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(54) **SPLIT-CHAMBER PRESSURE EXCHANGERS**

(57) The invention relates to split-chamber pressure exchangers. Split-chamber pressure exchangers are **characterized in that** the pressure exchange chambers and the pistons thereof are split in two. Each fluid passes through the corresponding chamber thereof, such that said fluids cannot be mixed. The cross sections of the chambers can be varied in order to vary the transmitted pressure. The reverse line operation can be established and synchronized using a U-shaped tube with telescopic sides and a fixed base filled with fluid or diametrically opposed curved lines, and multiple arrangements can be used. Split-chamber pressure exchangers can be used as surface or well pumping systems and the pumping fluid used can differ from the fluid to be pumped. Different levels of any material can be exploited at any storage site using a chamber with elastic walls filled with fluid and attached to the bottom. Electric power can be generated by centrifuging the pre-pumped fluid.

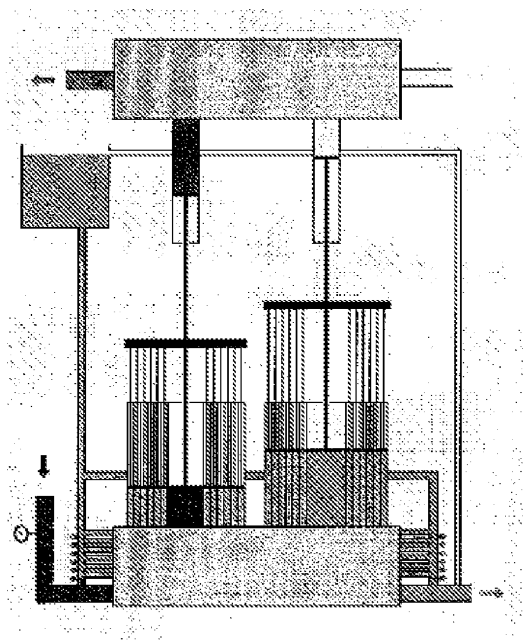

FIGURE 37

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Description

Field of the Art

[0001] The invention is comprised within the field of pressure exchangers, which are for transmitting dynamic pressure from one fluid to another different fluid.

[0002] Due to the innovations provided, the invention is transformed into a new pumping system for any type of fluids, and even into a new electric power generation system.

State of the Art

Pressure exchangers

[0003] Pressure exchangers were invented over more than twenty-five years ago and they basically consist of pressurizing one fluid (fluid 1 in Figure 1) from the pressure of another fluid, which is depressurized after the process (fluid 2). There are several models, but they all basically work according to the diagram of Figure 1. The fluid 1 is introduced in the interconnecting chambers by means of a system of shut-off and check valves, represented by the gray boxes. Once filled, the fluid 2 is allowed to pass through the other end, displacing said fluid by pushing an transmitting intermediate member which transmits the residual pressure between them, separating them (usually a disc or piston, though occasionally an intermediate fluid or any other system is used). The fluid 1 is thus pressurized. Then the inlet of the fluid 2 is shut off and a discharge valve opens. The fluid 1 is again allowed to pass through by means of the valve system, displacing fluid 2 (which now does not have pressure), discharging it through the drain.

[0004] The system is assembled with two parallel interconnecting lines and is electronically controlled such that at all times the disc or piston of each tube is located in the opposite position with regard to the center (reverse line operation) to thus achieve the most constant pressure possible at the outlet of the fluid 1, and to likewise achieve the greatest possible exploitation of the pressure of the fluid 2.

[0005] Figure 1 shows the fluids 1 and 2 using lighter shades when they do not have pressure and darker shades when they are pressurized. These different shades will be maintained throughout all the figures attached to this description.

[0006] A thorough worldwide search has been conducted in the espacenet database for patent documents relating to pressure exchangers, and it has been found that although there has been considerable development thereof, none of them provide the innovations described herein.

Current applications of pressure exchangers

[0007] Pressure exchangers have traditionally been used in mining to displace residual processing water with clean water and the system is used without discs or pistons since it does not matter if both fluids mix.

[0008] They are starting to be used today in reverse osmosis water desalination plants according to a scheme such as that depicted in Figure 2. The process is very simple: it pre-treats the water and then raises the pressure of the water until it exceeds its osmotic pressure. The water is then passed through reverse osmosis filters which have a semi-permeable membrane and produce two outputs: desalinated and depressurized water on one side and brine at a fairly high pressure on the other side. This pressure is used to pressurize part of the water coming from the pre-treatment, thus reducing the output of high pressure pumps with the subsequent electric power savings.

Pumping systems

[0009] Many types of horizontal, vertical and submerged electric pump units for clean water have been extensively developed to date, as have many pumping systems for all types of fluids (waste water, viscous fluids, toxic fluids, hazardous fluids, seawater, chemicals, concrete, turbid water, or any type of fluid imaginable, including fluids with solids in suspension).

Explanation of the Invention

Technical problems involved with traditional pressure exchangers

[0010] Although the system proposed in the previous section relating to desalination is fairly energetically efficient, it presents two problems:

- the outlet pressure of the reverse osmosis filters of the brine is always lower than that of the feed water, which means that it is necessary to install a booster pump increasing the pressure of the water
- since the pre-treatment water and the brine are separated in the pressure-transmitting intermediate members, there is always a small though significant mixture of both fluids, therefore the pre-treatment water leaves the pressure exchangers with a higher salt concentration, which obviously jeopardizes the process

[0011] Furthermore, traditional pressure exchangers generally present another drawback, which is that the fluid to be pressurized (fluid 1) is forced to displace the fluid 2 once it has been depressurized. This is not so much of a problem in the case of desalinators because the water to be pressurized comes from the pre-treatment process, from which it leaves with some pressure, but in other applications it may be a serious drawback, especially taking into account the fact that the reverse line operation is necessary, and the natural speeds of the discs or pistons in either direction are very different. This reduces the performance of the exchangers and complicates the system control electronics.

[0012] All these drawbacks are probably what have not allowed further development of pressure exchangers in all types of applications.

Technical problems involved with traditional electric pump units

[0013] Even though the designs of all types of electric pump units are well optimized today, they have some shortcomings which until now have been impossible to solve, such as:

- regarding electric pump units for removing water from wells or collection boxes, the motor of vertical units is on the surface, but they cause many mechanical problems with the long shaft they require, and submerged units have the problem that since the pump body and the motor are submerged in the well or collection box, any operating failure causes the unit to be out of service for a considerable time period since the unit must be disassembled and then assembled
- regarding the pumping systems for other fluids, they have a lower performance in many cases and usually offer many maintenance problems due to the inlet of solids, such as the case of waste water pumping, or due to corrosion of the delicate and expensive pump body, or due to both effects

General Description of the Invention and Solutions Provided

Split-chamber pressure exchangers (SCPEs)

[0014] These are pressure exchangers characterized in that the pressure exchange chambers are split in two, one for each of the fluids, as shown in Figure 3. Each of the fluids therefore only passes through the corresponding chamber thereof, such that said fluids cannot be mixed (and the second problem described in the preceding section is therefore solved).

[0015] The exchange of pressures takes place by replacing the pressure-transmitting intermediate members in traditional with two rigidly attached discs or pistons, as shown in Figure 3. The pressurized fluid will thus push and also displace the other fluid through the corresponding chamber thereof. The chambers obviously need to have an opening to the outside to allow the inlet and outlet of air during the movements of the discs or pistons and to prevent vacuums, as can also be seen in Figure 3.

[0016] Drains can be arranged at the opposite ends of the chambers in case it is necessary to drain a small amount of the fluids which may be lost through the disc or piston seals.

Arrangements

SCPEs with piston-type chambers

[0017] A first possible arrangement would be the one shown in Figure 3, in which the cross sections of each chamber are identical. The same pressure would thus be transmitted from the pressurized fluid to the fluid to be pressurized, except obviously mechanical losses.

[0018] The inventive system allows another arrangement, in which the cross sections of the chambers are different (Figure 4), and therefore the transmitted pressure is also different (the pressure ratio will be equal to the area ratio, except obviously for mechanical losses, since the net force is the same). The problem of the need for the booster pump mentioned above in the description of the technical problem involved can thus obviously be solved.

[0019] Obviously, the vertical or angled arrangement of the lines is possible (Figure 5), but this will worsen the problem that the fluid to be pressurized (fluid 1) must displace the fluid 2 once it has been depressurized, since in this case it must also overcome the weight of the fluid, plus that of the discs or pistons and the attachment between them. To that end an additional lifting system thereof could also be arranged, the control of which would be integrated in the electronic control system of the system, or the drain system shown in Figure 6 can be used, which consists of exploiting the energy from the pressurized fluid (fluid 2) not only to transmit it to the fluid to be pressurized (fluid 1), but also to aid the actual fluid 1 in displacing fluid 2 in the other line once it has been depressurized. This is achieved by means of an auxiliary U-shaped tube which interconnects both lines as shown in Figure 6, and it is a telescopic tube on both sides of the "U", being rigidly supported by the base of the "U". The ends of the "U" are attached to the discs or pistons of their respective lines, and the "U" is filled with an incompressible fluid. Therefore, when the fluid 2 under pressure enters its chamber, not only does it apply pressure to its disc or piston to displace fluid 1, but it also transmits part of its energy to the disc or piston of the other line to aid fluid 1 of the other line in displacing the depressurized fluid 2 in said line and in overcoming the friction of the discs or pistons and their weight and that of the depressurized fluid 2 if necessary. Logically, the cross section of the tube must be such that the energy transferred to the disc or piston of the other line is the necessary minimum. The reverse line operation is furthermore assured by means of this system, thus simplifying the system control electronics. It can be assembled in any type of pressure exchangers, whether they are split chambers or not. Obviously, instead of being a telescopic tube they could be several telescopic tubes equidistant from one another and from the center, or a ring made up of several sections of the same length and equidistant for the purpose of better distributing the stress on the discs or pistons.

[0020] Finally, curved or circular chamber lines can also be arranged, in which case the attachment between the discs or pistons will be curved and have the same radius, and will be attached to the center by means of a ball-type joint (Figure 7). An increase of the pressure transmitted can thus be achieved depending on the distance of the chambers of both fluids to the center, without needing to change the cross section of the chambers, though without jeopardizing the possibility of being able to combine both effects. Furthermore, if the two lines are placed diametrically opposed to one another, and the attachment parts between the discs or pistons of each line are in turn rigidly attached to one another, as shown in Figure 7, the same effect is achieved as with the previously described U-shaped part, i.e., on one hand the reverse line operation is achieved, thus simplifying the system control electronics, and on the other hand the fluid 2, once it is depressurized, is displaced from the corresponding chambers thereof without needing auxiliary pumping, in cases in which the fluid 1 enters under very little pressure.

[0021] The splitting of chambers can be applied to all types of traditional pressure exchangers developed today. There particularly exists another type of traditional pressure exchangers, which are mentioned perhaps because they are the most distinguished of all of them, which are based on the same operating principle but consisting of a cylinder with a series of inner conduits through which the fluids pass, the pressures being exchanged. They further have the particularity that the actual cylinder rotates about its own axis. The chambers of this type of exchanger can also be split to obtain the advantages herein explained.

SCPEs with telescopic chambers

[0022] These are SCPEs in which in order to transmit pressures the chambers are telescopic and push one another, rather than the rigidly attached double disc or piston system. Figure 8 shows a schematic depiction thereof. SCPEs with bellows-type chambers

[0023] These are SCPEs in which in order to transmit pressures the chambers are bellows-type chambers and push one another, rather than the rigidly attached double disc or piston system. Figure 9 shows a schematic depiction thereof.

SCPEs with membrane-type chambers

[0024] These are SCPEs in which the chambers in each line are arranged such that those corresponding to the fluid to be pressurized have rigid walls, and those of the fluid which yields its pressure are membrane-type chambers, the latter being included within the rigid wall type. Figure 10 shows a schematic depiction thereof.

SCPEs with mixed chambers

[0025] Obviously any of the possible arrangements (piston-type, telescopic, bellows-type or membrane-type) can be combined such that the chambers corresponding to one of the fluids can have one arrangement and the chamber corresponding to the other fluid can have a different arrangement.

[0026] Two of the possible combinations are depicted in Figures 11 (piston-type chambers/telescopic chambers) and 12 (telescopic chambers/bellows-type chambers).

Multistage SCPEs

[0027] Multistage SCPEs consist of the splitting the chambers of the fluid the pressure of which is yielded into several chambers, which may or may not be used depending on the available pressure of the fluid, by means of a valve system, thus being able to transmit the most homogenous pressure possible to the fluid to be pressurized, as shown in Figure 13.

[0028] They can also be arranged such that the chambers which are split are the chamber of the fluid to be pressurized, thus pressurizing it at different pressures depending on the needs at all times.

[0029] By means of the aid of an auxiliary tank, all the chambers can be filled continuously so as to allow opening auxiliary chambers midway through if the feed pressure changes, maximally exploiting the energy of the pressurized fluid, as shown in Figure 14.

[0030] Both Figures 13 and 14 depict multistage SCPEs with piston-type chambers, but they can obviously also be provided with telescopic, bellows-type, membrane-type or mixed chambers. They are further depicted with the different chambers by way of concentric and overlapping cylinders, but they can obviously be arranged with any possible geometry provided that the pressurized fluid pushes through all the chambers in the same direction.

[0031] Figure 15 depicts a multistage SCPE with a circular arrangement, which allows the aided reverse operation, as explained above. For those applications in which either the pressure at which the fluid the pressure of which is yielded must be returned once it has been depressurized, or the starting pressure of the fluid to be pressurized is variable, or both, with multistage SCPEs with a circular arrangement, or with other arrangements and the U-shaped tube system also described above, the control system can adjust the stages that must start operating also depending on these pressures.

[0032] Finally, it is also possible to complement the system with auxiliary pumping and a speed variator to keep the pressure of the fluid to be pressurized completely constant, controlling all this from the electronic control system. If the pressurized fluid comes from pumping, the speed variator can be placed in said pumping.

Variable section SCPEs (VSSCPEs)

[0033] Another interesting possibility regarding the design of SCPEs rests on their being able to have a variable section in any of the fluid chambers thereof fluid (one, several or all). To that end, it is essential for the piston, the actual chambers, or both, to be able to have variable sections. Both possibilities are described below.

Variable section pistons

[0034] These are pistons which have a section that changes along the piston stroke. To that end, the chamber on which they are housed must have a variable cross section.

[0035] The pistons must be designed such that their section can increase or decrease, maintaining their own rigidity and the seal of their attachments with the walls of the corresponding chamber thereof. To that end, any type of mechanical or pneumatic system, or a combination thereof, can be used.

[0036] Figures 16 and 17 depict the starts and the ends of the stroke of a variable section piston. For the sake of simplicity, a piston-type exchanger with a single line has been considered.

[0037] Since the section of the piston gradually reduces, the pressure exerted on the fluid to be pressurized increases.

[0038] This type of VSSCPE can be applied in those situations in which the distribution of pressures required by the system is known beforehand. Variable wall chambers

[0039] The distribution of pressures required by the system at all times is generally not known a priori in most of the possible applications, and the purpose is to attempt to modulate it depending on the needs of the actual system.

[0040] Variable geometry chambers, either telescopic or piston-type chambers, can be used in these cases, which can open or close and even open at one end and close at the other. Figures 18 and 19 depict a single-line piston-type VSSCPE with one of its chambers being a variable section chamber.

[0041] Any type of mechanical or pneumatic system can be used to move the walls of the variable section chambers. The use of auxiliary telescopic cylinders which are filled with an incompressible fluid and fixed at one end to the wall of the chamber and at the other end to a fixed wall, as shown in Figures 18 and 19, may be particularly interesting. The walls of the chamber are moved by extracting fluid from or introducing fluid into the cylinders according to the needs of the system.

[0042] Telescopic cylinders could obviously be replaced with a fixed chamber filled with an auxiliary fluid on which the actual wall of the chamber of the VSSCPE would move like a piston (Figures 20 and 21).

[0043] As explained above, it is also possible to provide chambers such that they can open at one end and close at the other end or vice versa (Figures 22 and 23).

[0044] It is important to point out that the walls of the chambers can move with very little force while the corresponding chamber is not loaded, therefore this would be the ideal time to do it. However, in certain applications it may be of interest to move them during the stroke of the piston, when the chamber is loaded, though to that end it is necessary to exert a greater force.

[0045] Finally, the possibility of using a membrane or elastic material so that a telescopic chamber opens or closes for the purpose of preventing the need for the piston to have a variable section (Figures 24 and 25) should also be mentioned.

Control of the speed of the piston

[0046] An additional advantage of considerable interest is that the VSSCPE can be designed such that the speed of the piston is constant, except in a small initial span in which it must be accelerated to the desired speed. The energy transfer performance is thus optimized since it is not used for an unnecessary acceleration of the double or single disc or piston. Figure 26 depicts a possible design for this purpose, which consists of providing the chamber with one of the fluids of an initial variable section span, during which the piston accelerates until reaching the design speed, at which time the straight span is reached, and the speed is kept constant since the system is designed so that at that time the force exerted on the piston by the fluid the pressure of which is yielded is equal to the force exerted by the fluid to be pressurized thereon plus losses due to friction corresponding to the design speed.

[0047] There is another way to design it to keep the speed of the piston constant which is explained in Figures 27 and 28, and it prevents the piston from having to be a variable section piston. As can be seen, the chamber has a section step, and again it is designed to reach the desired speed of the piston in the initial span with a larger section. In this case, the piston would have the possibility of being separated into two or more parts, such that during the first span it is kept rigidly attached and during the second span it separates. This could be done with any type of mechanical system.

[0048] Obviously, it is also possible to provide systems in which the initial acceleration of the piston is done by means of any other mechanical, electric, magnetic or pneumatic system imaginable, and even systems in which the piston accelerates while the gas is entering the chamber, such that the pressure to overcome is minimal.

Batteries of exchangers

[0049] As occurs with traditional pressure exchangers, SCPEs having any of the presented arrangements can be arranged in series (Figure 29), or in parallel (Figure 30). Likewise, when the pressure surges which are sought are very high, mixed systems with pumps can be arranged to increase the pressure of the pressurized fluid and/or the pressure of the fluid to be pressurized at the inlet and/or at the outlet of the pressure exchanger (Figure 31), without jeopardizing the fact that they can also be arranged in series or in parallel.

Control electronics

[0050] Regarding the control electronics of the valves, a card with a processor can be assembled *in situ,* or signals can be sent to a central computer controlling them. In the case of multistage SCPEs, the control system will be more complex as it must regulate the valves depending on the inlet and/or outlet pressures of the two fluids involved.

Number of lines per SCPE

[0051] Regarding the number of lines necessary per SCPE, there will usually be at least two in number but depending on the ranges of outputs and pressures worked with in each case, it may be appropriate to increase the number to three or more lines, although it may be appropriate for a line to not have the same length, since it would be used to achieve the most constant outlet pressure possible of the starting pressurized fluid.

[0052] In addition, on certain occasions it may be appropriate for only one line to be arranged, considerably simplifying the system control electronics.

Geometry of the chambers

[0053] Finally, regarding the geometry of the lines of the chambers, in any of the longitudinal arrangements they can be straight, curved and even circular, and the cross section thereof may be circular, elliptical, triangular, square, rectangular, polygonal or any imaginable cross section.

Alignment

[0054] Finally, the SCPEs in any of the arrangements put forth can be aligned in any possible way (horizontally, vertically or angled). Figures 32 and 33 show multistage SCPEs with vertical alignments, with the pressurized fluid pushing upwardly (Figure 32) or downwardly (Figure 33).

Design of the attachments in piston-type SCPEs

[0055] To reduce the effect of the bending stresses in piston-type SCPEs, another possibility consists of reinforcing the attachments of the rod, rods, sheets or central solid parts with the discs or pistons, as shown in Figures 34 and 35.

Advantages of the invention over the prior state of the art

[0056] As explained above in the general description of the invention, the essential advantages of the SCPEs are the following:

- each of the fluids only passes through the corresponding chamber thereof, such that said fluids cannot be mixed. This means that this system can be used to pump any type of fluid transmitting the necessary energy to another different fluid (which can be clean water, and even distilled water, or any other fluid that is found to cause less damage to the electric pump units), and then exchanging the pressures thereof. Very heavy and non-corrosive fluids can also be chosen to reduce the size of the pumping and storage installations. This will entail an increase of the performance achieved as well as a considerable savings in maintenance costs and even in installation design and execution costs
- they allow changing the cross sections of the chambers, thus changing the pressure transmitted to the fluid to be pressurized. This is another considerable advantage of this invention, since it allows choosing between pumping a greater output at a lower height, or a lower output at a greater height, which makes it possible to choose in each case the type of pump offering the best performance and better exploiting small pressure differences or small level differences of large amounts of fluid, as will be described below
- they allow assuring and harmonizing aided reverse line operation, either by means of the U-shaped tube with telescopic sides and fixed base filled with incompressible fluid or by means of the arrangement of diametrically opposed curved lines, and attachment parts between pistons of each line rigidly attached to one another
- they allow exploiting the energy of the level differences of any material in any storage form by means of the also innovative method described below,

and furthermore,

- SCPEs with telescopic, bellows-type, membrane-type or mixed chambers prevent the problem of bending stresses occurring in the discs or pistons rigidly attached to one another, reduce the space that the chambers occupy by half, and can be designed so that the reverse operation does not have to be aided, since it is possible to play with the elasticity of the membranes or design telescopic or bellows chambers such that they always automatically return to their starting position with enough force to drag the fluid, once depressurized, therein
- multistage SCPEs transmit the most homogenous pressure possible to the fluid to be pressurized, despite the variations of the pressure of the pressurized fluid at the inlet, or they pressurize it at different pressures depending on the needs at all times
- for those applications in which either the pressure at which the fluid the pressure of which is yielded must be returned once it has been depressurized, or the starting pressure of the fluid to be pressurized is variable, or both, with multistage SCPEs with a circular arrangement, or with other arrangements and the U-shaped tube system, the control system can adjust

the stages that must start operating also depending on these pressures

- in piston-type SCPEs, the reinforcement of the attachments of the rod, rods, sheets or central solid parts with the discs or pistons reduces the problem of bending stresses
- VSSCPEs open up the possibility of modulating the working pressures of split-chamber pressure exchangers, which will allow better adapting to the needs of a large amount of possible applications
- an additional advantage that is of considerable interest is that VSSCPEs can be designed such that the speed of the piston is constant, except in a small initial span in which it must be accelerated to the desired speed.

[0057] The energy transfer performance is thus optimized since it is not used for an unnecessary acceleration of the double or single disc or piston.

Description of the Drawings

[0058] Fifty drawings are attached to aid in explaining the operation, arrangements and applications of SCPEs. Reference is made thereto from several different points of this document, explaining in each case the content thereof. In any case, the relation and content of each drawing is provided below:

Figure 1: Diagram of traditional pressure exchangers
Figure 2: Process of a desalination plant with traditional pressure exchangers
Figure 3: Diagram of a split-chamber pressure exchanger
Figure 4: SCPEs with different cross sections
Figure 5: Vertical assembly of SCPEs
Figure 6: Aided reverse operation of SCPEs
Figure 7: Assembly of SCPEs with curved lines
Figure 8: SCPEs with telescopic chambers
Figure 9: SCPEs with bellows-type chambers
Figure 10: SCPEs with membrane-type chambers
Figure 11: SCPEs with mixed chambers (piston-type/telescopic)
Figure 12: SCPEs with mixed chambers (telescopic/bellows-type)
Figure 13: multistage SCPEs
Figure 14: multistage SCPEs with auxiliary tank
Figure 15: multistage SCPEs with circular arrangement
Figure 16: Diagram of a line of a piston-type VSSCPE with a fixed section chamber and the other chamber being a variable section chamber with fixed walls, the stroke of the piston starting
Figure 17: Diagram of a line of a piston-type VSSCPE with a fixed section chamber and the other chamber being a variable section chamber with fixed walls, the stroke of the piston ending
Figure 18: Diagram of a line of an immobile wall VSSCPE with telescopic pneumatic cylinders for securing the walls, the stroke of the piston starting
Figure 19: Diagram of a line of an immobile wall VSSCPE with telescopic pneumatic cylinders for securing the walls, the stroke of the piston ending and after having modified the section of the immobile wall chamber
Figure 20: Diagram of a line of an immobile wall VSSCPE with an outer chamber filled with fluid for securing the walls, the stroke of the piston starting
Figure 21: Diagram of a line of an immobile wall VSSCPE with an outer chamber filled with fluid for securing the walls, the stroke of the piston ending and after having modified the section of the immobile wall chamber
Figure 22: Diagram of a line of an immobile wall VSSCPE with two telescopic pneumatic cylinders for securing the walls, which allow the movement and the rotation of the walls of one of the chambers, the stroke of the piston starting
Figure 23: Diagram of a line of an immobile wall VSSCPE with two telescopic pneumatic cylinders for securing the walls, which allow the movement and the rotation of the walls of one of the chambers, the stroke of the piston ending and after having modified the geometry of the immobile wall chamber
Figure 24: Diagram of a line of an immobile wall VSSCPE with telescopic pneumatic cylinders for securing the walls, fixed section pistons and elastic span in the immobile wall chamber, the stroke of the piston starting
Figure 25: Diagram of a line of an immobile wall VSSCPE with telescopic pneumatic cylinders for securing the walls, fixed section pistons and elastic span in the immobile wall chamber, the stroke of the piston ending and after having modified the section of the immobile wall chamber
Figure 26: Diagram of a line of a VSSCPE in which one of the chambers has an initial variable section span to accelerate the piston
Figure 27: Diagram of a line of a VSSCPE in which one of the chambers has an initial smaller section span to accelerate the piston during the piston acceleration phase
Figure 28: Diagram of a line of a VSSCPE in which one of the chambers has an initial smaller section span to accelerate the piston during the constant piston speed phase once the two parts of the piston are set
Figure 29: Assembly in series of the SCPEs
Figure 30: Assembly in parallel of the SCPEs
Figure 31: Mixed systems of electric pump units and SCPEs
Figure 32: Multistage SCPEs in vertical arrangement, with the pressurized fluid pushing upwardly
Figure 33: multistage SCPEs in vertical arrangement, with the pressurized fluid pushing downwardly
Figure 34: Reinforcements in the attachments of the

Detailed Explanation of an Embodiment of the Invention

[0059] Figures 36 to 39 diagrammatically depict the operating process of a multistage SCPE, with seven concentric chambers located on the side of the pressurized feed fluid.

[0060] Figure 36 shows the first of the lines starting to be filled and the second one starting to drain. The pressure gage at the inlet of the pressurized fluid records a high pressure of the fluid, therefore the valve feeding the concentric chambers closes and therefore only pressurized fluid enters the central cylinder. The valve system in the gray box in the figure allows the passage of pressurized fluid to the first line and prevents the passage thereof to the second line. Likewise, said system allows draining said already depressurized fluid from the second line. In addition, since the valve feeding the concentric chambers in the valve system shown in the figure in the second line is closed, it allows draining the fluid from the central cylinder but not from the remaining cylinders. The fluid contained in the remaining cylinders therefore exits through the conduit leading it to the auxiliary tank.

[0061] The system therefore works by raising the fluid of the first line and lowering the fluid of the second line. The auxiliary tank furthermore feeds the concentric cylinders of the first line, since the valves giving access to each of them open. The level in the auxiliary tank does not drop, since it is in turn fed by the depressurized fluid of the concentric cylinders of the second line. For this reason such tank could even be eliminated and converted into a flow-off.

[0062] At a certain time, the lines work up to a mid point as depicted in Figure 37. At said time, the pressure gage detects a drop in the pressure of the pressurized feed fluid, and for this reason the control system immediately calculates how many chambers must start working in order to keep the pressure transmitted to the fluid to be pressurized as constant as possible depending on said drop. In the case that is shown, the control system would activate four of the concentric cylinders, as shown in Figure 38. Obviously, since the concentric cylinders are filled with fluid depressurized coming from the auxiliary tank, these cylinders are automatically pressurized with the single opening and closing of the corresponding valves, the fluid therefore not losing energy while it fills the concentric cylinders if they are empty.

[0063] After this time, since the concentric cylinders of the second line continue discharging into the auxiliary tank and the latter only feeds the remaining ones of the first line, the tank starts to fill and therefore overflow through the spillway, discharging the fluid into the corresponding drain, as shown in Figure 39, in which the lines are assumed to be reaching the end of their stroke.

[0064] Once the end of the stroke has been reached, it is necessary to start discharging the first line and loading the second line according to a process similar to that herein shown.

[0065] The process is repeated indefinitely

Industrial Applications of the Invention

[0066] Due to the described important advantages provided by the invention, the range of industrial applications opened up is very wide. The most relevant ones are listed below:

1) As a pumping system in general (Figure 40), since it has the following advantages as it has split chambers:

- the fluid which is used to pump (fluid 2 in Figure 40) does not have to be the same as that to be pumped (fluid 1), which is extremely important and applicable in infinite cases. In other words, whether dealing with wastewater, viscous fluids, toxic fluids, hazardous fluids, seawater, chemical products, concrete, turbid water or any type of fluid imaginable, even fluids with solids in suspension, clean water pumps and even pumps working with distilled water or any other fluid which has been proven to damage the electric pump units less can be used with exchangers of this type (very heavy and non-corrosive fluids can be chosen to reduce the size of the pumping and storage installations). This will involve an increase of the performances achieved as well as enormous savings in the maintenance and even design and execution of the installations

- a choice can be made between pumping greater output at a lower height, or a lower output at a greater height; the type of pump giving a better performance can thus be chosen in each case. Furthermore, this enables exploiting in a much better manner small pressure differences or small level differences of large amounts of fluid

2) in hydroelectric power stations, by inserting these SCPEs a choice can also be made between centrifuging greater output at a lower height, or a lower output at a greater height, which allows choosing in each case the type of turbine giving a better performance. Obviously, and as has been forth in the previous point, the fluid to be centrifuged does not have to be the same, which also involves another important advantage since fluids can again be chosen in a customized manner to reduce the manufacture and maintenance costs of power stations

3) regarding submersed or vertical pumps in wells or deep collection boxes, they can be replaced with surface pumps with SCPEs having long attachments between the discs of the order of the length of the well or collection box, such that some chambers are located on the surface and other at the bottom of the well or collection box (Figure 41). The chambers of the surface are fed with any fluid, again chosen to optimize the manufacture and maintenance costs of the installations. This system can be assembled in two stages, such that in the first stage the water or fluid to be pumped is raised to the surface and in the second stage its pressure is raised to the desired pressure. The system can also be assembled with the lower chambers of the SCPE in dry conditions, either in the same well or collection box above the water level, using a small auxiliary feed pumping, or in a contiguous tight collection box

4) the natural level differences of a river can also be exploited, placing the SCPEs in one of the banks of the river at a certain depth, which SPCEs are feed from an intake coming from the river, and by playing with the sections of the chambers the pressure of the fluid to be pumped (water from the river itself for irrigators, country estates, housing developments, municipalities or nearby industries, or any other fluid to be pumped for any type of process) is raised. The water of the river enters one of the chambers of the SCPEs with a certain pressure due to the depth at which the SCPEs are placed and/or to a prior feed pumping. Furthermore, by suitably placing the intake, the kinetic energy of the river current can also be exploited. At the outlet, this water is again discharged into the river through a conduit which moves it downstream such that it falls by gravity or at least the height to be pumped is reduced (Figure 42). If there is enough geographic level difference, a turbine can also be placed to exploit the residual energy of the water prior to returning it to the river bed

5) another application consists of exploiting the level difference caused in seas, rivers and river mouths by tides. Water can be taken directly from the sea or from a beach well when the tide is high and, after pumping it if necessary or driving it downwardly to increase its pressure, it feeds the SCPEs, and it is then stored in a basin or tank (Figure 43) in order to wait until the tide ebbs and it is then returned to the sea by means of a pumping if necessary, which will be provided with a check valve at the outlet to prevent the water from circulating in a reverse direction when the tide is high (Figure 44). While the tide is low, if the plant is to be kept operating, it will be necessary to pump or pump with a higher surge the feed water of the exchangers. To optimize the system, two pumps can be assembled in parallel or a pump can be assembled in parallel with a simple tube, according to the design needs

6) another way to exploit the level difference of the tides consists of using a fluid installed inside a chamber with elastic walls (membrane-type chamber). The chamber is placed inside the sea firmly attached by its base to the seabed, as shown in Figures 45 to 48. A pipe extending to solid ground emerges from the bottom of the chamber, which pipe has a shut-off valve. While the tide rises, the chamber is filled with the fluid and with the shut-off valve closed, such that the pressure of the fluid increases. When the tide is high, the shut-off valve opens and the chamber starts to be drained, feeding the SCPEs (Figure 45). If necessary, an additional pumping prior to the inlet to the exchangers would be added, as shown in Figure 45. The process continues until the chamber is completely drained (Figure 46). The depressurized fluid at the outlet of the exchangers has been stored in a basin or tank, to discharge it or pump it again to the chamber when the tide ebbs (Figure 47), until the chamber is filled again (Figure 48). If it is necessary to work continuously, the exchangers can be fed the rest of the time by means of pumping from the fluid storage basin or tank (Figure 49). A very heavy fluid can be chosen to optimize the dimensions of the system, or even the seawater itself or any other fluid, such as fresh water or even distilled water can be used to reduce the wear with the use of the installation. It is also important to emphasize

the environmental advantage of this system compared to other developed systems for exploiting the level difference caused by tides (which normally involves constructing dams or other works with a considerable environmental impact), as the environmental impact is zero since the chamber with elastic walls is submersed. To end this point, it must simply be added that rigid but telescopic walls, or rigid walls with the upper part moving upwardly and downwardly like a piston rather than elastic walls could be placed

7) obviously the system for exploiting the level differences caused by tides with the system of a chamber with elastic walls set forth in the previous application could be extrapolated to any other level difference occurring over time of any type of material imaginable, whatever the state in which it is, as is the case of reservoirs, tanks for drinking water, irrigation water or for any other fluid in any type of industrial process, and even any type of silo, tank or place in which solids are stored or pooled, since, in short, what this system does is exploit the fact that in a certain place there is something which is loaded and unloaded over time and the weight of which is exploited to press a fluid feeding the SCPEs. It will occasionally be suitable for the fluid to be used to be a gas so that it occupies less when it is compressed and storage capacity is not lost. The system can be electronically controlled by means of a computer to optimize the times in which the pressure of the fluid inside the chamber is exploited, since in many cases the levels do not change from maximum to minimum and vice versa, and therefore it may be suitable to exploit the turning points from being filled to being drained and vice versa

8) The geographic levels existing in sanitation networks and especially rainwater networks can also be exploited, because since the latter case involves clean (rain) water, it is easier to handle as a fluid for feeding the SCPEs. The mode of operation is similar to that described for rivers, i.e., an intake is made at a point of the network which feeds the exchangers, which are at a lower level to achieve a certain pressure at the inlet, and, once used to increase the pressure of the other fluid (any fluid which is to be pumped), it is again discharged into the network downstream, either completely by gravity or with the aid of a pumping

9) the residual pressure of multiple fluids involved in industrial processes, and generally any imaginable residual pressure can be similarly exploited with this system

10) another very important application is that relating to fluid distribution networks. The two probably most important cases are drinking water and irrigation water distribution networks. Generally, in a distribution network, the fluid is introduced at one or several points, and there are multiple outlets throughout it. However a minimum pressure is to be arranged at the most unfavorable point of the network, in many spans of the network there are overpressures which sometimes even force placing pressure-reducing valves. Furthermore, the output circulating at the start of the distribution of the network does not need to be complete for the first supplies, but rather it could very well be considerably reduced such that only that necessary one remains to attend to said first supplies. Thus, by means of the corresponding pipe network, a part of the fluid could be collected at the start of the network, it could be used to feed SCPEs, and finally it could be returned to the distribution network, downstream and with less pressure, particularly with the pressure necessary at that point of the network. The fluid which is placed on the side of the exchangers, which can be the fluid itself of the network to supply high points thereof or the header tanks, or any other fluid which it is necessary to pump (for example, wastewater in the case of drinking water distribution networks) is thus pressurized

11) any possible combination of the described applications; for example, by means of an integrated control of the system, seawater desalination plants could well use a combination for exploiting the level differences of tides, the level differences of a possible river running or opening out close to the location of the plant, nearby drinking water or irrigation water distribution networks, sanitation and/or rainwater networks, or any other fluid with residual pressure in any type of industrial process existing in the area. Figure 50 depicts the diagram of a seawater desalination plant with SCPEs (which obviously also corresponds to that of a brackish water desalinator but without the advantage in most cases of the level differences caused by tides). For the sake of simplicity, it has been depicted with a single storage basin or tank, assuming that level differences of tides, rivers or rainwater networks are exploited, and that therefore they are later discharged back into the sea, but obviously if other exploitations (supply, sanitation, industrial networks, etc) are combined, a basin or tank for each fluid that must be retuned to a different place must be made

12) finally, if in the described pressure there is a residual pressure available after it has been used in the multiple fluid pumping uses which may be necessary, there is obviously always the possibility of using it to centrifuge the fluid in question and producing electric power. Furthermore, by inserting SCPEs again, the execution and maintenance costs as well as the yield of the plants can be considerably improved, as has been described in point 2 above

[0067] There is a large variety of arrangements of SCPEs, as has been set forth above. For the sake of simplicity, single exchangers with parallel lines have been depicted in all the figures, but in each application the optimal arrangement thereof will be chosen depending on the design parameters of the installation.

Claims

1. Split-chamber pressure exchanger (SCPE), **characterized by** being a pressure exchanger, i.e., a system in which the push caused by a fluid (pressurized fluid) is transmitted to another different fluid (fluid to be pressurized), wherein the chambers in which the pressure exchange occurs are split in two, replacing the pressure-transmitting intermediate members of traditional pressure exchangers with two rigidly attached discs or pistons, eliminating any contact between the pressurized fluid and the fluid which is to be pressurized, and allowing changing the cross sections of the chambers corresponding to both fluids.

2. Assisted reverse operation in the pressure exchangers, **characterized by** the exploitation of the pressure of the pressurized fluid not only to transmit it to the fluid which is to be pressurized, but also to aid the actual fluid to be pressurized to displace the other fluid once it has been pressurized. This is achieved by means of an auxiliary U-shaped tube which is interconnecting both lines, and which is telescopic at both sides of the "U", being rigidly supported by the base of the "U". The ends of the "U" are attached to the discs or pistons of their respective lines, and the "U" is filled with an incompressible fluid. Thus, when the pressurized fluid enters its chamber, it not only presses its disc or piston to displace the fluid to be pressurized, but also transmits part of its energy to the disc or piston of the other line to aid the fluid to be pressurized of the other line to displace the other already depressurized fluid in said line and to overcome the friction of the discs or pistons and their weight and the weight of the already depressurized fluid if the assembly is vertical or angled. The reverse line operation is thus further assured, simplifying the system control electronics.

3. SCPE according to claim 1, **characterized by** incorporating a reinforcement of the attachments of the rod, rods, sheets or central solid parts with the discs or pistons, which achieves reducing the problem of bending stresses.

4. SCPE according to the previous claims, **characterized by** having curved or circular chambers, with the lines in a diametrically opposed manner, the chambers of each fluid with different curvature radii, and the attachment between the discs or pistons is curved with the same radius and attached to the center by means of a ball-type joint. This arrangement allows increasing the pressure transmitted depending on the distance of the chambers of both fluids to the center, without needing to change the cross section thereof, although without jeopardizing being able to combine both effects. The attachment parts between the discs or pistons of each line can in turn be assembled rigidly attached to one another to assure the reverse line operation, simplifying the system control electronics, and to be able to displace the fluid which has transmitted its pressure in the SCPE, once depressurized, from the corresponding chambers thereof without the need for auxiliary pumping, in the cases in which the fluid to be pressurized enters under very little pressure.

5. SCPE according to the previous claims, **characterized in that** its chambers open and close telescopically, eliminating the rigidly attached double discs or pistons to prevent bending stresses in the attachments, reducing the occupied space, and assuring the reverse operation without needing to aid it.

6. SCPE according to the previous claims, **characterized in that** its chambers open and close in the form of a bellows, eliminating the rigidly attached double discs or pistons to prevent bending stresses in the attachments, reducing the occupied space, and assuring the reverse operation without needing to aid it.

7. SCPE according to the previous claims, **characterized in that** in it the chambers in each line are arranged such that those corresponding to the fluid to be pressurized have rigid walls, and those of the fluid yielding its pressure are of the membrane type, the latter being included inside those of rigid walls, eliminating the rigidly attached double discs or pistons to prevent bending stresses in the attachments, reducing the occupied space, and assuring the reverse operation without needing to aid it.

8. SCPE according to the previous claims, **characterized in that** in it the chambers corresponding to one of the fluids adopt an arrangement (piston type, telescopic, bellows type or membrane type arrangement) and those corresponding to the other fluid adopt another different arrangement (mixed SCPE).

9. SCPE according to the previous claims, **characterized in that** in it the chambers of the fluid the pressure of which is yielded are split into several chambers, which are used or not depending on the available pressure of the fluid, by means of an electronically or computer controlled valve system, thus achieving transmitting the most homogeneous pressure possible to the fluid to be pressurized. It is therefore a multistage SCPE. It can also be arranged such that the chambers which are split are those of the fluid to be pressurized, thus achieving pressurizing it to different pressures depending on the needs at all times, and even extending the multiple stage con-

cept to both the chambers of the fluid to be pressurized and to those of the fluid the pressure of which is yielded.

10. Multistage SCPE according to claim 9, **characterized by** having an auxiliary tank or flow-off, from which the chambers of the stages which are not activated are filled, achieving a homogeneous filling of all the chambers, which allows activating other stages midway through depending on the needs of the system, without losses of energy of the pressurized fluid.

11. Multistage SCPE according to claim 9, **characterized by** having an auxiliary pumping and a speed variator to achieve keeping the pressure of the fluid to be pressurized completely constant, controlling it all from the electronic control system. If the pressurized fluid comes from pumping, the speed variator can be placed in said pumping.

12. The multistage SCPE according to claim 9, **characterized by** being provided with circular chambers, or with other arrangements and the reverse operation system being aided by means of the U-shaped tube for those applications in which the pressure at which the fluid the pressure of which is yielded must be returned once it has been depressurized is variable, the starting pressure of the fluid to be pressurized is variable, or both, programming the control system so that it adjusts the stages which must start operating also depending on these pressures.

13. SCPE according to the previous claims, **characterized by** having a variable section in any of its fluid chambers (one, several or all of them). To that end, it is essential for the piston, the actual chambers or both to have variable sections. It is therefore a variable section SCPE (VSSCPE).

14. VSSCPE according to claim 13, **characterized by** providing the chamber of one of the fluids with an initial variable section span, during which the piston accelerates until reaching the design speed, at which time a straight span of the chamber is reached, and the speed is kept constant since the system is designed so that at that time the force exerted on the piston by the fluid the pressure of which is yielded is equal to the force exerted by the fluid to be pressurized on such piston plus the losses due to friction corresponding to the design speed.

15. VSSCPE according to claim 13, **characterized by** providing the chamber of one of the fluids with an initial span with a different section, during which the piston accelerates until reaching the design speed, at which time a straight span of the chamber is reached, and the speed is kept constant since the system is designed so that at that time the force exerted on the piston by the fluid the pressure of which is yielded is equal to the force exerted by the fluid to be pressurized on such piston plus the losses due to friction corresponding to the design speed.

16. SCPE according to the previous claims, **characterized by** having three lines, with the third having a shorter length adjusted to optimally exploit the pressure of the pressurized fluid depending on the operating output and pressure ranges in each case.

17. SCPE according to the previous claims, **characterized by** having a single line, simplifying the system control electronics.

18. Batteries of SCPEs according to the previous claims, consisting of the arrangement of an assembly of SCPEs in series or in parallel, or mixed systems, even adding pumps to increase the pressure of the pressurized fluid and/or that of the fluid to be pressurized at the inlet and/or at the outlet of the SCPEs when the intended pressure surges are very high.

19. Pumping system for pumping by means of SCPEs according to the previous claims, consisting of using traditional electric pump units to pressurize the feed fluid for feeding the SCPEs, which will yield its pressure to the fluid to be pressurized, thus achieving pumping it, with the advantages that both fluids can be different, that a choice can be made between pumping a greater output at a lower height or a lower output at a greater height, and that, in the case of pumping in wells or collection boxes, this system allows extracting the fluid from the well or collection box by pumping another fluid on the surface. This system further allows exploiting the energy of geographic level differences existing in rivers, sanitation and rainwater networks, or of the overpressures existing in fluid distribution networks and the residual pressure of fluids in any type of industrial process, either to pump other fluids or even to produce electric power.

20. System for centrifuging by means of SCPEs according to the previous claims, consisting of the incorporation of SCPEs to hydroelectric power stations, as a step prior to centrifuging, allowing to choose between centrifuging at a greater output at a lower height or a lower output at a greater height, and also allowing the fluid to be centrifuged to differ from the fluid the energy of which is provided.

21. System for exploiting any level difference occurring over time of any type of material which can be imagined in any form of storage or pool, as is the case of tides, reservoirs, tanks for drinking water, irrigation water or for any other fluid in any type of industrial process, and even any type of silo, tank or place in which solids are stored or pooled, **characterized by** having a chamber with elastic walls which is filled with an incompressible fluid and which is located rigidly attached to the bottom of the tank, sea, reservoir or storage site, exploiting by means of an electronic control or by computer, the high level times to feed the SCPEs according to the previous claims with the fluid, and to thus pump another fluid or to centrifuge the fluid of the chamber or the pressurized fluid in the SCPEs and generate electric power.

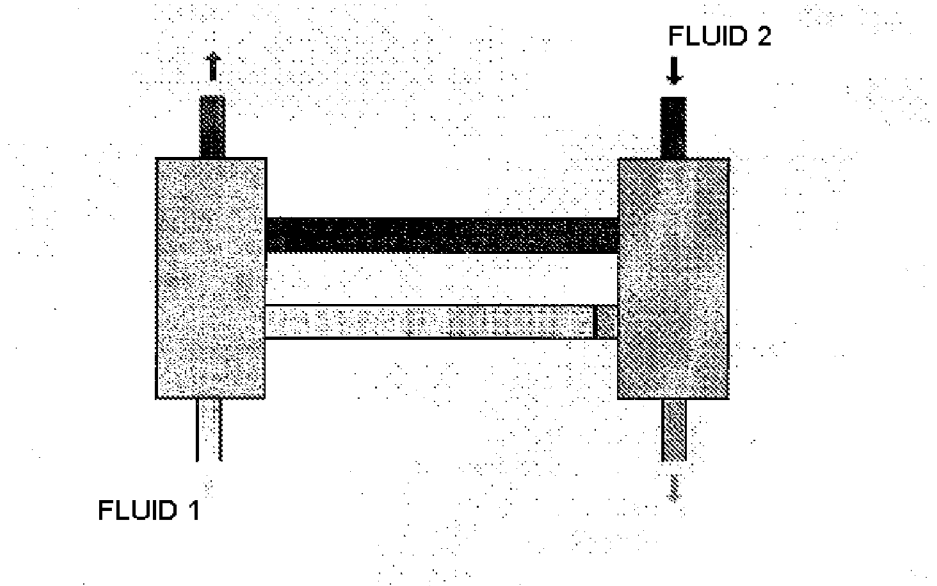

FIGURE 1

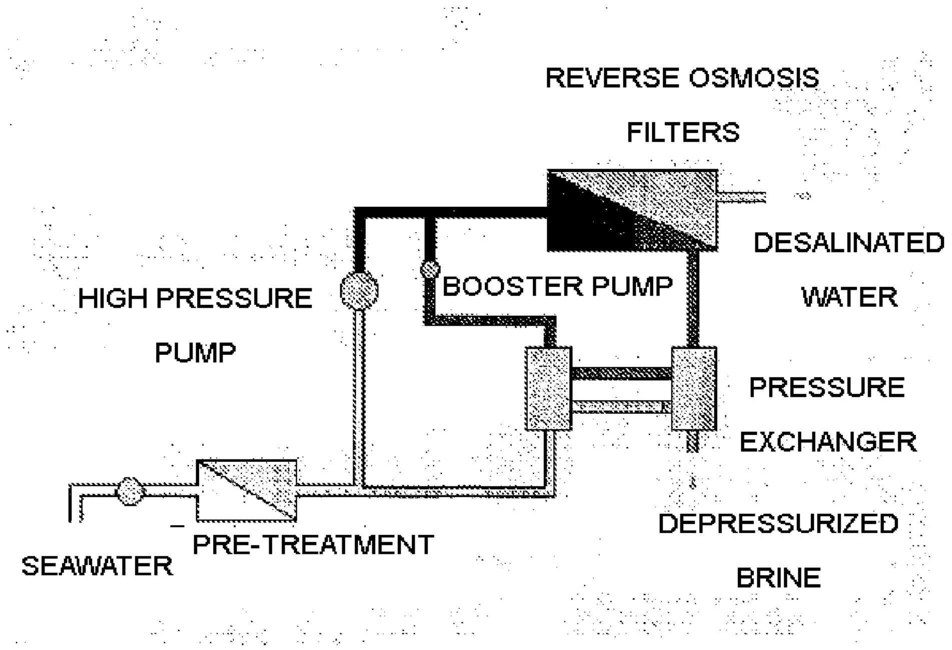

FIGURE 2

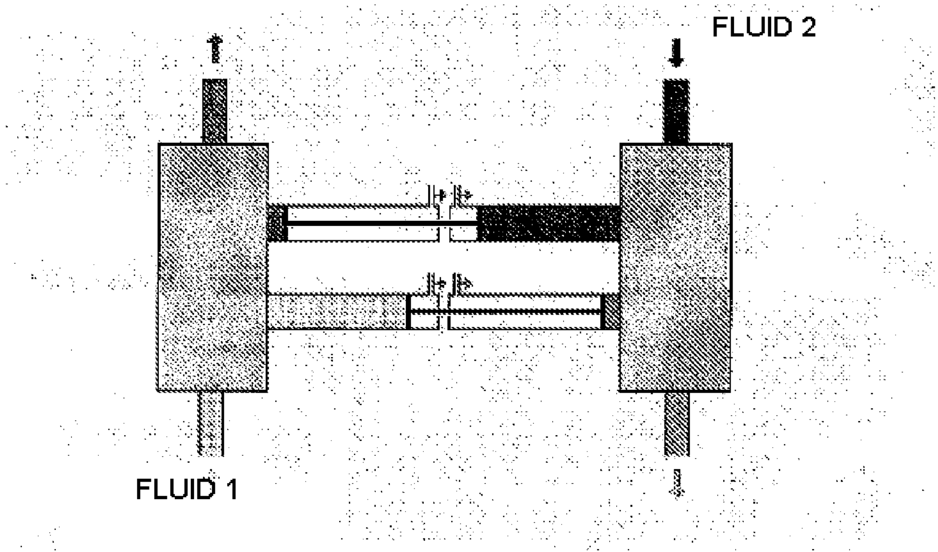

FIGURE 3

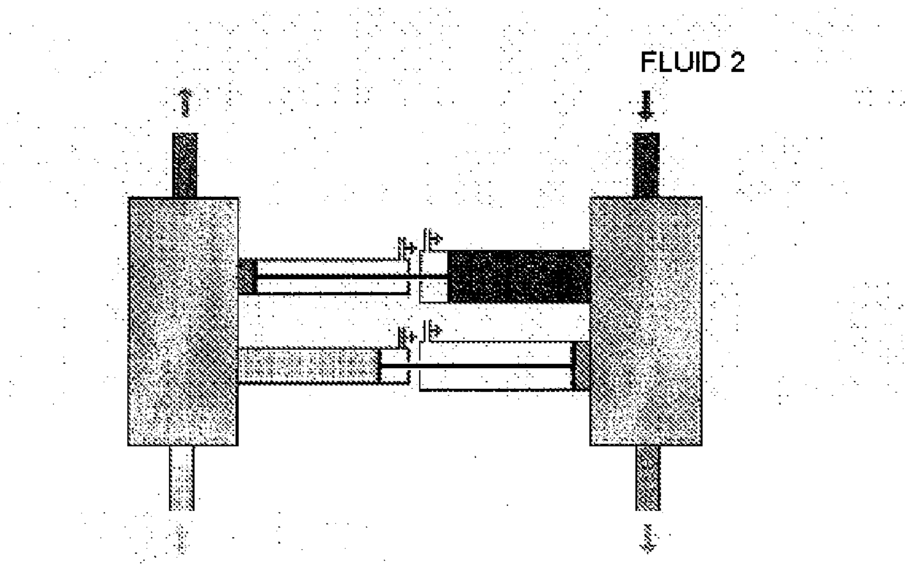

FIGURE 4

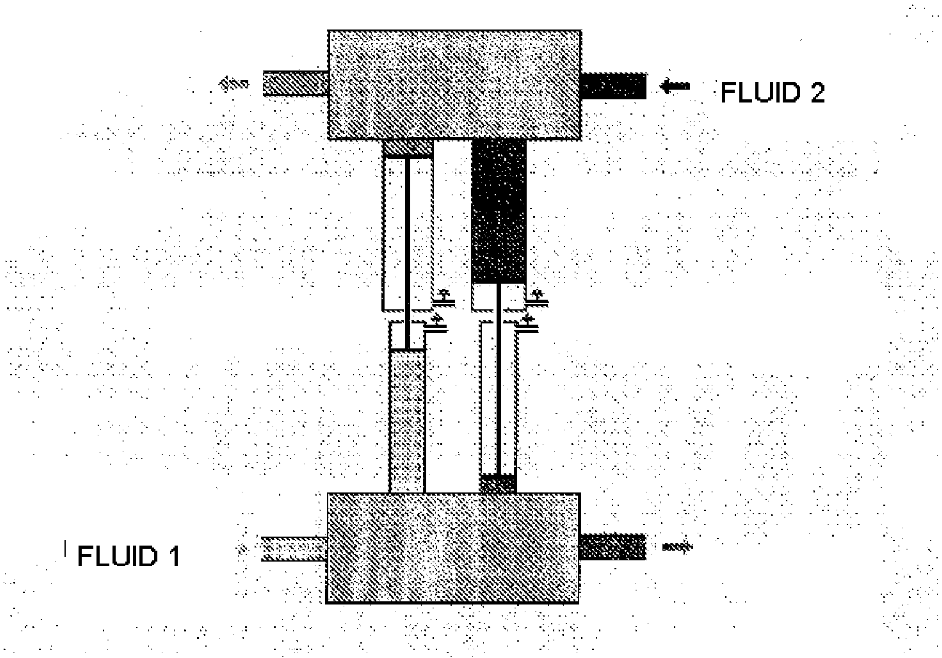

FIGURE 5

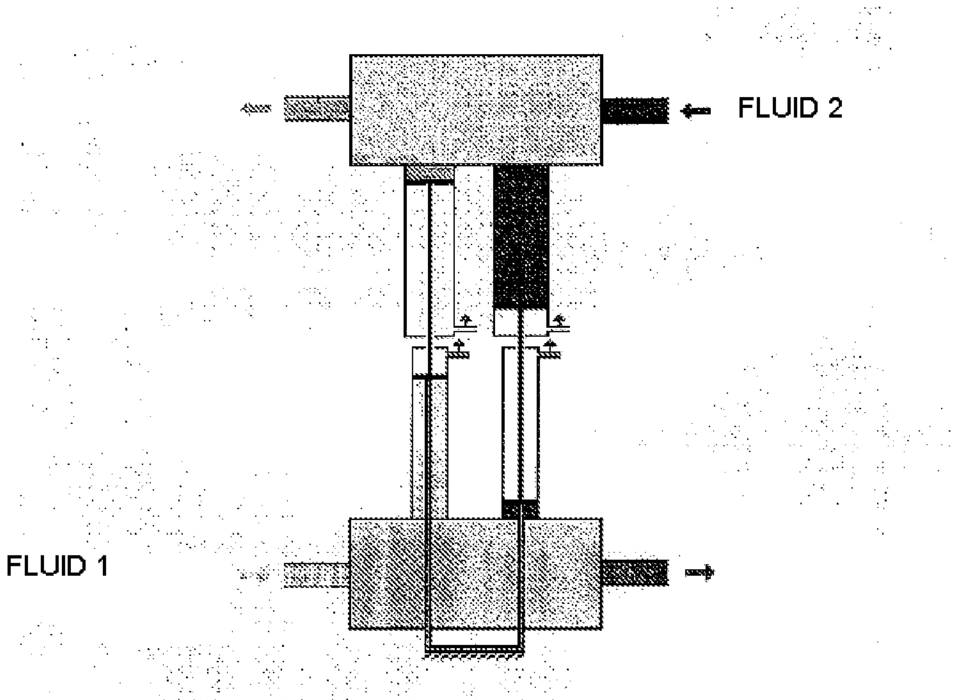

FIGURE 6

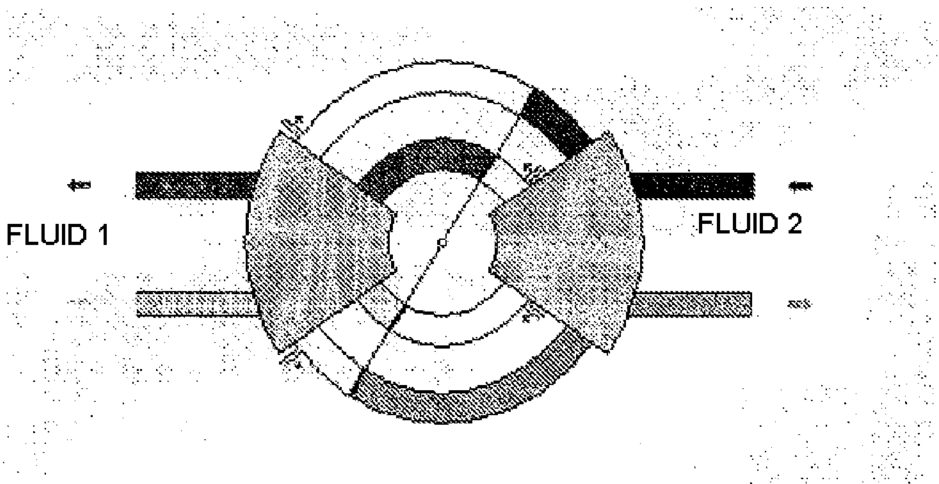

FIGURE 7

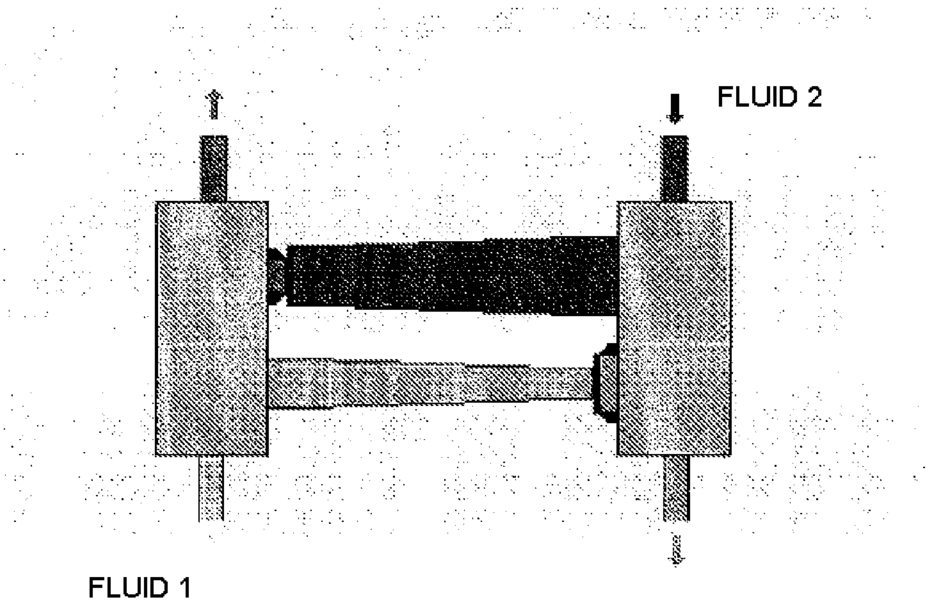

FIGURE 8

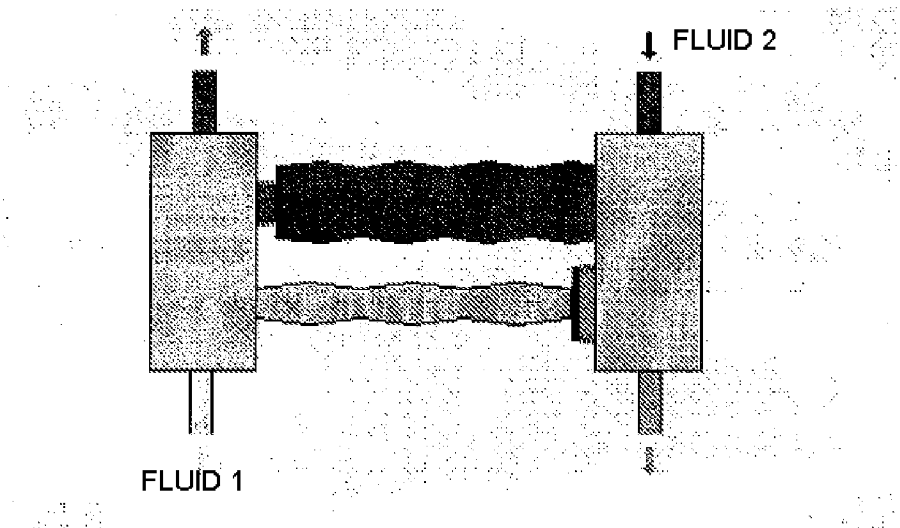

FIGURE 9

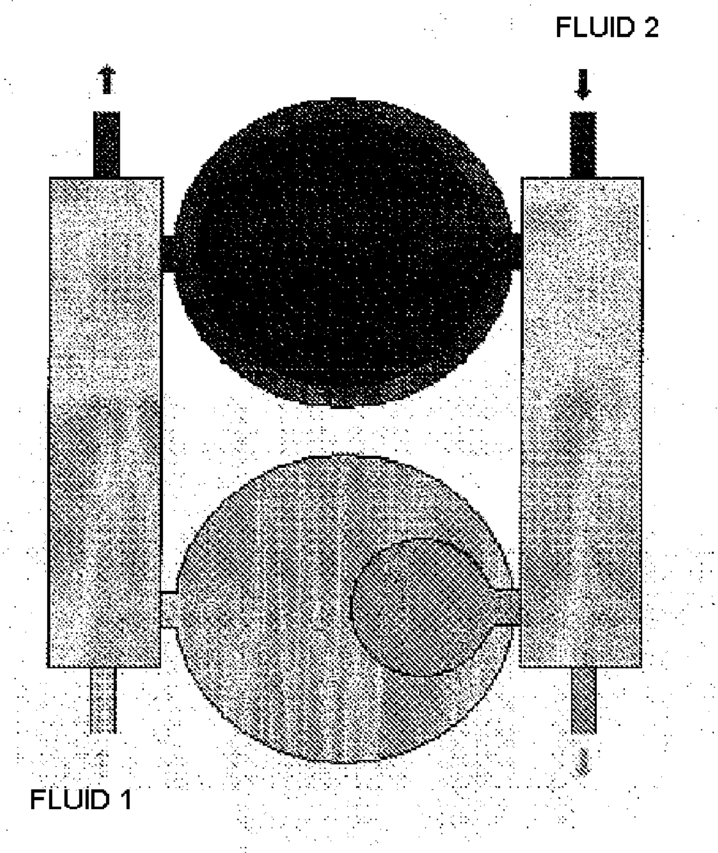

FIGURE 10

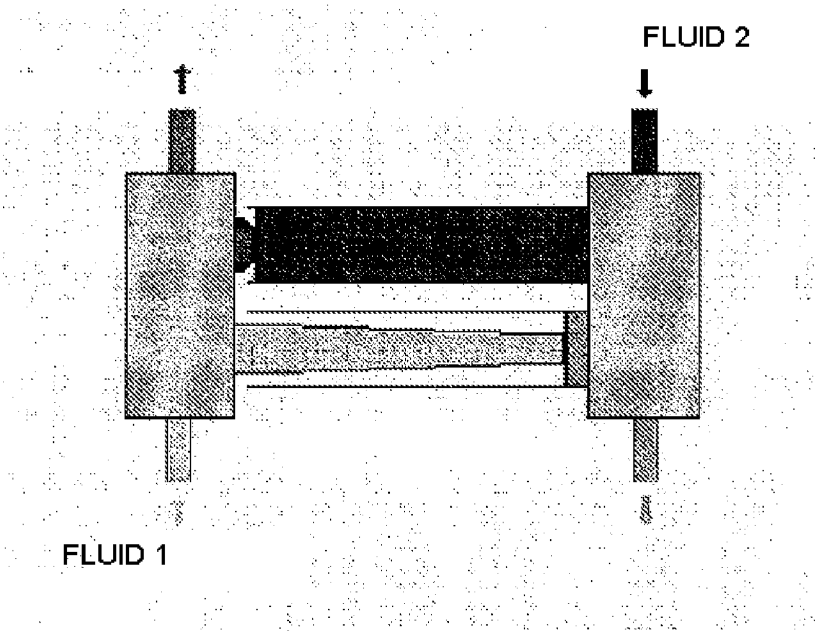

FIGURE 11

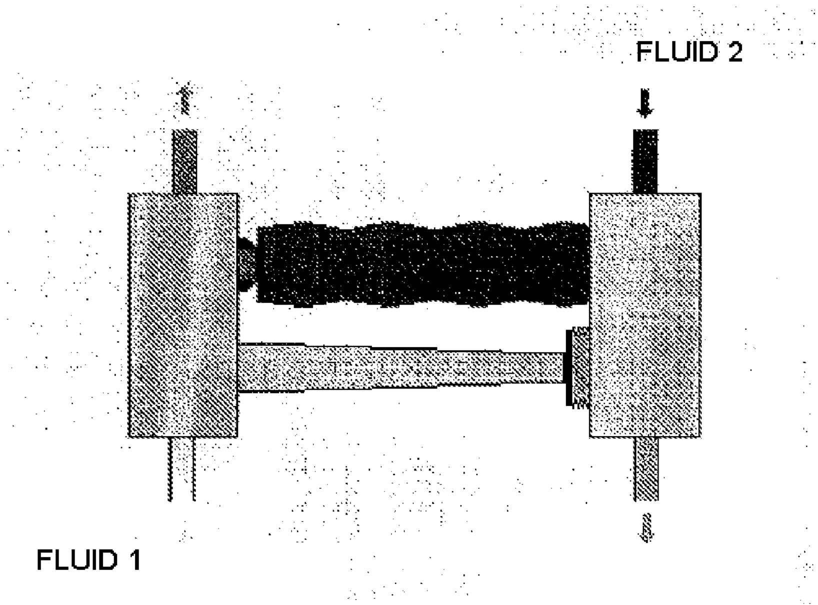

FIGURE 12

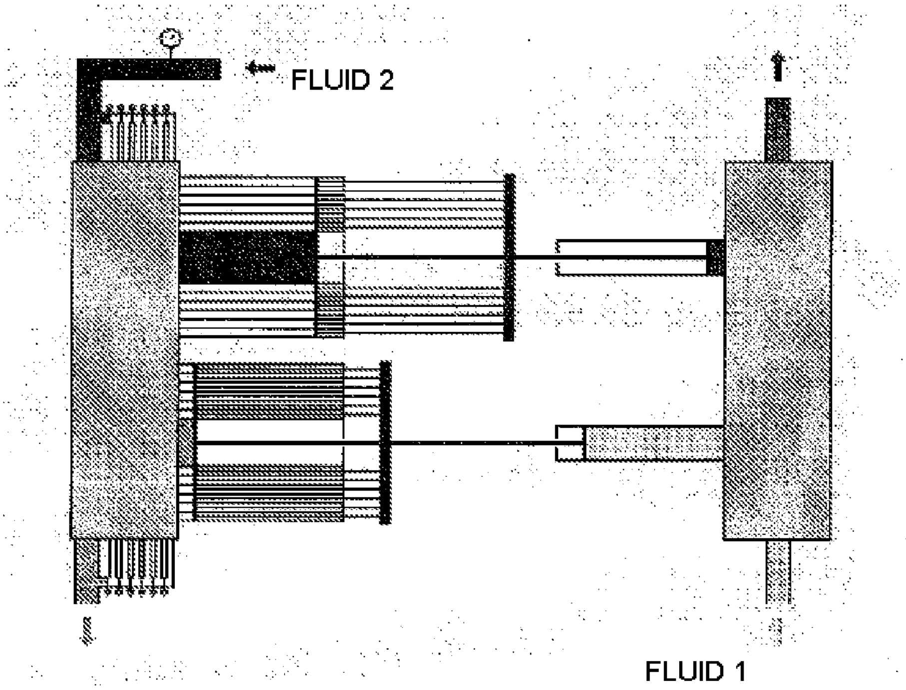

FIGURE 13

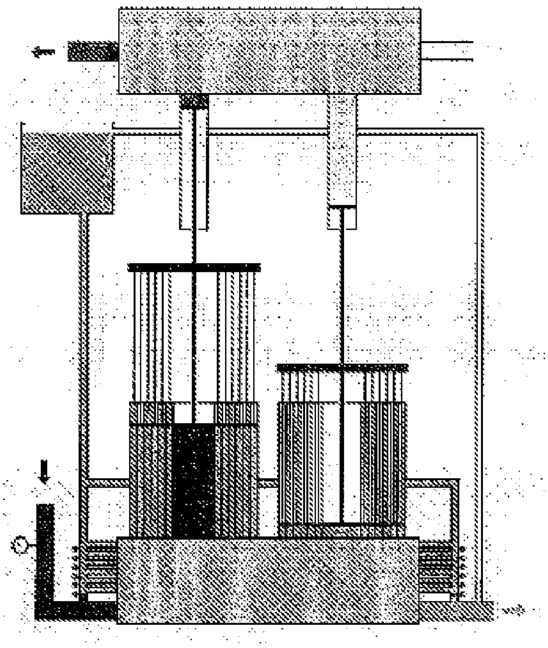

FIGURE 14

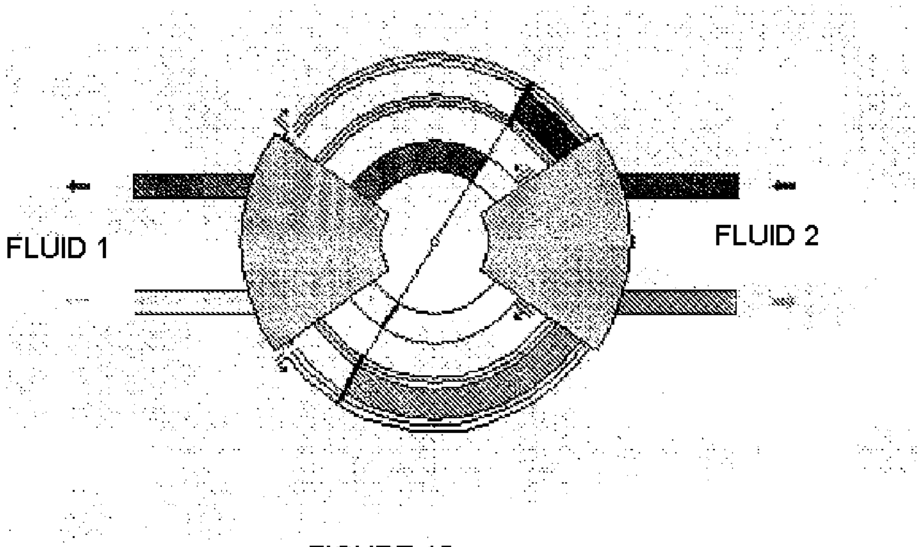

FIGURE 15

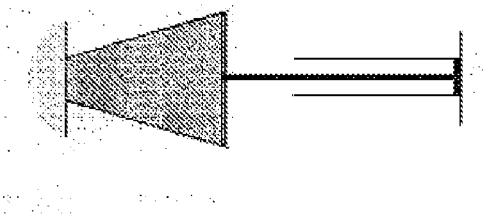

FIGURE 16

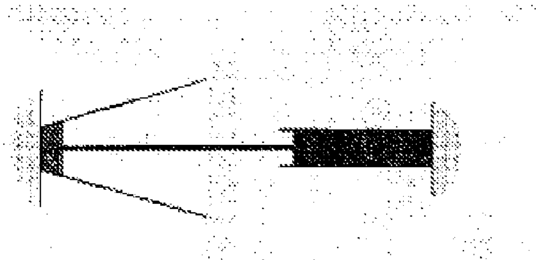

FIGURE 17

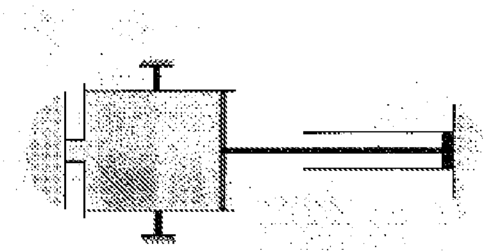

FIGURE 18

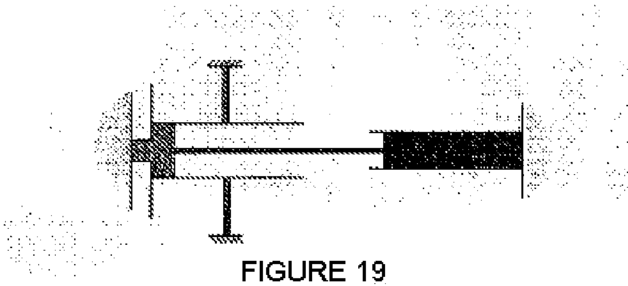

FIGURE 19

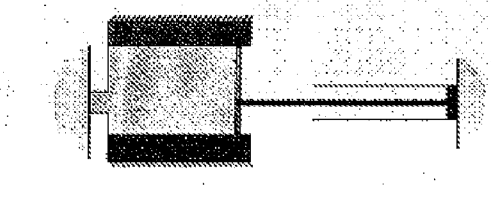

FIGURE 20

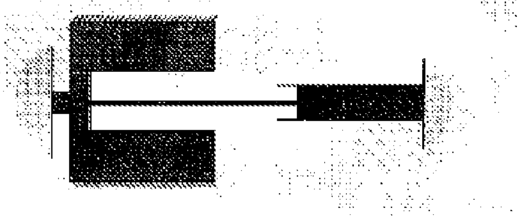

FIGURE 21

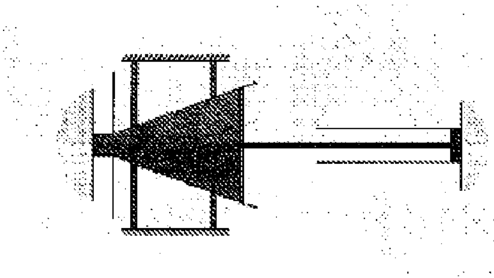

FIGURE 22

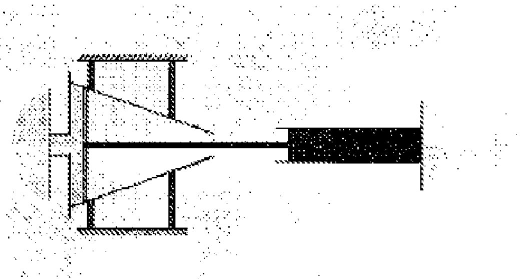

FIGURE 23

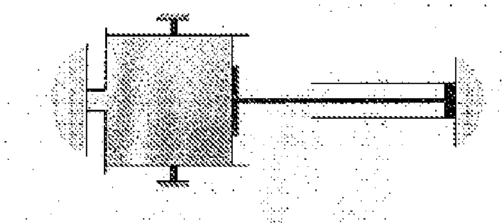

FIGURE 24

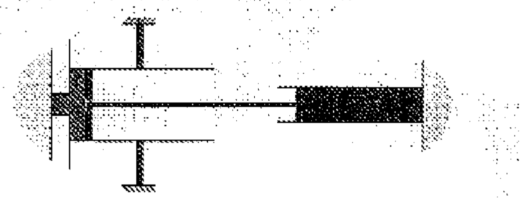

FIGURE 25

FIGURE 26

FIGURE 27

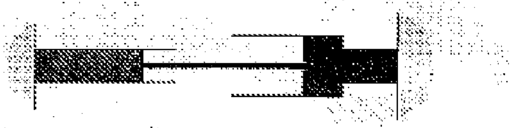

FIGURE 28

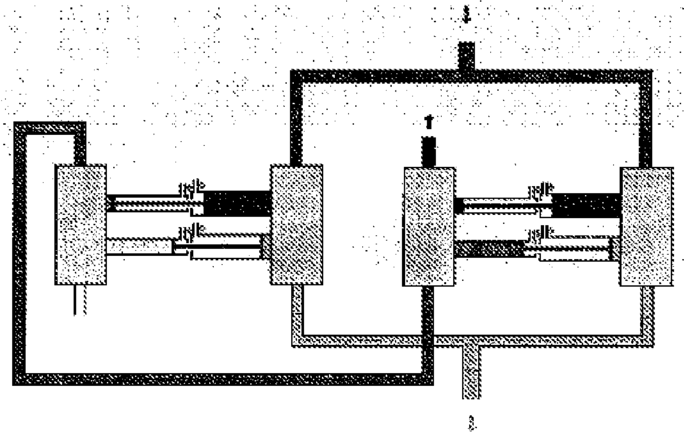

FIGURE 29

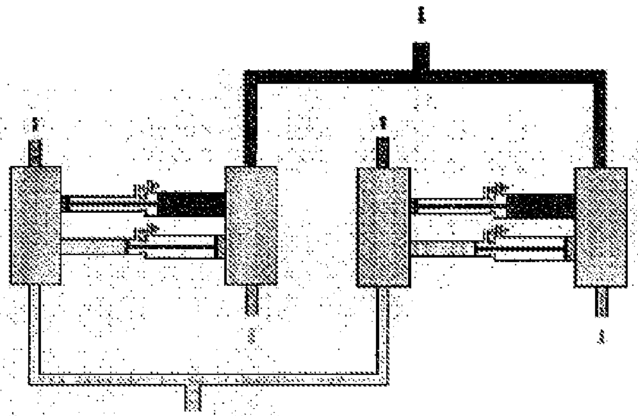

FIGURE 30

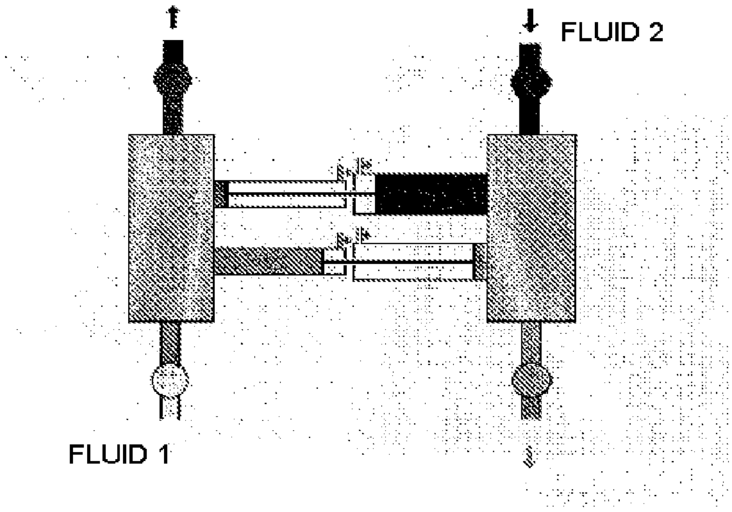

FIGURE 31

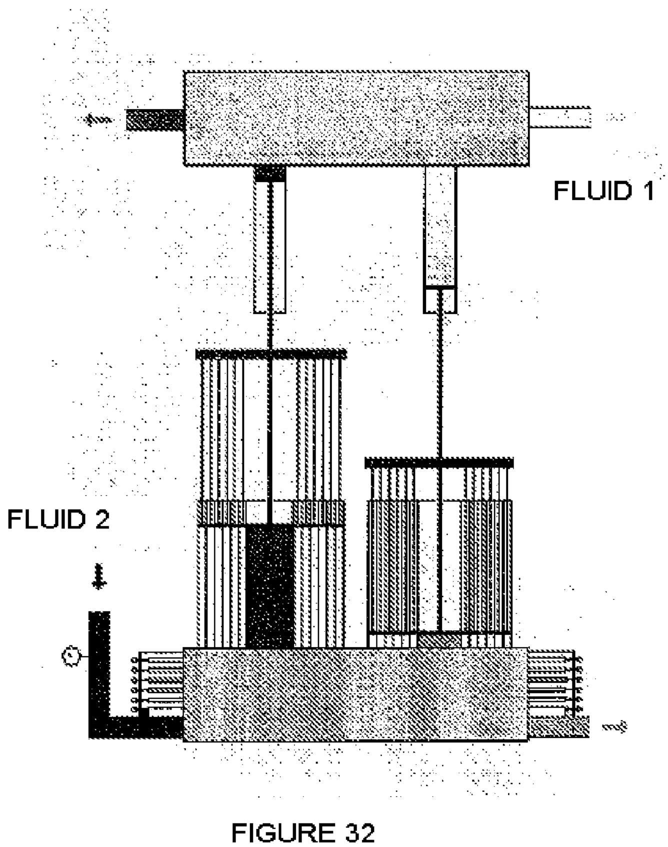

FIGURE 32

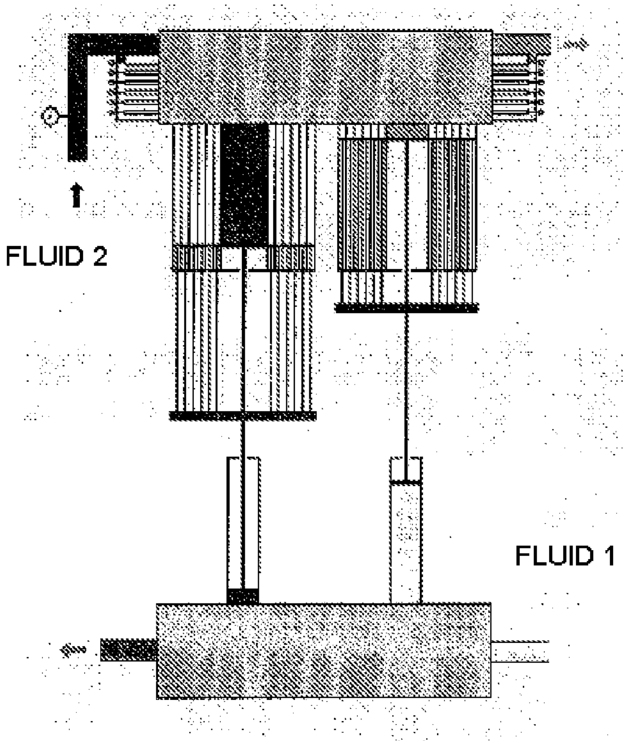

FIGURE 33

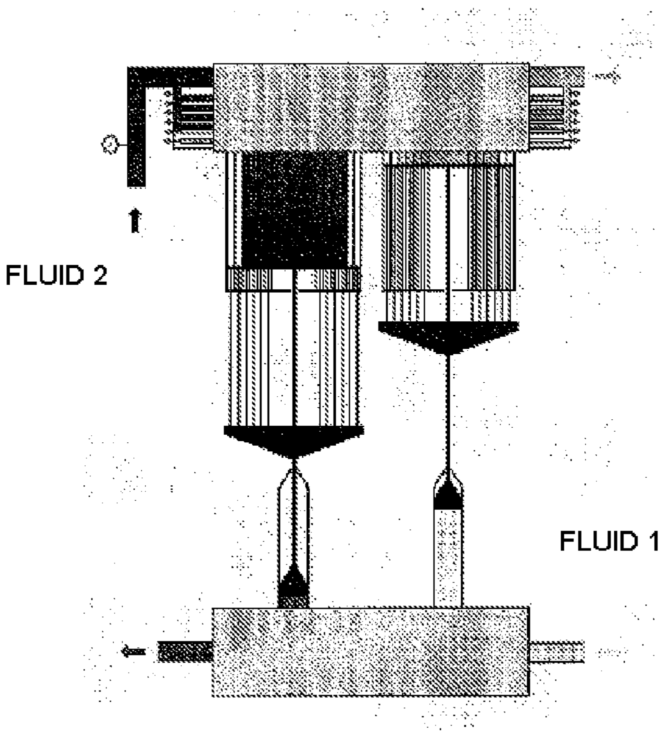

FIGURE 34

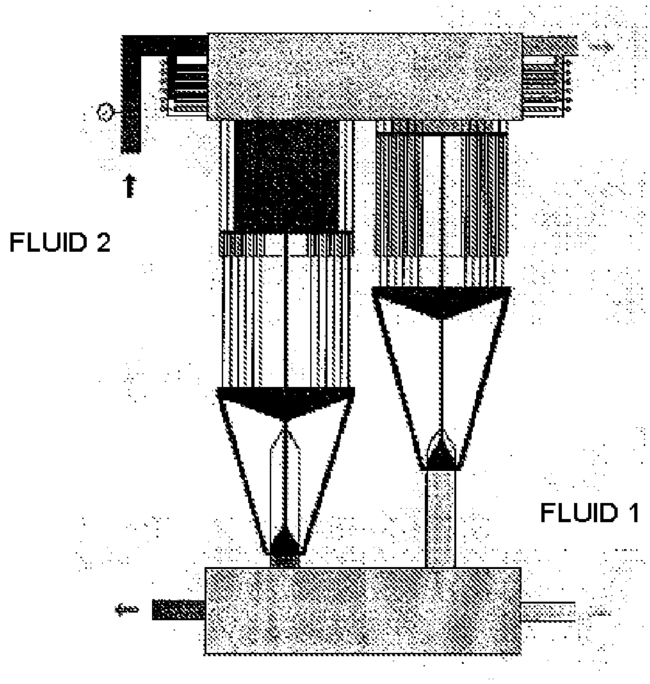

FIGURE 35

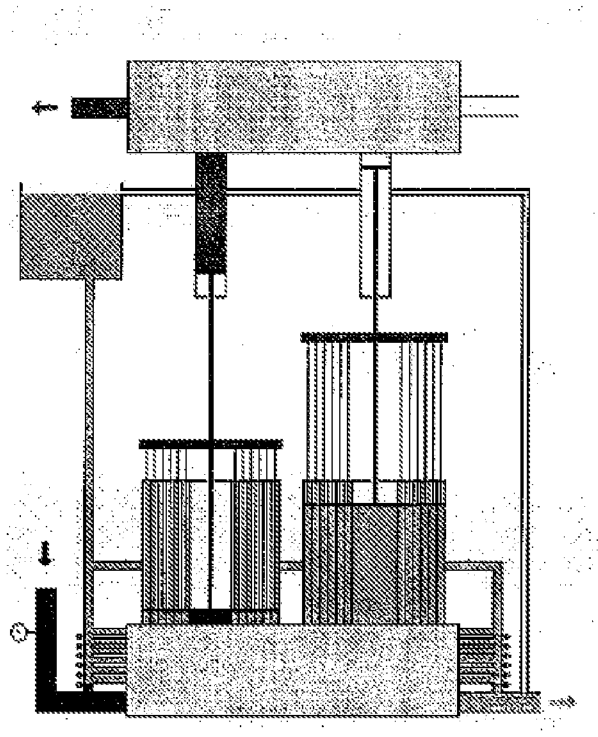

FIGURE 36

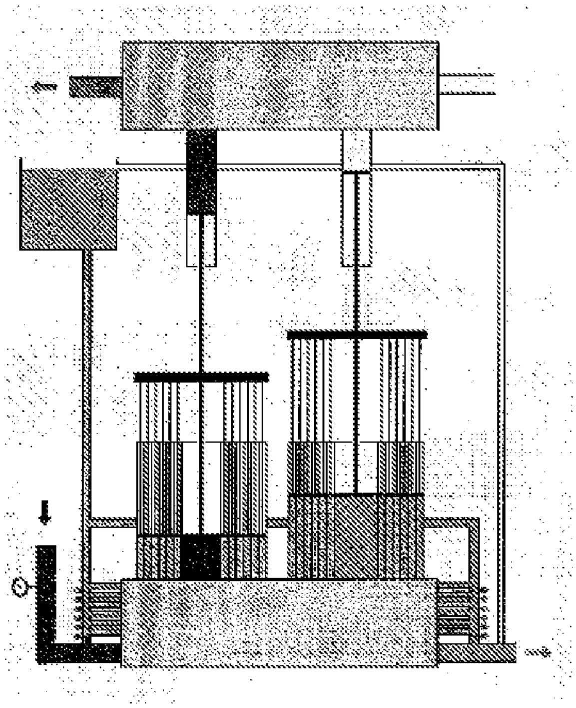

FIGURE 37

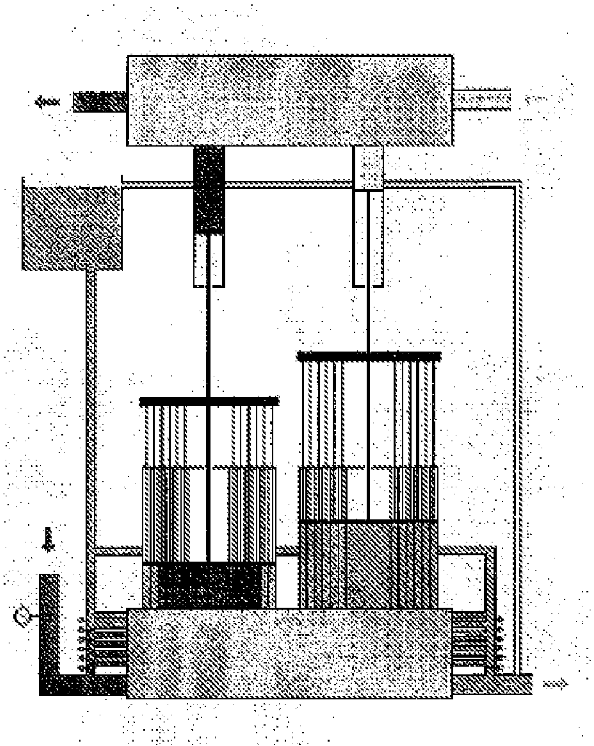

FIGURE 38

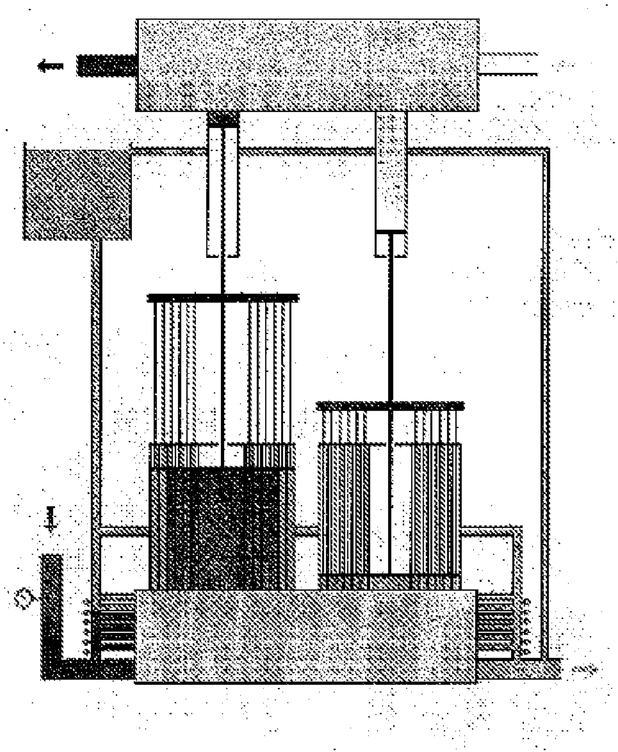

FIGURE 39

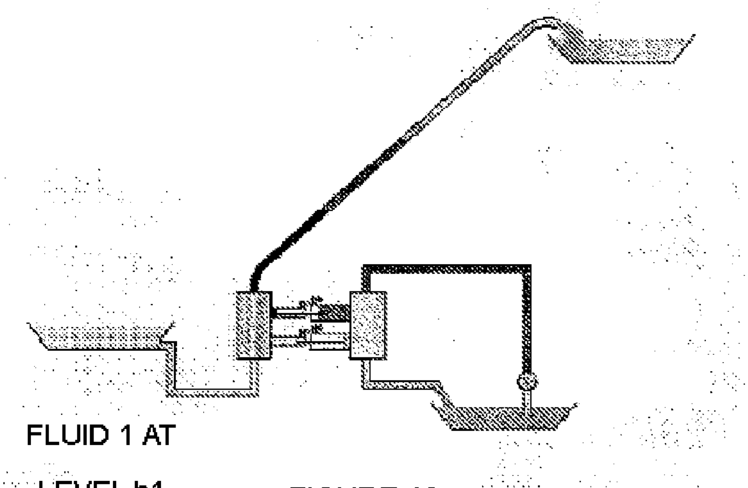

FIGURE 40

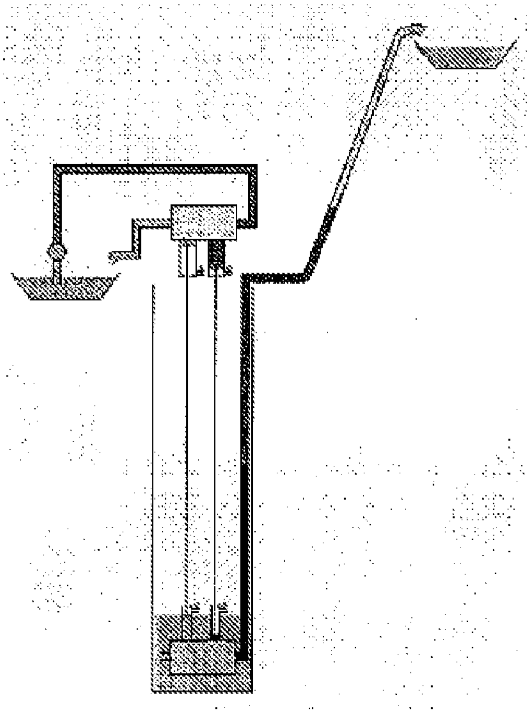

FIGURE 41

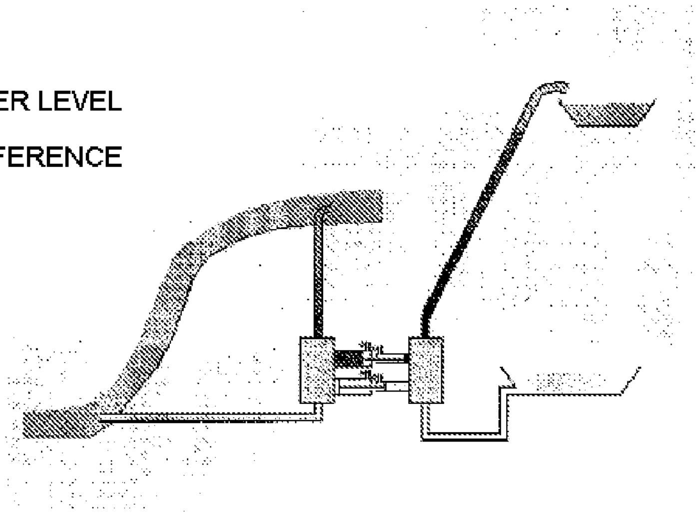

FIGURE 42

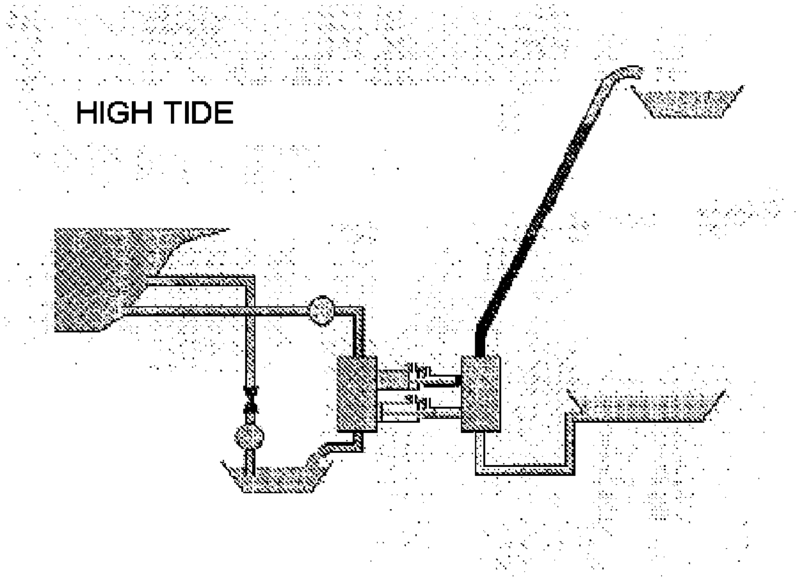

FIGURE 43

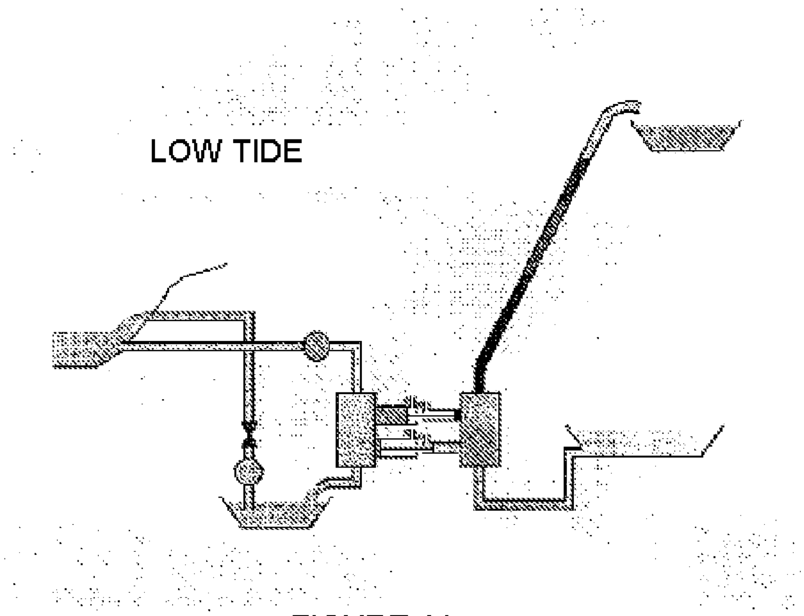

FIGURE 44

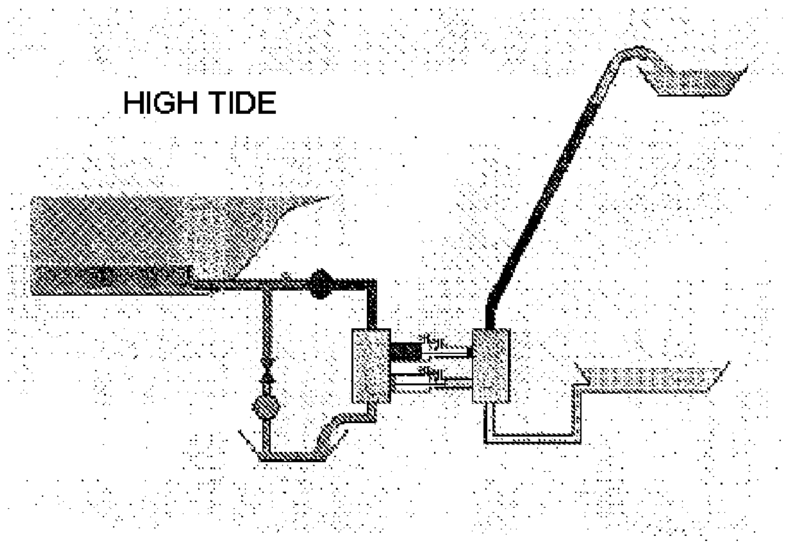

FIGURE 45

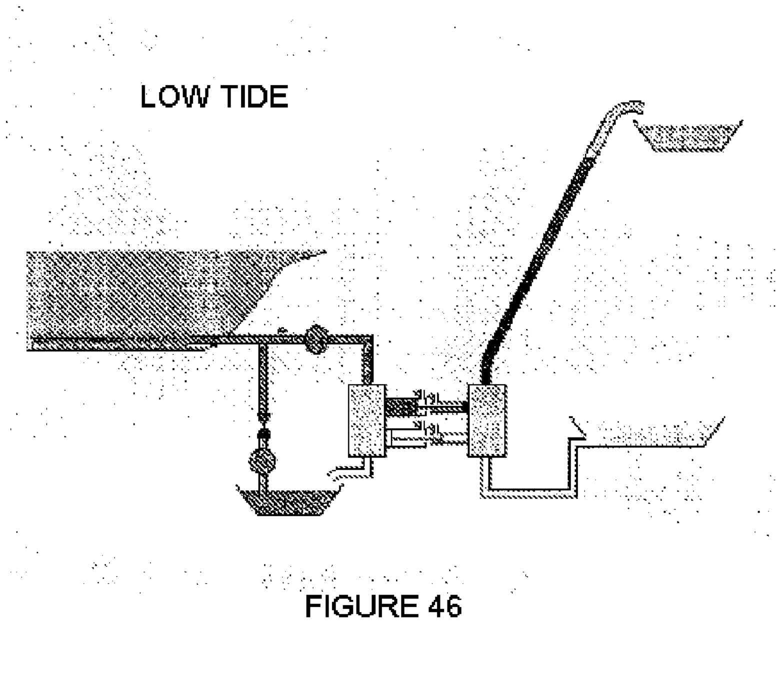

FIGURE 46

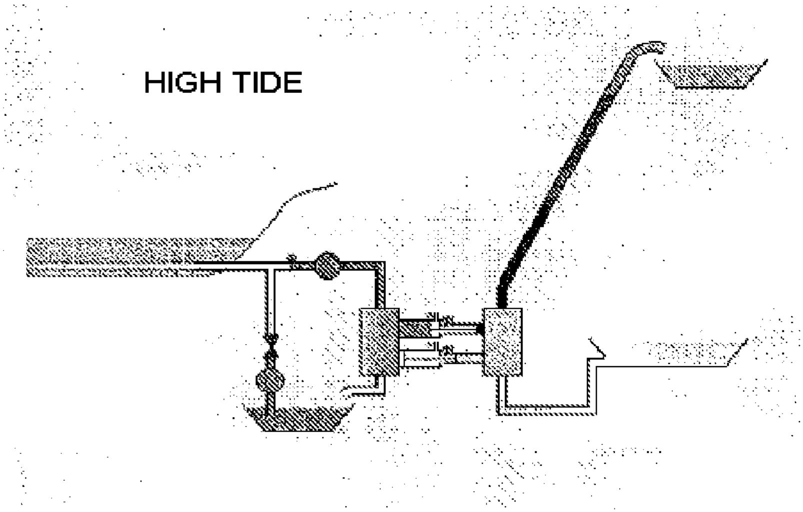

FIGURE 47

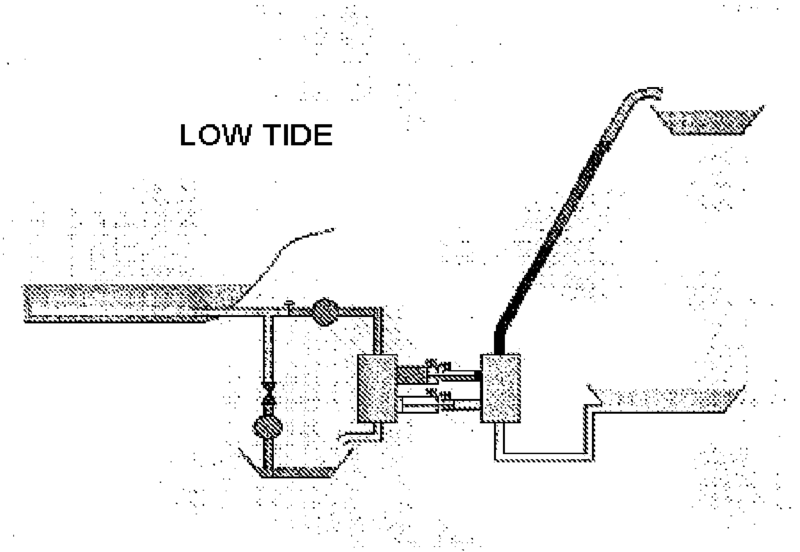

FIGURE 48

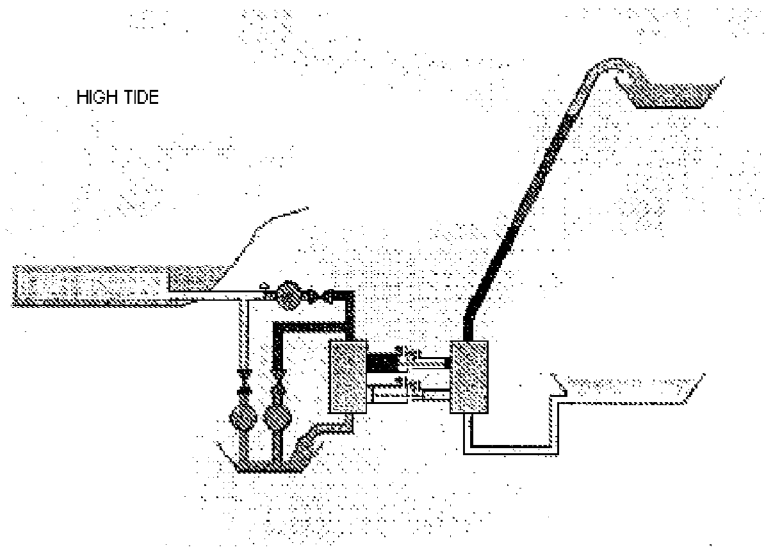

FIGURE 49

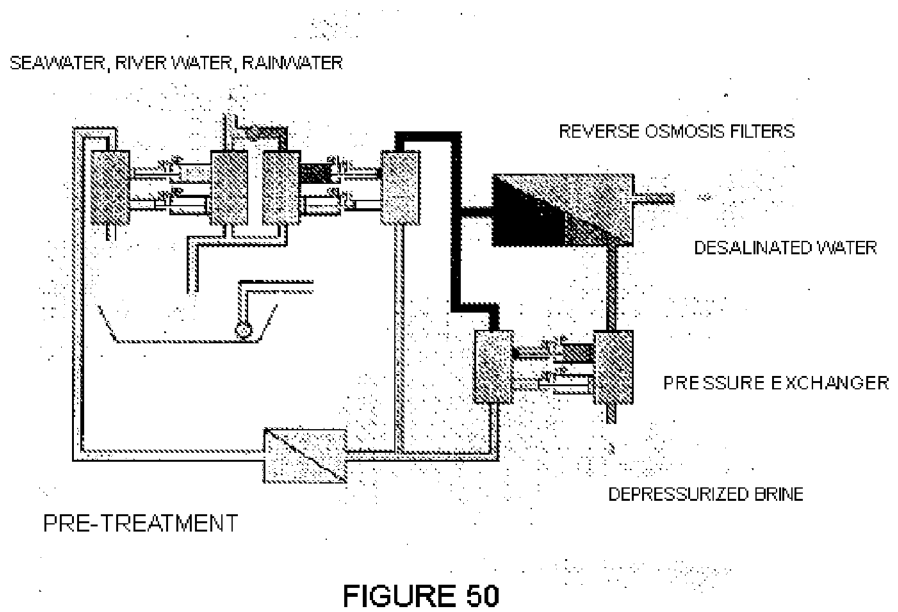

FIGURE 50

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ ES 2007/000346

A. CLASSIFICATION OF SUBJECT MATTER

F04B 9/10 (2006.01)
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)
F04B,F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CIBEPAT,EPODOC,WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 03002876 A1 (KARASAWA FINE LTD ; KARASAWA YUKIHIKO) 09.01.2003, abstract; figures.	1-3,16,18-20 5-8,21
Y A	DE 1294812 B (LEHLE; RUDOLF DIPL ING; CONEN; HELMUT DIPL ING) 08.05.1969, column 4, line 21 - column 5, line 35; figure 1.	5 1
Y A	US 2807215 A (STEPHEN) 24.09.1957, the whole document.	6,8 1,7
Y A	US 776106 A (BEURRIER) 29.11.1904, the whole document.	7 1
Y	GB 2403986 A (HATCHWELL PAUL KRISTIAN) 19.01.2005, abstract; figures.	21
X	US 5062268 A (DUNWOODY) 05.11.1991, the whole document.	1,9-11,16-19

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22.October.2007 (22.10.2007)	(25/10/2007)
Name and mailing address of the ISA/ O.E.P.M. Paseo de la Castellana, 75 28071 Madrid, España. Facsimile No. 34 91 3495304	Authorized officer J. Galán Mas Telephone No. +34 91 349 55 21

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES 2007/000346

C (continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of documents, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3885393 A (HANSON) 27.05.1975, column 2, lines 4-11; figure 1.	1,3,17-19
X	US 2490118 A (HARLAND) 06.12.1949, the whole document.	1,17-20

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/ ES 2007/000346

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
WO 03002876 A	09.01.2003	JP 2003013904 A TW 568982 B	15.01.2003 01.01.2004
DE 1294812 B	08.05.1969	NONE	------------
US 2807215 A	24.09.1957	NONE	-----------
US 776106 A	29-11-1904	NONE	-----------
GB 2403986 A B	19.01.2005	NONE	-----------
US 5062268 A	05.11.1991	US 5011180 A CA 2074514 A WO 9111339 A US 5058384 A EP 0513075 A EP 19910902966 US 5197285 A JP 5503903 T	30.04.1991 03.08.1991 08.08.1991 22.10.1991 19.11.1992 31.01.1991 30.03.1993 24.06.1993
US 3885393 A	27.05.1975	NONE	-----------
US 2490118 A	06.12.1949	NONE	-----------

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