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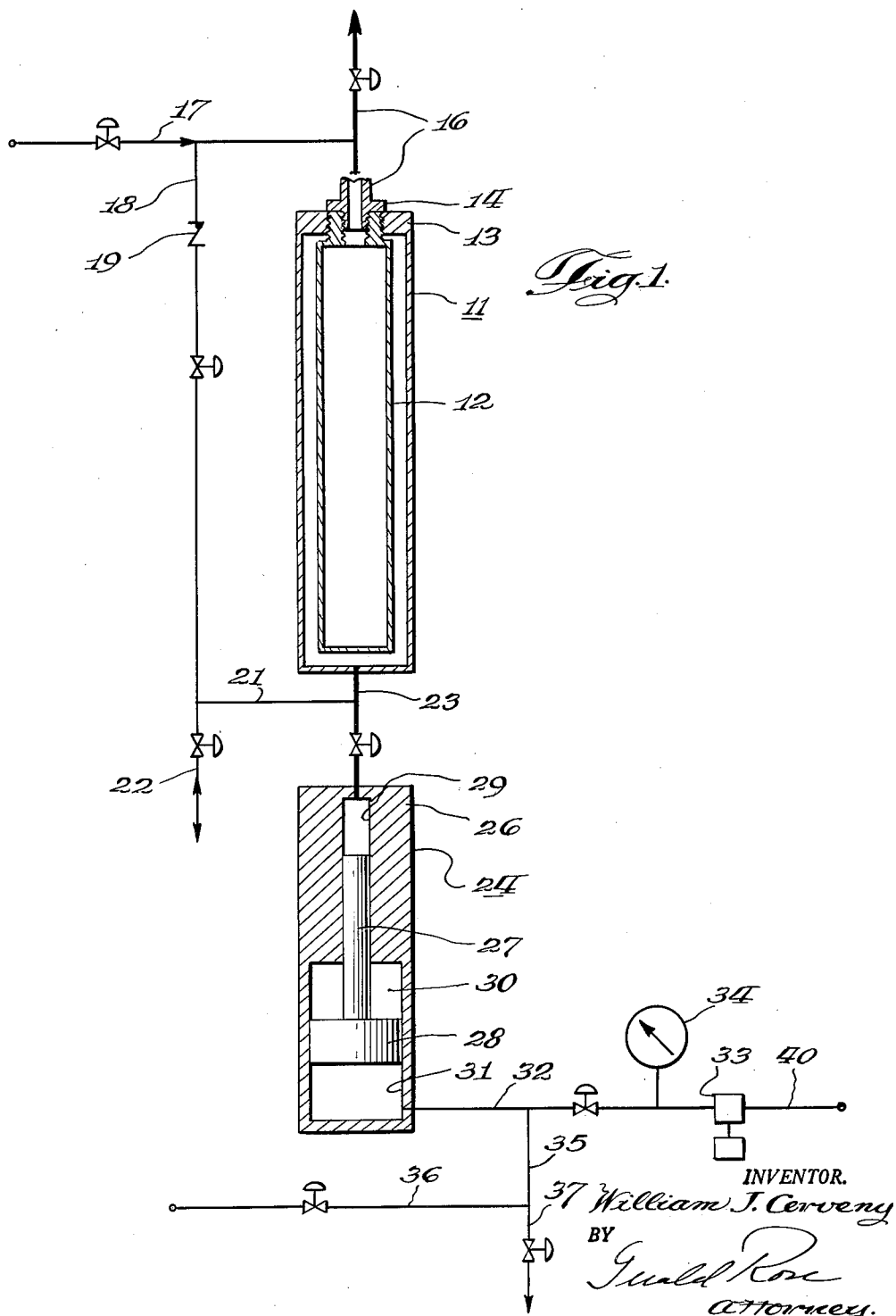
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ULTRA PRESSURE CONTAMINANT-FREE PUMPING MEANS

Filed Aug. 26, 1960

2 Sheets-Sheet 1



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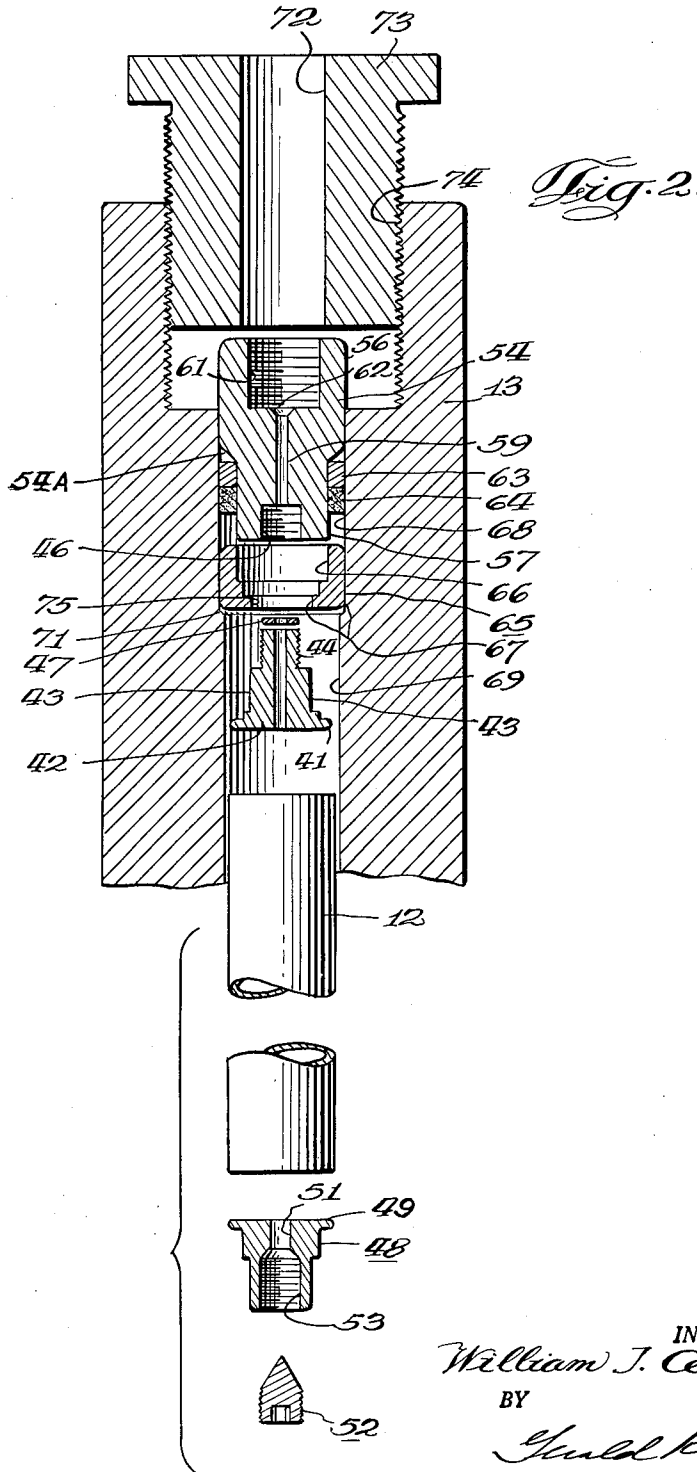
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ULTRA PRESSURE CONTAMINANT-FREE PUMPING MEANS

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This invention relates to means for pumping fluids at ultra high pressures. More particularly, the invention provides means for pumping fluids which means are characterized by freedom from contamination of such fluids by hydraulic fluids or by impurities from packing and lubricating systems.

In processes involving pressures upwards of 50,000 p.s.i. there is a serious problem of pumping reactant fluids. Pumps heretofore available for lower pressures suffer disadvantages associated with inadequate packing, prevalence of leaks, and contamination of fluids being pumped by packing materials, hydraulic fluids, and pump lubricants. These problems are magnified at higher pressures, and are particularly serious in laboratory-scale studies of such processes due to the small quantities of reactants involved and the requirements for contaminant-free reactants.

A primary object of the present invention is to provide a pumping means suitable for ultra high pressures, which pumping means are characterized by freedom from contamination due to lubricants and packing materials. Another object is to provide an ultra pressure pumping system which is particularly suitable for laboratory work. A further object is to provide a pumping system capable of use at pressures of 100,000 p.s.i. and higher. Yet another object is to provide such pumping means which are simple and rugged. Other and more particular objects will be apparent as the description of the invention proceeds.

In accordance with the invention, I provide a pumping means comprising a pressure resistant outer chamber and a deformable chamber of lead or other metallic material disposed within the outer chamber. The deformable chamber contains fluid to be pumped, and is provided with a suitable outlet conduit which communicates through a port in the outer chamber. As to the outer chamber itself, it is equipped with a hydraulic fluid inlet conduit communicating thereto and connected to a suitable hydraulic pump means. Thus by applying hydraulic pressure from the pump means to the outer chamber, the deformable chamber is constricted and thereby pumps fluid therewithin through the outlet conduit. By suitable design it is possible to eliminate all contact between fluid within the deformable chamber and any contaminants.

In a preferred aspect of the invention, a relief valve means is provided between the hydraulic fluid inlet conduit and the outlet conduit. By this device, should the pressure of the fluid being pumped exceed hydraulic fluid pressure when the pump is being filled, the former fluid is released into the hydraulic system thereby preventing rupture of the deformable chamber.

In another aspect, if any pressures much in excess of 50,000 p.s.i. are to be employed, the hydraulic pump system includes an intensifier. Intensifiers, as are well known, consist of a small-diameter piston connected to a large-diameter piston, and the application of hydraulic fluid to a chamber associated with the large-diameter fluid multiplies the pressure in a chamber associated with the small-diameter piston. This latter chamber discharges into the inventive ultra pressure pumping means.

In yet another and highly preferred embodiment, the outer chamber of the ultra high pressure pumping means is provided with a Bridgman closure. The deformable chamber is connected to the plug of such closure, and the

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outlet conduit communicates through the outer chamber to the plug and the deformable inner chamber.

The invention will be more fully described in the ensuing specification which is to be read in conjunction with the attached drawings wherein:

FIGURE 1 schematically depicts an embodiment of the invention in association with an intensifier and a hydraulic pump; and

FIGURE 2 is a sectional view showing an exploded view of a preferred embodiment of the inventive ultra pressure pumping means including a Bridgman closure.

Turning first to FIGURE 1, a pumping means 11 comprises an outer pressure resistant chamber 13 and an inner deformable chamber 12 disposed therewithin. Valved outlet conduit 16 communicates through outer chamber 13 between deformable chamber 12 and an ultra pressure reactor or similar device, not shown.

In the simplified schematic of FIGURE 1 deformable chamber 12 is shown as being threadably coupled to outer chamber 13 and outlet conduit 16, with a shoulder portion 14 serving to confine the deformable metal of chamber 12. However, as will be apparent in the subsequent discussion involving FIGURE 2, this closure is preferably of the Bridgman or floating type.

Hydraulic fluid is transmitted to the region between deformable chamber 12 and outer chamber 13 via valved line 23, which communicates with intensifier 24. Intensifier 24 is provided with a small diameter piston 27 in cylinder 29, and with a large diameter piston 28 in cylinder 31. Thus hydraulic pressure transmitted via valved line 32 to cylinder 31 transmits a pressure to cylinder 29 which is the product of cylinder 31 pressure by the area ratio of piston 28 and piston 27.

If desired, the upper space 30 in cylinder 31 may be filled with a hydraulic fluid, e.g. mineral oil, and connected to a graduated cylinder, not shown, so as to enable direct measurement of the displacement of piston 28, and by computation a measurement of the displacement of hydraulic fluid from cylinder 29 to outer chamber 13.

Cylinder 31 communicates via valved line 32 to a high pressure positive displacement pump 33. Gauge 34 is adapted to read the downstream pressure from pump 33, while valved line 36 is provided to admit fresh supplies of hydraulic fluid, and valved line 37 communicating with line 35 is adapted to drain excess fluid. Alternatively, depending upon the design of pump 33, hydraulic fluid may be admitted via line 40.

In order to avoid the possibility of rupturing deformable chamber 12 should its internal pressure materially exceed its external pressure, a valved line 18 may be provided which has a relief valve 19 therein. Valve 19 may be adjusted to release fluid from chamber 12 via outlet conduit 16 and line 21 when chamber pressure exceeds hydraulic fluid pressure by a predetermined amount, say 25 p.s.i. This may occur when filling chamber 12 with fluid to be pumped.

Hydraulic fluid for cylinder 29 may be admitted via valved line 22.

Turning now to FIGURE 2, an embodiment of the inventive ultra pressure pumping means is shown in partial sectional view.

The pumping means 11 herein incorporates a Bridgman or floating surface type closure suitable for pressures in excess of 100,000 p.s.i.g. This type of closure is improved in accordance with the present invention to accommodate deformable lead tube or chamber 12, which may be $\frac{7}{8}$ inch O.D. made from $\frac{1}{4}$ inch thick lead sheet, soldered into tube form. The outlet end of chamber 12 is soldered to flange 41 of a stainless steel bellows connector 42, which bellows connector is provided with wrench flats 43 and an annular threaded portion 44 which is receivable in a corresponding female threaded por-

tion 46 and is secured in pressure-tight relationship via copper gasket 47.

The bottom end of deformable chamber 12 is similarly soldered to a brass end fitting 48 at flange 49, while the annular hole 51 is sealed by means of an Allen point screw 52 threadably received in tapped hole 53.

The improved Bridgman type closure of pumping means 11 comprises a Bridgman closure plug 54 into which is threadably received stainless steel bellows connector 42. The external cylindrical surfaces 56 and 57 of plug 54, as well as 45° conical surface 54A thereof are machined to a mirror finish; plug 54 is suitably made of type 4140 steel having a Rockwell hardness of about C-42. Plug 54 is provided with an annular hole for port 59 and a threaded fitting 61 including conical portion 62 for effecting sealing with conventional high pressure tubing.

Surrounding necked portion 57 of Bridgman closure 54 are a pair of gaskets 63 and 64, each gasket being rectangular in cross section. Gasket 64 is the low pressure gasket and is made of a soft material such as lead, while gasket 63 is the high pressure gasket and is made of a material somewhat softer than that of plug 54. Suitably, gasket 63 may be made of 18-8 steel, annealed to Rockwell hardness C-10.

Bridgman packing and chamber wrench 65 is made of type 4140 steel having a Rockwell hardness of, say, C-42, and is provided with bore 66 which fits around necked portion 57 of Bridgman closure plug 54. Bore 66 has sufficient depth to permit packing and chamber wrench 65 to compress gaskets 63 and 64 when packing wrench 65 is initially compressed upward by torque on plug 54. Port 67 fits over wrench flats 43 of connector 42 and enables connector 42 to be threaded into tapped hole 46 of closure plug 54 by applying torque to packing wrench 65.

The side wall portions of bore 68 of outer chamber 13 are polished to a mirror finish. Bore 68 necks down to a smaller diameter portion 69 at shoulder 71.

To assemble the device shown in FIGURE 2, chamber connector 42 and end fitting 48 are soldered to lead chamber 12 and bottoms hole 51 is sealed by means of Allen point screw 52. Gaskets 63 and 64 are assembled onto Bridgman closure plug 54, and a suitable outlet conduit, not shown, is passed through port 72 of hold down nut 73. Chamber connector 42 is attached to plug 54 by placing copper gasket 47 atop connector 42, packing and chamber wrench 65 is placed around connector 42, and threaded portion 44 is thereupon screwed into tapped hole 46 of plug 54. Only a light sealing torque need be employed, since the pressure difference across copper gasket 47 is never more than 25 p.s.i.g.

The assembly of plug 54, gaskets 63 and 64, Bridgman packing and chamber wrench 65, gasket 47, connector 42, deformable lead chamber 12, end fitting 48, and Allen point screw 52 is then placed within the outer pressure resistant chamber 13 of pumping means 11.

Hold down nut 73 is then screwed in place in tapped hole 74. Sufficient torque is employed to cause lead gasket 64 to yield and effect initial sealing of the closure. This initial sealing is sufficient to seal the pumping means 11 against a pressure of about 75,000 p.s.i. However, the thrust of lead gasket 64 against steel gasket 63 as the pressure increases above the yield point of steel gasket 63 eventually causes this latter gasket to seat against conical portion 54A of Bridgman closure plug 54, thus forming a tight seal for pressures in excess of 75,000 p.s.i. At such high pressures Bridgman packing and chamber wrench 65 does not abut rigidly against the packing.

When disassembling the Bridgman closure, hold down nut 73 is first removed and the outlet conduit, not shown, is unscrewed from tapped hole 61. A steel bolt is screwed into tapped hole 61, plug 54 is rotated and plug 54 is extracted.

After plug 54 is removed, a second steel bolt is screwed into threaded portion 75 of packing and chamber wrench 65 and the assembly of packing and chamber wrench 65 and the entire chamber, together with gaskets 63 and 64 if not previously removed with plug 54, is extracted.

Returning to FIGURE 1, the mode of operation of the inventive apparatus will be described. After assembling pumping means 11, a reactant fluid to be pumped is admitted to deformable chamber 12 via valved line 17 and is permitted to fill outlet conduit 16. At this time valved line 22 is slightly open. The valved lines 17 and 22 are then closed off.

Hydraulic fluid is admitted into cylinder 31 via valved line 36, while additional hydraulic fluid for cylinder 29 may be admitted via valved line 22 to completely fill cylinder 29, valved line 23, and the space between deformable chamber 12 and pressure resistant outer chamber 13. (If desired, valved line 23 may be connected into chamber 13 via a Bridgman type closure of the type described in FIGURE 2.)

Hydraulic fluid pumping is then commenced, with hydraulic fluid being admitted via line 40 to pump 33 and thence via valved line 32 to cylinder 31 of intensifier 24. Large piston 28 moves upward, causing small piston 27 to move at the same rate but with a pressure equal to hydraulic fluid pressure in cylinder 31 times the area ratio of pistons 28 and 27.

Hydraulic fluid from cylinder 29 is pumped via line 23 to pressure resistant outer chamber 13 of pumping means 11, where it constricts the deformable lead chamber 12 and expels fluid contained within chamber 12 via line 16 to a suitable reactor or other receiving device. After at least a portion of the fluid in chamber 12 has been exhausted, valved line 23 may be blocked off and fresh fluid admitted via line 17, with excess hydraulic fluid being drained via line 22.

Thus I have provided an outstandingly simple, rugged, and useful ultra pressure pumping system suitable for use at pressures on the order of 100,000 p.s.i.g. While the invention has been described in conjunction with a specific embodiment thereof, it will be evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the invention.

I claim:

1. An ultra pressure contaminant-free pumping means featuring absence of contamination of fluid being pumped by hydraulic fluid, comprising:
 - a pressure resistant outer chamber;
 - a deformable metallic chamber within said outer chamber for containing fluid to be pumped;
 - a pump outlet conduit communicating through said outer chamber into said deformable chamber;
 - a hydraulic fluid inlet conduit communicating into the region between said deformable chamber and said outer chamber;
 - pump means for injecting hydraulic fluid into said hydraulic fluid inlet conduit;
 - a conduit communicating with said deformable chamber for injecting therein fluid to be pumped;
 - an additional conduit communicating between said deformable chamber and the region between said deformable chamber and said outer chamber;
 - and valve means in said additional conduit operable only when said fluid to be pumped is being injected into said deformable chamber, said valve means being adapted to prevent flow of hydraulic fluid into said fluid to be pumped but to release fluid from said deformable chamber into the region between said deformable chamber and said outer chamber should the pressure of fluid to be pumped exceed hydraulic fluid pressure when the deformable chamber is being filled.

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2. The pumping means of claim 1 wherein said pumping means has a floating surface type closure including a cylindrical port in said pressure resistant outer chamber, an outer plug member movable in said cylindrical port and having a conically tapered portion and a necked portion, said outer plug member being connected at its outer end to said pump outlet conduit and at its inner end to said deformable chamber, a first relatively soft gasket surrounding said necked portion, a second gasket of intermediate hardness disposed between said conically tapered portion and said first gasket, and means for seal-

ing said relatively soft gasket against said gasket of intermediate hardness.

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