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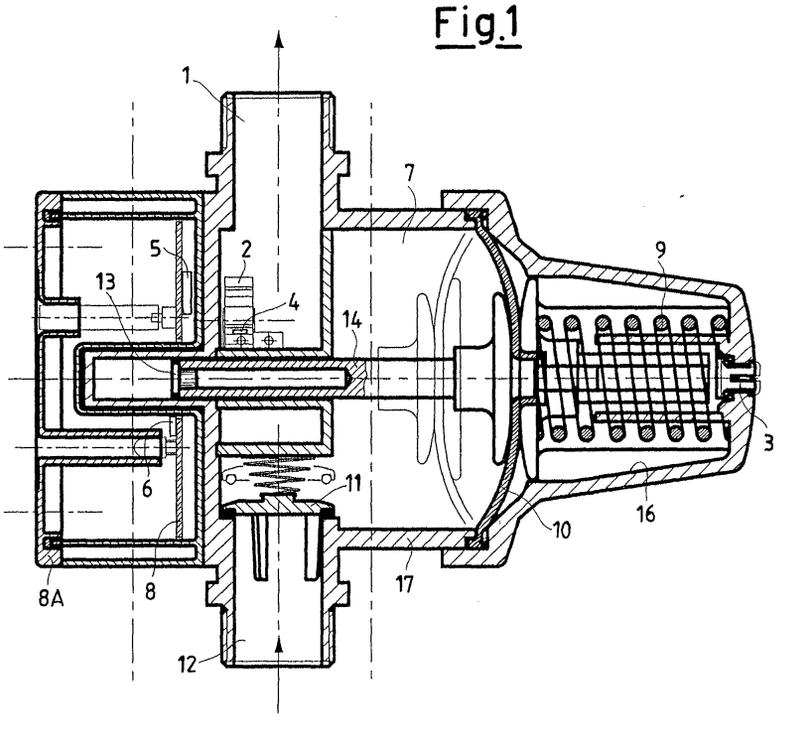
(54) Control device for autoclave pump

(57) A control device for operation of an autoclave pump of a water distribution network, of the type comprising a mechanical part, with the task of detecting pressures and flows by means of moving parts, and an electronic part, with the task of managing pump supply in relation to the parameters detected; all signals are sent to a microprocessor electronic control system which, thanks to simultaneous detection and measurement of flow and pressure, makes it possible to avoid the pressure oscillation typical of control devices of the traditional type and prevent the pump from starting up and shutting down continually. The device is also capable of detecting any abnormal conditions that take place, such as excessive flow, no water at the pump inlet side or a leak in the user circuit, taking steps to shut down operation of the entire system to prevent damage to the pump and the internal circuits.

Fig.1



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Description

[0001] The present invention relates to a control device for operation of an autoclave pump of a water distribution network.

[0002] Normally, pressure flow switches are able to replace all the elements normally utilized in a hydraulic circuit where there is a pump.

[0003] In fact, each pressure flow switch has a check valve, a pressure switch, a hydro-pneumatic accumulator and a level switch.

[0004] A pump controlled by a pressure switch is activated upon reaching a first predetermined value (low pressure) and deactivated upon reaching a second value corresponding to a high pressure; in this way, the life of the pump motor decreases as it is subjected to considerable stress by starting up and shutting down repeatedly.

[0005] Pressure flow switches in use are able to obviate all this thanks to the fact that they are designed to control not only pressures, but also flow rates, ensuring that the pump continues to operate for as long as the user continues to draw water.

[0006] A pressure flow switch of the traditional type designed to control switching on and switching off of a pump installed in a water distribution network comprises, inside the body, a chamber, with an inlet duct designed to be connected to the pump outlet side and an outlet duct designed to be connected to the water network, a control valve, provided on the inlet duct, and a pressure sensor, positioned inside the chamber and capable of sending a signal to switch on the pump if a predetermined pressure value is reached inside the chamber.

[0007] Normally, a device of this type also comprises a flow sensor, located on the outlet duct and designed to send a signal to switch on the pump if the flow of fluid circulating reaches a minimum predetermined value; in this case, when water is drawn from at least one of the user terminations, with the water intake valve to the water network open, an electric signal is sent to the pump to keep it switched on, even if the pressure inside the pump body exceeds a predetermined value dependent on the setting of the pressure sensor.

[0008] The use of the flow sensor prevents the pump from switching on and off repeatedly, if the quantity of flow drawn at the user terminations are about the same as the capacity of the pump and, consequently, the pressure value inside the pump body is about the same as the pressure value utilized to set the pressure sensor.

[0009] Nonetheless, the flow sensors currently utilized only detect whether or not there is a specific flow rate, but are unable to measure the extent of the flow; moreover, it is currently necessary to produce different models of pressure flow switches, with different sensitivities, in order to adapt each device to the performances of the various types of pump; this makes it necessary to modify each project individually to take account of the variation in setting of the flows circulating inside the pressure flow switch, with the inevitable consequences deriving from the fact that each device must be manufactured according to particular project specifications.

[0010] The object of the present invention is, therefore, to eliminate the technical drawbacks mentioned, by producing a control device for operation of an autoclave pump of a water distribution network which makes it possible to measure pressures and flows and therefore to vary the setting of flows simply by adjusting some constants of software installed in the microprocessor.

[0011] Another object of the invention is to produce a control device for operation of an autoclave pump of a water distribution network which makes it possible to have different models of pressure flow switches with different sensitivities, so that the device may be adapted to the performances of different types of pump.

[0012] Yet another object of the invention is to produce a control device for operation of an autoclave pump of a water distribution network which is capable of preventing the pressure oscillation typical of pressure switches and the pump from starting up and shutting down repeatedly and which is also capable of detecting, thanks to a microprocessor logic, any abnormal conditions that take place, such as excessive flow, no water at the pump inlet side or a leak in the user circuit, in this case shutting down the entire system to prevent damage to the pump and/or internal circuits.

[0013] Yet another object of the invention is to produce a control device for operation of an autoclave pump of a water distribution network which allows the remote control of pump operation, providing the customer with useful information on the state of the system.

[0014] Yet another object of the invention is to produce a control device for operation of an autoclave pump of a water distribution network which is substantially simple, safe and reliable.

[0015] These and other objects, according to the present invention, are attained by producing a control device for operation of an autoclave pump of a water distribution network according to claim 1, which is referred to for briefness.

[0016] Other characteristics of the present invention are defined, moreover, in the subsequent claims.

[0017] Advantageously, the control device according to the present invention utilizes a chamber, inside which water flows through a duct connected to the pump; the water flows from the outlet side towards the user.

[0018] The device is capable of measuring the flow circulating, by means of a turbine, and the pressure, by means of a mechanical assembly composed of a diaphragm and a spring.

[0019] All the signals, which are detected by means of reed contacts and magnets, are sent to an electronic control system, completely isolated from the circulating fluid, and to the remote control, by the microprocessor.

[0020] The device according to the invention also has a check valve and a safety valve.

[0021] According to the electronic logic programmed in the remote system, the pump is activated if the pressure drops below a first predetermined value or if the flow rate increases above a specific value; moreover, the pump is deactivated if the pressure increases above a certain value and if the flow rate drops to a specific value.

[0022] The pressure flow switch in question may also shut down the pump if there is no water, if there are small leaks or excessive flows; all these alarms can be excluded at the discretion of the user.

[0023] Thanks to the type of electronic logic installed, the control device can also be controllable by a remote control and has an isolating transformer in its power supply, to protect the system from overvoltages.

[0024] Further characteristics and advantages of a control device for operation of an autoclave pump of a water distribution network, according to the present invention, shall become more apparent from the description hereunder, provided as a non-limiting example, with reference to the attached schematic drawings, in which:

- figure 1 shows a partly longitudinal sectional view of the control device according to the invention;
- figure 2 is a partly sectional front view of the control device in figure 1, from which the spring-loaded accumulator element has been removed;
- figure 3 shows a block diagram exemplifying the management logic section of the control device in figure 1, according to the present invention;
- figure 4 shows a non-limiting embodiment of the electric circuit forming the management logic of figure 3.

[0025] With particular reference to figures 1-2 mentioned, the autoclave pump is connected to the inlet duct 12 of the control device according to the present invention, while the user circuit is connected to the outlet duct 1, so that the flow of water delivered by the pump flows through the device from one end to the other.

[0026] The pressure is controlled in the following way.

[0027] The position of the diaphragm 10, which is located inside the chamber 7, depends on the equilibrium of two opposite forces, the force exerted by the pressure in the chamber 7 and the force exerted by the counter spring 9; on the other side, a shaft 14, made of plastic and integral with the diaphragm 10, incorporates a first magnet 13, the position of which is picked up by a first reed contact 6, and an electronic circuit, located on the terminal plate 8, is thus able to detect whether the pressure is above or below a predetermined value, by detecting the state of the reed contact 6.

[0028] In particular, the electric-electronic management circuit 8 is housed inside an electric box 8A, which remains completely isolated from the fluid circulating in the control device, so as to avoid unwanted faults and/or malfunctions in the microprocessor management logic, caused by the operating temperatures of the device, the relative humidity, any vibrations or thermal shocks.

[0029] The diaphragm 10-spring 9 assembly also forms a small spring-loaded accumulator, able to accumulate a predetermined quantity of water (about 200 cc).

[0030] The flow of circulating liquid is also detected in the following manner.

[0031] To go from the inlet duct 12 to the outlet duct 1 the water is forced to flow through a cylindrical duct, which directs the flow to a small turbine 2, which starts to rotate with extremely low flows and, as long as there is flow, maintains a rotation speed directly proportional to this.

[0032] A second magnet 4, fixed to the turbine 2 rotates with it and causes a second reed contact, indicated with 5 in figure 1, to close and open with each turn of the turbine 2.

[0033] The electronic logic is therefore able to measure the flow, monitor the trend and consequently decide whether to keep the pump switched on or to switch it off, also taking account of the pressures inside the system.

[0034] Owing to the small dimensions of the nozzle, indicated with 15 in figure 2, which directs the flow of water to the turbine 2, when the flow rates are considerable a by-pass valve, indicated with 15A in figure 2, also opens to help convey the water to the user; moreover, to obviate turbulence and interference which are triggered off between the two flows (the one travelling through the turbine 2 and the one from the by-pass valve 15A) it was necessary to introduce a separating baffle.

[0035] Finally, the vent of the chamber 16 which houses the spring 9, is provided with a safety valve 3, which closes the vent if there is a flow of water inside the chamber 16 caused, for example, by breakage of the diaphragm 10; in this way, in the event of breakage, indiscriminate leakage of water and consequent flooding of the room are avoided.

[0036] The check valve 11 prevents the water from flowing towards the pump when the latter is shut down, so that the chamber 7 and the user circuit may remain pressurized, even when the pump is switched off, thanks to the thrust of the spring 9 on the diaphragm 10.

[0037] The electric box 8A, to house the printed circuit 8, connected to the power mains and to the pump, which supervises management of the overall operation of the device, is fixed.

[0038] In particular, the electronic logic provided decides whether or not to supply the pump with power according to the pressure and flow values detected and measured and according to the delays found between the variations in pressure and flow.

[0039] In particular, the flow sensor according to the invention is substantially composed of the turbine 2, disposed on the outlet duct 1 of the device, while the pressure sensor, of the diaphragm type, is positioned inside the chamber 7 of the body 17.

[0040] The pressure sensor comprises the diaphragm 10 which delimits the chamber 7 and which is operated

by the pressure inside the chamber 7; the diaphragm 10, substantially ring-shaped, is provided with the shaft or central stem 14 which is mobile and extends horizontally towards the inlet duct 12 of the pump.

[0041] The diaphragm 10 is then subjected to the action of the counter spring 9 and is deformable (as can be seen in figure 1) as a result of the pressure existing inside the chamber 7, after the elastic force of the spring 9 has been overcome.

[0042] The pressure sensor includes the magnet 13, associated with the shaft 14, and the reed contact detector 6, associated with the printed circuit 8, designed to detect the position of the aforesaid shaft 14.

[0043] The magnet 13 and the contact 6 are facing each other and interact with each other at a predetermined pressure value existing inside the chamber 7, while they are spaced apart at greater pressure values to the predetermined one; moreover, in the condition in which the magnet 13 and the contact 6 are facing each other, the pressure sensor emits a signal, through the electronic logic, to enable pump switch-on.

[0044] The flow sensor of the control device according to the invention comprises the turbine 2, rotating as a result of the flow of water circulating in the outlet duct 1, and a second position detector, composed of the magnet 4, associated with the turbine 2, and of the reed contact 5, associated with the printed circuit 8 and able to interact with the magnet 4.

[0045] Operation of the control device for operation of an autoclave pump of a water distribution network, according to the present invention, is substantially as follows.

[0046] In initial conditions, all the terminations of the user or of output 1 are closed, the chamber 7 inside the body 17 is subjected to a maximum pressure value and the pump is switched off; in these conditions, the pressure sensor is not active.

[0047] When water is drawn through at least one of the user terminations 1, the water flows from the pressurized chamber 7 to the distribution network and, therefore, the turbine 2 is operated and the flow increases to a minimum predetermined value at which the flow sensor starts to operate and causes the pump to switch on, or the internal pressure of the chamber 7 decreases to a predetermined minimum value, at which the pressure sensor starts to operate and causes the pump to switch on.

[0048] The flow of water, moreover, causes the check valve (or input valve) 11 to open, so that the water flows into the chamber 7 of the body 17.

[0049] The decrease in pressure inside the chamber 7 causes deformation of the diaphragm 10, as the counter spring 9 is released, and return of the shaft 14 to a position in which the reed contact 6 and the magnet 13 interact with each other; at this point, mutual interaction between the contact 6 and the magnet 13 make it possible to automatically send, through the associated electronic circuit, a signal to the motor of the pump to switch it on.

[0050] In practice, the direct causes for which the pump is operated are determined by the fact that inside the chamber 7 of the body 17 a minimum predetermined pressure value is reached or a minimum predetermined flow value is reached; the position detector composed of the magnet 4 and the contact 5 provided on the turbine 2 at the outlet duct 1, is also utilized to keep the pump operating, even if the magnet 13-contact 6 assembly, associated with the pressure sensor, does not interact (for example, due to a further increase in pressure in the chamber 7).

[0051] The position detector provided on the turbine 2 is also able to ensure correct shut-down of the pump in the conditions in which the pressure inside the chamber 7 is greater than a specific predetermined value and the quantity of outflowing water is below a predetermined value.

[0052] The pump is therefore started up according to the detection and measurement of pressure and flow and starts up if the pressure is below a predetermined value or if the flow is above a further predetermined value; shut-down of the pump is also influenced by pressure and flow, in the sense that the pump is shut down if the pressure exceeds a predetermined value and if the flow is below a further predetermined value.

[0053] In particular, if the flow is below the predetermined value, but the pressure does not increase above the predetermined value within a certain time, the electronic logic inside the device senses that there is no water at the pump inlet side and stops the pump, shutting down the system; at this point the user may reset the system using a specific reset button.

[0054] The electronic management logic also supervises the time lapse between one start-up and the next during normal operation; in practice, when a certain number of consecutive start-ups which are short-lasting and close to one another are detected, the electronic logic stops the pump due to the leaks found in the user circuit and shuts down the system; once again the user may rid the system of the alarm condition using the reset button.

[0055] A third alarm provided is the maximum flow alarm; in fact, if the flow rate reaches a predetermined value (for example, 100 l/min) and remains for a certain period of time at a value greater than or equal to this, the alarm cuts it and shuts down the pump; once again the reset button can be used to remove the alarm condition.

[0056] All the alarms described above may be excluded by means of specific jumpers on the printed circuit present in the electric box 8A.

[0057] Finally, the device is provided with a panel with a series of LEDs to indicate the presence of the power supply, pump operating and pump shut down and a reset button that can be used to restore the pump to operation.

[0058] With particular reference to figures 3 and 4, the electric-electronic management circuit for total opera-

tion of the control device according to the present invention is composed of a feed section, a logic section, a driver relay and reed sensors.

[0059] More specifically, the object of the power supply section, indicated generically with 30 in figure 3, is to provide, through the use of a transformer 21 and a rectifier 22, a voltage of 12 volts designed to supply the relay 20, a possible remote interface 23 and the LEDs 24, 25, respectively indicating pump operation and mains power supply.

[0060] The section 30 also generates a voltage of 5 volts stabilized, by means of a specific stabilizer 26, which is used to supply the management microcontroller 27 and at least an alarm LED 28, and a possible analogue output 29.

[0061] The electronic operating logic of the control device is imparted by the microcontroller 27 by means of a series of commands or impulses sent to a latch; for example, following a "PUMP ON" command, the pump remains on until the next "PUMP OFF" command, even if the start-up condition ceases (that is, even if the pressure inside the chamber 7 increases above a maximum value).

[0062] The commands sent by the microcontroller logic according to a preferred although non-limiting example of embodiment of the present invention, are summarized hereunder:

"PUMP ON", if (pressure <1.6 bar) OR (flow >0.4 l/min);
"PUMP OFF" if (pressure >1.8 bar) AND (flow <0.3 l/min AND (TIMER1=end of count);
"PUMP SHUT DOWN", if (no water) OR (leak) OR (excessive flow);
"NO WATER ALARM", if (pressure <1.6 bar) AND (flow <0.3 l/min AND (TIMER2=end of count);
"LEAK ALARM", if COUNTER3=end of count;
"EXCESSIVE FLOW ALARM" if (flow >100 l/min AND (TIMER4=end of count).

[0063] The no water, leak and excessive flow alarms shut down the pump and activate a LED 28; in this case, the logic is restored from the shut-down state when a reset button is pressed.

[0064] As mentioned previously, all commands sent by the microprocessor 27 make use of information from the internal timers and counters.

[0065] In particular, according to the logic described, 3 timers (TIMER1, TIMER2, TIMER4) and one counter (COUNTER3) are used.

[0066] TIMER1 starts its count when the logic condition to switch off the pump is reached (that is, high pressure and low flow) and only switches off the pump if this condition is maintained for the full count time; the timer is then reset (and therefore the pump continues to be supplied) if the start-up condition (that is, low pressure or flow above a certain value) is restored during the count and when the pump restarts for normal use.

[0067] TIMER2 starts to count each time there is the condition (low flow) AND (low pressure) and is reset with the condition (low flow) AND (high pressure); if the timer reaches the end of the count, a no water alarm is emitted and the pump shuts down until the reset button is pressed.

[0068] The COUNTER3 increases each time the pump starts up, the counter is reset if the pump remains on for more than 20 seconds; if the counter counts 30 short-lasting start-ups close to one another, a leak alarm is emitted and the pump is shut down until being subsequently reset.

[0069] The TIMER4 starts counting when the flow delivered reaches 100 l/min and shuts down the pump if the flow remains greater than or equal to 100 l/min for 5 seconds.

[0070] Therefore, according to the invention it is possible to vary the flow settings of the control device simply by modifying some constants in software installed in the microcontroller 27.

[0071] This allows different models with different sensitivities to be used to adapt the device to the performances of the various types of pump; to modify the settings in the application software the predefined threshold values relative to the flow rates must be adjusted, while different counter springs must be used to adjust the pressure.

[0072] Moreover, according the invention and unlike other control devices for autoclave pumps of the traditional type, it is possible to add an alarm for excessive flow to stop the pump when an abnormal condition such as the breakage of a pipe occurs and to add, thanks to the microprocessor logic 27, another alarm for small leaks.

[0073] The device is also designed to conform with the current European regulations on this subject.

[0074] From the description, the characteristics of the control device for operation of an autoclave pump of a water distribution network and the advantages attained compared to prior art are apparent.

[0075] In any case, the control device thus conceived may undergo numerous modifications and variants, all falling within the invention and all parts may be replaced with technically equivalent elements, just as the materials utilized and the dimensions may vary according to technical requirements.

[0076] For this purpose, it is further emphasized that it is also possible to use a remote control, which controls pump operation at a distance, provides the customer with useful information on the state of the system and warns, by an acoustic signal (buzzer, which may be disabled at the discretion of the user) of any faults.

[0077] The remote control, suitable for wall-mounting, may be positioned at a maximum distance of 50 metres from the pressure flow switch and can be used to switch the pump on and off, start up or reset the system and monitor the state by means of viewing the parameters on a liquid crystal display.

[0078] The dialogue between the microcontroller of the remote control and the microcontroller of the control device takes place by cable, through serial transmission and dedicated protocol.

[0079] In particular, the remote control comprises an interface module and the actual remote control. The interface module is composed of a serial communication card which is added to the control device to transmit data and commands from the microprocessor 27 to the remote control and vice versa; it also supplies power to the remote control and is housed inside the electric box 8A and connected directly to the printed circuit by means of a specific connector.

[0080] The remote control is a command and control module for the pump, which dialogues with the microprocessor 27 of the control device of the pump by cable, through an interface module; it is provided with a liquid crystal display, on which to view information concerning the state of the pump (power supply, pump operating, pump enabled), with a buzzer and relative visual indicators to warn the user of an alarm (no water, leak in the circuit, excessive flow) and the necessary control buttons (pump enabling, reset, acoustic alarm exclusion).

Claims

1. Control device for operation of an autoclave pump of a water distribution network of the type comprising means for detecting and measuring pressures and flows by means of moving parts and electronic means for managing pump supply in relation to the parameters detected, **characterized in that** said electronic means comprise a microprocessor electronic control system (27) designed to simultaneously detect and measure flow and pressure and designed to detect any abnormal operating conditions of the device.

2. Control device according to claim 1, **characterized in that** said electronic management system utilizes an electronic logic programmed so that the pump is activated if the pressure inside the device drops below a first predetermined value or if the flow rate circulating inside the device is above a second predetermined value, said pump being deactivated in the case in which said pressure is greater than a third predetermined value and if said flow rate decreases to a fourth predetermined value.

3. Control device according to claim 1, **characterized in that** said pump is connected to an inlet duct (12), comprising at least a check valve (11), said device also having an outlet duct (1), to which a user circuit is connected, so that the flow of water delivered by the pump flows through the device from one end to the other, a body (17) inside which is at least a chamber (7) to which the fluid flows, and at least a casing (8A), annexed to said body (17) and isolated from the fluid circulating inside said chamber (7), containing said electronic management system.

4. Control device according to claim 3, **characterized in that** the liquid circulating inside the device flows from said inlet duct (12) to said outlet duct (1), through at least a duct that directs the flow to at least a turbine (2), which starts to rotate with low flow values and, with flow values above zero, maintains a rotation speed directly proportional to said flow.

5. Control device according to claim 4, **characterized in that** said turbine (2), disposed on said outlet duct (1) of the device, constitutes a flow sensor of the fluid circulating inside said body (17), the control device also comprising a pressure sensor, of the diaphragm type, positioned inside said chamber (7) of the body (17), said pressure sensor comprising a diaphragm (10), which delimits said chamber (7) and which is operated by the pressure of the fluid present inside said chamber (7), said diaphragm (10) also being provided with a shaft or central stem (14) which is mobile and extends horizontally towards said inlet duct (12) of the pump.

6. Control device according to claim 5, **characterized in that** said diaphragm (10) is subjected to the action of a counter spring (9) and is deformable as a result of the pressure existing inside said chamber (7), after the elastic force of the spring (9) has been overcome, said pressure sensor including at least a magnet (13), associated with said shaft (14), and at least a contact detector (6), associated with the printed circuit (8), designed to detect the position of said shaft (14), said magnet (13) and contact (6) facing each other and interacting with each other at a predetermined pressure value existing inside said chamber (7), according to which said pressure sensor is designed to emit a signal to enable pump switch-on.

7. Control device according to claim 5, **characterized in that** said flow sensor comprises a position detector, composed of a magnet (4), associated with said turbine (2), and of a contact (5), associated with the printed circuit (8) and able to interact with said magnet (4) if said circulating flow reaches a minimum predetermined value according to which said flow sensor is designed to emit a signal to enable pump switch-on.

8. Control device according to claim 7, **characterized in that** said pump is switched on when, inside said chamber (7), a minimum and predetermined pressure value is reached or when a minimum and predetermined flow value is attained, said position detector provided on said turbine (2) being utilized to

maintain said pump operating and being able to guarantee correct shutdown of the pump in the conditions in which the pressure inside said chamber (7) is above a certain predetermined value and said flow circulating at the outlet side is below a predetermined value, said pump thus operating if the pressure inside said chamber (7) is below a predetermined value or if said flow is above a further predetermined value, said pump shutting down if said pressure exceeds a predetermined value and if said circulating flow is below a further predetermined value.

9. Control device according to claim 8, **characterized in that** said electronic management system controls actuation of a series of alarms, which shut down said device if there is no water on the inlet side of the pump, if leaks are detected in the user circuit and if the circulating flow, for a certain period of time, is above a predetermined maximum value, said alarms being excludable by the user by means of specific jumpers.

10. Control device according to claim 9, **characterized in that** said electronic control system comprises a series of timers and/or counters, designed to produce counts to reach predetermined logic conditions and to send control signals to said pump and/or alarms to the user.

11. Control device according to claim 2, **characterized in that** said electronic management system includes at least a microcontroller (27) inside which it is possible to adjust some constants in the software which allow the setting of the flows circulating inside the device to be varied, so that it is possible to have different models with different sensitivities to adapt the device to the performances of different types of pump.

12. Control device according to claim 1, **characterized in that** it comprises a possible remote control, which controls pump operation at a distance, provides the customer with useful information on the state of the system and warns, by an acoustic signal, of any faults, said remote control being designed to dialogue with said electronic management system by cable, through serial transmission and dedicated protocol.

13. Control device according to claim 12, **characterized in that** said remote control comprises an interface module and a remote control apparatus, said interface module being composed of a serial communication card between said electronic management system and said remote control, while said remote control apparatus is composed of a command and control module for said pump, which dialogues with said electronic management system of the control device of the pump, said control apparatus also comprising at least a display for viewing operation and faults and/or alarms generated inside said control device.

Fig.1

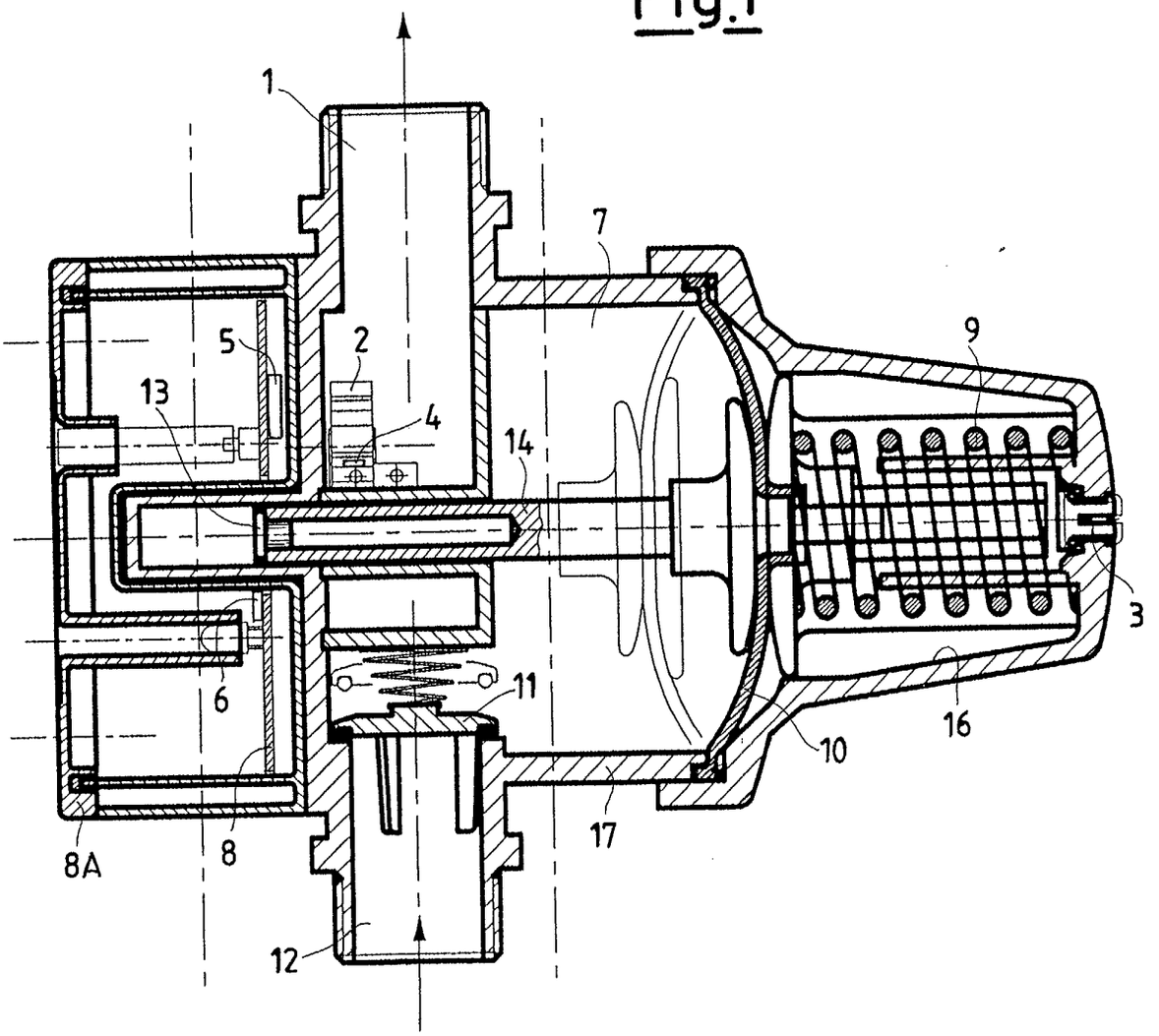

Fig.2

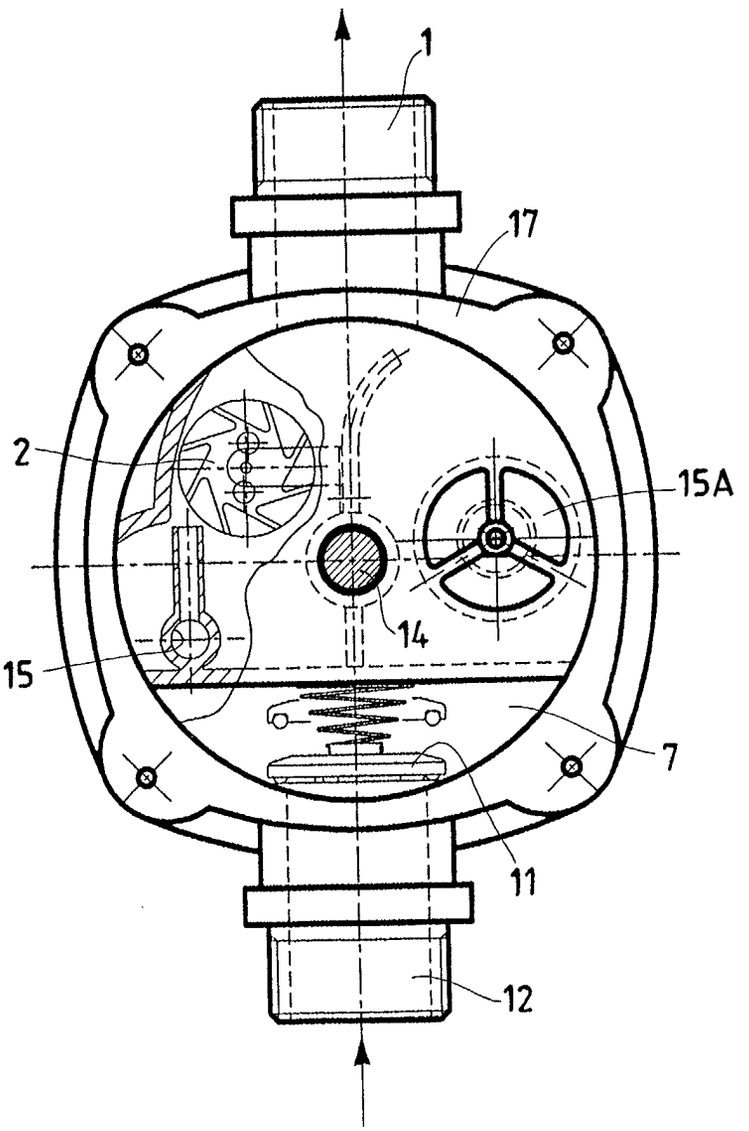

Fig.3