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(54) OPERATING EQUIPMENT FOR GATE VALVES AND PENSTOCKS

(71) I, JEREMY BARROW CHITTENDEN, of Lyts Cary Manor, Lytes Cary, Somerton, Somerset, a British subject, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to operating equipment for gate valves and penstocks.

According to this invention there is provided in combination, a gate valve or penstock having a reciprocally moveable gate, and operating equipment therefor having a fluid operated cylinder and piston mechanically connected to the gate for the operation thereof, a hydraulic liquid reservoir to supply hydraulic liquid to the cylinder, an inlet for the supply of compressed gas to the equipment, and control means for controlling the gas, control means being operable to deliver gas to pressurize stored hydraulic liquid and cause delivery thereof to the cylinder to move the gate.

A hydraulic circuit is well suited to operation at a controlled rate (though this can be quite fast if desired) and to moving through only part of the available travel. Gas operated equipment is simple and clean but a gas operated piston and cylinder tends to act too rapidly and cannot readily achieve less than its full travel. The combination of gas and hydraulic liquid combines the advantages of both. The most convenient gas is compressed air. Preferably the cylinder and piston is double acting either

(a) with the reservoir supplying hydraulic liquid to one chamber of the cylinder and the control means supplying gas to the other chamber of the cylinder, the control means then being selectively operable to delivering gas to the reservoir and cause delivery of pressurized liquid to the cylinder to move the gate of the penstock or gate valve in one direction, or to deliver gas to the other chamber of the cylinder to move the gate in the opposite direction, or

(b) with a pair of reservoirs supply hydraulic liquid to respective chambers of the cylinder, the control means being selectively operable to deliver gas to one or other reservoir as appropriate and cause delivery of pressurized liquid therefrom to move the gate in whichever direction is desired.

It is preferred that the operating equipment includes a normally closed liquid valve through which hydraulic liquid from the reservoir passes to the cylinder and which is opened upon operation of the control means to allow movement of liquid in response to operation of the control means. The valve may be a gas operated valve, which is supplied with pressurized gas to open it upon operation of the control means.

It is desirable to provide for at least one further operation upon failure of the supply of the compressed gas (e.g. resulting from failure of the electricity supply to an air compressor) and for this the operating equipment may include a reservoir for compressed gas supplied to the equipment, the gas passing from the said inlet to the reservoir through a non-return valve.

The equipment may provide solely for manual control at the site of the penstock or gate valve, in which case the control means, the cylinder and piston, the hydraulic liquid reservoir and the said normally closed valve (if any) may be an assembly mounted on a common supporting structure. It may provide solely for remote operation, in which case the cylinder and piston, the hydraulic liquid reservoir and the said normally closed valve (if any) may be mounted on a common supporting structure, and the control means connected to this assembly by air lines. The operating equipment may include (as part of such an assembly) manual control means at the site of the penstock or gate valve, and also have control means remote from the assembly and connected to it by air lines.

Automatic operation may be provided, using at least one solenoid operated valve in the, or one of the, control means. Automatic operation may, but need not, use control means remote from the penstock or gate valve. With a double acting cylinder and piston a pair of solenoid operated valves is preferred, operation of one solenoid operated valve delivering gas to cause delivery of pressurized hydraulic liquid to one chamber of the cylinder to move the gate in one direction, and operation of the other solenoid operated valve delivering gas to the other chamber of the cylinder or to cause delivery of pressurized hydraulic liquid connected to the other chamber of the cylinder as appropriate to move the gate in the reverse direction.

Automatic operation can be controlled by a time clock or by appropriate sensors detecting for example the level in a tank which has the penstock or gate valve as its outlet. Preferably the control signal from the sensor(s) or timer(s) passes to a sequence timer and starts a sequence of operations consisting of energizing the solenoid concerned, keeping it energized for a predetermined time, and then de-energizing it (or the converse in the case of a normally energized solenoid).

Where a gas reservoir is provided or if the gas supply does not depend on electrical power it can be arranged that if the electrical power supply fails, the gate will be moved to one or other end of its travel whichever is designated as the fail-safe state. For this purpose it is arranged that the solenoid of the valve which operates to move the gate to the fail-safe position is normally energized, and operates if de-energized.

The supply of electricity to the normally energized solenoid may be passed through a pressure-responsive switch connected to the inlet for the supply of compressed gas to the equipment so that the switch is maintained closed by the pressure of the gas supply at the inlet unless this drops below a predetermined value when the switch will open, de-energizing the solenoid so that it operates to move the gate to the fail-safe position, using gas from a reservoir.

This invention may be used as part of apparatus for separating sludge from liquid, and which comprises a settling tank having an outflow pipe leading from a low point of the tank to the penstock or gate valve, this having operating equipment, in accordance with this invention, with sensing or timing means to supply actuating signals to the or the further control means and arranged automatically to give signals to the control means to open and then reclose the valve, to allow outflow of settled sludge from the settling tank through the valve during the interval in which the valve is open.

The penstock or gate valve may be opened periodically in response to signals from a timer, or may be opened in response to a suitable sensor, e.g. a level sensor responsive to the sludge settled in the settling tank rising to an upper limit level. The penstock or valve may remain open for a timed interval, or be closed in response to a signal from a sensor. This may be a sensor detecting whether or not the material at or near the entry to the outflow pipe, or at a chosen point within the outflow pipe, is sludge, or may be a level sensor responsive to the sludge settled in the settling tank falling to a lower limit level. Preferably at least one movement of the penstock or gate valve, either opening or closing, is in response to a sensor.

Embodiments of the invention will now be described with reference to the accompanying drawings wherein:—

Fig. 1 is a diagram of a simple form of operating equipment,

Fig. 2 is a view of an operating equipment,

Fig. 3 is a diagram of operating equipment which has provision for remote operation, and which includes an air compressor,

Fig. 4 is a diagram of operating equipment which has provision for remote operation and a fail-safe provision, and

Fig. 5 is a diagrammatic section of a sewage settling tank, illustrating use of the invention in apparatus for separating sewage sludge.

In the drawings Fig. 1 shows a basic form of operating equipment. It has a double acting hydraulic cylinder 101 which would be mounted above a gate valve or penstock (assuming that the travel of the gate is vertical). The cylinder has a piston 103 and a shaft 105 to be connected to the gate of the gate valve or penstock. The lower chamber 107 of the cylinder is supplied with hydraulic oil from an oil reservoir 109. Its upper chamber 127 contains air. An inlet for a supply of compressed air is provided at 111, and the supply of compressed air is connected through a non return valve 113 to an air reservoir 115, which feeds control means, namely a manual control valve 117 via line 119. This valve has an operating knob with an inoperative normal position, but which can be pushed to either of two positions. The first position is used for raising the gate; the line 119 is connected to the line 121 (and the line 123 is connected to an exhaust port 125 of the control valve). Air from the air reservoir 115 pressurizes the oil reservoir 109 and drives oil into the lower chamber 107 of the cylinder 101. The upper chamber 127 of the cylinder 101 is free to exhaust at port 125. The other operative position of the valve is used for lowering the gate. The line 119 is connected to the line 123 and hence to the upper chamber 127 of the cylinder, while the line 121 is connected to the exhaust port 125 so that air can escape from the oil reservoir 109. In either case the speed of travel of the piston 103, and hence of the gate of the penstock or gate valve, is governed by the rate at which hydraulic oil can be driven along the connection 129 between the oil reservoir 109 and the chamber 107. If desired a flow restrictor can be incorporated in the connection to reduce the speed of travel.

The equipment is suitable for use where the gate of a valve or penstock is normally kept lowered, and the need will be to raise the gate, and keep it fully raised for a fairly short time, so that it is unobjectionable to maintain the hydraulic pressure which raised the gate in order to keep it raised.

The air reservoir 115 holds enough air to move the piston 103 along its full travel in one direction. This guards against the consequences of a failure of the compressed air supply. If it fails after the gate has been moved from its normal position to its abnormal position the air in the reservoir 115 can be used to return the gate to its normal position. On the other hand, if the air supply fails while the gate is in its normal position and it becomes essential to move the gate before the air supply is restored (e.g. to prevent overflow from a tank) the reservoir 115 will provide air for this. An air inlet 131, in the form of a Schrader type tyre valve is provided for the connection of a foot pump as a last resort. "Schrader" is a Registered Trade Mark.

A modification to this equipment is shown by chain dotted lines. A valve 133 (referred to hereafter as a lock valve) is provided between the oil reservoir 109 and the lower chamber 107. The valve is normally closed to prevent the flow of hydraulic oil. However, it is opened if air is supplied along the line 135, and this line is connected via a shuttle valve 137 to each of the lines 121 and 123. The function of the shuttle valve 137 is to connect whichever of the lines 121 or 123 that is pressurized to the line 135; when the control valve 117 is operated either to raise or lower the gate, air is also supplied to the lock valve 133 to open it, and the gate can move. However, when the control valve 117 is returned to its inoperative position the valve 133 closes and prevents oil from flowing into or out of the chamber 107. The valve 133 thus functions to lock the gate at any position at which it comes to rest, and the operating equipment can be used for penstocks and gate valves which it may be desired to open partially, and then hold at the partially open position, or where it is desired to hold the gate fully raised for long periods. It will be appreciated that delivery of oil to the chamber 107 is used at all parts of the gate's travel to effect any and all movement in one direction.

Such an operating equipment is shown in Fig. 2. It has the cylinder 101 disposed centrally, with the oil reservoir 109 at one side of it, and the air reservoir 115 at the other side. All three are mounted on a common supporting structure consisting of a base plate 141 supported on a block 143 through which the shaft 105 (not shown in Fig. 2). The block 143 has a bottom flange 145 for attachment of the equipment above the gate valve or penstock.

The manual control valve 117 the lock valve 133, and the non-return valve 113 are located beneath the plate 141. The valve 117 is mounted by its ports directly onto a ported block (behind, and obscured by, the valve 117 in Fig. 2). This has the shuttle valve 137 within it. It provides the exhaust port 125, and connections within it provide the line 119, connections from the lines 121 and 123 to the valve 137, and a connection from the valve 117 to the exhaust port 125. The line 123 is led up through the reservoir 115 (but does not communicate with it). The hydraulic oil line 129 is constituted by the rigid pipe 129′ and the flexible base 129″.

Referring next to Fig. 3 of the accompanying drawings, this operating equipment has an electrically driven air compressor 150 delivering air through a non return valve 152 to a reservoir 154 (which is larger than the reservoir 115). The air compressor delivers air through a pressure regulator 156 and is governed by an air pressure operated switch 158 so that it runs only when required. The reservoir 154 is also provided with a foot pump connection 131.

This equipment has a pair of oil reservoirs 109, 110. Air from reservoir 154 is supplied through a filter and pressure regulator 159 to control means in the form of a pair of solenoid operated valves 162, 163 which deliver air to a pressure operated 4-way valve 164 governing the supply of air from line 160 along lines 165, 166 to oil reservoirs 109, 110. Oil lines lead from these reservoirs through flow regulators 168, 169 to the chambers 107, 127 of the double acting cylinder 101. One oil line contains a lock valve 133 (which in this case is a two-way valve with one outlet looped back to the inlet). When air is delivered from the valve 164 along either of the lines 165, 166 it operates a shuttle valve 137 and is delivered to the valve 133 to open it and allow flow of hydraulic oil. The solenoid operated valves 162, 163 are connected to respective sequence timers 176, 177, which are connected to one or more sensors and/or timers (e.g. a 24 hour clock) indicated generally at 178. Connection to an electricity supply is indicated at 179.

Each sequence timer will respond to a signal from the sensors/timers 178 by going through an operating cycle consisting of energizing the solenoid operated valve to which it is connected, maintaining the solenoid energized for a predetermined period, and then de-energizing the solenoid.

The parts within the chain dotted outline would be located above the gate valve or penstock in an assembly similar to that shown in Fig. 2, with the oil reservoir 110 in the place of the air reservoir 115. The remaining parts would be at a remote location, and connected through the air lines 165 and 166. If remote operation was not desired, these remaining parts could, of course, be included in the assembly at the penstock or gate valve.

Operation is as follows. The compressor 150 runs as and when required to maintain a pressure of air in the vessel 154, and hence a supply of compressed air to the valves 162, 163 and 164.

To raise the gate of the gate valve or penstock, a signal from the sensors/timers 178 causes the sequence timer 177 to energize the solenoid of valve 163, which supplies air to valve 164 so as to open it for the passage of air from line 160 to oil reservoir 109 (simultaneously opening oil reservoir 110 to atmosphere) and to shuttle valve 137 to open lock valve 133. This pressurizes the oil in reservoir 109 and drives it into the lower chamber 107 of the cylinder 101. The time taken to raise the gate is determined by the setting of the oil flow regulator 169. The sequence timer 177 keeps the solenoid of valve 163 energized for rather longer than this, but not vastly longer, e.g. if the gate takes 10 seconds to raise, the sequence timer 177 keeps the solenoid of valve 163 energized for 20 seconds, if it takes 1 minute to raise, the timer energizes the solenoid for 1 minute 20 seconds.

Correspondingly, to close the penstock the sensors/timers 178 cause the sequence timer 176 to energize the solenoid of valve 162. Air from this operates valve 164 so that lock valve 133 is opened and oil reservoir 110 is pressurized. Oil from this is driven into chamber 127, and piston 103 is forced down until the gate is closed. The time taken in closing the penstock is determined by flow regulator 168. It need not be the same as the time taken to open the penstock.

If desired the solenoid of valve 162 or 163 can be energized for only a short time so as only partially to open or close the gate valve or penstock.

As a guard against the effects of a temporary failure of the public electricity supply, the reservoir 54 stores enough air to raise and lower the gate a number of times say twelve times. The electrical control equipment does not require a great deal of power, and can be made so as to change over automatically to an alternative source of electrical energy such as a vehicle battery when necessary.

Fig. 4 of the accompanying drawings shows equipment having a fail-safe provision. An assembly mounted above the gate to be operated is identical to that shown in Figs. 1 and 2 (it having a lock valve 133) except that the manual control valve 117 is connected to the lines 121 and 123 through shuttle valves 181 and 183 (which would be included in the ported block mentioned earlier).

At a remote location there is a large air reservoir 154 supplying control means in the form of a pair of solenoid operated two way valves 185, 186. Two air lines 189, 191 lead from the remote location to the shuttle valves 181, 183. These shuttle valves allow operation either by the manual control valve 117 or the control means at the remote location. They prevent air from the lines 189 and 191 exhausting at port 125 on the manual control valve, and prevent air from the manual control valve 117 exhausting at the remote location. If it were not desired to provide for manual operation at the site of the gate valve or penstock the manual control valve 117 could be dispensed with, and then of course, there would be no requirement for the shuttle valves 181 and 183, the lines 189 and 191 being directly connected to the lines 121 and 123.

Each of the valves 185, 186 has a port 187 which is connected to one of alternative ports 188 when the solenoid is energized and to the other of them when the valve is de-energized. It is desired that, as a fail-safe operation, the gate should be lowered in the event of failure of electrical power, and for this purpose the valve 185 is connected in a different manner to valve 186.

The valve 185 is not normally energized, and in this condition the line 189 is connected to port 190 which functions as an exhaust. When the valve 185 is energized air from the reservoir 154 is supplied along the line 189 to pressurize the reservoir 109 and hence raise the gate. The valve 185 is energized by means of a sequence timer 177 in a manner analogous to that described in connection with Fig. 3.

The valve 186, on the other hand, is normally energized, in which state the line 191 is connected to the port 192 and hence is free to exhaust to atmosphere, but when the valve 186 is de-energized the line 191 is pressurized from the reservoir 154 so pressurizing the line 123 and the chamber 127 and closing the gate of the valve or penstock. The valve 186 is controlled by a sequence timer 176′ whose function is converse to that of the sequence timer 176 of Fig. 3. On receipt of a signal from the sensors/timers 178 the sequence timer de-energizes the solenoid valve 186, maintains it in a de-energized state for a pre-determined time and then re-energizes it.

This equipment can be operated by means of the manual control valve 117 if desired, and can be remotely operated under the command of the sensors/timers 178 through the sequence timers 176′, 177. In the event of failure of the electricity supply, the solenoid or valve 186 will necessarily become de-energized, and air pressure from the reservoir 154 will pressurize upper chamber 127 through the lines 191 and 123 to lower the gate and so fail-safe.

The equipment can also be made responsive to a drop in the pressure of the air supply delivered to the reservoir 154 at the inlet 111′ by connecting that air supply to a pressure operated electrical switch 193 which, when an adequate pressure is present holds closed the switch in the electrical supply to the solenoid of the valve 186, but opens the switch if the pressure is not maintained and thereby causes the gate of the valve or penstock to be moved (using pressure from the reservoir 154) to the fail-safe state.

If it were desired that the fail-safe state were with the gate raised, the valve 185 would be permanently energized and of course connected appropriately, whereas the valve 186 should be normally de-energized.

Numerous modifications are possible to the equipment described. The fail-safe provision described in Fig. 4 can of course be employed in equipment using a pair of oil reservoirs so that both the lower and the upper chambers 107 and 127 of the cylinder 101 are filled with oil. For automatic operation the solenoid operated valves could be at the site of the gate valve or penstock, with electrical connection to the remote location. Additional control equipment could be incorporated. For example, detectors could be fitted to the shaft 105 to detect whether or not the gate achieved its desired travel, and additional control valves could be incorporated in an operating equipment assembly mounted above the gate to cause the equipment to repeat its opening and closing cycle in the event of failure to achieve the desired travel at the first attempt.

Operating equipment as described above may be used to operate a penstock or a gate valve controlling the outflow of settled sludge from a settling tank for sewage or other effluent. To illustrate this Fig. 5 of the drawings shows a sewage separation tank 81 of the type with a conical bottom (but a radial flow tank, in which scrapers draw the settled sludge to a central wall could be used). Raw sewage enters by the pipe 80. Sludge 82 settles to the bottom of the tank. An outflow pipe 84 leads to a penstock 86 which is at a distance H below the water level 88 maintained in the tank. The penstock is as described above. By opening this penstock when a quantity of sludge has settled in the tank the settled sludge is removed.

Automatic operation can be achieved in several ways dependent on the nature of the sensors/timers 78.

One possibility is that there would be a level sensor in the tank 81 governing an upper limit level. It would open the penstock in response to the level of settled sludge rising to that level. The length of time for which the penstock remains open could be determined by a timer, or by a suitable sensor.

A sensor to close the penstock 86 could be a level sensor governing a lower level of sludge in the tank. An alternative would be a sensor able to detect whether the substance at a particular point was liquid or sludge. A suitable position for such a sensor would be close to the entrance 90 to the outflow pipe, either in the tank 81 or in the outflow pipe 84. Such a sensor could for example use a photoelectric cell to measure ability to transmit, absorb, or reflect light (either white light or light of a particular colour) or other radiation. It could for example use the principle of nephilometry, or could operate by measuring viscosity.

Both opening and closing of the penstock could be governed by a timer, but it may be preferable for at least one movement of the penstock to be governed by a sensor. Use of a sensor in the tank or in outflow pipe near the tank can give better separation of solids from liquid (and so increase the solids content of the separated sludge) than can be achieved by visual observation of the material flowing out of the penstock.

An advantageous mode of operation when it is desired to run off settled sludge from a conical bottomed tank is first to open the penstock for 30—60 second and then close it rapidly. This starts the settled sludge sliding towards the bottom of the tank, and then after perhaps 10 minutes or so re-open the penstock to run off the settled sludge. A hydraulically operated penstock can achieve the required rapid closing.

WHAT I CLAIM IS:—

1. In combination, a gate valve or penstock having a reciprocally moveable gate, and operating equipment therefor having a fluid operated cylinder and piston mechanically connected to the gate for the operation thereof, a hydraulic liquid reservoir to supply hydraulic liquid to the cylinder, an inlet for the supply of compressed gas to the equipment, and control means for controlling the gas, control means being operable to deliver gas to pressurize stored hydraulic liquid and cause delivery thereof to the cylinder to move the gate.

2. Combination according to claim 1 wherein the operating equipment includes a normally closed liquid valve through which hydraulic liquid from the reservoir passes to the cylinder and which is opened upon operation of the control means so as to allow movement of hydraulic liquid in response to operation of the control means.

3. Combination according to claim 2 wherein the said normally closed valve is a gas opearted valve which is supplied with pressurized gas to open it upon operation of the control means.

4. Combination according to any one of the preceding claims wherein the fluid operated cylinder and piston is double acting, the reservoir supplying hydraulic liquid to one chamber of the cylinder and the control means supplying air to the other chamber of the cylinder, the control means being selectively operable to deliver gas to the reservoir and cause delivery of pressurized liquid to the cylinder to move the gate of the penstock or gate valve in one direction, or to deliver gas to the other chamber of the cylinder to move the gate in the opposite direction.

5. Combination according to any one of claims 1, 2 or 3 wherein the fluid operated cylinder and piston is double acting with a pair of reservoirs supplying hydraulic liquid to respective chambers of the cylinder, the control means being selectively operable to deliver gas to one or other reservoir and cause delivery of pressurized liquid therefrom to move the gate of the penstock or gate valve in the desired direction.

6. Combination according to any one of the preceding claims wherein the operating equipment includes a reservoir for compressed gas supplied to the equipment, the gas passing from the said inlet to the reservoir through a non-return valve.

7. Combination according to any one of the preceding claims having at least the cylinder and piston, the reservoir and the said normally closed valve, if any, mounted on a common supporting structure.

8. Combination according to any one of the preceding claims wherein the control means is or includes at least one solenoid operated valve.

9. Combination according to any one of claims 1 to 8 wherein the operating equipment has manually operable control means and further control means including at least one solenoid operated valve, operation of either the manually operated control means or of the further control means delivering gas to cause delivery of pressurized liquid to the cylinder to move the gate.

10. Combination according to claim 9 or claim 10 wherein the or the further control means is a pair of solenoid operated valves, the fluid operated cylinder and piston being double acting, operation of one solenoid operated valve delivering gas to cause delivery of pressurized hydraulic liquid to one chamber of the cylinder to move the gate in one direction, and operation of the other solenoid operated valve delivering gas either to the other chamber of the cylinder or to cause delivery of pressurized hydraulic liquid to the said other chamber of the cylinder to move the gate in the reverse direction.

11. Combination according to claim 10 wherein the solenoid of one solenoid operated valve is normally energized and the solenoid of the other solenoid operating valve is not normally energized, de-energizing of the one solenoid or energizing of the other solenoid operating that the respective solenoid operated valve to deliver gas and thereby move the gate.

12. Combination according to claim 11 wherein the operating equipment includes a reservoir for compressed gas supplied to the equipment, the gas passing from the said inlet to the reservoir through a non-return valve and wherein the normally energized solenoid is supplied with electricity through a pressure-responsive switch connected to the inlet for the supply of compressed gas to the equipment, for the switch to be maintained closed by the compressed gas but not open if the pressure of the compressed gas at the inlet falls below a predetermined value.

13 Combination according to any one of claims 8 to 12 wherein the solenoid of the or each solenoid operated valve is connected to a sequence timer to de-energize a normally de-energized solenoid for a pre-determined period.

14. Combination according to claim 13 wherein the or each sequence timer is connected to a sensor or timer to be controlled thereby.

15. A penstock or gate valve and in combination therewith operating equipment substantially as herein described with reference to any one of Fig. 1, Figs. 1 and 2, Fig. 3 or Fig. 4 of the accompanying drawings.

16. Combination according to any one of the preceding claims having a compressed gas supply connected thereto.

17. Apparatus for separating sludge from liquid which comprises a settling tank having an outflow pipe leading from a low point of the tank to a penstock or gate valve having operating equipment therefor, according to any one of claims 1 to 16, with sensing or timing means supplying actuating signals to the or the further control means and arranged automatically to give signals to the control means to open and then reclose the valve, to allow outflow of settled sludge from the settling tank through the valve during the interval in which the valve is open.

18. Apparatus according to claim 17 substantially as described with reference to Fig. 5 of the accompanying drawings.

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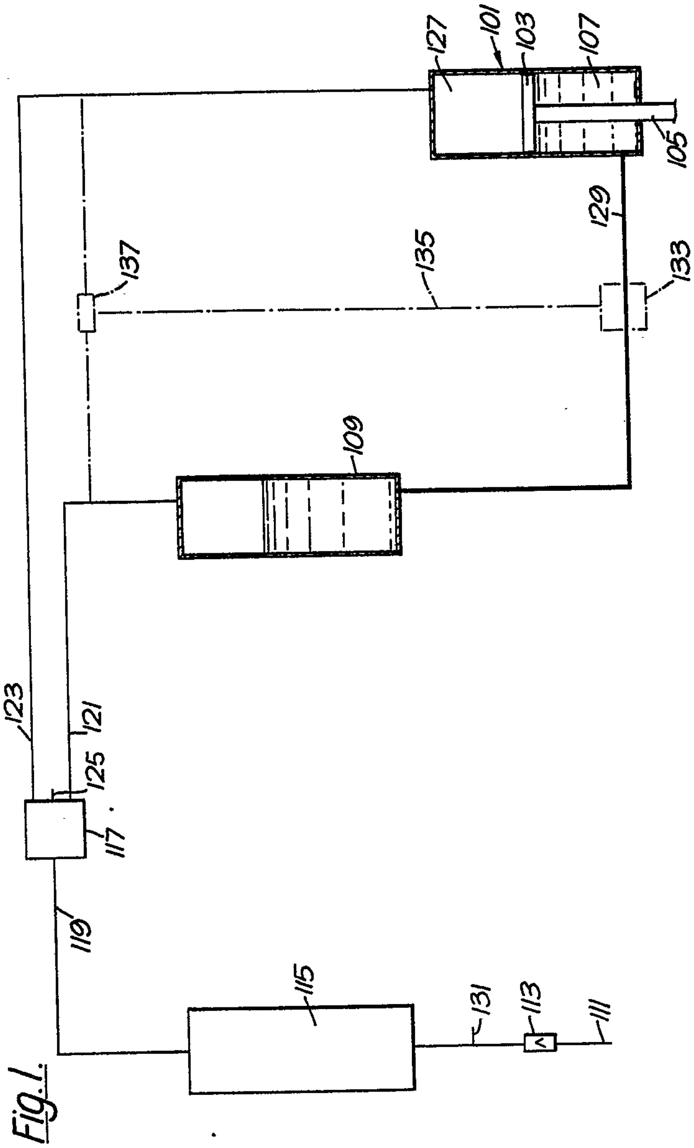
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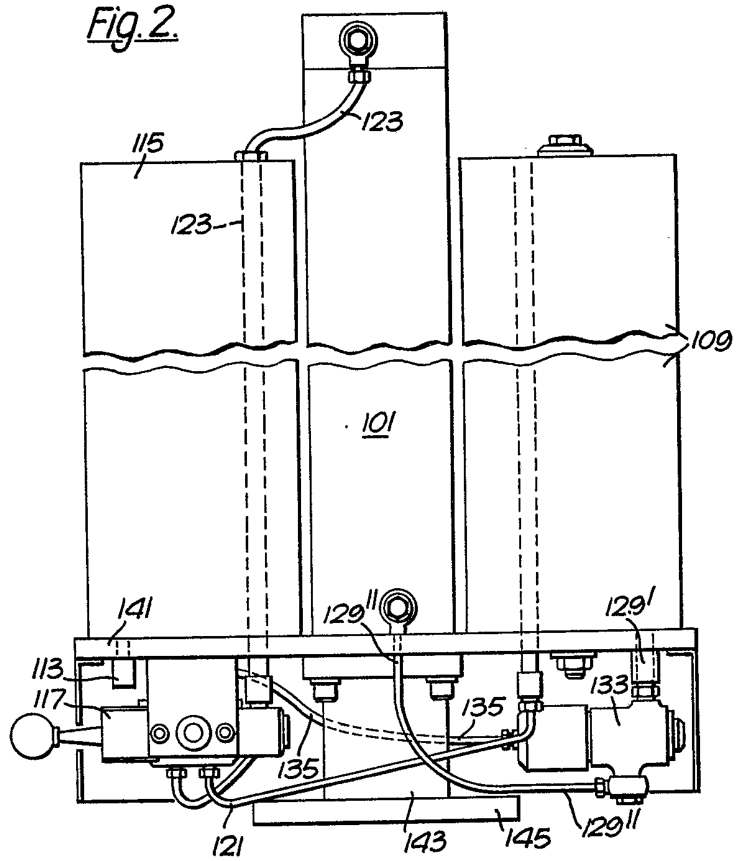
Fig. 1.

Fig. 2.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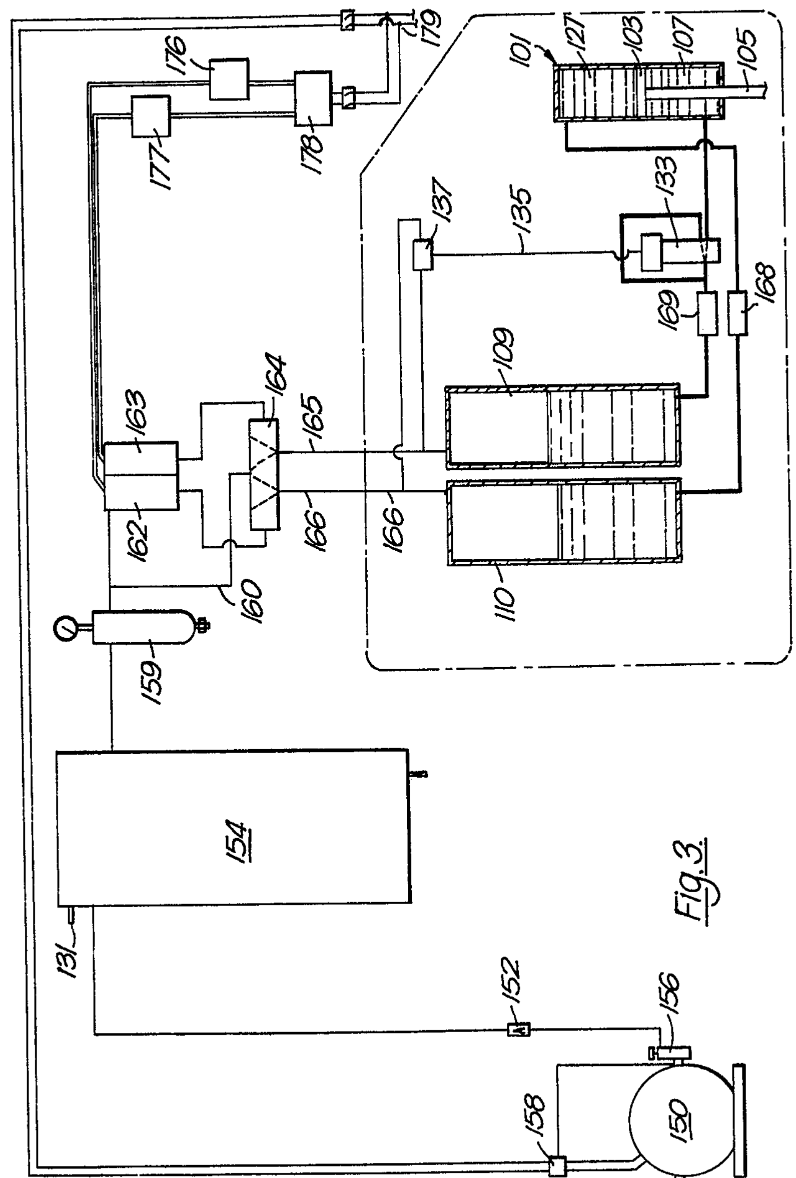
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Fig.3

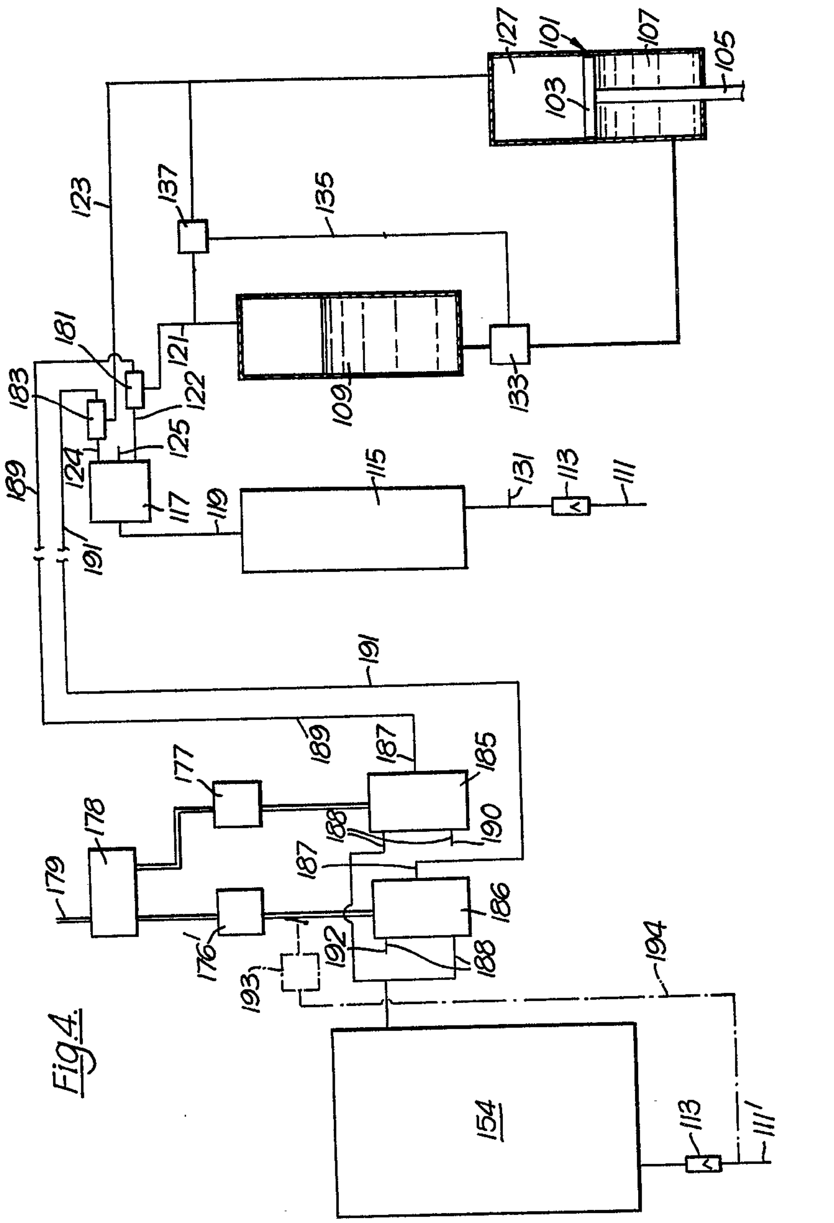
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Fig.4.

Fig.5.