

[54] **RECIPROCATING PISTON PUMP**

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137/512.2, 512.3, 512.5

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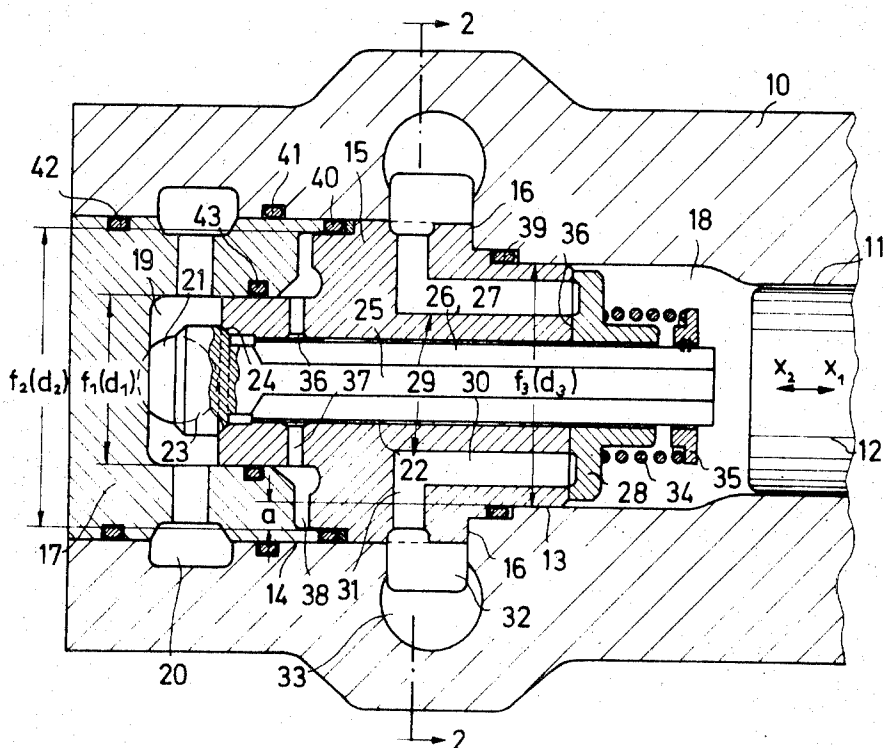
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[57] **ABSTRACT**

A reciprocating piston pump having a pump housing with an axial bore of two different diameters separated by an annular shoulder and a cylinder at the end of the narrower part of the bore in which a piston is movable,

and a valve housing inserted into the bore and having an annular shoulder which is formed between an enlarged part and narrower part of the valve housing and is pressed against the shoulder of the pump housing. For preventing varying stresses from being exerted especially upon this shoulder area of the valve housing and for making the latter of a very compact size, the invention provides the pump chamber between the piston and one end of the valve housing and containing a suction valve for opening and closing suction channels in the valve housing, a pressure-valve chamber of a smaller diameter than that of the pump chamber axially beyond the other end of the valve housing, a flow channel extending longitudinally through the valve housing from the pump chamber to the pressure-valve chamber and terminating at this other end in a valve seat for the pressure valve the valve stem of which extends through the flow channel, and a compensating chamber which communicates through transverse channels with the flow channel and is formed between the other end of the enlarged part of the valve housing and the rim part of a cup-shaped plug which is inserted into and closes the open end of the wider part of the bore in the pump housing, while the bottom wall and the adjacent inner wall parts of the plug together with the end wall of the narrowest part of the valve housing define the pressure-valve chamber. Both valves are adapted to be closed at the respective strokes of the piston by a single spring one end of which acts upon the suction valve and the other end upon a spring bearing which is mounted on the end of the valve shaft in the pump chamber.

14 Claims, 2 Drawing Figures



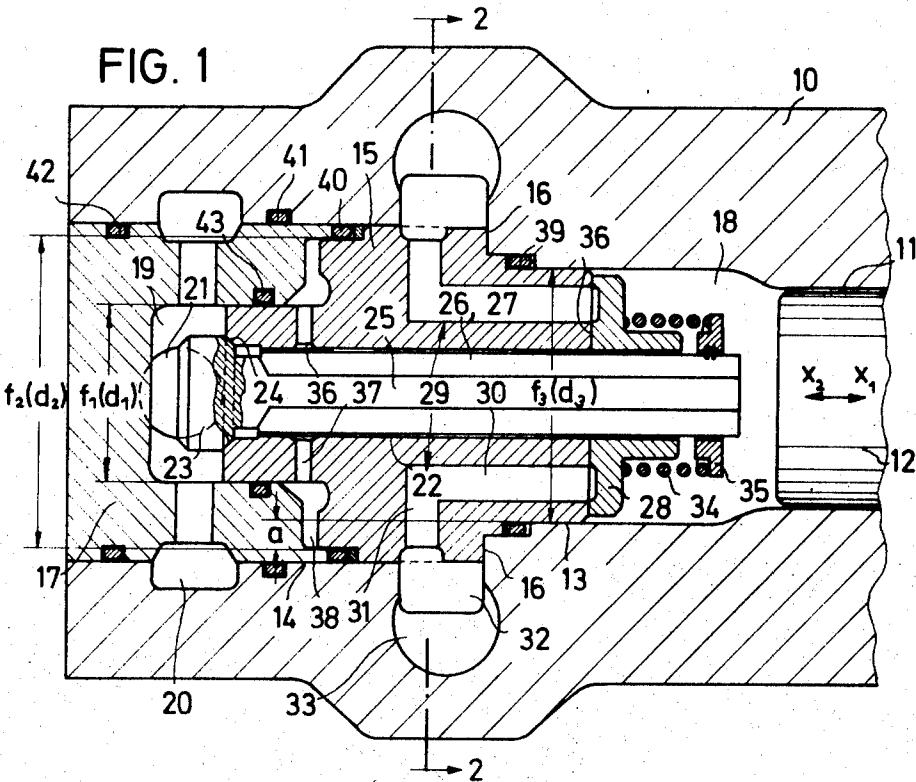
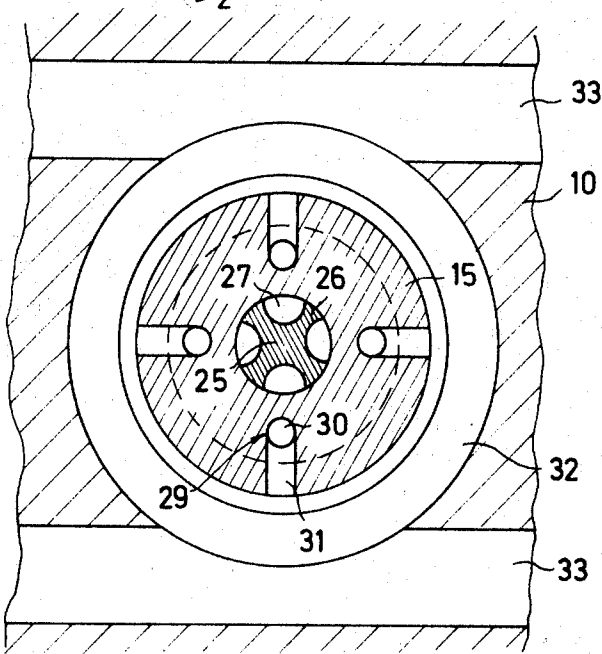


FIG. 2



RECIPROCATING PISTON PUMP

The present invention relates to a reciprocating piston pump, especially for high pressures, which comprises a pump chamber, a valve housing which is inserted into the pump housing and is axially supported thereon, a suction valve for controlling a suction channel, a pressure valve within or on the valve housing, a valve chamber for the pressure valve which is located behind the latter, as seen in the direction of flow of the pressure medium through the pump, and behind the end of the valve housing opposite to the end facing the pump chamber, and a flow channel which connects the pump chamber and the pressure-valve chamber and is controlled by the pressure valve.

Due to the variation of the pressures alternating at every reversal of the piston stroke, such a valve housing which is inserted into the pump housing is subjected to very high stresses which may cause the valve housing to crack and to be prematurely destroyed. This danger increases in accordance with the height of the pressure produced by the pump and the speed of its operation, and it occurs especially at such points where a transverse bore in the valve housing joins a longitudinal bore, for example, the intake bore of the medium to be pumped, or where sudden angular changes occur in the outer diameters of the valve housing. If the valve housing is supported, for example, at such or similar endangered points in the axial direction on the pump housing in order to take up the alternating forces acting upon the valve housing, the alternating stresses occurring at these points may become so high as to exceed the breaking limits of the material.

It is the principal object of the present invention to eliminate this danger of excessive stresses acting upon the valve housing of a reciprocating piston pump or upon other housings which are subjected to similar stresses which are caused by alternating forces which are changing in direction and strength.

An important feature of the invention therefore consists in providing the pump with a compensating chamber in which the pressure medium acts upon the valve housing in the same general direction as the pressure medium which is located in the valve chamber of the pressure valve and in the opposite direction to the pressure medium which is contained in the pump chamber and acts upon the valve housing, so that during the suction and compression strokes of the pump the valve housing will be pressed with substantially the same force and in the same direction against an axial supporting surface of the pump housing.

According to one preferred embodiment of the invention, this purpose is attained by providing the pump housing with an axial bore or channel, one end part of which forms the cylinder for the reciprocating piston and the pump chamber, while the other end part has a larger outer size so as to form an intermediate shoulder. Into this bore the valve housing is inserted from the wider end. A central part of this valve housing is likewise made of a larger outer size and its end facing the pump chamber forms a shoulder which abuts against the first mentioned shoulder in the pump housing, while the other end of this enlarged part forms one end wall of a compensating chamber which communicates through a channel with the pump chamber. The wider end of the bore in the pump housing is closed by a cup-shaped plug member the inner recess of which receives

the reduced other end of the valve housing which also forms the valve seat for the pressure valve, while between this other end of the valve housing and the bottom of the recess in the plug member the valve chamber for the pressure valve is formed. The opposite end wall of the compensating chamber is formed by the inner end surface of the plug member. The effective end surfaces of the valve housing which are acted upon by the pressure medium are therefore formed by the parts of the valve housing directly facing the pump chamber, the annular end surface of the enlarged part of the valve housing which forms one wall of the compensating chamber, and the end parts of the valve housing facing the valve chamber of the pressure valve in the recess in the plug member. According to the invention, these effective end surfaces are made of such dimensions that the difference in size between the effective end surfaces of the valve housing upon which the pressure medium acts in one axial direction within the pressure-valve chamber and in the compensating chamber and in the opposite axial direction within the pump chamber is equal or substantially equal to the effective size of the end surface of the valve housing facing the pressure-valve chamber.

The result of these features is as follows:

During the suction stroke of the piston when the suction valve is opened and the pressure valve is closed so that the pump chamber and the valve chamber of the pressure valve are closed relative to each other, a suction pressure prevails in the pump chamber and also in the compensating chamber, while in the pressure-valve chamber a high pressure prevails. The valve housing is therefore pressed in the direction toward the pump chamber, that is, in the direction of the suction stroke, and the shoulder on the valve housing is pressed against the corresponding shoulder of the pump housing with an axial force which is exerted by the high pressure of the pressure medium upon the effective end surface of the valve housing in the pressure-valve chamber. The strength of the pressures which actually occur during the suction strokes in the pump chamber and in the compensating chamber are generally of no particular consequence.

During the compression stroke of the piston, however, when the suction valve is closed and the pressure valve is opened, the axial pressure which is exerted upon the valve housing in the pressure-valve chamber is opposed by the same pressure which acts in the pump chamber upon the other end of the valve housing. However, this pressure in the pressure-valve chamber is at the same time increased by the pressure which acts in the same direction in the compensating chamber upon the end wall thereof which is formed by the enlarged central part of the valve housing. The effective pressure during the compression strokes is therefore the difference in the pressure acting in one direction upon the valve housing within the compensating chamber and the pressure acting in the opposite direction in the pump chamber. Since according to the invention this pressure difference is equal or substantially equal in strength and direction to the axial pressure which is exerted by the pressure medium upon the valve housing during the suction strokes of the piston, no or at least no substantial change of pressure will ever occur on the abutting shoulders of the valve housing and pump housing and alternating stresses upon this part of the valve housing will thus be fully or practically avoided.

This relief of the shoulder of the valve housing from alternating pressures is especially of importance if this shoulder is located adjacent to transverse or longitudinal channels, for example, the transverse and longitudinal intake channels which extend from the intake line in the pump housing through the valve housing to the suction valve for supplying the medium to be pumped into the pump chamber during the suction strokes of the piston.

It is a further object of the invention to provide a valve unit which is designed so as to take up a very small space. For attaining this object, the invention provides that the channel which connects the pump chamber with the pressure-valve chamber and which is controlled by the pressure valve extends substantially centrally in the axial direction through the valve housing, that the intake or suction channel means which preferably consists of interconnected transverse channels and longitudinal channels are located around the main central channel, and that the suction valve preferably consists of an annular valve which projects into the pump chamber.

According to a very advantageous embodiment of the invention, both valves, that is, the pressure valve and the suction valve, extend coaxially to each other on the valve housing and both valves are closed in opposite directions to each other during the respective strokes of the piston by means of a common valve spring. One of these valves, that is in this case the pressure valve, is for this purpose preferably secured to one end of a valve shaft which extends through the central channel of the valve housing and through the other valve, that is, in this case the annular suction valve and the valve spring thereon, while the other end of this valve shaft carries a bearing member for the other end of the valve spring. The actual channel means through which the pressure medium flows during the compression strokes from the pump chamber to the pressure-valve chamber preferably consist of longitudinal grooves which are provided in the shaft of the pressure valve which is slidable along the wall of the central channel. The valve structure according to the invention therefore has not only the advantage of being very compact, but also of only requiring a single valve spring for both valves.

These and additional features and advantages of the present invention will become further apparent from the following detailed description thereof which is to be read with reference to the accompanying drawings, in which-

FIG. 1 shows a central longitudinal section of a part of a reciprocating pump containing a valve housing according to the invention; while

FIG. 2 shows a cross section which is taken along the line 2 — 2 in FIG. 1.

As illustrated in the drawings, the pump housing 10 is provided with a bore 11 forming the cylinder in which a plunger piston 12 is movable back and forth so as first to carry out a suction stroke in the direction of the arrow x_1 and then a compression stroke in the direction of the arrow x_2 . This bore 11 terminates in the direction of the arrow x_2 into a larger bore 13 and the latter into a still larger bore 14. From the left of FIG. 1, a valve housing 15 the outer diameters of which correspond to the diameters of bores 13 and 14 are inserted in the axial direction into these bores so that an annular shoulder 16 on valve housing 15 abuts in the

direction of the arrow x_1 against a corresponding shoulder between the adjacent ends of bores 13 and 14. The left end of bore 14 is closed toward the outside by a cup-shaped plug member 17 which is prevented from turning or shifting in its axial direction by any suitable means, not shown.

The free parts of bores 11 and 13 between the end of piston 12 and valve housing 15 define a pump chamber 18 the volume of which alternately increases and decreases in accordance with the reciprocating movements of piston 12. Between the left end of valve housing 15 and the inner bottom of the cup-shaped plug member 17, as seen in FIG. 1, a valve chamber 19 is formed. This valve chamber 19 is connected by transverse bores in plug member 17 and an annular channel 20 with a pressure delivery line 21 which in a multiple-cylinder pump may extend to the cylinder heads of all cylinders.

Valve housing 15 is provided with a continuous central axial channel 22 which connects the pump chamber 18 with the valve chamber 19. This valve chamber 19 contains a pressure valve 23 which is operatively associated with a conical valve seat 24 in the left end of valve housing 15 and controls the connection between pump chamber 18 and the pressure-valve chamber 19 via the channel 22. Valve 23 is secured to one end of a valve shaft 25 which is provided with, for example, four guide webs 26 which are slidable axially along the wall of channel 22 and are separated from each other by longitudinal grooves 27, as shown particularly in FIG. 2, through which the medium to be pumped may flow from the pump chamber 19 when the pressure valve 23 is opened by being lifted off its valve seat 24 during each compression stroke of piston 12.

On its end projecting into the pump chamber 18, shaft 25 of the pressure valve 23 carries an annular suction valve 28 which is slidable thereon in the axial direction and controls the connection between the pump chamber 18 and the suction valve channels 29 which are provided in the valve housing 15 and consist of longitudinal channels 30 and transverse channels 31. These transverse channels 31 communicate with one or more suction lines 33 through an annular channel 32 which is provided in the wall of bore 14 adjacent to the annular shoulder 16.

For closing the suction valve 28 as well as the pressure valve 23 a single valve spring 34 is provided one end of which acts directly upon the suction valve 28 and its other end upon a spring bearing 35 which is mounted on the end of valve shaft 25 which projects into the pump chamber 18. Spring 34 thus tends to press the two valves 28 and 23 in opposite directions upon their valve seats by means of the spring bearing 35 and the valve shaft 25, that is, the suction valve 28 upon a flat valve seat 36 which is formed by the end surface of valve housing 15 facing the pump chamber 18, and the pressure valve 21 upon the conical valve seat 24.

Channel 22 further communicates, preferably through an annular groove 36 in the wall of channel 22 and transverse bores 37 in valve housing 15 with an annular compensating chamber 38 which is located between the valve housing 15 and the inner end of the plug member 17. The pressure medium which is contained in the compensating chamber 38 then presses the valve housing 15 in the direction toward the pump chamber 18.

During the suction stroke of piston 12 in the direction of the arrow x_1 the suction valve 28 will be opened against the action of spring 34, while the pressure valve 23 will be firmly pressed upon its valve seat 24 by the pressure of the pressure medium which is contained in valve chamber 19 and by the pressure of spring 34. The pressure medium, especially a liquid, will then be drawn from the suction line 33 through the valve channels 29 into the pump chamber 18. This pump chamber 18 including the grooves 27 in valve shaft 25, the transverse bores 37 and the compensating chamber 38 will then be under a suction pressure, while the pressure-valve chamber 19 will be under a high pressure. The pressure medium contained in valve chamber 19 will then press the valve housing 15 in the direction of the arrow x_1 , that is, in the direction toward the pump chamber 18, so that shoulder 16 will be pressed against the corresponding shoulder of the pump housing 10. The effective pressure surface of valve housing 15 which is then acted upon by the pressure medium in the pressure-valve chamber 19 is indicated in FIG. 1 by the arrow f_1 and has a diameter d_1 .

During the following compression stroke of piston 12 in the direction of the arrow x_2 the suction valve 28 will be closed and pressure valve 23 will be opened against the action of spring 34. The pump chamber 18, the grooves 27 in valve shaft 25, the valve chamber 19 and the compensating chamber 38 will then be under the full pump pressure. Since this pressure acts in one axial direction upon valve housing 15 from the pressure-valve chamber 19 and from the compensating chamber 38 and in the other axial direction from pump chamber 18, the opposing axial pressures will balance each other with the exception of those axial pressures which result from the difference between the diameter d_2 of the end surface f_2 and the diameter d_3 of the surface f_3 which corresponds to the diameter of bore 13, in which the diameter d_2 exceeds the diameter d_3 by twice the value of a .

In accordance with the invention, the respective parts are preferably made of such dimensions that $f_2 - f_3 = f_1$ or that

$$(\pi/4) \cdot (d_2^2 - d_3^2) = (\pi/4) d_1^2.$$

Since the differential surface area $f_2 - f_3$ equals the surface area f_1 , the same pressure will be exerted upon the valve housing 15 during the compression stroke from the valve chamber 19 and the compensating chamber 38 as will be exerted thereon during the suction stroke. The shoulder 16 of valve housing 15 will therefore always abut with the same pressure or at least substantially the same pressure against the corresponding shoulder of the pump housing 10. Alternating stresses will therefore be avoided at this point which increases the durability of the valve housing 15 considerably.

FIG. 1 further illustrates gaskets 39, 40, 41, 42 and 43 which seal the pump chamber 18, the annular channel 32, the compensating chamber 38 and the pressure-valve chamber 19 including the pressure channel 20 relative to each other or toward the outside.

The present invention is not limited to the particular embodiment thereof as previously described and illustrated in the drawings. Thus, for example, in place of a valve housing another device may be employed which may operate in a similar manner or be subjected to similar stresses and the various channels or chambers may

also be arranged in a different manner relative to each other.

Having thus described our invention, what we claim is:

1. A reciprocating piston pump, especially for high pressures, comprising a pump housing having an aperture therein, said aperture having a radially larger part and a radially smaller part axially separated by a shoulder from each other, a valve housing inserted into said aperture and having a radially enlarged part and a radially smaller part axially extending from one end of said enlarged part and separated from it by a shoulder abutting against said shoulder on the wall of said aperture in said pump housing, a pump chamber defined by a wall portion of said smaller aperture part of said pump housing and by the end of said smaller part of said valve housing, a flow channel extending through said valve housing for passing a pressure medium therethrough, suction channel means adapted to communicate with said pump chamber, a suction valve in said pump chamber for controlling said suction channel means, a pressure valve on said valve housing for controlling said flow channel, closure wall means closing said aperture in said pump housing at the side thereof opposite to the side of said valve housing facing said pump chamber, a pressure-valve chamber between said valve housing and said closure wall means and located behind said pressure valve, as seen in the direction of flow of said pressure medium from said pump chamber, and a compensating chamber separate from said pressure-valve chamber and communicating with said flow channel between said pump chamber and said pressure-valve chamber, said compensating chamber having a wall forming the other end of said enlarged part of said valve housing so that the pressure medium contained in said compensating chamber will act upon said other end of said enlarged part in the same direction as the pressure medium contained in said pressure-valve chamber acts upon said valve housing so as to press said valve housing in the direction toward said pump chamber and thereby to press said shoulder of said valve housing against said shoulder on the wall of said aperture in said pump housing, the surface area of said valve housing acted upon in said direction by said pressure medium in said pressure-valve chamber and in said compensating chamber being larger than the surface area of said valve housing acted upon by said pressure medium in the opposite direction.

2. A reciprocating piston pump as defined in claim 1, in which said surface area of said valve housing acted upon by the pressure medium in said compensating chamber in said direction toward said pump chamber has such a size that the difference between the surface areas of said valve housing acted upon by the pressure medium in said opposite direction in said pump chamber and in said first direction in said compensating chamber is at least substantially equal to the surface area of said valve housing acted upon by said pressure medium in said first direction in said pressure-valve chamber.

3. A reciprocating piston pump as defined in claim 1, in which said valve housing has a second radially smaller part axially extending from the other end of said radially larger part, said compensating chamber forming an annular chamber surrounding the part of said second smaller part adjacent to said other end of said larger part.

4. A reciprocating piston pump as defined in claim 3, in which said flow channel extends substantially axially through said valve housing, said valve housing having channel means extending substantially transverse to said flow channel and connecting the same to said compensating chamber.

5. A reciprocating piston pump as defined in claim 1, in which said suction channel means are provided in said valve housing and consist of longitudinal channels and transverse channels each having one end terminating into the associated channel, and further suction channel means in said pump housing, the other ends of said transverse channels being open at the outer periphery of said enlarged part of said valve housing and communicating with said further suction channel means, and the other ends of said longitudinal channels adapted to be opened and closed by said suction valve.

6. A reciprocating piston pump as defined in claim 5, in which said flow channel extends substantially axially through said valve housing, and said suction channel means in said valve housing extend radially outside of and around said flow channel, said suction valve forming an annular valve.

7. A reciprocating piston pump as defined in claim 6, in which said suction valve and said pressure valve are provided at the opposite ends of said valve housing, a valve shaft secured to a first of said valves and extending through said valve housing and also through and projecting from the other valve, a spring bearing mounted on the projecting end of said valve shaft, and a common valve spring having one end acting upon said other valve and another end acting upon said spring bearing, said valve spring tending to close both of said valves on said valve housing.

8. A reciprocating piston pump as defined in claim 7, in which said pressure valve is secured to one end of said valve shaft.

9. A reciprocating piston pump as defined in claim 7, in which said other valve is slidable along and guided by said valve shaft of said first valve.

10. A reciprocating piston pump as defined in claim 1, in which said closure wall means forms an insert inserted into said aperture and secured to said pump chamber and having an inner end surface forming a second wall opposite to and axially spaced from said first wall of said compensating chamber and defining the latter between said two walls, said insert containing said pressure-valve chamber having an outer diameter smaller than that of said compensating chamber.

11. A reciprocating piston pump as defined in claim 10, in which said valve housing has a second radially smaller part axially extending from the other end of said enlarged part and having a smaller diameter than said first part, said insert being cup-shaped, the rim part of said cup forming said second wall of said compensating chamber, the inner wall surface of the recess of said cup containing the free end of said second smaller part and further defining the side wall of said pressure-valve chamber which is further defined by the bottom of said cup and the free end wall of said second smaller part of said valve member, said free end wall into which said flow channel terminates forming a valve seat, said pressure valve projecting into said pressure-valve chamber and adapted to open and close said valve seat, and

transverse outlet channel means extending from said pressure-valve chamber through the side wall of said cup and communicating with further outlet channel means in said pump housing.

12. A reciprocating piston pump as defined in claim 11, in which said insert has an outer diameter equal to the diameter of said radially larger part of said aperture in said pump housing.

13. A reciprocating piston pump, especially for high pressures, comprising a pump housing having an aperture therein, said aperture having a radially larger part and a radially smaller part axially separated by a shoulder from each other, a valve housing inserted into said aperture and having a radially enlarged part and a radially smaller part axially extending from one end of said enlarged part and separated from it by a shoulder abutting against said shoulder on the wall of said aperture in said pump housing, a pump chamber defined by a wall portion of said smaller aperture part of said pump housing and by the end of said smaller part of said valve housing, flow channel means extending from said chamber, suction channel means adapted to communicate with said pump chamber, a suction valve in said pump chamber for controlling said suction channel means, a pressure valve for controlling said flow channel means, closure wall means closing said aperture in said pump housing at the side thereof opposite to the side of said valve housing facing said pump chamber, a pressure-valve chamber between said valve housing and said closure wall means and located behind said pressure valve, as seen in the direction of flow of said pressure medium from said pump chamber, and a compensating chamber separate from said pressure-valve chamber and communicating with said flow channel means between said pump chamber and said pressure-valve chamber, said compensating chamber having a wall forming the other end of said enlarged part of said valve housing so that the pressure medium contained in said compensating chamber will act upon said other end of said enlarged part in the same direction as the pressure medium contained in said pressure-valve chamber acts upon said valve housing so as to press said valve housing in the direction toward said pump chamber and thereby to press said shoulder of said valve housing against said shoulder on the wall of said aperture in said pump housing, the surface area of said valve housing acted upon by the pressure medium in said compensating chamber in said direction toward said pump chamber has such a size that the difference between the surface areas of said valve housing acted upon by the pressure medium in said opposite direction in said pump chamber and in said first direction in said compensating chamber is substantially equal to the surface area of said valve housing acted upon by said pressure medium in said first direction in said pressure-valve chamber.

14. A reciprocating piston pump as defined in claim 13, in which said flow channel means extends substantially axially through said valve housing, said valve housing having channel means extending substantially transverse to said flow channel and connecting the same to said compensating chamber.

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