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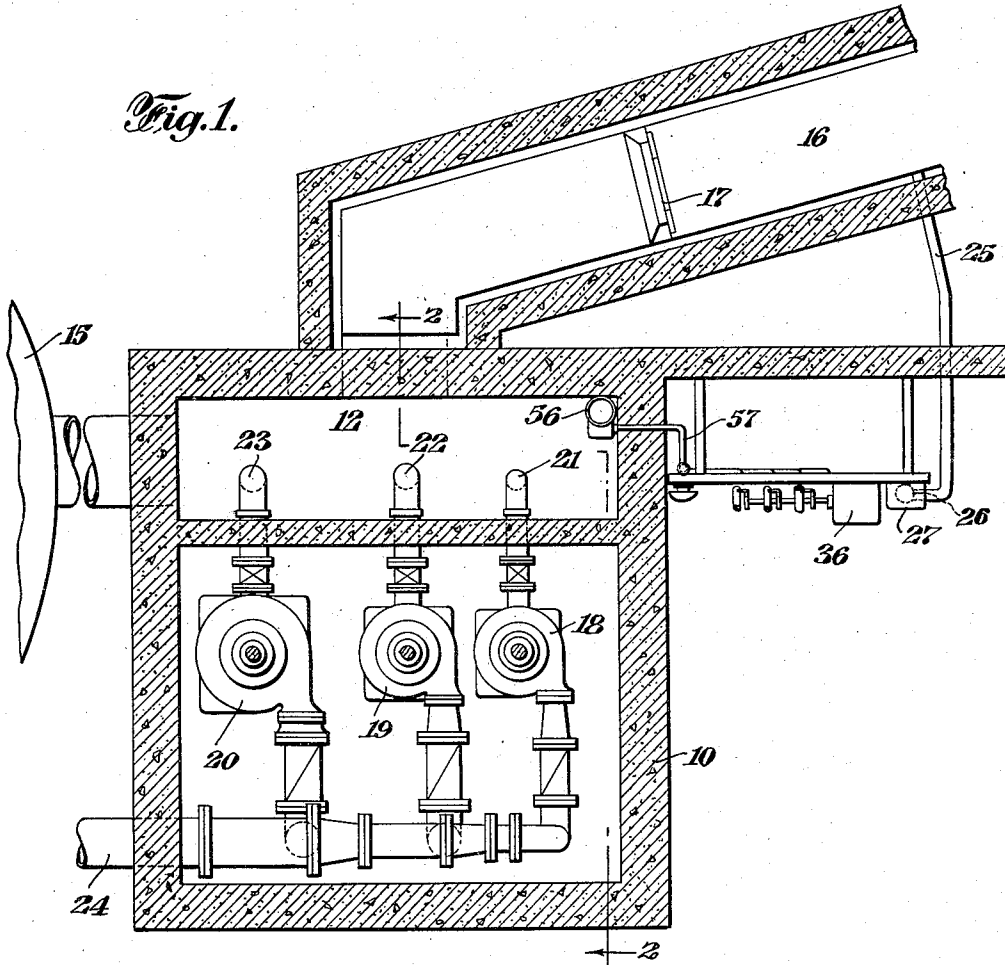
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PUMP CONTROL

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2 Sheets-Sheet 1



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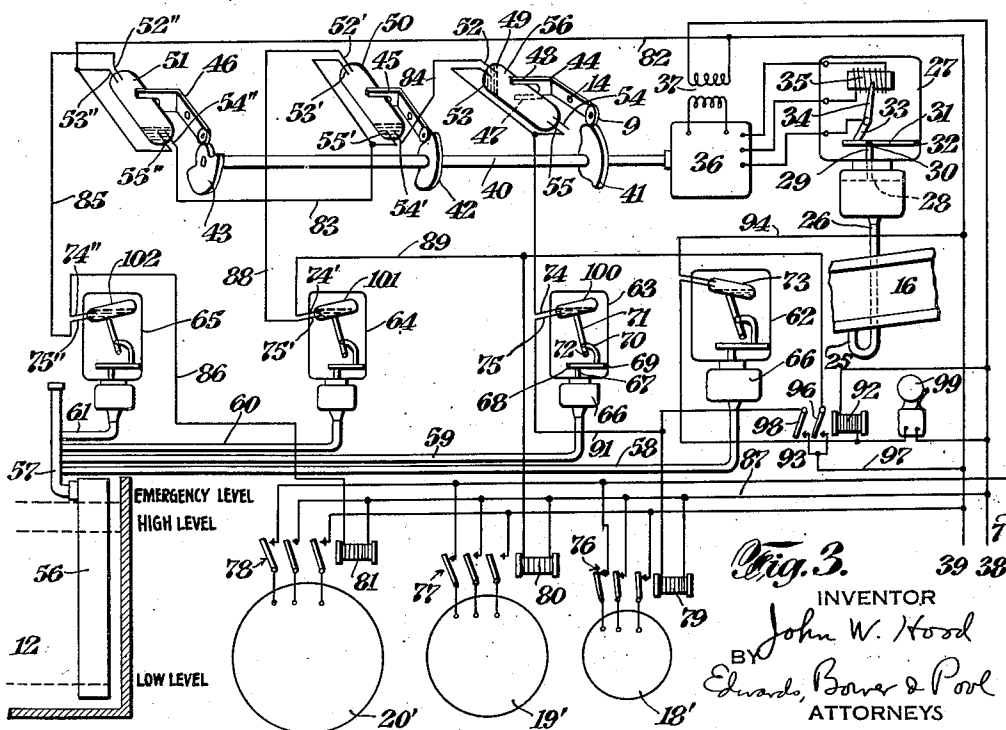
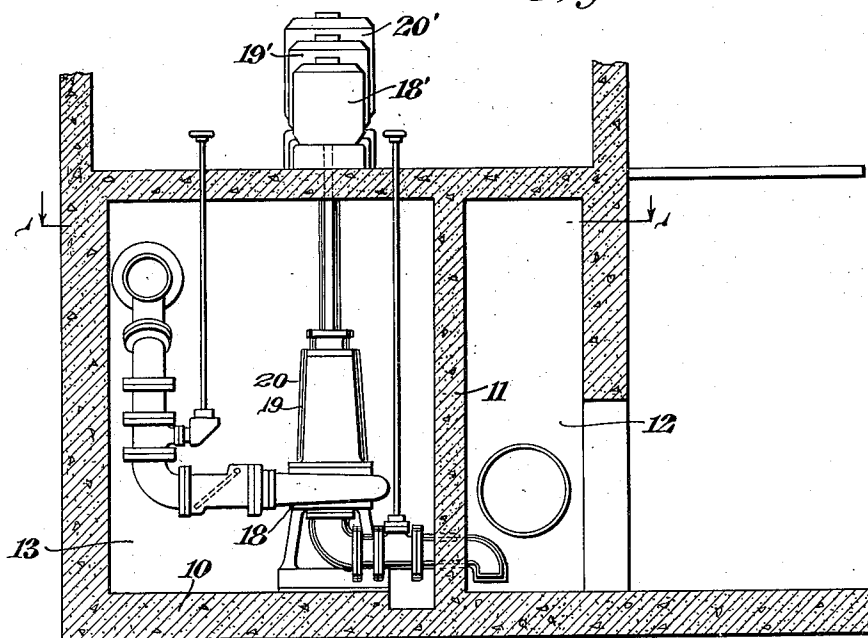
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Fig. 2.



UNITED STATES PATENT OFFICE

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PUMP CONTROL

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8 Claims. (Cl. 103—25)

This invention relates to pump control mechanism and has for its object to provide a control which increases the efficiency and economy of operation.

The invention is especially useful in the pumping of flows of sewage or the like which vary greatly between minimum and maximum limits during the day and during the year.

It has been the practice to provide pumps of large enough capacity to pump at the rate of the maximum inflow, and to employ pump control apparatus which automatically starts the pump when the fluid accumulated in a well by the inflow rises to a high level and automatically shuts off the pump when it falls to a low level. In such systems, whenever the rate of inflow is considerably less than the capacity or pumping rate of the pump, the pump rapidly empties the well and is then shut off by the low level cut-off. The level then rises again due to the inflow until the high level cut-in starts the pump again. This has heretofore involved the use of pumps of much larger pumping capacity than is required for all rates of inflow except the maximum, with attendant relatively large losses of power due to the use, most of the time, of larger pumping equipment than is required by the flow, and the resulting frequent on and off operation of the pumps.

In accordance with this invention there is provided a control which permits the use of a plurality of pumps of smaller pumping capacity than the maximum flow; and which automatically selects and operates the pump having the capacity more nearly equal to the actual flow at any time, resulting in less frequent on and off operation.

The invention will be more fully understood from the following description and the accompanying drawings of which

Fig. 1 is in part a sectional view along line 1—1 of Fig. 2 and illustrates a wet well and pumps controlled according to this invention;

Fig. 2 is a vertical view in section taken at line 2—2 of Fig. 1;

Fig. 3 illustrates control apparatus and circuits for selecting and operating the pumps according to the flow.

The drawings illustrate equipment adapted for pumping an inflow of sewage, received in a well, to a subsequent receptacle. The pump and well arrangement shown in Figs. 1 and 2 comprises a pit 10 having a vertical bulkhead 11 providing a wet well 12 and a dry pit 13. A flume 16 carries the inflow over a weir 17 into the wet well 12

from where it flows into a storage tank 15 which acts as a balancing or storage reservoir for minimizing changes of the fluid level in the relatively small well.

In the dry pit there are located three pumps 18, 19 and 20 of different pumping capacities, driven by electric motors 18', 19' and 20', respectively. Preferably, the smallest pump 18 is of sufficient pumping capacity to handle the average minimum rate of flow, the largest pump 20 is of sufficient capacity to handle the maximum rate of flow, and pump 19 is of intermediate capacity.

The pumps are arranged in multiple, each being adapted to pump from the wet well 12 by suction pipes 21, 22 and 23 respectively to a force main 24 which is a pipe through which the flow is raised to a tank or other receiving medium from where it may be further dealt with as desired. Preferably, the combined pumping capacities of the two smallest pumps 18 and 19 should be approximately equal to the capacity of the largest pump 20, for in that case there is present a standby pumping capacity capable of pumping the maximum rate of flow.

For the purpose of energizing the respective pump motors 18', 19' and 20' there are provided switches 76, 77 and 78, which when closed connect their respective motors with the power source 38, 39. These motor switches are of the magnetically operated type, having operating magnets 79, 80 and 81, which when energized close their respective switches, and, when de-energized, allow the switches to drop open.

For the purpose of automatically selecting and operating the pumps in accordance with the rate of inflow of fluid and the level of the fluid in the well there is provided the following control apparatus, including control circuits for energizing the motor switch magnets:

A small diameter pipe 25 connected into the flume above the weir leads to a vertical pressure pipe 26 at the top of which is attached a receptacle 27, the inside of which is shown in Fig. 3. In this receptacle, and over the opening of the pipe 26 is an air-tight flexible bellows 28 sealed to prevent the leakage of air from the pipe 26 above the fluid level in that pipe, so that an increase in the fluid level in the flume, corresponding to greater flow over the weir, raises the fluid level in pipe 26, compressing the air above it in the pipe and expanding the bellows upward. There is fastened to the top surface of the bellows a rod 29 pivoted at 30 to a lever 31 attached to a fixed pivot 32. On this lever is a standard 33

carrying a metallic member 34 which acts as a wiper arm on a potentiometer resistance 35.

The potentiometer is included in the control circuit of an electric motor 36 receiving its source of power through a transformer 37 from a power line 38, 39. This motor is of a known type having an armature which moves to and stops in a position of equilibrium of its control circuit, so that the position of its armature shaft 40 is changed by moving the potentiometer arm. When the potentiometer arm 34 is in contact with the center of the resistance 35, the shaft 40 is at rest in a central position of angular rotation; but when the arm 34 moves either way off center in response to the rise or fall of the bellows, the motor shaft turns one way or the other depending on the direction in which the arm moves, until an electrical balance is again established and the number of degrees of rotation is varied with the amount of movement of arm 34.

On the motor shaft 40 are fastened three cams 41, 42 and 43 which operate, respectively, the cam riders 44, 45 and 46. Each cam rider is pivoted on a rod 14, and carries a roller 9 on its free end in contact with the cam surface. Each rider also carries a pair of forked fingers 47 and 48, and each pair of fingers operates a flow responsive control switch, there being three of these switches, 49, 50 and 51, one for the energizing circuit of each motor switch magnet. The switches illustrated are of the well known mercury type operated by tilting. Each switch comprises a glass envelope containing a pair of switch contacts 52, 53, sealed through the glass at one end and another pair of switch contacts 54, 55 sealed through the glass at the other end, the contacts 53 and 55 being connected together externally of the glass tube, as shown. (In switch 50, the contacts are numbered 52', 53', 54' and 55' and in switch 51 they are numbered 52'', 53'', 54'' and 55''). Each switch tube, held approximately horizontally between the fingers 47 and 48, contains sufficient mercury 56 to cover the two contacts at either end at which the tube is tilted downward. The arrangement is such that when the cam rider rides up on the cam protuberance, it pivots on rod 14 tilting its mercury switch tube backwards to establish the back contacts 52 and 53, but when the cam rider is off the cam protuberance, the tube is tilted forward to cause the mercury to cover the front switch contacts 54 and 55.

The cam 41 is preferably fastened on the shaft so that even when the potentiometer arm position corresponds to zero flow, the cam roller 9 rests on the cam protuberance, and stays there at least until the next cam 42 raises its rider; and cam 42 is adjusted to raise its rider whenever the flow exceeds an amount a little under the capacity of the smallest pump 18, and cam 43 is adjusted to raise its rider whenever the flow exceeds an amount a little under the capacity of the intermediate pump 19.

There is also provided in each motor control circuit a fluid level responsive switch whose contacts make or break in dependence on the level of liquid in the well 12. These are mercury switches 100, 101 and 102 similar to switches 49, 50 and 51 except that only one pair of contacts is employed, these being 74 and 75 (74' and 75' in switch 101 and 74'' and 75'' in switch 102) located at one end of the switch tube. For operating these switches there is provided a pipe 56, closed at the top and open at the bottom, which extends into the well almost to its bot-

tom. Near the top of the pipe an air tight tube 57 is led from the pipe; and into this tube there are connected auxiliary tubes 59, 60 and 61, leading respectively to receptacles 63, 64 and 65, the bottoms of the receptacles being provided with air tight bellows 66 located over the entering tube so that the bellows are bulged upwardly by air pressure by an amount depending on the level of fluid in the well, in a manner similar to the operation of the previously described bellows 28. Attached to each of these bellows is a rod 67 pivoted to a lever 68 which in turn is attached to a fixed pivot 69. An arm 70 of the lever is fastened to an arm 71 pivoted at 72 and supporting the mercury switch 100 (and 101 and 102 in casings 64 and 65, respectively). The mechanisms holding switches 100, 101 and 102 are so adjusted relative to the air pressure in the tubes and the fluid level in the well that the switch controls are closed at a predetermined "high level" in the well and opened at a predetermined "low level."

The flow responsive switches and the fluid level responsive switches are interconnected and connected into the energizing circuits of the magnets of the motor switches in the following manner: Contacts 53'' and 54'' of flow controlled switch 51 are connected by lead 82 to power wire 39; contact 54'' of switch 51 is connected by a lead 83 with the commonly connected contacts 53' and 55' of switch 50 and contact 54' of switch 50 is connected by a lead 84 with contact 52 of switch 49.

The level controlled switches are connected in circuit with the flow controlled switches and with the motor switches as follows: Contact 52'' of switch 51 is connected by a lead 85 with contact 75'' of switch 102, and the other contact 74'' is connected by lead 86 with the magnet 81 of switch 78, the other side of the magnet being connected with power lead 38 by wire 87. Switch 101 is similarly connected in series with contact 52' of flow switch 50 and with magnet 80 of motor switch 77 by leads 88 and 89. Level switch 100 is likewise connected with the commonly connected contacts 53 and 55 of flow switch 49 by lead 90, and with magnet 79 by lead 91.

A high level safety cut-in is provided by the mercury switch 73 in receptacle 62, operated in response to the fluid level through tube 58. This switch is connected by leads 94 and 95 in series with power line 39, magnet 92 of magnetic switch 93 and power line 38. Switch blade 96 of switch 93 serves, when closed, to energize magnet 79 of motor switch 76 over lead 97, and switch blade 98 simultaneously energizes magnet 80 of motor switch 77 over the same lead 97, so that when the contacts of switch 73 are closed, pumps 18 and 19 are operated together. An alarm gong 99 connected between power lead 38 and lead 95 operates to sound an alarm whenever switch 62 is closed. The mechanism holding switch 73 is adjusted so that its contacts close at the high "emergency level" in the well and open at about the "low level."

In operation, the level of the liquid in the flume 16 rises in accordance with the flow over the weir so that the pressure on the air sealed within the top of pipe 26 increases as the flow increases, thus expanding the bellows 28 accordingly and moving the wiper arm 34 in correspondence. This causes the control motor 36 to rotate, the rotation being in the direction of the arrow when the flow has increased, thus establishing the position of the shaft 40 and its cams.

When the shaft continues to rotate in response to increasing flow, cam riders 44, 45 and 46 are raised in that order; and when the shaft rotates in the opposite direction in response to decreasing flow, the riders drop accordingly. In the case of a flow somewhere near the minimum flow, the shaft is rotated sufficiently to elevate cam rider 44 but not riders 45 or 46, so that mercury switch 49 is tilted downwardly at the rear but switches 50 and 51 remain tilted downwardly at the front. Under this condition, the contacts 52 and 53 of switch 49 are closed by the mercury, the control circuit for the operating magnet 79 of motor switch 76 now being complete from power lead 39, through lead 82, switch contacts 55'' and 54'' of switch 51, lead 83, switch contacts 55' and 54' of switch 50, lead 84, switch contacts 52 and 53 of switch 49 and lead 90 to contact 74 of switch 100.

Upon the level in the well reaching the predetermined "high level" at which the level switches 100, 101 and 102 are adjusted to tilt, the liquid rising in pipe 56 compresses the air sealed in pipe 57 and the attached air tubes 59, 60 and 61, distending the bellows in the respective switch receptacles, thereby causing these three level switches to tilt in the direction which causes the mercury to establish their switch contacts.

Since the control circuit has already been established through switch 49, as explained above, the closure of switch 100 completes this control circuit through lead 91 and magnet 79, thus energizing the magnet and closing the switch 76 of motor 18', which runs pump 18. Since neither of the other two flow controlled switches 50 and 51 have closed their rear control contacts, their motor controlling circuits are open so that closure of the level controlled switches 64 and 65 in those circuits has no effect. As pump 18 is now running and has a capacity at least as great as the inflow, the level in the tank will not rise above the "high level." Hence, the emergency switch 73 is not closed. If the in-flow through weir 16 is substantially equal to the pumping rate of pump 18, the level in the well will remain substantially constant and pump 18 will keep running. But ordinarily the in-flow will be somewhat less than the pumping rate so that the liquid in the well and storage tank gradually falls. When the "low level" is reached, the air pressure in the tubes 59, 60 and 61 falls to the value required to tilt the switch tubes 100, 101 and 102 to open position, thus de-energizing magnet 79 and causing switch 76 to drop open, which shuts off the pump motor. When the "high level" is again reached due to continued inflow without any pumping the tilting of switch 100 again starts the motor 18'.

When the flow increases to the point where cam 42 lifts rider 45, which should preferably occur at practically the capacity of pump 18, flow controlled switch 50 is tilted downward at the rear, opening its front contacts 54' and 55' which opens the control circuit for motor 18'; and closes its rear contacts 52' and 53', thus setting up the control circuit for motor 19' through wire 88. Then, if or when the condition of the fluid in the well has closed switch 101 this control circuit is completed through magnet 80 of switch 77, starting motor 19' and pump 19. Pump 19 then stops and starts as the level changes between the high and low levels, the operation remaining on this pump so long as rider 45 remains on cam 42 and provided the cam shaft is not turned far enough to lift rider 46.

When the flow itself rises to such a level that rider 46 is lifted, which preferably should occur as the capacity of pump 19 is neared, the operation is then accordingly transferred to the large pump 20 because wire 85 of its control circuit is now energized over rear contacts 52'' and 53'' of switch 51, the front contacts 54'' and 55'' opening to break the other control circuits. This large pump then is turned on and off by the level controlled switch 102 as the fluid level changes from high to low.

If the large pump fails to operate, or if for any other reason the level rises to "emergency level," the switch 73 is closed, establishing its switch contacts and energizing the circuit through leads 94, 95 and magnet 92, thus closing the arms 96 and 98 of switch 93. This energizes magnets 79 and 80 of switches 76 and 77, causing pumps 18 and 19 both to run together. At the same time, the gong 99 is energized over switch 73, calling the attendant's attention to the fact that the pumps are now operating on the emergency basis.

By the use of this pump control system, it will be appreciated that the use of different size pumps and combinations of pumps may be used in the pumping station and that there is automatically selected the pump having the rated pumping rate nearest above the rate of inflow at the time. In this way, the fluid is pumped out of the receiving well at nearly the same rate as it flows in, so that the well is not rapidly pumped out in intermittent pumping at close intervals, but remains at a nearly uniform level, thereby permitting the use of a well of smaller storage capacity than otherwise. This results in substantial power savings and less wear and tear on the pumping equipment because it reduces the frequency of the on and off operation of the pump. It also permits each pump to be run at its designed speed, which yields the maximum efficiency. It furthermore results in the requirement of less power in pumping the fluid up through the force main, due to the fact that most of the time the smaller size pumps are in operation, with the result that the fluid is not being pumped up through the force main at the rapid rate at which the maximum capacity pump pumps it. There are greater frictional losses in forcing fluid through a main at a high rate than at a lower rate.

Although the invention has been illustrated with reference to three pumps and their control circuits, it will readily be understood that it may be extended to any number of pumps or combinations of pumps. Furthermore, the apparatus is not limited to the specific types shown, but instead, considerable latitude is permissible in the selection of the individual instrumentalities such as flow measuring and responsive devices, level indicating and responsive devices, and in the particular forms of control switches and motor operating switches employed.

I claim:

1. A control means for a pumping system which pumps from a well supplied by a varying flow, and has a plurality of pumps of different pumping capacities, a driving motor for each of said pumps, a switch for energizing each motor, and a control circuit for closing each of the switches, said control means comprising: a flow-controlled switch in each control circuit, a fluid level controlled switch in series with the flow-controlled switches, so that each control circuit is energized to close the corresponding motor switch when its flow-controlled switch and the

fluid level controlled switch are both closed, a device responsive to the rate of flow for closing the flow-controlled switch in the control circuit which corresponds to the rate of flow and opening the flow-responsive switches in the other control circuits, and a device responsive to the fluid level in the well for closing the fluid level responsive switches at a high level and opening them at a low level.

2. Apparatus according to claim 1 in which said motor energizing switches are closable by magnets connected into the respective control circuits and energized upon closure of the latter.

3. A control means for a pumping system which pumps from a well supplied by a varying flow, and has a plurality of pumps of different pumping capacities and a driving motor for each of said pumps, said control means comprising: a control circuit for operating each motor having in series a flow-controlled switch and a well-level controlled switch, a selective device operated in response to the rate of flow for closing the flow-controlled switch in the control circuit which corresponds to the flow and opening the flow-controlled switches of the other circuits, and a well-level operated device for closing the well-level controlled switches of all the control circuits at a high well level and opening them at a low well level.

4. Apparatus according to claim 3 having an auxiliary control circuit for energizing some of the motors and an auxiliary well level operated device for closing said auxiliary circuit at an energizing high level in the well.

5. A control means for a pumping system which pumps from a well supplied by a varying flow, and has a conduit through which said well is supplied by the flow, a plurality of pumps of different pumping rates, a driving motor for each of said pumps, and a control circuit for operating each motor, said control means comprising: a pipe leading into said conduit, a device in the conduit for creating variations in pressure in the pipe in response to change of flow in the conduit, a pressure sensitive device

attached to said pipe, a flow-controlled switch in each control circuit closed by said pressure sensitive device during a predetermined range of flow rate, and a control switch in circuit with the closed flow-controlled switch which is closed at a predetermined high fluid level in the well and opened at a predetermined low fluid level.

6. Apparatus according to claim 5 in which said pressure sensitive device includes a motor controlled by the pressure to operate the control switches closed thereby.

7. In a pumping system comprising a plurality of pumps for pumping from a well supplied by a varying flow, a driving motor for each of the pumps and a switch for energizing each motor: a control circuit for closing each of the motor-energizing switches, each control circuit containing a flow controlled switch which when closed closes the corresponding motor switch, a device responsive to the rate of flow for closing the flow controlled switch which corresponds to the rate of flow and opening the flow controlled switches in the other control circuits.

8. A control means for a pumping system which pumps from a well supplied by a varying flow, and has a plurality of pumps of different pumping capacities, a driving motor for each of said pumps, and a control circuit for operating each motor, said control means comprising: a separate flow-operated switch in the respective control circuits, a well level operated switch arranged to be in series with each flow-operated switch, flow-responsive means for closing the respective flow-operated switches within different ranges of flow rates, said means comprising: a selecting device operated in response to the rate of flow for closing the particular flow-operated switch corresponding to that rate of flow and opening the other flow-operated switches, and a well level operated device for closing the well level operated switch which is in series with the closed flow-operated switch at a high well level and opening it at a low well level.

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