

Description

Field of the Invention:

This invention relates to high pressure fluid intensifier systems. More particularly, this invention relates to double-acting hydraulic intensifiers.

Background of the Invention:

In a typical high pressure fluid intensifier system, hydraulic fluid acts on a reciprocating double-acting, low pressure -- high pressure piston assembly to compress water to several thousand Pa. The piston assemblies of such systems are exposed to hydraulic fluid pressures on the order of 20,000 Pa and to water pressures on the order of 140-420,000 Pa. These assemblies must be designed to withstand tremendous pressure fluctuations while at the same time maintain hydraulic fluid/water separation.

The pressure chambers within which such a piston assembly works, and the various pressure seals incorporated in the assembly are severely stressed. The pressure chambers are often made up of members that are screwed and/or bolted together to resist cyclic pressure build-up and release. Replacement of the high pressure seals periodically is difficult because of the attachment of the various members making up the intensifier pressure chambers and piston assembly. Usually, the intensifier must be completely dismantled to reach and repair or replace internal elements.

FR-A-2110263 discloses a fluid pressure intensifying device including two separate axially aligned low pressure cylinders, pistons for moving in the cylinders, a fluid input passage for applying a pressurised fluid to the pistons, plungers moved by the pistons for fluid tight movement in a cavity of an end body and movement of the pistons results in pressurisation of air in the cavity. The device is held in alignment by tensioning rods and bolts. The present invention has a single low pressure cylinder, and a single, double-acting piston mounted for reciprocal movement in the single cylinder. Furthermore, the present invention is held together by a cylindrical housing which includes end retainers.

Summary of the Invention:

The intensifier of this invention comprises a fluid pressure-intensifying apparatus comprising a low pressure--high pressure cylinder means including a cylindrical low pressure chamber portion (14) and a pair of elongated cylindrical high pressure chambers (20), the high pressure chambers (20) extending coaxially from opposite ends of said low

pressure chamber portion (14), low pressure--high pressure piston means including a low pressure piston section (26) mounted for reciprocal movement in said low pressure chamber portion (14) and a pair of elongated high pressure piston sections (28, 30) connected to opposite sides of said low pressure piston section (26) and extending from said low pressure chamber portion (14) into an adjacent high pressure chamber for reciprocal movement therein, fluid inlet-outlet means (25) in fluid communication with said high pressure chambers (20) to simultaneously introduce fluid to be pressurized to one high pressure chamber and withdraw pressurized fluid from the other high pressure chamber, and working fluid inlet-outlet means (62) mounted in fluid communication with said low pressure chamber portion (14) such that working fluid may alternately work against one said or the other of said low pressure piston section (26) to cause said low pressure piston means to reciprocate, characterized in that the cylindrical low pressure chamber portion (14) is a single chamber, in that the low pressure piston section (26) is a double acting low pressure piston section, in that a cylindrical housing means (10) encloses and constrains said low pressure--high pressure cylinder means to position and maintain said pressure chambers in alignment, said housing means (10) includes end retainer means (12) for threadedly mounting said fluid inlet-outlet means (25) to the ends of said housing means (10) and compressively engaging said fluid inlet-outlet means (25) to the outer ends of said low pressure--high pressure piston means whereby said cylindrical housing means (10) is placed in tension and said low pressure-high pressure cylinder means is placed in compression to establish and maintain alignment of said fluid inlet-outlet means (25) and the elements making up said low pressure--high pressure cylinder means.

Another aspect of the invention is the provision of a low pressure fluid control valve actuator. This actuator involves a piston assembly, in fluid communication with the low pressure chamber, coupled to an external limit switch. Two such activators are provided, one on each side of the low pressure chamber, for actuating the low pressure fluid control valve. The piston assembly of each actuator extends into one end of the low pressure chamber and is shifted by the low pressure piston to activate the external limit switch and effect a change in the flow direction of the low pressure fluid. As a consequence, the low pressure piston will be moved out of contact with the actuator piston and low pressure fluid will act on the piston to extend it back into the low pressure chamber and out of contact with the external limit switch. As the low pressure piston travels to the opposite side of the

low pressure chamber, the process will be duplicated with respect to the other low pressure fluid control valve actuator. These actuators are mounted by cylinder blocks that also define the adjacent end boundaries of the low and high pressure chambers. The activators are accessible through housing cut outs.

Brief Description of the Drawings

Figure 1 is a front elevation of the right half of the intensifier of this invention in partial cross section; and

Figure 2 is an enlarged front elevation of a portion of the Figure 1 intensifier in partial cross-section.

Figure 3 is another partial front elevation of the intensifier of this invention illustrating a preferred check valve assembly;

Figure 4 is an enlarged cross-section of the preferred check valve assembly depicted in Figure 3;

Figure 5 is a view similar to Figure 4 illustrating the preferred check valve assembly.

Description of the Invention

The intensifier of this invention utilizes hydraulic fluid (oil) to drive a high pressure - low pressure piston assembly to produce a high pressure water flow. The intensifier shown in Figure 1 is double-acting. It comprises a housing 10 in the form of an elongated steel cylinder. One half, the right half, is shown in Figure 1. The left half is a duplicate. Each end of the housing mounts an end retainer ring 12, the end of housing 10 being internally threaded to mate with external threads on end retainer ring 12 as shown. Within housing 10, a low pressure chamber 14 is provided by a steel cylinder 16 fitted onto a cylindrical end cap 18 at each end (the right hand cap being shown; the left hand end cap is an opposite hand duplicate). Also within housing 10, a left hand and a right hand high pressure chamber are provided (the right hand high pressure chamber 20 being shown; the left hand high pressure chamber is a duplicate), each by an elongated steel barrel cylinder 22 fitted at its inner end into end cap 18 and at its outer end onto a valve body 24 of an inlet/outlet water check valve assembly. Sleeve and ring bearings, 26 and 28, center the outer end of barrel cylinder 22 in end retainer 12.

The outer surface of end cap 18 conforms to the inner surface of housing cylinder 10, with a small allowance for a slip-fit clearance. Tightening the end retainers 12 places the pressure chamber elements in longitudinal compression and the housing cylinder 10 in longitudinal tension. When one or both end retainers 12 are removed, however, these

elements may be removed from the housing in a very expeditious manner. The low pressure and high pressure cylinders, 16 and 22, are mounted in axial alignment with the housing cylinder 10 by the end caps 18 and the retainer rings 12. Because of the relative dimensions of the elements thus far described, the pressure chamber elements are confined against any lateral or longitudinal movement.

The low pressure - high pressure piston assembly comprises a low pressure piston 26 and left and right hand high pressure pistons 28 and 30. The low pressure piston is a cylindrical disk contained within low pressure chamber 14. Its outer surface conforms to the inner surface of low pressure cylinder 16, with a small allowance for a slip-fit clearance, and mounts appropriate hydraulic pressure seals 32 to seal one side of low pressure chamber 14 from the other. The high pressure pistons are connected to opposite faces of the low pressure piston 26 and extended through the respective cylinder block 18 into high pressure chamber sleeve 20.

Each high pressure piston is a one piece element machined to provide an elongated solid cylindrical rod 30a having a diameter slightly smaller than the inside diameter of sleeve 20, and to provide a cylindrical flange 30b at its inner end having a diameter larger than its rod. The high pressure piston flange 30b is fitted within a cylindrical counter bore 34 machined in the respective face of the low pressure piston 26. The flange 30b is held in place by a retaining ring 36, the latter being retained in a groove machined in the counterbore for that purpose. The cylindrical passage in end cap 18, through which the high pressure piston rod 30a extends, has a diameter slightly larger than the piston rod diameter. The high pressure side of the cylinder block 18 is machined to provide a stepped cylindrical counterbore 18a of inwardly-reducing diameters, the outermost portion to fit high pressure cylinder 22, the middle to fit a cylindrical piston rod centering ring 38, and the innermost to fit an appropriate high pressure static seal 40.

The centering ring 38 is machined to provide a middle portion that conforms to the diameter of the middle portion of counterbore 18a and an inner extension that conforms to the diameter of the innermost portion of counterbore 18a. The inner extension of centering ring 38 bears against and retains hydraulic seal 40 in place. Centering ring 38 also has an outer extension that extends outward beyond the middle portion of counterbore 18a and conforms to the inner diameter of high pressure cylinder 22. The high pressure cylinder 22 abuts the outermost portion of counterbore 18a in load bearing contact, and also abuts the outer extension of centering ring 38 to hold it in position. The

reactive hydraulic force of the fluid working in low pressure chamber 14 is transmitted through the end cap 18 and high pressure cylinder 22 into the end retainer 12 and the internal threads of housing cylinder 10.

The centering ring 38 is made of a non-ferrous metal, such as beryllium-copper or an aluminum-nickel-bronze alloy. It serves as a bushing for the high pressure piston rod 30a as well as a retainer for hydraulic seal 40. It also holds high pressure cylinder 22 concentric with high pressure piston rod 30a. It also provides a metal back up for a high pressure dynamic seal group 42.

The opposite end of high pressure cylinder 22 fits over a stub that protrudes from the check valve body 24. Valve body 24 is machined to provide a cylindrical stub 24a for that purpose. The end of the stub is machined to provide a smaller cylindrical end surface as a seat for a high pressure dynamic seal group 44. The stepped transition between the high pressure cylinder - mounting stub and the high pressure seal seat provides a metal back up for seal group 44. The end diameter of stub 24a corresponds to the diameter of high pressure piston rod 30a as shown.

High pressure piston rod 30a reciprocates within the sleeve 20 inside of the cylinder 22 between the position shown and a position indicated by the dotted line adjacent seal group 42 that depicts the end of piston rod 30 in full retracted position. Seals groups 42 and 44 maintain the high pressure integrity within cylinder 22 as piston rod 30a reciprocates back and forth. Seal group 42 comprises a delrin dynamic back-up seal ring 42a that abuts center ring 38 and a polyurethane lip type seal 42b. Seal group 44 is composed of the same commercial lip seal 44a abutting a delrin ring 44b in turn abutting a non ferrous back up ring 44c.

As high pressure piston rod 30a is retracted from the position shown, low pressure water is drawn into high pressure chamber 20 through an inlet check valve 48, mounted by valve body 24, with passage 50 to valve body opening 52. When piston rod 30a is driven back to the position shown, inlet check valve 48 closes, water is compressed to a high pressure and then forced out through valve body opening 52, outlet passage 54 and through outlet check valve 56, mounted by valve body 24.

Reciprocation of the high pressure piston is effected as a consequence of hydraulic fluid being pumped into low pressure chamber 14 on one side of low pressure piston 26 or the other. Each end cap 18 is ported as at 60 to provide for hydraulic fluid flow into and out of low pressure chamber 14. An inlet tube 62 is screwed into port 60 for connection to a hydraulic fluid supply. When hydraulic fluid is pumped through port 60 into chamber 14, low pressure piston will be driven leftward from the

position shown, thus retracting the right hand high pressure piston rod 30a and extending the left hand high pressure piston rod 28a. Concurrently, hydraulic fluid will be vented through the hydraulic fluid port in the left hand cylinder block, and water in the left hand high pressure chamber will be compressed and forced out through the left hand valve body. When low pressure piston 26 reaches the left end of low pressure chamber 14, hydraulic fluid flow will be reversed and low pressure piston 26 will be driven rightward. Hydraulic fluid will be vented through right hand cylinder block port 60 and water in high pressure chamber 20 will be compressed and forced out through valve body 24.

As low pressure piston 26 reciprocates, hydraulic fluid will accumulate between high pressure piston flange 30b and the low pressure piston counterbore 34. To prevent undue pressure buildup behind flange 30b, the base of counterbore 34 is vented through vent passage 64 and check valve 66 to the opposite side of the low pressure piston 26. High pressure piston flange 28b and its mating counterbore 34 are likewise vented through vent passage 68 and check valve 69. By this arrangement, a relatively loose fit can exist between the high pressure piston flanges and their respective counterbore seats, and the high pressure pistons can be easily retained by their respective counterbore seat snap rings 36.

A limit switch 74 for signaling a hydraulic fluid control valve is mounted adjacent each end cap 18. The signal condition of each switch is affected by the reciprocal movement of an actuator piston assembly which is slidably mounted in the adjacent cylinder block 18 as shown. It is contemplated that a solenoid-operated 4-way directional control valve will be provided to control hydraulic fluid flow into and out of low pressure chamber 14. Each limit switch 74 would actuate one of two control valve solenoids.

With respect to the right hand assembly shown, rightward travel of an actuator shifter pin 72 toward the outer side of end cap 18 is effected by mechanical contact with low pressure piston 26, and leftward travel of shifter pin 72 toward the inner side of end cap 18 is effected by hydraulic fluid from low pressure chamber 14.

When low pressure piston 26 begins to travel leftward from the position shown, hydraulic fluid will enter chamber 70 and force shifter pin 72 leftward to effect a change in the signal condition of limit switch 74. Chamber 70 is defined between shifter pin 72, a seal ring 73 and a cylindrical passage provided in end cap 18. This passage has an outer portion of larger diameter than its inner portion, and the stepped surface 78 between them provides a stop to limit the leftward travel of shifter pin 72. Shifter pin 72 comprises a cylindrical member that

is machined to the configuration of the passage and has a smaller diameter inner end portion and a large diameter middle portion with the stepped surface 78 between them provided to engage surface 76 to limit leftward travel of the pin. Shifter pin 72 has a smaller diameter outer end portion that extends through seal ring 73 toward limit switch 74 and mounts limit switch actuating plunger 77.

Shifter pin 72 contains an axial passage 80 extending from its inner end and an interconnecting diametral passage 82 providing fluid communication between low pressure chamber 14 and chamber 70. The stepped surface 84 between the middle portion and the smaller diameter outer portion of shifter pin 72 provides a piston face 84. The diameter of the pin outer portion is sufficiently reduced so that the area of piston face 84 is greater than the area of the inner pin end 86. When piston 26 travels leftward from the position shown, hydraulic fluid from low pressure chamber 14 enters chamber 70 through passages 80 and 82 in shifter pin 72. The hydraulic fluid in chamber 70 acts against piston face 84. Because the area of piston face 84 is greater than the area of the inner end 86 of shifter pin 72, the hydraulic fluid in chamber 70 will drive shifter pin 72 leftward, until travel of shifter pin 72 is stopped by contact between the stepped surface 78 and surface 76 in end cap 18. When piston 26 is reversed and travels rightward to the position shown, piston 26 will contact the protruding piston pin end 86 and drive the pin rightward to the position shown. The chamber 71 between stepped surfaces 76 and 78 is vented through passage 79 to the ambient atmosphere. The inner and middle portions of shifter pin 72 are provided with appropriate hydraulic fluid seals as shown to substantially prevent hydraulic fluid from entering chamber 71.

Plunger 77 comprises an elongated rod 77a loosely fitted within an axial passage provided in the outer portion of pin 72. The outer end of plunger 77 is capped by a switch contact 77b. A coil spring 75 extends between the end of the pin outer portion and plunger contact 77b to urge plunger 77 rightward. As piston 26 drives shifter pin 72 rightward to the position shown, spring 75 is compressed and urges plunger 77 into effective contact with limit switch 74. When piston 26 travels leftward and pin shifter 72 is driven leftward from the position shown, shifter pin 72 travels relatively to plunger 77. This relative movement relieves the compressive force on spring 75 and permits plunger 77 to release from effective contact with limit switch 74. The loose, sliding connection between pin 72 and plunger 77 affords some leeway in the positioning of switch 74 during installation and protects the limit switch from damage if pin 72 should overtravel.

By providing a cutout in housing 10 as shown, limit switch 74 can be mounted within the confines of housing 10 and still be accessible. Switch 74 is bolted to a mounting bracket 90. Bracket 90 is bolted at one end to a mounting plate 92 which itself is bolted to end cap 18. Mounting plate 92 has a passage machined through it that fits over the outer end portion of pin shifter 72. Mounting plate 92 also closes the outer end of the actuator pin passage provided in end cap 18, and abuts the outer end of sealing ring 73 to hold it in place against the reactive force of hydraulic fluid acting in chamber 70.

An intensifier arrangement utilizes hydraulic fluid (oil) to drive a high pressure - low pressure piston assembly to produce a high pressure water flow. The intensifier shown in Figure 1 is double-acting. It comprises a housing 10 in the form of an elongated steel cylinder. One half, the right half, is shown in Figure 1. The left half is a duplicate. Each end of the housing mounts an end retainer ring 12, the end of housing 10 being internally threaded to mate with external threads on end retainer ring 12 as shown. Within housing 10, a low pressure chamber 14 is provided by a steel cylinder 16 fitted onto a cylindrical end cap 18 at each end (the right hand cap being shown; the left hand end cap is an opposite hand duplicate). Also within housing 10, a left hand and a right hand high pressure chamber are provided (the right hand high pressure chamber 20 being shown; the left hand high pressure chamber is a duplicate), each by an elongated steel barrel cylinder 22 fitted at its inner end into end cap 18 and at its outer end onto a valve body 24 of an inlet/outlet water check valve assembly. End retainer 12, acting through valve body 24, centers the outer end of cylinder 22.

The outer surface of end cap 18 conforms to the inner surface of housing cylinder 10, with a small allowance for a slip-fit clearance. Tightening the end retainers 12 places the pressure chamber elements in longitudinal compression and the housing cylinder 10 in longitudinal tension. When one or both end retainers 12 are removed, however, these elements may be removed from the housing in a very expeditious manner. The low pressure and high pressure cylinders, 16 and 22, are mounted in axial alignment with the housing cylinder 10 by the end caps 18 and the retainer rings 12. Because of the relative dimensions of the elements thus far described, the pressure chamber elements are confined against any lateral or longitudinal movement.

The low pressure - high pressure piston assembly comprises a low pressure piston 26 and left and right hand high pressure pistons 28 and 30. The low pressure piston is a cylindrical disk contained within low pressure chamber 14. Its outer

surface conforms to the inner surface of low pressure cylinder 16, with a small allowance for a slip-fit clearance, and mounts appropriate hydraulic pressure seals 32 to seal one side of low pressure chamber 14 from the other. The high pressure pistons are connected to opposite faces of the low pressure piston 26 and extended through the respective cylinder block 18 into high pressure chamber sleeve 20.

The outer end of high pressure cylinder 22 fits over a pilot or shoulder that protrudes from the check valve body 24. Valve body 24 is machined to provide a cylindrical pilot 24a for that purpose. The end of the pilot is machined to provide a smaller cylindrical end surface as a seat for a high pressure static seal group 44. The stepped transition between the high pressure cylinder-mounting pilot and the high pressure seal seat provides a metal back up for seal group 44. The end diameter of pilot 24a corresponds to the diameter of high pressure piston rod 30 as shown.

As high pressure piston rod 30 is retracted from the position shown, low pressure water is drawn into high pressure chamber 20 through inlet passage 50 in inlet/outlet water check valve assembly 25. When piston rod 30 is driven back to the position shown, water is compressed to a high pressure and then forced out through outlet passage 54 in check valve assembly 25. Water flow into and out of high pressure chamber 20 is controlled by a water pressure-influenced poppet-type check valve mechanism 52.

Inlet/outlet water check valve assembly 25 comprises valve body 24, low pressure water inlet manifold 51 communicating with low pressure water inlet passage 50, poppet check valve mechanism 52, high pressure outlet water line adapter 53 communicating with high pressure water outlet passage 54, and manifold lock nut 55 receiving manifold 51 to valve body 24. The outer end of valve body 24 is externally threaded and lock nut 55 screwed thereon to position manifold 51. Low pressure inlet water line 56 is attached to manifold 51 and high pressure outlet water line 57 is attached to adapter 53. The inner face of manifold 51 is machined to provide an annulus 58 for distribution of inlet water from inlet line 56 to inlet passage 50.

The check valve mechanism 52, as shown in enlarged detail in Figures 4 and 5, comprises an inlet poppet 100, an outlet poppet 102, a valve stem 104 connecting the two poppets, a high pressure poppet seat 106, and an enlarged abutment end 108 of stem 104 to retain and secure outlet poppet 102. The stem 104 extends through high pressure water outlet passage 54 and mounts the poppets at opposite ends. The inner end or head 110 of stem 104 is machined to provide an inner annular groove 111 for a return coil spring 114 and

a spring retainer "E" ring clip 112 for retaining poppet 100. The mechanism is so arranged that inlet poppet 100 seats on the inner end surface of pilot 24a to seal low pressure water inlet passage 50, and outlet poppet 102 seats on high pressure seat element 106 to seal high pressure water outlet 54. Inlet poppet 100 is slidably mounted by and is axially moveable on the inner end of stem 104. Outlet poppet 102 is slidably mounted by and is axially movable on the outer end of stem 102 and retained thereon by enlarged stem end 108. The length of stem 104 between head 110 and the end 108 is sufficient to enable outlet poppet 102 to be unseated (as shown in Figure 2) when high pressure water bears against head 110 and shifts stem 104 as far outward as head 110 permits. Head 110 and the inner end portion of stem 104 are axially counterbored to provide a passage that communicates with one or more diametric passages 116 cross-bored in stem 104. The outer end of stem 104, just inward of outlet poppet 102, is shaped to provide a passage 118 between that portion of stem 104 and the bore through valve body 24 high pressure water outlet passage 54.

The intermediate length of stem 104 is shaped to provide a passage 120 between that portion of stem 104 and the bore through valve body 24, which bore provides high pressure water outlet passage 54. Passage 120 interconnects cross-bore 116 and passage 118 to enable high pressure water to pass through water outlet passage 54 when outlet poppet 102 is lifted from its seat 106 to the position shown in Figure 2. Adapter 53 is provided with an inner cavity 122 that extends from seat element 106 to the high pressure outlet water line 57 and encloses outlet poppet 102 and enlarged stem 108 with space to spare for high pressure water travel around poppet 102 and end 108 from passage 54 to outlet line 57. Adapter 53 has a beveled annular surface 124 at the base of cavity 122. Surface 124 bears against a corresponding beveled surface on seat element 106 to secure seat 106 in a recess 126 provided therefore in the outer end of valve body 24, when adapter 53 is screwed onto valve body 24. Inlet poppet 100 is provided with an annular recess 128 that communicates with inlet water passage 50 when inlet poppet 100 is seated against the end surface 130 of stub 24a. Spring 114 seats in a depression machined in the adjacent face of inlet poppet 100.

When water has been compressed by the high pressure piston rod to a pressure sufficient to overcome the spring force of spring 114, valve stem 105 is shifted to the position shown in Figure 2 by water pressure acting on valve stem head 110. Prior to that point in time, water pressure acting on inlet poppet 100 would have closed inlet poppet 100 against surface 130 on valve body plug 24a to

seal off low pressure inlet water passage 50. With valve stem 104 positioned as shown in Figure 2, outlet poppet is raised from its seat element 106 and high pressure water is forced by the high pressure piston rod through passages 114, 116, 120 118 into cavity 122 and out through line 57. When the high pressure piston rod reaches the end of its pressurization cycle, reverses, and begins to retract, the spring force of spring 110 and the reverse force of high pressure water in line 57 forces valve stem 104 to the position shown in Figure 3, seating outlet poppet 102 against seat element 114 to close off the high pressure outlet to line 57. As the high pressure piston rod is retracted, the force of low pressure water from passage 50, acting concentrically within annular recess 128 on inlet poppet, lifts poppet 110 from its seat 130 on pilot 24a and flows around poppet 100 into the high pressure chamber. The spring force of spring 114 is sufficiently small that the force of low pressure water acting on the opposite side of poppet 100 will shift poppet 100 along valve stem 104 from the position shown in Figure 3 toward valve stem head 110 to release water from passage 50 into the high pressure chamber. The travel length of poppet 100 is limited by spring clip 112.

Of the two poppet sealing surfaces, the sealing surface 132 associated with outlet poppet 102 incurs much more severe stress. Consequently, seat element 124 is provided as a replaceable element. Moreover, the mating surfaces of poppet 102 and seat element 124 undergo wear, necessitating that these surfaces must be periodically polished to avoid high pressure water back leakage from line 57. The configuration and arrangement of adaptor 53 permits convenience handling of these matters. Without dislodging or disassembly of any part of the rest of the system, adaptor 53 can be unscrewed and removed from valve body 24 to expose seat element 106, poppet 102 and enlarged stem end 108. Poppet 102 can be removed to permit polishing of the sealing surfaces, replacement of the seat element 106 or poppet 102, or whatever else may be required in connection with the high pressure outlet check valve mechanism by removing the assembly and disconnecting clip 112. High pressure outlet line 57, typically a stainless steel tubing, is preferably coiled in the vicinity of adaptor 53 and screwed thereto by means of a coupling that permits adapter 53 to be turned relative to line 57. The resiliency of the coiled tubing permits the removal of adapter 53 away from the valve body 24 for working on the exposed mechanism.

Claims

1. A fluid pressure-intensifying apparatus comprising

a low pressure--high pressure cylinder means including a cylindrical low pressure chamber portion (14) and a pair of elongated cylindrical high pressure chambers (20), the high pressure chambers (20) extending coaxially from opposite ends of said low pressure chamber portion (14)

low pressure--high pressure piston means including a low pressure piston section (26) mounted for reciprocal movement in said low pressure chamber portion (14) and a pair of elongated high pressure piston sections (28, 30) connected to opposite sides of said low pressure piston section (26) and extending from said low pressure chamber portion (14) into an adjacent high pressure chamber for reciprocal movement therein

fluid inlet-outlet means (25) in fluid communication with said high pressure chambers (20) to simultaneously introduce fluid to be pressurized to one high pressure chamber and withdraw pressurized fluid from the other high pressure chamber,

and working fluid inlet-outlet means (62) mounted in fluid communication with said low pressure chamber portion (14) such that working fluid may alternately work against one said or the other of said low pressure piston section (26) to cause said low pressure piston means to reciprocate,

characterized in that the cylindrical low pressure chamber portion (14) is a single chamber, in that the low pressure piston section (26) is a double acting low pressure piston section, in that a cylindrical housing means (10) encloses and constrains said low pressure--high pressure cylinder means to position and maintain said pressure chambers in alignment, said housing means (10) includes end retainer means (12) for threadedly mounting said fluid inlet-outlet means (25) to the ends of said housing means (10) and compressively engaging said fluid inlet-outlet means (25) to the outer ends of said low pressure--high pressure piston means whereby said cylindrical housing means (10) is placed in tension and said low pressure--high pressure cylinder means is placed in compression to establish and maintain alignment of said fluid inlet-outlet means (25) and the elements making up said low pressure--high pressure cylinder means.

2. The intensifier of claim 1 characterized in that said low pressure-high pressure means in-



seal off low pressure inlet water passage 50. With valve stem 104 positioned as shown in Figure 2, outlet poppet is raised from its seat element 106 and high pressure water is forced by the high pressure piston rod through passages 114, 116, 120 118 into cavity 122 and out through line 57. When the high pressure piston rod reaches the end of its pressurization cycle, reverses, and begins to retract, the spring force of spring 110 and the reverse force of high pressure water in line 57 forces valve stem 104 to the position shown in Figure 3, seating outlet poppet 102 against seat element 114 to close off the high pressure outlet to line 57. As the high pressure piston rod is retracted, the force of low pressure water from passage 50, acting concentrically within annular recess 128 on inlet poppet, lifts poppet 110 from its seat 130 on pilot 24a and flows around poppet 100 into the high pressure chamber. The spring force of spring 114 is sufficiently small that the force of low pressure water acting on the opposite side of poppet 100 will shift poppet 100 along valve stem 104 from the position shown in Figure 3 toward valve stem head 110 to release water from passage 50 into the high pressure chamber. The travel length of poppet 100 is limited by spring clip 112.

Of the two poppet sealing surfaces, the sealing surface 132 associated with outlet poppet 102 incurs much more severe stress. Consequently, seat element 124 is provided as a replaceable element. Moreover, the mating surfaces of poppet 102 and seat element 124 undergo wear, necessitating that these surfaces must be periodically polished to avoid high pressure water back leakage from line 57. The configuration and arrangement of adaptor 53 permits convenience handling of these matters. Without dislodging or disassembly of any part of the rest of the system, adaptor 53 can be unscrewed and removed from valve body 24 to expose seat element 106, poppet 102 and enlarged stem end 108. Poppet 102 can be removed to permit polishing of the sealing surfaces, replacement of the seat element 106 or poppet 102, or whatever else may be required in connection with the high pressure outlet check valve mechanism by removing the assembly and disconnecting clip 112. High pressure outlet line 57, typically a stainless steel tubing, is preferably coiled in the vicinity of adaptor 53 and screwed thereto by means of a coupling that permits adaptor 53 to be turned relative to line 57. The resiliency of the coiled tubing permits the removal of adaptor 53 away from the valve body 24 for working on the exposed mechanism.

Claims

1. A fluid pressure-intensifying apparatus comprising

a low pressure--high pressure cylinder means including a cylindrical low pressure chamber portion (14) and a pair of elongated cylindrical high pressure chambers (20), the high pressure chambers (20) extending coaxially from opposite ends of said low pressure chamber portion (14)

low pressure--high pressure piston means including a low pressure piston section (26) mounted for reciprocal movement in said low pressure chamber portion (14) and a pair of elongated high pressure piston sections (28, 30) connected to opposite sides of said low pressure piston section (26) and extending from said low pressure chamber portion (14) into an adjacent high pressure chamber for reciprocal movement therein

fluid inlet-outlet means (25) in fluid communication with said high pressure chambers (20) to simultaneously introduce fluid to be pressurized to one high pressure chamber and withdraw pressurized fluid from the other high pressure chamber,

and working fluid inlet-outlet means (62) mounted in fluid communication with said low pressure chamber portion (14) such that working fluid may alternately work against one said or the other of said low pressure piston section (26) to cause said low pressure piston means to reciprocate,

characterized in that the cylindrical low pressure chamber portion (14) is a single chamber, in that the low pressure piston section (26) is a double acting low pressure piston section, in that a cylindrical housing means (10) encloses and constrains said low pressure--high pressure cylinder means to position and maintain said pressure chambers in alignment, said housing means (10) includes end retainer means (12) for threadedly mounting said fluid inlet-outlet means (25) to the ends of said housing means (10) and compressively engaging said fluid inlet-outlet means (25) to the outer ends of said low pressure--high pressure piston means whereby said cylindrical housing means (10) is placed in tension and said low pressure--high pressure cylinder means is placed in compression to establish and maintain alignment of said fluid inlet-outlet means (25) and the elements making up said low pressure--high pressure cylinder means.

2. The intensifier of claim 1 characterized in that said low pressure-high pressure means in-



cludes a low pressure cylinder (16) a pair of end caps (18) fitted to opposite ends of said low pressure-cylinder (16) to define said low pressure chamber portion (14), and a pair of centering rings (38) in that each end cap (18) includes a longitudinal passage therethrough for receiving one of said high pressure piston sections (28, 30) for reciprocal movement therein, each such passage being counterbored for containing one of said centering rings (38), in that a pair of high pressure cylinders (22) define said high pressure chambers (20), each fitted over a portion of one of said centering rings (38), and fitted to and extending outward from an end cap (18) whereby each centering ring (38) maintains the adjacent high pressure cylinder inner end in alignment with said low pressure cylinder (16) and with said cap longitudinal passage.

3. The intensifier of claim 2 characterized in that said fluid inlet-outlet means (25) includes a pair of check valve bodies (24) each having a portion fitted into the outer end of one of said high pressure cylinders (22) whereby the adjacent outer ends of said high pressure cylinders (22) are maintained in alignment with said low pressure cylinder (16).

4. The intensifier of claim 3 characterized in that said housing means (10) includes threaded and sections, a pair of threaded retainers (12) each having a bore in which one of said valve bodies (24) is fitted, each end retainer (12) being so constructed and arranged to compressively engage an adjacent valve body with the adjacent one of said high pressure cylinders, when said end retainers (12) are screwed to said housing cylinder, with sufficient force to hold together and position the aforesaid intensifier elements under operating conditions.

5. the intensifier of claim 1 characterised in that it further includes a working fluid inlet-outlet means mounted in fluid communication with said low pressure chamber such that working fluid may alternately work against one side or the other of said low pressure piston section (26) to cause said low pressure-high pressure piston means to reciprocate; and working fluid flow control actuating means for actuating a working fluid flow control means to change the direction of working fluid flow through said working fluid inlet-outlet means (62), said actuating means including actuating piston means (72) mounted in fluid communication with said low pressure chamber portion (14) for

reciprocal movement and so constructed and arranged to be shifted from a first, inert position to a second, actuating position by contact with said low pressure piston section (26) and to be returned to said first position by working fluid in said low pressure chamber portion (14).

6. The intensifier of claim 5 characterized in that said low pressure-high pressure cylinder means includes a pair of low pressure chamber and caps (18) defining opposite ends of said low pressure chamber portion (14), each end cap being provided with a bore in which an actuating piston means extends; and in that each actuating piston means includes a shifter pin (72) having an inner end exposed to said low pressure chamber portion (14), an outer end extended outward from said end cap (18) and a mid portion providing a piston face in fluid communication with said low pressure chamber portion (14), said shifter pin (72) being so constructed and arranged that the area of said piston face is greater than the area of said inner end whereby pressurized working fluid in said low pressure chamber portion (14) acting on both said pistons pace and said inner end will effect movement of said shifter pin (72) into said low pressure chamber portion (14).

7. The intensifier of claim 6 characterised in that said actuating piston means includes a spring-loaded switch-contacting plunger (77) telescopically mounted in the outer end of said shifter pin (72) for actuating contact with a switch when said actuating piston means is shifted to its actuating position.

8. The intensifier of claim 3 characterized in that each valve body (24) is provided with a longitudinal axial fluid passage (54) opening at one end into an adjacent high pressure piston chamber and opening at the other end into a cavity provided in an adjacent high pressure outlet line coupling (56), in that said fluid inlet-outlet means (25) includes a valve mechanism for each valve body (24), each such valve mechanism comprising an elongated valve stem (104) extended through said axial fluid passage into the high pressure chamber at the inner end and the coupling cavity (122) at the outer end and being so configured as to enable high pressure fluid passage into said coupling cavity; in that an outlet seat element (124) exposed to said coupling cavity and through which said coupling passage, an outlet poppet (102) mounted by said valve stem (104) outer end within said coupling cavity



ein Paar mit Gewinde versehene stirnseitige Halteeinrichtungen jeweils eine Bohrung enthalten, in die einer der Ventilkörper (24) eingesetzt ist, wobei die Halteeinrichtungen (12) jeweils so aufgebaut und angeordnet sind, daß sie beim Einschrauben der stirnseitigen Halteeinrichtungen (12) in den Gehäusezylinder den jeweils angrenzenden Ventilkörper so fest auf den jeweils angrenzenden Hochdruck-Zylinder aufdrücken, daß die vorgenannten Elemente des Verstärkers unter den Arbeitsbedingungen in der Sollage zusammengehalten werden.

5. Verstärker nach Anspruch 1, **dadurch gekennzeichnet**, daß weiterhin eine Einlaß/Auslaß-Einrichtung für Arbeitsfluid in Strömungsverbindung mit der Niederdruck-Kammer so angeordnet ist, daß das Arbeitsfluid abwechselnd auf die eine oder andere Seite des Niederdruck-Kolbenteils (26) arbeiten kann, um die Niederdruck-Hochdruck-Kolbeneinrichtung hin- und herzufahren, daß eine Arbeitsfluid-Betätigungseinrichtung eine die Strömung des Arbeitsfluid steuernde Einrichtung aufweist, um die Strömungsrichtung des Arbeitsfluids in der Fluid-Einlaß/Auslaß-Einrichtung (62) zu ändern, wobei die Betätigungseinrichtung eine Betätigungs-Kolbeneinrichtung (72) aufweist, die zur Hin- und Herbewegung in Strömungsverbindung mit dem Niederdruck-Kammerteil (14) angeordnet und 50 aufgebaut und angeordnet ist, daß sie durch Kontakt mit dem Niederdruck-Kolbenteil (26) aus einer ersten Ruhe- in eine zweite Betätigungslage gebracht und von dem Arbeitsfluid in den Niederdruck-Kammerteil (14) zurückgeführt wird.

6. Verstärker nach Anspruch 5, **dadurch gekennzeichnet**, daß die Niederdruck-Hochdruck-Zylinder-Einrichtung ein Paar stirnseitiger Niederdruckkammer-Endkappen (18) aufweist, die die entgegengesetzten Enden des Niederdruck-Kammerteils (14) abschließen, wobei jede Kappe mit einer Bohrung versehen ist, in der sich ein Betätigungskolben erstreckt, und daß jeder Betätigungskolben einen Schaltstift (72) aufweist, dessen inneres Ende zum Niederdruck-Kammerteil (14) offenliegt, dessen äußeres Ende aus der Kappe (18) hinaus vorsteht und dessen Mittelteil eine mit dem Niederdruck-Kammerteil (14) in Strömungsverbindung stehende Kolbenfläche aufweist, wobei der Schaltstift (72) so aufgebaut und angeordnet ist, daß der Flächeninhalt der Kolbenfläche größer ist als der des inneren Endes, so daß das im Niederdruck-Kammerteil (14) auf beide Kolbenflächen und das innere Ende wirkende

druckbeaufschlagte Arbeitsfluid eine Bewegung des Schaltstifts (72) in den Niederdruck-Kammerteil (14) hinein bewirkt.

7. Verstärker nach Anspruch 6, **dadurch gekennzeichnet**, daß die Betätigungskolben-Einrichtung einen einen Schalter berührenden federvorgespannten Schaltkolben (77) aufweist, der teleskopartig im äußeren Ende des Schaltstifts (72) angeordnet ist und sich betätigend an einen Schalter anlegt, wenn die Betätigungskolbeneinrichtung in die Betätigungsposition gebracht wird.

8. Verstärker nach Anspruch 3, **dadurch gekennzeichnet**, daß jeder Ventilkörper (24) mit einem längsverlaufenden axialen Fluidkanal (54) versehen ist, der an einem Ende in die angrenzende Hochdruck-Kolbenkammer und am anderen Ende in einen Hohlraum im angrenzenden Hochdruck-Auslaßleitungsanschluß (56) mündet, daß die Fluid-Einlaß/Auslaß-Einrichtung (25) für jeden Ventilkörper (24) eine Ventilmekanik aufweist, die jeweils einen langgestreckten Ventilschaft (104) aufweist, der durch den axialen Fluidkanal in die Hochdruckkammer am inneren Ende und in den Hohlraum (122) im Anschluß verläuft und so konfiguriert ist, daß Hochdruck-Fluid in den Hohlraum im Anschluß strömen kann, und daß ein Auslaß-Sitzelement (124) zum Hohlraum im Anschluß hin offenliegt, durch den der Anschlußkanal verläuft, und daß auf das äußere Ende des Ventilschafts (104) im Hohlraum (124) im Anschluß ein Verschlusskopf (102) aufgesetzt und so gestaltet ist, daß er auf das Auslaß-Sitzelement aufsetzen und den axialen Fluidkanal gegen einen Rückfluß von Hochdruckfluid aus dem Hohlraum (122) sperren kann.

9. Verstärker nach Anspruch 8, **dadurch gekennzeichnet**, daß die Fluid-Einlaß/Auslaß-Einrichtung (25) auf jedem Ventilkörper (24) einen Niederdruckfluid-Einlaßverteiler (51) aufweist, daß jeder Ventilkörper (24) einen langgestreckten Fluid-Einlaßkanal (50) aufweist, der an einem Ende in eine angrenzende Hochdruck-Kolbenkammer und am anderen Ende in einen angrenzenden Niederdruck-Fluideinlaßverteiler mündet, und daß jede Ventilmekanik einen Einlaß-Verschlusssteller (100) aufweist, der in der Hochdruckkammer verschiebbar auf dem inneren Ende des Ventilschafts (104) angeordnet und so gestaltet ist, daß er sich über die Mündung des Fluid-Einlaßkanals zur Hochdruck-Fluidkammer legt und sie verschließt, und daß der Druck in der Hochdruck-fluidkam-



mer die vom Einlaßfluid im Fluid-Einlaßkanal ausgeübte Kraft übersteigt.

Revendications

1. Dispositif d'intensification de la pression d'un fluide comprenant :

un moyen de cylindre de basse pression-haute pression comprenant une partie de chambre de basse pression cylindrique (14) et une paire de chambres de haute pression cylindriques allongées (20), les chambres de haute pression (20) s'étendant coaxialement depuis les extrémités opposées de ladite partie de chambre de basse pression (14),

un moyen de piston de basse pression-haute pression comprenant une section de piston de basse pression (26) monté pour effectuer un déplacement en va-et-vient dans ladite partie de chambre de basse pression (14) et une paire de sections de piston de haute pression allongées (28, 30) reliées aux extrémités opposées de ladite section de piston de basse pression (26) et s'étendant depuis ladite partie de chambre de basse pression (14) jusqu'à l'intérieur d'une chambre de haute pression adjacente pour y effectuer un déplacement en va-et-vient,

un moyen d'entrée-sortie de fluide (24) en communication fluïdique avec lesdites chambres de haute pression (20) pour introduire simultanément un fluide destiné à être mis sous pression dans une première chambre de haute pression et à extraire le fluide sous pression de l'autre chambre de haute pression,

et un moyen d'entrée-sortie de fluide actif (62) monté en communication fluïdique avec ladite partie de chambre de basse pression (14) de façon telle que le fluide actif puisse agir d'une manière alternée contre la première

ou l'autre de ladite section de piston de basse pression (26) pour amener ledit moyen de piston de basse pression à effectuer un déplacement en va-et-vient,

caractérisé en ce que la partie de chambre de basse pression cylindrique (14) est une chambre unique, en ce que la section de piston de basse pression (26) est une section de piston de basse pression à double effet, en ce qu'un moyen de logement cylindrique (10) renferme et amène ledit moyen de cylindre de basse pression-haute pression à positionner et maintenir lesdites chambres de pression alignées, ledit moyen de logement (10) comprenant un moyen de retenue d'extrémité (12) destiné à maintenir ledit moyen d'entrée-sortie de fluide (25) par filetage sur les extrémités dudit moyen de logement (10) et appliquant

par compression ledit moyen d'entrée-sortie de fluide (25), sur les extrémités extérieures dudit moyen de piston de basse pression-haute pression, ce qui fait que ledit moyen de logement cylindrique (10) est mis sous tension et que ledit moyen de cylindre de basse pression-haute pression est mis sous compression pour établir et maintenir l'alignement dudit moyen d'entrée-sortie (25) et les éléments constituant ledit moyen de cylindre de basse pression-haute pression.

2. Dispositif d'intensification selon la revendication 1, caractérisé en ce que ledit moyen de basse pression-haute pression comprend un cylindre de basse pression (16), une paire de capuchons d'extrémité (18) montés sur les extrémités opposées dudit cylindre de basse pression (16) en vue de définir ladite partie de chambre de basse pression (14) et une paire de bagues de centrage (38), en ce que chaque capuchon d'extrémité (18) comprend un passage longitudinal qui le traverse en vue de recevoir l'une desdites sections de piston haute pression (28, 30) pour y effectuer un déplacement en va-et-vient, chacun de tels passages étant contre-percé en vue de contenir l'une desdites bagues de centrage (38), en ce qu'une paire de cylindres de haute pression (22) définit lesdites chambres de haute pression (20), chacun des cylindres étant monté sur une partie de l'une desdites bagues de centrage (38) et étant monté sur un capuchon d'extrémité (18) à partir duquel il s'étend vers l'extérieur, ce qui fait que chacune des bagues de centrage (38) maintient l'extrémité interne des cylindres de haute pression adjacents alignés avec ledit cylindre de basse pression (16) et avec ledit passage longitudinal.

3. Dispositif d'intensification selon la revendication 2, caractérisé en ce que ledit moyen d'entrée-sortie de fluide (25) comprend une paire de corps de clapet anti-retour (24) dont chacun possède une partie qui est montée dans l'extrémité externe de l'un desdits cylindres de haute pression (22), ce qui fait que les extrémités extérieures adjacentes desdits cylindres de haute pression (22) sont maintenues alignées avec ledit cylindre de basse pression (16).

4. Dispositif d'intensification selon la revendication 3, caractérisé en ce que ledit moyen de logement (10) comprend des sections d'extrémité filetées, une paire d'éléments de retenue filetés (12), dont chacun possède un alésage dans lequel est monté l'un desdits corps de clapet (24), chaque élément de retenue d'ex-



trémité (12) étant conçu et agencé de façon à appliquer par compression un corps de clapet adjacent sur le cylindre adjacent desdits cylindres de haute pression lorsque lesdits éléments de retenue d'extrémité (12) sont vissés sur ledit cylindre de logement avec une force suffisante pour maintenir ensemble et positionner les éléments du dispositif d'intensification précédemment mentionnés dans des conditions de fonctionnement.

5. Dispositif d'intensification selon la revendication 1, caractérisé en ce qu'il comprend en outre un moyen d'entrée-sortie de fluide actif monté en communication fluidique avec ladite chambre de basse pression de façon telle que le fluide actif puisse, d'une manière alternée, agir contre un premier côté, ou l'autre, de ladite section de piston de basse pression (26) pour amener ledit moyen de piston de basse pression--haute pression à effectuer un déplacement en va-et-vient et un moyen d'actionnement de commande d'écoulement fluidique actif destiné à actionner un moyen de commande d'écoulement fluidique actif en vue de modifier la direction d'écoulement fluidique actif à travers ledit moyen d'entrée-sortie de fluide actif (62), ledit moyen d'actionnement comprenant un moyen de piston d'actionnement (72) monté en communication fluidique avec ladite partie de chambre de basse pression (14) pour effectuer un déplacement en va-et-vient, celui-ci étant conçu et agencé de façon à être déplacé d'une première position inerte vers une seconde position d'actionnement par contact avec ladite section de piston de basse pression (26) et à être ramené vers ladite première position par le fluide actif dans ladite partie de chambre de basse pression (14).

6. Dispositif d'intensification selon la revendication 5, caractérisé en ce que ledit moyen de cylindre de basse pression--haute pression comprend une paire de capuchons d'extrémité de chambre de basse pression (18) définissant des extrémités opposées de ladite partie de chambre de basse pression (14), chaque capuchon d'extrémité étant pourvu d'un alésage dans lequel s'étend un moyen de piston d'actionnement; et en ce que chaque moyen de piston d'actionnement comprend une broche de déplacement (72) comprenant une extrémité interne exposée à ladite partie de chambre de basse pression (14) une extrémité externe s'étendant vers l'extérieur depuis ledit capuchon d'extrémité (18) et une partie intermédiaire qui constitue une face de piston en communication fluidique avec ladite partie de chambre

de basse pression (14), ladite broche de déplacement (72) étant conçue et agencée de façon telle que la surface de ladite face de piston est plus grande que la surface de ladite extrémité interne, ce qui fait que le fluide actif sous pression présent dans ladite partie de chambre de basse pression (14) agissant à la fois sur lesdites faces de piston et sur ladite extrémité interne effectuera un déplacement de ladite broche de déplacement (72) pour l'amener dans ladite partie de chambre de basse pression (14).

7. Dispositif d'intensification selon la revendication 6, caractérisé en ce que ledit moyen de piston d'actionnement comprend un plongeur de contact de commutateur chargé élastiquement (77) monté d'une manière télescopique dans l'extrémité externe de ladite broche de déplacement (72) pour actionner un contact muni d'un commutateur lorsque ledit moyen de piston d'actionnement est déplacé vers sa position d'actionnement.

8. Dispositif d'intensification selon la revendication 3, caractérisé en ce que chaque corps de clapet (24) est pourvu d'un passage de fluide axial longitudinal (54) s'ouvrant à une première extrémité dans une chambre de piston de haute pression adjacente et s'ouvrant en l'autre extrémité dans une cavité formée dans un raccord de conduite de sortie de haute pression adjacent (56), en ce que ledit moyen d'entrée-sortie de fluide (25) comprend un mécanisme de clapet destiné à chaque corps de clapet (24), chacun desdits mécanismes de clapet comprenant une tige de soupape allongée (104) passant à travers ledit passage de fluide axial dans la chambre de haute pression au niveau de l'extrémité interne et à travers la cavité de raccordement (122) au niveau de l'extrémité externe et étant configurée de façon à permettre un passage du fluide haute pression dans ladite cavité de raccordement, en ce qu'un élément de siège de sortie (124) exposé à ladite cavité de raccordement et à travers ledit passage de raccordement, une poupée de sortie (102) supportée par ladite extrémité extérieure de tige de soupape (104) à l'intérieur de ladite cavité de raccordement (124) et configurée de façon à pouvoir reposer contre ledit élément de siège de sortie en vue d'étanchéifier ledit passage de fluide axial contre un reflux fluidique haute pression de ladite cavité de raccordement (122).

9. Dispositif d'intensification selon la revendication 8, caractérisé en ce que ledit moyen d'en-



trée-sortie de fluide (25) comprend un distributeur d'entrée de fluide basse pression (51) supporté par chacun des corps de clapet (24), en ce que chacun des corps de clapet (24) comprend un passage d'entrée de fluide allongé (50) s'ouvrant à une extrémité dans une chambre de piston haute pression adjacente et s'ouvrant à une extrémité dans un distributeur d'entrée de fluide basse pression adjacent; et en ce que chaque mécanisme de clapet comprend une poupée d'entrée (100) montée à coulissement sur l'extrémité interne de ladite tige de soupape (104) à l'intérieur de ladite chambre de haute pression et étant configurée de manière à recouvrir et étanchéifier le passage d'entrée de fluide s'ouvrant dans ladite chambre de fluide haute pression en dépassant la force exercée par le fluide entrant dans ledit passage d'entrée de fluide.

5

10

15

20

25

30

35

40

45

50

55