United States Patent

[11] 3,617,153

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[21] Appl. No. 7,527
[22] Filed Feb. 2, 1970
[45] Patented Nov. 2, 1971

[54] **HYDRAULIC CYCLE PUMP**
8 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** 417/241
[51] **Int. Cl.** F04f 7/00
[50] **Field of Search** 417/240, 241, 92, 93, 94, 95; 233/22

[56] **References Cited**

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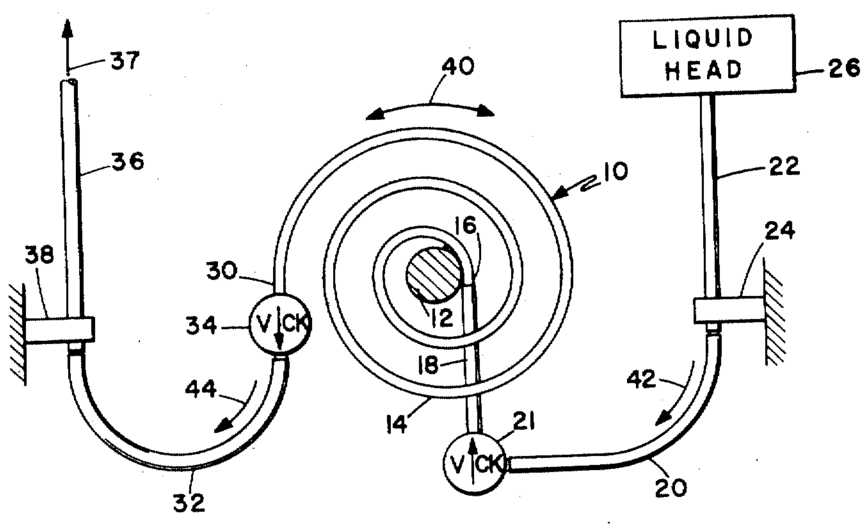
ABSTRACT: A kinetic acceleration, hydraulic pump having a spiral tube connected between a liquid head and a liquid discharge line with a one-way intake valve at one end of the tube and a one-way output valve at the other end of the tube, which spiral tube is rotated circumferentially with a reciprocating, accelerating movement, the acceleration of which moves the fluid through the tube from the liquid head to the discharge line by inertial displacement of liquid in the tube.



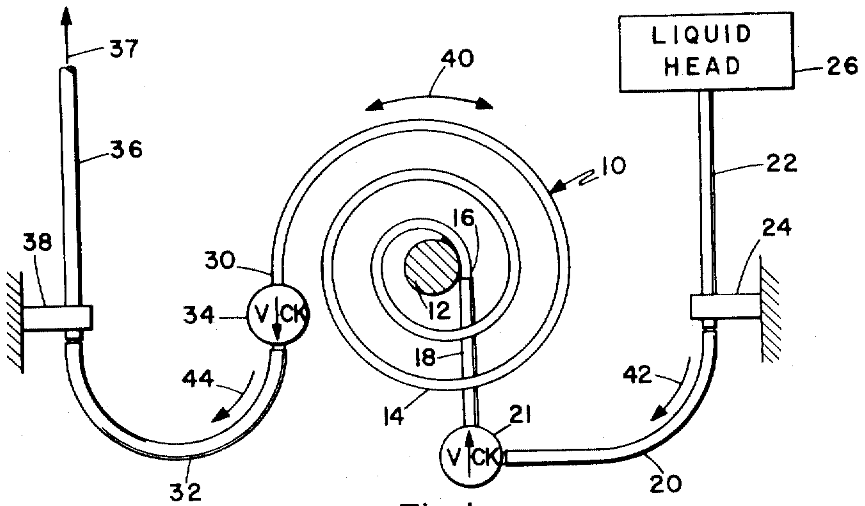


Fig. 1

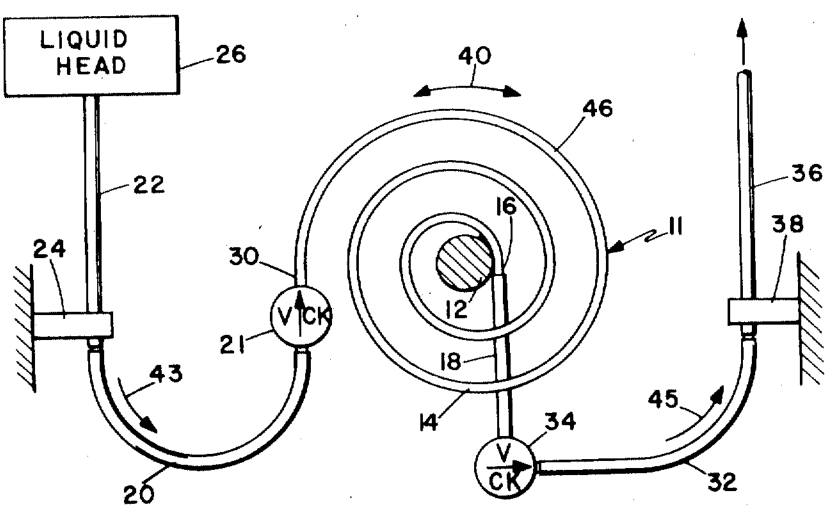


Fig. 2

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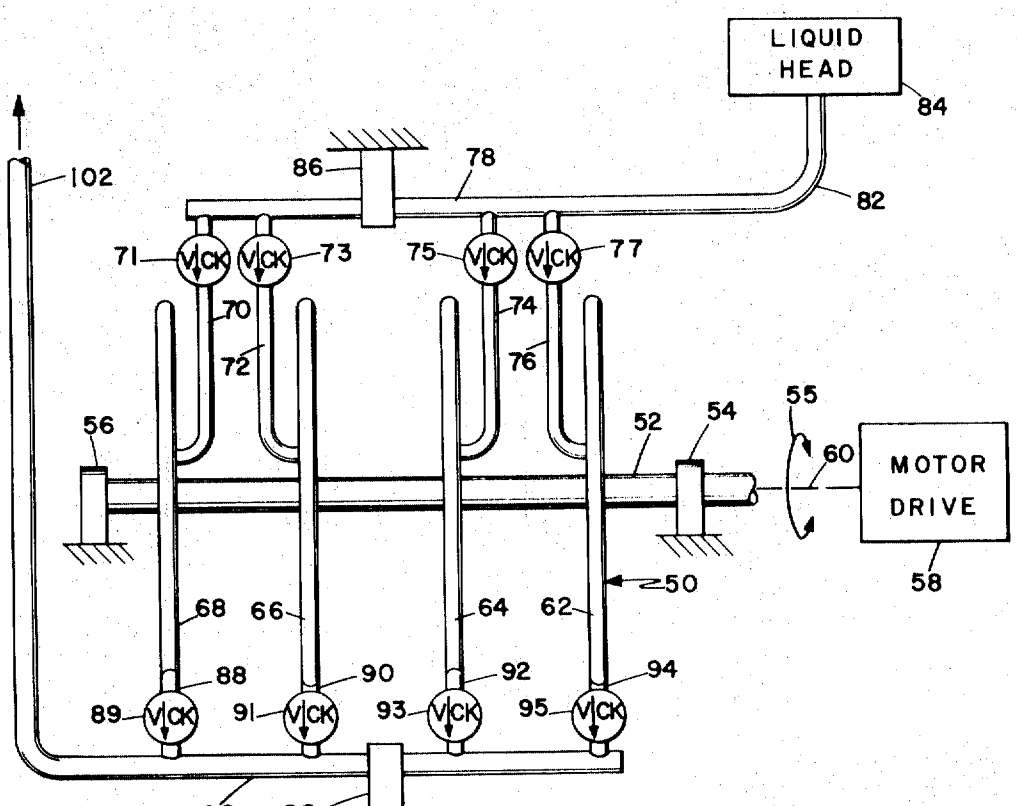

Fig. 3

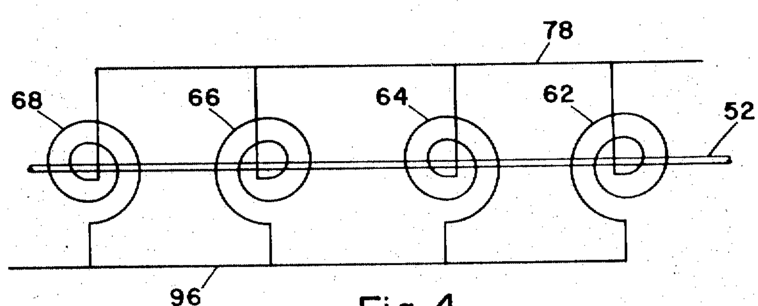

Fig. 4

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HYDRAULIC CYCLE PUMP

BACKGROUND OF THE INVENTION

There are many known kinds of pumps for moving liquids. Such known pumps normally employ mechanisms that push or lift the liquid by direct force contact of a moving member. Such pumps are usually complicated and require strong and rugged construction and often require some initial operating time to effectively pump at their rated volume output. There are other pump systems that are used to move smaller quantities of liquid, by bending tubes or the like with the liquid therein. This causes the liquid to be moved out of the tube in a pumping action. However these devices are limited in the quantity of liquid they are capable of pumping, and further require some rather complex mechanisms to provide any degree of efficient operation.

It is therefore advantageous to have a new and efficient hydraulic pump that utilizes the kinetic "water hammer" effect to move liquid, and which pump is driven by a rotary reciprocating power source in an efficient power utilization cycle while only requiring a simplified pump construction.

SUMMARY OF THE INVENTION

In an exemplary embodiment of this invention, a spiral coil or tube of rigid construction is connected at its radially inner end to a drive shaft that may, for example, be driven by a motor drive providing circumferential, reciprocating motion through the shaft to the spiral tube. The coil tube is connected between a liquid supply line and a liquid discharge line. Upon reciprocating rotational movement of the tube in a first half-cycle, the tube in its acceleration movement moves a greater distance than the liquid in the tube, which liquid is not restrained from movement therein other than by the frictional contact between the liquid and the inner surface of the tube. The inertia of the liquid thus causes a portion of the liquid to be passed in effect out the end of the discharge line, which fluid is immediately replaced by the liquid supply at the other end of the spiral tube. In the return-reciprocating movement or the other half-cycle of operation, one-way intake and output valves at each end of the spiral tube holds the liquid against movement from the discharge line into the tube and from the tube to the liquid head. In this return-reciprocating half-cycle, the liquid in the tube acquires considerable momentum. Near the end of this reverse movement cycle as the spiral tube begins to decelerate, the liquid pressure in the tube exceeds the liquid back pressure in the discharge line. This opens the output one-way valve discharging liquid, which discharge flow is in addition to the flow caused by the movement of the tube in the first half-cycle. Thus by the reciprocating circumferential movement, the spiral tube pumps liquid from the liquid head to the discharge line.

The liquid supply may comprise a liquid head with gravity feed or may comprise some other suitable liquid source. The liquid supply and discharge connections may be connected either to, respectively, the radially inner and radially outer ends of the spiral tube or the reverse thereof. Also more than one coil may be connected to the shaft to provide multiple pumping action from a common liquid supply and a common discharge output line. Also the coils may be connected in pairs with the spirals wound in opposite directions to provide intake and discharge of liquid in a pumping action by one of each pair of coils on each half-cycle of the reciprocating rotational movement of the shaft. This provides continuous pumping of the liquid during the reciprocating movement of the drive shaft.

Thus the kinetic acceleration pump of this invention utilizes the momentum effect or surge effect as distinct from the act of compression or suction to move liquids. The liquids can be moved by this pump whether compressible or not as long as the liquid is essentially a liquid. Thus liquids having entrained gas therein may be pumped by this pump system without the occurrence of gas locking.

It is therefore an object of this invention to provide a new and improved liquid pump.

It is another object of this invention to provide a new and improved liquid pump that may be powered by a drive system that moves with a reciprocating, rotational movement.

It is another object of this invention to provide a new and improved hydraulic cycle pump that requires no standby energy consumption for maintaining full pressure on the system.

It is another object of this invention to provide a new and improved hydraulic cycle pump that provides an efficient conversion of kinetic energy to hydraulic energy in moving a liquid.

Other objects and many advantages of this invention will become more apparent upon a reading of the following detailed description and an examination of the drawings, wherein like reference numerals designate like parts throughout and in which:

FIG. 1 is an end elevational view with parts broken away and partially in schematic of a single spiral tube embodiment of the hydraulic cycling pump of this invention.

FIG. 2 is an end elevational view with parts broken away and parts in schematic of a single spiral tube embodiment with the discharge line connected to the radially inner end of the spiral tube.

FIG. 3 is a side elevational view of a multiple-spiral tube embodiment of the hydraulic cycle pump of this invention.

FIG. 4 is a schematic diagram of the alternate connections of the spiral tube units of the embodiment illustrated in FIG. 3.

Referring to FIG. 1, the hydraulic cycle pump **10** comprises a spiral tube or coil **14** that may be made of any suitable material such as metals or plastics that have a rigid construction and that will follow rotational circumferential movements of the drive shaft **12** without substantial deformation. The radially inner end **16** is secured to the shaft **12** by any suitable means, such as by brazing or by other suitable connections. The remainder of the tube structure **14** is supported by the connection to the shaft **12**. In this embodiment, the radially inner end **16** is connected by a short flexible line **18** to a unidirectional flow valve **21** that may comprise a check valve or other suitable type valve. The check valve **21** is connected by a flexible hose or line **20** to a rigid line **22** that in turn is connected to a supply of liquid **26**. Connection **24** supports the line **22**. The radial outer end of the coil **14** at **30** has a unidirectional flow valve **34**. The flow valve **34** is connected to a flexible line **32** that in turn is connected to a discharge line **36** that is supported by a suitable fastener **38** to an adjacent structure.

Check valve **21** is oriented to prevent fluid flow from the spiral tube **14** back into the line **20** and into the liquid head **26**. The check valve **34** is connected to prevent liquid flow from the discharge line **36** into the spiral tube **14**. It may be understood that the check valves **21** and **34** may be directly secured to the ends of the tube **14**, or they may be connected in the input and discharge connecting lines.

In operation of the embodiment of FIG. 1, a motor drive as for example the motor drive illustrated in FIG. 3, rotates the shaft **12** in a cyclic reciprocating rotational movement. This movement may be any given part of a circle, such as an arc of 25°. This cyclic reciprocating motion is followed by the spiral tube **14**. The liquid from the liquid head **26** flows through the connection lines **22** and **20** and through check valve **21** and connection **18** into the spiral tube **14**. The liquid may flow out the spiral end **30** of the tube **14** and through check valve **34** to the flexible discharge line **32**. Accordingly, the liquid fills the tube and the intake and discharge lines under initial conditions. Upon radial rotational movement of the spiral tube **14**, the tube **14** moves in the clockwise direction of arrow **40**. However the liquid having an inertial condition tends to remain in the original position of the spiral tube **14**. Thus this fluid passes through the check valve **34** and flexible line **32** and out the discharge line **36** in the direction of arrows **44** and **37**. While the spiral tube **14** is moving in the clockwise direction, the liquid is displaced from the spiral tube **14** at the radially inner end **16** of the tube. However this liquid is continually replaced by the liquid from the liquid head **26** through the input lines **18**, **20** and **22**. Upon the reverse movement of the axle 12 and the spiral tube 14, the liquid and the spiral tube 14 are moved in the counterclockwise direction of arrow 40. In this movement, check valves 21 and 34 prevent movement of the liquid relative to the tube by virtue of its inertia effect, thus holding the liquid in the tube. However the liquid in the tube, having been accelerated in its held position in the tube, acquires considerable momentum. Near the end of the reverse movement as the shaft begins to decelerate prior to reversing its direction of rotation, the momentum-induced pressure of the moving liquid exceeds back pressure of the liquid in the discharge line. When this pressure relationship occurs then the check valve 34 opens allowing liquid to, in effect, be thrown out of the end 30 of tube 14 to the discharge line 32. Upon reaching the end of the reverse or counterclockwise movement, the shaft 12 again rotates the spiral tube 14 in a clockwise direction causing fluid to be discharged out of the discharge tube 37. The momentum-induced discharge of liquid in combination with the inertia-induced discharge, provides the pumping action of the pump unit 10. The reciprocating rotational movement of the spiral tube 14 by shaft 12 pumps fluid in the direction of arrows 42 and 44 from the liquid head 26 to the discharge line 36.

Referring to FIG. 2, the pump 11 has a spiral tube 46 connected to the shaft 12 in the manner previously described in FIG. 1. In this embodiment, the liquid head 26 is connected to the radially outer end 30 of the spiral tube 46 and the liquid discharge line 36 is connected to the radially inner end 16 of the spiral tube 46. Check valves 21 and 34 operate in the manner previously described to prevent liquid flow back into the liquid head 26 or from the discharge line 36 back into the tube 14.

In operation of the embodiment of FIG. 2, the liquid is moved in the same manner previously described relative to FIG. 1 with the liquid passing in the direction of arrows 43 and 45.

In both of the embodiments of FIGS. 1 and 2, the rotational speed primarily determines the volume and pressure of the output liquid discharge. Further it has been found that any reasonable size spiral tube may be used. Also there can be any given number of spirals in the tube with the more spirals tending to increase the pressure of the liquid output. The speed of rotation of the shaft 12 is limited to a certain extent by cavitation in the input line resulting from the use of a gravity liquid head. Where there is a higher degree of pressure in the liquid input, then the problems of cavitation decrease. For quick-acting operation, butterfly-type check valves can be used for valves 21 and 34.

Referring now to the embodiments of FIGS. 3 and 4, a shaft 52 is driven in a reciprocating rotational movement by drive motor 58 and drive connection 60 and is supported by bearing 54 and 56. Mounted on the shaft 52 in the manner previously described in FIGS. 1 and 2 are a plurality of spiral tubes 62, 64, 66 and 68. Each of these tubes are connected to a liquid head 84 by plurality of flexible lines 70, 72, 74 and 76 that communicate with a manifold 78 that is held in position by a strap 86. Check valves 71, 73, 75 and 77 function the same as check valve 21 in FIG. 1.

The discharge line 102 is connected through a manifold 96 that is held in position by strap 98. Flexible lines 88, 90, 92 and 94 and check valves 89, 91, 93 and 95 function in the same manner as the flexible line 32 and check valve 34 of FIG. 1. Rotational movement in the direction of arrow 55 causes the fluid to be pumped by the hydraulic cycle pump 50 in the manner previously described relative to FIG. 1.

It may be noted that the spiral tubes 62, 64, 66 and 68 are spiralled in opposite directions as illustrated in FIG. 4. So upon rotation of shaft 52 in a reciprocating rotational movement, two of the four pump units are pumping liquid on each half-cycle of rotational movement. This provides a continuous liquid flow to the output lines and utilizes both half-cycles of the cyclic power output of the motor drive 58.

In each embodiment, the respective check valves 21, 34, 71, 73, 75 and 77 function to prevent movement of liquid back into the liquid source or head 26 or 84. It should be understood that where, for example, the liquid head is substantially at the level of the spiral tubes, that the pump unit can function without check valves 21, 34, 71, 73, 75 and 77. In such an embodiment, the vacuum adjacent the discharge end of the spiral tubes at the output check valves is sufficient to restrict movement of the liquid in the reverse direction to the input liquid head. This embodiment would be primarily used to pump fluid in large volumes with relatively low output pressure.

It should be further evident in FIG. 3 that the coils 62 and 66 as well as coils 64 and 68 may be paired in series for a higher pressure head in the final output rather than in parallel as shown. That is to say, the output of 62 and 64 respectively, connected to the input of 66 and 68 and hence doubling the output pressure. In this case valves 73 and 95 as well as valves 71 and 93 may be the same valves, the input of one coil at the output of the other coil.

Having described my invention, I now claim:

1. A hydraulic cycle pump comprising,
a rigid, spiral, liquid-conducting hollow tube having an input end and a discharge end,
first means for connecting a liquid head to said input end,
second means for connecting a liquid discharge line to said discharge end,
valve means for preventing liquid movement from the discharge line into the tube,
other valve means for preventing liquid movement from the tube to the liquid head,
and means for moving the spiral tube in reciprocating circumferential rotational movement, substantially about the axis of the spiral, whereby liquid is moved through the tube from the input end and out of the discharge end.

2. A hydraulic cycle pump as claimed in claim 1 in which,
the moving means comprises a shaft secured to the radially inner end of the spiral tube and positioned substantially on the axis of the spiral tube, which shaft is capable of being reciprocatingly rotated over arc portions of a circle.

3. A hydraulic cycle pump as claimed in claim 2 in which,
the spiral tube is solely supported by the inner end connection to the shaft.

4. A hydraulic cycle pump as claimed in claim 1 in which,
the spiral tube has more than one circumferential spiral,
and the one end of the tube is the radial inner end of the tube and the other end of the tube is the radial outer end of the tube.

5. A hydraulic cycle pump as claimed in claim 1 in which,
the spiral tube has more than one circumferential spiral,
and the one end of the tube is the radial outer end of the tube and the other end of the tube is the radial inner end of the tube.

6. A hydraulic cycle pump comprising,
a shaft for being rotated about its axis in reciprocating movement,
at least a pair of rigid, spiral, hollow tubes secured at their radial inner ends to said shaft,
first means for connecting a liquid head to one of the ends of each of the tubes,
second means for connecting a liquid discharge line to the other ends of each of the tubes,
first valve means for preventing liquid movement from each of the tubes to the liquid head,
and second valve means for preventing liquid movement from the discharge line to each of the tubes.

7. A hydraulic cycle pump as claimed in claim 6 in which,
in one tube of each of the pair of tubes, the one end is the radial inner end and the other end is the radial outer end,
and in the other tube of each of the pair of tubes, the one end is the radial outer end and the other end is the radial inner end.

8. A hydraulic cycle pump as claimed in claim 7 in which,
the output of one tube of the paired tubes is connected as the input of the other tube of the pair.