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CONTROLLER FOR FLUID PUMP

FIELD OF THE INVENTION

- 5 The present invention relates to a method to control the water supply in multiple dwelling building. In particular, it pertains to an intelligent controller for booster pump for supplying water to multiple dwelling high rise building where actual demand of water is detected to minimise energy consumption.

10 BACKGROUND OF THE INVENTION

- A prior art variable speed controller for controlling at least a booster pump, and receiving signals from at least one flow sensor and at least one pressure sensor is disclosed in U.K. patent application no. 9419037.8 by the
15 same applicant of the present invention. The flow sensor is coupled to a water pipe downstream from the booster pump for measuring the demand of water and for sending appropriate feedback signals to the variable speed controller which in turn varies the speed of the booster pump. A pressure
20 sensor coupled to the water pipe downstream from or at a one-way valve (disposed downstream from the booster pump) detects a first demand for water and transmits a feedback signal to the variable speed controller which in turn operates the booster pump to supply water to the first and subsequent user with the minimum required water pressure. This prior art controller
25 supplies the end user with sufficient water pressure at any time of the day in multiple dwelling high-rise building. It also minimizes energy consumption. Moreover, maintenance and installation costs of the prior art controller are expected to be lower and the water pump set's life cycle is prolonged.

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The flow sensor of the above prior art invention is costly as it must meet stringent regulatory approval from the health, safety and utility authorities before it can be installed. As a result, the overall cost of the prior art variable speed controller is higher than those that use exclusively pressure sensors.

- 5 In general, pressure sensors suitable for use in drinking water supply system are cheaper than the flow sensor counterparts.

OBJECT OF THE INVENTION

It is an object of the present invention to control water supply to high rise dwelling units by using inexpensive pressure sensor and providing adequate fluid pressure throughout the day.

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It is an additional object of the present invention to control water supply to high rise dwelling units by using inexpensive pressure sensor and detecting the actual demand of water use throughout the day.

10 It is yet another object of the present invention to control water supply to high rise dwelling units by using inexpensive pressure sensor, meeting customer satisfaction requirements while minimizing the overall energy consumption and maintenance cost of such systems.

15 **SUMMARY OF THE INVENTION**

The present invention comprises a controller for controlling at least a booster pump, and receiving signals from at least two pressure sensors. The first pressure sensor is coupled to a water pipe downstream from the booster
20 pump and a one-way valve for detecting and setting a high pressure threshold P_H and sending appropriate feedback signals to the controller which in turn varies the speed of the booster pump. P_H represents near zero or no demand of water. P_H also serves as a reference for the present invention to confirm automatically the actual demand for water in the
25 pipeline without using flow sensors. A second pressure sensor is also coupled to the water pipe downstream from the booster pump and a one-way valve for detecting and setting a low pressure threshold P_L and for transmitting a feedback signal to the controller which in turn operates the

booster pump to supply water to the first and subsequent user with the minimum required water pressure. P_L represents a high level of demand for water. P_H and P_L offers controller a range of pressure which is larger than that of the sensitivity of the pressure sensors. By forcing the booster pump to

5 run at a pressure below the threshold P_H , the present invention confirms automatically the actual demand for water in the pipeline even if the demand is not sensitive enough for the pressure sensors to detect. The controller then varies the speed of the booster pump to compensate for the difference between the actual demand for water and the output of the booster pump

10 without using any flow sensor. As such, the present invention controls water supply to high rise dwelling units without using more expensive components while offering building managers the benefits of using economically based controller using pressure sensors.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the layout of a prior art booster pump control system employed recently to improve the water pressure of upper floor units of multiple dwelling buildings. The system uses at least one pressure sensor and one flow sensor.

Fig. 2 is an embodiment of the present invention where a new controller is being integrated with at least two pressure sensors to a prior art booster pump system.

Fig. 3 is a schematic of the new controller of the present invention as referred to in Fig. 2.

Fig. 4 is a flow chart illustrating the method of controlling water supply to high rise dwelling by using inexpensive pressure sensors while delivering comparable performance in terms of energy efficiency, maintenance and longevity of booster pumpset.

DESCRIPTION OF THE EMBODIMENT OF THE INVENTION

A method and apparatus for controlling fluid supply in high rise dwellings is described. In the following description, numerous specific details are set forth such as bit pattern and program steps, etc. in order to provide a thorough understanding of the present invention. It will be obvious to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known parts such as those involved with the valves and piping are not shown in order not to obscure the present invention.

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Notation and Nomenclature

The detailed description with respect to the method of controlling fluid supply by forcing the system to confirm whether the flow of water corresponds to the actual demand of fluid without using flow sensors are presented partially in terms of algorithm and symbolic representation upon operation on data bits within the computer memory. These algorithmic descriptions and representations are the means used by those skilled in the art in the data processing arts to most effectively convey the substance of their work to others skilled in the art.

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An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. These steps are those require physical manipulation of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, and otherwise manipulated.

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In this case, the physical quantities are electrical signals which correspond to the pressure of fluids in the pipe. It proves convenient at times, principally for reason of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers or the like. It should be

borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities.

Further, the manipulations performed are often referred to in terms
5 such as adding or comparing, which are commonly associated with the mental operations performed by a human operator. No such capability of a human operator is necessary, or desirable. In most cases, in any of the operations described herein which form part of the present invention; the operations are machine operations. Useful machines for performing the
10 operations of the present invention include general purpose digital computers or similar devices such as digital signal processors. In all cases, it should be borne in mind that there is a distinction between the method operation in operating a computer and the method of computation itself. The present invention relates to method steps for operating a computer in
15 converting electrical signals to generate other desired physical signals.

The present invention also relates to an apparatus for performing these operations. This apparatus may be specially constructed for the required purpose or it may comprise a general purpose computer as selectively activated or reconfigured by a computer program stores in the
20 computer. The algorithms presented herein are not inherently related to any particular computer or other apparatus. In particular, various general purpose machines may be used with programs written in accordance with the teachings herein, or it may prove more convenient to construct specialized apparatus such as digital signal processor to perform the
25 required method steps. The required structure for a variety of these machines would appear from the description given below.

Fig. 1, is a prior art booster pump control system employed recently to improve the water pressure of upper floor units of multiple dwelling buildings. The system is the subject of pending U.K. patent application no. 9419037.8, Singapore patent application no. ? and Malaysian patent application no. ?? by the same applicant as the present invention.

The existing booster pump water supply system comprises a water pipe 12 connected at one end to a water tank 10 and the other end to required outlets below (not shown). Coupled to this water pipe is a booster pump 14 with a one-way valve 15. The valve maintains pressure downstream therefrom in the water pipe. The booster pump 14 is connected to and controlled by a control panel 22. The panel 22 is connected to a power source (not shown) from which it draws power. It is also connected to the water tank 10 via a water level sensing device (not shown) disposed therein for monitoring the water level.

The prior art control system comprises a controller 20, a flow sensor 16 and a pressure sensor 18. The controller 20 operates the booster pump 14 by outputting power with varying frequencies to control the speed of the booster pump such that water demand is met. Therefore, for instance, if the demand for water increases, then, the controller 20 operates the booster pump at a higher frequency. The flow sensor 16 outputs a current signal to the controller 20 which varies proportionally with the rate of water flow detected and it enables the controller to drive the booster pump at a speed that will meet the demand rate.

The pressure sensor 18 has adjustable pressure setting and sends a current signal to a processing circuit (not shown) integrated with a control panel 22 when the pressure in the water pipe drops below a predetermined pressure setting. The predetermined water pressure corresponds to the

minimum amount of water pressure necessary to activate essential appliance such as water heater.

With the integration of the prior art control system, the booster pump is no longer controlled by the control panel 22. Instead, the existing control panel is connected to the variable speed controller 20 via a power line (not shown) providing power thereto. The power supply to the controller 20 is cut off when the control panel senses that the water level in the water tank 10 is too low. The booster pump is now controlled by the controller 20. Depending on the water demand, indicated by the flow sensor 16 disposed downstream from the booster pump (but can be either upstream or downstream from the one-way valve 15), the controller actuates the booster pump to operate at a speed to meet the demand for water. It varies the speed of the booster pump by varying the input frequency thereto. Therefore, energy consumption is minimized and the booster pump is operated at its best efficiency point.

The flow sensor 16 of the prior art controller in Fig. 1 is costly as it must meet stringent regulatory approval from the health, safety and utility authorities before it can be installed. As a result, the overall cost of the prior art variable speed controller is higher than those that use exclusively pressure sensors. In general, pressure sensors suitable for use in drinking water supply system are cheaper than the flow sensor counterparts.

Fig. 2 is an embodiment of the present invention where a new controller is being integrated with at least two pressure sensors to a prior art booster pump system. Like the booster pump system in Fig. 1, the existing booster pump water supply system comprises a water pipe 32 connected at one end to a water tank 30 and the other end to required outlets below (not shown). Coupled to this water pipe is a booster pump 34 with a one-way valve 35. The valve maintains pressure downstream therefrom in the water

pipe. The booster pump 34 is connected to and controlled by a control panel 42. The panel 42 is connected to a power source (not shown) from which it draws power. It is also connected to the water tank 30 via a water level sensing device (not shown) disposed therein for monitoring the water level.

Referring to Fig. 2, the present invention comprises a controller 40, at least two pressure sensors 36 and 38. The pressure sensors 36 and 38 are coupled to the pipe downstream from the valve 35 for sensing pressure therein. The pressure sensors 36 and 38 are also each coupled to the controller 40 for providing signals to a processing circuit therein (shown in Fig. 3).

The function of the pressure sensor 36 and 38 in Fig. 2 is to detect predetermined pressure thresholds in the pipeline. Pressure sensor 36 is set at a predetermined low pressure threshold P_L to transmit an appropriate signal to the controller 40 to activate or deactivate the booster pump 34. Likewise, pressure sensor 38 is set at a predetermined high pressure threshold P_H to transmit an appropriate signal to the controller 40 to activate or deactivate the booster pump 34. P_L represents a high level of demand for water in the pipeline, while P_H represents near zero or no demand of water in the pipeline. P_H also serves as a reference for the present invention to confirm automatically the actual demand for water in the pipeline without using flow sensors. P_H and P_L offers the controller a range of pressure which is larger than that of the sensitivity of the pressure sensors. By sensitivity of a pressure sensor, the present invention refers to the minimum amount of change in pressure a sensor is rated to detect. For example, most pressure sensors for controlling fluid supply detect pressure change of 1 pound per square inch (psi). Some sensors can however detect change in pressure of as little as 0.5 psi. Referring to pressure sensors 36 and 38 (assuming the

sensitivity of the sensors are rated at 1psi) of the present invention, the present invention sets the thresholds P_L and P_H at, for instance, 1.5 psi above and below a predetermined minimum pressure in the pipeline.

It can be appreciated that P_L and P_H define a range of pressure that is
5 larger than one which relies on the sensitivity of the sensors. The purposes of setting the predetermined pressure thresholds P_L below and P_H above the sensitivity rating of the pressure sensors are multiple fold and are the key features of the present invention. First, there is a limit on how much change in pressure the existing pressure sensors can detect in a pipeline of multiple
10 high rise dwellings. As a result, the booster pump provides incorrect amount of pressure when it relies on the feedback signals from a pressure sensor. Second, as will be elaborated below, by forcing the booster pump 34 to run at a pressure lower than the predetermined high pressure threshold P_H , the present invention obtain a true confirmation of the actual demand of water
15 without using flow sensors. Finally, as the number of inaccurate reading of the actual demand of water is reduced by the system disclosed in Figs 2 - 4, the present invention controls water supply to high rise dwelling units effectively without using more expensive components while delivering comparable performance in terms of energy efficiency, maintenance and
20 longevity of booster pumpset as systems using pressure sensors.

Fig. 3 is a schematic of the new controller of the present invention as referred to in Fig. 2. Controller 40 comprises a series of CMOS "NOR" R-S latch flip flops 50, another series of CMOS "NOR" logic gates 51 and 52, yet another series of CMOS Schmitt trigger NAND gates 53 and 54, three NPN
25 transistors 55, 56, and 57, two low voltage relays 58 and 59, and capacitors 60, 62 and resistors 61 and 63. The controller 40 has at its input two switches for connecting to the pressure sensors 36 and 38 respectively. At its output, the relays 58 and 59 are coupled to control panel 42.

Operationally, the upon the start up of the process as will be described in detail below in connection with the flow chart in Fig. 4, capacitor 60 and resistor 61 ensures that transistors 56 and 57 are turned off. This makes sure that the booster pump 34 is off. When there is demand for fluid in the pipe, pressure sensor 38 is activated, but transistors 56 and 57 remains off. With further demand for fluid in the pipeline, pressure sensor 36 is then activated. Here, pressure sensors 36 and 38 are both activated. Therefore, transistors 56 and 57 are turned on. These two transistors will remain on until the pipeline pressure fall below both the threshold P_H and P_L .

When the pipeline pressure fall below both the threshold P_H and P_L transistor 56 is turned off and transistor 57 remains on for n second interval. The interval n is adjustable by varying the values of capacitor 62 and resistor 63. As will be elaborated below, this is the confirmation stage of the present invention where the booster pump is forced to run at lower pressure L . If during this interval, both P_H and P_L are activated (i.e., sudden increase in demand for fluid in the pipeline), transistor 56 will be turned on. This will cause the booster pump to run at high speed H .

However, if there is no sudden surge in demand for fluid during this interval, the present invention checks whether the pressure sensor 36 is closed. If it is, transistors 56 and 57 are turned on again. Booster pump 34 resumes running at high speed H . Otherwise, both transistors 56 and 57 are turned off, and booster pump is shut off.

Fig. 4 is a flow chart illustrating the method of controlling water supply to multiple high rise dwellings by using inexpensive pressure sensors while delivering comparable performance in terms of energy efficiency, maintenance and longevity of booster pumpset. The process starts in step 80 after which in step 82 where the system tests whether the pressure in the pipeline P_p is less than that of the predetermined threshold P_H . If it is not, it

means that P_p is at P_H and there appears to be no demand for water in the pipeline. Therefore, the booster pump remains off, and P_p is maintained at P_H . If P_p is indeed less than P_H , it means that there is some demand for water in the pipeline. With demand for water in the pipeline, the pressure in the pipeline decreases. Pressure sensor 38 transmits a signal to the controller 40 in Fig. 2 to run the booster pump at high pressure H. P_p is then tested in step 84 to determine if it is lower than the predetermined lower threshold P_L . This step helps to determine if the demand for water in the pipeline is high or low. If P_p is not less than P_L or the demand for water is low, the booster pump remains off in order to conserve energy, and maintains the pipeline pressure just below pressure P_H . However, if the demand for water is high, the pressure in the pipeline P_p drops below P_L , then step 86 occurs. Here, the pressure sensor 36 sends a signal to the booster pump 34 so that the latter runs at high pressure H.

Again in Fig. 4, the pressure P_p in the pipeline is tested to determine if it exceeds the threshold P_L in step 88. Here, the present invention determines if the demand for water in the pipeline continues to be high. If it is, P_p will be less than P_L and the booster pump continues to run at pressure H. Otherwise, P_p is tested in step 90 to determine if it is greater than the threshold P_H . If it is not, then the booster pump continues to run at H. If the pipeline pressure P_p is now greater than the threshold P_H , it means that the present invention suspects that the demand for water could drop to near zero. Hence, in step 92 the booster pump 34 is forced to reduce to run at lower pressure L for a predetermined period n.

In Fig. 4, steps 92 - 98 illustrate the crucial confirmation procedure of the present invention. As mentioned briefly above, the present invention forces the booster pump to run at a low pressure L which is below the predetermined threshold P_H of the high pressure sensor 38. It follows that

the feedback provided from this confirmation reflects the true state of demand of water such that the system can do without a flow sensor.

Should any unexpected surge in demand for water occur before the expiry of the n second interval, a test is provided in step 94 to deal with this event. Here, P_p is tested whether it is lower than P_L . If it is, it means there is actual demand for water is high. As such, the booster pump 34 is activated to run at high pressure H and steps 86 - 92 are repeated. If the status of pressure sensor 38 remains unchanged, i.e., P_p is greater than P_L , it means that there is no real demand for water in the pipeline. It follows that the booster pump runs for the full interval of n seconds as shown in step 96. Thereafter, the pipeline pressure P_p is tested to determine if it is less than the threshold P_H in step 98. This step is to ensure that there is near zero or no demand of water in the pipeline. If it is, the present invention shuts off the booster pump in step 100 to conserve energy. If it is not, then the booster pump is switched from low pressure L to run at high pressure H and steps 82 - 98 are repeated.

It will be appreciated that the present invention conserves energy by running the booster pump as close to the actual demand of water in the pipeline without shutting off unnecessarily. This not only prolong the life of the booster pump, but also reap the benefit of running the booster pump at low pressure as long as practically possible.

While the present invention has been described particularly with reference to FIGS. 1 to 4 with emphasis on a method for controlling fluid supply in high rise dwelling environment, it should be understood that the figures are for illustration only and should not be taken a limitation on the invention. In addition, it is clear that the method and apparatus of the present invention has utility in many applications where control of fluid supply is required. It is contemplated that many changes and modifications

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may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention as described.

CLAIMS

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- 1 1. A method for controlling fluid flow in a fluid supply system
2 including at least a fluid tank connected to one end of at least a fluid pipe for
3 supplying fluid therethrough with the other end of said fluid pipe distributing
4 fluid to required outlets, at least one booster pump coupled to said fluid pipe
5 for pumping fluid therethrough, at least one one-way valve coupled to said
6 fluid pipe and downstream from said booster pump for preventing fluid back-
7 flow and maintaining pressure downstream therefrom in said fluid pipe, at
8 least a first pressure sensing device coupled to said fluid pipe and
9 downstream from or at said one-way valve for detecting pressure in said
10 fluid pipe, said first pressure sensing device being further connected to a
11 processing circuit for controlling said booster pump, said processing circuit
12 being integrated within a control panel for processing signal received from
13 said first pressure sensing device, said control panel being connected to a
14 power source for drawing power therefrom, said control panel being further
15 connected to said water tank, said method comprising the steps of:
- 16 (a) setting a first predetermined threshold P_H for said pressure
17 sensing device, said P_H corresponding to near or zero demand
18 for fluid in said pipe, said P_H corresponding additionally to a
19 reference for confirming the actual demand for fluid whose
20 change is not within the sensitivity of said pressure sensing
21 device;
- 22 (b) setting a second predetermined threshold P_L for a second
23 pressure sensing device in said pipe, said P_L corresponding to
24 low or high demand for fluid in said pipe;

- 25 (c) detecting pressure in said fluid pipe with said pressure sensing
 26 devices being coupled to said water pipe downstream from or
 27 at said one-way valve;
- 28 (d) actuating said booster pump to run at high pressure H when
 29 pressure in said pipe is below said thresholds P_H and P_L ;
- 30 (e) monitoring the pressure in said pipe to determine if the
 31 pressure exceeds said threshold P_H ;
- 32 (f) forcing said booster pump to run at low pressure L for a first
 33 predetermined interval n to determine if the pressure in said
 34 pipe falls below said threshold P_L , confirmation of the fall in the
 35 pipe pressure corresponding to actual demand of fluid which is
 36 beyond the sensitivity of said pressure sensing devices;
- 37 (g) varying the speed of said booster pump according to either
 38 steps (d) or shutting off said booster pump with said variable
 39 speed controlling device connected thereto in response to said
 40 confirmation or disconfirmation of the step in (f);
- 41 whereby said processing circuit compensates for the difference
 42 between the actual demand for water and the output of the booster
 43 pump without using any flow sensor.

1 2. A method for controlling fluid flow in a fluid supply system as in
 2 claim 1 wherein said threshold P_H is equal or larger than the sum of the
 3 minimum pressure of said pipe and the sensitivity of said pressure sensing
 4 devices.

1 3. A method for controlling fluid flow in a fluid supply system as in
 2 claim 1 wherein said threshold P_L is equal or larger than the difference
 3 between the minimum pressure of said pipe and the sensitivity of said
 4 pressure sensing devices.

1 4. A method for controlling fluid flow in a fluid supply system as in
2 claim 1 wherein said pressure H is between that of thresholds P_H and P_L .

1 5. A method for controlling fluid flow in a fluid supply system as in
2 claim 1 wherein said pressure L is between that of thresholds P_H and P_L but
3 is less than H.

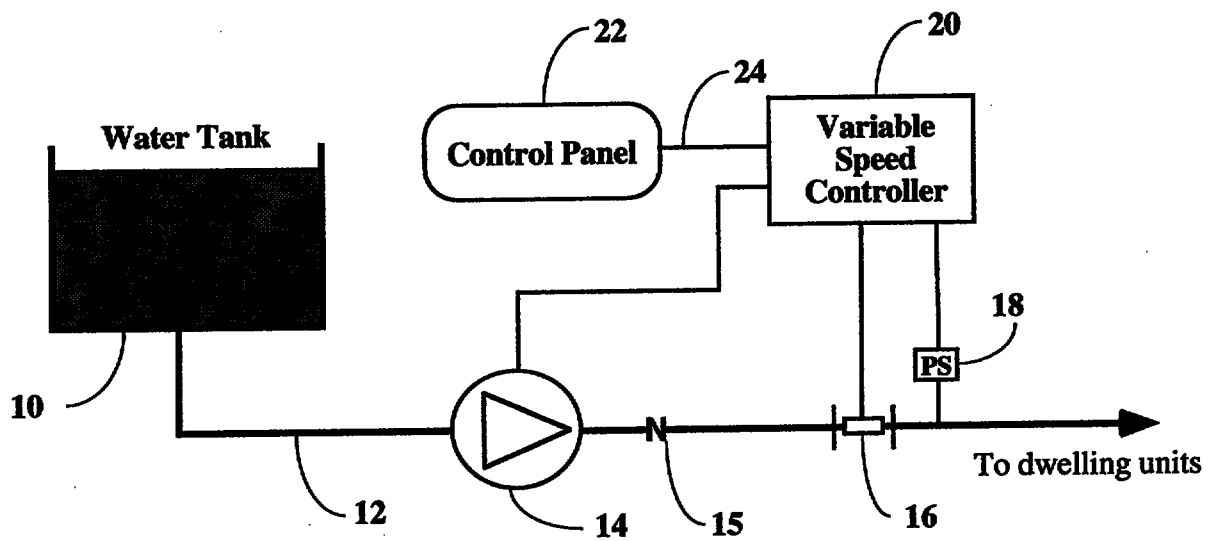
1 6. A method for controlling fluid flow in a fluid supply system as in
2 claim 1 wherein said second pressure sensing device is a transmitter.

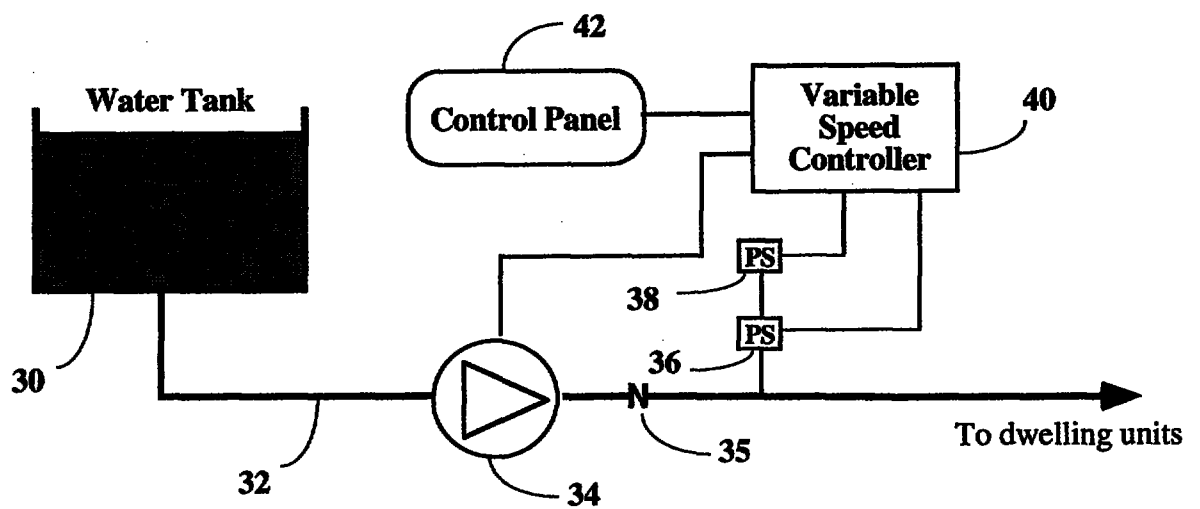
1 7. A method for controlling fluid flow in a fluid supply system as in
2 claim 6 wherein said transmitter sends to said processing circuit a signal
3 corresponding to said threshold P_L .

ABSTRACT
CONTROLLER FOR WATER PUMP

The present invention comprises a controller for controlling at least a booster pump, and receiving signals from at least two pressure sensors. The first pressure sensor is coupled to a water pipe downstream from the booster pump and a one-way valve for detecting and setting a high pressure threshold P_H and sending appropriate feedback signals to the controller which in turn varies the speed of the booster pump. P_H represents near zero or no demand of water. P_H also serves as a reference for the present invention to confirm automatically the actual demand for water in the pipeline without using flow sensors. A second pressure sensor is also coupled to the water pipe downstream from the booster pump and a one-way valve for detecting and setting a low pressure threshold P_L and for transmitting a feedback signal to the controller which in turn operates the booster pump to supply water to the first and subsequent user with the minimum required water pressure. P_L represents a high level of demand for water. P_H and P_L offers controller a range of pressure which is larger than that of the sensitivity of the pressure sensors. By forcing the booster pump to run at a pressure below the threshold P_H , the present invention confirms automatically the actual demand for water in the pipeline even if the demand is not sensitive enough for the pressure sensors to detect. The controller then varies the speed of the booster pump to compensate for the difference between the actual demand for water and the output of the booster pump without using any flow sensor.

FIGURE 2.

**FIG. 1 (Prior Art)**

**FIG. 2**

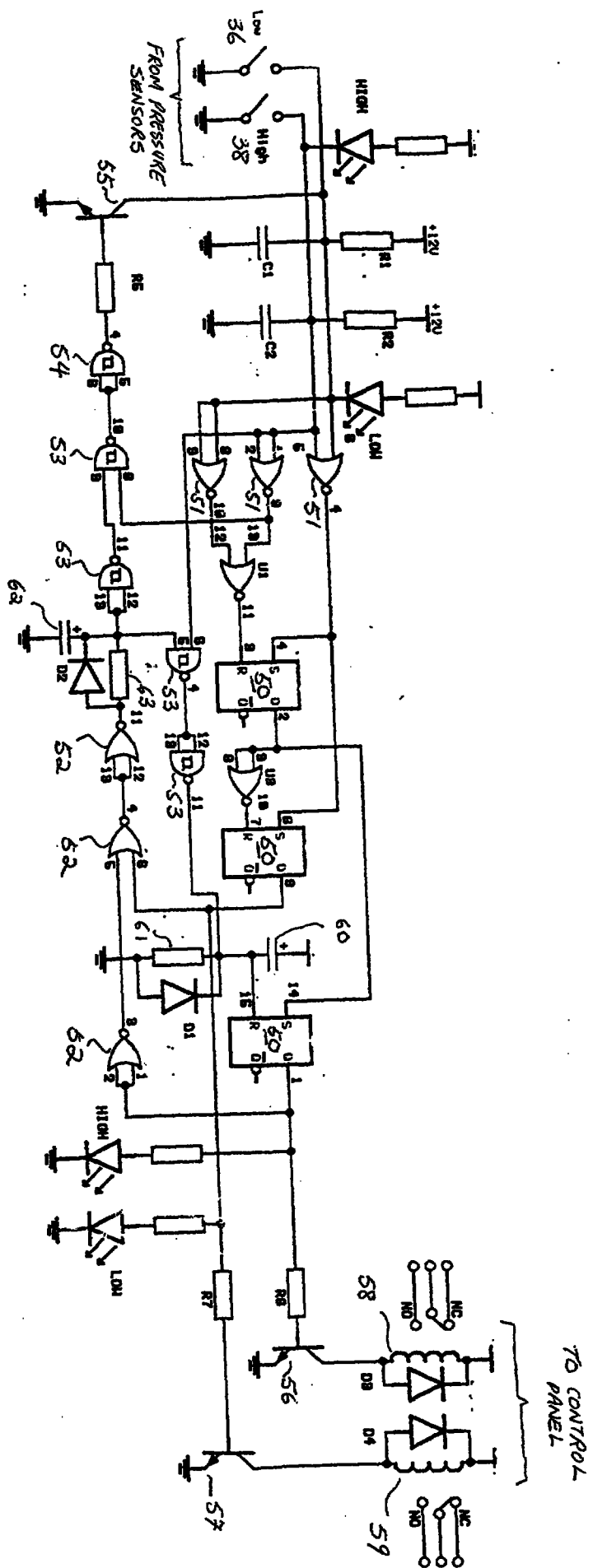


Fig. 3

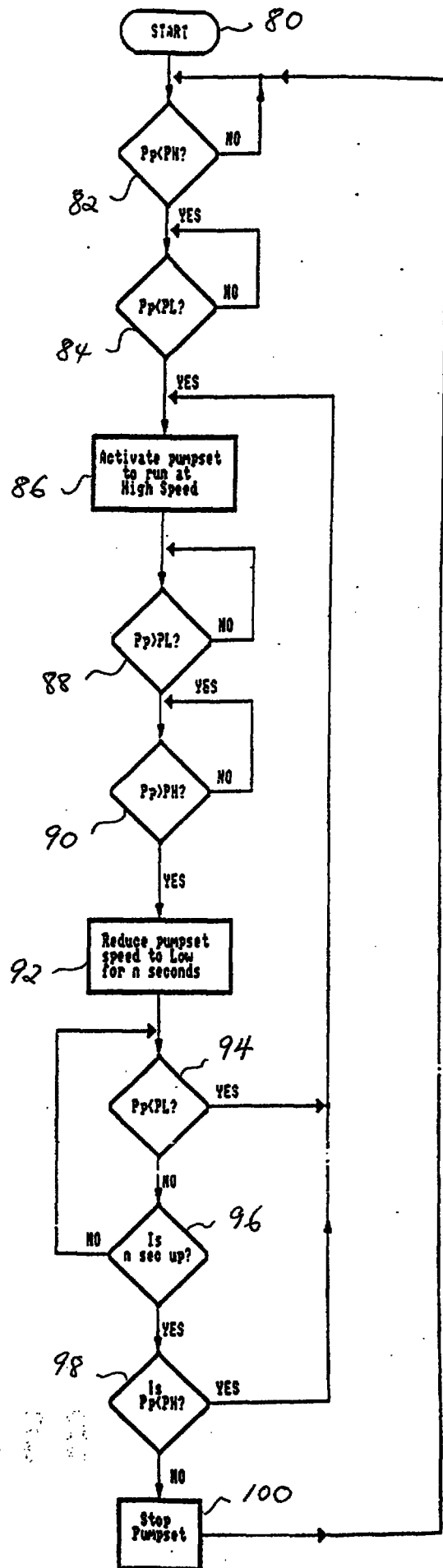


Fig. 4