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[54] **HYDRAULIC PUMP CONTROL ARRANGEMENT**

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[51] **Int. Cl.²** **F04B 49/00**

[58] **Field of Search** 417/287, 288, 299, 301, 417/307, 309, 310, 311, 253, 300, 251, 252

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[57] **ABSTRACT**

A main pump discharging into a consumer conduit, receives fluid through the outlet conduit of a filler pump. A pressure limiting valve is connected with the outlet conduit and urged by the fluid to an open position against the action of a spring. A piston is controlled by the pressure differential upstream and downstream of a throttle in the consumer conduit, to urge the pressure limiting valve to a closed position so that the pressure limiting valve opens when the filler pump supplies more fluid to the main pump than can be absorbed by the same, and the pressure differential does not increase.

10 Claims, 2 Drawing Figures

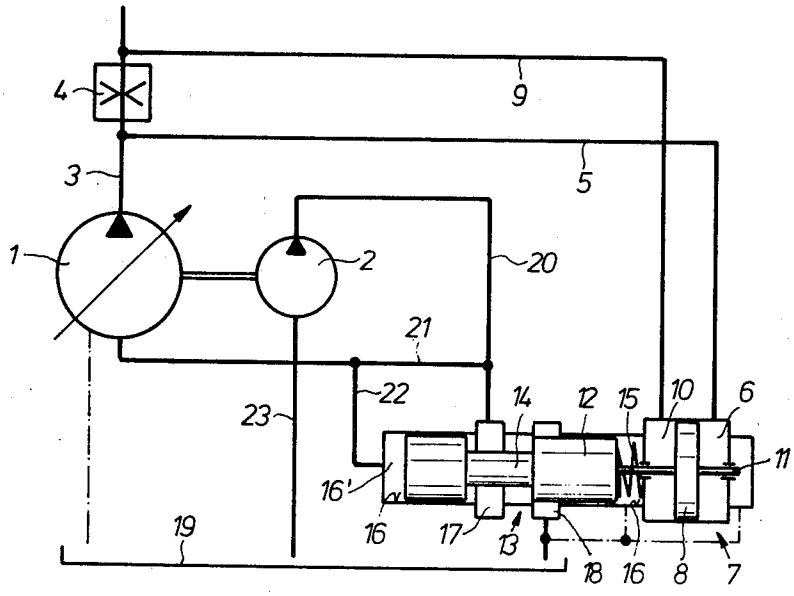


Fig. 1

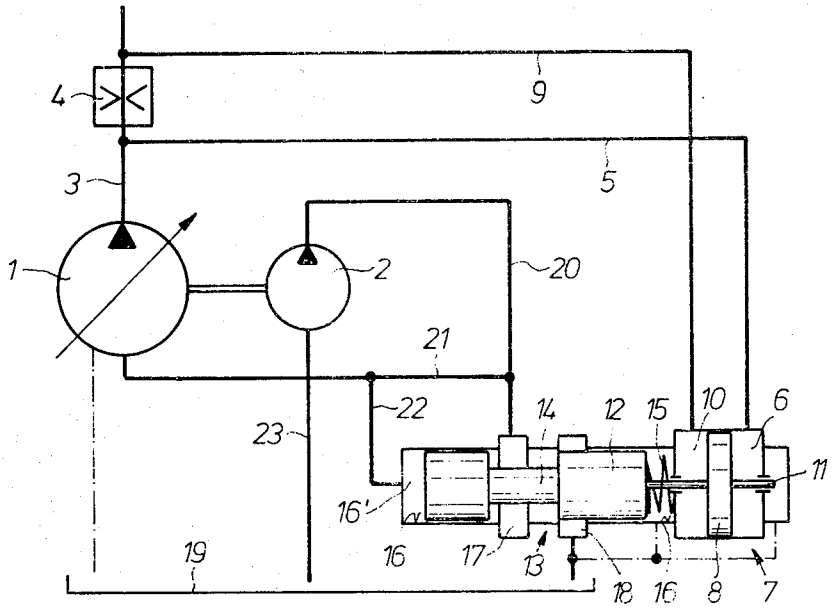
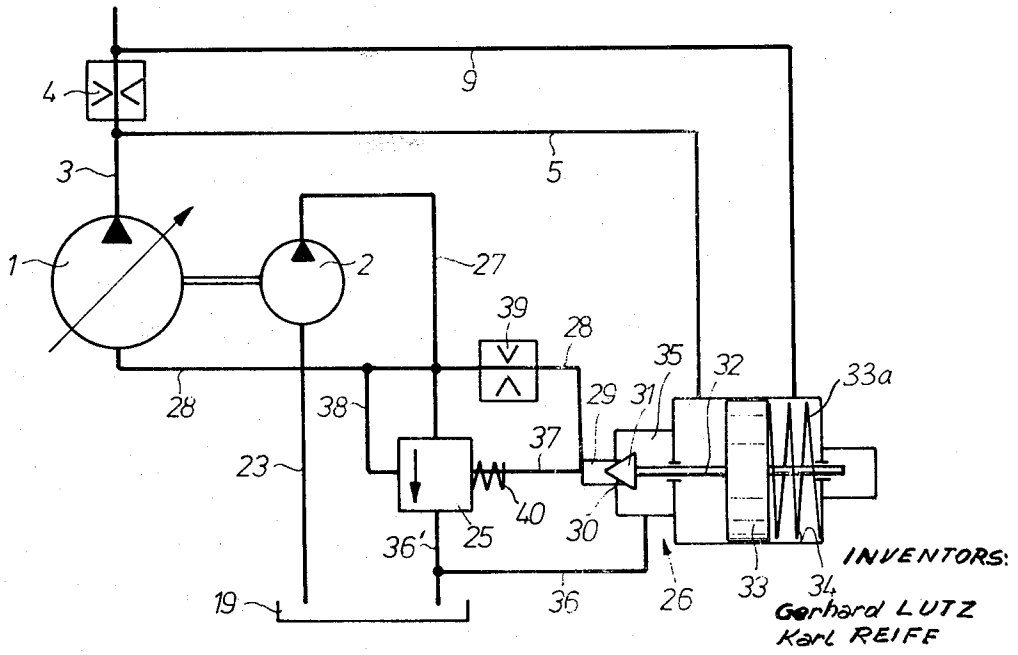


Fig. 2



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HYDRAULIC PUMP CONTROL ARRANGEMENT

BACKGROUND OF THE INVENTION

The present invention is concerned with a hydraulic control arrangement for a displacement pump whose output volume is variable, and whose suction spaces are filled by a filler pump whose output volume is greater than the maximum volume transported by the displacement pump so that the excess pumped by the filler pump must be discharged to a container at low pressure.

The German Auslegeschrift No. 1,255,010 discloses an arrangement of this type in which a pressure limiting valve permits discharge of the excess volume pumped by the filler pump. In order to completely fill the suction spaces of the main pump even at very high rotary speeds, the volume pumped by the filler pump must be greater than the maximum pumped volume of the main pump. The excess fluid pumped by the filler pump, is discharged by means of a bypass or pressure limiting valve, which causes substantial losses in the efficiency of the apparatus.

SUMMARY OF THE INVENTION

It is one object of the invention to provide a hydraulic pump control arrangement which permits the reliable and complete filling of the suction spaces of a main pump in the entire range of operations, while the losses are substantially reduced as compared with prior art arrangements serving the same purpose.

Another object of the invention is to control the discharge of the excess fluid pumped by the filler pump by the pressure prevailing in the output consumer conduit of the main pump.

With these objects in view, a throttle is provided in the output consumer conduit of the main pump, and the pressure differential produced by the throttle acts on a pressure limiting valve which is spring biassed and subjected to the pressure of the output conduits of the filler pump.

In a preferred embodiment of the invention, the pressure limiting valve is controlled by a control valve which is controlled by the pressure differential.

A control arrangement according to the invention comprises a main pump having a consumer conduit and an inlet conduit; a throttle in the consumer conduit producing a pressure differential upon operation of the main pump; a filler pump having an outlet conduit connected with the inlet conduit for supplying at least as much fluid to the main pump as the same can absorb; pressure limiting valve means connected with the outlet conduit and including spring means biassing the pressure limiting valve means to a closed position while the pressure of the fluid from the outlet conduit urges the pressure limiting valve to an open position for discharging the fluid to a low pressure space; piston and cylinder means connected to the consumer conduit upstream and downstream of the throttle, and including a movable member subjected to the pressure differential; and connecting means connecting the pressure limiting valve with the movable member.

The pressure limiting valve moves to the open position when the filler pump supplies more fluid to the main pump than the same can absorb and the pressure in the outlet conduit of the filler pump increases, while the pressure differential in the consumer conduit of the main pump does not increase.

In one embodiment of the invention, the piston and cylinder means include a piston having a piston rod directly connected to a valve slide of the pressure-limiting valve.

In another embodiment of the invention, a branch conduit communicating with the outlet conduit of the filler pump has another throttle, and the connecting means include a control valve having an inlet connected with the branch conduit downstream of the throttle in the same, and a discharge outlet communicating with a low pressure space. The valve member of the control valve is mechanically connected with the piston of the piston and cylinder means, and the pressure limiting valve is connected with the branch conduit downstream of the throttle in the output conduit for being urged to a closed position until the valve member of the control valve connects the branch conduit downstream of the throttle with the discharge outlet.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a fragmentary schematic view illustrating a pump control arrangement according to one embodiment of the invention; and

FIG. **2** is a fragmentary schematic view illustrating a pump arrangement according to another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A main pump **1** provided with means for varying the pumped volume, as indicated by an arrow, has an inlet connected with a filler pump **2** which is connected for rotation with the main pump **1**, and is driven with the same. The main pump **1** pumps a fluid or liquid into the consumer conduit **3** in which a throttle **4** is provided. A first conduit **5** is connected with consumer conduit **3** upstream of throttle **4**, and a second conduit **9** is connected with consumer conduit **3** downstream of the throttle **4**. conduits **5** and **9** communicate, respectively, with chambers **6** and **10** formed by a piston **8** in a cylinder of a cylinder and piston means **7**. When main pump **1** operates, a pressure differential is produced upstream and downstream of throttle **4**, and the same pressure differential acts on piston **8** to move it to the left as viewed in FIG. **1**.

Piston **8** has a fixed piston rod **11** which is axially movable in bearings of the housing of the cylinder and piston means **7**, and is fixedly secured to a piston portion of a valve slide **12**, which has a casing **16** in which another piston portion of valve slide **12** forms a pressure chamber **16'**. Casing **16** has two annular channels **17** and **18** of which channel **17** communicates with the output conduit **20** of the filler pump **2**, which is also connected by output conduit **21** with the inlet of the main pump **1**. Another conduit **22** connects the output conduit **20, 21** with pressure chamber **16'**.

The other annular channel **18** is connected with a discharge opening from which fluid can be discharged into

a reservoir **19** from which filler pump **2** sucks fluid through the inlet conduit **23**. Main pump **1** may also be provided with an inlet conduit communicating with the reservoir **19**.

Valve slide **12** has between the two piston portions at the ends thereof, a reduced portion **14** so that communication between the annular channels **17** and **18** is possible when valve slide **12** is moved to the right as viewed in FIG. **1** out of the illustrated position.

Filler pump **2** sucks through inlet conduit **23** fluid from reservoir **19** and pumps it through outlet conduits **20** and **21** to the inlet of the main pump for filling the suction chambers of the same. The fluid pumped by main pump **1** through consumer conduit **3** flows through throttle **4** so that a pressure differential prevails between conduits **5** and **9** and the chambers **6** and **10**, the pressure in conduit **9** and chamber **10** being lower than the pressure in conduit **5** and chamber **6**. Piston **8** is urged to the left as viewed in FIG. **1** to displace valve slide **12** of the pressure limiting valve means **13**, and a spring **15** is provided surrounding piston rod **11** and abutting the end face of valve slide **12** to urge valve slide **12** in the same direction to reduce the volume of the pressure chamber **16'** which is supplied with pressure fluid from the outlet conduit **20, 21** and **22** of the filler pump **2**.

When the pumps **1** and **2** are started, piston **8** is in its left end position due to the action of spring **15** on valve slide **12**, with which piston **8** is fixedly connected by the connecting piston rod **11**. The pressure differential between chambers **6** and **10** is still negligibly small, and it can be assumed that the same pressure prevails in chambers **6** and **10**.

As the rotary speed of the filler pump **2** and the main pump **1** is increased, the volume of the fluid pumped by filler pump **2** into outlet conduit **20, 21** increases, so that its pressure is also increased. The high pressure fluid supplied through conduits **22** from the outlet conduit **20, 21** to the pressure chamber **16'** urges the valve slide **12** to the right as viewed in FIG. **1** against the action of spring **15**.

Due to the fact that main pump **1** now pumps fluid into the consumer conduit **3** and through throttle **4**, a pressure differential develops upstream and downstream of throttle **4** and in the chambers **6** and **10**, by which piston **8** is urged to the left and acts on slide **12** in the same direction as spring **15**.

After a certain starting period, the pressure produced by the filler pump **2** in the pressure chamber **16'** becomes greater than the force exerted by spring **15** and piston **8**, so that valve slide **12** is moved to the right, as viewed in the drawing against the action of spring **15**. While in the position shown in FIG. **1**, the right piston portion of valve slide **12** closes the annular channel **18**, movement of valve slide **12** to the right due to the action of the pressure fluid in pressure chamber **16'** displaces the piston portion to open the annular channel **18** which communicates with the annular channel **17** so that pressure fluid from outlet conduit **20** flows around portion **14** of valve slide **12** into the annular channel **18** and from there through a discharge outlet into the reservoir **19**.

The fluid volume discharged in this manner is the excess fluid pumped by filler pump **2** which is not any more required by the main pump **1** since its suction chambers are already completely filled so that the pressure in the outlet conduit means **20, 21**, and **22** and in the pressure chamber **16'** rises sufficiently to move valve slide **12** to the open position in which fluid is discharged and the pressure reduced. By the force exerted by spring **15** and piston **8** on the one hand, and the opposite force exerted by the fluid in pressure chamber **16'** on the other hand, valve slide **12** of pressure limiting valve **13** is placed in a balanced position of equilibrium of the forces in which only a minimal excess volume is discharged into reservoir **19** while the required pressure is produced in the outlet conduit **20, 21** of the filler pump **2**, and rises as the rotary speed of the pumps increases. Due to the provision of an additional control force exerted by piston **8** under control of the pressure differential in the consumer conduit **3**, the complete filling of the suction spaces of the main pump **1** is obtained.

FIG. **2** illustrates a modified embodiment, and corresponding parts are indicated in FIG. **2** by the same reference numerals as in FIG. **1**. As compared with the embodiment of FIG. **1**, the embodiment of FIG. **2** is provided with a control valve **26** by which a pressure limiting valve **25** is hydraulically controlled.

The outlet conduit **27** of the filler pump **2** is connected by branch conduit **28** with the inlet of the main pump **1**. The branch conduit **28** connects the outlet conduit **27** also with a first chamber **29** in a casing of control valve **26**, which has a second, larger chamber **35** connected by valve seat **30** with chamber **29**. A frustoconical valve member **31** cooperates with valve seat **30** and is fixedly secured to the piston rod **32** of piston **33** which forms in cylinder **34** two chambers respectively communicating with conduits **5** and **9** so that the pressure differential prevailing upstream and downstream of throttle **4**, is also present on opposite sides of piston **33**. A spring **33***a* is mounted in the chamber on the right of piston **33** and urges piston **33** to the left so that valve member **31** abuts valve seat **30**.

The chamber or space **35** is connected with a discharge conduit **36** which opens into the reservoir **19**.

The pressure limiting valve **25** is connected at one side by conduit **38** with the outlet conduit **27** of filler pump **2**, and on the other side by a conduit **37** with space or chamber **29** and branch conduit **28** downstream of a throttle **39**, while conduit **38** communicates with the outlet conduit **27** upstream of throttle **39**. A spring **40** acts on the pressure limiting valve **25** to urge the same to a normal closed position, while high pressure in conduit **38** acts on the pressure limiting valve **25** against the action of spring **40** to move the same to an open position for discharging fluid supplied from outlet conduit **27** and conduit **38**, out of discharge conduit **36'** into reservoir **19**.

When upon an increase of the speed of pumps **1** and **2**, a pressure differential is present in conduits **5** and **9** and chambers on opposite sides of piston **33**, piston **33**, comprising springs **33***a*, is displaced together with the valve member **31** of control valve **26** so that conduit **28** is connected through spaces **29, 35** with discharge conduit **36** and reservoir **19**. The pressure limiting valve **25** was at first closed due to the pressure of spring **40** and conduit **37**, but when the fluid is discharged through control valve **26** into reservoir **19**, a pressure differential is produced upstream and downstream of throttle **39**, and the pressure in conduit **37** is reduced, while the pressure produced in conduit **38** remains substantially the same. The higher pressure in conduit **38** displaces and opens pressure limiting valve **25**, overcoming the

lower pressure from conduit 28 and the force of spring 40. Consequently, pressure limiting valve 25 opens and discharges excess fluid pumped by pump 2 from outlet conduit 27 through discharge conduit 36' into reservoir 19.

The excess volume of the fluid pumped by filled pump 2 flows directly through the opened pressure limiting valve 25 into reservoir 19.

The forces acting on valve member 31 and piston 33 reach a condition of equilibrium so that the position of the pressure limiting valve 25 is controlled whereby the required pressure is produced in the outlet conduit 27 of the filler pump 2, while the discharged excess volume is a minimum, so that the apparatus operates at high efficiency.

While the conduits are schematically shown in the drawing outside of any casing, it will be understood that all conduits can be provided in the form of ducts in a body or housing.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of pump control arrangements differing from the types described above.

While the invention has been illustrated and described as embodied in a control arrangement for a filler pump discharging into a main pump and including means responsive to a pressure differential in the consumer conduit of the main pump, it is not intended to be limited to the details shown since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. Hydraulic pump control arrangement comprising main pump means having a consumer conduit and an inlet conduit; a throttle in said consumer conduit producing a pressure differential upon operation of said main pump means; a filler pump having an outlet conduit connected with said inlet conduit for supplying at least as much fluid to said main pump means as the same can absorb; pressure limiting valve means including a casing having a discharge outlet, an inlet having a connecting conduit connected with said outlet conduit, a valve slide in said casing, and spring means biasing said valve slide in one direction to move to a closed position disconnecting said inlet from said discharge outlet while the pressure of the fluid from said outlet conduit urges said pressure limiting valve means to an open position for discharging the fluid to a low pressure space; said fluid from said connecting conduit urging said valve means in the opposite direction to said open position against the action of said spring means; piston and cylinder means forming a high pressure chamber and a low pressure chamber connected to said consumer conduit upstream and downstream of said throttle, respectively, and including a movable member subjected to said pressure differential; and connecting means mechanically connecting said movable member of said piston and cylinder means with said valve slide so that the pressure differential biases said valve slide to move in said one direction whereby said pressure limiting valve means moves to said open position when said filler pump supplies more fluid to said main pump means than the same can absorb and the pressure in said outlet conduit increases while said pressure differential does not increase.

2. Pump control arrangement as claimed in claim 1, wherein said piston and cylinder means include a stationary cylinder, and a piston in the same having a piston rod projecting out of said cylinder into said casing and being directly connected with said valve slide; and wherein said spring means surrounds the portion of said piston rod located in said casing and abuts said valve slide.

3. Hydraulic pump control arrangement comprising main pump means having a consumer conduit and an inlet conduit; a throttle in said consumer conduit producing a pressure differential upon operation of said main pump means; a filler pump having an outlet conduit connected with said inlet conduit for supplying at least as much fluid to said main pump means as the same can absorb; pressure limiting valve means including a spring means biasing said pressure limiting valve means to a closed position; a connecting conduit connecting said outlet conduit with said pressure limiting valve means so that the pressure of said fluid from said outlet conduit urges said pressure limiting valve means to an open position for discharging the fluid to a low pressure space; piston and cylinder means forming a high pressure chamber and a low pressure chamber connected to said consumer conduit upstream and downstream of said throttle, respectively, and including a movable member subjected to said pressure differential; and connecting means connecting said pressure limiting valve means with said movable member so that said pressure limiting valve means moves to said open position when said filler pump supplies more fluid to said main pump means than the same can absorb and the pressure in said outlet conduit increases while said pressure differential does not increase.

4. Pump control arrangement as claimed in claim 3 wherein said main pump means include regulating means for adjusting the pumped volume of fluid.

5. Pump control arrangement as claimed in claim 3 and including means connecting said main pump means and filler pump for rotation.

6. Pump control arrangement as claimed in claim 3 wherein said piston and cylinder means include a stationary cylinder, and a piston defining said two chambers in said cylinder respectively communicating with said consumer conduit on opposite sides of said throttle; and wherein said connecting means include a piston rod secured to said piston and projecting out of said cylinder.

7. Pump control arrangement as claimed in claim 3 comprising a branch conduit communicating with said outlet conduit; and a throttle means in said branch conduit; wherein said connecting means include a control valve having an inlet connected with said branch conduit downstream of said throttle means and a discharge outlet communicating with a low pressure space, and a valve member mechanically connected with said movable member of said piston and cylinder means; and

wherein said pressure limiting valve means is connected on one side with said outlet conduit of said filler pump upstream of said throttle means to be urged in one direction to the open position against the action of said spring means, and is connected on the other side thereof with said branch conduit downstream of said throttle means for being urged in the opposite direction to the closed position until said valve member of said control valve connects said branch conduit downstream of said throttle means with said discharge outlet.

8. Pump control arrangement as claimed in claim **7** wherein said piston and cylinder means include a stationary cylinder and a piston in the same having a piston rod projecting out of said cylinder and being directly connected with said valve member of said control valve.

9. Pump control apparatus as claimed in claim **8** wherein said control valve includes a casing having said inlet and said discharge outlet, and forming a first space communicating through said inlet with said branch conduit, a second space communicating with said discharge outlet, and a valve seat between said first and second spaces; wherein said valve member is secured to said piston rod and cooperates with said valve seat; said control valve comprising another conduit connecting said first space with said other side of said pressure limiting valve means.

10. A pump control apparatus as claimed in claim **9** wherein said valve member is a frustoconical head fixedly secured to the end of said piston rod; and wherein said second space is larger than said first space.

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