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[54] **CLOSE CLEARANCE VISCOUS FLUID SEAL SYSTEM**

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[51] **Int. Cl.** **F01b 31/00**

[58] **Field of Search** 417/437; 92/168, 92/86.5, 86

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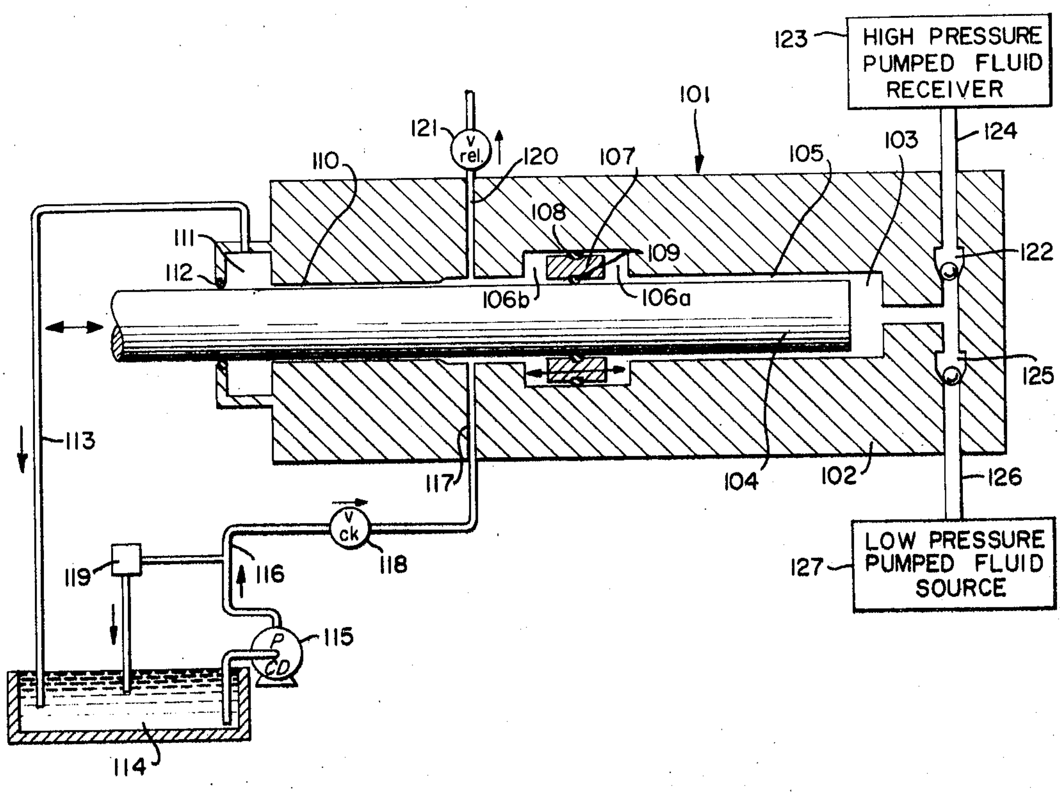
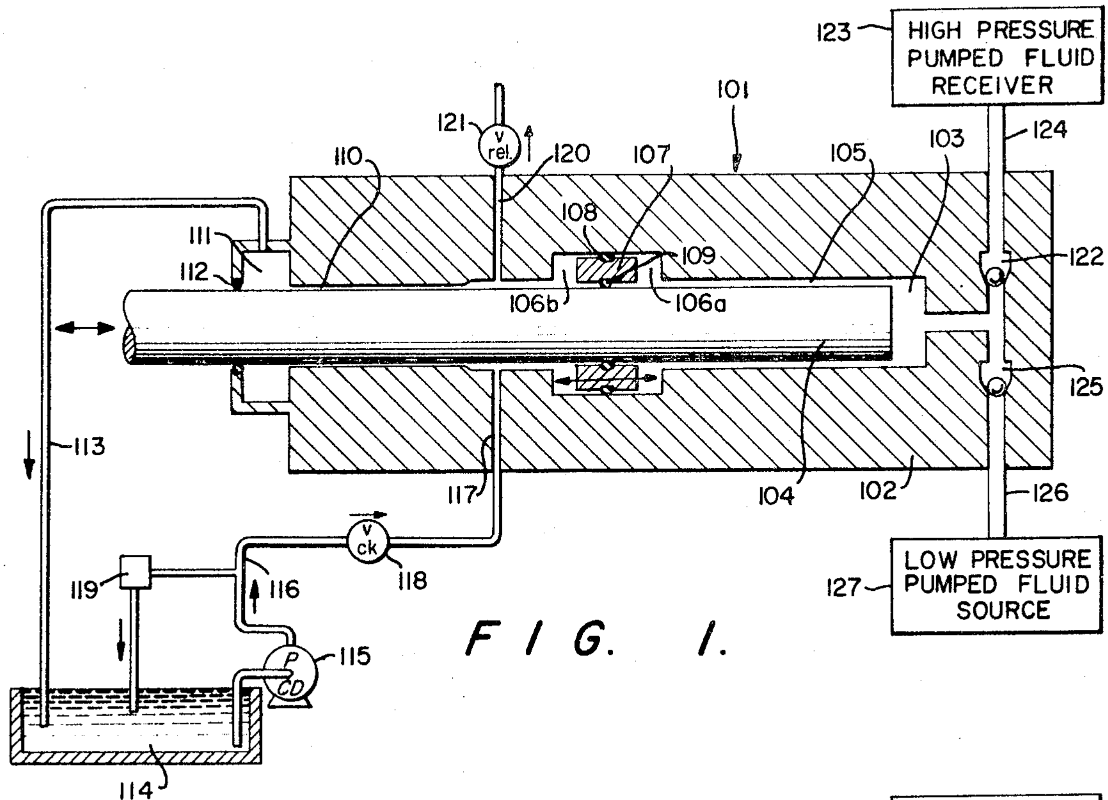
[57] **ABSTRACT**

A close clearance viscous fluid seal system has been developed for use in high pressure reciprocating pumps. This system does away with the conventional high pressure packings used in such pumps and relies on a viscous fluid to form the seal between the plunger and the pump body. A floating piston seal is employed to separate the pumped fluid from the viscous fluid and impose the pumped fluid pressure to the viscous fluid sealant.

5 Claims, 4 Drawing Figures





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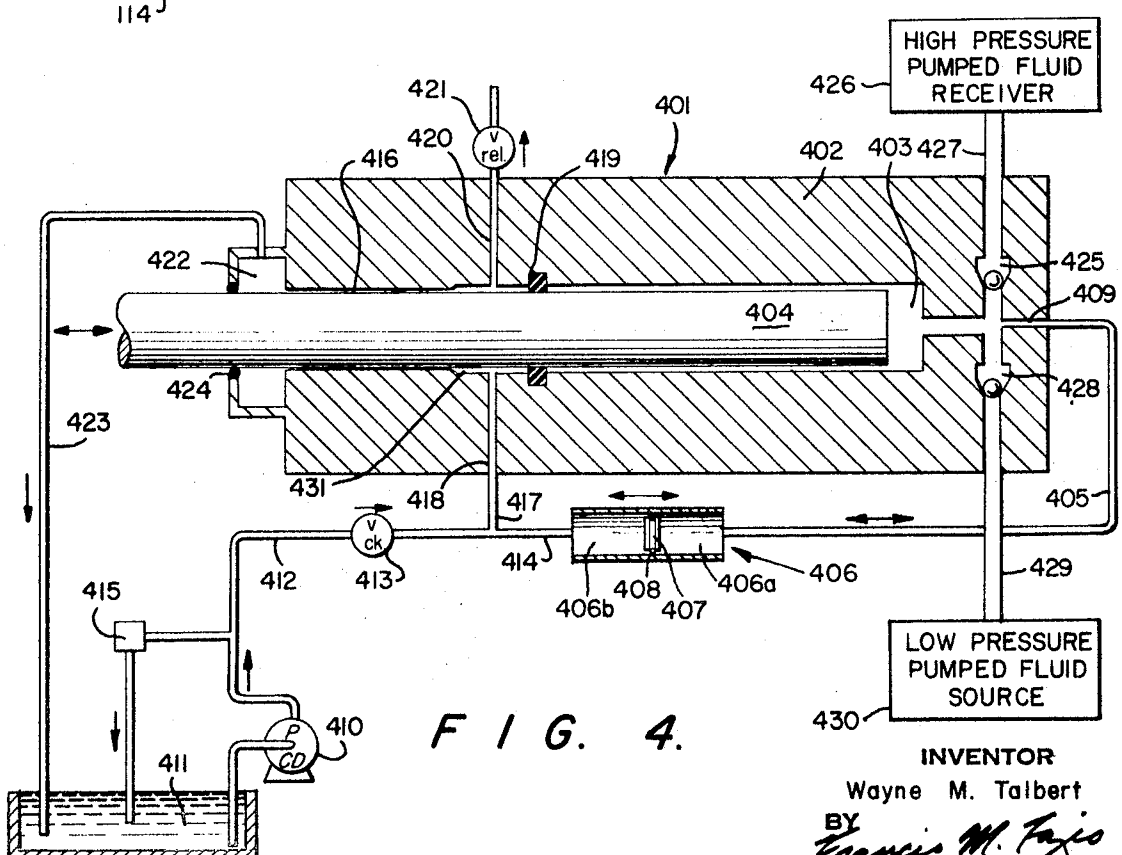

F I G. 4.

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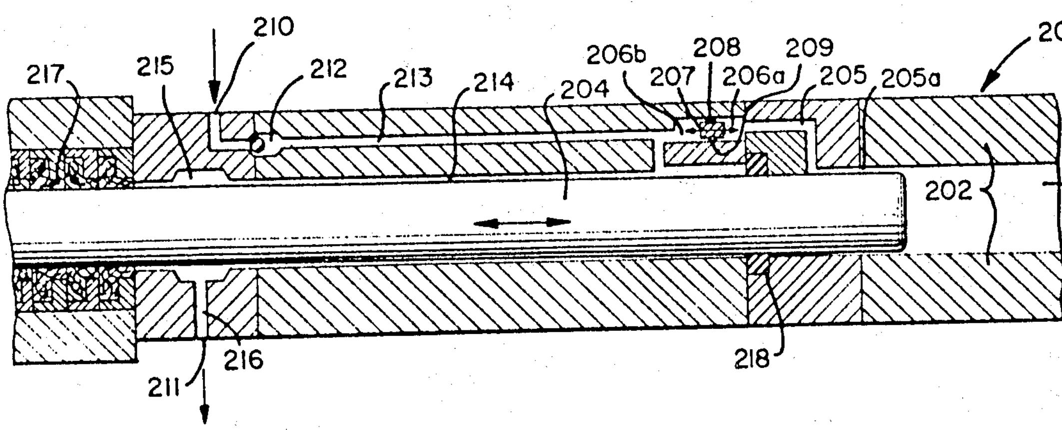

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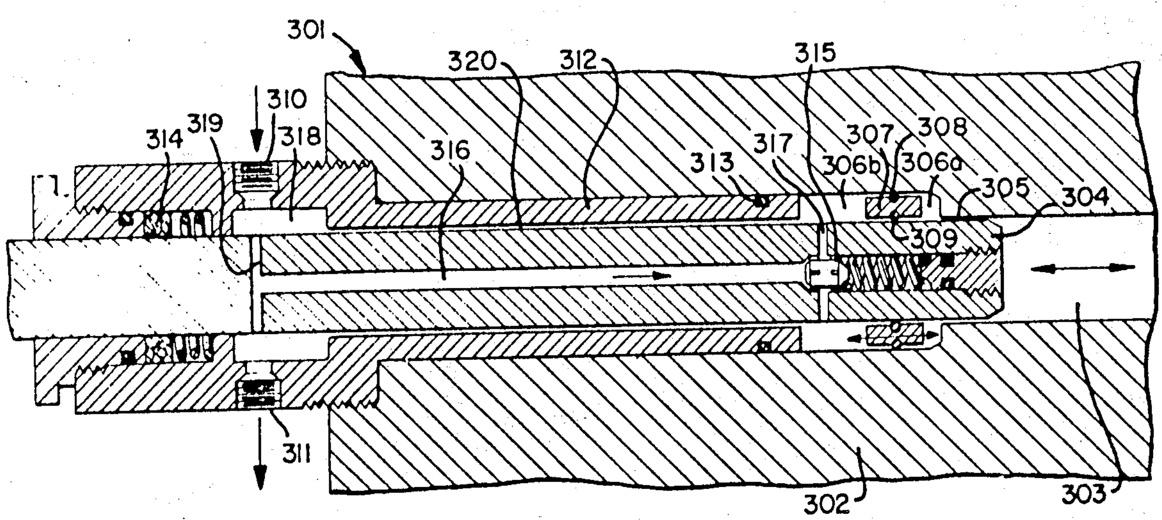

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CLOSE CLEARANCE VISCOUS FLUID SEAL SYSTEM

The present invention relates to an improvement in apparatus for producing high pressures in pumped fluids and more particularly to a close clearance viscous fluid seal system used in such apparatus.

Many of today's commercial processes require the use of extremely high pressures for the introduction of materials into reaction equipment that is being operated at extremely high pressures. Such pressures require specially designed equipment that will withstand the pressure and also require the use of pumps that have the capacity of functioning for prolonged periods of time at the high pressures. It is known that in many instances the pressure will exceed 40,000 psig.

Positive displacement type pumps in which a reciprocating plunger is used to compress the pumped fluid and raise it to the desired pressure are commonly used in high pressure processes. One of the major problems encountered in this equipment is the deterioration and failure of the packing materials and plungers used in the pumps. The reciprocating action of the plunger rapidly deteriorates the packing materials surrounding the plunger, necessitating the shutting down of the equipment. This requires the replacement of the packing material with consequent loss in operating time. To date most of the reciprocating pumps in use rely on solid packing materials to maintain a seal. Though these packing materials are not completely satisfactory they are practically the sole known means used in the industry, and much effort in time and money has been expended in attempts to improve the known materials and to find better lower cost substitutes. The reciprocating motion of the plungers has a wearing effect on them and in many applications solid tungsten carbide plungers must be used to obtain reasonable packing and plunger life. These plungers are very expensive and present a hazard due to the brittle type fracture failure that is characteristic of this material. Several instances have been reported in which solid tungsten carbide plungers have failed and shattered fragments thereof together with a flammable fluid or gas were released into an operating area.

According to the instant invention the use of conventional packing materials in high pressure positive displacement pumps can be obviated. This is accomplished by the use of pumping apparatus having a close clearance viscous fluid seal in the annular space between the reciprocating plunger and the barrel of the pump in which the plunger is located. Throughout this annular close clearance seal zone there is maintained a flowing viscous fluid which has approximately the same pressure imposed on its high pressure side as the pressure of the pumped fluid. The viscous sealant fluid acts as a seal and it is introduced into the annular close clearance seal zone by sealant fluid circulating means that are readily constructed from available equipment with known technology. The upstream pressure of the viscous fluid in the annular close clearance seal zone is maintained by means of said sealant fluid circulating means and by means of a floating piston seal which separates the pumped fluid chamber from the viscous sealant fluid and imposes the pressure of the pumped fluid on the sealant fluid.

In the present invention, as the plunger compresses the pumped fluid, the pumped fluid in turn applies an

equivalent pressure to the floating piston seal located in a floating piston seal chamber. This floating piston seal moves in the opposite direction of the movement of the plunger during the compression stroke and exerts pressure on the viscous sealant fluid located on the sealant fluid side of the floating piston chamber forcing viscous sealant fluid into the annular close clearance zone between the plunger and the main body of the pump. During the return stroke of the plunger, when low pressure pumped fluid is drawn into the pumped fluid chamber, the floating piston seal reverses direction and the viscous sealant fluid circulating means replaces any viscous fluid which passed out of the system during the cycle. In one version, where the viscous sealant fluid is introduced via a bore in the plunger (see FIG. 3), the viscous sealant fluid is replenished during a short period of the suction stroke, and sealant fluid passes through the annular close clearance zone during the pumping cycle. In the operation of this invention, viscous fluid sealant physically separated from the pumped fluid chamber is always present between the plunger and the main body of the pump. It is possible to maintain this viscous sealant fluid in the annular close clearance zone even at relatively high pressures because of the close clearance between the plunger and the main body of the pump and the viscosity of the lubricant itself.

The seal is so designed and a viscous sealant selected so that classic laminar flow conditions will always exist in the annular close clearance zone. With laminar flow conditions, the flow rate of sealant through the annular clearance zone is directly proportional to pressure differential, varies as the square of the clearance in the annulus, is inversely proportional to the sealant viscosity and the length of the annulus. The speed and direction of the plunger also affects the flow rate in accordance with basic text book laminar flow theory. An acceptable flow rate of sealant through the annulus for a given pump and a given set of operating conditions can be obtained by selecting proper values for the above variables.

Pressure and temperature both significantly change the viscosities of most fluids. As an example the viscosity of a typical paraffinic oil with a given viscosity at atmospheric pressure and 100° F. will have a viscosity 500 times greater at 40,000 psig and 100° F., 4 times greater at 40,000 psig and 210° F., and 0.08 times at 40,000 psig and 425° F. Silicone fluids have significantly different properties. As an example, the viscosity of a typical silicone oil with a given viscosity at atmospheric pressure and 100° F. will have a viscosity 1,900 times greater at 40,000 psig and 100° F., 10 times greater at 40,000 psig and 210° F., and 0.64 times at 40,000 psig and 425° F.

Heat is generated in the annulus as viscous fluid is sheared by differential pressure and the motion of the plunger. A typical temperature rise for a silicone sealant passing from 38,000 psi to atmospheric pressure through an annulus is 350° F., provided no heat is removed during the throttling. A controlled rate of sealant leakage through the annulus can be obtained by controlling sealant viscosity. This is achieved by knowledgable selection of sealant fluid, initial viscosity of the fluid, and the amount of heat removed as it passes through the annulus. The approximate leakage rate for a 2⅞ inches diameter plunger during the compression stroke, moving at 1 foot per second, is 1.8

cubic inches per second when the plunger is positioned concentrically in the annulus, the annulus radial clearance is 0.008 inch, the length of the annulus is nine inches, the differencial pressure across the annulus is 38,000 psig, the average viscosity of the sealant in the annulus is 5,000 centipoises. Clearance at operating conditions is greater than initial clearance due to the expansion of the cylinder and contraction of the plunger caused by the very high operating pressures. This effect must be calculated so that a seal can be assembled to an initial clearance that will give the desired clearance at operating pressure.

The present invention finds particular application in the known high pressure process for the polymerization of ethylene both in the compression pumps used to compress the ethylene to the desired pressure and in the injection pumps used to introduce catalysts and other reactants into the reaction process.

Accordingly, the present invention comprehends a system for pumping fluids at high pressures wherein reciprocating plungers of positive displacement pumps, intensifiers or injection pumps are sealed against leakage along their axial length and annularly by means of an annular close clearance seal and a floating piston seal which forces the viscous sealant fluid to flow through the close clearance annulus. This eliminates the need for conventional packing materials and their periodic replacement.

With the foregoing in mind and other features which shall hereinafter more fully appear, the present invention will be described in greater particularity with reference to the appended drawings.

FIG. 1 is a schematic diagram of the mechanical portion of a high pressure process system containing the close clearance viscous fluid seal according to the present invention.

FIG. 2 is a schematic diagram of another modification of the mechanical portion of a high pressure process system containing the close clearance viscous fluid seal showing only the main body, plunger and seal sections of the pump.

FIG. 3 is a schematic diagram of a modification of the mechanical portion of a high pressure intensifier or injection pump system containing the close clearance viscous fluid seal, showing only the main body, plunger and seal sections of the pump.

FIG. 4 is a schematic diagram of a modification in which the free floating piston seal is located extraneous of the high pressure process system containing the close clearance viscous fluid seal.

Referring to FIG. 1 of the drawings there is shown a positive displacement pump, designated generally as **101**, comprising a main body **102** and a pumped fluid chamber **103**. A plunger **104** is arranged in the pumped fluid chamber **103**. Not shown are the mounting means for the positive displacement pump **101**, the motive means for activating the plunger **104**, viscous fluid reservoir means and cylinder cooling facilities. The plunger **104** moves reciprocally in the pumped fluid chamber **103** during operation of the pump. An annular pressure zone **105** connects the pumped fluid chamber **103** to annular seal chamber **106***a* and **105***b* which contains therein an annular floating piston seal **107** having thereon an outside and inside scraper-seal **108** and **109** (both made of conventional packing material) thus dividing the seal chamber into two sections, **106***a* connecting through annular pressure zone **105** to pumped fluid chamber **103** and **106***b* connecting through a close clearance annular seal zone **110** to viscous fluid chamber **111**, which is sealed by an annular seal **112** made of conventional packing material. Viscous fluid chamber **111** connects via pressure fluid conduit **113** to viscous fluid reservoir **114**. Constant pressure viscous fluid pump **115** operates with a discharge pressure slightly higher than the minimum pressure that occurs during the suction stroke in fluid chamber **103**, it pumps the viscous fluid through pressure fluid conduit **116** into the viscous fluid side of seal chamber **106b** through passage **117** bored through the main body **102** of the positive displacement pump **101**. Located on pressure fluid conduit **116** are suitable viscous fluid check valves **118** and pressure regulator **119**. At a point distant from passage **117** a vent passage **120** attached at its exterior end to a suitable pressure valve **121** activatable in the event of an emergency can be included; this, however, is not a necessary part of the apparatus.

In an embodiment shown in FIG. **1**, the compression stroke of the pump **101** involves a movement of the plunger **104** from left to right. During the compression stroke plunger **104** will displace pumped fluid from pumped fluid chamber **103** through the discharge valve **122** into the high pressure pumped fluid receiver **123** through high pressure pumped fluid conduit **124**. During this compression stroke inlet suction valve **125** is closed preventing the pumped fluid from escaping via low pressure pumped fluid conduit **126** into low pressure pumped fluid source **127**. At the same time the pressure produced on the pumped fluid by the compression stroke exerts a pressure on floating piston seal **107** causing it to move from right to left; this movement imposes a pressure on the viscous fluid in seal chamber **106***b* forcing some of it into close clearance annular seal zone **110**. The amount of this leakage is low because of the laminar flow conditions established by the fluid viscosity and the close clearance in the annulus. The amount of viscous fluid or pumped fluid flowing past scraper-seals **108** and **109** is minimal since there is essentially no differential pressure across the scraper seals to force flow. The return stroke involves a movement of the plunger **104** from right to left. During this return stroke discharge valve **122** is closed, inlet suction valve **125** opens permitting pumped fluid to fill pumped fluid chamber **103** from low pressure pumped fluid source **127** via low pressure pumped fluid conduit **126**. At the same time floating piston seal **107** is forced from left to right until it mechanically rests against the end of floating piston seal chamber by viscous fluid that is pumped into oil seal chamber **106***b* by the constant pressure viscous fluid pump **115** via pressure fluid conduit **116** and passage **117** to replace the viscous fluid that may have leaked out through annular seal zone **110** during the compression stroke. In this manner pumped fluid is transferred from a low pressure source to a high pressure zone using pumping means that do not have the conventional packing materials in annular close clearance seal zone **110**. The annular close clearance surface and the plunger are not subject to excessive wear since they are separated by a continuous strata of viscous fluid having lubricating properties.

Referring to FIG. **2** of the drawings, there is shown the barrel portion of a reciprocating compressor pump designated generally as **201**, comprising a main body **202**, a pumped fluid chamber **203** and a plunger **204** arranged in the pumped fluid chamber **203**. Not shown are the mounting means for the reciprocating compressor pump **201**, the motive means for activating the plunger **204**, cylinder cooling facilities, the pumped fluid portion of the equipment designated by numerals **122** to **127** inclusive of FIG. **1** and the viscous fluid circulating means designated by numerals **113, 114, 115, 116, 118** and **119** of FIG. **1**. The plunger **204** moves reciprocally in the pumped fluid chamber **203** during operation of the pump. The main body **202** is preferably of several pieces that are assembled together. A pressure pumped fluid passage **205** connects via an annular pressure zone **205**a to the pumped fluid chamber **203** and to annular seal chamber **206*a*** and **206*b*** which contains therein an annular floating piston seal **207** having thereon a scraper-seal **208** and **209** (made of conventional packing material) thus dividing the seal chamber into two sections with **206*a*** connecting through annular pressure zone **205*a*** through pressure pumped fluid passage **205** to pumped fluid chamber **203**, and **206*b*** connecting to the viscous fluid circulating means of the close clearance seal **214**. The external viscous fluid circulating means are not shown except for the viscous fluid inlet point **210** and the viscous fluid exit point **211** both of which connect to circulating means similar to those described in FIG. **1**. The viscous fluid is pumped in through viscous fluid inlet point **210**, passes check valve **212**, continues through viscous fluid conduit **213** bored through a section of main body **202** and into the viscous fluid side of seal chamber **206*b*** which connects to a close clearance annular seal zone **214** to annular viscous fluid receiving chamber **215** which connects to viscous fluid exit point **211** via viscous fluid passage **216** bored through a section of main body **202**. Conventional low pressure packing **217** is used to confine the viscous fluid. A plunger scraping seal ring **218** prevents excessive amounts of viscous fluid from entering pumped fluid chamber **203** and in operation the end of plunger **204** does not pass to the left of plunger scraping seal ring **218**.

In an embodiment as shown in FIG. **2**, the compression stroke of the reciprocating compressor pump **201** involves a movement of the plunger **204** from left to right. During the compression stroke plunger **204** will displace pumped fluid from the pumped fluid chamber **203** into the high pressure fluid receiver (not shown). At the same time the pressure produced on the pumped fluid by the compression stroke exerts a pressure on the floating piston seal **207**; this pressure is imposed on the viscous fluid in seal chamber **206*b*** forcing some of the viscous fluid to flow in close clearance annular seal zone **214**. The amount of this leakage is low for the reasons discussed in relation to FIG. **1**. The return stroke involves a movement of the plunger **204** from right to left. During this return stroke pumped fluid fills pumped fluid chamber **203** from a low pressure pumped fluid source (not shown). At the same time floating piston seal **207** moves from left to right until it is in its full position to the right. Viscous fluid is pumped into seal chamber **206*b*** via viscous fluid conduit **213** by viscous fluid circulating means (not shown) to replace viscous fluid that passes through annular seal zone **214** into annular viscous fluid receiving chamber **215** and out through viscous fluid receiving chamber **215** and out through viscous fluid passage **216** during the compression stroke. In this manner pumped fluid is transferred from a low pressure source to a high pressure zone using pumping means that do not have the conventional packing materials in annular close clearance seal zone **214** without excessive wear or significant sealant contamination of the pumped fluid, as discussed in relation to FIG. **1**.

Referring to FIG. 3 of the drawings, there is shown the barrel portion of a reciprocating pump, designated generally as **301**, comprising a main body **302**, a pumped fluid chamber **303** and a plunger **304** arranged in the pumped fluid chamber **303**. Not shown are the mounting means for the reciprocating pump **301**, the motive means for activating the plunger **304**, the cylinder cooling facilities, the pumped fluid portion of the equipment designated by numerals **122** to **127** inclusive of FIG. **1** and the viscous fluid circulating means designated by numerals **113, 114, 115, 116, 118** and **119** of FIG. **1**. The plunger **304** moves reciprocally in the pumped fluid chamber **303** during operation of the pump. An annular pressure zone **305** connects pumped fluid chamber **303** to annular seal chamber **306*a*** and **306*b*** which contains therein an annular floating piston seal **307** having thereon an outside scraper-seal **308** and an inside scraper-seal **309** (both made of conventional packing material) thus dividing the seal chamber into two sections, **306*a*** connecting via annular pressure zone **305** to pumped fluid chamber **303**, and **306*b*** connecting to the viscous fluid close clearance seal system. The external viscous fluid circulating means are not shown except for the viscous fluid inlet point **310** and the viscous fluid exit point **311** both of which connect to viscous fluid circulating means similar to those described in FIG. **1**. These points can be located on throttling bushing **312** which can have a static annular packing seal **313** to prevent viscous fluid leakage from seal chamber **306*b*** along main body **302** and low pressure packing seal **314** to prevent viscous fluid leakage from plunger **304**. Fitted into the face end of plunger **304** is check valve **315** at the end of viscous fluid passage **316** bored through the lengthwise direction of plunger **304**. Viscous fluid passage **316** is connected at the check valve **315** end to annular seal chamber **306*b*** via viscous fluid conduit **317** and at the other end to annular viscous fluid chamber **318** via viscous fluid conduit **319**. Viscous fluid conduits **317** and **319** are borings through plunger **304** that intersect viscous fluid passage **316**.

In an embidiment as shown in FIG. **3**, the compression stroke of reciprocating injection pump **301** involves a movement of plunger **304** from left to right. During the compression stroke plunger **304** will displace pumped fluid from pump fluid chamber **303** into the high pressure pumped fluid receiver (not shown). At the same time the pressure produced on the pumped fluid by the compression stroke exerts a pressure on annular floating piston seal **307** causing it to impose a pressure on the viscous fluid in seal chamber **306*b*** forcing viscous fluid to flow in annular close clearance seal zone **320**. During the compression stroke check valve **315** is closed preventing viscous fluid from leaving seal chamber **306*b*** via viscous fluid conduit **317** and into viscous fluid passage **316**; the only path for the viscous fluid to follow is into annular close clearance seal zone **320**. The small amount of viscous fluid that flows through annular close clearance seal zone **320** enters annular viscous fluid chamber **318** and by the external viscous fluid circulating means is recycled; the amount is small for the reasons discussed in relation to

FIG. 1. The return stroke of plunger **304** involves a movement from right to left. During the latter portion of this return stroke pumped fluid fills pumped fluid chamber **303** from a low pressure pumped fluid source (not shown). During the initial portion of the return stroke annular floating piston seal **307** moves from right to left until viscous fluid conduit **319** contacts the viscous fluid chamber **318.** When this occurs check valve **315** opens because the pressure in the viscous fluid circulating means system is greater than the pressure of the suction pressure of the pumped fluid and viscous fluid is pumped in to fill seal chamber **306*b*** by external viscous fluid circulating means (not shown) via viscous fluid inlet point **310** passing through viscous fluid conduit **319**, viscous fluid passage **316** and viscous fluid conduit **317** into seal chamber **306*b*.** This forces the free floating piston seal **307** to its extreme right position. In this manner pumped fluid is transferred from a low pressure source to a high pressure zone using pumping means that do not have the conventional packing materials in annular close clearance seal zone **320** without excessive wear, or significant sealant contamination of the pumped fluid as discussed in relation to FIG. **1.** An advantage of the arrangement shown in FIG. **3** is that viscous fluid passages are not required to be drilled in the main body **302** section of the high pressure reciprocating pump, but rather the viscous fluid sealant enters via the plunger **304.** This arrangement eliminates stress raisers in the main body **302** of the high pressure pump which would lessen its fatigue resistance and reduce its service life. Stress raisers in the plunger **304** do not shorten its life since it is always in compression and stress raisers are of little significance to the life of a component that is always in compression.

Referring to FIG. **4** of the drawings, there is shown a reciprocating compression pump, designated generally as **401**, comprising a main body **402** and a pumped fluid chamber **403.** A plunger **404** is arranged in the pumped fluid chamber **403.** Not shown are the mounting means for the reciprocal compression pump **401**, the motive means for activating plunger **404**, the cylinder cooling facilities and the viscous fluid circulating means. Plunger **404** moves reciprocally in pumped fluid chamber **403** during operation of the pump. A pressure fluid conduit **405** connects pumped fluid chamber **403** to floating piston seal chamber **406** which contains therein a floating piston seal or diaphragm **407** having thereon a scraper-seal **408** (made of conventional packing material) that divides the floating piston means into two sections, seal chamber **406*a*** connecting to pumped fluid chamber **403** through pressure fluid conduit **405** and bore **409** and seal chamber **406b** connecting to viscous fluid circulating means hereinafter described. Bore **409** can enter pumped fluid chamber **403** at any point through main body **402** and is not limited to the position shown. Viscous fluid is pumped into seal chamber **406*b*** by constant pressure pump **410** from viscous fluid reservoir **411.** The viscous fluid sealant travels through pressure conduit **412**, check valve **413** and pressure conduit **414**; essentially constant pressure is maintained by means of pressure regulator **415.** The same pump **410** is used to pump viscous fluid into annular close clearance seal zone **416** via pressure conduit **412**, check valve **413**, pressure conduit **417** and bore **418.** Annular oil seal and scraper rings **419** prevent mixing of the viscous fluid and the pumped fluid. At a point distant from bore **418**, one can, if desired and as shown, have a vent bore **420** attached at its exterior end to a suitable pressure valve **421** activatable in the event of an emergency. This feature is optional and not a necessity. Viscous fluid chamber **422** connects annular close clearance seal zone **416** to viscous fluid reservoir **411** via pressure conduit **423.** Conventional packing material is used in annular seal **424.**

In an embodiment shown in FIG. **4**, the compression stroke of pump **401** involves a movement of plunger **404** from left to right. During the compression stroke plunger **404** will displace pumped fluid from pumped fluid chamber **403** through discharge valve **425** into high pressure pumped fluid receiver **426** through high pressure pumped fluid conduit **427.** During this compression stroke inlet suction valve **428** is closed preventing pumped fluid from escaping via low pressure pumped conduit **429** into low pressure pumped fluid source **430.** At the same time the pressure on the pumped fluid by the compression stroke exerts a pressure on floating piston seal **407**, this imposes a pressure on the viscous fluid in seal chamber **406*b***, closing check valve **413** and pressuring viscous fluid via pressure conduit **417** and bore **418** into annular chamber **431** and through annular close clearance seal zone **416.** The amount of viscous fluid passing through annular close clearance seal zone **416** is low for the reasons discussed in relation to FIG. **1.** The return stroke involves a movement of plunger **404** from right to left. During this return stroke discharge valve **425** is closed, inlet suction valve **428** opens permitting pumped fluid to fill pumped fluid chamber **403** from low pressure pumped fluid source **430** via low pressure pumped fluid conduit **429.** At the same time floating piston seal **407** moves from left to right until it is restrained by the end of floating piston seal chamber **406** due to the viscous fluid sealant pumped into viscous fluid seal chamber **406*b*** by constant pressure pump **410** via pressure conduits **412** and **414** and through check valve **413** to replace the viscous fluid that has passed through annular close clearance zone **416** during the compression stroke of the pumping operation. In this manner pumped fluid is transferred from a low pressure source to a high pressure zone using pumping means that do not have the conventional packing materials in annular close clearance seal zone **416** without excessive wear or significant sealant contamination of the pumped fluid as discussed in relation to FIG. **1.**

From the foregoing description it will be recognized by those familiar with the art that the apparatus according to this invention comprehends a high pressure fluid activating system or pumping system comprising a reciprocating pump having a plunger arranged interior of the pump and adapted to move reciprocally therein in a continual series of compression and return strokes to compress and transfer pumped fluid from pumped fluid chamber to the high pressure pumped fluid receiver or reactor, a close clearance viscous fluid seal zone situated annularly to the plunger and the pump body and separated from the pumped fluid chamber by a floating piston seal, and viscous fluid circulating means. During each compression cycle, pumped fluid at high pressure is expelled from the pumped fluid chamber into the high pressure pump fluid receiver. Simultaneously, the pressure of the pumped fluid exerts a pressure on a floating piston seal that separates the pumped fluid chamber from the viscous fluid sealant side of the seal chamber in which the floating piston seal is situated and from the close clearance viscous fluid seal zone. The pressure exerted on the free floating piston is transmitted to the viscous fluid sealant forcing viscous fluid from the viscous fluid seal chamber into the annular close clearance seal zone and forcing the floating piston seal in a direction opposite to the direction of the plunger. The pressure of the viscous fluid sealant is essentially equivalent to the pressure of the pumped fluid. During the return stroke low pressure pumped fluid is drawn into the pumped fluid chamber and simultaneously the floating piston seal or diaphragm again moves in a direction opposite to the direction of movement of the plunger during a period that is all or just a portion of this stroke. During the compression and return strokes, the viscous fluid circulating means are in continuous operation to maintain an adequate supply of viscous fluid in the high pressure fluid activating system, particularly in the viscous fluid seal chamber and the annular close clearance seal zone. During the return stroke, accompanied by the movement of the floating piston seal, the viscous fluid circulating means pumps viscous fluid sealant into the viscous fluid sealant seal chamber to replace that viscous fluid that was forced through the annular close clearance seal zone during the compression stroke and return stroke. By this manner of operation high pressure can be achieved in a system that does not employ the conventional solid packing materials normally used as sealants around the plunger of a reciprocating pump. The pressure of the system can vary from slightly above atmospheric pressure to a pressure of about 40,000 psig or higher.

The clearance between the plunger and the pump body will vary depending upon the size, alignment capability, the specific viscous fluid sealant selected, and the operating pressure, temperature and speed of the pump. This clearance is sufficient to permit free movement of the plunger in the pump but it is not of such a size as to permit the viscous fluid sealant to flow through in uncontrolled amounts. In view of the teachings disclosed herein, one skilled in the art of constructing high pressure pumps and determining viscous flow rates can readily determine the clearance required for a particular size pump. Among the main reasons that the dimensions of the annular close clearance viscous fluid seal zone cannot be set forth with particularity is that the dimensions will vary not only for the reasons previously stated but also with the size of the pump, and the pumping capacity of the reciprocating compressor pump. Thus, this invention can be used in pumps that vary in size from small laboratory units in which capacity is measured in grams per hour to large commercial units in which capacity is measured in tons. The pressure at which the unit is operated will also vary from slightly above atmospheric to 40,000 psig, or higher.

The apparatus and system described in this specification can be used, for example, in the high pressure polymerization of ethylene. In such processes ethylene is compressed to reaction pressures of from 10,000 psig to 40,000 psig by huge reciprocal compressor pumps and pumped into the polymerization reactors. Often these processes employ additionally, high pressure reciprocating injection pumps used to introduce catalysts and other modifiers to the reaction. The concept disclosed here can be used in both types of these high pressure pumps. The pumps of the instant invention are, of course, used in conjunction with the necessary support equipment in which the reaction is carried out.

What is claimed is:

1. A pumped fluid actuating system comprising, in combination, a reciprocating positive displacement pump having pressure viscous fluid circulating means, pumped fluid chamber, low pressure pumped fluid source means and a high pressure pumped fluid receiver means; a plunger arranged interior of said reciprocating positive displacement pump and adapted to move reciprocally therein in a continual series of compression strokes and return strokes to effect discharge of pumped fluid at a high pressure from said pumped fluid chamber during each of the compression strokes and intake of pumped fluid into said pumped fluid chamber during each of the return strokes; an annular close clearance viscous fluid sealant seal zone annularly surrounding at least a portion of said plunger at an area discrete from the pumped fluid chamber; floating piston seal means separating said pumped fluid chamber from said annular close clearance viscous fluid sealant zone contacting said pumped fluid chamber on one side thereof and responsive to changes in pressure in said pumped fluid chamber and contacting said annular close clearance viscous fluid sealant seal zone situated between the plunger and the pump body on the other side thereof to impose the pumped fluid pressure on the viscous fluid sealant; said pressure viscous fluid circulating means connected to said annular close clearance viscous fluid sealant seal zone to effect substantially constant delivery of viscous fluid sealant thereto; control means operatively connected to said pressure viscous fluid circulating means to effect delivery of viscous fluid sealant into and out of the annular close clearance seal zone.

2. A pumped fluid actuating system as claimed in claim **1**, wherein the floating piston seal means is in contact with and between the main body and plunger of said reciprocating positive displacement pump, and wherein the viscous fluid sealant passage means and check valve means are located in the plunger.

3. A pumped fluid actuating system as claimed in claim **1**, wherein the floating piston seal means and viscous fluid sealant check valve are located in the main body of said reciprocating positive displacement pump.

4. A pumped fluid actuating system as claimed in claim **1**, wherein the floating piston seal means is in contact with and between the main body and plunger of said reciprocating positive displacement pump and the viscous fluid check valve means is located externally thereto.

5. A pumped fluid actuating system as claimed in claim **1**, wherein the floating piston seal means and the viscous fluid check valve means are located externally of said reciprocating positive displacement pump.

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