

Jan. 18, 1966

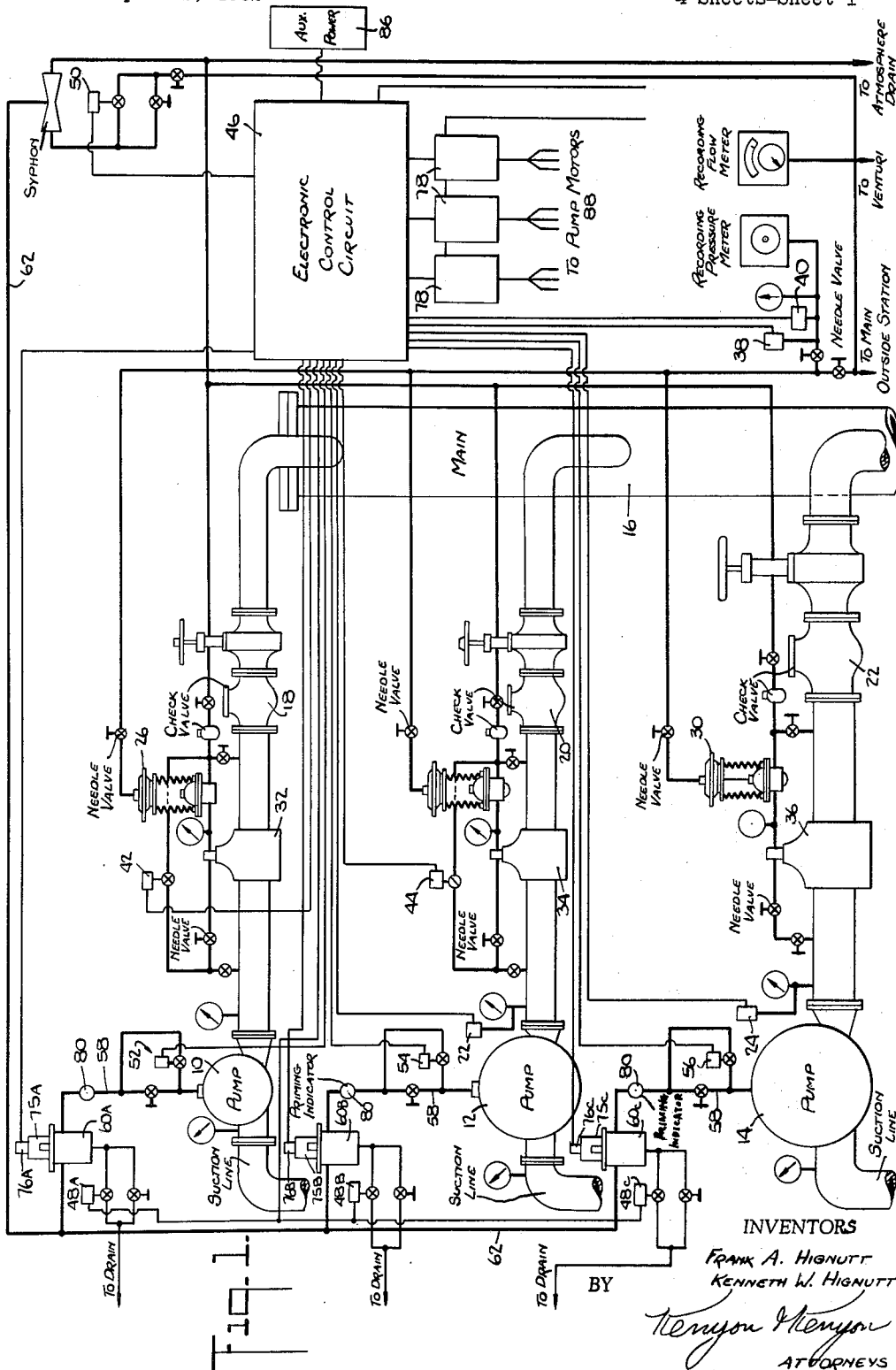
F. A. HIGNUTT ET AL

3,229,639

PUMP CONTROL SYSTEM

Filed April 2, 1962

4 Sheets-Sheet 1



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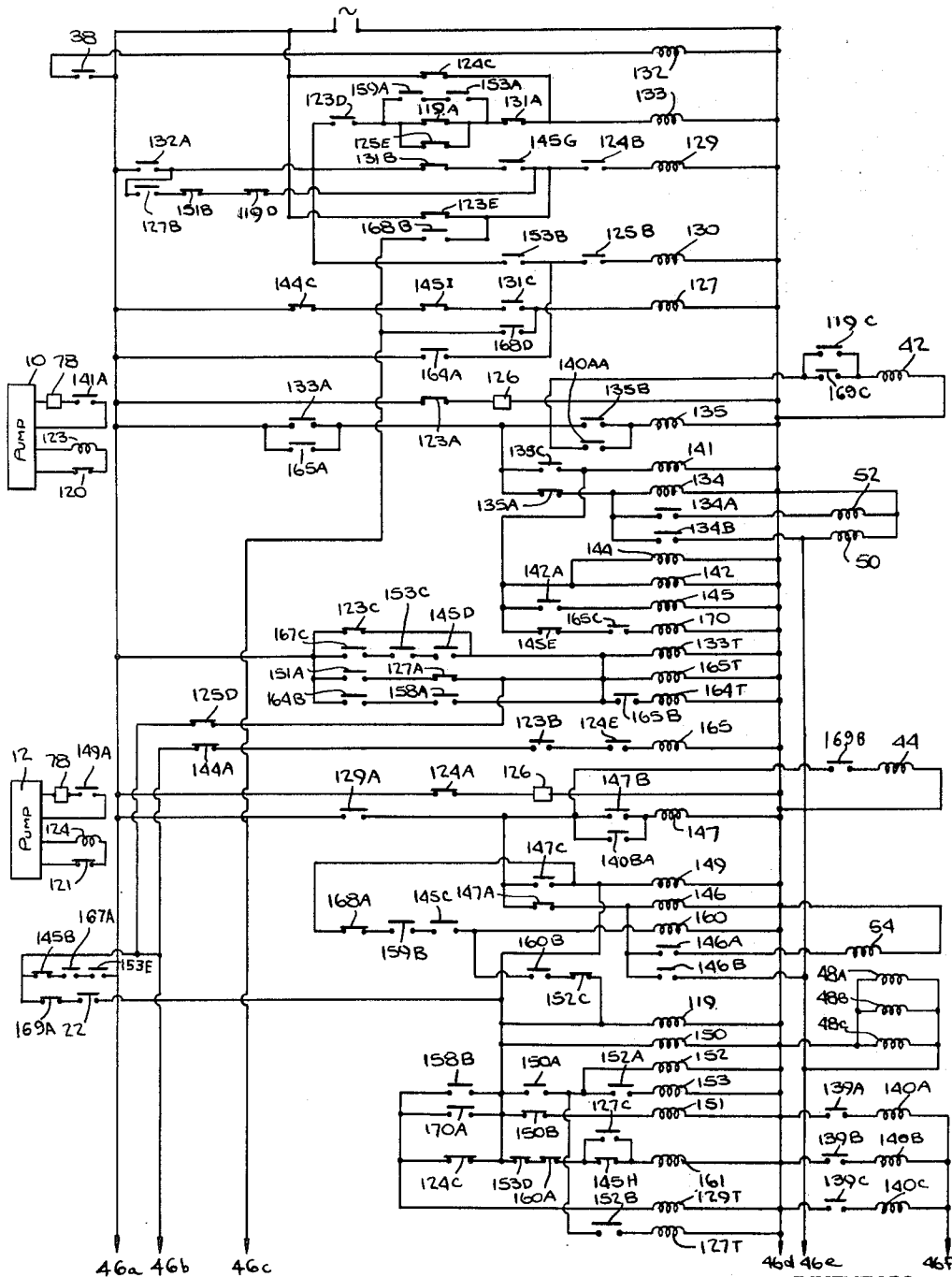
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INVENTORS

FRANK A. HIGNUTT
KENNETH W. HIGNUTT

KENNETH W. HIGNUTY

BY

Kenny & Kenny
ATTORNEYS

ATTORNEYS

Jan. 18, 1966

F. A. HIGNUTT ET AL

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PUMP CONTROL SYSTEM

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4 Sheets-Sheet 3

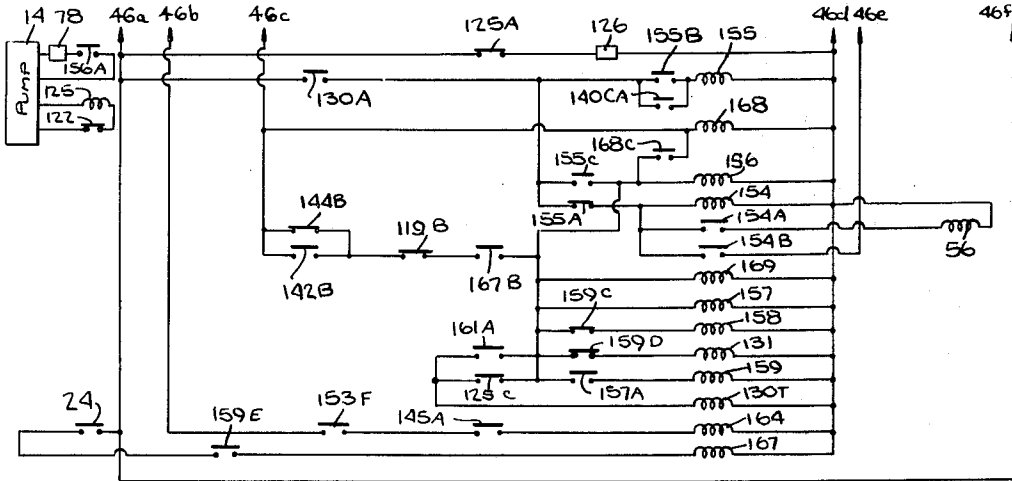


Fig. 2B.

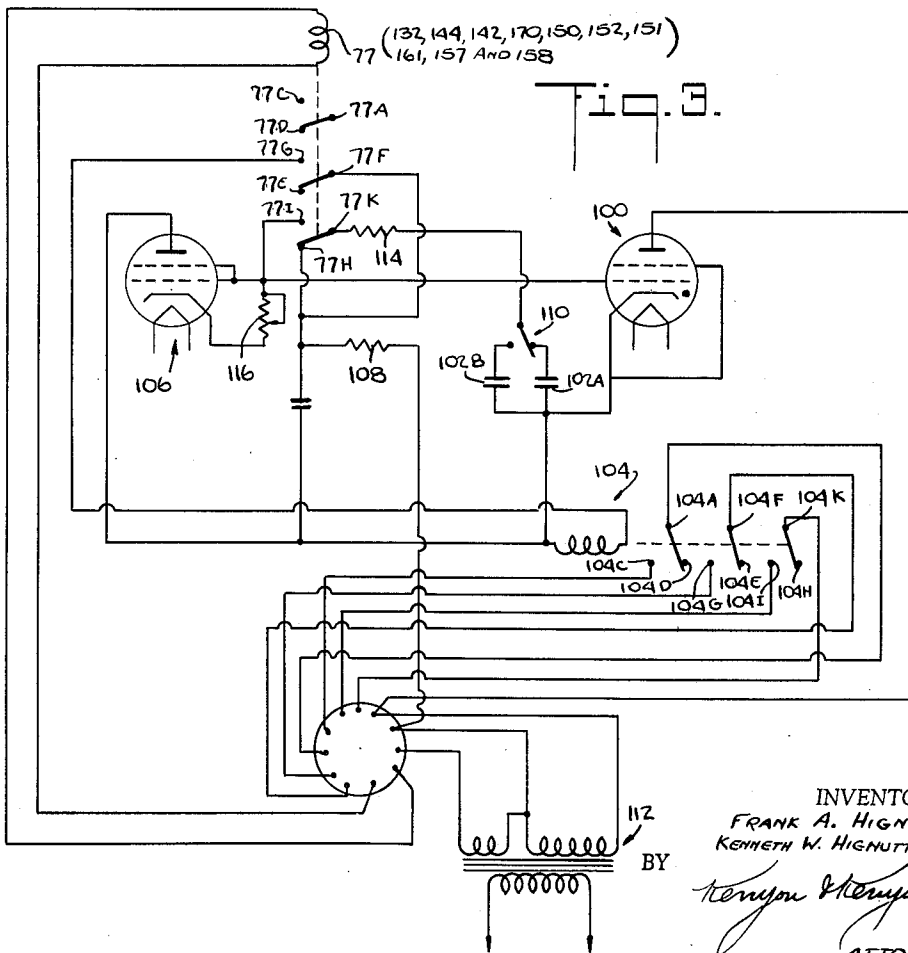


Fig. 3.

INVENTORS
FRANK A. HIGNUTT
KENNETH W. HIGNUTT

BY *Kennison & Kenyon*
ATTORNEYS

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F. A. HIGNUTT ET AL

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PUMP CONTROL SYSTEM

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4 Sheets-Sheet 4

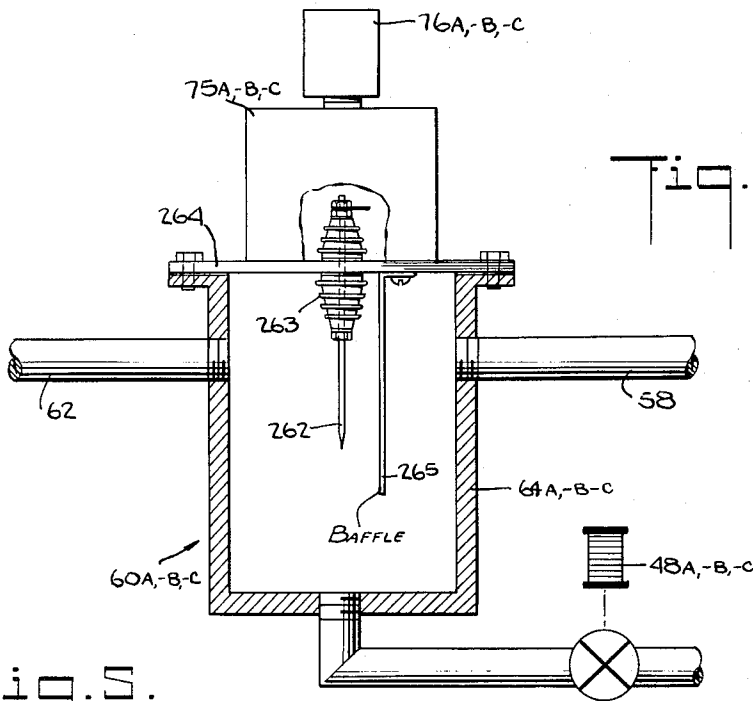
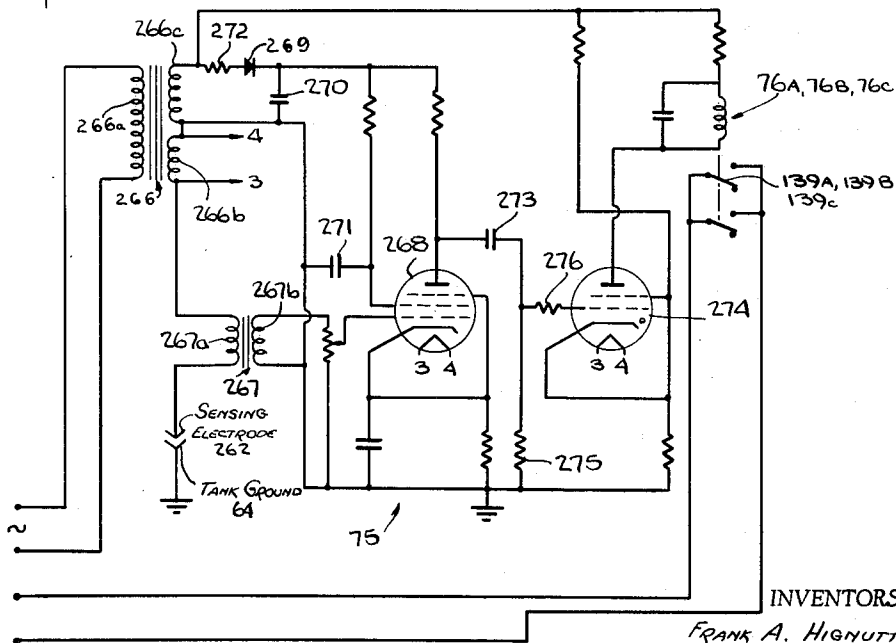


Fig. 4.

Fig. 5.



INVENTORS

BY

FRANK A. HIGNUTT
KENNETH W. HIGNUTT

Kenny & Kenny
ATTORNEYS

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3,229,639

PUMP CONTROL SYSTEM

Frank A. Hignutt, 602 E St., and Kenneth W. Hignutt,
609 F St., both of Millville, N.J.
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12 Claims. (Cl. 103—11)

This invention relates to pump control systems and more particularly to an automated pump control for maintaining a minimum pressure throughout a fluid system.

The pump control of this invention is particularly applicable for maintaining adequate water pressure under varying demand throughout a municipal water distribution system although it may also be used for distribution of other fluids in other settings.

The postwar boom in commercial and residential construction has greatly accelerated the obsolescence of existing municipal water distribution systems and thereby confronted many communities with problems of costly rejuvenation. This is quite vividly witnessed by the ever more frequent newspaper headlines reciting the latest instance of waterless taps, emergency restrictions on the use of water or the bursting of a feeder main forced to carry a pressure greater than that for which it was designed.

To increase flow capacity by piecemeal replacement and addition of conduits, and to reinforce pressure by addition of elevated storage tanks or standpipes, are solutions not only inherently duplicative and continuous, but also quite costly. Using pumps to augment pressure is both more flexible and economical. Moreover, using, as this system does, variable pumping capacity to supply ample water at a pressure sufficient for good service but no higher, not only increases the economy and efficiency of the installation still further, but also decreases wear and tear on the pumping system as a whole.

This invention has the further advantage of monitoring maximum pressure at a plurality of points in the water distribution grid to forecast impending ruptures in the mains. If the pressure at any one of these points exceeds a predetermined safe value, the supplemental pressure head supplied by the pumping station will automatically step down. In this way, a chaotic rupture in the main is averted and the conduit can be replaced, if necessary, at the community's leisure.

In addition, this invention is fully automated and needs a minimum of supervision. Maximum and minimum pressures are monitored at a plurality of points in the distribution grid and pumps are automatically energized and deenergized according to need. If there is a failure of power, there is provision for excitation of an auxiliary power source for standby service. If a pump becomes overloaded or its bearing overheated, there are automatic cutouts to deenergize the pump and energize another in its place. Other advantages of this invention are the low cost of maintenance, the ease of installation and of subsequent adaptation to changed needs, and the elimination of unsightly elevated storage reservoirs.

An object of this invention is to provide an automated system for reinforcing fluid pressure in a close fluid distribution system when, due to a modification of the demand pattern, fluid pressure in said system becomes inadequate for use.

A further object of this invention is to provide an automated system for reinforcing fluid pressure in a closed fluid distribution system which, with a minimum of expense and inconvenience, can be adapted to satisfy future changes in the pattern of demand.

A further object of this invention is to provide a method for automatically priming fluid pumps.

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A further object of this invention is to provide a priming sensing control which will automatically actuate a pump once the latter is primed.

A still further object of this invention is to provide an electronic timing device to furnish a predetermined time delay which can be variously used to provide continuity of pumping, prevent over-sensitive response to transient line surges and also preclude pumping until the system's control valves adjust.

Other objects and a further understanding of my invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagrammatic view of a specific embodiment of pump control system of this invention;

FIGS. 2 and 2B are electrical schematic drawings of the control system;

FIG. 3 is an electrical schematic of the electronic timer employed in the control system;

FIG. 4 is a vertical sectional view showing a device for sensing the level of priming liquid;

FIG. 5 is a schematic representation of an amplifier responsive to the priming level sensing device.

The pump control system of this invention basically comprises two subsystems: first, a hydraulic system which includes provision for automatic priming and actuation of pumps; second, electronic control circuitry.

Considering the hydraulic aspect first, FIG. 1 shows a particular specific embodiment of the system of this invention wherein three pumps 10, 12 and 14 are hydraulically connected to a water distribution main 16 through check valves 18, 20, 22, pressure switches 22, 24 and pressure-actuated pilot valves 26, 28, 30. Also shown are pressure-actuated control valves 32, 34, 36, pressure switch 38 and by-pass solenoid valves 42, 44.

Assuming no pumps are operating and a decrease in water pressure is sensed by pressure switch 38, said switch will close and energize the electronic control circuitry 46. As explained below, the electronic control circuitry 46 will cause the normally open priming tank drain solenoid valves 48A, 48B, and 48C to close and the main priming solenoid valve 50 and the pump 10, priming solenoid valve 52 to open. This will cause priming fluid to be sucked up the priming line 58, through the sensing control 60A and into the vacuum line 62. When the pump 10 is primed, the priming fluid will gradually fill the priming tank 64A of the sensing control 60A and thereby raise to a point where it will come in contact with the sensing element.

The priming system is so calibrated that when the water rises above a predetermined point and thereby indicates the pump 10 is adequately primed, the closure of the circuit through the water between sensing element and tank ground is sufficient to drive amplifier 75A to operate relay 76A. Closing of this relay 76A causes the pump 10 to be started by a starter 78. At this point, the electronic control circuitry 46 will open the priming tank drain solenoid valves 48A, 48B, 48C and drain the priming tank 64A and also close the priming valves 50, 52.

As will be discussed below, if the supplemental pressure head supplied to the system by this pump 10 is not enough to increase the pressure in the distribution main 16 to the preset value of pressure switch 38, additional pumps will be energized. Similarly, if the pressure head in the line increases above the value of a pressure switch 40 which monitors the maximum safe value in the main, or if the supplemental pressure required for good service decreases, pumps will be deenergized.

Priming indicators 80 are used to visually indicate priming. These instruments may be of the rotating disk, rotary vane, lobed impeller or of any equivalent type. Also, manual valves are used to close the priming tank 64

and to by-pass solenoid valve 48 and the priming solenoid valves 52, 54, 56 in the event the automatic priming system ceases to operate. In addition, provision is made for an auxiliary power source 86 to drive the electronic control circuitry 46 and the pump motors 88 in the event of a power line failure.

Consider now the control circuitry of this invention as shown in FIGS. 2 and 3.

FIG. 3 is the electrical schematic for an electronic timer which supplies a predetermined time delay variously used by the control circuitry 46 to provide continuity of pumping while the pump output is stepping up or down, to prevent the pumps from responding to transient line surges and to preclude changes in pump operation prior to adjustment of the systems' control valves.

The electronic timer of FIG. 3 is powered by means of transformer 112. The timer is shown in FIG. 3 in its de-energized condition. The plate circuit of thyratron 100 is connected across the secondary of transformer 112. The grid of thyratron 100 is biased by means of either capacitor 102A or 102B as determined by whether switch 110 is in the High or Low position, respectively. When relay 77 is deenergized thyratron 100 is not conducting, but during this period it serves the alternate function of acting at a half-wave rectifier which supplies D.C. voltage to the plate of tube 106 and also supplies the charging potential to capacitors 102A or 102B.

The capacitance of capacitors 102A and 102B is selected with different values to provide different timing ranges. As shown in FIG. 3, capacitor 102A which is connected to the cathode of thyratron 100 is charged in a negative sense with respect to the grid of the thyratron through switch 110 in the High position, surge resistor 114, switch contacts 77K and 77H and surge resistor 108. Tube 106 acts as a variable resistance and the high internal resistance of the tube is used and is controlled by the comparatively small resistance 116. The high internal resistance of tube 106 enables large RC time constants to be obtained with comparatively small capacitance values.

When relay 77 is energized, contacts 77I and 77K close with the result that capacitor 102A is connected through surge resistor 114 to the grid of tube 106. The grid of thyratron 100 is connected to the grid of tube 106. At this point capacitor 102A begins to discharge through tube 106, but the thyratron remains cut off so long as the bias from capacitor 102A is of a sufficient level. After a predetermined time determined by the resistance of tube 106 and the capacitance of capacitor 102A the bias voltage on the grid of the thyratron falls below a value at which its plate takes control. The firing of thyratron 100 energizes relay 104 which is connected in its cathode circuit. The energization of relay 104 actuates its contacts so that the circuitry for the next operation whether it be stepping up or down can be completed. It should be noted that the energization of relay 77 closes contacts 77F and 77G in order that the circuit from the thyratron through relay 104 is completed.

The timer set forth in FIG. 3 starts timing when the relay 77 is energized. The timer can be conditioned to start the timing cycle after the deenergization of relay 77 by interchanging the connections to contacts 77I and 77H and by moving the lead shown connected with contact 77G to contact 77E.

FIG. 3 shows an electronic timer of which a plurality is used in the system. In FIG. 3, the timer is actuated by timer relay 77 which operates relay 104 after the predetermined time delay period. In FIGS. 2A and 2B, the plurality of timers are represented by coil symbols and reference numerals 132, 142, 144, 150, 151, 152, 157, 158, 161, and 170. The contacts operated by each timer are identified by the timer reference numeral with a letter. Thus for example timer 132 in FIG. 2A includes contacts 132A.

FIG. 4 shows sensing devices 60A, B, and C which determine when the priming of a pump is completed. The

application of vacuum to line 62 causes water to be drawn through priming line 58 into tank 261. An accumulation of a predetermined quantity of water within tank 64 is sensed by electrode 262 which extends into the interior of the tank. Electrode 262 is insulated from the grounded tank by insulator 263. Rubber gaskets seal cover 264 to the insulator and the tank. Baffle 265 disposed within tank 64 between the locations of line 58 and electrode 262 prevents water entering into the tank from striking the electrode and causing a premature starting of the pump before it is completely primed.

FIG. 5 is a schematic representation of the amplifier for operating priming tank relay 76 in response to the detection of the completion of priming by sensing electrode 262. Upon water completing the circuit from grounded tank 64 to sensing electrode 262, current flows through secondary winding 266B of transformer 266 and primary winding 267a of transformer 267. Primary winding 266A is energized by an 115 volt alternating current source. Current from secondary winding 267b is connected to the grid of tube 268 in order that the signal from the sensing electrode be amplified. The plate of tube 268 is energized by secondary winding 266c which is connected to rectifier 269 and filter capacitors 270 and 271. Resistor 272 protects the circuit from power surges. The amplifier signal from the plate of tube 268 is connected by capacitor 273 to the control grid of tube 274. Tube 274 which is a gas tube of thyratron-type is operated with alternating current from transformer 266 in order that the grid completely controls the tube's firing cycle. Bias for tube 274 is developed by resistors 275 and 276. Tube 274 is held at cutoff until a relatively large signal is applied at its grid. Conduction of tube 274 energizes the winding of priming tank relay 76A, 76B or 76C which is connected to contacts 139A, 139B or 139C which are employed to close the circuit to relays 140A, 140B or 140C, these relays in turn start the various pumps and reset the circuitry for further use.

FIGS. 2A and 2B when connected at points 46a, 46b, 46c, 46d, 46e, and 46f comprises the electrical schematic of the control circuitry 46. Basically, this circuitry controls the operation of the pumps 10, 12, 14, the motors 88 and the auxiliary power source 86 in response to signals from sensors monitoring the distribution main 16 for maximum and minimum fluid pressures and monitoring the pumps 10, 12, 14 for overheated bearings and overload. To increase the variety of available augmenting pressure heads, pump 12 is larger than pump 10 and pump 14 is larger than pump 12.

If a pump bearing overheats, relay contacts 120, 121, 122 are actuated by a thermocouple located on each of the pumps 10, 12, 14 to take that pump off the line. Similarly, if a pump is overloaded, relays 123, 124, 125 having contacts 123A-E, 124A-E, and 125A-E, respectively, will take the pump off the line, light indicator lamps 126 and also start a substitute pump.

If the pressure switch 38 closes due to a pressure drop in the distribution main 16 below the desired minimum, timer 132 will be energized and begin to count down its preset time delay. If, at the end of this period, the pressure switch 38 is still closed, indicating the decrease in pressure is not a transient surge, normally open contacts 132A will close. This will energize latching relay 133 through contacts 123D, 119A and 131A and thereby close contacts 133A. Closing contacts 133A energizes relay 134 through contacts 135A. Contacts 134A and 134B then close and energize the pump 10 priming solenoid valve 52, the main priming solenoid valve 50 and the priming tank solenoid valves 48A, 48B, and 48C.

As discussed earlier, when pump 10 is adequately primed, the sensing control 60A actuates a relay 76A. This closes the starting switch 139A which energizes the starting relay 140A, and thereby closes normally open contact 140AA. Closing contact 140AA energizes relay 135 which is thereupon locked in by the closing of con-

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tact 135B. Also, contact 135A open and reset the priming valves 48, 50, 52. Contacts 135C close and energize relay coil 141, thereby closing contacts 141A and energizing the motor starter for pump 10.

It should be noted that although closing contacts 135C energizes timers 142 and 144, the latter timer has no effect upon the system at this time. Throughout the following discussion, dead-end paths of this nature will not be averted to. Only those signal paths resulting in significant circuitry response will be set forth.

After passage of its preset time delay, timer 142 closes contacts 142A and thereby energizes relay 145. Contacts 145G close to set up circuitry for next pump when needed. Pump 10 is now pumping.

If the pressure in the distribution main 16 is once again below the desired minimum, the pressure switch 38 will again close and energize timer 132. Latching relay 129 will then be energized through contacts 132A, 131B, 145G and 124B. This will close contacts 129A and thereby energize relay 146 through contacts 147A. Closing contacts 146A and 146B energizes the pump 12 priming solenoid valve 54, the main primary solenoid valve 50 and the primary tank drain solenoid valves 48A, 48B, and 48C.

As discussed earlier, when pump 12 is primed, the sensing control 60B closes the starting switch 139B and energizes the starting relay 140B. This closes contact 140BA and thereby energizes relay 147. Relay 147 is then locked in by the closing of contacts 147B. Opening of contacts 147A resets the priming valves 54, 50, 48. Closing of contacts 147C energizes relay 149 and thereby closes contacts 149A.

This energizes the motor starter 78 for pump 12 and also timer 150 and relay coil 119. Prior to passage of the preset time delay of timer 150, contacts 150B remain normally closed and energize timer 151. The predetermined time delay of timer 151 is set to be less than that of timer 150; thus, contacts 151A will close to stop pump 10 by energizing the trip coil 133T of latching relay 133 through contacts 127A. Also, contacts 119A will open to prevent restart of pump 10 by the next closure of the pressure switch 38.

When timer 150 finishes counting down, giving the control valves time to adjust prior to subsequent pump activation, contacts 150B open to deenergize timer 151 and contacts 150B open to deenergize timer 151 and contacts close to energize timer 152. After the preset time delay of timer 152, its normally open contacts 152A close to energize relay 153. This closes normally open contacts 153B and resets the system for response to further changes in pressure in the distribution main 16. Pump 12 is now pumping.

Should the pressure in the distribution main once again decrease below the setting of the pressure switch 38, said pressure switch will close and energize timer 132. This energizes latching relay 130 through contacts 132A, 153B and 125B and closes contacts 130A. This energizes relay 154 through normally closed contacts 155A and thereby energizes the pump 14 priming solenoid valve 56, the main priming solenoid valve 50 and the priming tank drain solenoid valves 48A, 48B and 48C through contacts 154A and 154B.

Once pump 14 is primed, the sensing control 60C energizes the starting relay 140C to close contacts 140CA. This energizes relay 155 which is then locked in by its contacts 155B. Also, contacts 155A open to deenergize relay 154 and contacts 155C close to energize relay 156. Closing contacts 156A energizes the motor starter 78 and starts pump 14.

Closing contacts 155C also energizes timer 157, timer 158 through contacts 159C, and relay 131 through contacts 159D. After the elapse of the preset time delay of timer 158, contacts 158B close and energize the trip coil 129T of latching relay 129 through contacts 129A, 147C and 158B. This takes pump 12 off the line.

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Also, contacts 131A and 131B open to prevent the starting of any additional pumps until the control valves adjust. Contacts 131C close to energize latching relay 127 through contacts 144C and 145I. After elapse of the preset time delay of timer 157, contacts 157A close and energize relay 159. Contacts 159C and 159D then open to deenergize timer 158 and relay 131 respectively. This prepares the system for further changes in pump operation. Pump 14 is now pumping.

Should the pressure in the distribution main once again decrease below the setting of the pressure switch 38, said pressure switch will close and energize timer 132. This energizes latching relay 133 through contacts 132A, 123D, 119A and 131A. This closes contacts 133A and energizes relay 134 through contacts 135A. Relay 134 then energizes the pump 10 priming solenoid valve 52, the main priming solenoid valve 50 and the priming tank drain solenoids 48A, 48B, and 48C through contacts 134A and 134B. Once pump 10 is primed, the sensing control 60A energizes the starting relay 140A to close contacts 140AA. This energizes relay 135 which is then locked in by its contacts 135B. Also, contacts 135A open to reset the priming valves and contacts 135C close to energize relay 141. Closing contacts 141A starts pump 10.

Closing contact 132A also energizes latching relay 129 through contacts 127B, 151B, 119D and 124B. Contacts 129A then close to energize relay 146 through contacts 147A. This in turn energizes the pump 12 priming solenoid valve 54, the main priming solenoid valve 50 and the priming tank drain solenoid valves 48A, 48B, 48C through contacts 146A and 146B.

As soon as pump 12 is primed, the starting relay 140B is energized. Contacts 140BA then close to energize relay 147 which is thereupon locked in by contacts 147B. Also, contacts 147A open to deenergize relay 146 and thereby reset the priming valves. At the same time, contacts 147C close to energize relay 149 which in turn closes its contacts 149A to start pump 12.

Contacts 147C also energize timers 150 and 151 and relay 119. Timer 151 is energized through contacts 150B. After elapse of its preset time delay, timer 151 opens contacts 151B and thereby deenergizes latching coil 129. After elapse of its preset time delay, timer 161, which is also energized at this time through contacts 153D, 160A and 127C, closes contacts 161A and thereby energizes the trip coil 130T of latching relay 130. This takes pump 14 off the line.

The energizing of relay 119 opens contacts 119D to prevent feedback after contacts 151B close, and closes contacts 119C to energize pump 10 bypass solenoid valve 42 to by-pass the control valve 32 of pump 10 and thereby prevent the larger pump 12 from overriding the smaller pump 10.

After a preset time delay to give the control valves time to adjust, timer 150 opens contacts 150B to deenergize timer 151 and closes contacts 150A to energize timer 152. After its preset time delay, timer 152 closes contacts 152A to energize relay 153, and closes contacts 152B to energize the trip coil 127T of latching relay 127. This resets relay 127 for future use.

Energizing relay 153 opens contacts 153D to deenergize timer 161 and closes contacts 153B to prepare the system for further changes in pump operation. Both pumps 10 and 12 are now pumping.

If the pressure in the distribution main continued to fall below the desired level, the control circuitry would continue to excite the three pumps in a manner analogous to that heretofore set forth. Thus, the pumping would next be by pumps 10 and 14, then by pumps 12 and 14 and finally by pumps 10, 12, and 14. The aggregate pressure head of the three pumps would be the maximum capacity of this embodiment although, of course, additional pumps could be added to augment said maximum.

Assume now the demand in the distribution main stops increasing and instead begins to decrease. As soon as

the pressure on pressure switch 22 rises to the point where pump 14 can carry the load alone, switch 22 closes, energizing latching relay 164 through normally open contacts 145A, 153F which, as indicated above, are now closed.

Energizing latching relay 164 closes contacts 164A and energizes latching relay 130 through contacts 125B. This closes contacts 130A and energizes relay 154 through contacts 155A. This in turn energizes the pump 14 priming solenoid valve 56, the main priming solenoid valve 50 and the priming tank drain solenoid valves 48A, 48B, 48C through contacts 154A and 154B.

As soon as pump 14 is primed, the sensing control 60C energizes the starting relay 140C. Contacts 140CA then close to energize relay 155 which is thereupon locked in by contact 155B. Also, contacts 155A open to de-energize relay 154 and thereby reset the priming valves. At the same time contacts 155C close to energize relay 156 which in turn closes contacts 156A and starts pump 14.

Contacts 155C also energize timers 157 and 158 and relay 131. Timer 158 is energized through contacts 159C. After its preset time delay, timer 158 closes contacts 158B to energize the trip coil 129T of latching relay 129 to stop pump 12.

Contacts 158A also close to energize the trip coil 133T of latching relay 133 and the trip coil 165T of latching relay 165 through contacts 164B and 158A. Trip coil 164T is then energized through contacts 165B and the circuitry is reset. At this point pumps 10 and 12 are dropped off the line.

Relay 131 is energized through contacts 159D thereby opening contacts 131A and 131B to prevent the start of additional pumps until adjustment of the control valves. Timer 157, energized by contacts 155C, provides the delay for this valve adjustment. When contacts 131C close, latching relay 127 is energized through contacts 144C and 145I. After its preset time delay, timer 157 closes contacts 157A and thereby energizes relay 159. This in turn opens contacts 159C and 159D to deenergize timer 158 and relay 131 and prepare the circuits for the next step. Pump 14 is now pumping.

If the demand in the distribution main continues to decrease, pump 14 control valve 36 will gradually close, thereby increasing the head pressure on pump 14. When the head pressure is such as to indicate pump 12 can carry the load, pressure switch 24 will close, energizing relay 167 through contacts 159E. Contacts 167B then close and energize relay 168 through contacts 119B and 144B. Relay 168 is thereupon locked in by its contacts 168C and contacts 168D close to energize latching relay 127. At the same time, contacts 168B energize latching relay 129 through contacts 124B. Relay 129 in turn closes contacts 129A which energizes relay 146 through contacts 147A. Relay 146 then energizes the pump 12 priming solenoid valve 54, the main priming solenoid valve 50 and the priming tank drain solenoid valves 48A, 48B, 48C through contacts 146A and 146B.

As soon as pump 12 is primed, the sensing control 60B energizes starting relay 140B, contacts 140BA close and energize relay 147 which is then locked in by the closing of its contacts 147B. Contacts 147A open to deenergize relay 146 and contacts 147C close to energize relay 149 which in turn closes contacts 149A and starts pump 12.

Contacts 147C also energize timer 161 through contacts 153D, 160A and 145H. Timer 161 closes contacts 161A to energize the trip coil 130T of latching relay 130 to take pump 14 off the line.

Contacts 147C also energize timer 150 which, after a preset time delay to allow the control valves to adjust, opens contacts 150B to deenergize timer 151 and closes contacts 150A to energize timer 152. After its preset time delay, timer 152 closes contacts 152A to energize relay 153 and also closes contacts 152B to deenergize the trip coil 127T of latching relay 127. At this point,

the circuit is ready for a subsequent change in pumping requirements. Pump 12 is now pumping.

If the demand in the distribution main continues to decrease, pump 12 control valve 34 will gradually close, thereby increasing the head pressure on pump 12. When the head pressure is such as to indicate pump 10 can carry the load, pressure switch 22 will close, energizing latching relay 165 through contacts 169A, 144A, 123B and 124 E. Closing contacts 165A energizes relay 134 through contacts 135A. Relay 134 in turn energizes pump 10 priming solenoid valve 52, main priming solenoid valve 50 and priming tank drain solenoid valves 48A, 48B, 48C through contacts 134A and 134B.

As soon as pump 10 is primed, the sensing control 60A energizes starting relay 140A. Contacts 140AA then close and energize relay 135. Relay 135 is locked in by the closing of its contacts 135B. Contacts 135A open to reset the priming valves and contacts 135C close to energize relay 141 which in turn closes contacts 141A and starts pump 10.

Contacts 135C also energize timers 142 and 170. Timer 170, energized through contacts 145E and 165C, closes contacts 170A to energize trip coil 129T of latching relay 129 to take pump 12 off the line.

After its preset time delay, timer 142 closes contacts 142A to energize relay 145. Contacts 145G then close to reset the system for a subsequent change in pumping requirements. Pump 10 is now pumping alone.

Although the invention is described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and the numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

We claim:

1. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of each of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing pressure in said distribution system, means for sensing the discharge pressure of each of said plurality of pumping means upstream of said flow varying means related thereto, means for priming each of said plurality of pumping means, means for energizing and deenergizing each of said pumping means, and means for activating said priming means and said energizing and deenergizing means for each of said pumping means in a predetermined sequence in response to the departure of said discharge pressure and said distribution system pressure being sensed from predetermined pressure levels, whereby the operation of said plurality of pumping means is controlled to maintain the pressure in said distribution system at said predetermined pressure level.

2. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of each of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing pressure in said distribution system, said distribution system having a predetermined minimum pressure level, means for sensing the discharge pressure of each of said plurality of pumping means upstream of said flow varying means related thereto, said pumping means each having a predetermined maximum discharge pressure level, means for priming each of said plurality of pumping means, means for energizing and deenergizing each of said pumping means, and means for activating said priming means and said energizing and deenergizing means for each of said pumping means in a predeter-

mined sequence in response to a discharge pressure level being sensed in excess of said predetermined maximum discharge pressure level and a distribution system pressure less than said predetermined minimum pressure level, whereby the operation of said plurality of pumping means is controlled to maintain the pressure in said distribution system at said predetermined pressure level.

3. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of each of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing pressure in said distribution system, means for sensing the discharge pressure of each of said plurality of pumping means, means for priming each of said plurality of pumping means upstream of said flow varying means related thereto, means for energizing and deenergizing each of said pumping means, means for activating said priming means and said energizing and deenergizing for each of said pumping means in a predetermined sequence in response to the departure of said discharge pressure and said distribution system pressure being sensed from predetermined pressure levels, and means for delaying the priming and deenergization of said pumping means for predetermined time intervals following the response of said activating means, whereby the operation of said plurality of pumping means is controlled to maintain the pressure in said distribution system at said predetermined pressure level.

4. In a fluid distribution system having a plurality of means for pumping said fluid and means for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing pressure in said distribution system, means for sensing the discharge pressure of each of said plurality of pumping means, means for priming each of said plurality of pumping means, means for energizing and deenergizing each of said pumping means, means for activating said priming means and said energizing and deenergizing means for each of said pumping means in a predetermined sequence in response to the departure of said discharge pressure and said distribution system pressure from predetermined pressure levels, and means for biasing to a maximum flow condition at least one of the flow varying means of a plurality of activated pumping means, whereby the operation of said plurality of pumping means is controlled to maintain the pressure in said distribution system at said predetermined pressure level.

5. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of each of said plurality of pumping means and said distribution system, the method comprising the steps of pumping fluid by at least one of a plurality of pumping means, varying the flow through at least one of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, sensing the pressure in said distribution system, sensing the discharge pressure of each of said pumping means upstream of said flow varying means related thereto, and activating the priming of said pumping means to be energized and activating the energizing and deenergizing of said pumping means in response to the departure of said discharge pressure and said distribution pressure from predetermined pressure levels, whereby the operation of said plurality of pumps is controlled to maintain the pressure in said distribution system at said predetermined pressure level.

6. A fluid distribution system in accordance with claim 5 and further comprising the step of delaying the activating of the priming and the deenergizing of said pumping means for predetermined time intervals following the

departure of said discharge pressure and said distribution pressure from predetermined pressure levels.

7. A fluid distribution system in accordance with claim 6 and further comprising the step of biasing to a maximum flow condition the flow through at least one of a plurality of activated pumping means.

8. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of each of said plurality of pumping means and said distribution system, the method comprising the steps of pumping fluid by at least one of a plurality of pumping means, varying the flow through at least one of said plurality of pumping means in order to maintain said distribution system at a predetermined minimum pressure level, sensing the pressure in said distribution system, sensing the discharge pressure of each of said pumping means upstream of said flow varying means related thereto, said discharge pressure having a predetermined maximum level, and activating the priming means of said pumping means to be energized and activating the energizing and deenergizing of said pumping means in response to a discharge pressure in excess of said predetermined maximum level and said distribution system pressure less than said predetermined minimum pressure level, whereby the operation of said plurality of pumping means is controlled to maintain the pressure in said distribution system at said predetermined pressure level.

9. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing a decrease in the pressure of the distribution system from a predetermined pressure, means for sensing an increase in the discharge pressure of each of said pumping means of said plurality upstream of said flow varying means related thereto from another predetermined pressure, means responsive to the sensing of a decrease in the pressure of the distribution system for selecting at least one other pumping means of said plurality to be activated, said selecting being in accordance with a predetermined sequence of activating the pumping means of said plurality, additional means responsive to the sensing of an increase in the discharge pressure of one of the pumping means of said plurality for selecting at least one other pumping means of said plurality to be activated, said selecting being in accordance with another predetermined sequence of activating the pumping means of said plurality, means responsive to said selecting means and said additional selecting means for priming the pumping means selected thereby, means responsive to the completion of said priming of said selected pumping means for starting said selected pumping means, means responsive to the starting of said selected pumping means for terminating the operation of said one pumping means of said plurality thereof after a predetermined time interval following the starting of said selected pumping means, and means for preventing the starting of any additional pumping means of said plurality thereof for an additional predetermined time interval which is greater than said predetermined time interval.

10. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing a decrease in the pressure of the distribution system from a predetermined pressure, means for sensing an increase in the discharge pressure of at least some of said pumping means of said plurality upstream of said flow varying means related thereto from another predeter-

mined pressure, means responsive to the sensing of a decrease in the pressure of the distribution system for selecting at least one other pumping means of said plurality to be activated, said selecting being in accordance with a predetermined sequence of activating the pumping means of said plurality, additional means responsive to the sensing of an increase in the discharge pressure of one of the pumping means of said plurality for selecting at least one other pumping means of said plurality to be activated, said selecting being in accordance with another predetermined sequence of activating the pumping means of said plurality, means responsive to said selecting means and said additional selecting means for priming the pumping means selected thereby, means responsive to the completion of said priming of said selected pumping means for starting said selected pumping means, means responsive to the starting of said selected pumping means for terminating the operation of said one pumping means of said plurality thereof after a predetermined time interval following the starting of said selected pumping means, and means for preventing the starting of any additional pumping means of said plurality thereof for an additional predetermined time interval which is greater than said predetermined time interval.

11. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the combination comprising means for sensing a decrease in the pressure of the distribution system from a predetermined pressure, means for sensing an increase in the discharge pressure of at least some of said pumping means of said plurality upstream of said flow varying means related thereto from another predetermined pressure, means responsive to the sensing of a decrease in the pressure of the distribution system for selecting at least one other pumping means of said plurality to be activated, said selecting being in accordance with a predetermined sequence of activating the pumping means of said plurality, additional means responsive to the sensing of an increase in the discharge pressure of one of the pumping means of said plurality for selecting at least one other pumping means of said plurality to be activated, said selecting being in accordance with another predetermined sequence of activating the pumping means of said plurality, means responsive to said selecting means and said additional selecting means for priming the pumping means selected thereby, means responsive to the completion of said priming of said selected pumping means for starting said selected pumping means, means responsive to the starting of said selected pumping means for terminating the operation of said one pumping means of said plurality thereof after a predetermined time interval following the starting of said selected pumping means, means for pre-

venting the starting of any additional pumping means of said plurality thereof for an additional predetermined time interval which is greater than said predetermined time interval, and means responsive to the starting of said selected pumping means for biasing to a maximum flow condition at least one of said flow varying means related to as activated pumping means.

12. In a fluid distribution system having a plurality of means for pumping said fluid and means connected between the discharge side of said plurality of pumping means and said distribution system for varying the flow through each of said plurality of pumping means in order to maintain said distribution system at a predetermined pressure level, the method comprising the steps of sensing a decrease in the pressure of the distribution system from a predetermined pressure, sensing an increase in the discharge pressure of each of said pumping means of said plurality upstream of said flow varying means related thereto from another predetermined pressure selecting in response to the sensing of a decrease in the pressure of the distribution system at least one other pumping means of said plurality to be activated, said selection being in accordance with a predetermined sequence of activating the pumping means of said plurality, additionally selecting in response to the sensing of an increase in the discharge pressure of one of the pumping means of said plurality at least one other pumping means of said plurality to be activated, said selecting being in accordance with another predetermined sequence of activating the pumping means of said plurality, priming the pumping means selected in response to said selecting and said additional selecting, starting the selected pumping means in response to the completion of the priming thereof terminating the operation of one of said pumping means in response to the starting of the selected pumping means at a predetermined time interval following the starting of said selected pumping means, and preventing the starting of any additional pumping means of said plurality thereof for an additional predetermined time interval which is greater than said predetermined time interval.

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LAURENCE V. EFNER, *Primary Examiner*.