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[54] VARIABLE DISPLACEMENT PUMP

[75] Inventors: **Richard J. Lech**, Hickory Hills; **Lawrence R. Reinbach**, Westchester, both of Ill.

[73] Assignee: **International Harvester Company**, Chicago, Ill.

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[58] **Field of Search** 92/13.1, 134; 417/388, 214, 417/216, 269, 270

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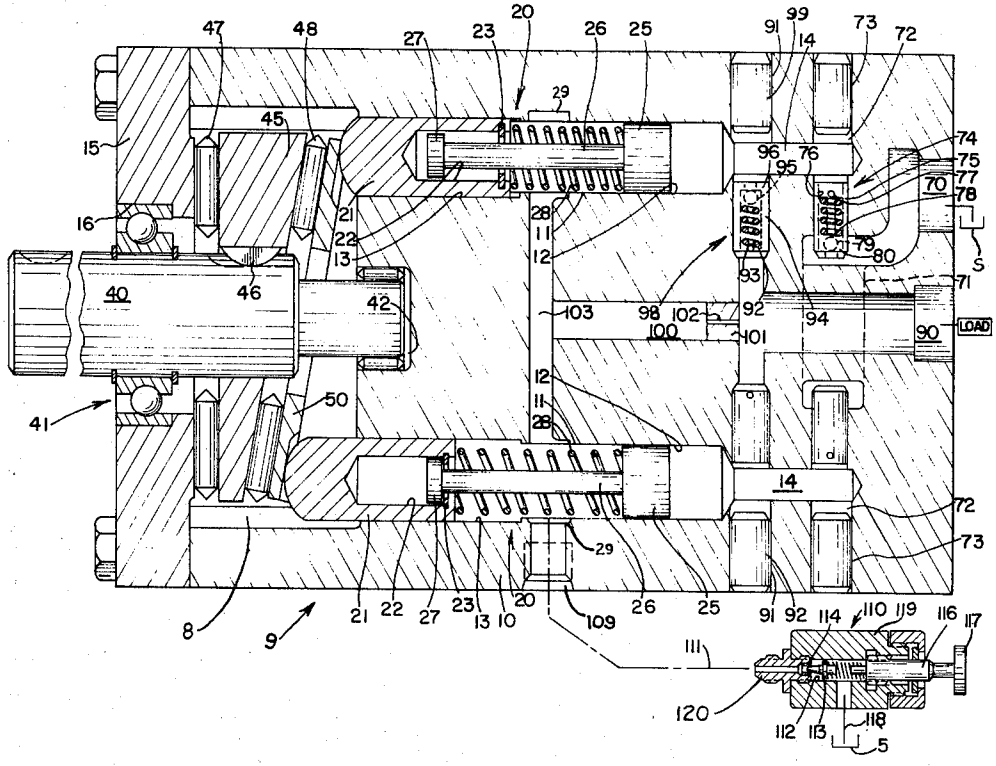
Primary Examiner—William L. Freeh

Attorney—Floyd B. Harman

[57] **ABSTRACT**

A pump unit for providing fluid energy having a housing with movable piston unit therein, mechanical means for directing power input to said piston unit, with hydraulic control means for controlling the fluid output from said unit.

2 Claims, 1 Drawing Figure



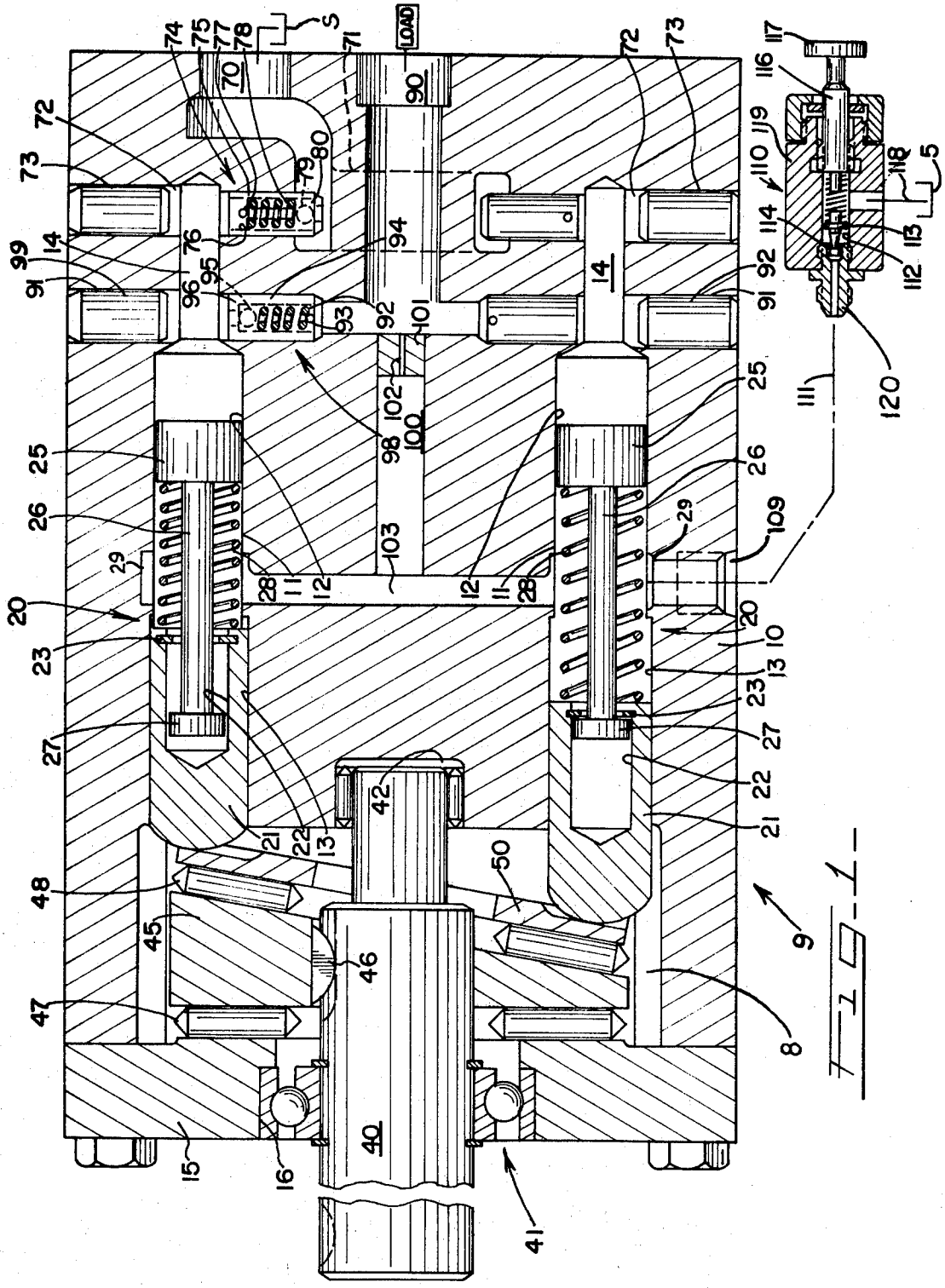


FIG. 1

INVENTORS
RICHARD J. LECH
LAWRENCE R. REINEBACH
BY Harvey L. Baker
ATT'Y.

VARIABLE DISPLACEMENT PUMP

BACKGROUND OF THE INVENTION

This invention relates to a pump unit for converting input energy into fluid output energy. A preferred embodiment as disclosed herein takes the form of a piston pump having one or more piston units receiving input power from a cam plate to deliver fluid energy from the unit as the piston units are controllably actuated by the cam plate. The invention also relates to a control means for varying the displacement of such a unit.

Many types of fluid pumping devices of the axial piston type are known in the prior art. For example U.S. Pat. No. 3,256,830 discloses an axial piston pump having a rotating barrel in which piston units are reciprocated by a swash plate whose angle with respect to the barrel may be changed so as to vary the displacement of said pump. U. S. Pat. No. 3,514,223 discloses an axial piston pump in which the barrel unit is fixed with the pistons being reciprocated by a rotating type wobble plate. Such units, although most adaptable for some applications are deficient in other respects. Thus, exotic control means may be required to control either the quantity of fluid discharged from said pumps or the pressures at which said pumps operate, or they may have speed limitations due to what is commonly regarded as "lift off" of the pistons from the swash plate. Finally parasitic operational losses are excessive as well as are costs of manufacture and repairs.

SUMMARY OF THE INVENTION

In overcoming such deficiencies, the instant invention comprises a housing having a piston unit movable therein upon receiving input power from a mechanical or other means so as to displace fluid and create a pumping action. The movable piston units are so designed as to vary in size according to a unique hydraulic control system and thus effect in a simple manner both pressure and volumetric control of the fluid energy delivered from the unit. Accordingly, it is an object of our invention to provide a fluid energy pump having one or more piston units receiving input power and converting same into fluid energy. It is a primary object of the instant invention to provide an economical fluid energy pump of the variable displacement or constant pressure type which can utilize a simple valve means so as to destroke the unit upon reaching the desired pressure, and thus provide infinitely volumetric control. Another object is to provide an axial piston pump unit having a simple control unit effective to control pressure output and flow as well as functioning as a relief valve. A derivative objective is to provide a superior fixed displacement pump. Finally it is an object of the instant invention to provide a piston pump which may be operated at very high speeds, which has an increased efficiency, and minimizes parasitic losses of input power.

DESCRIPTION OF THE DRAWINGS

The manner in which the objects of the invention is attained will be made clear by a consideration of the following specification and claims when taken in conjunction with the accompanying drawing in which:

FIG. 1 is a side elevational view to the longitudinal center line of a preferred embodiment of our invention.

DETAIL DESCRIPTION

Referring now to FIG. 1, the pump unit 9 comprises a housing 10 which is cylindrical in shape and having an indentation or large recess 8 in the left or rearward end thereof. Extending from this recess to the right or forward end as viewed in the drawing is one or more axial bores 11 containing piston units 20. From left to right, these axial bores comprise a first enlarged diameter bore 13 which joins a reduced diameter bore 12 which in turn is connected to a fluid transfer bore 14 of still reduced diameter. Preferably, the housing 10 might contain up to 6 or more such axial bores 11 and piston units 20.

The left end of the barrel unit 10 is closed by an annular plate 15 which may appropriately be held in place by bolts as depicted. Within a bore 16 in this annular plate 15 is a bearing 41 carrying input shaft 40 which is constrained for rotation (through key 46) to a drive means 45 depicted here in the form of a rotating wobble plate 45. Bearings 47 and 48 on either side of the wobble plate 45 minimize frictional losses which would otherwise by quite evident. The bearings 48 in turn support a thrust plate 50 which may transmit the rotational motion of the wobble plate 45 into reciprocating action of piston units 20.

These piston units 20 comprise a primary transmitting piston portion or element 21 which is cylindrical in shape and reciprocates within enlarged bore 13, and a pumping piston 25 which is also cylindrical in shape and reciprocates within the pumping bore or reduced bore 12. The primary piston 21 has a counterbore 22 therein designed to receive the head 27 of a piston rod 26 attached to the pumping piston 25, snap ring 23 being interposed within the annular bore 22 so as to maintain the piston head 27 within this bore. A spring 28 is then interposed between the primary pistons 21 and the pumping pistons 25. Thus, as rotational power is transmitted from input shaft 40 through the wobble plate 45, primary piston units 21 will be caused to reciprocate within the enlarged bores 13. Forward movement of the primary piston unit 21 will permit piston 25 to move to the right as snap ring 23 no longer retains it, and the force of spring 28 will be increased due to compression between the pistons to move it forwardly. As later discussed fluid between these piston units may also transmit force urging unit 25 forwardly while pressure in transfer passage 14 may preclude its displacement.

To the right of these piston units as shown in the drawings, a suction port 70 permits fluid to be drawn from the sump S and delivered to an internal annulus 71, this annulus 71 being interconnected with each of the axial bores or transfer passages 14 through bores 72 drilled radially into the housing 10 so as to intersect transfer passages 14. Between each of the transfer passages 14 and the internal annulus 71 is placed a one way check valve 74 comprising a tubular member 75 having a bore 76 extending therethrough, a seat 80 at the inner end with a check ball 79 riding upon said seat. A spring 78 interposed between a cross pin 77, passing diametrically through the tube 75, and the check ball 79 urges this check valve 74 to a closed position. Between the transfer bore 14 and the external surface of the barrel is placed a plug 73 within the bore 72 to

close this fluid passage. The plug **73** as well as the check valves **74** may either be pressed into place or held there by threads or other conventional means. Thus it should be appreciated that as each of the piston units **20** reciprocate rearwardly upon rotation of the cam plate **45**, hydraulic fluid may be drawn from the sump S through the passage **70**, the annulus **71** and through the one way check valves **74** to the transfer bores **14** and into the pumping chamber or reduced bore **12**, the lower piston unit **20** as viewed in the drawings being disclosed at the end of its intake stroke.

Discharge fluid is also directed through a one way valve. Thus if pumping piston **25** is displaced forwardly, fluid within the pumping chamber **12** will be displaced therefrom. Such fluid will be directed into transfer passage **14** through a check valve **98** and into the discharge passage **90** to act against the load. These check valves are manufactured in a manner quite similar to those within the suction passage in that a radial bore **91** is provided for each piston unit **20** with the valve structure **98** to be interposed between the transfer passage **14** and the discharge passage **90**. Again this check valve structure comprises a tubing **94** having a bore **92** therethrough with a valve seat **96** being provided adjacent the transfer passage. Against this seat **96** is a ball type check **95** urged against same by a spring **92** held in place by a cross pin **93**. The external end of the radial passage **91** is closed by a plug **99**. Consequently it should be appreciated that on the suction stroke, the check valve **91** will be closed with the check valve **74** being open. During the pumping cycle the check valve **74** remains closed while the check valve **91** opens.

The displacement of the unit is controlled through a unique system of internal conduits with or without valves. As previously indicated, reciprocation of element **21** will cause an increased spring force to be exerted upon element **25** and will urge same forward to displace fluid from chamber **12** until the resistance to flow caused by a load exerts a rearward force on element **25** which exceeds the spring force. As flow resistance increases, fluid will be directed to the control section of the pump which comprises an orifice **102** carried by a plug **101** within a control port **100** which in effect is a mere extension of the discharge passage **90** but of reduced diameter. This control port **100** extends to the left so as to intersect radial bores **103** which in turn interconnect each of the piston units at a point between the primary piston unit **21** and the pumping piston element **25**. Preferably such bores are formed by cores in a casting process, but drilling or other manufacturing methods may be utilized. Outwardly, each of the radial bores **103** is shown terminate in an annulus **29** which encompasses each of the piston units provided within the housing **10**. At this point it should be appreciated that as fluid energy is being delivered by the pumping unit to the load through the passage **90**, pressure within the control port **100** and the radial bores **103** will increase and thus a hydrostatic link may be created between the piston elements **21** and **25**. Under such conditions the piston units **20** would act as a solid piston unit. Assuming that no further means of controlling the pressure within the piston units **20** were provided, it should be clear that a fixed displacement pump would result since the displacement of each piston upon revolution of plate **45** would be constant and the unit could be utilized in open center systems.

In order to convert the above described unit from a fixed displacement pump to a variable displacement pump, a simple and effective relief valve **110** may be provided either internally or externally so as to cooperate with the control section. As shown, this control valve may be connected to an outlet port **109** by a conduit **111**, the control port **109** being interconnected through annulus **29** to all of the radial bores **103**. The valve **110** may comprise a housing **119** having a bore **112** adapted for connection to the conduit **111** through a fitting **120** which may additionally carry a valve seat **114** whereby a piston unit **113** controls discharge of fluid from the radial bores **103** to a sump S through the conduit **118**. The piston valve **113** is urged against the valve seat **114** by a spring **121** which abuts against the valve stem **116** within the bore **112** and thus constitutes a simple relief valve. As later discussed, stem **116** may additionally be provided with a handle **117** and be threaded into the bore **112** so as to vary the spring force applied against the piston valve unit so as to provide infinite pressure control of the fluid discharge.

MODE OF OPERATION

In considering the control of the disclosed unit when utilized as a variable displacement pump, special attention should be given to the piston units **20**. It should be clear that the primary pistons **21** will always be subject to a reciprocating force applied by the wobble plate **45**, and thus will always reciprocate upon the delivery of input power thereto. Whether or not the pumping piston units **25** reciprocate is dependent upon the forces applied thereto. As previously mentioned initial power input will create some pumping action by these pistons **25**. In the absence of pressure in the discharge port **90**, the springs **28** will transmit reciprocable forces from the primary piston **21** to the pumping piston **25**, and actually cause same to reciprocate so as to displace fluid from the bores **12**. As such fluid acts against the load, the pressure will be built up within the discharge port **90**, and fluid will be directed into the control port **100** and radial bores **103** to act against the rearward face of pumping piston **25**. Thus as pressure builds up within the system, the piston elements **25** are subject to the spring force of springs **28**, control fluid pressure between the piston elements **21** and **25** both of which urge same forwardly while resistance to flow in the discharge port **90** acts to preclude displacement of these pumping pistons. If the pump is operated at any substantial pressure, the displacement of these pistons **25**, after the delivery of input power, is primarily dependent upon the amount of fluid pressure within the control port **100**.

Thus assuming that the maximum desired pressure of the system is set upon the valve **110**, initial input power delivered to the wobble plate **45** will cause some displacement of fluid through the springs **28**. As fluid pressure builds up in acting against the load, this pressure in the discharge port **90** will be reflected in the control port **100** and such will continue to act against the rearward face of the pistons **25** to insure continued pumping action and displacement of these elements. As soon as the relief pressure in discharge port **90** is reached, such will be reflected in the control port **100**

and will act against the piston element **113** of the control valve **110**. Upon reaching maximum pressure this valve will open and direct fluid from the control bore **100** to the sump S. As such fluid is bled to the sump, the forces acting rearwardly of the piston **25** will be reduced due to the pressure drop across orifice **102** and the displacement of the piston and the pump will accordingly be reduced. Under such circumstances the pistons **25** may return to zero displacement as shown in FIG. **1** with the primary pistons reciprocating but the pump pistons **25** remaining substantially stationary, thus destroking the pump. If flow is demanded by the system due to a pressure reduction at port **90**, such reduction is sensed through control port **100** permitting the control valve **110** to close. The reduced pressure in port **90** will permit displacement of pistons **25**, and flow will increase until pressure in control port **100** reaches the valve setting of valve **110**. It should further be appreciated that by providing the control handle **116** for the valve **110**, infinite pressure settings may be made for the pump unit. Further, other controls in the form of a single lever might be provided so as to give quite rapid manual control means to the operator for providing for variable pressure outputs in the discharge port **90**. Should one merely desire a fixed displacement pump, the control valve **110** may be deleted with a plug inserted into port **109**. This substitution insures that the piston units **20** will rapidly move to maximum displacement upon delivery of input energy, and remain at that displacement under operating conditions.

A superior advantage of the instant inventions relate to the hydraulic return mechanism available in both the fixed and variable displacement applications. For example, fluid pressure between the pumping piston **25** and the primary piston **21** will exert a net leftward force upon the primary piston **21** to urge same against the bearing plate **50** since the cross-sectional area of this primary piston **21** has a larger exposed area to fluid pressure than does the pumping piston **25**. Further it should be appreciated that as one piston **21** is urged inwardly, some fluid must be displaced from the enlarged bore **13**, and such will be transmitted to other piston units **21** which are permitted to reciprocate to the left as the thickness of the cam plate **45** diminishes. Thus fluid energy is always acting against the primary piston units **21** to urge same rearwardly against the bearing plate **50** to effect a superior piston hold down against the thrust plate, and such will be true regardless of whether or not any charge pressure is provided by the sump S against the pumping piston **25**. This hydraulic hold down in effect is effective to preclude what is commonly called lift off of the reciprocating pistons from the thrust plate **45** if they are operated at higher speeds. It should be especially noted that fluid pressures which create this superior hold down function may be completely independent of any controls exterior to the barrel **10** and represents hydraulic piston hold down system in its simplest form.

Accordingly Applicants have proffered herein a pump which may be utilized as a constant displacement pump or as a constant pressure, variable displacement pump. Alternatively additional control means in the form of a lever **116** may be utilized so as to provide for a variable pressure pump. The dual piston arrangement provides for a unique piston hold down arrangement in which the primary piston unit is always forced against its bearing plate and there will be no tendency of such pistons to lift off the bearing plate. Such an exceptional hydraulic control mechanism greatly increases the rotational speed or capability of an axial piston pump and thus in effect increases fluid displacement. Frictional and parasitic losses are obviously minimized while response time in increasing displacement as well as the destroking of the pump upon reaching maximum pressure are most favorable. Thus the pump should operate very close to maximum pressure without tendency to destroke until such pressure is reached.

As disclosed, Applicants suggest that power input be delivered through a rotating shaft with the housing being stationary. The converse is equally proffered. Additionally structure might include a one-way check valve within control port **100** to insure fluid does not flow from this bore into the discharge port, and other changes within the spirit of the invention may be made.

I claim:

1. A variable displacement pump comprising: a housing having a plurality of cylindrical chambers arranged about an axis and connected to suction and discharge conduits;

a cam means rotatable relative to said chambers about said axis;

a primary piston having a counterbore reciprocally mounted in each of said chambers;

a pumping piston reciprocally mounted in each of said chambers and having a rod extending toward said primary pistons;

a head attached to said rod and reciprocally mounted within said counterbore;

spring means interposed between said primary piston and said pumping piston for urging said pistons apart;

means for introducing fluid to each of said chambers between said pistons;

means for selectively controlling the pressure of said fluid; and

each of said cylindrical chambers having an enlarged diameter portion and a reduced diameter portion;

said primary piston sealingly engaging said enlarged diameter portion and said pumping piston sealingly engaging said reduced diameter portion;

whereby fluid pressure within said chamber between said pistons acts to hold said primary piston against said cam means.

2. An apparatus according to claim **1**, wherein retaining means carried by said primary piston retains said head within said counterbore.

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