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Buse et al.

[11] **3,811,801**

[45] **May 21, 1974**

[54] **MULTI-PLUNGER RECIPROCATING PUMP**

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[52] **U.S. Cl.** **417/454**, 417/539

[51] **Int. Cl.** **F04b 21/02**

[58] **Field of Search** 417/454, 539, 569, 570

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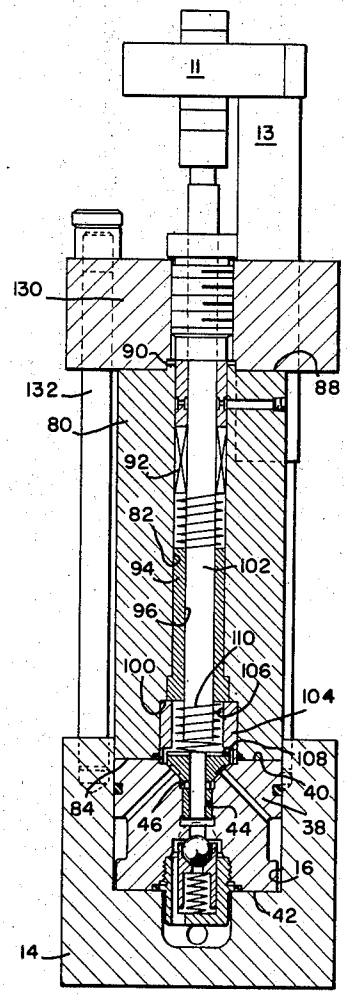
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Attorney, Agent, or Firm—Robert R. Paquin; David W. Tibbott

[57] **ABSTRACT**

A multi-plunger reciprocating pump having a cylinder head with internal manifolding and valving arrangement that permits removal of valves as units from selected pumps, valve bodies with bias porting, and studs in constant tension. A solenoid actuated rod may be added to unload the compression chambers by inhibiting the inlet or suction valve from seating.

6 Claims, 9 Drawing Figures



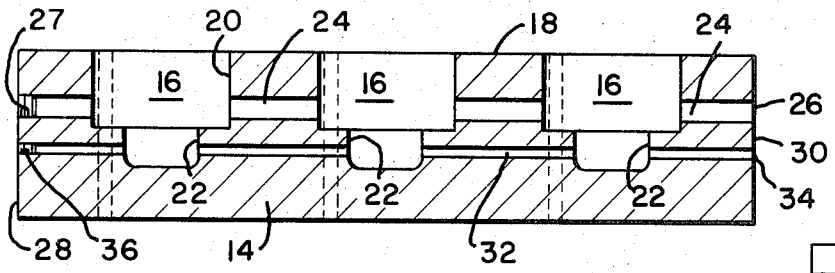


FIG. 2

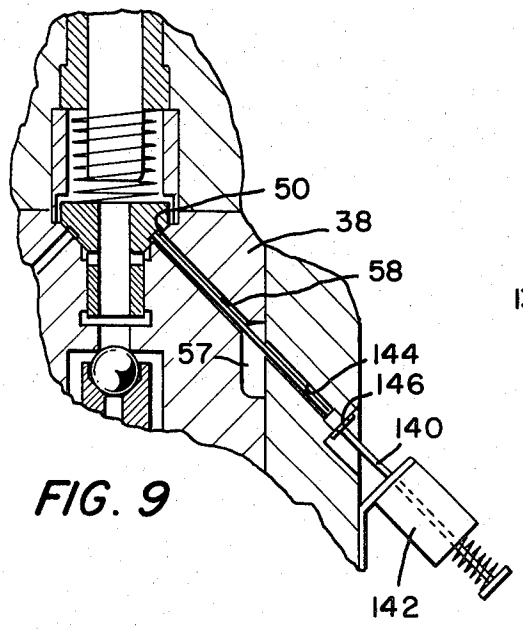


FIG. 9

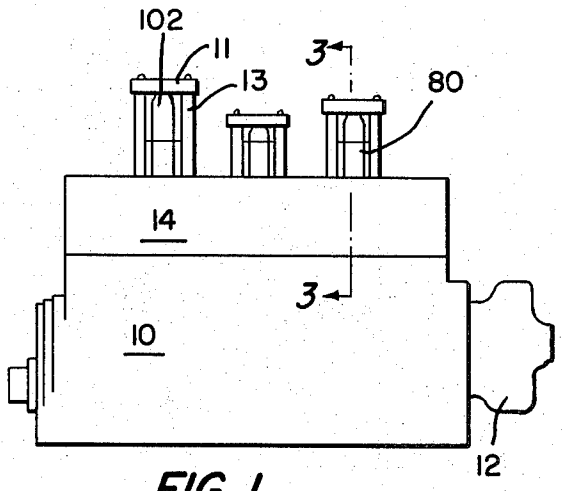


FIG. 1

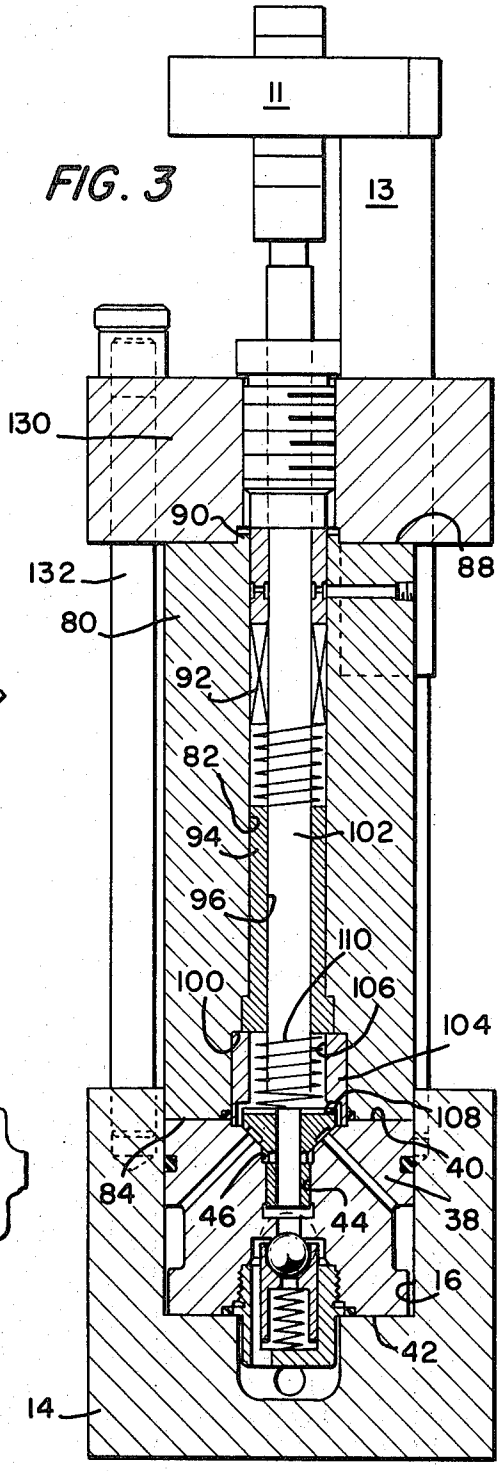
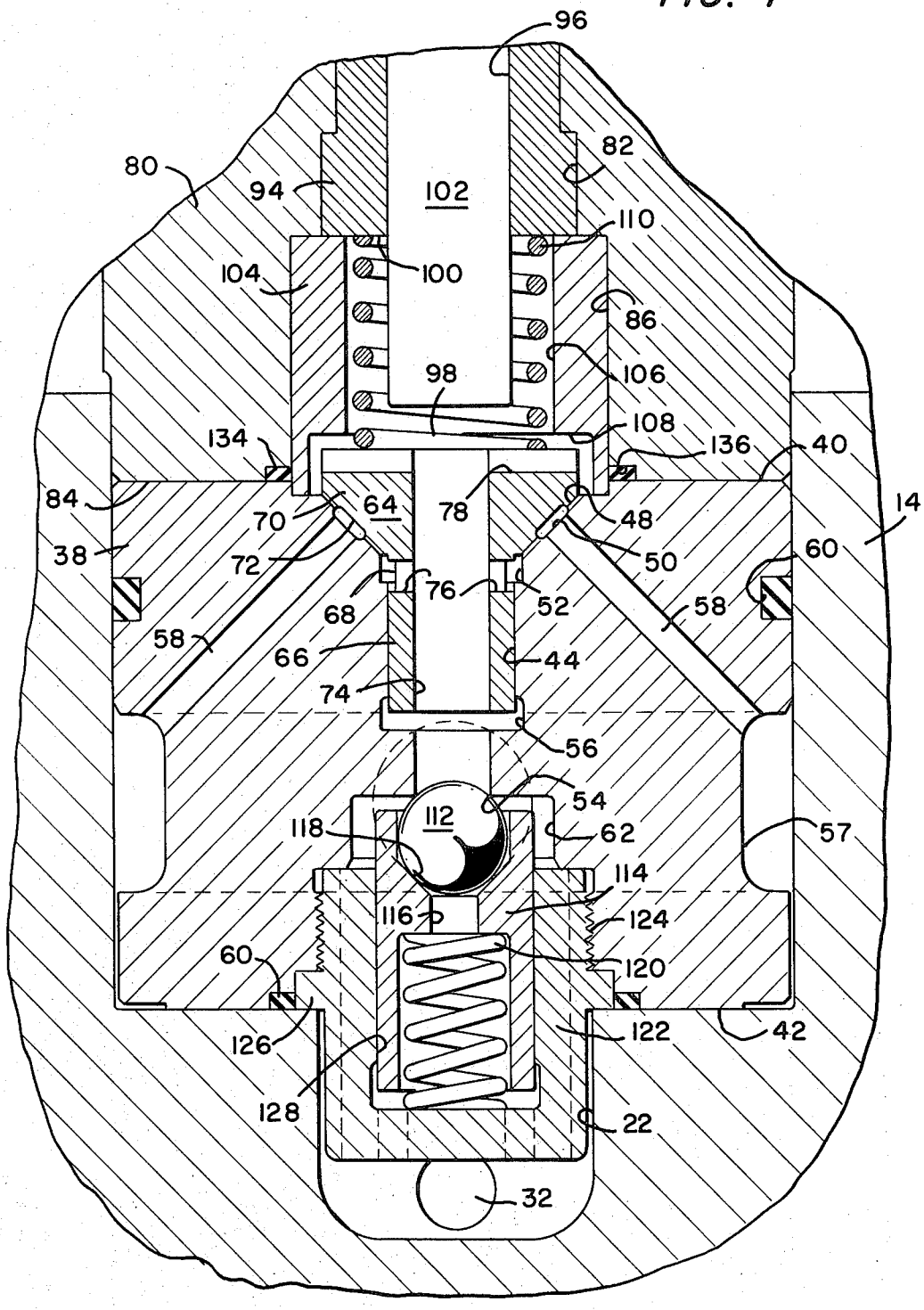


FIG. 3

FIG. 4


96
80
94
102
82
110
104
100
86
106
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108
134
136
40
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64
78
48
14
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68
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58
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122
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128
22
32

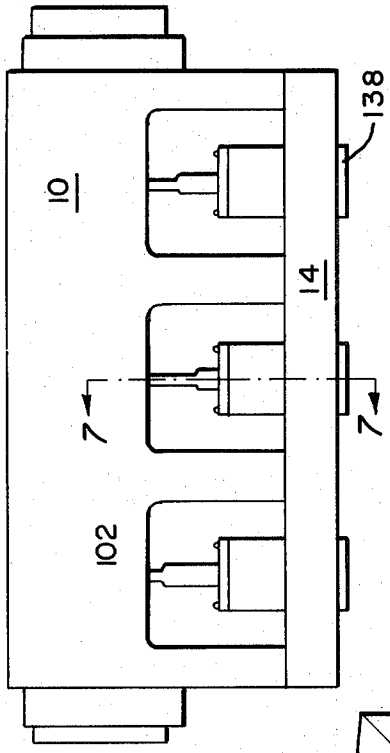


FIG. 5

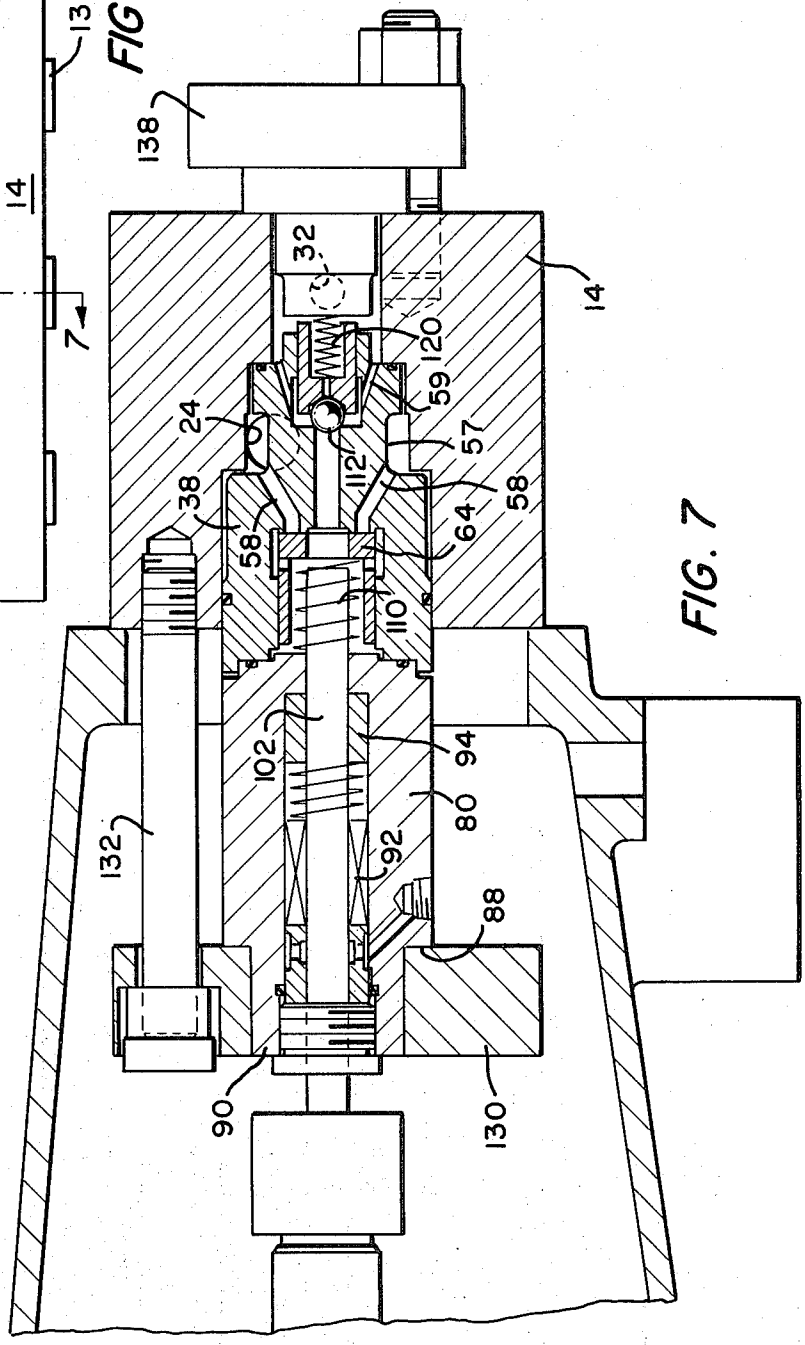


FIG. 7

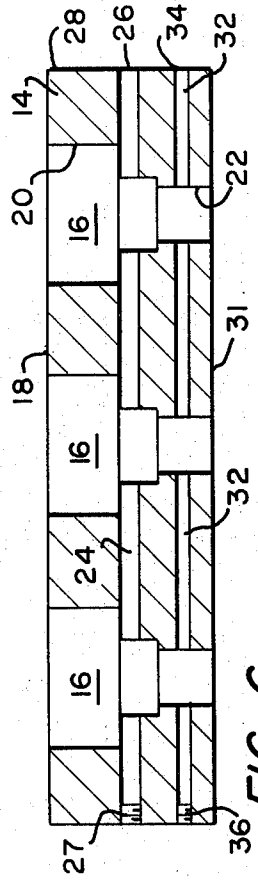


FIG. 6

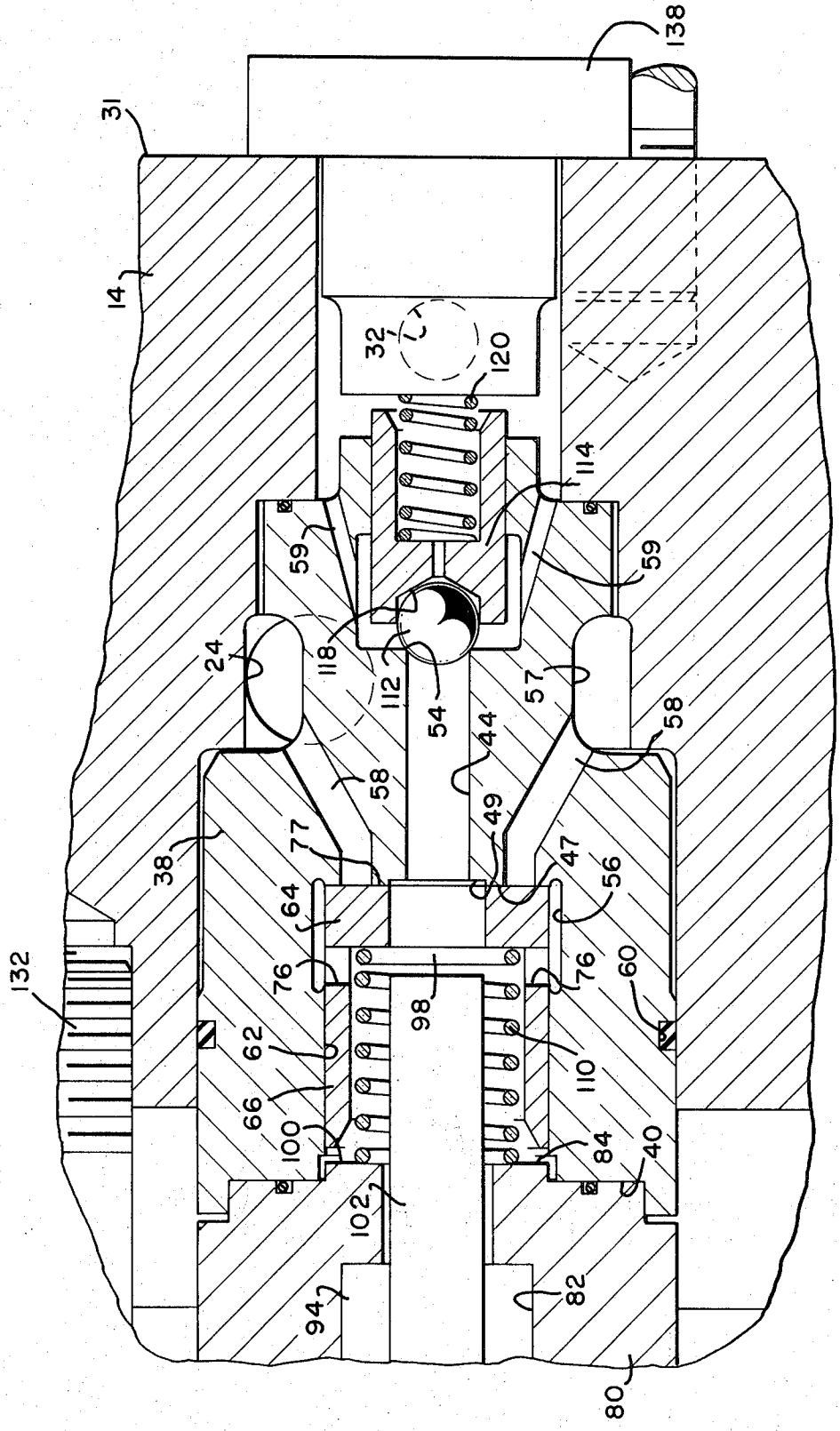

138
31
14
32
120
114
59
59
24
118
112
54
57
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44
58
49
77
38
47
56
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76
76
60
132
98
62
110
66
100
84
40
102
94
82
80

FIG. 8

MULTI-PLUNGER RECIPROCATING PUMP

DESCRIPTION OF THE INVENTION

This invention relates to reciprocating pumps. More particularly the invention relates to a multi-plunger in-line reciprocating pump which provides economy in manufacture and servicing by internal manifolding and valving arrangement within a cylinder head permitting removal of the suction and exhaust valves as units from selected pumps, and which also includes valve bodies with bias porting providing increased thickness of walls separating high and low pressure areas, and studs in constant tension minimizing stress reversal to reduce this cause of fatigue failure.

Among the disadvantages of high pressure pumps subject to the continuous pulsation and shock inherent in reciprocating pumps is the external manifolding which results in greater assembly cost and more complicated disassembly to the service a single pump unit. In these pumps the inlet ports have generally been holes parallel to discharge ports and subject to failure at great pressure differentials. The studs that hold these assemblies together have been subjected to cyclical stresses with each stroke of the piston, a condition which results in premature failure due to fatigue.

These problems have been resolved in my invention through the use of a cylinder head with internal manifolding and valving arrangement, bias porting of the valve bodies, and an arrangement of the stuffing box, valve bodies and cylinder head which maintains the studs under a relatively constant tension governed by the outlet pressure of the pump.

It is the object of this invention to provide a multi-plunger in-line reciprocating pump with a novel arrangement that affords economy in manufacture and servicing.

Another object is to increase the thickness of the walls separating high and low pressure areas in the valve body.

Another object is to minimize stress reversal in the studs that hold the stuffing box, valve body and cylinder head together.

Still another object is to provide the inlet valve with an integral guide and/or with bias seating to improve sealing.

A further object is to arrange inlet and discharge valves entirely within the valve body to permit servicing them as a subassembly. Another object is to arrange the stuffing box and plunger in a subassembly for convenience in removal and servicing. Yet another object is to provide an unloading means to automatically reduce the pressure within the pump when it is shut off.

A better understanding of the invention will be had by referring to the following description and drawings in which:

FIG. 1 is an elevational view of a vertical in-line pump with three pistons;

FIG. 2 is an elevational cross-section of the cylinder head in FIG. 1;

FIG. 3 is an elevational cross-section of the pump of FIG. 1 taken along line 3—3 showing the piston and valving arrangement;

FIG. 4 is an enlarged fragmentary view of the valves in FIG. 3;

FIG. 5 is a plan view of a horizontal in-line pump with three pistons;

FIG. 6 is a plan view in cross-section of the cylinder head in FIG. 5;

FIG. 7 is a plan cross-section of the pump in FIG. 5 taken along line 7—7 showing the piston and valving arrangement;

FIG. 8 is an enlarged fragmentary view of the valves in FIG. 7; and

FIG. 9 is a partial section of a pressure unloader.

In the drawings similar reference characters refer to corresponding parts in the several views. Referring to FIG. 1 a multi-plunger reciprocating pump **10** is seen to comprise a drive unit **12** and a cylinder head **14.** FIG. 2 shows that the cylinder head **14** has a plurality of chambers **16,** each opening through a common first face **18** of the head **14** and having a large diameter portion **20** and a smaller diameter portion **22.** An inlet manifold **24** communicates with the larger diameter portions **20** and terminates in inlet ports **26** at second face **28** and third face **30** of the cylinder head. A discharge manifold **32** similarly communicates with the smaller diameter portions **22** of the chambers **16** and terminates in outlet ports **34** in faces **28** and **30.** The manifolds **24, 32** are each generally sealed at one of the faces **28, 30** by an inlet port plug **27** and an outlet port plug **36.**

FIG. 3 is an elevational cross-section showing the cylindrical valve body **38** positioned in one of the chambers **16** of the cylinder head **14.** The valve body **38** has an inlet face **40** and a discharge face **42** which bears against a step in the cylinder head. As shown in FIG. **5,** the valve body **38** has a stepped bore **44,** which includes a bore step **46,** a conical valve seat **48,** and a valve seat annulus **50.** The bore **44** further comprises an enlarged diameter portion **52,** a discharge valve seat **54,** a chamber or recess **56,** and an outlet valve cavity **62.** The valve body **38** has a suction annulus **57** in the outer periphery and inlet passages **58** providing communication between the suction annulus **57** and the bore **44.** O-ring annuli **60** are provided in the cylindrical periphery and the discharge face **42** of the cylindrical valve body.

A funnel-shaped inlet valve **64** is slidably located at the inlet end of the valve body bore **44.** It comprises a cylindrical portion **66** having a first annular recess **68,** and a conical portion **70** having a second annular recess **72.** An inlet valve bore **74** communicates with the first annular recess through ports **76,** and the wide end of the conical portion is provided with inlet valve slots **78.** When the valve is in the closed position, the second annular recess **72** mates with the valve seat annulus **50** of the valve body.

A stuffing box **80,** having a step bore **82,** mates along a first face **84** with the valve body inlet face **40.** At the first face the bore has an enlarged diameter defining a chamber and step for a valve stop **104.** A second face **88** of the stuffing box has an annular projection **90** which locates gland ring **130.** Within the stuffing box bore **82** are packing **92** and a sleeve **94.** The sleeve bore **96** partially defines a cylinder or compression chamber **98.** An end face of the sleeve **100** provides a bearing surface for the inlet valve spring **110** and the valve stop **104.** A piston **102** is slidably and coaxially positioned in the cylinder **98.**

The cylindrical stop **104** comprises a stepped bore **106** which retains inlet valve spring **110** and a step face **108** which provides a bearing surface that limits the

axial movement of the inlet valve **64** during the suction stroke of the piston.

A discharge valve **112** rests in the closed position on the valve seat **54,** and is guided by discharge valve plug **114.** The plug has a stepped bore **116** which includes discharge valve retainer cup **118** at one end and a cavity for the discharge valve spring **120** at the other end. The plug is slidably positioned in the discharge valve spring retainer **122** and is coaxial with it and all the cylindrical elements described hereto.

The discharge valve spring retainer **122** has a threaded diameter **124** which engages the outlet valve cavity of the valve body **62.** A sealing flange **126** partially defines an O-ring recess with the annulus **60** in the valve body discharge face **42.** Studs **132** threadedly engage cylinder head **14** and gland ring **130** thereby compressively binding the gland ring, stuffing box, valve body and cylinder head.

An unloader system may be provided as shown in FIG. **9** comprising an unloader rod **140,** actuated by a solenoid to control diaphragm cylinder **142** to move axially through an unloader port **144** in the cylinder head, the suction annulus **57,** and one of the inlet passages **58** to valve seat annulus **50.** A seal **146** in the unloader port **144** prevents leakage to the atmosphere.

In the horizontal modification shown in FIGS. **5** through **8,** the cylinder head chambers **16** also communicate with a fourth face **31** of the cylinder head as shown in FIG. **6.** This opening is sealed with a cylinder head plug **138** which has an O-ring annulus in the surface that interfaces with the fourth face of the cylinder head. Instead of a funnel configuration, the cylindrical valve body has a flat inlet valve seat **47** and a valve seat recess **49** which provides clearance and reduces the amount of lapping that is required. It is further provided with discharge passages **59** which are biased to increase material thickness in the guide portion and facilitate machining. The discharge valve spring retainers described in the vertical pump is eliminated. The inlet valve is cylindrical, its body serving as a guide, and has a flat seal **77.** As the valve stop has been eliminated, face **84** of the stuffing box serves as a spring abutment and inlet valve stop.

OPERATION OF THE INVENTION

In the operation of the pump of FIGS. **1** through **4,** when the driving means retracts piston **102** in the stuffing box **80,** the volumetric increase of compression chamber **98,** decreases the pressure therein sufficiently to overcome the force of the inlet valve spring **110,** so that inlet valve **64** moves axially toward the piston until it bears against step face **108** of valve stop **104.** Fluid is drawn into the system through inlet port **26,** inlet manifold **24,** and the annular chamber defined by the annular recess **57** in cylinder valve body **38.** From there the fluid moves through inlet passages **58** around the conical surface **70** of the inlet valve **64.** Part of the fluid flows towards the second annular recess **52** in the valve through the inlet valve ports **76** to fill the inlet valve bore **74,** while a greater volume is diverted around the conical portion **70** through the slots **78** in the end face of the inlet valve and fills the compression chamber **98.** As the inlet pressure is lower than the pressure in the discharge manifold **32,** discharge valve **112** is urged to its closed position against discharge valve seat **54** by the greater fluid pressure in the discharge manifold and by the discharge valve spring. The spring urges the discharge valve plug **114** axially toward the piston **102** within the stepped bore **128** of the discharge valve spring retainer **122.** As the discharge valve **112** is carried in the discharge valve retainer cup **118** of the discharge valve plug **114,** proper seating of the valve on discharge valve seat **54** is assured.

During the discharge stroke the piston **102** is driven into the compression chamber **98** guided by stuffing box sleeve **94.** Compression of the fluid impels inlet valve **64** axially. The cylindrical portion **66** is guided by the bore **44** of cylinder valve body **38.** The conical portion **70** mates with conical valve seat **48,** closing the inlet passages **58.** Although the inlet manifold **24** is sealed off from this piston during the compression stroke the intake fluid may flow around annular recess **57** in the cylinder valve body **38** and be diverted to another pump in-line and undergoing suction stroke. When the fluid pressure in the compression chamber **98** exceeds the combined force of the fluid in the discharge manifold **32** and the discharge valve spring **120** upon the discharge valve **112,** the discharge valve plug **114** will move axially away from the piston **102** carrying the discharge valve with it and thereby allowing the fluid in the compression chamber **98** to discharge through the discharge manifold **32.**

O-rings effectively seal the fluid from leakage at the interfaces of the various components, and packing **92** prevents leakage of the fluid from the compression chamber **98** past the piston. A gland ring **130** and studs **132** compressively mate the stuffing box, the cylinder head, and the cylinder valve body. Because the studs **132** are constantly in tension, fatigue failure due to cyclical reversal of stress is avoided, and therefor smaller diameter studs may be used than with conventional pumps. At the beginning of the intake stroke inlet fluid pressure upon inlet valve **64** is distributed evenly around the conical portion **70** because second annular recess **72** and conjoining valve seat annulus **50** provide communication between inlet passages **58.** This prevents mis-alignment and uneven wear of the inlet valve. For servicing the stuffing box and piston may be removed as a unit and worked on at a bench. Similarly the valves and valve body may be taken out as a unit to be worked upon separately. Leaving the cylinder head in place thereby avoids complicated disconnecting of manifolds.

When the pump is shut off for emergency or operational reasons the pressure built up in compression chambers **98** will continue to exhaust fluid into the discharge manifold until the internal pressure is reduced to that at outlet port **30.** Where it is necessary to provide for immediate dumping of this pressure, the unloading system projects an unloader rod **140** a predetermined distance beyond valve seat annulus **50** thereby preventing the seating of inlet valve **64.** As communication between compression chamber **98** and suction annulus **57** is open, the internal pressure is prevented from rising above inlet pressure. During normal operation of the pump, solenoid **142** retracts rod **140** sufficiently to allow proper seating and sealing of valve **64.** At all times seal **146** prevents leakage of the fluid to atmosphere through the cylinder head unloader port **144.**

In reciprocating pumps with conventional manifolding, the studs join the stuffing box to a working barrel which contains the compression chamber. Thus, the force transmitted through the box to the gland and

studs fluctuates as the pressure in accordance with the chambers fluctuates. In this invention, the force transmitted to the gland **130** through the stuffing box **80** is the relatively constant force of the discharge fluid working to separate valve body block **38** from cylinder head **14.** This force places studs **132** in fairly constant tension, reducing the cyclical reversals that cause fatigue failure and thereby permitting the use of smaller diameter studs.

In the horizontal modification of the pump the cylinder head plug **138** may be removed providing ready access to the discharge valve and valve plug assembly. The operation of this modification differs in the fluid flow within the valve body because of the modified inlet valve and discharge passage structure. On the intake stroke of the piston the inlet valve is opened by the pressure differential between the inlet manifold **24** and compression chamber **98.** The cylindrical portion of the valve **66** guides its axial movement in the enlarged diameter **62** of the valve body. Bearing face **100** in the stuffing box which serves as an abutment surface for the inlet valve spring also serves as a valve stop in this modification. With the valve in the open position inlet fluid flows through inlet passages **58** partially diverting around inlet valve seat **77** to the inlet valve bore **74** and to valve body bore **44,** and partially through annular recess **56** in the valve body through inlet valve ports **76** to the compression chamber **98.** During the compression stroke of the piston the inlet valve is axially moved to close upon the flat valve seat **47** in the valve body. The valve seat recess **49** and the recess **56** prevent binding of the valve in its closed position. The compressed fluid is forced through bore **44,** opening discharge valve **112,** and flows through discharge passages **59** to the discharge manifold **32.**

From the foregoing description and the drawings, it can be seen that the objects of the invention have been achieved. While the preferred embodiments have been described with particularity, the details of construction presented here should not be regarded as limiting the scope of the claims which follow.

We claim:

1. A reciprocating pump comprising

1. a cylinder head having
   a. first, second, and third faces:
   b. a plurality of cylindrical chambers with
      1. a larger diameter portion communicating with and axially normal to the first face, and
      2. a smaller diameter portion coaxial with the larger diameter portion;
   c. an inlet manifold serially connecting the larger diameter portions of the chambers; and
   d. a discharge manifold providing communication between the smaller diameter portions; and for each said chamber
2. a cylindrical valve body coaxially positioned in the chamber having
   a. an inlet face and a discharge face;
   b. a bore coaxial with the chamber terminating in a conical valve seat at the inlet face and an enlarged diameter at the discharge face, and having a second valve seat where the bore diameter changes;
   c. an annular recess aligned with the inlet manifold; and
   d. a plurality of inlet passages communicating between the annular recess and the conical valve seat;
3. a funnel shaped inlet valve having
   a. a cylindrical portion dimensioned to permit reciprocating movement of the inlet valve in the valve body bore;
   b. a conical portion with an annular recess that conjoins with the inlet passages of the conical valve seat when the inlet valve is seated;
   c. a bore coaxial with the valve body bore;
   d. a plurality of ports communicating between the bore and the cylindrical face of the inlet valve; and
   e. at least one slot in the base of the cone;
4. a stuffing box with first and second faces adapted to matably bear the first face against the inlet face of the valve body and having
   a. a stepped bore extending between the first face and the second face, coaxial with the cylinder head chamber and an enlarged diameter at the first face; and
   b. a sleeve positioned against a step in the bore defining a compression chamber coaxial with the bore;
5. a piston adapted to reciprocate axially in the stuffing box;
6. packing means adapted to prevent fluid leakage between the piston and stuffing box at the second face of the stuffing box;
7. a cylindrical inlet valve stop coaxial with and positioned within the larger diameter bore of the stuffing box having a stepped bore adapted to receive the inlet valve;
8. a discharge valve; and
9. a cylindrical discharge valve plug slidably positioned in the valve body having a stepped bore adapted to receive the discharge valve; whereby a reciprocating motion imparted to a piston when the inlet manifold is connected to an external source of fluid will produce axial motion of the inlet valve and discharge valve plug in the same direction and seating of the inlet and the discharge valve in alternate strokes, thereby resulting in fluid flow from the inlet to the outlet manifold and permitting flow of inlet fluid through said annular recess around the valve body of a piston in the discharge stroke to the valve body of a piston in the suction stroke.

2. The reciprocating pump of claim **1** wherein the inlet and outlet manifolds each have ports at second and third faces of the cylinder head, and the pump further comprises plug means whereby an inlet and an outlet port may be selectively sealed.

3. The reciprocating pump of claim **2** further comprising

an inlet valve spring positioned in the valve stop, bearing against the stuffing box sleeve and inlet valve so as to urge the inlet valve to seat in the closed position on its conical portion,

a discharge valve spring, and

a cylindrical discharge valve spring retainer having a stepped bore coaxial with the valve body bore and positioned in the enlarged diameter of the valve body bore with the cylindrical discharge valve plug slidably positioned in the spring retainer bore and the discharge valve spring positioned in the valve

plug bore urging the plug and discharge valve to the closed position in which the discharge valve blocks the bore,

whereby both valves are closed when the pump is not operating.

4. The reciprocating pump of claim **3,** further comprising O-rings and a plurality of annuli in the cylindrical valve body adapted to receive O-rings in the peripheral surface and inlet and discharge faces thereby sealing the suction manifold from the inlet and discharge faces of the valve body.

5. The pump of claim **4,** further comprising gland ring and stud means compressively mating said stuffing box and valve block.

6. A reciprocating pump according to claim **5,** wherein said gland ring and valve block are at opposite ends of said stuffing box, and said stud means are external to said stuffing box and connected at opposite ends to said gland ring and said valve block.

* * * * *