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[54] **FLUID PUMPING APPARATUS**

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[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** 417/25, 33, 338, 417/363, 455, 460, 463, 467, 258, 273, 38, 212, 214, 523, 471; 92/117, 118, 60.5

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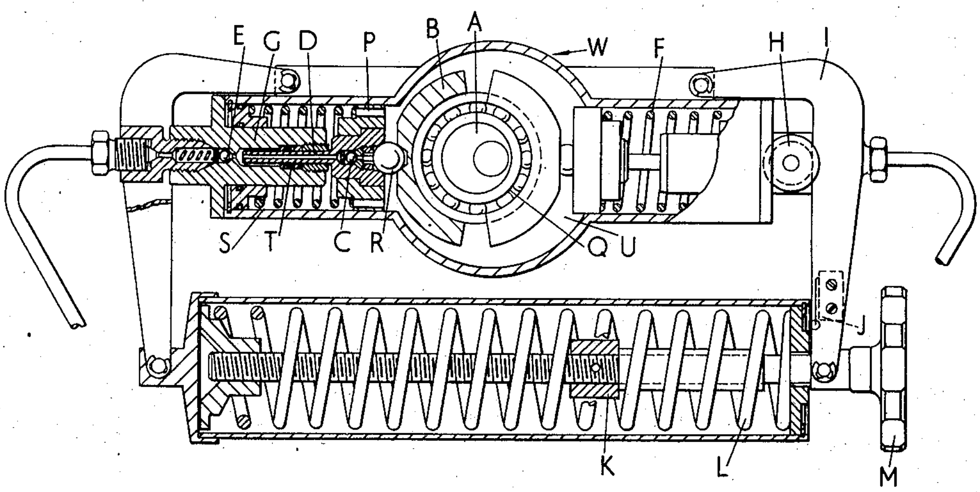
[57] **ABSTRACT**

In one aspect a hydraulic pump unit comprises fluid pumping apparatus having a pair of axially aligned cylinder and piston units, wherein the cylinder body is movable independently of the piston, the movement of the cylinder body being critically restrained by a resilient member so that the movement of the cylinder body may only occur upon attainment of a predetermined pressure within the body, a motor for driving the pumping apparatus, and a rapid acting brake operable upon movement of a cylinder body to stop the motor and hence the operation of the pumping apparatus. In a further aspect a hydraulic pump unit comprises a high pressure pump, a motor for driving the pump, a pressure switch operable upon attainment of a desired pressure, and a rapid acting brake responsive to the switch and arranged to stop the pump.

6 Claims, 2 Drawing Figures



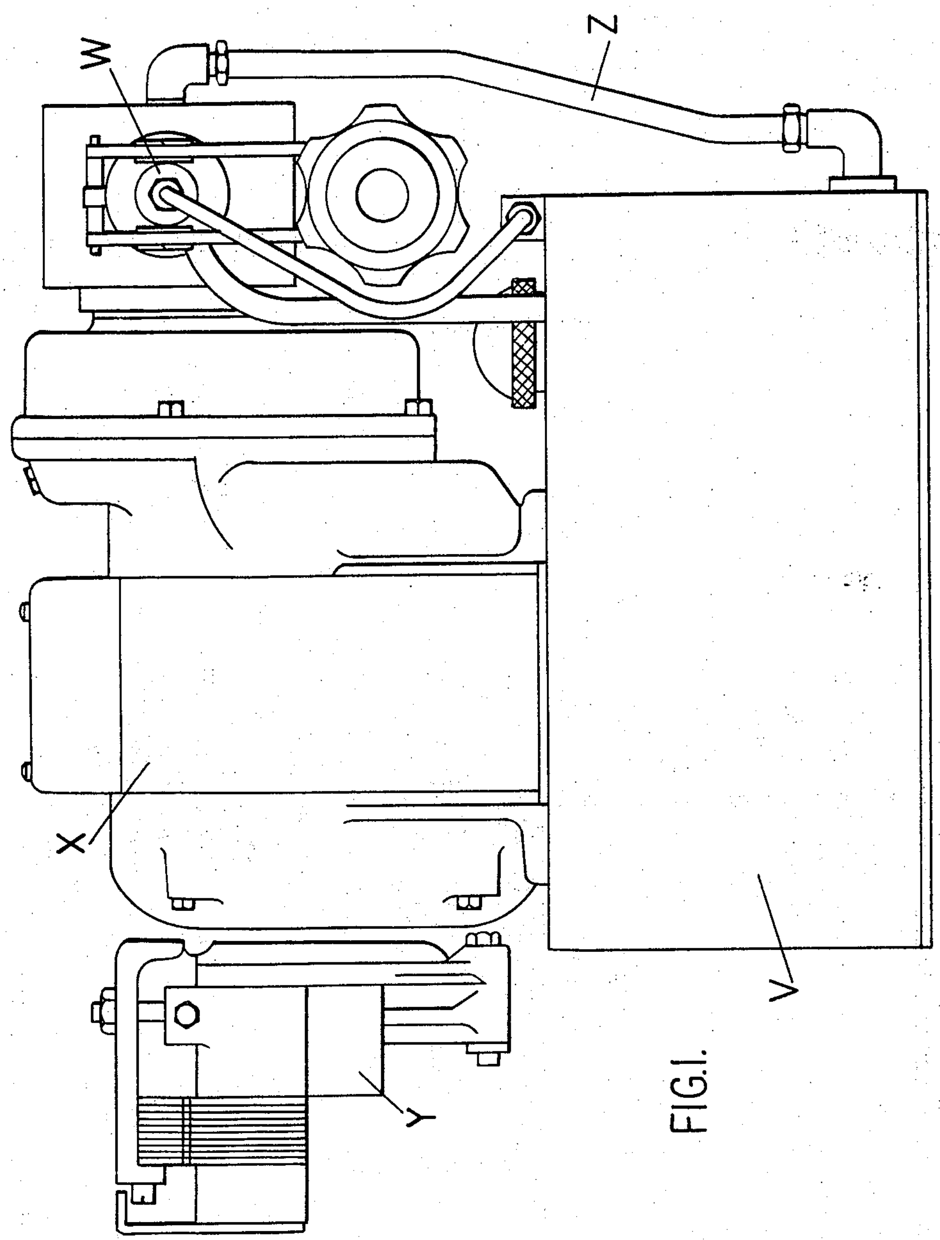


FIG.1.

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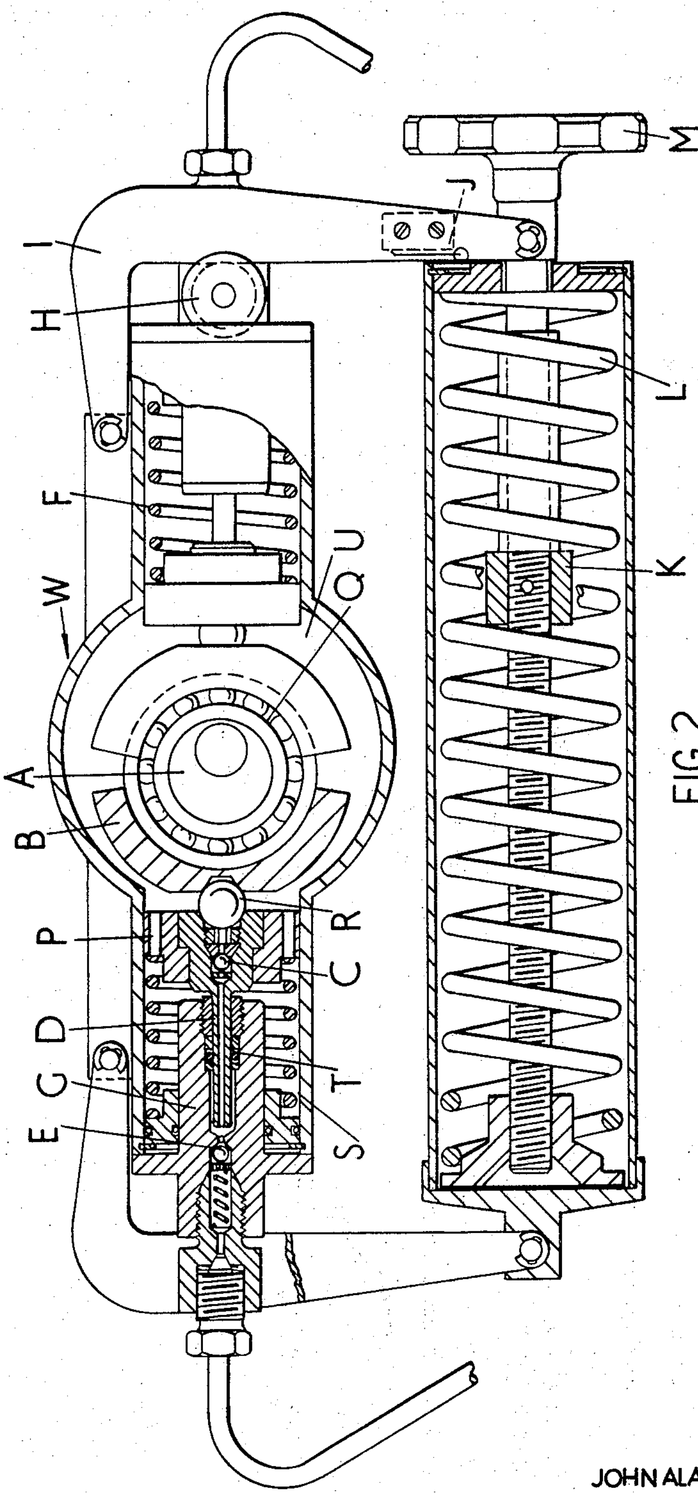

FIG. 2.

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FLUID PUMPING APPARATUS

This invention relates to fluid pumping apparatus, and more particularly to motor driven hydraulic pumps and gas compressors.

Conventional motor driven pumps suffer from the disadvantage that when sufficient pressure has been raised the pump continues to operate and discharges surplus fluid at pressure through a relief valve, thus causing considerable generation of heat and resulting in unnecessary power consumption. Furthermore high pressure relief valves operating as surplus valves are unable to tolerate erosion by the fluid, and have generally proved impractical. Similarly a system incorporating pressure switches and hydraulic accumulators is also impractical at very high pressures, in addition to being cumbersome.

Furthermore, the conventional air driven type of high pressure pump has disadvantages in that it requires a local supply of compressed air which is frequently found to be inadequate to supply the substantial demand of air required to drive the pump, and is frequently subject to wide pressure fluctuations resulting from other demands which may be made on the compressed air supply by other independent equipment. Moreover, other problems arise due to the effect of excess water, oil and rust, which can be carried over in the air supply and which may contaminate the working parts of the air motor which drives the pump. In addition, air driven pumps are very wasteful in their consumption of power.

The invention in one aspect consists in fluid pumping apparatus having at least one pair of cooperating members movable with respect to each other for increasing the pressure of the fluid, one of the members being resiliently supported and the movement of said one of said members being resiliently restrained, movement of said one member serving to stop the operation of the apparatus on attainment of a desired pressure.

A pump utilising apparatus in accordance with the invention may be more than four times as efficient in its utilisation of electric power than comparable air hydraulic pumps.

In a preferred arrangement the apparatus comprises at least one reciprocating piston movable within a cylinder body, the cylinder body being movable independently of the piston, and the movement of the cylinder body being critically restrained by a loaded compression spring so that the movement of the cylinder body may only occur upon attainment of a predetermined pressure within the cylinder body. Movement of the cylinder body operates a switch to stop the operation of the pumping apparatus.

The invention in another aspect consists in a hydraulic pump unit comprising a high pressure pump, a motor for driving said pump, in a pressure switch operable upon attainment of a required pressure, and a rapid action brake responsive to said switch and arranged to stop said pump.

The invention will be further described, by way of example only, with reference to the drawings, in which:

FIG. 1 is a side view of a hydraulic pump unit, and

FIG. 2 is a vertical section through a hydraulic pump.

In FIG. 1 a hydraulic pump W is driven by an electric motor X which is fitted with a rapid acting magnetic brake Y arranged to stop the motor and pump when the electric power is switched off. Hydraulic fluid is passed to the pump W from a tank V via a pipe Z.

The pump W is shown in detail in FIG. 2. A drive shaft from the electric motor is keyed to drive an eccentric cam A arranged within a crank case U. The cam A carries a ball race Q the outer ring of which bears freely against a pair of big end shoes B. Associated with each of the big end shoes is a high pressure reciprocating piston D arranged to slide within a cylinder body G. Balls R provide articulating thrust joints between the shoes B and the bases of the respective pistons D.

Each of the pistons D is supported by cross-head bearings P which are able to reciprocate with the pistons D and are guided within bores S so as to restrain all side of forces produced by movement of the pistons. Housed within each of bores S is a return spring F which maintains contact between crosshead bearings P and their respective pistons D, balls R and big end shoes B with the ball race Q, so that rotation of the eccentric cam A will cause the pistons D to reciprocate.

Each piston and cylinder body unit is provided with a high pressure hydraulic fluid inlet valve C and a high pressure outlet valve E. The cylinder bodies G are provided with seals T which seal against the pistons D to ensure that fluid drawn in through inlet valve C from the crank case U is discharged through outlet valves E.

The ends of the cylinder bodies G remote from the crank case are provided with roller bearings H which bear against bell crank levers I. Movement of the levers I is restrained by a loaded compression spring L whose load is adjustable by a hand wheel M. The load in spring L is predetermined so that each cylinder body G may move in the direction of the pressure stroke of the piston D only upon attainment of a critical pressure within the cylinder body. A microswitch J is associated with one lever I and arranged to operate the brake Y to stop the motor X upon movement of either lever I. A wormscrew stop K prevents overloading of the spring L by the adjustment wheel M.

Since each lever I is connected to an end of the compression spring L, movement of either lever will operate the micro-switch J.

In operation hydraulic fluid is drawn from tank V into the crank case U, and the eccentric cam A is rotated by the drive shaft from the motor X.

The thrust produced by the rotation of the cam A is transmitted via the shoes B and the balls R to cause the pistons D to reciprocate within the cylinder body G. Fluid contained in the crank case U is drawn into the cylinder body G through inlet valves C and discharged through outlet valves E. As pumping continues the thrust resulting from the pressure generated in the cylinders G is transmitted via the roller bearings H to the bell crank levers I. Movement of the levers I is restrained by the spring L so that only when a critical pressure has been obtained within at least one of the cylinder bodies G will that cylinder body move the respective lever I; the micro-switch J will then operate and thereby switch off the motor X and apply the brake Y and thus stop the pump.

The placing of the points about which the levers I pivot, and the arrangement whereby contact between the levers I and the rollers H is maintained as the lever pivots, compensates for the variation in the spring force during movement of the levers, and thus permits the load in the spring to be accurately predetermined.

During the short period in which the motor is stopped by the brake the cylinder body G which has moved will continue to move with the piston D and thus prevent any further displacement of fluid during this period.

Thus when sufficient pressure has been raised by the pump the motor stops operating and remains at rest until the pump is required to function again. Since the pump stores energy in the compression spring prior to switching off the motor it has been found possible to control pressure with great accuracy in conditions where the quantity of fluid required from the pump varies between zero and the maximum delivery of the pump. The pump is especially useful at very high pressures in the range of 10,000 to 100,000 lbs per square inch but can also be used at lower pressures.

The cylinder bodies are floating and thereby effective:

i. to switch off the motor and apply a positive brake.

ii. To permit the cylinder to move freely with the piston, thus avoiding further displacement of fluid into the system during the fraction of a stroke whilst the brake is stopping the pump.

iii. During the movement of the cylinder to store energy in the resilient member, so that fluid may be delivered at pressure after the motor has stopped and before the motor restarts by the action of the resilient force urging the cylinder back onto the piston, the piston being held rigidly by the brake, to resist this force.

The principal advantages of the described pump are that power is not dissipated into heat when the pump is merely holding pressure, and that the pump does not depend upon a pressure relief valve to control pressure.

Moreover, the pump does not depend upon a compressed air supply and thus overcomes the operating problems and inefficiency associated with this form of driving power. In addition, the pump is suitable for pumping hydraulic oil or soluble oil and water mixture, and in a modified arrangement, in which the inlet valves C are fitted into the cylinder head so that none of the fluid being pumped passes through the crank case U, other fluids, including pure water, may be pumped. The use of twin horizontally opposed cylinders provides virtually pulse free pumping.

An alternative method of controlling the pump which may be used when charging a large capacity vessel or system, incorporates a pressure switch in the system to control the starting and stopping of the pump. Such an arrangement has been found to afford advantages in the accuracy of controlling and in the simplicity of changing the control pressure setting. Moreover, the basic pump control effected by the floating cylinder body G remains operative and would be set at a higher pressure so as to ensure the ultimate safety of the pump and the system. A pump generally as shown in FIG. 2 combined with a drive motor and fast acting magnetic brake is able to respond with great precision to a pressure switch or an electrical contact fitted to a pressure gauge.

The use of a rapid acting brake, in both aspects of the invention, affords the following advantages:

1. By rapidly stopping the motor it prevents the overshoot of pressure due to the unchecked mechanical momentum of the pump.

2. After the pump has stopped the piston is held rigidly still, together with the column of fluid which it is supporting under pressure, thus preventing any drop of pressure as would happen if the piston were free to fall back, which would permit a small pressure drop due to the outlet check valve having to re-seat.

3. Because the charge within the cylinder is held in the manner described in (2) above, the jump is able to compensate for minute variations of pressure by injecting fluid at a fraction of a stroke's displacement at a time, this action being possible by virtue of having the rapid acting brake and therefore being able to 'inch' the motor at a fraction of a revolution each time, at least one cylinder remaining in a charged condition at all times.

I claim:

1. A hydraulic pump unit comprising a pumping chamber, a cylinder body arranged in said pumping chamber, an inlet valve to and an outlet valve from said cylinder body for the passage of fluid through said pumping chamber, a reciprocating piston movably displaceable within said cylinder body for increasing the pressure of fluid being displaced through said cylinder body, means for resiliently restraining said cylinder body against movement as pressure within said cylinder body is increased to a predetermined value and for permitting the movement of said cylinder body in unison with said piston when the predetermined pressure value has been reached, means including a motor for driving said piston and a rapid acting brake fitted on said motor and arranged to stop said motor, a switch operatively associated with said resilient restraint means and arranged to operate said rapid acting brake for stopping said motor and the movement of said piston when said cylinder body moves in unison with said piston when the predetermined pressure value is reached, so that said cylinder body continues to move in unison with said piston while said motor is being stopped for preventing further displacement of the fluid through said cylinder body and the movement of said cylinder body as said motor is being stopped stores energy in said resilient restraint means and maintains the fluid pressure by urging said cylinder body onto said piston and restarting said motor to sustain said pressure at the predetermined value.

2. A hydraulic pump unit, as set forth in claim **1**, wherein said resilient restraint means includes means for adjusting the load applied by said resilient restraint means against said cylinder body.

3. A hydraulic pump unit, as set forth in claim **1**, wherein said resilient restraint means includes a compression spring.

4. A hydraulic pump unit as set forth in claim **1**, wherein a lever is associated with the end of said cylinder body remote from said piston and said resilient restraint means acting on said lever for restraining its movements.

5. A hydraulic pump unit, as set forth in claim **4** wherein a roller bearing is mounted on the end of said cylinder body in contact with said lever for compensating for variations in the resilient load during movement of said lever.

6. A hydraulic pump unit, as set forth in claim **1**, wherein two said pumping chambers are arranged in axial alignment, with one said cylinder body and piston axially aligned within each said pumping chamber and with said pistons disposed in axial alignment.

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