, let us assume that the pump **23** stops providing pressure to the system when the second piston member is **62** is just beginning to contact the engagement surfaces **85** and **105** as shown in FIGS. **6**–**8**. If the biasing members **100** and **122** were not present, the transition of the valves **78** and **80** are solely relied upon the force of the second piston member **62** to move the central shafts **84** and **104** to the left as shown in FIGS. **7** and **8**. If this were the case, when the pump **23** shuts off, the system **20** would be in a stall state where the fluid that returns from the return line **38** would communicate with both of the inner subchambers **72** and **76**. These subchambers would further be in communication with the exit passage **58**. Therefore, the returning operating fluid would pass through the chambers **72** and **76** to the ambient pressure and the first inner subchamber **72** would not receive operating fluid under intensified pressure to bias the fist piston member **60** to the left in FIG. **6**. Further, the flow in the return line will be diminished because the operating fluid must be under intensified pressure to pass through the reverse osmosis filter (or high pressure requiring device) of the high pressure receiving member **26**. The pressure entering the high pressure receiving member **26** would only be the operating pressure produced by the pump **23**.

However, the biasing members **100** and **122** do not allow the valves **78** and **80** to remain in the intermediate zone for more than an instant. Therefore, if the pump **23** were to shut off when the piston assembly **46** is in a position as shown in FIGS. **6**–**8**, the stored energy in the biasing members **100** and **122** would continue to bias the shafts **84** and **104** to the left and place the pressure distributor system **48** in the second position. Thereafter when the pump is restarted the first and second valves **78** and **80** are in the position as shown in FIGS. **10** and **11** and the piston assembly travels to the right (the second direction). The check valve **140** has a lower crack pressure than the check valve **142** (see FIG. **1**). Therefore, the fluid will initially pass through line **30** and inter the first laterally outer subchamber **70**.

Now let us assume the other potential stall scenario where the piston assembly **46** is located in a position as shown in FIGS. **13**–**15** when the pump **23** shuts off. In this scenario the biasing members **102** and **100** in FIG. **14** could potentially have balanced opposing lateral forces. When the pressure in the entire system **20** is atmospheric, the first valve **78** could be in a where both the stops **94** and **90** are unseated from their respective stop seats **98** and **92**. When the pump begins to operate and provides pressure through lines **32** and **32** (see FIG. **1**), the operating fluid will first initially flow through line **30**. The operating fluid would then enter the first laterally outer subchamber **70** and would bias the piston assembly to the right whereby forcing the central shafts **84** and **104** to the right until the stop members **90** and **116** engage their respective stop seats **92** and **118**. Thereafter, the first laterally inner subchamber **72** is solely in communication with the high pressure passage **56** and the second laterally inner subchamber **76** is solely in communication with the exit passage **58**. Therefore the piston assembly will travel to the left (the first direction) and the pressure multiplier **24** will supply intensified pressure to the high pressure receiving member **26**.

It should be noted that any movement of the piston will remove the stall mode because the stored energy in the biasing members **100** and **122** will bias the pressure distributor system **48** to the second position if the piston assembly moves to the left. If this were the case than the piston assembly would immediately begin moving back to the right and begin the valve transition to the first position as shown in FIGS. **13**–**18** and described above. After the transition it would then again begin moving to the left.

The first and second valves **78** and **80** could be integrated in a manner so the first and third biasing members **100** and **122** are combined and the second and fourth biasing members **102** and **124** are combined where as the springing action of the combined spring providing the function of the biasing members **102** and **124** would unseat the valve elements **88** and **106**. Likewise, the single spring that combines the function of the first and third biasing members **100** and **122** would be adapted to unseat the valve elements **86** and **108**. Of course the present invention could take various forms without departing from the spirit and scope of the invention as presented in the proceeding claims.

A second embodiment of the present invention will now be described with reference to FIG. **19**. In this second embodiment, components which are similar to components of the first embodiment will be given like numerical designations, with an "a" suffix, distinguishing those of the second embodiment. The following components that appear both in the first embodiment and also in the second embodiment, are for ease of illustration not shown in FIG. **19**. These components that are not shown are the pressurizing system **22**, the pressure cylinder **44**, the piston assembly **46**, the fluid distributor system **35**, and the high pressure receiving member **26**, with the understanding that these components or "equivalent components" are also part of the second embodiment. The components of the second embodiment which may differ from those of the first embodiment are primarily in the pressure distribution system **48***a* of the second embodiment. In the second embodiment, there are the high pressure passage **56***a* through which the intensified return fluid passes, and also the exit passage **58***a* where the low pressure fluid is discharge is also in the second embodiment. The main differences in the second embodiment relative to the first embodiment are in the two valves **78***a* and **80***a*.

The valve **78***a* comprises a spool valve member **150***a* which is positioned for back and forth motion in an adjacent first valve housing **152***a*. The spool valve member **150***a* has a central cylindrical spool portion **154***a* with right and left circumferential grooves **156***a* and **158***a* adjacent thereto. Extending oppositely from the location of the grooves **156***a* and **158***a*, are right and left cylindrical connecting sections **160***a* and **162***a* which connect, respectively, to retaining end members **164***a* and **166***a*.

The two connecting members **160***a* and **162***a* have a center longitudinally aligned passageway, **168***a* and **170***a*, respectively, opening to opposite ends of the valve member **150***a*. The inner ends of these passageways **168***a* and **170***a* connect to radially aligned through openings **172***a* and **174***a*, respectively, which in turn extend through the grooves **156***a* and **158***a*.

Thus, it can be seen that in the position of FIG. **19** that the valve member **150***a* is positioned so that the flow downwardly from the passageway **56***a* flows through the passageways **172***a* and **168***a* into the adjacent subchamber **76***a*. The left portion of the central cylindrical spool **154***a* blocks the passageway to the left, since the circular groove **158***a* is not in connection with the high pressure inlet passageway **56***a*.

The valve **80***a* is also shown in FIG. **19**. This valve **80***a* comprises a valve element **178***a* which is mounted for back and forth movement in a related valve housing **180***a*. The valve element **168***a* has right and left end seal plates **182***a* and **184***a*. These seal plates **182***a* and **184***a* may have a circular configuration and are connected by a single connecting member **186***a* that has at outer end portions a cross sectional configuration similar to that shown in FIG. **20**. Thus, it can be seen that with the valve element **178***a* in the position of FIG. **19**, the fluid in the adjacent laterally inner subchamber **72***a* to the left is passing around the connecting portion **186***a* of the valve element **168***a*, and out the exit opening **58***a*.

The longitudinally connecting member **186***a* of the valve element **168***a* has an elongate longitudinal, cylindrically shaped center opening **188***a* in which is positioned a rod **190***a* that has a diameter moderately less than the central opening **178***a*.

With regard to the valve element **178***a*, it will be noted that there are two springs **192***a* and **194***a*, and these function in generally the same manner as the corresponding biasing springs in the first embodiment. Accordingly, there will not be detailed explanation of their operation in this text describing this second embodiment.

There is also a biasing spring **196***a* which is positioned on the left-hand side of the connecting member **186***a* that urges the valve element **178***a* to the left, and this functions in substantially the same way as the corresponding biasing spring described in the first embodiment.

In addition, there is a spring **198***a* (see FIGS. **19** and **21**) which is connected to a frusto-conical closure member **200***a* that is adjacent to the left end opening of the center passageway **188***a*. Also, there is a retaining member **202***a* which connects through a small shaft **204***a* to the seal member **200***a*. A circumferential flange **206***a* retains the spring **198***a* onto the shaft **204***a*. It can be seen that when the end flange **206***a* is engaged by the left piston, this will compress the spring **198***a* and cause the sealing member **208** to close the left end of the passageway **188***a*. At the same time, this will function to open another sealing member **208***a* that is at the opposite end of the rod **190***a*. There is a port **210***a* which is drilled through the center portion of the connecting member **186***a* to connect to the exit passageway **58***a*. Thus, this will cause the right inner subchamber to be vented to atmospheric pressure. This venting function would be of benefit in a situation where there may be a pressure lock in one or the other of the inner subchambers that would impede movement of the valve element **80***a*.

It is believed that the functioning of this second embodiment is apparent from the earlier description of the functioning of the first embodiment. With the two valves **78***a* and **80***a* in the positions shown in FIGS. **19** and **20**, respectively, it is evident that the piston assembly is moving from left to right, and when the piston on the left of the two valves **78***a* and **80***a* comes into contact with the left end of the valve elements **150***a* and **168***a*, the two valve elements **150***a* and **168***a* will be moved to the opposite positions so that the piston assembly will reverse its path of travel.

I claim:

1. A pressure intensifier system adapted to increase the pressure of an operating fluid, the pressure intensifier comprising,

a) a pressure cylinder having a first region, a central region and a second region where the lateral direction from the central region to the first region indicates a first direction and an opposing lateral direction from the central region to the second region indicates a second direction, the pressure cylinder having an interior surface, a high pressure passage, and an exit passage;

b) a piston assembly comprising,

a first piston member positioned in the first region of the pressure cylinder, the first piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a first laterally outer subchamber and a first laterally inner subchamber;

a second piston member positioned in the second region of the pressure cylinder, the second piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a second laterally outer subchamber and a second laterally inner subchamber, a connecting member having first and second lateral ends that are fixedly connected to the first and second piston members respectively;

c) a pressure distributor system positioned in the pressure cylinder comprising,

a first valve located in the central region of the pressure cylinder and allowing communication between the high pressure passage and either the first laterally inner subchamber or the second laterally inner subchamber, the first valve having a first biasing member that biases the first valve to a second position of the first valve that provides communication between the second laterally inner subchamber and the high pressure passage, a second biasing member adapted to change the first valve to a first position of the first valve that provides communication between the first laterally inner subchamber and the high pressure passage;

a second valve located in the central region of the pressure cylinder and allowing communication between the exit passage and either the first laterally inner subchamber or the second laterally inner subchamber, the second valve having a third biasing member that biases the second valve to a first position of the second valve that provides communication between the second laterally inner subchamber and the exit passage, a fourth biasing member adapted to change the second valve to a second position of the second valve that provides communication between the first laterally inner subchamber and the exit passage;

d) a pressurizing system having a first line portion that is in communication with the first laterally outer subchamber and the second laterally outer subchamber where a check valve system allows unidirectional flow to the first or second laterally outer subchambers;

a high pressure receiving member having a high pressure inlet port connected to the first and second laterally outer subchambers and a check valve system allows unidirectional flow to the inlet port, a return line that provides communication between the high pressure inlet port and the high pressure passage of the pressure cylinder; the high pressure receiving member having a high pressure operating device in communication with the high pressure inlet port;

whereby the piston assembly is adapted to oscillate to alternately displace operating fluid contained therein the first laterally outer subchamber and the second laterally outer subchamber to deliver the operating fluid under intensified pressure to the high pressure receiving member whereby a portion of this fluid is directed to the high pressure passage of the pressure cylinder;

e) the second biasing member positioning the first valve at the first position of the first valve by employing stored energy of the second biasing member; and

f) the second biasing member having a higher spring constant than the first biasing member whereby when the second biasing member positions the first valve to the first position of the first valve, the first biasing member stores potential energy therein.

2. The pressure intensifier system as recited in claim **1** where the first valve is adapted to remain in the first position of the first valve while the operating fluid is under intensified pressure in the high pressure passage and the second laterally inner subchamber is at a respective lower pressure.

3. The pressure intensifier system as recited in claim **2** where the first valve is adapted to change to the second position of the first valve when the motion of the piston assembly in the first direction unseats the first valve element thereby unlocking the potential energy stored in the first biasing member seating the second valve element.

4. A pressure intensifier system adapted to increase the pressure of an operating fluid, the pressure intensifier comprising,

a) a pressure cylinder having a first region, a central region and a second region where the lateral direction from the central region to the first region indicates a first direction and an opposing lateral direction from the central region to the second region indicates a second direction, the pressure cylinder having an interior surface, a high pressure passage, and an exit passage;

b) a piston assembly comprising,

a first piston member positioned in the first region of the pressure cylinder, the first piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a first laterally outer subchamber and a first laterally inner subchamber;

a second piston member positioned in the second region of the pressure cylinder, the second piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a second laterally outer subchamber and a second laterally inner subchamber, a connecting member having first and second lateral ends that are fixedly connected to the first and second piston members respectively;

c) a pressure distributor system positioned in the pressure cylinder comprising,

a first valve located in the central region of the pressure cylinder and allowing communication between the high pressure passage and either the first laterally inner subchamber or the second laterally inner subchamber, the first valve having a first biasing member that biases the first valve to a second position of the first valve that provides communication between the second laterally inner subchamber and the high pressure passage, a second biasing member adapted to change the first valve to a first position of the first valve that provides communication between the first laterally inner subchamber and the high pressure passage;

a second valve located in the central region of the pressure cylinder and allowing communication between the exit passage and either the first laterally inner subchamber or the second laterally inner subchamber, the second valve having a third biasing member that biases the second valve to a first position of the second valve that provides communication between the second laterally inner subchamber and the exit passage, a fourth biasing member adapted to change the second valve to a second position of the second valve that provides communication between the first laterally inner subchamber and the exit passage;

d) a pressurizing system having a first line portion that is in communication with the first laterally outer subchamber and the second laterally outer subchamber where a check valve system allows unidirectional flow to the first or second laterally outer subchambers;

a high pressure receiving member having a high pressure inlet port connected to the first and second laterally outer subchambers and a check valve system allows unidirectional flow to the inlet port, a return line that provides communication between the high pressure inlet port and the high pressure passage of the pressure cylinder; the high pressure receiving member having a high pressure operating device in communication with the high pressure inlet port;

whereby the piston assembly is adapted to oscillate to alternately displace operating fluid contained therein the first laterally outer subchamber and the second laterally outer subchamber to deliver the operating fluid under intensified pressure to the high pressure receiving member whereby a portion of this fluid is directed to the high pressure passage of the pressure cylinder;

e) the fourth biasing member positioning the second valve to the first position of the second valve by employing stored energy of the fourth biasing member;

f) the fourth biasing member having a higher spring constant than the third biasing member whereby when the fourth biasing member positions the second valve to the first position of the second valve, the third biasing member stores potential energy therein.

5. The pressure intensifier system as recited in claim **4** where the second valve is adapted to remain in the first position of the second valve while operating fluid in the first laterally inner subchamber is under intensified pressure and the exit passage is at a respective lower pressure.

6. The pressure intensifier system as recited in claim **5** where the second valve is adapted to change to the second position of the second valve when the motion of the piston assembly in the first direction unseats the fourth valve element whereby unlocking the potential energy stored in the third biasing member thereby seating the second valve element.

7. A pressure intensifier system adapted to increase the pressure of an operating fluid, the pressure intensifier comprising,

a) a pressure cylinder having a first region, a central region and a second region where the lateral direction from the central region to the first region indicates a first direction and an opposing lateral direction from the central region to the second region indicates a second direction, the pressure cylinder having an interior surface, a high pressure passage, and an exit passage;

b) a piston assembly comprising,

a first piston member positioned in the first region of the pressure cylinder, the first piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a first laterally outer subchamber and a first laterally inner subchamber;

a second piston member positioned in the second region of the pressure cylinder, the second piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a second laterally outer subchamber and a second laterally inner subchamber, a connecting member having first and second lateral ends that are fixedly connected to the first and second piston members respectively;

c) a pressure distributor system positioned in the pressure cylinder comprising,

a first valve located in the central region of the pressure cylinder and allowing communication between the high pressure passage and either the first laterally inner subchamber or the second laterally inner subchamber, the first valve having a first biasing member that biases the first valve to a second position of the first valve that provides communication between the second laterally inner subchamber and the high pressure passage, a second biasing member adapted to change the first valve to a first position of the first valve that provides communication between the first laterally inner subchamber and the high pressure passage;

a second valve located in the central region of the pressure cylinder and allowing communication between the exit passage and either the first laterally inner subchamber or the second laterally inner subchamber, the second valve having a third biasing member that biases the second valve to a first position of the second valve that provides communication between the second laterally inner subchamber and the exit passage, a fourth biasing member adapted to change the second valve to a second position of the second valve that provides communication between the first laterally inner subchamber and the exit passage;

d) a pressurizing system having a first line portion that is in communication with the first laterally outer subchamber and the second laterally outer subchamber where a check valve system allows unidirectional flow to the first or second laterally outer subchambers;

a high pressure receiving member having a high pressure inlet port connected to the first and second laterally outer subchambers and a check valve system allows unidirectional flow to the inlet port, a return line that provides communication between the high pressure inlet port and the high pressure passage of the pressure cylinder; the high pressure receiving member having a high pressure operating device in communication with the high pressure inlet port;

whereby the piston assembly is adapted to oscillate to alternately displace operating fluid contained therein the first laterally outer subchamber and the second laterally outer subchamber to deliver the operating fluid under intensified pressure to the high pressure receiving member whereby a portion of this fluid is directed to the high pressure passage of the pressure cylinder; and

e) the first piston being adapted to engage the second biasing member thereby storing potential energy therein as the piston assembly travels in the second direction and when the second stop member is unseated from the second stop seat, the hydrostatic forces on the second stop member are equalized on either side thereof, and the stored energy of the second biasing member biases the central shaft in the second direction thereby seating the first stop member in sealing engagement with the first stop seat.

8. A pressure intensifier system adapted to increase the pressure of an operating fluid, the pressure intensifier comprising,

a) a pressure cylinder having a first region, a central region and a second region where the lateral direction from the central region to the first region indicates a first direction and an opposing lateral direction from the central region to the second region indicates a second direction, the pressure cylinder having an interior surface, a high pressure passage, and an exit passage;

b) a piston assembly comprising,

a first piston member positioned in the first region of the pressure cylinder, the first piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a first laterally outer subchamber and a first laterally inner subchamber;

a second piston member positioned in the second region of the pressure cylinder, the second piston member in sealing engagement with the inner surface of the pressure cylinder thereby defining a second laterally outer subchamber and a second laterally inner subchamber, a connecting member having first and second lateral ends that are fixedly connected to the first and second piston members respectively;

c) a pressure distributor system positioned in the pressure cylinder comprising,

a first valve located in the central region of the pressure cylinder and allowing communication between the high pressure passage and either the first laterally inner subchamber or the second laterally inner subchamber, the first valve having a first biasing member that biases the first valve to a second position of the first valve that provides communication between the second laterally inner subchamber and the high pressure passage, a second biasing member adapted to change the first valve to a first position of the first valve that provides communication between the first laterally inner subchamber and the high pressure passage;

a second valve located in the central region of the pressure cylinder and allowing communication between the exit passage and either the first laterally inner subchamber or the second laterally inner subchamber, the second valve having a third biasing member that biases the second valve to a first position of the second valve that provides communication between the second laterally inner subchamber and the exit passage, a fourth biasing member adapted to change the second valve to a second position of the second valve that provides communication between the first laterally inner subchamber and the exit passage;

d) a pressurizing system having a first line portion that is in communication with the first laterally outer subchamber and the second laterally outer subchamber where a check valve system allows unidirectional flow to the first or second laterally outer subchambers;

a high pressure receiving member having a high pressure inlet port connected to the first and second laterally outer subchambers and a check valve system allows unidirectional flow to the inlet port, a return line that provides communication between the high pressure inlet port and the high pressure passage of the pressure cylinder; the high pressure receiving member having a high pressure operating device in communication with the high pressure inlet port;

whereby the piston assembly is adapted to oscillate to alternately displace operating fluid contained therein the first laterally outer subchamber and the second laterally outer subchamber to deliver the operating fluid under intensified pressure to the high pressure receiving member whereby a portion of this fluid is directed to the high pressure passage of the pressure cylinder;

e) the second valve comprising a central shaft of the second valve, a third valve element comprising a third stop member attached to the central shaft of the second valve and a third stop seat, and a fourth valve element comprising a fourth stop member attached to the central shaft of the second valve and a fourth stop seat in a manner that the third valve element controls communication between the second laterally inner subchamber and the exit passage and the fourth valve element controls communication between the first laterally inner subchamber and the exit passage whereby the third biasing member biases the central shaft toward the first direction and the fourth biasing member biases the central shaft in the second direction; and

f) the first piston being adapted to engage the fourth biasing member thereby storing potential energy therein as the piston assembly travels in the second direction and when the third stop member is unseated from the third stop seat the hydrostatic forces on the third stop member are equalized on either side thereon and the stored energy of the fourth biasing member biases the central shaft of the second valve in the second direction thereby seating the first stop member in sealing engagement with the first stop seat.

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