Sept. 9, 1969 F. A. NUGIER 3,465,686

AIR OPERATED HYDRAULIC PUMP

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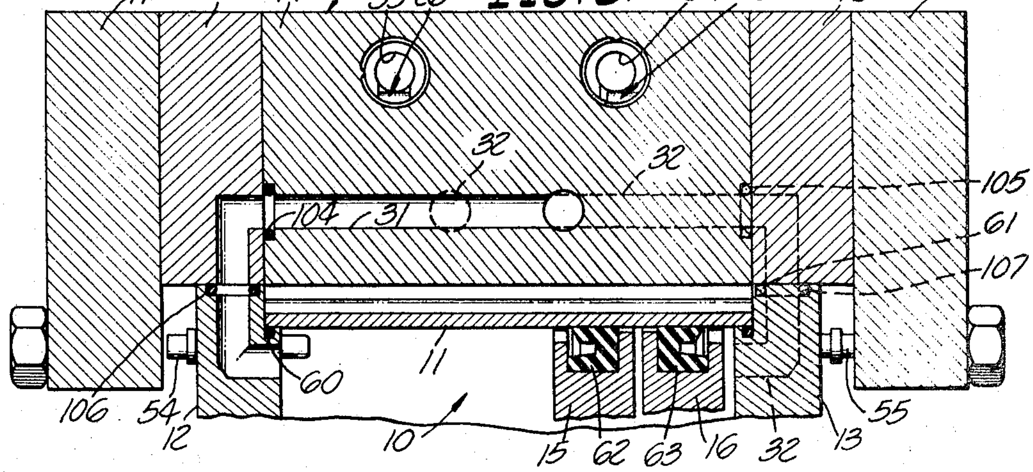
FIG. 5.



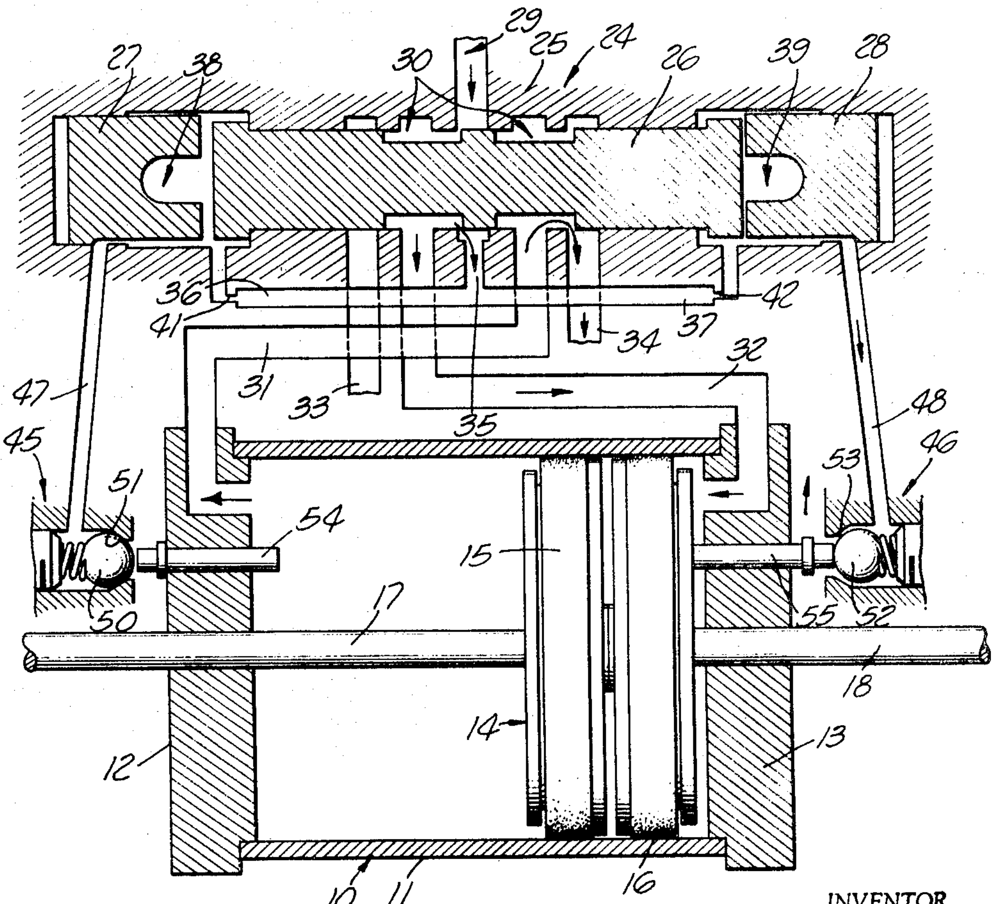


FIG. 1.

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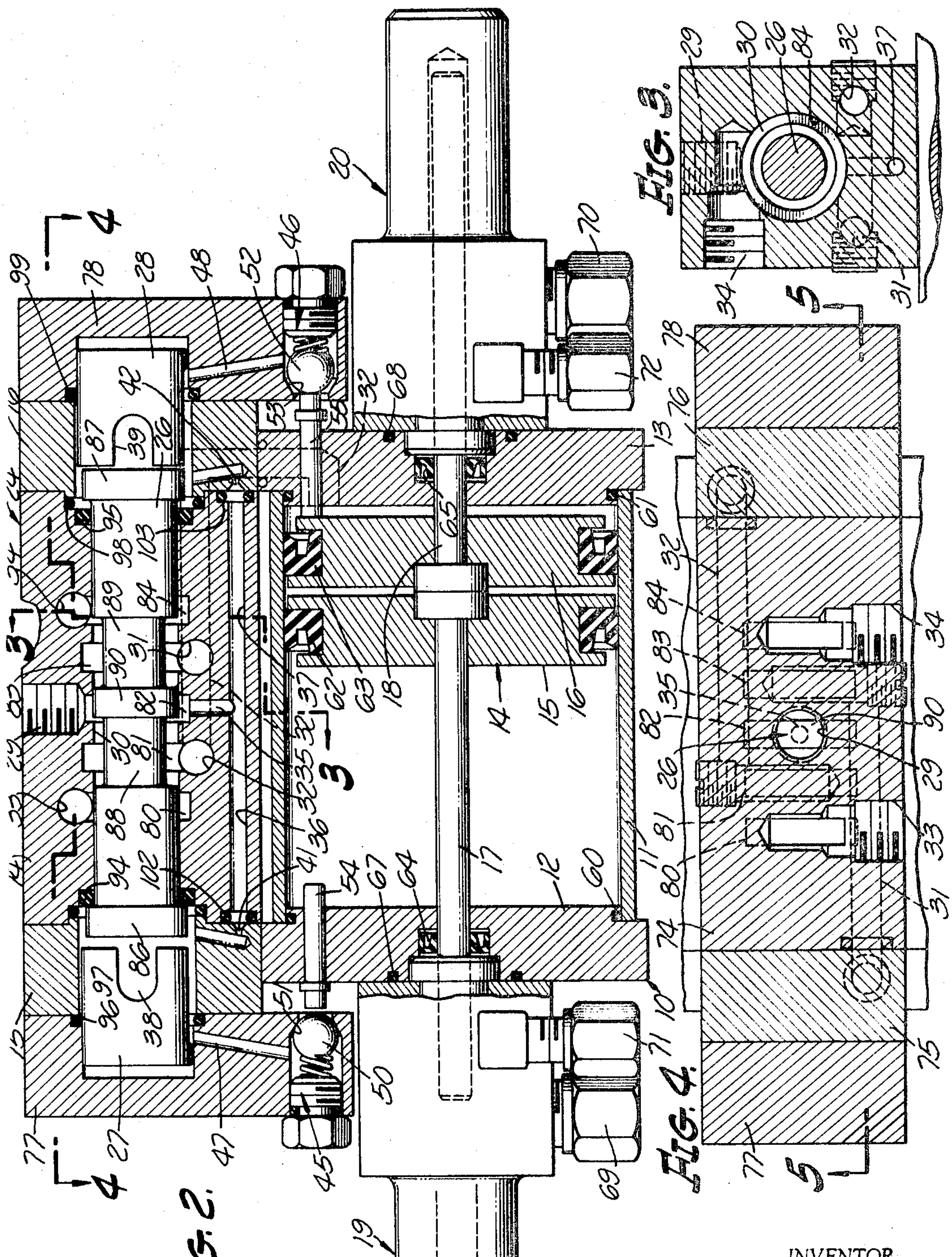

FIG. 2.

FIG. 3.

FIG. 4.

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United States Patent Office

3,465,686
Patented Sept. 9, 1969

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3,465,686

AIR OPERATED HYDRAULIC PUMP

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Filed Oct. 16, 1967, Ser. No. 675,658
Int. Cl. F04b *17/00;* F01l *25/08*
U.S. Cl. 103—51 11 Claims

ABSTRACT OF THE DISCLOSURE

An air operated hydraulic pump and shuttled valve assembly therefor. An air piston mounted within a cylinder reciprocates back and forth under air pressure to operate an oil plunger. Reciprocation of the piston is controlled by a shuttle valve assembly which causes air to be alternately supplied to opposite sides of the piston. Differential air pressure and magnets in the shuttle valve assembly cause the shuttle thereof to positively move to one position or another.

The present invention relates to pumps and more particularly to air operated hydraulic pumps and an improved shuttle valve assembly used in combination therewith.

Various types of hydraulic pumps and valves for controlling the operation thereof have been devised. A typical hydraulic pump includes one or more plunger pumps operated by a piston and cylinder assembly to which a fluid, such as air, is supplied to move the piston. Generally a shuttle valve is coupled with the piston and cylinder assembly and includes a spool or shuttle which reciprocates to appropriately control airflow thereto. The operation of the shuttle valve must be positive, that is, it must operate fully from side to side and not stop in an intermediate position which would cause stalling. Typical shuttle valve assemblies have employed arrangements including detents, springs, or the like to ensure positive operation of the shuttle. With such arrangements, there exists undesirable friction and required adjustments, as well as poor wear characteristics. Attempts have been made to employ permanent magnets in a shuttle valve assembly to give more positive operation, but typical prior art arrangements do not provide reliable operation over a wide range of air pressures and pump speeds.

Accordingly, it is a principal object of the present invention to provide a relatively simple and reliable fluid operated hydraulic pump.

It is an additional object of this invention to provide an air operated pump employing an improved shuttle valve assembly for control thereof.

A further object of this invention is to provide an improved shuttle valve assembly.

These and other objects and features of this invention will become more apparent from a consideration of the following description taken in conjunction with the drawings in which:

FIGURE 1 is a simplified schematic diagram of an air operated hydraulic pump according to the present invention;

FIGURE 2 is a cross-sectional view of a pump according to the present invention;

FIGURE 3 is a cross-sectional view taken along a line 3—3 of FIGURE 2;

FIGURE 4 is a cross-sectional view taken along a line 4—4 of FIGURE 2; and

FIGURE 5 is a cross-sectional view taken along a line 5—5 of FIGURE 4.

Turning now to the drawings, an air operated hydraulic pump including an improved shuttle valve assembly is shown in simplified schematic form in FIGURE 1. A cylinder **10** including a cylindrical barrel section **11** and

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end walls **12** and **13** houses a piston assembly **14** including a pair of pistons **15** and **16**. The piston **15** is coupled with an oil plunger **17**, and the piston **16** is coupled with an oil plunger **18**. The oil plungers **17** and **18** extend into plunger pumps **19** and **20** (note FIGURE 2) equipped with check valves for pumping hydraulic fluid for operating hydraulic equipment, such as, hydraulic presses, hydraulic rams, and the like.

Coupled with the cylinder and piston assembly is a shuttle valve assembly **24** including a valve housing **25** and a shuttle **26**. Permanent magnets **27** and **28** are mounted in the housing **25** spaced from but adjacent the ends of the shuttle **26**. An air inlet **29** is provided through the housing **25** and communicates with an intermediate chamber **30** of the valve assembly. Air passageways **31** and **32** communicate with the intermediate chamber **30**, and extend through the respective end walls **12** and **13** of the cylinder **10** to supply air pressure on the respective pistons **15** and **16**. Exhaust ports **33** and **34** also communicate with the intermediate chamber **30**. Additionally, a control air passageway **35** in the valve body **25** communicates through passageways **36** and **37** with respective control chambers **38** and **39** at the ends of the assembly. The passageway **35** communicates with the inlet **29** at all times irrespective of the position of the shuttle **26**. Orifices or restrictions **41** and **42** are provided in the respective passageways **36** and **37** for purposes which will be described subsequently. The shuttle valve assembly also includes escapement valves **45** and **46** which communicate through respective passageways **47** and **48** with the respective end chambers **38** and **39**. The escapement valve **45** includes a spring biased ball **50** cooperating with a valve seat **51**, and the valve **46** includes a spring biased ball **52** cooperating with a valve seat **53**. Escapement valve push rods **54** and **55** are provided through the respective end walls **12** and **13** to operate a respective escapement valve **45** or **46** as a push rod is contacted by a respective piston **15** or **16**. It will be apparent, that as a rod engages a ball, the escape valve opens thereby venting one of the passageways **47** or **48** to the atmosphere. For example, as shown in FIGURE 1 the piston **16** has engaged the push rod **55** thereby depressing the ball **52** and allowing the passageway **48** to be vented to the atmosphere. This action reduces the pressure in the right-hand end chamber **39** having caused shuttle **26** to move to the right as shown in FIGURE 1.

Turning now to the operation of the pump illustrated in FIGURE 1, it will be seen that air pressure at the inlet **29** is supplied through the intermediate chamber **30** and the passageway **32** to the right-hand side of the piston **16**. The left-hand side of the cylinder **10** now is vented through passageway **31**, chamber **30** and exhaust port **34**. Air pressure also is supplied through the chamber **30** and the passageways **35**, **36** and **37** to the end chambers **38** and **39**. At this time, the chamber **39** still is vented to the atmosphere through the passageway **48** and the escapement valve **46**. The differential pressure between the chambers **38** and **39** along with the force of the magnet **28** acting on the right-hand end of the shuttle **26** prevent the shuttle **26** from moving from the position shown in FIGURE 1. Air pressure through the passageway **32** into the cylinder **10** causes the piston **16**, and hence the piston **15**, to move to the left. As the piston **16** moves away from the push rod **55**, the escapement valve **46** closes and pressure slowly builds up in the right-hand chamber **39**. The rate of pressure buildup is determined by the size of the orifice **42** which is selected to have a smaller airflow capacity than the escapement valve **46**.

When the piston **15** contacts the push rod **54**, the escapement valve **45** opens thereby venting the left-hand chamber **38** to the atmosphere through the passageway **47**. The airflow capacity of the orifice **41** likewise is smaller than the capacity of the escapement valve **45** thereby allowing the pressure in the chamber **38** to drop below the pressure in the chamber **39**. This differential pressure between the chambers **38** and **39** causes the shuttle **26** to move to the left as viewed in FIGURE 1, and as the shuttle approaches the magnet **27** additional pull is exerted on the left-hand end of the shuttle **26** to cause a positive action thereof, i.e., the shuttle moves positively to the left without stopping in an intermediate position. An example pressure in each chamber before the valve **45** opens may be twenty pounds per square inch, with the pressure in the chamber **38** dropping to ten pounds per square inch after the valve **45** opens. The particular differential pressure is not critical. When the shuttle moves to the left, air pressure is supplied through the inlet **29**, the intermediate chamber **30** and the air passageway **31** into the cylinder **10**. The pressure acts on the left-hand side of the piston **15** thereby causing the piston assembly **14** to move to the right as viewed in FIGURE 1. Air in the cylinder **10** between the piston **16** and end wall **13** is exhausted through the passageway **32**, the chamber **30** and the exhaust port **33** inasmuch as the shuttle **26** now is in its left-most position. With the foregoing pump, the structural details of which will be described subsequently, the shuttle valve assembly provides reliable operation without stalling in a neutral position. The pump can operate over a large range of speeds, for example, between less than one stroke per minute to over several hundred cycles per minute. Also, the pump operates reliably over a wide range of air pressures, such as approximately eight to ten pounds per square inch to almost as high a pressure as can be accommodated by the structure of the pump. No adjustments are required in the present pump or shuttle valve assembly to enable the same to operate over a wide range of pressures. Some prior art pumps require a substantial pressure buildup within the cylinder **10** after a piston moves to the limit of travel before shifting of the shuttle will occur; whereas, the present shuttle operation is independent of cylinder pressure.

An exemplary construction of an air operated hydraulic pump and shuttle valve assembly therefore is illustrated in FIGURES 2 through 5 which are substantially to scale. Like reference numerals are used on like components. The end walls **12** and **13** of the cylinder assembly **10** are secured to the barrel section **11**, and are sealed therewith by means of respective O-rings **60** and **61**. The pistons **15** and **16** are affixed to the respective oil plungers **17** and **18** and need not be coupled together, and rubber seals **62** and **63** are arranged about the peripheries of the respective pistons. The plungers **17** and **18** extend through the end walls **12** and **13** and are air sealed at **64** and **65**. The plunger pumps **19** and **20** are affixed to the respective end walls **12** and **13** and are sealed therewith by O-rings **67** and **68** to prevent air from entering the pumps. The balls **50** and **52** of the valves **45** and **46** are spring biased toward the seats **51** and **53**, and the valves are closed by plugs. The plunger pumps **19** and **20** are conventional check valve type oil pumps which receive oil which in turn is pumped by the respective plunger to an outlet. Each has an oil inlet **69** and **70**, and an oil outlet **71** and **72**. The outlets of both pumps typically are coupled together and to an oil cylinder of the hydraulic equipment to be operated by the present hydraulic pump. By employing two plunger pumps in this manner twice the number of oil impulses are provided to give a more even oil flow. Alternatively, each plunger pump may be coupled to identical size cylinders or rams to cause each to move an equal amount. Also, different size plungers may be used to obtain different output oil pressures and volumes. It will be noted that the piston assembly **14** is considerably larger than the plungers **17** and **18** thereby giving a substantial multiplication factor, e.g., one pound per square inch air pressure provides approximately one hundred and twenty-five pounds per square inch oil pressure output.

The shuttle valve housing **24** is formed of a valve body **74**, brackets **75** and **76** and escapement housings **77** and **78**. As previously discussed in connection with the description of FIGURE 1, the air inlet **29** communicates with an intermediate chamber **30** within the body **74**. The chamber **30** is formed by a bore within the body **74**, and five grooves **80** through **84**. The groove **80** communicates with the exhaust port **33**, the groove **81** communicates with the air passageway **32**, the groove **82** communicates with the control air passageway **35**, the groove **83** communicates with the air passageway **31**, and the groove **84** communicates with the exhaust port **34**. An exemplary size for the orifices **41** and **42** is sixty-thousandths inch in diameter.

The shuttle **26** is an elongated cylindrical member, which may have a diameter of, for example, seven-eighths inch, and which has heads **86** and **87** at the ends thereof and an intermediate portion which is necked-down at **88** and **89** thereby forming a cylindrical land **90**. The heads **86** and **87** may be integral or separate pieces affixed to the remainder of the shuttle. The groove **82** allows air to flow from the inlet **29** to the passageway **35** even when the land **90** of the shuttle **26** is centered with respect to the groove **82**. The land **90** is slightly wider than the groove **82** to prevent air pressure in passageways **31** and **32** at the same time. O-rings **94** and **95** are provided in the body **74** about the shuttle **26** to prevent the heads **86** and **87** thereof from contacting the respective magnets **27** and **28** and thereby serve to reduce noise. The various passageways may be formed by drilling and any unnecessary remaining openings may be sealed with screw plugs.

The brackets **75** and **76** are sealed with respect to the body **74** and the escapement housings **77** and **78** by O-rings **96** through **99** thereby forming the chambers **38** and **39**. A seal also is provided for the passageways **36** and **37** by means of O-rings **102** and **103**. Seals also are provided for the passageways **31** and **32** by respective O-rings **104** and **105** (note FIGURE 5), and respective O-rings **106** and **107**. The magnets **27** and **28** are alike, and they may be cylindrical and press-fit into the respective housings **77** and **78**. These magnets may have, for example, approximately a fourteen pound pull. With twenty thousandths of an inch spacing between the heads **86** and **87** of the shuttle **26** and the respective magnets **27** and **28** when the shuttle is at its respective limits of travel, these magnets provide a pull of approximately eight pounds. As noted above, the shuttle operates back and forth as a result of the difference in pressures in the chambers **38** and **39**. Each magnet exerts an additional pulling force on the shuttle to ensure that it moves to its limit of travel. This is particularly important when the air pressure to the overall pump device is turned off during movement of the shuttle to prevent the shuttle from stopping in a center position.

The present embodiment of this invention is to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims therefore are intended to be embraced therein.

What is claimed is:

1. A hydraulic pump for delivering a hydraulic fluid under pressure comprising:

reciprocating piston means mounted within a cylinder said piston means being coupled with hydraulic fluid pumping means which supplies said hydraulic fluid under pressure,

shuttle valve means coupled with said cylinder means, said shuttle valve means including a valve housing having an intermediate chamber for communicating with a fluid inlet, fluid exhaust ports, and outlet fluid passageways coupled with said cylinder for causing said piston means to move, said valve housing including a pair of control chambers, said valve housing including a control fluid passageway coupling said intermediate chamber with said control chambers, said control fluid passageway having predetermined restrictions therein between said intermediate chamber and said control chambers, said shuttle valve means including a shuttle member mounted within a bore said valve housing for controlling communication from said inlet to said passageways and from said passageways to said ports, and

a pair of escape valve means separately communicating with said respective control chambers for venting the same to the atmosphere as a function of the position of said piston means.

2. A pump as in claim 1 wherein:

said escape valve means having a larger fluid passing capability than said respective restrictions.

3. A pump as in claim 1 wherein:

said intermediate chamber is formed by said bore and a plurality of grooves, said grooves being directly coupled with a respective port or passageway, and said shuttle member includes neck portions defining an intermediate land.

4. A pump as in claim 1 including:

a pair of permanent magnets respectively mounted in said control chambers always spaced from said shuttle member for exerting additional operating force upon said shuttle member, said shuttle member moving back and forth within said bore in said valve housing as a function of differential pressure in said control chambers and the pull of said respective magnets for causing fluid to be applied successively on opposite sides of said piston means to cause the same to reciprocate.

5. A pump as in claim 2 including:

a pair of permanent magnets respectively mounted in said control chambers always spaced from said shuttle member for exerting additional operating force upon said shuttle member, said shuttle member moving back and forth within said bore in said valve housing as a function of differential pressure in said control chambers and the pull of said respective magnets for causing fluid to be applied successively on opposite sides of said piston means to cause the same to reciprocate.

6. A shuttle valve assembly for supplying a fluid from an inlet thereof successively to a pair of outlets for operating a hydraulic device comprising:

a valve housing having a bore therein,

a shuttle mounted within said bore, said shuttle having enlarged ends thereby defining an intermediate chamber within said valve housing,

said valve housing including a fluid inlet, a pair of fluid outlets and a pair of ports, said shuttle having an intermediate land for controlling fluid flow between said inlet and said respective outlets as a function of the position of said shuttle within said bore,

said valve housing including a pair of control chambers at the ends of said shuttle, a control fluid passageway communicating directly between said intermediate chamber through respective alike fluid restrictions with said respective control chambers, and

a pair of escapement valve means separately coupled with said respective control chambers for venting the same, said escapement valve means having a larger fluid passing capability than said respective fluid restrictions.

7. A shuttle valve assembly as in claim 6 including:

a pair of permanent magnets respectively mounted in said control chambers always spaced from the ends of said shuttle for exerting a pull on the respective ends of said shuttle, and

said escapement valve means including means responsive to the operation of said hydraulic device.

8. A hydraulic pump for delivering hydraulic fluid under pressure comprising:

reciprocating piston means mounted within a cylinder, said piston means dividing said cylinder into a pair of chambers and said piston means having opposing faces respectively coupled through the respective ends of said cylinder with a pair of hydraulic fluid pumping means which supply hydraulic fluid under pressure,

shuttle valve means coupled with said cylinder means, said shuttle valve means including a valve housing having a fluid inlet and fluid exhaust ports, and having a pair of outlet fluid passageways coupled with said cylinder for supplying a fluid respectively to said chambers of said cylinder for causing said piston means to move, said valve housing including a pair of control chambers and a control fluid passageway for coupling said fluid inlet with said control chambers, said control fluid passageway having predetermined restrictions therein between said fluid inlet and said respective control chambers, and said shuttle valve means including a shuttle member mounted within said housing for allowing communication between said fluid inlet and said control fluid passageway, and for controlling communication between said fluid inlet and said outlet fluid passageways and for controlling communication between said outlet fluid passageways and said exhaust ports to supply a fluid from said fluid inlet alternately to said chambers of said cylinder and to alternately vent said chambers of said cylinder through said exhaust ports, and

a pair of escape valve means having separate passageways respectively communicating with said control chambers for alternately venting said control chambers as a function of the position of said piston means within said cylinder.

9. A pump as in claim 8 wherein:

said piston means comprises a pair of adjacent pistons mounted within said cylinder and which move together, each of said pistons being coupled through respective ends of said cylinder with said respective pair of hydraulic fluid pumping means, said pair of hydraulic fluid pumping means having like pumping capacity.

10. A pump as in claim 8 wherein:

said piston means comprises a pair of adjacent pistons mounted within said cylinder and which move together, each of said pistons being coupled through respective ends of said cylinder with said respective pair of hydraulic fluid pumping means, said hydraulic fluid pumping means having different pumping capacities.

11. A pump as in claim 8 wherein:

each of said escape valve means comprises a normally closed check valve communicating with a respective one of said control chambers, and a control member for opening said check valve upon movement of a respective one of said pistons to near its limit of travel.

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U.S. Cl. X.R.

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