May 1, 1962 H. JANICKE 3,031,972

FREE PISTON ENGINE DRIVEN PUMP ASSEMBLY

Filed June 17, 1957 3 Sheets-Sheet 1

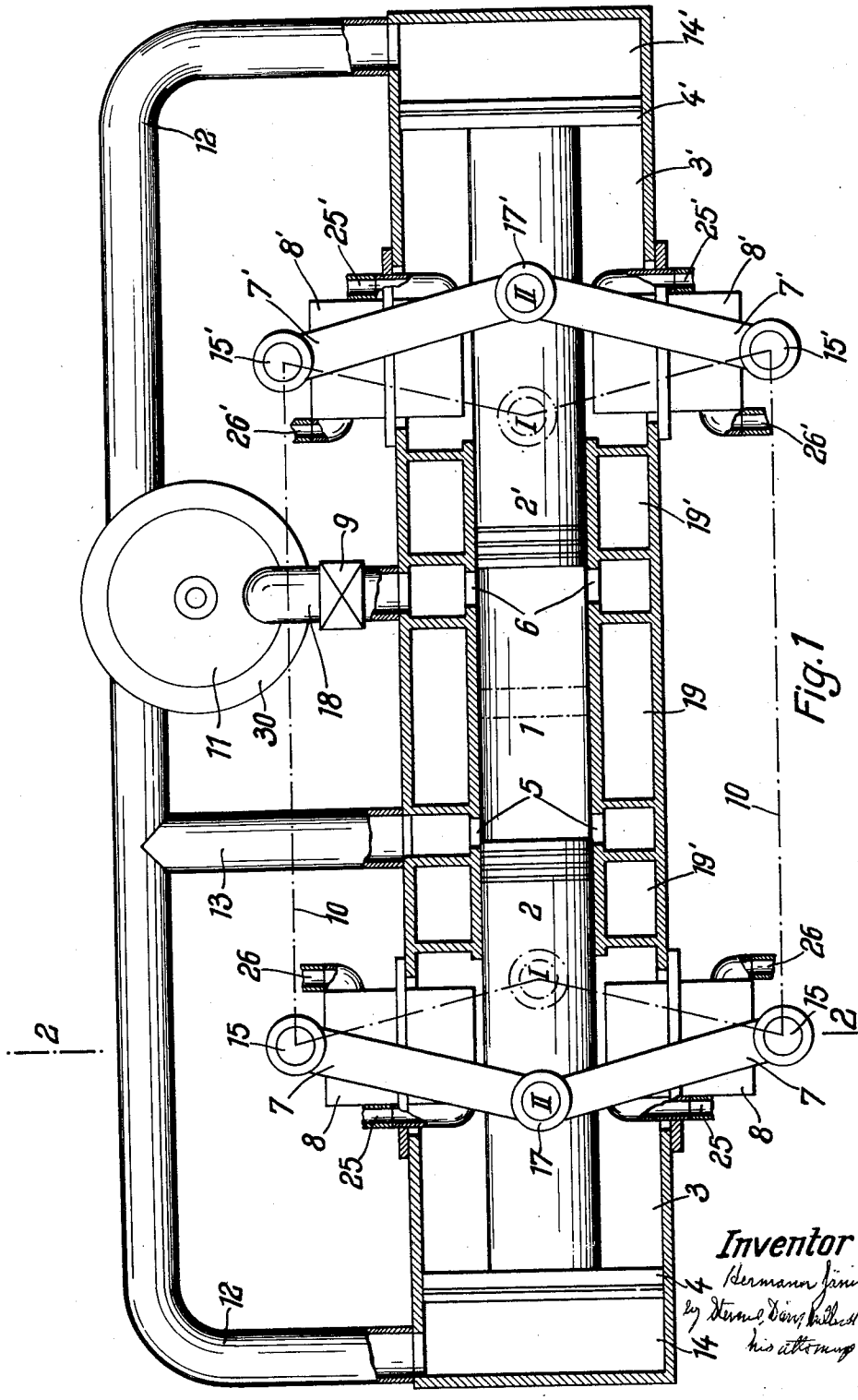

Fig. 1

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Filed June 17, 1957 3 Sheets-Sheet 2

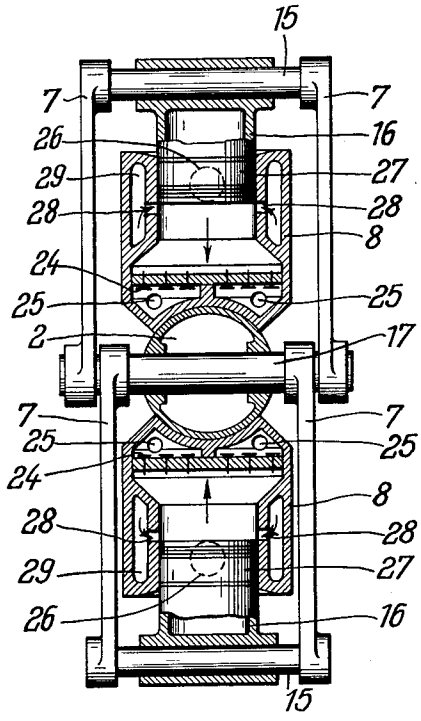

Fig. 2

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May 1, 1962 H. JANICKE 3,031,972

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Filed June 17, 1957 3 Sheets-Sheet 3

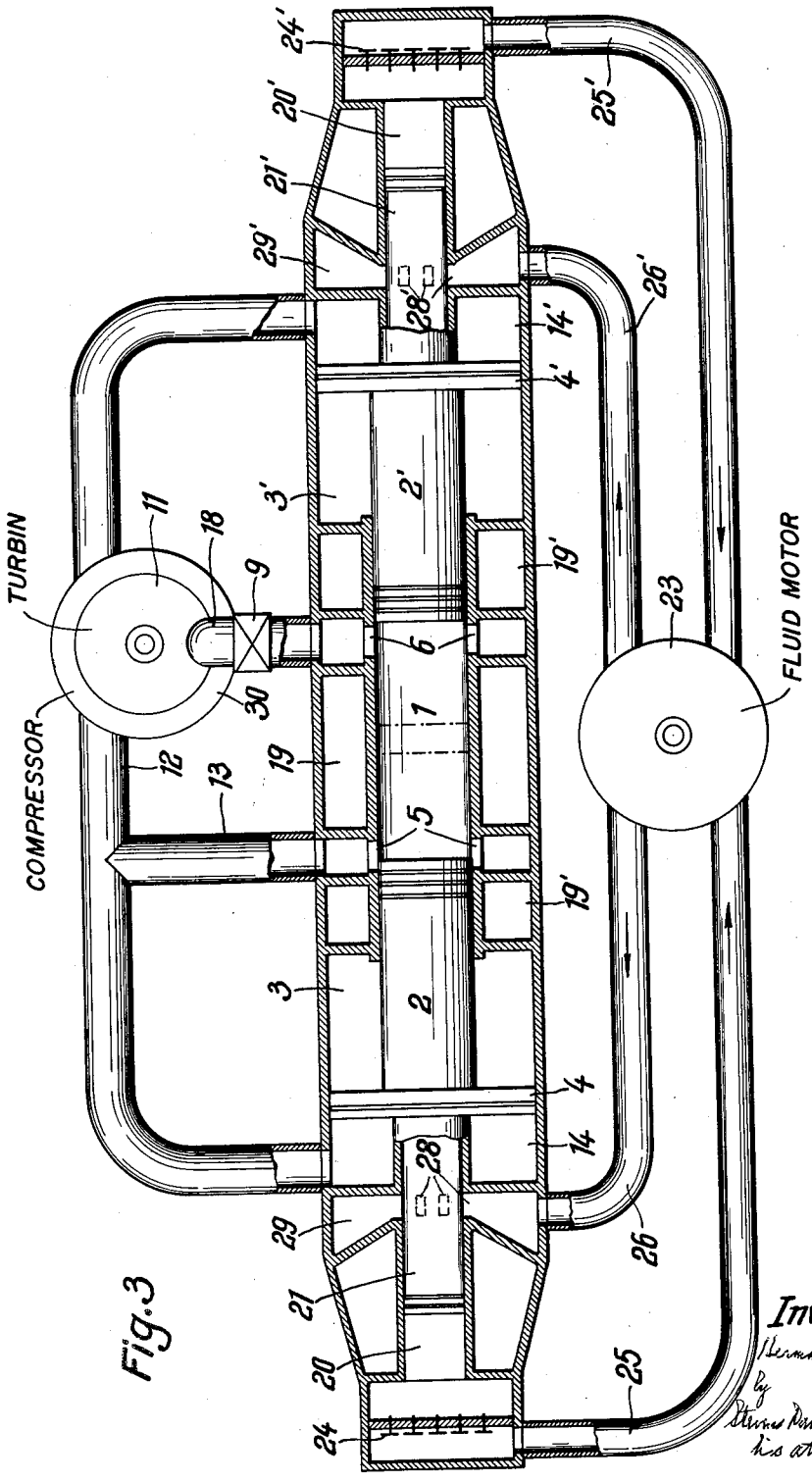

Fig. 3

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FREE PISTON ENGINE DRIVEN PUMP ASSEMBLY

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6 Claims. (Cl. 103—54)

The present invention relates to a free piston engine driven pump assembly which is coupled to a fluid pump for driving the same.

Free piston internal combustion engines in which the free pistons are rigidly connected to a piston of a fluid pump so as to drive the same coaxially thereto are already known in the art. The pump piston of such machines carries out a pumping operation along the entire path of movement of the free piston. This constitutes a disadvantage insofar as the engine can thus not be operated while running idle when the pump is not supposed to convey any fluid.

The present invention overcomes this deficiency and permits a free piston engine to run idle and then to interrupt the conveying action of the pump entirely. This is of importance, for instance, if the fluid conveyed by the pump is to be used for driving a hydraulically operated motor, for example, for operating a vehicle. It is in such cases not possible to stop the vehicle by stopping the free piston engine. Although the vehicle could be stopped by the engagement of a clutch between the wheels and the hydraulic motor even through the motor might continue to run, such a clutch constitutes an additional element which is subject to wear and breakdowns, and which may, according to the invention be omitted entirely.

The present invention consists in the provision of means for preventing the pump from conveying any fluid to the hydraulic motor during that part of the stroke of the pump piston which corresponds to the idling operation of the free piston. These means may consist, for example, in arranging the intake openings in the pump cylinder in such a manner that they will not be passed by the pump piston until the free piston has completed its idling stroke. These means may also consist of a valve leading into the fluid return conduit and, for example, of mechanical means for holding the valve in the open position during that part of the stroke of the pump piston which corresponds to the idling operation of the free piston, and for closing the valve during the remainder of the stroke of the pump piston.

By interrupting the conveyance of fluid to the hydraulic motor during that stroke portion of the pump piston which corresponds to the idling operation of the free piston, the further advantage will be attained that the torque produced by the hydraulic motor may be controlled solely by the quantity of fuel supplied to the internal combustion engine, since the fluid pressure produced by the pump and thus also the torque produced by the hydraulic motor are directly dependent upon the fuel quantity.

The driving connection between the free piston and pump piston is preferably to be designed so that the total stroke of the pump piston is smaller than that of the free piston and that during the idling operation of the internal combustion engine the pump piston will move through a relative short distance, while after the free piston has completed its idling stroke, the path of movement of the pump piston will continuously increase relative to such idling stroke. In other words, during the idling and working strokes of the free piston and pump piston, the ratio between the distance passed by the free piston and the distance passed by the pump piston should at first be high and should be thereafter reduced. This may be attained, for example, by mounting the pump pistons so as to carry out their pumping stroke in a direction at an angle relative to the free piston so as to move inwardly, that is, toward the axis of the internal combustion engine, and by connecting both pistons to each other by connecting rods which are pivotally secured to the two pistons. For avoiding the action of larger lateral forces upon the free piston, the same is preferably associated with a pair of pumps which are arranged at opposite sides thereof.

For returning the free pistons, the same are usually connected to pistons which run in air-filled cylinders and compress the air during the outward stroke of the free pistons, and which again pass off the energy accumulated during the return stroke of the free pistons.

According to another feature of the present invention, the clearance volume of the air cylinders is enlarged to such an extent that the compression ratio in these cylinders will be low. Furthermore, the initial pressure in the air cylinders is preferably made higher than the atmospheric pressure. This may be attained by a compressor which may be operated, for example, by an exhaust-driven turbine which may be the same compressor as that which furnishes the necessary scavenging and combusition air for the free piston combustion engine.

Two preferred embodiments of the invention are illustrated in the accompanying drawings, in which—

FIG. 1 shows a diagrammatical elevation, partly in cross section, of a free piston internal combustion engine, in which each of the free pistons is connected to a pair of pump pistons which are movable at a right angle relative to the free pistons;

FIG. 2 shows a cross section taken along line 2—2 of FIG. 1 and with the pump pistons being in the position corresponding to the inner dead-center position of the free pistons; while

FIG. 3 shows a view similar to FIG. 1 of a modification of the invention in which the pump pistons form coaxial extensions of the free pistons.

In the embodiment of the invention as shown in FIG. 1, the internal combustion engine comprises a cylinder 1 in which the two free pistons 2 and 2' operate in opposite directions to each other. Cylinder 1 is surrounded in the usual manner by cooling chambers 19 and 19'. Toward each outer end of the engine, cylinder 1 merges into a larger cylinder 3 or 3', respectively, in which a piston 4 or 4' which is rigidly connected to piston 2 or 2', respectively, is movable coaxially thereto.

Cylinder 1 of the combustion engine is provided with slots 5 for supplying the scavenging and combustion air and also with exhaust slots 6.

The combustion engine is further associated with two pairs of pumps 8, 8 and 8', 8' which are to be driven either by the free piston 2 or the free piston 2' and are to supply a hydraulic apparatus, for example, a hydraulic motor, with a pressure fluid through a conduit 25 or 25', respectively. The fluid return to pumps 8, 8 or 8', 8', respectively, passes through conduits 26 or 26' and an annular chamber 29 or 29' to the intake slots 28 or 28' of each pump cylinder. The individual pumps of each pair, as shown diagrammatically in FIG. 1 and in cross section in FIG. 2, are located at opposite sides of each free piston 2 and 2', their axes extend at right angles to the latter, and their pistons 27 are connected to free pistons 2 and 2' by means of connecting rods 7, 7 and 7', 7', respectively. These connecting rods 7, 7 and 7', 7' are pivotally connected to the piston rods 16 of the piston pumps by means of wrist pins 15, 15 and 15', 15', respectively, while their other ends, as shown in FIGS. 1 and 2, are pivotally connected to a pin 17 or 17', respectively, which extends through free piston 2 or 2', respectively. The working stroke of pistons 27 of pumps 8, 8

or 8', 8' is in each case directed inwardly, that is, toward the axis of cylinder 1 and free pistons 2, 2'. Slots 28 in the cylinder walls of pumps 8, 8' are disposed in such a position that the pump pistons 27 will not pass beyond the same until the free pistons 2, 2' have arrived at the end of their idling strokes.

If, after the fuel supplied into the space in cylinder 1 between the free pistons has been ignited, the latter move from their innermost position, as indicated in dotted lines, in opposite outward directions, connecting rods 7, 7 and 7', 7', respectively, first pivot from position I, as indicated in dotted lines, in a toggle motion through the dead center position to position II. At this time, free pistons 2, 2' have arrived substantially at the end of that stroke which they carry out when the combustion engine is running idle. The pivotal movement of connecting rods 7, 7 and 7', 7' from position I to position II corresponds to the distance of travel of pistons 27 of the two pairs of pumps 8, 8 and 8', 8', respectively, which is outwardly directed between position I and the dead-center position of the connecting rods and inwardly between such dead-center position and position II. When the connecting rods are in the last-mentioned position, pump pistons 27 have just passed slots 28 so that up to this point there will only be a small fluid movement through slots 28 first in the outward and then in the inward direction. It is therefore proper to say that the combustion engine and the pumps are running idle during a pivotal movement of the connecting rods up to position II. If the two pairs of pumps 8, 8 and 8', 8' should really start to convey fluid, it is only necessary to supply a larger quantity of fuel to the combustion engine. If the free pistons 2, 2' are thereby moved further outwardly, connecting rods 7, 7 and 7', 7' pivot more or less beyond position II and the pump pistons place the fluid in the pump cylinders beyond slots 28 under pressure whereby the fluid will then be conveyed through check valves 24 and conduits 25, 25' to the hydraulic motor. The more the connecting rods pivot beyond position II, the greater will be the reduction of the ratio between the length of the strokes of the free pistons and the pump pistons.

If, during their working stroke, the free pistons 2, 2' move outwardly in opposite directions, pistons 4 and 4' which are connected thereto will compress the air contained in chambers 14, 14' of cylinders 3 and 3' in front of pistons 4 and 4', respectively. The compressed air then causes the return of pistons 4 and 2, and 4' and 2', respectively, to their starting position, as indicated in dotted lines.

In order to enlarge the clearances of air cylinders 3 and 3' so that a low compression ratio will be attained therein, these clearances are connected to a conduit 12 which, in turn, may be connected to an additional receiving chamber, not shown. It is also advisable to maintain the initial pressure in the chambers of cylinders 3, 3' in front of pistons 4, 4' above the atmospheric pressure. This may be done by means of the compressor 30 which supplies the scavenging and combustion air through conduit 12, conduit 13, and slot 5, and which is driven by an exhaust-driven turbine 11. This turbine is driven by the exhaust gases of the combustion engine which are supplied thereto through the exhaust slots 6, a pressure-maintaining valve 9, and conduit 18. During the operation of the combustion engine, the pressure in conduit 12 and in chambers 14, 14' of cylinders 3, 3' should preferably be maintained as constant as possible. Conduit 12 may also be connected to an air tank or the like for balancing any variations in pressure.

A synchronous operation of free pistons 2, 2' may be insured by providing a gear coupling, not shown, for example, in the form of a rack-and-pinion gear, or by providing a hydraulic coupling between the two pistons 2 and 2'.

Lateral forces on the pump pistons may be avoided by providing the connecting rods 10 and 10', as shown in dotted lines, between wrist pins 15 and 15' of the two pairs of connecting rods 7, 7 and 7', 7', respectively.

The modification of the invention as illustrated in FIG. 3 is substantially similar to the embodiment shown in FIG. 1, and similar parts are therefore identified by the same reference numerals. However, this modification differs from FIG. 1 insofar as the pump pistons 21, 21' are connected coaxially to free pistons 2 and 2' and to the air compressor pistons 4 and 4', respectively, which are provided for returning the free pistons. Pump pistons 21, 21' operate in cylinders 20, 20', respectively, which communicate through slots 28, 28' with an annular chamber 29 or 29' surrounding the respective cylinder. The clearance of cylinder 20, 20' in front of piston 21 or 21', respectively, is connected through check valves 24, 24' with a pipe line 25, 25' leading to the hydraulic motor 23 for supplying the same with pressure fluid. Conduit 26 or 26' which returns the pressure fluid from the discharge side of the hydraulic motor 23 to pump cylinder 20 or 20', respectively, terminates into chamber 29 or 29', respectively, which communicates through slots 28 or 28' with pump cylinder 20 or 20', respectively.

When free pistons 2, 2' move outwardly from their inner position as shown in dotted lines, the open fluid circuit leading through the hydraulic motor and slots 28, 28' and cylinder 20 or 20' will obviously prevent the fluid from being conveyed by pistons 21, 21' to the hydraulic motor until these pistons pass beyond slots 28, 28' and thus interrupt the open fluid circuit through the hydraulic motor and slots 28, 28'. Also, in this case, the pump pistons therefore do not convey the fluid to the hydraulic motor at the very beginning of their outwardly directed stroke but only after they have passed a certain distance which corresponds substantially to the idling stroke of the free pistons of the combustion engine.

I claim:

1. A free piston engine driven pump assembly comprising, a free piston internal combustion engine including at least one cylinder having a free piston working therein, at least one fluid pump adapted to supply operating fluid and including a pump cylinder and piston, means transmitting the operating stroke of the free piston to the pump piston and means for preventing the pump piston from supplying any fluid during the initial part of its stroke corresponding to the idling operation of the free piston, said pump having an intake line and said last means including intake means in the pump cylinder connected with the intake line and arranged in the pump cylinder in a manner so that the pump piston does not pass over them until after the free piston has completed its idling stroke.

2. A free piston engine driven pump assembly comprising, a free piston internal combustion engine including at least one cylinder having a free piston working therein, at least one fluid pump and including a pump cylinder and piston, means transmitting the operating stroke of the free piston to the pump piston and means for preventing the pump piston from supplying any fluid during the initial part of its stroke corresponding to the idling operation of the free piston, said last means including outlet means for the operating fluid from the pump cylinder, valve means controlling the outlet means and intake means in the pump cylinder and arranged in the pump cylinder in a manner so that the pump piston does not pass over them until after the free piston has completed its idling stroke.

3. A free piston engine driven pump assembly comprising a free piston internal combustion engine including at least one cylinder having a free piston working therein, at least one fluid pump and including a pump cylinder and piston, means transmitting the operating stroke of the free piston to the pump piston and means for preventing the pump piston from supplying any fluid during the initial part of its stroke corresponding to the idling operation of the free piston, said last means in-

cluding a fluid circuit extending from the pump cylinder, said circuit including fluid lines connected to the pump cylinder by openings in the cylinder, check valve means operatively mounted in one opening and said pump piston closing off the other opening after completion of the idling stroke of the free piston so as to interrupt the open fluid circuit, said pump piston being unable in its initial stroke, corresponding to the idling stroke of the free piston, to close off such opening whereby, during such idling stroke, no operating fluid is effectively transmitted.

4. A free piston engine driven pump assembly comprising, a free piston internal combustion engine including a cylinder having oppositely working free pistons disposed therein, pump means operatively connected with the cylinder and including pump cylinders having pump pistons working therein, means transmitting the stroking power of the free pistons to the pump pistons for supplying operating fluid, and means preventing the pumps from supplying any operating fluid during the first part of the stroke of the pump pistons which corresponds to the idling operation of the free pistons, said pump cylinder being disposed normal to the engine cylinder, connecting rods pivotally connected between the free pistons and the pump pistons to constitute the power transmitting means and said last means including fluid lines extending from the pump pistons and communicated by openings in the cylinder walls with the cylinders, said openings being arranged so that the pump pistons do not pass over them until the free pistons have completed their idling strokes.

5. A free piston engine driven pump assembly comprising, a free piston internal combustion engine including a cylinder having oppositely working free pistons disposed therein, pump means operatively connected with the cylinder and including pump cylinders having pump pistons working therein, means transmitting the stroking power of the free pistons to the pump pistons for supplying operating fluid, and means preventing the pump means from supplying any operating fluid during the first

part of the stroke of the pump pistons which corresponds to the idling operation of the free pistons, said pump cylinders being coaxially aligned with the engine cylinder and disposed at opposing ends thereof and said last means including fluid circuits extending from the pump cylinders and including openings arranged in the pump cylinders so as to be open during the first part of the strokes of the pump pistons, corresponding to the idling strokes of the free pistons, and provide open fluid circuits and so as to be closed by the pump pistons, during the latter portion of their stroke, when the operation is effective to supply operating fluid from the pump means.

6. A free piston engine driven pump assembly comprising, a free piston internal combustion engine including at least one cylinder having a free piston working therein, at least one fluid pump and including a pump cylinder and piston, means transmitting the operating stroke of the free piston to the pump piston and means for preventing the pump piston from supplying any fluid during the initial part of its stroke corresponding to the idling operation of the free piston, said pump having an intake line and said last means including intake means in the pump cylinder connected with the intake line and a valve in the intake means and means for holding the valve in the open position during that part of the stroke of the pump piston which corresponds to the idling operation of the free piston and for closing the valve during the remainder of the stroke of the pump piston.

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