May 22, 1962 O. M. KÄSTNER 3,035,524

PUMP FOR CONVEYING CONCRETE OR OTHER VISCID MASSES

Filed April 8, 1958 3 Sheets-Sheet 1

Fig. 1

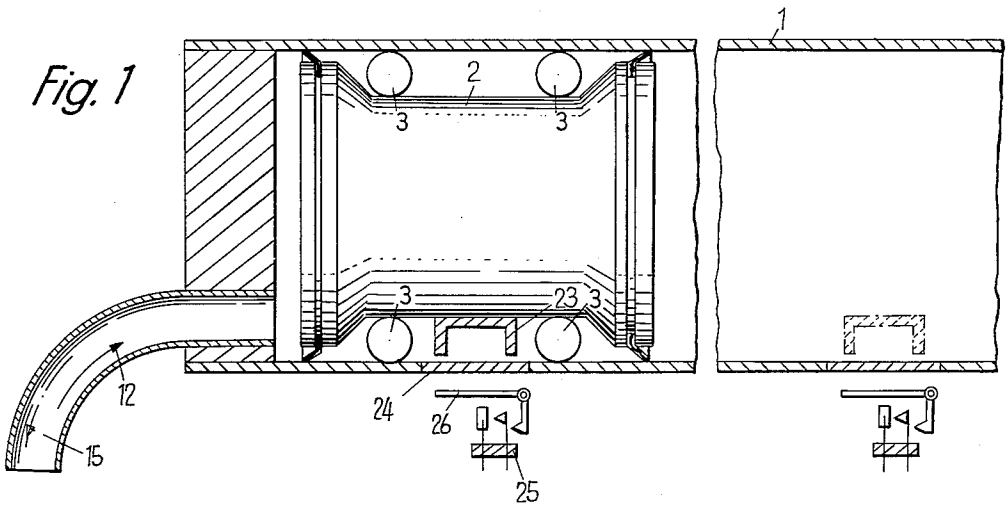
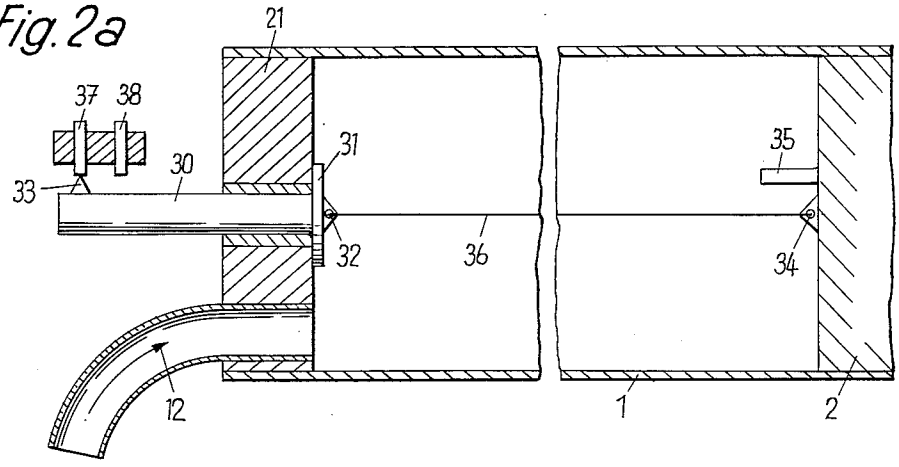


Fig. 2a



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Filed April 8, 1958 3 Sheets-Sheet 2

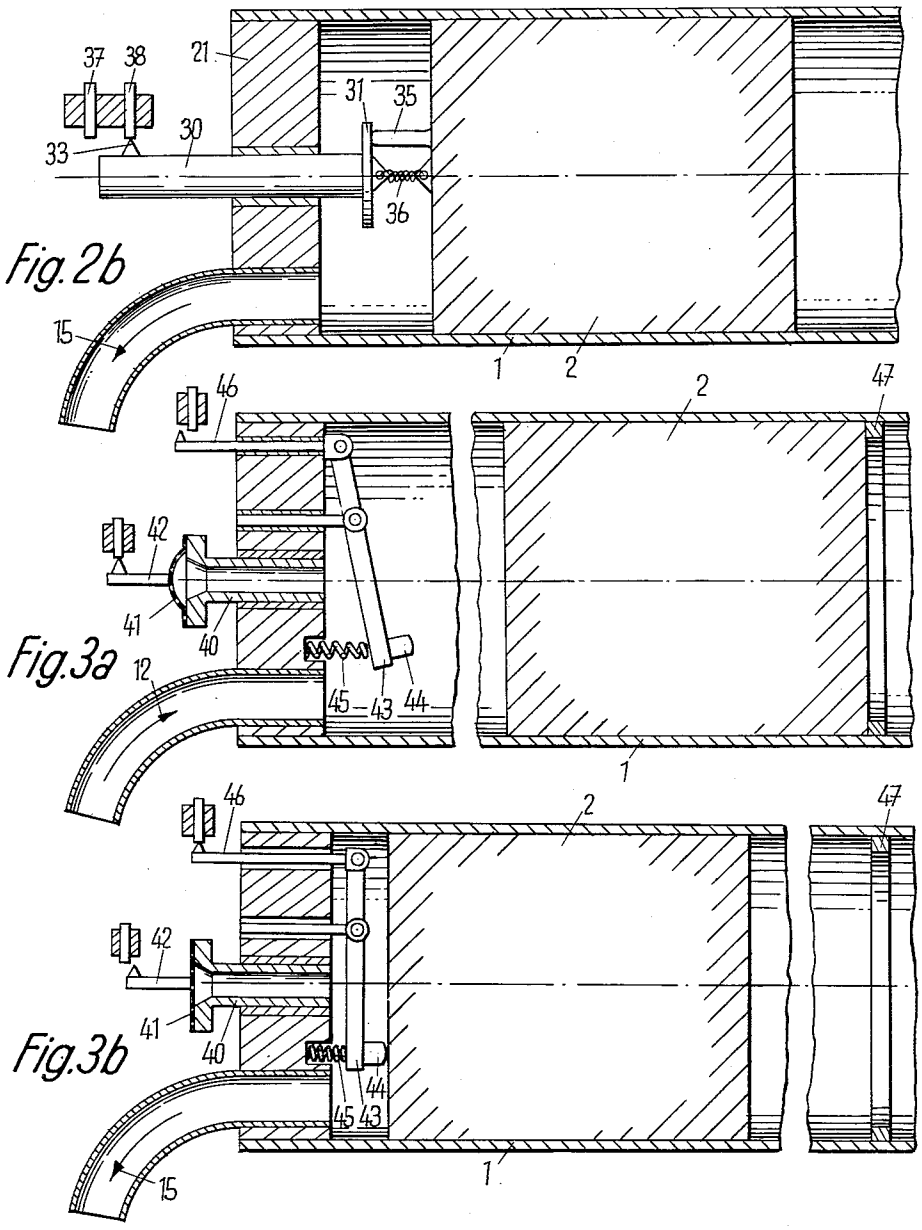

Fig. 2b

Fig. 3a

Fig. 3b

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PUMP FOR CONVEYING CONCRETE OR OTHER VISCID MASSES

Filed April 8, 1958 3 Sheets-Sheet 3

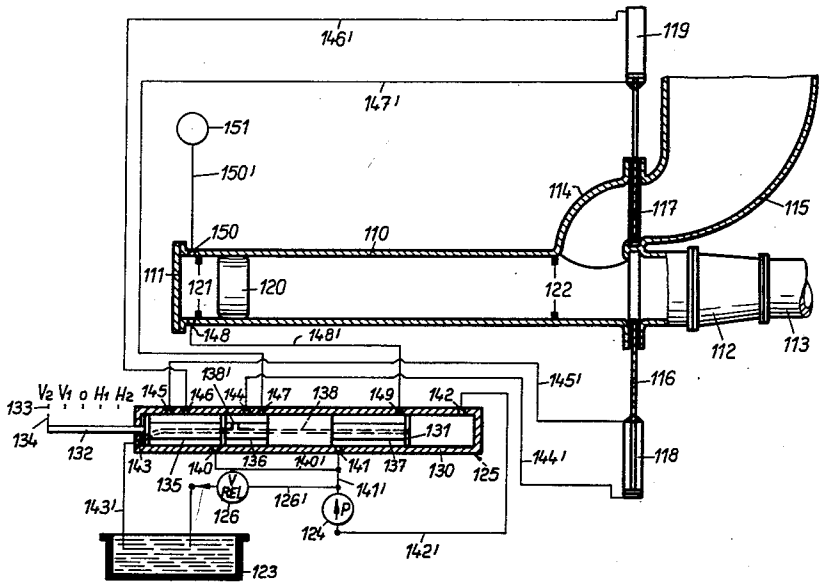

Fig. 4

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United States Patent Office 3,035,524 Patented May 22, 1962

3,035,524

PUMP FOR CONVEYING CONCRETE OR OTHER VISCID MASSES

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Filed Apr. 8, 1958, Ser. No. 727,142
Claims priority, application Germany May 23, 1957
1 Claim. (Cl. 103—52)

The invention relates to pumps, and relates more particularly to pumps for conveying viscid masses, such as concrete, grout, or the like.

Mixed concrete is not a homogeneous substance, but a pulp-like mass that includes not only stones of different sizes but also air in the form of bubbles, and is to a certain extent compressible. To convey concrete through pipes or hoses over great heights and distances has proved to be a difficult problem, as the mixed concrete mass wears out the walls of the conveyor pipe.

Much work has been done in the past decades in the endeavor to solve the problem.

Two methods have been employed for mechanically conveying concrete through a conveyor pipe. According to one method, concrete is subjected directly to the effect of compressed air in such a way that the concrete is pressed forward or is sucked by an air current. According to the other method piston pumps are used for pressing the concrete periodically through the conveyor pipe. If the first method is used, the concrete moves at a considerable speed which, as a result of the abrasive and knocking effects of the substance conveyed, destroys the conveyor pipe within a very short time and, in the past has caused accidents. If the second method is applied, a piston pump operating with short strokes (approximately 48 strokes per minute) is used, which causes frequent acceleration and retardation of the concrete mass column in the conveyor pipe and correspondingly high speed peaks. As a result, clogging and segregation occur because the stones are retarded relative to the mass of the concrete. They are the more retarded the greater and heavier they are. Furthermore, the efficiency is very low since as a result of the frequent compression and expansion of the grout a large portion of the driving power is consumed for the compression and thus is lost for use in conveying power.

In order to overcome these difficulties, the inventor has designed a pump having a long stroke suitable for conveying grout or concrete or similar viscid masses (U.S. Patent No. 2,797,645, German Patents 938,521 and 944,286, French Patent 1,103,605 and United Kingdom Patent 755,677). This pump includes a freely movable or freely flying piston, namely a piston without a piston rod, the driven side of which is subjected alternately to the compression and suction effects of a driving medium, for instance water, while its driving side exerts alternately a compression effect and a suction effect on the substance to be conveyed, for instance the concrete mass. Control valves make certain that the driven side of the piston is subjected alternately to the compression and suction effects of the driving medium by, for instance, connecting the driven side of the piston alternately to the compression side and to the suction side of a pump for the pressure medium, for instance of a centrifugal pump for water. Other controlled elements, for instance slide valves, simultaneously cause the driving side of the piston to be connected alternately to a suction pipe and to a discharge pipe for the concrete conveyed. Preferably, the valves for the driving medium and the slide valves for the substance conveyed are displaced by servomotors which in turn are reversed by a central control device.

The last mentioned method of conveying concrete is considerably improved by this new pump. This success is based on the interaction of the following details:

(1) The stroke of the piston is of considerable length so that in particular the delivery stroke may be correspondingly slow, and an over-frequent and over-sudden acceleration of the grout column is avoided (for instance between one and two strokes per minute).

(2) The considerable length of the stroke is rendered possible in a very favorable way by using a freely flying piston which, in view of the horizontal arrangement of the cylinder made necessary in view of its great length, is provided with roller guides, so that in spite of the increased weight of the piston the packing around the piston covers the piston evenly and thus makes certain that a reliable and durable seal is produced and further that seizing as a result of sliding friction is prevented.

(3) The concrete is conveyed from the cylinder of the pump into the conveyor pipe without its cross-sectional area being constricted, since the diameters of both components hardly differ.

(4) Even the valve required between the cylinder and the conveyor pipe does not cause any considerable constriction or increase of resistance, since wide orifices are provided for sucking and discharging the grout. These orifices may be sealed with the aid of slide valves blocking the pump in a direction transverse to the direction of delivery, and these slide valves are adjusted by servomotors rather than by the compression or suction effect of the piston.

(5) To make certain that the slide valves operate under the most favorable conditions, the servomotors are reversed in dependence on the actuation of the valve arrangement by which the driving side of the cylinder is connected alternately to the compression and suction sides of the pressure-medium pump for driving the freely flying piston.

If in such a pump the freely movable piston and the valves for the driving medium and the side valves for the substance to be conveyed are reversed by means of time switches, the resulting reversals at the ends of the strokes of the piston are not reliable, because if plastic masses such as concrete are conveyed the duration of the delivery strokes differs due to the varying consistency of the mass.

It is among the objects of the invention to overcome this difficulty, and to arrange that the freely movable piston when reaching its two end positions actuates electric switches which reverse the piston. Thus, the piston is always reversed at the appropriate moment irrespective of the duration of the stroke of the piston and without any loss of time or waste of power for the pump.

In a preferred embodiment of the invention the piston when reaching the end positions of its stroke magnetically actuates electrical switching devices arranged outside the cylinder. For this purpose the piston is provided with a permanent magnet which at each end of the piston stroke actuates through the cylinder wall suitable magnetic armatures and thus causes the electrical switching devices to operate. If as usual the cylinder wall consists of steel, non-magnetic bodies are inserted at suitable positions in the cylinder wall. These non-magnetic bodies permit an unimpeded passage of the magnetic flux of the permanent magnet to the electrical switching devices or the magnetic armatures.

In another embodiment of the invention the piston when reaching the end positions of its stroke mechanically actuates either directly or indirectly a switching device arranged inside or outside the cylinder. For this purpose, the piston may be coupled to a member which actuates the electrical switching device and which, possibly, extends through the cylinder. For instance, the piston at the one end position of its stroke may displace either directly or with the aid of a lever a reciprocatable actuating member, for instance a tappet guided in the cylinder base, and at the other end position of its stroke

may displace said member with the aid of a pulling member, possibly with the aid of a cord.

The invention further provides that the increased pressure of the driving medium occurring at the end of the compression stroke on the driving side of the cylinder is used for reversing. For this purpose there is provided according to a further embodiment of the invention in the cylinder wall or in the cylinder base a diaphragm which at the end of the delivery stroke actuates the electrical switching device for reversing. As previously described, the reversal at the end of the suction stroke may be effected mechanically. There may, however, be provided instead a diaphragm which is actuated by the reduction of pressure at the end of the suction stroke and which as a result thereof actuates the electrical switching device for reversing. The switching device may be arranged inside or outside the cylinder. A sealed diaphragm case housing the contact device may be arranged inside or outside the cylinder.

Some of the embodiments of the invention are by way of exemplification described below and illustrated in the drawing, in which

FIGURE 1 is a fragmentary schematic longitudinal sectional view of a conveyor pump with a piston and electrical reversal means initiated magnetically in accordance with a first embodiment of the invention;

FIGURE 2*a* is a fragmentary sectional view, similar to FIGURE 1, but embodying a modification wherein the electrical reversal of the piston is initiated mechanically, showing the piston near one end position;

FIGURE 2*b* is a fragmentary sectional view similar to FIGURE 2*a*, but showing the piston near the opposite end position;

FIGURE 3*a* is a fragmentary sectional view, similar to the preceding views, but illustrating a further modification of initiation of the electrical reversal of the piston by means of a diaphragm, and illustrating the piston near one end position;

FIGURE 3*b* is a fragmentary sectional view similar to FIGURE 3*a*, but showing the piston near the opposite end position; and

FIGURE 4 is a fragmentary sectional view of a conveying pump of the type in connection with which the instant invention may be used.

In carrying the invention into effect in the embodiments which have been by way of example illustrated in the drawings and which are described below, a freely movable piston **2** moves in a cylinder **1** in all embodiments illustrated. The cylinder **1** may be composed of steel. The left-hand side of the piston **2** is subjected to a compression or suction effect of a driving medium, for instance water, which is impelled or expelled in the direction of the arrows **12** and **15** respectively. The right-hand side of the piston acts upon the substance to be conveyed, for instance grout.

Referring to FIGURE 1, the piston **2** is supported in the cylinder **1** by antifriction members such as wheels or rollers **3**, and carries a permanent magnet **23** which in each end position of the piston is located opposite a plate **24**. This plate **24** is inserted into the cylinder **1** and, in contrast to this cylinder, is composed of a non-magnetic material such as aluminum, a copper alloy or other suitable non-magnetizable material. A switching device **25** is arranged outside the cylinder in front of each plate **24**. The switching device **25** is provided with an armature **26** in such a way that, as a result of the effect of the magnetic field of the permanent magnet **23** on the armature **26**, the switching device **25** is actuated. Due to the actuation of the switching device **25**, a control device is operated either directly or through a relay or through an amplifier, and thus the compression and suction medium for driving the piston is reversed and, possibly simultaneously, the control elements for the substance to be conveyed are actuated.

In the embodiment illustrated in FIGURES 2*a* and 2*b* a contact tappet **30** is guided in the cylinder base **21**. The tappet **30** is provided outside the cylinder with a cam **33** for actuating a switching device **37**, **38** and is provided inside the cylinder with a head in the form of a flange **31** and with an eye **32**. Correspondingly, the piston **2** is provided with a trip pin **35** and an eye **34**. The eyes **32** and **34** are connected by a thin cord **36** that may be composed of steel, nylon or of a similar flexible material.

The operation of the aforedescribed exemplified embodiments is as follows: If, as illustrated in FIGURE 2*a*, the driving medium flows in the direction of the arrow **12** into the cylinder **1**, the piston **2** is pushed forward while as a result of the internal pressure in the cylinder the flange **31** is retained against the cylinder base **21**. When the piston **2** approaches its right-hand end position, the cord **36** is tensioned and pulls the tappet **30** towards the right-hand side into the position illustrated in FIGURE 2*b* as a result of which the cam **33** moves from the contact arm **37** to the contact arm **38** and thus actuates the control device. As a result thereof, the valves for the driving medium are reversed so that the suction stroke is started and the driving medium previously impelled into the cylinder is expelled in the direction of the arrow **15** as illustrated in FIGURE 2*b*.

When the piston approaches its left-hand end position, the pin **35** arranged in the piston presses against the flange **31** of the tappet **30** and pushes the latter with its flange to the cylinder base **21** as illustrated in FIGURE 2*a*. As a result, the cam **33** moves from the contact arm **38** to the contact arm **37** and again actuates the control device in such a way that the piston is reversed from a suction stroke to a compression stroke.

The mechanical actuation of the electrical switching device may be modified in many ways. For instance, the cord may project beyond the cylinder. Further, a winding device for the cord may be provided inside or outside the cylinder.

The rotation of the winding device may be utilized to actuate the switching device. While a cord is particularly advantageous for coupling the piston to the actuating members in the event of long strokes of for instance 3 m., it may be replaced by a rigid coupling in the event of shorter strokes. The actuating member may also be arranged to pivot and may be located either entirely inside the cylinder or may project through its wall or its base.

In the embodiment illustrated in FIGURES 3*a* and 3*b* a diaphragm **41** is arranged in front of an orifice **40** in the cylinder base. This diaphragm actuates a contact tappet **42**. A lever **43** is pivotally mounted on the inside of the cylinder base. One end of the lever **43** is provided with a cam **44** and is biased by a spring **45**, and the other end of the lever actuates a contact tappet **46**.

At the end of the compression stroke of the piston, which is limited by stops **47**, the diaphragm **41** as a result of the increase in pressure bends, as illustrated in FIGURE 3*a*, and thus displaces the tappet **42**. At the end of the suction stroke the piston reverses the lever **43** as illustrated in FIGURE 3*b* and thus adjusts the tappet **46**. As a result, a circuit is closed or interrupted at the end of each stroke. Whenever the circuit is closed or interrupted, the control device is actuated and the piston is reversed.

The pump illustrated in FIG. 4 of the drawings comprises a cylinder **110** closed at one end by a disc **111** and preferably inclined upward towards its other end at which the cylinder is connected to a tapered pipe section **112** attached to a conveyor pipe **113**. Near said other end the cylinder **110** is provided with a branch pipe **114**, by which it communicates with a container **115** for the mass to be conveyed by the pump. The communication between the cylinder **110** on one hand and the pipe **113** and the container **115** on the other is controlled by valves **116** and **117**, respectively, said valves being displaceable between open and closed positions by hydraulic servo-motors **118**

and 119, respectively. The cylinder 110 contains a piston 120 which is freely movable axially therein and in its end positions engages stops 121 and 122, respectively. The piston 120 is adapted to be reciprocated in the cylinder by a medium which is forced into and drawn off from the space of the cylinder 110 between the piston 120 and the disc 111.

As seen in FIG. 4 this is accomplished by a hydraulic system which is also connected with the hydraulic servo-motors 118 and 119, respectively, of the two valves 116 and 117. The hydraulic system comprises a reservoir diagrammatically shown at 123, a hydraulic reciprocating machine such as a pump 124, a control valve 125, and a relief valve 126 connected with one another and with the cylinder 110 and the servo-motors by pipes, shown as lines only. The hydraulic medium is preferably water.

The control valve 125 is of the sliding type and comprises a cylindrical valve housing 130 with a reciprocable slide valve 131 therein, said slide valve being connected with an operating bar 132 for manually reciprocating the slide valve, said bar extending through an opening in one end of the valve housing 130. There are five different positions for the slide valve 131 which in FIG. 4 of the drawing are indicated by a scale 133 and designated V2, V1, O, H1, and H2, an index 134 on the bar 132 being adapted to indicate the actual position of the slide valve 131. In FIG. 4 the slide valve is in its extreme left hand position V2. The slide valve 131 is formed with three annular grooves 135, 136, and 137 and is provided with an axially extending duct 138 permanently communicating with the groove 136 at 138' and with the interior of the valve housing 130 at the ends of the slide valve 131. The outlet of the pump 124 is connected with openings 140 and 141 in the valve housing 130 by pipes 140' and 141' and to the reservoir 123 by a pipe 126', the water flowing through the pipe 126' being controlled by the relief valve 126 therein. The inlet of the pump 124 is connected with an opening 142 in the valve housing 130 by a pipe 142'. One end of the housing 130 also communicates with the reservoir 123 through an opening 143 and a pipe 143'.

By openings 144 and 145 in the housing 130 and pipes 144' and 145' connected therewith the control valve is connected with the servo-motor 118 and by openings 146 and 147 in the housing 130 and pipes 146' and 147' with the servo-motor 119 for delivering water to and draining off water from the cylinders of the respective servo-motors on both sides of the piston of the servo-motor. The cylinder 110 is connected with an opening 149 in the housing 130 by an opening 148 in the cylinder wall and a pipe 148' and with a pressure gauge 151 by an opening 150 and a pipe 150', said gauge being arranged to indicate positive and negative pressures in the cylinder 110.

In all positions of the slide valve 131 the groove 135 communicates with the output of the water pump 124 by the opening 140 and the pipe 140'. Assuming the slide valve 131 is in the centre position indicated by O the two servo-motors 118 and 119 are supplied with water under pressure from the output of the water pump 124 by the passages 140', 140, 135, 144, 144', and 140', 140, 135, 146, 146', respectively, at one end of the respective servo-motors, the other end of the servo-motors being connected with the reservoir 123 by the passages 145', 145, 143, 143' and 147', 147, 136, 138', 138, 143, 143', the valves 116 and 117 thus being in their closed positions. The pump 124 is connected to the reservoir 123 by the passages 142', 142, 138, 143, 143'. If the slide valve 131 is displaced to the right as viewed in FIG. 4 to the position designated by H1, the servo-motor 119 is connected to the reservoir 123 by the passages 146', 146, 143, 143' and to the outlet of the pump 124 by the passages 147', 147, 135, 140, 140'. Thereby, the servo-motor 119 is reversed and opens the valve 117. By further displacement of the slide valve 131 to the right into the position designated H2 the inlet of the pump 124 will be connected to the cylinder 110 by the passages 148, 148', 149, 137, 142, 142'. Assuming the piston initially was in its extreme right-hand position engaging the two stops 122 and the cylinder 110 was filled with water in the space between the piston 120 and the disc 111, this water will now be drawn off from the cylinder by the pump 24. Thereby, the piston 120 will be displaced to the left and mass from the container 115 will flow past the open valve 117 and through the branch pipe 114 into the cylinder 110.

When the piston 120 has reached its extreme left-hand position and engages the two stops 121 the slide valve is brought to the centre position, thereby interrupting the drawing off of water from the cylinder 110 and causing the valve 117 to be closed.

If the slide valve 131 is displaced to the left to the position V1 the servo-motor 118 will be connected to the outlet of the pump 124 by the passages 145', 145, 135, 140, 140' and with the reservoir 123 by the passage 144', 144, 136, 138', 143, 143', thereby reversing the servo-motor 118. Thus the valve 116 will be brought to its open position. If the slide valve 131 is displaced to the position V2, shown in FIG. 4 of the drawings the outlet of the pump 124 will also be connected to the cylinder 110 by the passages 141', 141, 137, 149, 148', 148, whereby the piston 120 will be moved to the right into engagement with the stops 122 and force the mass, previously drawn into the cylinder 110, past the open valve 116 into the pipe 113.

The relief valve 126 is adapted to connect the outlet of the pump 124 with the reservoir 123 by the pipe 126' when the pressure in the outlet of the pump 124 exceeds a predetermined value.

The disclosure has been proposed to be amended in the foregoing by the addition, with but minor changes, of one sheet of drawing of the British Patent No. 755,-677/1956, and by the addition of a portion of the text, again with but some minor changes, from said British patent. Since the British patent in its entirety has been printed at the time of the instant application, and originated with the instant inventor (cf. U.S. Patent No. 2,797,645), and has in the instant application as originally filed expressly been made reference to, applicant believes that owing to this form of incorporation by reference, there can not arise any question of new matter.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

Having thus described the invention, what I claim as new and desire to be secured by Letters Patent, is as follows:

In a pump, for use in conveying concrete, or a similar viscid mass, the combination with a reciprocating hydraulic machine and conveyor means having intake and exhaust sides, an elongated cylinder, a freely movable piston reciprocable in said cylinder, first valve means adapted to be actuated to connect one end of the cylinder interior alternately with the pressure side and respectively the suction side of said hydraulic machine for concrete conveyance by one side of said piston, second valve means adapted to be actuated to connect the opposite end of the cylinder interior alternately with the intake and respectively the exhaust sides of said conveyor means, power means for said first valve means for driving said piston in opposite directions alternately by pressure and suction from said machine by the hydraulic fluid thereof applied to the other side of said piston, of control means for said power means and said second valve means and adapted to actuate both said valve means simultaneously comprising a permanent magnet connected to and reciprocable with said free piston and generating a field extending radially beyond the cylinder near the end positions of the cylinder stroke and two electric switches disposed outside said cylinder, each switch including a magnetizable movable member being disposed near an end position of

said piston and being traversed by and actuated by said magnetic field when the piston is near the end of a stroke adjacent said member and operable when actuated to operate said switch, whereby both said valve means will be actuated from said switches when the piston is near the end of each stroke to reverse simultaneously the piston movement and to shift the connection from the cylinder among the two sides of the conveyor means.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,035,524 May 22, 1962

Otto Max Kästner

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 33, beginning with "The disclosure" strike out all to and including "of new matter." in line 44, same column 6.

Signed and sealed this 11th day of September 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents