May 16, 1967 — A. L. HAVENS — 3,319,575

PISTON

Filed June 14, 1965

Fig. 1.

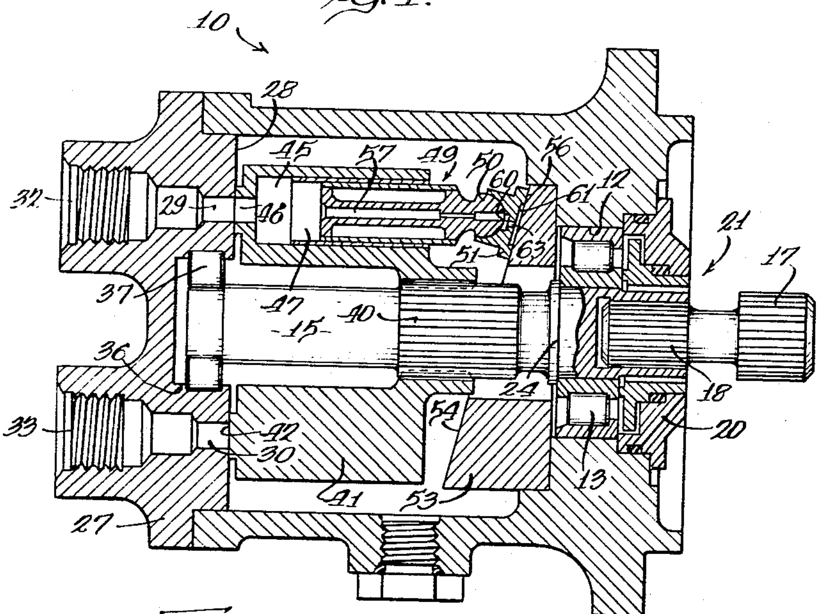


Fig. 2.

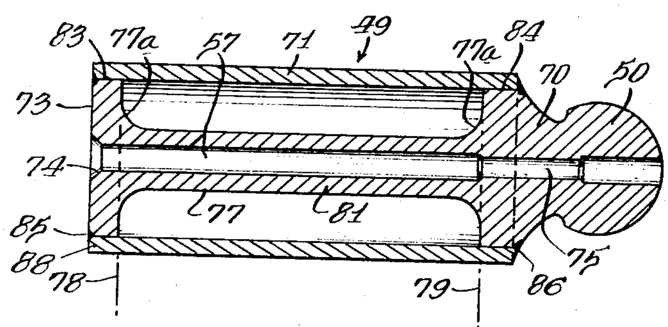
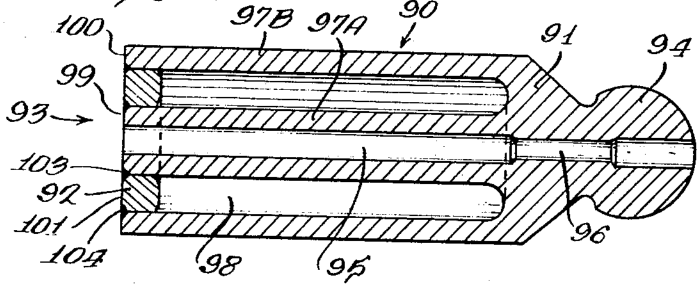


Fig. 3.



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PISTON

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This invention relates generally to fluid pressure translating devices of the reciprocating type, and more particularly to a new and improved piston construction adapted for use in hydraulic pumps or motors.

In the axial, as well as radial, piston types of pumps and motors, as the operating speed of the unit increases, the inertia forces on the piston increase in proportion to the square of the speed. Thus, in a high speed and high pressure hydraulic pump or motor the pistons and cylinders are subjected to high stresses and high rubbing velocities. In order to reduce the effects of these high inertia forces, it is desirable that the piston be made of a wear-resistant material capable of withstanding high stresses, while at the same time it is necessary that the piston be made as light as possible. In order to reduce the weight of the piston, it is conventional to remove the center section of the piston by means of a drilled or otherwise formed cavity.

In the use of prior hollow piston constructions, it has been found that adverse side effects are introduced into the system due mainly to the compressibility of the oil which fills the hollow piston cavity. The compressibility of the fluid has a marked effect upon the over-all efficiency of the unit and also produces cavitation, erosion, noise and undesirable fluid pressure moments on the swashplate mechanism when used in an axial piston type pump or motor.

The general purpose of the present invention is, therefore, to provide a light weight piston device of the type having an axially extending lubrication passage therein for use in a hydraulic pump or motor which obviates the disadvantages noted above. To achieve this, the present invention generally consists of a piston having an elongated integral piston body with a spherical slipper projection at one end and a generally flat surface at the other end defining the working face of the piston with an axially extending lubrication passage through the integral body, an annular recess in the body between the working end and the spherical projection, and a cylindrical cover member enclosing the recess.

Another prior type of lightweight piston has a hollow interior filled with a lighter material than the piston casing, but these have the problem of retaining the plugs in position during extended hard use.

A primary object of the present invention is to provide a new and improved piston construction of the character described above including an inseparable piston assembly that is virtually free from mechanical failure, resists cavitation and erosion, and has no critical temperature limitation.

Another object of the present invention is to provide a new and improved piston construction for a hydraulic pump or motor including an elongated recessed integral piston body having a generally spherical projection at one end adapted to be received by one of the swashplate slippers of the hydraulic pump or motor, with the other end of the integral body defining a portion of the working face of the piston with a lubrication passage extending axially through the body so that the slippers may be adequately lubricated by working fluid; the piston body further having an annular recess extending radially therein to reduce the weight of the over-all piston with the recess having a diameter substantially less than the diameter of the over-all piston, and a separate cylindrical sleeve-like cover extending

over a major portion of the length of the piston body and completely enclosing the recess.

A further object of the present invention is to provide a new and improved hollow piston of the type having an axially extending lubrication passage therethrough in which an integral body member has a radial surface at one end thereof defining a major portion of the working face of the piston and has a spherical projection at the other end thereof adapted to be received by one of the slippers of a multiple piston hydraulic unit so that a substantial part of the load absorbed by the piston from the working fluid will be transferred through the integral body member to the swashplate of the hydraulic unit.

A still further object of the present invention is to provide a new and improved piston construction of the character described including an annular recess extending axially from the working face of the integral body member with an annular plug fixed in the recess adjacent the working face of the piston.

Another object of the present invention is to provide a new and improved multiple piston hydraulic unit of the type employing a rotating cylinder block with pistons slidable therein having spherical projections engaged and driven through slippers by a relatively stationary cam member with the improved piston constructions of the character and detail described above.

These and other objects of the present invention will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view of a hydraulic pump or motor employing lightweight pistons according to the present invention;

FIG. 2 is a longitudinal sectional view of a piston incorporating the first embodiment of the present invention; and

FIG. 3 is a longitudinal sectional view of a piston incorporating a second embodiment of the present invention.

While this invention is susceptible of embodiment in many different forms, there are shown in the drawings and will herein be described in detail several embodiments of the invention and modifications thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention will be pointed out in the appended claims.

Referring now to the drawings, and more particularly FIG. 1, an axial piston pump is generally designated by the numeral **10**. It should be understood that the pump **10** could equally well be employed as a motor rather than a pump. The pump **10** includes a generally cylindrical housing member **11** which has a centrally disposed bore **12** for receiving and mounting the outer race of a roller bearing **13**. An input shaft **15** is provided for the pump **10** and is rotatably mounted at one end in the inner race of bearing **13**. Input shaft **15** may be driven from a suitable prime mover through a coupling **17** splined at both ends thereof, one end of which engages mating female splines in the right end of the input shaft **15** as indicated at **18**.

A generally annular end cap **20** closes the right end of bore **12** in the housing **11** and carries a suitable shaft seal **21** to prevent leakage. The other end of the housing member **11** is closed by a generally cylindrical valve plate **27** fixed to the housing member by suitable fasteners (not shown). The valve plate **27** has conventional arcuate inlet and outlet ports formed therein opening to valve face plate **28**. The arcuate ports communicate respectively with passages **29** and **30**. The passage **29** communicates with a threaded inlet boss **32** (or outlet, depending on the direction of shaft rotation) adapted to receive a fitting connected to a suitable source of hydraulic fluid, or the outlet passage of a motor as when the pump **10** is connected in closed circuit fashion with the motor. The passage **30** communicates with a threaded outlet boss **32** (or inlet) adapted to receive a fitting connected to a hydraulic load such as the inlet of a fluid motor.

A centrally disposed bore **36** extending from the valve plate face **28** in the valve member **27** receives a suitable roller bearing **37** which rotatably supports the left end of the input shaft **15**.

The input shaft **15** has a splined portion **40** which engages mating female splines on a rotatable cylinder block **41**. The cylinder block **41** is generally cylindrical in shape and has a porting face **42** which slidably engages the valve plate face **28** when the cylinder block is driven in rotation by the input shaft **15**. Suitable springs (not shown) may be provided for urging the cylinder block **41** leftward into engagement with the valve plate face **28** to prevent excessive fluid leakage.

The cylinder block **41** has a pluarlity of axially disposed cylinders **45** in annular array about the axis of rotation of shaft **15**. Each of the cylinders **45** communicates with a corresponding arcuate cylinder passage **46** which opens to the port face **42**. As the cylinder block rotates the passages **46** serially communicate with the inlet passage **29** and the outlet passage **30**. Bonded within each cylinder **45** is a cylindrical sleeve bushing **47** constructed of a suitable bearing metal to reduce the sliding friction and take wear. Pistons **49**, described in more detail below, are slidably mounted in the bushings **47**. Each piston **49** has a semi-spherical projection **50** at the free end thereof which is received by a semi-spherical socket in one of a plurality of bearing slippers **51**.

A fixed cam member **53** mounted within the housing member **11** has a flat camming surface **54** engaging the bearing surface **56** of each of the slippers **51** to reciprocate the pistons **49** in the cylinders **45** as the cylinder block and pistons rotate. It should be understood, however, that while the cam member **53** is shown as being of the fixed displacement type, a variable angle cam member could equally well be employed in the pump **10**, as will be apparent to those skilled in this art.

When the hydraulic unit **10** is employed as a pump, a prime mover rotates the cylinder block **41** through the shaft **15**, and the pistons **49** are reciprocated in the cylinders by the cam member **53**. As the cylinder block rotates, the pistons **49** deliver high pressure fluid through outlet passage **30** as they pass over the outlet port in valve plate **27**, and receive inlet fluid through inlet passage **29** as the pistons pass over the inlet port in valve plate **27**. A lubricaation passage **57** is provided in each of the pistons for conveying lubricating fluid to the associated slipper member **51**. The slippers **51** each have a lubricating pocket **60** opening adjacent the spherical projection **50** on the piston, and a lubricating pocket **61** in the rear surface **56** which communicates through a small passage **63** with the lubricating pocket **60**. As the pistons reciprocate, a small quantity of hydraulic fluid in each cylinder **45** passes through passage **57** into the lubricating pocket **63** to provide a lubricating film between the spherical projection **50** and the socket in the slipper **51**. Further, fluid in the pocket **60** flows through passage **63** to the lubricating pocket **61** to lubricate the bearing surface **56** on the slipper and the camming surface **54** on the cam member.

Referring now to FIG. 2, wherein the piston **49** is shown in greater detail, the piston is seen to consist generally of an integral elongated body member **70** surrounded by a cylindrical cover member **71**. The integral body **70** is generally cylindrical and has a flat radial surface **73** at one end thereof which constitutes a major portion (for example, two-thirds to three-fourths) of the working face of the piston **49**. At the other end of the integral body **70** the spherical projection **50** is formed. Much of the force of the fluid in the cylinders **45** is transferred through the integral body **70** to the cam member **53**. This is a distinct advantage over prior pistons that are constructed in multiple parts, as in the present construction mechanical failure due to the loosening of the piston parts is significantly reduced.

The lubrication passage **57** is centrally disposed in the generally cylindrical body **70** and opens at one end to the radial surface **73** and at the other end to the spherical surface of the projection **50**. The passage **57** is chamfered as at **74** adjacent the surface **73** and has a reduced portion **75** adjacent the other end of the body member **70**, both of which are adapted to control and improve the flow of fluid to the associated slipper. A recess **77** is machined or otherwise formed in the outer cylindrical surface of the integral body member **70** and extends from a plane **78** adjacent but spaced from the working surface **73** axially to a plane **79** adjacent the spherical projection **50**. Elimination of this material from the body member **70** significantly reduces the weight of the piston **49** over conventional constructions. The diameter of the cylindrical recessed portion **81** of the body member **70** is sufficiently great so that it will withstand the forces of the working fluid under operating conditions. The recess **77** is preferably formed as at **77a** with rounded corner surfaces to avoid sharp corners in areas of high stress. The outer cylindrical surface of the body member **70** and the recess **77** define cylindrical mounting surfaces **83** and **84** on the integral body **70**. Integral body **70** may, as an example, be constructed of a suitable tool steel such as AISI E–52100, but it should be understood that other suitable steels may be employed as well.

The cylindrical tube-like cover member **71** is constructed of the same steel as the body member **70** to eliminate the adverse effects of differential expansion at high temperature operating conditions. Member **71** is sized so that it snugly fits over the cylindrical mounting surfaces **83** and **84** enclosing the recess **77**. The cover member **71** is welded as by electron beam welding along the circular parting line **85** and along the circular parting line **86** adjacent the ends of the mounting surfaces **83** and **84**, respectively. By known and reliable inspection techniques, strong weld joints may be assured. Subsequent to welding the cover **71** to the body member **70**, the piston **49** may be heat-treated to approximately 55 to 60 Rockwell C.

As the cover member **71** and the integral body **70** of the piston **49** are constructed of the same material, the temperature limitation of the piston is much higher than would be expected from a piston fabricated from dissimilar metals.

It should be noted that radial surface **88** on the left end of the cylindrical cover member **71** defines a portion of the working face of the piston **49**. This is only a small portion (on the order of one-third) of the total working face defined also by the radial surface **73** on the integral body **70**, so that the cover member **71** absorbs a minor portion of the fluid pressure force. In this manner, the piston **49** acts substantially like a solid piston rather than a multiple part piston and is virtually free from failure due to loosening of the parts.

Referring now to FIG. 3, wherein another embodiment of the present invention is shown, a piston generally designated by the numeral **90** is shown and it may be equally well employed in the hydraulic unit **10** in place of the pistons **49**. The piston **90** is generally cylindrical in shape and may be constructed of the same steel as the piston **49**, described above. Piston **90** consists generally of an integral body member **91** and an annular plug **92** fixed in the body member **91** adjacent the working face **93**. The integral body member **91** has a spherical projection **94** at the right end thereof identical in configuration to the projection **50**. A centrally disposed axially extending lubrication passage **95** is formed in the body member **91** by a suitable drilling operation. The passage **95** has a restricted portion **96** to control the flow of lubricating fluid from the cylinders to the slippers **51**. An annular axially extending recess **98** is formed in the body member **91** and extends from the working end thereof to a plane adjacent the projection **94**. The recess **98** defines an inner cylindrical wall **97***a* and a concentric outer cylindrical wall or cover **97***b* in the integral body member **91**. The recess **98** defines two annular working surfaces **99** and **100** which constitute a major portion of the piston working face **93**. The annular plug **92** is fixed in the working end of the piston **90** and has its left surface **101** in the same radial plane with the surfaces **99** and **100** on the integral body **91**. The surface **101** thus defines a portion of the working face **93**, but similar to the surface **88** on the piston **49** of FIG. 2, constitutes a minor portion of the working face. The plug **92** is fixed to the body **91** as by electron welding the plug along the circular parting lines **103** and **104**, respectively.

The advantages obtained with the embodiment of FIG. 3 are substantially the same as those described above with respect to the piston **49**.

I claim:

1. A multiple piston hydraulic translating device, comprising: a cylinder block having a plurality of cylinders therein, valve means having inlet and outlet ports, each of said cylinders communicable serially with said inlet and outlet ports as said cylinder block rotates with respect to said valve means, pistons slidable in each of said cylinders including, an elongated rigid cylindrical piston element constructed in one piece and having at one end thereof a generally spherical projection, bearing means engaging said spherical projection, the other end of said element defining a working face of the piston, said cylindrical element serving to transfer the hydraulic force on said working face to said bearing means, an axial lubrication passage in said element extending from the working face through said spherical projection, an annular recess in the cylindrical surface of said one piece element extending axially from a plane adjacent the projection to a plane adjacent but spaced from said working face, said recess having an inner diameter substantially less than the diameter of the piston, said recess defining spaced cylindrical surfaces on said element one adjacent each end thereof, a separate cylindrical cover surrounding and enclosing said recess being thin with respect to said piston element, the ends of the cover engaging and fixed to the cylindrical surfaces on the one piece element, the outer diameter of the cover being equal to the desired piston diameter, at least one of said surfaces having a diameter throughout its length less than the inner diameter of the cover to permit insertion of the element in the cover, and a cam member for reciprocating said pistons and having a cam surface engaging said bearing means.

2. A multiple piston hydraulic translating device, comprising: a cylinder block having a plurality of cylinders therein, valve means having inlet and outlet ports, each of said cylinders communicable serially with said inlet and outlet ports as said cylinder block rotates with respect to said valve means, pistons slidable in each of said cylinders including, an elongated rigid cylindrical piston element constructed in one piece and having at one end thereof a generally spherical projection, bearing means engaging said spherical projection, the other end of said element defining a working face for the piston, said cylindrical element serving to transfer the hydraulic force on said working face to said bearing means, an axial lubrication passage in said element extending from the working face through said spherical projection, an annular recess in said element extending axially from the working face of the one piece element to a plane adjacent the projection thereby defining an integral cylindrical inner wall and an integral cylindrical outer wall, said recess dividing said working face into two concentric end surface portions, the end surface portions of said walls lying in a generally radial plane and constituting a major portion of said working face, an annular plug fixed in said recess adjacent the working face, and a cam member for reciprocating said pistons and having a cam surface engaging said bearing means.

3. An axial piston hydraulic unit, comprising a cylinder block having a plurality of cylinders therein, a valve plate having inlet and outlet ports therein, each of said cylinders communicable successively with said inlet and outlet ports as the cylinder block rotates with respect to the valve plate; pistons slidable in each of said cylinders each including an elongated rigid cylindrical piston element constructed in one piece and having at one end thereof a generaly spherical projection adapted to be engaged by one of the slippers of the hydraulic device, the other end of said piston element defining a working face for the piston, said cylindrical element serving to transfer the hydraulic force on said working face to said bearing means, an axial lubrication passage in said element extending from the working face through said spherical projection, an annular recess in the cylindrical surface of said element extending from a plane adjacent the projection to a plane adjacent but spaced from said working face, said recess having an inner diameter substantially less than the diameter of the piston, said recess defining spaced cylindrical surfaces one adjacent each end thereof, and a separate cylindrical cover surrounding and enclosing said recess being thin with respect to said piston element, the ends of the cover engaging and fixed to the cylindrical surfaces on the one piece element, the outer diameter of the cover being equal to the desired piston diameter, at least one of said surfaces having a diameter throughout its length less than the inner diameter of the cover to permit insertion of the element in the cover; a slipper having a spherical socket therein engaging the spherical projection on each of said pistons, each of said slippers having a lubricating pocket opening into its associated spherical socket and adapted to receive lubricating fluid through the passage in the associated piston to lubricate the mating surfaces on the shperical projection and the spherical socket, a bearing surface on each of said slippers on the side of the slipper opposite said spherical socket, a second lubricating pocket in said bearing surface communicating with said first pocket whereby fluid may pass from the lubricating passage through the first pocket to the second pocket to lubricate said bearing surface, and a cam member for reciprocating said pistons having a camming surface engaging the bearing surfaces on said slippers.

4. An axial piston hydraulic unit, comprising: a cylinder block having a plurality of cylinders therein, a valve plate having inlet and outlet ports therein, each of said cylinders communicable successively with said inlet and outlet ports as the cylinder block rotates with respect to the valve plate, pistons slidable in each of said cylinders each including an elongated rigid cylindrical piston element constructed in one piece and having at one end thereof a generally spherical projection adapted to be engaged by one of the slippers of the hydraulic device, the other end of said piston element defining a working face for the piston, said cylindrical element serving to transfer the hydaulic force on said working face to said slippers, an axial lubrication passage in said element extending from the working face through said spherical projection, an annular recess extending axially from the working face of the one piece element to a plane adjacent the projection thereby defining an integral cylindrical inner wall and an integral cylindrical outer wall, said recess dividing said working face into two concentric end surface portions, the end surface portions of said walls lying in a generally radial plane and constituting a major portion of said working face, and an annular plug fixed in said recess adjacent the working face; a slipper having a spherical socket therein engage-

ing the spherical projection on each of said pistons, each of said slippers having a lubricating pocket opening into its associated spherical socket and adapted to receive lubricating fluid through the passage in the associated piston to lubricate the mating surfaces on the spherical projection and the spherical socket, a bearing surface on each of said slippers on the side of the slipper opposite said spherical socket, a second lubricating pocket in said bearing surface communicating with said first pocket whereby fluid may pass from the lubrication passage through the first pocket to the second pocket to lubricate said bearing surface, and a cam member for reciprocating said pistons having a camming surface engaging the bearing surfaces on said slippers.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,319,575 Dated May 16, 1967

Inventor(s) Arnold L. Havens

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 4, cancel "Illinois" and insert --Delaware--.

SIGNED AND
SEALED
MAR 10 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents