

[54] **RECIPROCATING PUMP CONTROL SYSTEM**

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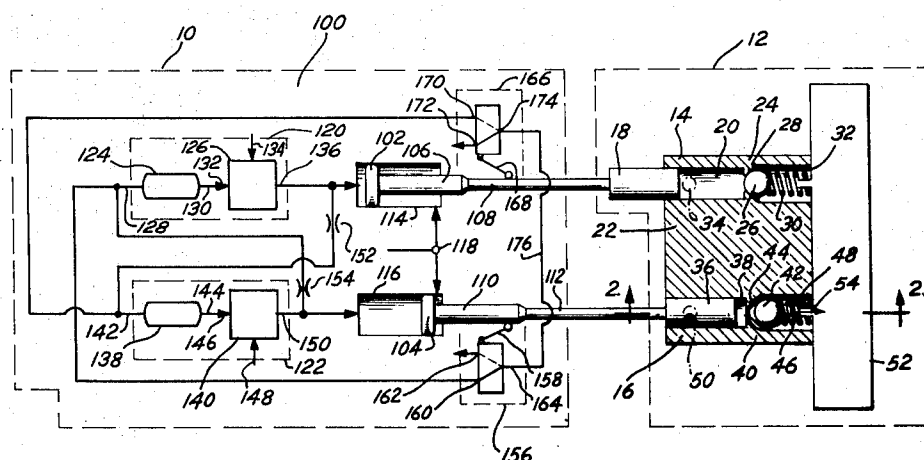
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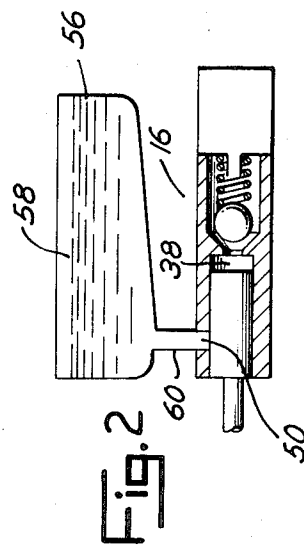
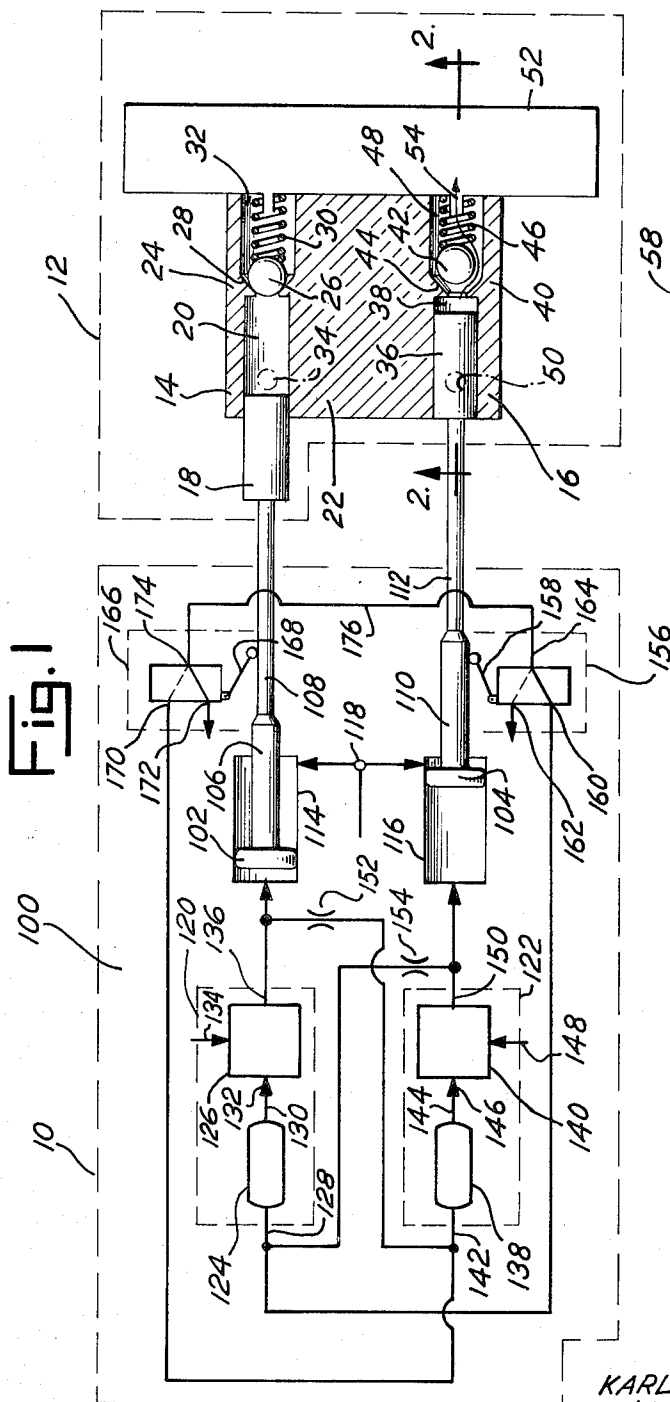
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[57] **ABSTRACT**

First and second reciprocating pumps are adapted to pump fluid continuously from a fluid source to a fluid output manifold. The control system operates the pumps maintaining at least one of them always in the pumping cycle. The control system includes a flip-flop circuit utilizing pneumatic accumulators, NOT logic elements and restrictors. Pneumatically operated drive pistons and associated cylinders are provided to control the reciprocating pumps.

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RECIPROCATING PUMP CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This invention relates generally to a control system for reciprocating pumps. In various pumping applications, the nature of the application of the fluid to be pumped requires uniform and uninterrupted pressure of the fluid to be delivered. For example, glue fluids must be smoothly pumped without pulsations in order to provide a uniform and continuous feed of adhesive.

One method for providing a supply-on-demand pump system involves a reciprocating pump device. However, such a device generally delivers a pulsating flow of fluid which can prevent a uniform discharge of the pumped fluid. It is possible to employ three or more reciprocating pumps to obtain minimized pulsation. Even then, however, the pumps must be interlocked mechanically. Also, this is a costly and inefficient solution to the problem.

Accordingly, it is desirable to provide a control system for reciprocating pumps which will operate two reciprocating pumps to deliver a continuous and smooth flow of the fluid to be pumped. It is also desirable to provide such a system which will prevent stalling of the pumps when the pumping cycle is initiated.

SUMMARY OF THE INVENTION

In a principal aspect, the present invention is related to a pulse-minimizing pumping system which utilizes reciprocating pumps. The control system generally includes first and second pumps for pumping fluid from a fluid source to an output manifold. Pump control means responsive to the movement of the pumps are provided for forwardly biasing the retracted pump when the other pump passes a predetermined point along its forward stroke. The control system maintains at least one of the pumps in forward pumping motion at all times.

In a preferred embodiment, the control system includes pneumatically operated drive pistons and associated cylinders which are drivingly connected to the pumps. An interconnected pneumatic flip-flop circuit is provided for controlling the drive pistons and is operated by a pair of limit valves which are responsive to the movement of the pumps.

BRIEF DESCRIPTION OF THE DRAWINGS

There follows a brief description of the drawings showing a presently preferred embodiment of the present invention wherein like numerals refer to like elements and wherein:

FIG. 1 is a view of two reciprocating pumps connected to the control system of the present invention shown schematically; and

FIG. 2 is a side view of the pumps, fluid source and fluid output manifold of the present invention taken substantially along the lines 2—2 of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The Reciprocating Pumps

As shown in FIG. 1, a control system 10 is provided for controlling the movement of a reciprocating pump system 12. The pump system 12 includes a first pump 14 and a second pump 16. The first pump 14 includes a

pump piston 18 and a pump cylinder 20 defined in a pump housing 22. The cylinder 20 is adapted to receive the piston 18 for reciprocal movement therein.

The first pump 14 also includes a ball check valve 24. The ball check valve 24 is one of the type known to those skilled in the art. A spring 30 housed within a chamber 32 acts to bias a ball 26 into position against a ball seat 28 to block the flow of fluid from the chamber 32 to the cylinder 20. A fluid input port 34 is connected to the cylinder 20 to deliver fluid to the cylinder 20 to be pumped by the piston 18.

The second pump 16 is identical to the first pump 14 and includes a pump piston 36 and cylinder 38 adapted to receive the piston 36. A ball check valve 40 having a ball 42 biased into a ball seat 44 by a spring 46 operates to control the flow of fluid from the cylinder 38. The spring 46 is mounted within a chamber 48 and biased against the ball 42. A fluid input port 50 is connected to the cylinder 38 to deliver fluid to the cylinder 38 for pumping.

As shown in the side view of FIG. 2, the fluid output source 56 containing a fluid 58 is disposed above the pump 16. The fluid source 56 is connected to the fluid input port 50 of the cylinder 38 through a channel 60. A similar fluid source (not shown) is provided to deliver fluid through the input port 34 to the chamber 20 of the first pump 14. The valves 24 and 40 operate to allow only unidirectional fluid flow from the source 56 to the output manifold 52.

The Control System

The control system 10 for the reciprocating pumps 14 and 16 takes the form of a pneumatic control circuit 100. The pneumatic control circuit 100 operates a first drive piston 102 and a second drive piston 104. The first drive piston 102 is drivingly connected to the pump piston 18 of the first pump 14 through a piston rod 106 and a drive shaft 108. The cross-sectional area of the piston rod 106 is less than that of the piston 102 and somewhat greater than that of the drive shaft 108. In a similar manner, the piston 104 is drivingly connected to the pump piston 36 of the first pump 16 by means of a piston rod 110 and a drive shaft 112. The piston rod 110 has a cross-sectional area somewhat less than that of the piston 104 and somewhat greater than that of the drive shaft 112.

The piston 102 is housed for reciprocating movement in a first pneumatic control cylinder 114 and piston 104 is housed for reciprocating movement within a second pneumatic control cylinder 116. A pneumatic pressure source 118 is connected to the forward ends (to the right as shown in FIG. 1) of each of the cylinders 114 and 116. The pressure source 118 acts as a means for continuously reverse biasing the pumps 14 and 16. In other words, pressure from the source 118 tends to move the pistons 102 and 104 and, therefore, the pump pistons 18 and 36, towards the left into retraction.

Alternatively, the pressure source 118 could be replaced by springs (not shown) positioned within cylinders 114 and 116 so as to reverse bias the piston 102 and 104 towards the left. In this embodiment, the right ends of cylinders 114 and 116 should be vented to the atmosphere to facilitate movement of pistons 102 and 104.

A first means 120 for forwardly biasing the first pump 14 is provided together with a second means 122 for forwardly biasing the second pump 16. The forwardly biasing means 120 includes an accumulator 124 and a NOT logic element 126, hereafter referred to as NOT element 126. The accumulator 124 has an input port 128 and an output port 130 connected to the input port 132 of the NOT element 126. The NOT element 126 also includes a second input port 134 connected to the pressure source 118 (this connection is not shown).

When pressure is applied to the input port 128 of accumulator 124, the accumulator fills and applies pressure from its output port 130 to the input port 132 of NOT element 126. When this occurs, the output port 136 of the NOT element 126 is switched "off" or depressurized. Conversely, when the input port 128 of the accumulator 124 is depressurized, no pressure is delivered from accumulator output port 130 to NOT element input port 132 and the NOT element output port 136 is switched "on" or pressurized.

The means 122 for forwardly biasing the second pump 16 includes an accumulator 138 and a NOT logic element 140, hereinafter referred to as NOT element 140. Accumulator 138 has an input port 142 and an output port 144. Output port 144 is connected to a first input port 146 of the NOT element 140. A second input port 148 of the NOT element 140 is connected to the pneumatic pressure source 118 (this connection is not shown).

When pressure is applied to the input port 142 of accumulator 138, the accumulator 138 fills and applies pressure through its output port 144 to the input port 146 of NOT element 140. When this occurs, the output port 150 of the NOT element 140 is switched "off" or depressurized. Conversely, when no pressure is applied to the input port 142 of accumulator 138, no pressure is applied to the NOT element input port 146 and the output port 150 of NOT element 140 is switched "on" or pressurized.

A first delay means or restrictor 152 is connected between the output port 136 of the NOT element 126 and the input port 142 of accumulator 138. In like manner, a second delay means or restrictor 154 is connected between the output port 150 of NOT element 140 and the input port 128 of accumulator 124. These first and second delay means 152 and 154 may be orifices which regulate fluid flow to a predetermined rate.

A first three-port limit valve 156 includes a limit arm 158 positioned to slide along the piston rod 110 and drive shaft 112. The limit arm 158 operates the three ports 160, 162 and 164 of the valve 156. Limit arm 158 is continuously biased upwardly as shown in FIG. 1 against the piston rod 110 or piston drive shaft 112. When the limit arm 158 is depressed by the piston rod 110 as shown in FIG. 1, ports 160 and 164 are interconnected. When the limit arm 158 is extended upwardly or deactivated and rides against the drive shaft 112, ports 162 and 164 are connected and port 160 is closed.

A second three-port limit valve 166 has a limit arm 168 and ports 170, 172, and 174 respectively. The limit arm 168 is biased downwardly to ride against the drive shaft 108 or piston rod 106. When the piston 102 is retracted (towards the left) the limit arm 168 rides against the drive shaft 108 and is deactivated with ports

172 and 174 interconnected and port 170 closed. When the piston 102 advances forwardly (towards the right) the limit arm 168 is biased upwardly by the piston rod 106 and is actuated with ports 170 and 174 interconnected and port 172 closed. The ports 164 and 174 of the first and second limit valves 156 and 166 respectively are interconnected by means of line 176. Ports 172 and 162 of the valves 166 and 156 are connected to the atmosphere.

Although the previous description of the pneumatic control circuit 100 and associated pumps 14 and 16 is sufficient to make and use the same, a description of the operation of this circuit 100 will be explained for greater clarity.

When the piston 36 of the second pump 16 advances forwardly (towards the right) fluid is pumped from the cylinder 38 through the chamber 48 to the output manifold 52. The first limit valve 156 is positioned at a point along the piston rod 110 and piston drive shaft 112 so that the limit arm 158 is actuated by the piston rod 110 before the pump piston 36 of the second pump 16 reaches the end of its forward stroke.

The second limit valve 166 is similarly positioned with respect to the piston rod 106 and the piston drive shaft 108. When the limit arm 158 is actuated during the forward stroke of the piston 36 of the second pump 16, ports 160 and 164 are interconnected. If the pumps are oscillating in sequence, the second limit valve 166 is deactivated at that time and the limit arm 166 rides against the drive shaft 108 interconnecting ports 174 and 172. The input port 128 of the accumulator 124 is thus depressurized through ports 160, 164, 174 and 172. When the accumulator 124 is depressurized, the output port 136 of NOT element 126 is pressurized, to forwardly bias drive piston 102 and pump piston 18. At the same time, pressurized fluid flows at a controlled rate through the first delay means or restrictor 152 to the input port 142 of the accumulator 138. After a predetermined delay time which may be set by selecting the appropriate restrictor 152 and accumulator 138, the output port 144 of accumulator 138 pressurizes the input port of the NOT element 140 which switches off the output port 150 of NOT element 148. The piston 104 is no longer forwardly biased and pressure from the source 118 acts upon the drive piston 104 to reverse it and the pump piston 36 of the second pump 16. The delay time during which the second pump 16 continues moving forwardly to the pump fluid after the first limit valve 156 is actuated allows sufficient time for the pump piston 18 of the first pump 14 to begin forward movement.

In a similar manner, when the piston 18 of the first pump 14 extends to a predetermined point along its forward movement, the piston rod 106 actuates the limit valve 166 by moving the limit arm 168. When the second limit valve 166 is actuated, ports 170 and 174 are interconnected. At this time, if the pumps 14 and 16 are reciprocating in sequence, the drive piston 104 and the pump piston 36 are retracted (towards the left) so that the limit valve 166 is deactivated. Thus, the input port 142 of the accumulator 138 is depressurized through ports 170, 174, 164 and 162. As has been explained when the input port 142 of accumulator 138 is depressurized, the output port 150 of NOT element 140 is pressurized and produces a forward biasing force

on the piston 104. This commences the pumping cycle of the second pump 116. At the same time, pressurized fluid flows to the restrictor 154 and fills the accumulator 124 at a predetermined rate. After a predetermined time period which may be controlled by selecting the appropriate values for the restrictor 154 and the accumulator 124, the input port 132 of the NOT element 126 is pressurized and causes a termination of pressure at the NOT element output port 136 allowing the drive piston 102 and associated pump piston 18 to be retracted by the reverse biasing force from the supply source 118.

As may be seen from the foregoing, the pneumatic control circuit 100 for the reciprocating pumps 14 and 16 provides for a system which will maintain the oscillating pumps in a condition so that at least one of the pumps is always pumping fluid from the source 56 to the output manifold 52 whenever output is demanded. The three-way limit valves 156 and 166 and the interconnected line 176 provide an anti-stall action which will be described hereafter.

The anti-stall function is accomplished by maintaining the control system in an unstable condition until the pistons 102 and 104 begin oscillating in sequence. For example, if at the time the power to the control circuit 100 is initiated, both pistons 102 and 104 are retracted (towards the left), ports 170 and 160 are blocked by the deactivated limit valves 166 and 156 respectively. As soon as power is supplied to the system 100, the NOT elements 126 and 140 produce a biasing force on the pistons 102 and 104 respectively causing the pistons 18 and 36 to commence pumping. During this time, the accumulators 124 and 138 commence filling through restrictors 154 and 152 respectively. The NOT element which first switches "off" terminates the forward biasing force on its associated drive piston and pump piston. These pistons are then retracted, allowing the circuit 100 to commence oscillating in sequence.

The interconnection between ports 164 and 174 of the limit valves 156 and 166, respectively, has been added in order to prevent stalling when the drive pistons 102 and 104 are extended forwardly. In such a condition, port 170 is interconnected with port 174 and port 160 is interconnected with port 164. Therefore, no bleedoff of pressure from the input ports 148 and 142 of accumulators 124 and 138 respectively, can occur. In this mode with the pistons 102 and 104 extended forwardly (towards the right), the accumulators 124 and 138 are pressurized through restrictors 154 and 152 respectively until such time as the NOT elements 126 and 148 are switched "off". The drive pistons 102 and 104 return to the retracted position. Thereafter, the circuit will remain unstable until the drive pistons 102 and 104 commence sequential oscillations.

While in the foregoing there has been described a preferred embodiment of the present invention, numerous other embodiments may be made to this embodiment by those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed is:

1. A control system for a pulse-minimizing pumping system utilizing a first reciprocating pump and a second reciprocating pump for pumping fluid from a fluid source to a fluid output manifold, comprising, in combination:

pump biasing means including a first fluid means for biasing said first pump forwardly, a second fluid means for biasing said second pump forwardly, and means for continuously reverse biasing both of said pumps,

first valve means responsive to the movement of said second pump for actuating said first fluid biasing means when said second pump is in a prescribed position of the forward stroke thereof,

second valve means responsive to the movement of said first pump for actuating said second fluid biasing means when said first pump is in a prescribed position of the forward stroke thereof,

first fluid time delay means activated by said first valve means and providing means for deactivating said second biasing means at a predetermined time after said second pump passes the prescribed position of the forward stroke thereof, and

second fluid time delay means activated by said first valve means and providing means for deactivating said first biasing means at a predetermined time after said first pump passes the prescribed position of the forward stroke thereof such that at least one of said pumps is always forwardly moving thereby masking out any reverse stroke pulse from the other pump.

2. The system as set forth in claim 1 including first and second control cylinders and first and second drive pistons within said cylinders, said pistons drivingly connected to said first and second pumps respectively.

3. The combination as set forth in claim 2 wherein said reverse biasing means comprises a source of fluid under pressure, said source connected to each of said cylinders at the forward ends thereof such that said pistons are continuously reverse biased.

4. The combination as set forth in claim 2 wherein each of said forwardly biasing means comprises an accumulator and a NOT logic element, the output port of said accumulator being connected to one of the input ports of said NOT logic element, said NOT logic element also having a second input port connected to a source of fluid under pressure and an output port connected to one of the control cylinders for forwardly biasing the drive piston within said control cylinder such that the output of said NOT logic element is pressurized when the input from said accumulator is depressurized and such that the output of the NOT logic element is depressurized when the input from said accumulator is pressurized.

5. The combination as set forth in claim 4 wherein each of said delaying means comprises a restrictor connected between the output of the NOT logic element for one of said forwardly biasing means and the input for the accumulator for the other of said forwardly biasing means such that when the output of the NOT logic element for one of said forwardly biasing means is pressurized to forwardly bias one of said pistons and associated pump, the other of said NOT logic elements is depressurized after a delay time sufficient for the fluid to flow through the one restrictor and fill the other accumulator.

6. The system as set forth in claim 1 wherein each of said valves includes first, second and third fluid flow ports and a limit arm adapted to interconnect said first and second ports when the arm is actuated and to inter-

connect said first and third ports when the arm is not actuated.

7. The combination as set forth in claim 6 wherein the second port of each of said valves is connected to the input of the associated biasing means and the third port of each of the valves is connected to the atmosphere to allow bleeding of pressure from the valve.

8. The combination as set forth in claim 7 wherein the first ports of each of said valves are interconnected.

9. An improved fluid control system for alternately driving first and second reciprocating pumps to provide a non-pulsing single output comprising, in combination:

a first pump having a reciprocating piston with a drive rod attached thereto for operating a pump;
a second pump having a reciprocating piston with a drive rod attached thereto for operating a pump,
each of said pistons having a forward pumping stroke and a return stroke said pumps providing a single output;

fluid supply means;

means for returning said pistons on said return stroke;

first sensor means for sensing a prescribed position of said first piston;

second sensor means for sensing a prescribed position of said second piston;

first valve means connecting said fluid supply means to said first pump, said first valve means operated in response to said second sensor means to open fluid supply means to said first piston for driving said first piston in the forward pumping stroke;

second valve means connecting said fluid supply means to said second pump, said second valve means operated in response to said first sensor means to open fluid supply means to said second piston for driving said second piston in the forward pumping stroke;

first time delay valve control means for sensing supply pressure to said first piston from said first valve means, said first time delay valve control means operating to close said second valve means and thereby stop fluid supply to said second piston subsequent to a time interval so that said return means operates to return said second piston by said return stroke; and

second time delay valve control means for sensing supply pressure to said second piston means from said second valve means; said second time delay valve control means operating to close said first valve means and thereby stop fluid supply to said first piston subsequent to a time interval so that said return means operates to return said first piston by said return stroke.

10. The improved control system of claim 9 wherein said first and second sensor means are interconnected to provide identical control output signals whenever the prescribed position of said first and second pistons is substantially the same.

11. The control system of claim 9 wherein said first valve means and said second valve means comprise

fluid operative NOT devices.

12. The control system of claim 9 wherein said first and second time delay valve control means comprise restrictors.

13. The apparatus of claim 9 wherein said first and second time delay means comprise accumulators.

14. The apparatus of claim 9 wherein said piston rods include indicia and said first and second sensor means include means for sensing said indicia.

15. A control system for a pulse minimizing pumping system utilizing first and second separate pumps which pump fluid from a single outlet means, each of said pumps having a forward pumping stroke to said outlet means and a reverse stroke comprising, in combination:

means for biasing each of said pumps in the direction of said reverse stroke;

forward stroke biasing means for each of said pumps;
first and second means for sensing the extent of the forward stroke of said first and second pumps respectively;

first and second switch means operable respectively by said second and first means for sensing, said first switch means operable to initiate operation of said forward stroke biasing means for said second pump and said second switch means operable to initiate operation of said forward stroke biasing means of the first pump; and

first and second time delay means for sensing the forward stroke of said first and second pumps respectively and for subsequently deactivating said forward stroke biasing means for said second and first pumps respectively to permit simultaneous forward stroking by each pump prior to the reverse stroke by one of the pumps.

16. A pneumatic control system for a pulse minimizing pumping system of the type including first and second separate pumps which pump through a single outlet means, said pumps each having a forward stroke and a reverse stroke comprising, in combination:

fluid means for continuously biasing said pumps in the direction of one stroke;

fluid means for each of said pumps for intermittently biasing and driving each of said pumps in the direction of the other stroke;

separate means for each of said pumps for sensing a predetermined change in said other stroke, each of said means for sensing including means for operating said means for intermittently biasing upon sensing said predetermined change, and time delay means operative to terminate said means for intermittently biasing subsequent to the initiation of the of the other stroke by said means for intermittently biasing, said means for sensing associated with said first pump operative to initiate the other stroke of said second pump and subsequently terminate the one stroke of said first pump, said means for sensing associated with said second pump operative to initiate the other stroke of said first pump and subsequently terminate the one stroke of said second pump.

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