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Hartley

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[54] PUMPING SYSTEM

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[52] **U.S. Cl.** .....**417/44,** 200/83 J

[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** .....200/82 C, 82 A, 83 T, 83 S, 200/83 SA, 89.1; 417/44, 38

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[57] **ABSTRACT**

A pumping system comprising a pump, a drive mechanism for driving the pump, and a differential pressure switch responsive to the pressure of the fluid in a sensing zone on a discharge side of the pump for turning the pump on and off. A restricted fluid passage is interposed between the pump discharge and the sensing zone.

10 Claims, 6 Drawing Figures

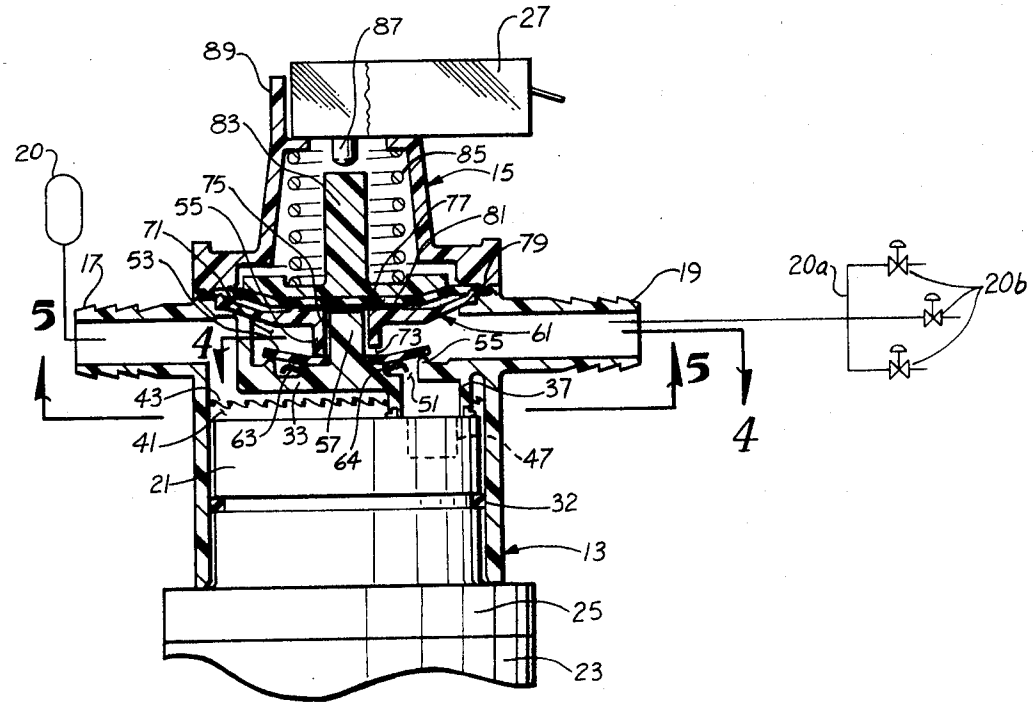

Fig. 1

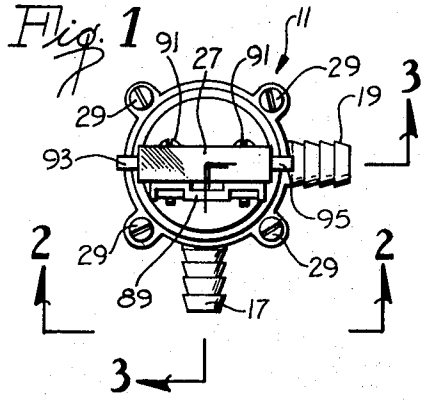

Fig. 2

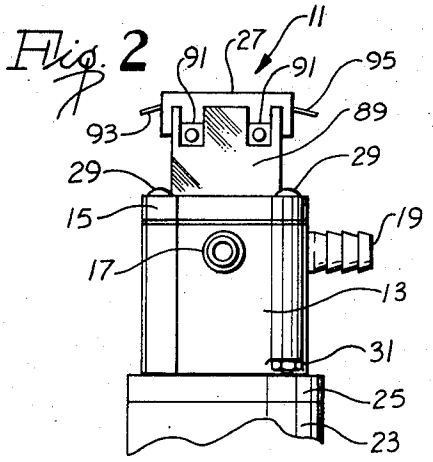

Fig. 3

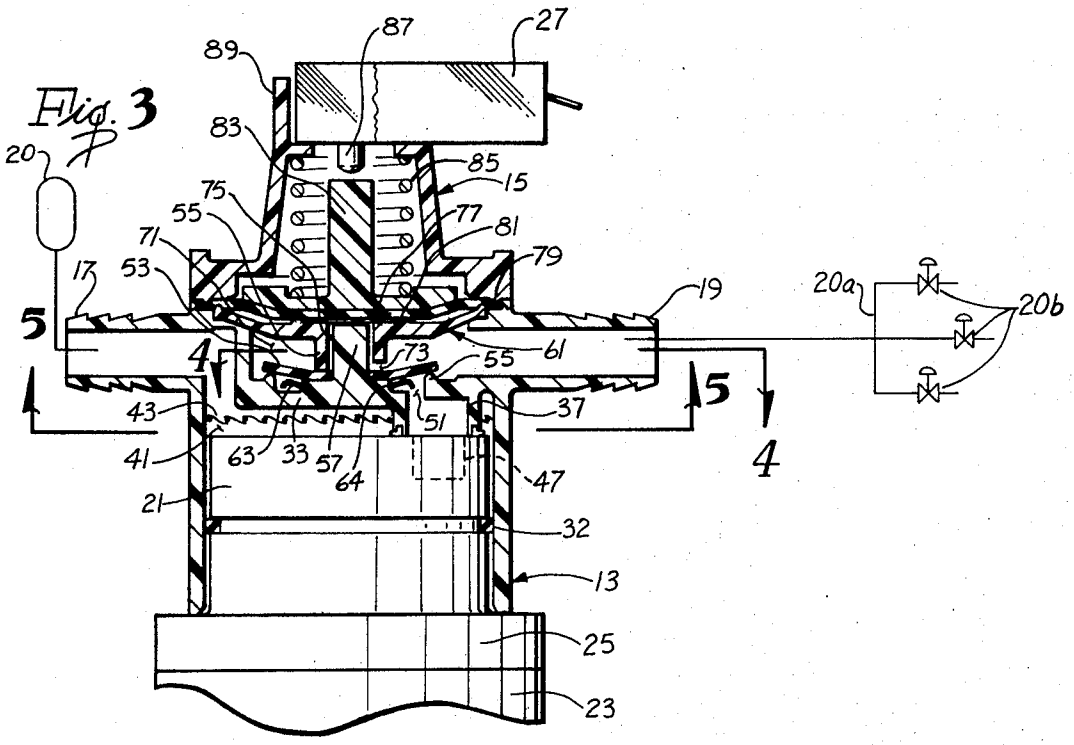

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Fig. 4

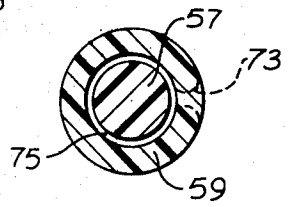


Fig. 5

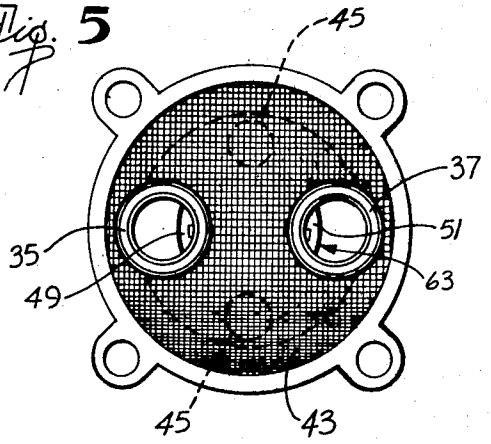
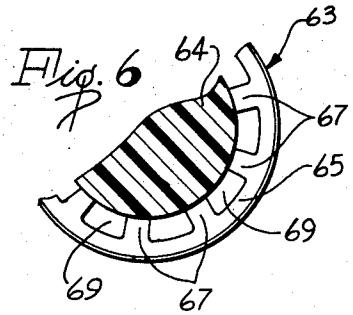


Fig. 6



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PUMPING SYSTEM

BACKGROUND OF THE INVENTION

Pumping systems typically include a pump for pumping liquid from a source to a preselected destination and control means for controlling the operation of the pump. In many pumping systems, such as in a pumping system utilized for providing water in a recreational vehicle, the control means turns the pump on in response to the pressure downstream of the pump dropping to a predetermined low level and turns the pump off when the downstream pressure reaches a desired maximum level.

With this type of water supply system, the pump cycles on and off substantially simultaneously with the opening and closing of the faucet or other water utilization control valve. As the minimum on-time for the faucet cannot be predicted and may be only a fractional portion of a second, the pump may be cycled on and off very rapidly. This may damage the pump and the pump motor. If the water demand is low but continuous, the pump will cycle on and off rapidly. This causes vibration and causes the water to spurt through the faucet outlet rather than flow evenly.

To avoid rapid cycling of the pump, conventional systems employ an accumulator. An accumulator, however, adds to the cost of the system and to the cost of assembling the system. In addition, the accumulator takes up space which is often at a premium in a recreational vehicle.

SUMMARY OF THE INVENTION

The present invention provides a pumping system which eliminates the accumulator and still prevents rapid cycling of the pump. This invention establishes a minimum cycle time for the pump which is substantially independent of the rate or frequency of fluid utilization thereby providing protection for the pump and pump motor. The minimum cycle time is set so as to avoid vibration and the water spurting problem noted above.

The present invention uses two separate principles, either individually or in combination, to establish the minimum cycle time. Optimum results are achieved when the two principles are used in combination.

First, the present invention uses a differential pressure control device to turn the pump on when the pressure downstream thereof is at a relatively low level and to turn the pump off when the downstream pressure reaches a relatively high level. The time required to obtain this pressure change constitutes a first increment of the minimum cycle time.

The pressure levels to which the differential pressure control device is responsive can be selected by those having ordinary skill in the art. Generally, however, the larger the differential pressure, the longer is the resulting time increment. On the other hand, the size and cost of the unit generally increases as the pressure differential is increased.

The differential pressure control device preferably includes a pressure responsive member at a sensing zone, a valve seat, conduit means for providing communication between the discharge side of the pump and the sensing zone and means for mounting the pressure responsive member for movement between the low pressure position in which the pressure responsive member engages the valve seat and a first area of the pressure responsive member is exposed to the fluid pressure and a high pressure position in which the pressure responsive member is moved away from the seat to expose a second area of the piston to the fluid pressure. Yieldable means such as a spring urges the pressure responsive member toward the low pressure position. The second area includes the first area and has a greater effective area. Accordingly, the pressure responsive member is a differential area member.

The pressure responsive member is moved from the low pressure position to the high pressure position in response to a relatively high pressure and cannot return from the high pressure position to the low pressure position until the pressure drops to a lower level. The force of the yieldable means and the relative effective areas of the first and second faces determine the differential pressures at which the pressure control device is operative. This construction is preferred because of its low cost, compactness and simplicity.

The pressure responsive member can actuate various control devices such as a switch for controlling the pump motor in various ways. The pressure responsive member may engage the actuating member of a switch in the high pressure position and be out of contact with the actuating member in the low pressure position.

Secondly, the present invention uses a restriction between the pump discharge and the sensing zone at which the pressure responsive member senses system pressure. The restriction is sufficient to provide a pressure drop thereby providing a time delay between the instant at which a pressure change occurs in the system and the instant at which a corresponding pressure change occurs at the sensing zone. This constitutes the second increment of the minimum time cycle and is additive with the first increment to establish the minimum cycle time of the pump.

The time delay afforded by the restriction increases as the cross sectional area of the restricted passage section decreases; however, the effective area of the restricted passage section should not be made too small because the tendency of the restricted passage section to clog increases as the passage section is made smaller.

To facilitate production particularly when the components of the device are molded, the restriction can advantageously be formed as a circumscribing passage. This can be accomplished by utilizing a first member for defining a conduit and inserting a second member into the first member with the two members being spaced by a clearance space which circumscribes the inner member. It is much easier to form the restriction in this manner than by molding a small diameter hole.

Another feature of this invention is a novel check valve which can be interposed between the pump discharge and the restricted passage section. The check valve includes a flexible valve element of washer-like configuration and a valve seat against which the flexible valve element can be seated. To prevent collapse of the flexible element, a support member on the upstream side of the flexible valve element is provided. In order that fluid can flow through the check valve with minimum resistance, the support member preferably includes opening means.

The invention can best be understood by reference to the following description taken in connection with the accompanying illustrative drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a pumping unit constructed in accordance with the teachings of this invention.

FIG. 2 is a fragmentary side elevational view taken generally along line 2—2 of FIG. 1.

FIG. 3 is a sectional view of the pumping unit taken generally along line 3—3 of FIG. 1 and with other portions of a typical water supply system being shown diagrammatically.

FIG. 4 is an enlarged sectional view showing the restricted passage section and taken generally along line 4—4 of FIG. 3.

FIG. 5 is a sectional view taken generally along line 5—5 of FIG. 3.

FIG. 6 is an enlarged fragmentary plan view of the support member for the flexible check valve element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1–3 show a pumping unit **11** which generally includes housing sections **13** and **15** each of which is preferably integrally molded of plastic material. The housing section **13** defines an inlet **17** and an outlet **19** adapted for connection to conduits leading to other portions of a fluid system such as a source of water **20** and a water distribution system **20***a* for a recreational system, respectively. The distribution system **20***a* may include a plurality of water valves **20***b*. Water is drawn in through the inlet **17** by a pump **21** (FIG. 3) which is driven by a motor **23** such as a dc motor with the motor being drivingly connected to the pump **21** by an adaptor **25**. The motor **23** is turned on and off by a switch **27** which in turn is controlled by the pressure responsive means of this invention.

More specifically, the housing sections **13** and **15** are interconnected by a plurality of bolts **29** (FIGS. 1 and 2) and nuts **32**. The pump **21** and a portion of the adaptor **25** are securely and suitably mounted within the housing section **13**, and the housing section **13** is suitably affixed to the adaptor **25**. Leakage from the housing section **13** to the motor **23** is prevented by a seal **32**. The pump **21** is preferably a positive displacement pump such as a roller pump; however, other pump constructions can be utilized.

With reference to FIGS. **3** and **5**, the housing section **13** has a wall **33** which divides the housing into an inlet chamber **41** and an outlet chamber **71**. The wall has a pair of bosses **35** and **37** thereon which define portions of the outlet chamber. Water enters the inlet **17** and passes through a filter **43** in the form of a screen which is mounted in the inlet chamber **41**.

The pump **21** in the embodiment illustrated has a pair of inlets **45** (the location of which is shown in dashed lines in FIG. **5**) in the inlet chamber **41** and a pair of outlets **47** (only one being shown in FIG. **3**) communicating with the passages formed by the bosses **35** and **37**, respectively, and suitably sealed thereto. Accordingly, the pump **21** draws water from the inlet chamber **41** into the inlets **45** and discharges the latter under pressure into the passages formed by the bosses **35** and **37**, respectively.

As shown in FIGS. **3** and **5**, the wall **33** contains apertures **49** and **51** which communicate with the bosses **35** and **37**, respectively. Back flow through the apertures **49** and **51** is normally prevented by a flexible valve element **53** which, in the embodiment illustrated, is in the form of a rubber washer. The wall **33** defines a valve seat **55** against which the flexible valve element **53** can be seated by the pressure downstream thereof. The wall **33** has a post or restrictor member **57** projecting upwardly therefrom and the flexible valve element **53** has an opening therein which permits the latter to be mounted over the post. The flexible valve element **53** is retained in position on the post **57** by a tubular section **59** of an isolating plate **61** which clamps an inner annular region of the valve element against the wall **33**.

To prevent the fluid pressure downstream of the check valve **53** from depressing the flexible valve element **53** into the ports defined by the bosses **35** and **37**, a thin disc-like support member **63** is mounted on an annular shoulder **64** of the wall **33** immediately beneath the post **57** and immediately upstream of the valve element as shown in FIGS. **3** and **6**. The support member **63** must possess sufficient rigidity to support the flexible valve element **53** against collapse and must underlie a sufficient area of the flexible valve element to prevent such collapse.

A preferred configuration of the support member **63** is shown in FIG. **6**, it being understood that other configurations suitable to support the flexible valve element against collapse and provide it with a capability of allowing water passage therethrough can also be utilized. The support member **63** includes a peripheral ring section **65** and a plurality of fingers **67** extending radially inwardly of the ring section. The fingers **67** are circumferentially spaced to define openings **69** to permit fluid passage through the support member. In addition, the periphery of the support member **63** is spaced radially inwardly of the outer regions of the apertures **49** and **51** to provide further room for water passage. As shown in FIG. **3**, the ring section **65** of the support member **63** is curved downwardly. The support member **63** is preferably constructed of a thin sheet of metal such as stainless steel.

The water discharged by the pump **21** passes through the apertures **49** and **51** of the outlet chamber **71** and from there through the outlet **19** to the water distribution system **20***a*. To provide control of the cycling of the pump **21**, a radial port **73** and an annular restricted passage section **75** (FIGS. **3** and **4**) provide communication between the outlet chamber **71** and a sensing zone **77**. The isolating plate **61** separates the outlet chamber **71** from the sensing zone **77**. The restricted passage section **75** is in the form of an annular clearance space between the post **57** and the tubular section **59** and, in the embodiment illustrated, the post **57** and the interior of the tubular section **59** are cylindrical and concentric.

A pressure responsive member such as a flexible diaphragm **79** is clamped between the housing sections **13** and **15** and is adapted to sealingly engage an annular valve seat **81** formed integrally with the isolating plate **61**. A plunger **83** is mounted for movement on the side of the diaphragm **79** opposite the valve seat **81**. The plunger **83** is biased toward the valve seat **81** by a coil spring **85**.

Although different kinds of control devices could be used, the illustrated embodiment of the invention employs the switch **27** as the control device for the motor **23**. The switch **27** has an actuating member **87**. With

the actuating member fully extended as shown in FIG. 3, the switch 27 closes the circuit to the motor 23 and with the actuating member 87 depressed, i.e., moved further into the housing of the switch 27, the switch opens the circuit to the motor 23. Although the switch 27 can be mounted in various ways, in the embodiment illustrated the housing section 15 includes a bracket 89 (FIGS. 1 and 2) to which the switch 27 is secured by a pair of threaded fasteners 91. The switch 27 has a pair of terminals 93 and 95 for attachment to the power supply circuit (not shown) to the motor 23.

In operation of the device, the switch 27 controls the cycling of the motor 23. Assuming that the components of the pumping unit 11 are in the low pressure position shown in FIG. 3, the switch 27 will complete a circuit to the motor 23 to energize the latter and start the pump 21. The pump 21 draws in water through the inlet 17 and the inlet chamber 41 to the pump inlets 45 and discharges the water through the pump outlets 47, the ports defined by the bosses 35 and 37 and the apertures 49 and 51. The pressure of the water in the apertures 49 and 51 forces the flexible valve element 53 off its seat and accordingly the water passes through the apertures and the outlet 19 to the water distribution system 20*a*. Water flow through the apertures 49 and 51 is assisted by the openings 69 (FIG. 6) and by the peripheral gap separating the support member 63 from the periphery of the apertures 49 and 51.

Some of the water in the outlet chamber 71 will flow through the port 73 (FIGS. 3 and 4) and the restricted passage section 75 to the sensing zone 77. As the pump continues to operate, the pressure of the water in the outlet chamber 71 increases; however, because of the small effective cross sectional area of the restricted passage 75, there is a pressure drop thereacross. Accordingly, there is a time delay between the instant at which a pressure increase occurs in the outlet chamber 71 and the instant at which a corresponding pressure change occurs at the sensing zone 77.

The pressure of the fluid in the sensing zone 77 acts on the area of the diaphragm 79 which is circumscribed by the valve seat 81. When the force acting on the diaphragm 79 exceeds the force of the spring 85 urging the diaphragm against the seat 81, the diaphragm is lifted off of the seat 81. As soon as the diaphragm 79 leaves the valve seat 81, substantially the full area thereof is exposed to fluid under pressure with the result that the diaphragm and the plunger 83 snap upwardly to a high pressure position. In the high pressure position, the plunger 83 engages the actuating member 87 of the switch 27 to open the circuit to the motor 23.

If the water pressure in the outlet chamber 79 decreases, as may occur, for example, by utilization of the water in the distribution system, there will be a corresponding decrease in pressure at the sensing zone 77. However, such decrease in pressure at the sensing zone 77 will lag the pressure drop in the outlet chamber 71 due to the time delay interposed by the restricted passage section 75. When the pressure at the sensing zone 77 multiplied by the full exposed area of the diaphragm 79 drops to a value less than the force of the spring 85, the spring is operative to urge the diaphragm 79 back to the low pressure position in which the diaphragm sealingly engages the valve seat 81. Because of the differential areas of the diaphragm 79 which are exposed to the fluid pressure in the low pressure and high pressure positions, the diaphragm will not return to the low pressure position until the pressure at the sensing zone is reduced substantially below the value necessary to move the diaphragm to the high pressure position.

It is apparent that the illustrated embodiment of the invention operates to interpose a minimum on-time and a minimum off-time for the pump 21 and motor 23 which are independent of the rate of utilization of water by the water distribution system 20a. This minimum cycle time is established by the time delay caused by the restricted passage section 75 plus the time necessary to increase or decrease the pressure at the sensing zone 77 an amount equal to the difference in actuating pressures of the device.

The flexible valve element 53 remains open so long as the pressure upstream thereof exceeds the downstream pressure. If this pressure condition reverses, the downstream pressure urges the flexible valve element 53 against the seat 55 to prevent reverse flow. The support member 63 supports the flexible valve element 53 and prevents it from being depressed into the apertures 49 and 51.

The pressure responsive control apparatus of this invention including the restricted passage section 75 and the differential area diaphragm 79 can obviously be utilized as a pressure responsive device in other environments. The diaphragm 79 is not limited to actuating a switch such as the switch 27. The check valve formed by the flexible valve element 53, the seat 55 and the support member 63 can also be utilized with other devices.

Although an exemplary embodiment of the invention has been shown and described, many changes, modifications and substitutions may be made by one having ordinary skill in the art without necessarily departing from the spirit and scope of this invention.

I claim:

1. A pumping unit comprising:
a pump for moving a fluid;
drive means for driving the pump;
a pressure responsive member;
means defining a valve seat;
conduit means for providing communication between the discharge side of said pump and the valve seat;
means for mounting said pressure responsive member for movement between a low pressure position in which said pressure responsive member engages said valve seat and a first area of said pressure responsive member is exposed to the fluid pressure and a high pressure position in which said pressure responsive member is moved away from said valve seat to expose a second area of the pressure responsive member to the fluid;
yieldable means for urging said pressure responsive member toward the low pressure position, said second area having a greater effective area than the first area whereby the pressure responsive member is moved from the low pressure to the high pressure position in response to a first pressure level and cannot return from the high pressure position to the low pressure position until the pressure level drops below the first pressure level;

first means responsive to movement of the pressure responsive member to the low pressure position for causing said drive means to drive said pump and responsive to movement of the pressure responsive member to the high pressure position for causing said drive means to cease driving said pump; and

said conduit means including a restricted passage section of relatively small cross sectional area intermediate said pressure responsive member and the pump discharge to thereby interpose a time delay between the instant at which a change in the pressure of the fluid on one side of said restricted passage section occurs and the instant at which such change occurs on the other side of said restricted passage section.

2. A pumping unit as defined in claim 1 wherein said restricted passage section includes means defining a circumscribing passage section.

3. A pumping unit as defined in claim 1 including a restrictor member in said conduit means defining said restricted passage section, said restricted passage section circumscribing said restrictor member, said first means including a switch having an actuating member engageable with said pressure responsive member at least in said high pressure position, a flexible valve element mounted on said restrictor member adjacent the upstream end of said restricted passage section, means defining a valve seat against which the flexible valve element can bear, and a support member on the upstream side of said flexible valve element for supporting the latter, said support member having means defining an opening therethrough.

4. A pumping unit as defined in claim 1 including a housing, a first wall dividing said housing into an inlet chamber and an outlet chamber, said pump being in said housing and having an inlet and an outlet communicating with said inlet chamber and said outlet chamber, respectively, said pressure responsive member being at a sensing zone, a second wall separating said sensing zone from said outlet chamber, said second wall having an aperture therein and said first wall having a restrictor member thereon projecting into said aperture to define said restricted passage section between said outlet chamber and said sensing zone.

5. A pumping unit comprising:

a pump for moving a fluid;

drive means for driving the pump;

means defining a fluid passage for conducting the fluid from the discharge side of said pump;

wall means defining a conduit leading from said fluid passage;

a restrictor member in said conduit and spaced from said wall means by a radially narrow clearance space which substantially circumscribes the restrictor member to define a restricted passage section, said conduit on the side of said restricted passage section downstream from said fluid passage defining a sensing zone with said restricted passage section causing a time delay for the transmission of pressure changes between said sensing zone and the other side of said restricted passage section; and

means responsive to a first fluid pressure level at said sensing zone for causing said drive means to drive said pump and responsive to a second fluid pressure level at said sensing zone for causing said drive means to cease driving said pump, said second level being higher than said first level.

6. A pumping unit as defined in claim 5 including a flexible valve element mounted on said restrictor member adjacent the upstream end of said restricted passage section, means defining a valve seat against which the flexible valve element can bear, and disc-like support means mounted on the upstream side of said flexible valve element for supporting said flexible valve element against substantial movement in the upstream direction whereby said flexible valve element serves as a check valve to prevent reverse flow to the pump, said support means having means defining at least one opening therethrough.

7. A device responsive to fluid under a variable pressure comprising:

a conduit for conducting the fluid under pressure from a first zone to a second zone;

means defining a restriction in said conduit between said zones, said restriction delaying the flow of fluid between said zones to thereby interpose a time delay between the instant at which a pressure change occurs at said first zone and the instant at which such change occurs at said second zone;

a pressure responsive member;

means defining a valve seat at said second zone;

means for mounting said pressure responsive member for movement between a low pressure position in which said pressure responsive member engages said valve seat and a first area of said piston is exposed to the fluid under pressure and a high pressure position in which said pressure responsive member is moved away from said seat to expose a second area of the piston to the fluid under pressure;

yieldable means for urging the pressure responsive member toward the low pressure position;

said second area having a greater effective area than said first area whereby the pressure responsive member is moved from the low pressure position to the high pressure position in response to a first pressure level at said second zone and cannot return from the high pressure position to the low pressure position until the pressure level at said second zone drops below the first pressure level;

a control device for performing first and second control functions; and

means responsive to movement of the pressure responsive member to the low pressure position for causing said control device to perform said first control function and responsive to movement of the pressure responsive member to the high pressure position for causing said control device to perform a second control function.

8. A device as defined in claim 7 wherein said control device includes a switch having an actuating member for causing the switch to perform said control functions, said pressure responsive member being engageable with said actuating member in said high pressure position.

9. A device as defined in claim 7 including a restrictor member in said conduit and spaced from the wall of said conduit to define said restriction, said restriction circumscribing said restrictor member.

10. A pumping unit comprising:
a pump for moving a fluid;
drive means for driving the pump;
a pressure responsive member;
means defining a valve seat;
conduit means for providing communication between the discharge side of said pump and the valve seat;
means for mounting said pressure responsive member for movement between a low pressure position in which said pressure responsive member engages said valve seat and a first area of said pressure responsive member is exposed to the fluid pressure and a high pressure position in which said pressure responsive member is moved away from said valve seat to expose a second area of the pressure responsive member to the fluid;
yieldable means for urging said pressure responsive member toward the low pressure position, said second area having a greater effective area than the first area whereby the pressure responsive member is moved from the low pressure position to the high pressure position in response to a first pressure level and cannot return from the high pressure position to the low pressure position until the pressure level drops below the first pressure level;
first means responsive to the pressure responsive member being in the low pressure position for causing said drive means to drive said pump and responsive to the pressure responsive member being in the high pressure position for causing said drive means to cease driving said pump;
means defining a fluid passage leading from the pump discharge for carrying the fluid from the pump discharge;
a check valve seat in said fluid passage;
a flexible washer-like valve element;
means for mounting said flexible valve element in said fluid passage so that said flexible valve element can bear against said check valve seat; and
a disc-like support member mounted on the upstream side of said flexible valve element for supporting said flexible valve element against substantial movement in the upstream direction wherein said flexible valve element serves as a check valve to prevent backflow to the pump, said support member having means defining at least one opening therethrough.

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