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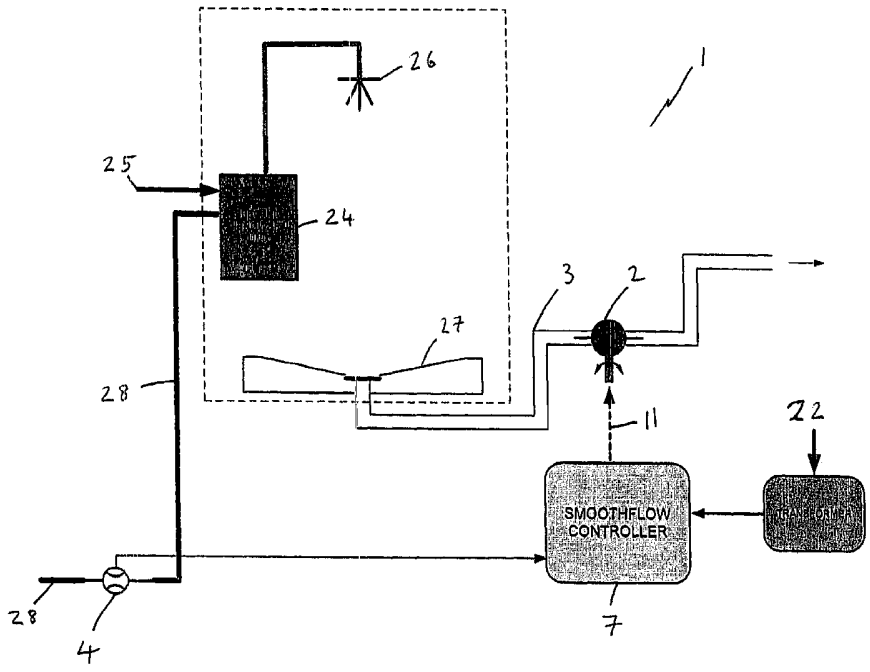
(54) **Title:** A SYSTEM FOR CONTROLLING THE RATE OF A PUMP ON A WATER DRAINAGE OUTLET OF A WATER DISPENSING UNIT



(57) **Abstract:** A system for controlling the rate of a pump (2) on a water drainage outlet (3) of a water dispensing unit. The system comprises means for measuring the water inlet flow rate of an inlet water supply to the water dispensing unit and means for controlling the rate of the pump (2) on the water drainage outlet (3) based on the measured water inlet flow rate.

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A SYSTEM FOR CONTROLLING THE RATE OF A PUMP ON A WATER DRAINAGE OUTLET OF A WATER DISPENSING UNIT

This invention relates to a system for controlling the rate of a pump on a water drainage outlet of a water dispensing unit and in particular to a system for controlling the rate of a pump on a water drainage outlet of a shower.

In certain situations it is necessary to be able to pump water from the outlet pipe of a water dispensing unit such as a shower into the surrounding main water drainage system. One example of this is the situation where a shower tray is located level with the ground level to allow wheelchair occupants to roll directly onto the shower tray. In these circumstances, it is not possible for the water draining from the shower tray to flow under gravity into the surrounding drainage system because the shower tray outlet pipe is below the other drainage pipes. A further example of a situation where it is necessary to pump water from a shower tray outlet pipe occurs in boats where water drained from a shower tray must be pumped overboard. At present, the method of controlling water outlet pipe drainage pumps is to place an on/off sensor in the water supply conduit which turns the drainage pump on when the sensor indicates that water is flowing in the water supply conduit.

It is an object of the present invention to obviate or mitigate the problem of variation between water inlet flow rate and water outlet flow rate in water dispensing units such as domestic showers incorporating a water outlet pipe drainage pump.

Accordingly, the present invention provides a system for controlling the rate of a pump on a water drainage outlet of a water dispensing unit, the system comprising means for measuring the water inlet flow rate of an inlet water supply to the water dispensing unit and means for controlling the pump on the water drainage outlet based on the measured water inlet flow rate.

Preferably, the means for controlling the pump comprises means for controlling a voltage applied to an electric motor of the pump.

Ideally, the means for controlling the voltage sets a pump rate which substantially equalises the water inlet flow rate of the water dispensing unit and the water outlet flow rate of the pump.

Preferably, the means for measuring the water inlet flow rate comprises at least one flow sensor in communication with the inlet water supply.

Ideally, the at least one flow sensor generates a digital signal containing information in relation to the water inlet flow rate.

Ideally, the means for controlling the voltage applied to the pump motor is a microcontroller with a control program running thereon.

Ideally, the microcontroller has a pulse width modulator for applying a pulse width modulated signal to the pump motor.

Advantageously, the pulse width modulated duty cycle during which a voltage is to be applied to the pump motor is variable in response to a variation in the measured water inlet flow rate allowing the pump speed to vary with varying water inlet flow rates.

Preferably, the microcontroller is an Atmel AVR ATmega 32.

Ideally, the pump is a 24V Gulper ® 220 manufactured by Munster Simms Engineering Limited.

Ideally, the digital signal generated by the at least one flow sensor is transmitted to a timer of the microcontroller.

Preferably, the timer calculates a water inlet flow rate.

Ideally, the control program monitors signals received from the at least one flow sensor and generates a pulse width modulated control signal to be applied to the pump motor based on these flow sensor signals.

Ideally, two flow sensors are in communication with the microcontroller. Two flow sensors are required when a shower system incorporates a mixer with two water inlets where a flow sensor is located on each water inlet. A single flow sensor is sufficient where there is only one water inlet such as an electric shower.

Ideally, the flow sensor is a turbine flow sensor.

Preferably, a GEMS FT-110 series sensor is used.

Ideally, the microcontroller has a user configuration interface.

Preferably, the microcontroller has an RS232 interface. This allows external access to important data on the microcontroller. A laptop can be coupled to the microcontroller via the RS232 interface for in-house diagnostics.

Preferably, the microcontroller has an analog to digital A/D converter.

Ideally, a series transformer power supply is connected between the mains electricity supply and the microcontroller.

Preferably, the output of the series transformer power supply is full wave rectified.

Ideally, a 5V power supply for the microcontroller is generated from the series transformer power supply using a linear regulator.

Advantageously, the Pulse Width Modulation (PWM) mode of control for the pump motor lowers the parts count/cost and reduces power losses/heat generation.

Ideally, a PWM carrier frequency in the range of 7 to 9 KHz is used.

Most preferably, the PWM carrier frequency is 8KHz. This figure strikes a balance between minimising the audible noise that is emitted from the motor at the PWM frequency whilst providing adequate motor speed control resolution.

Preferably, a memory of the microcontroller stores a table of acceptable values for the A/D converter. Advantageously, the table of acceptable values indicate acceptable values of AC mains voltage.

Ideally, the memory of the microcontroller has at least one set of default tables containing empirical values of pulse width modulated duty cycle versus inlet flow rate. These are the default settings which an installer can adjust to suit the particular dimensions associated with the specific shower tray being installed.

Preferably, the memory of the microcontroller has a set of default tables for each different diameter of outlet pipe on which the pump is to be mounted.

Ideally, the installer can select the relevant default table to suit the outlet pipe diameter when installing the control system via the user configuration interface.

Ideally, the control system has means for delaying the start-up of the pump until a predetermined volume of inlet water has passed the inlet water measuring means. Advantageously, the start-up delay based on the volume of inlet water delivered is adjustable by the installer via the user configuration interface.

Ideally, the microcontroller has a reset means. The reset means ensures that the microcontroller will reset to a safe mode for a re-start in the event of a microcontroller crash.

Preferably, the means for controlling the voltage applied to the pump motor has start-up means for identifying when the predetermined volume of inlet water has been delivered via the water dispensing unit.

Ideally, the start-up means comprises a start-up software control module reading values from the timers of the microcontroller and comparing them to a pre-set start-up volume of inlet water prior to initiating the pump. Advantageously, the start-up volume is stored in the memory of the microcontroller which is adjustable by the installer via the user configuration interface.

In the event of system configuration values such as start-up delay volume being corrupted / lost, the microcontroller has a safe mode which initiates the pump immediately upon detection of a flow of water by at least one flow sensor. The system will also run at full speed to avoid flooding and will overrun for the maximum duration to ensure that the tray is clear.

Ideally, the control system has means for compensating for variation in AC mains input voltage.

Preferably, the compensating means monitors values from the analogue to digital converter of the microcontroller.

AC mains input voltage variations are mirrored in the output value of the A/D converter.

Preferably, the compensating means comprises a compensating software control module executing on the microcontroller for reading values from the A/D converter and for determining exception values outside an accepted envelope of values and in response to identification of exception values modifying the pulse width modulated signal being applied to the pump motor to compensate for the exception values.

Preferably, the control system has over pumping means.

Ideally, the control system has means for monitoring the operating current and voltage values of the pump motor.

Preferably, the control system has means for shutting down the pump in response to a threshold pump operating current value being read.

Ideally, the pump operating current shutdown threshold value is stored in the memory of the microcontroller.

Preferably, the control system has means for briefly reactivating the pump a number of minutes after the pump is switched off in response to the water inlet flow stopping. Advantageously this removes any runoff water from shower curtains and the like.

Ideally, the pump is reactivated for a short period of time. This time period is preferably in the range of 10 to 45 seconds.

The present invention also provides a control program executable on a microcontroller for controlling the rate of a pump on a water drainage outlet of a water dispensing unit, the control program having a software control module for reading signals from water inlet flow rate measuring means and a software control module for controlling the pump on the water drainage outlet based on the signals read from the water inlet flow rate measuring means.

Ideally, the pump software control module controls a voltage applied to an electric motor of the pump. Ideally, the software control module for controlling a voltage applied to the pump motor sets the rate of the pump so that the water inlet flow rate of the water dispensing unit and the water outlet flow rate of the pump are substantially equal.

Ideally, the control program comprises a start-up software control module reading values from timers of the microcontroller and comparing them to a pre-set start-up volume of inlet water prior to initiating the pump. Advantageously, the start-up volume of inlet water is stored in the memory of the microcontroller and is adjustable via a user configuration interface.

Preferably, the control program has a compensating software control module executing on the microcontroller for reading values from the A/D converter and for determining exception values outside an accepted envelope of values and in response to identification of exception values modifying the pulse width modulated signal being applied to the pump motor to compensate for the exception values.

Ideally, the control program has a pump shutdown software control module for gradually ramping the pump motor speed down via the PWM signal when the water inlet flow stops and monitoring the load current on the pump for shutting the pump down when the load current falls below a predetermined threshold value.

Ideally, the control program has a pump reactivating software control module which has means for identifying a pump shut down condition, means for counting a predetermined period of time and means for initiating the voltage control means to run the pump for a short duration of time.

The present invention further provides a water dispensing unit having a water supply means and a water retaining means having a water drainage outlet and a pump on the water drainage outlet, the water dispensing unit having a system for controlling the rate of the pump on the water drainage outlet of the water dispensing unit, the system comprising means for measuring the water inlet flow rate of the water supply means to the water dispensing unit and means for controlling the pump on the water drainage outlet based on the measured water inlet flow rate.

Preferably, the pump control means has a means for controlling a voltage applied to an electric motor of the pump.

Ideally, the means for controlling the voltage applied to the pump motor of the pump sets a pump rate which substantially equalises the water inlet flow rate of the water supply means and the water outlet flow rate of the pump.

Ideally, the water dispensing unit is a shower unit, the water supply means is a shower head supplied with water and the water retaining means is a shower tray.

The invention will now be described with reference to the accompanying drawings, which show by way of example only, two embodiments of a system for controlling the rate of a pump on a shower drainage outlet. In the drawings:-

Fig. 1 is a schematic drawing of a system for controlling the rate of a pump on the drainage outlet of an electric shower unit;

Fig. 2 is a schematic drawing of a system for controlling the rate of a pump on the drainage outlet of a shower unit with two water inlet supplies and a mixing valve; and

Fig. 3 is a schematic drawing of a microcontroller and peripheral devices.

Referring to the drawings, there is shown a control system and shower apparatus indicated generally by the reference numeral 1 for controlling the rate of a pump 2 on a shower drainage outlet 3 having one flow sensor 4, see Fig. 1, or two flow sensors 5, 6, see Fig. 2 and Fig. 3 in communication with a microcontroller 7. The microcontroller 7 has a pulse width modulator 9 for applying a pulse width modulated signal 11 to the motor of the pump 2 via a MOSFET (not shown). The flow sensors 4, 5, 6 are coupled to the microcontroller 7 which has a control program running thereon. The speed of the pump 2 is controlled to obtain a pump rate which is substantially equal to the water inlet flow rate measured by the flow sensor 4 or flow sensors 5, 6.

The mains electricity supply is coupled to the microcontroller 7 via a transformer 22 which steps the mains voltage down to 24V. The 24V supply is full wave rectified and smoothed using a smoothing capacitor. The smoothing capacitor is preferably a 6600μF reservoir capacitor. In Fig. 1, the water inlet 28 flows into the electric shower unit 24 which also has a mains electricity supply 25 for powering a heating element. A shower head 26 is located above a shower tray 27 which is

possibly in a boat or located level with ground level to allow wheelchair occupants to roll straight on. The outlet pipe 3 of the shower tray 27 has the pump 2 in fluid communication therewith.

In Fig. 2, the control system and shower apparatus 1 is identical to the control system and shower apparatus 1 shown in Fig. 1 except that the shower has a flow sensor 5, 6 located on both the hot and cold inlets 31, 32 which are fed into a mixing unit 33. The flow sensors 5, 6 are both connected to the microcontroller 7.

Referring now to Fig. 3, the microcontroller 7 has an analogue to digital A/D converter 41. The flow sensors 5, 6 are turbine flow sensors which convert the water inlet flow into digital signals 35, 36 which are transferred to timers 13 on the microcontroller 7 which compute values for water inlet flow rates. The microcontroller 7 also has an RS232 interface 38 which enables developers/engineers to view data from the microcontroller 7 using another computer such as a laptop 39. The laptop 39 has a Visual Basic ® diagnostic interface program loaded thereon for the purposes of in-house testing. The microcontroller 7 also has system memory 41 such as Flash, EEPROM and SRAM and general purpose I/O lines 42 which are connected to a parameter setup and configuration interface 43.

The configuration interface 43 allows the operator to restore default operating settings on the microcontroller 7. The configuration interface 43 allows the operator to manually set an overall inlet flow rate v pump speed profile at the installation phase. In order to set the overall inlet flow rate versus pump speed profile the installer selects a water inlet flow rate and maintains a watch on the level of the pool of water in the shower tray 27. The installer can increase or decrease the speed of the pump 2 until the level of the water in the shower tray remains constant. This calibration information is then stored within the control systems non-volatile memory 41 and the calibration is only required at a single point using a typical inlet water flow rate.

The configuration interface 43 also allows the operator to manually adjust a non-linear section of the overall water inlet rate v pump speed profile. As part of the installation process, an installer adjusts the flow rate of the shower unit across its full range and observes the pool of water

in the shower tray 27. This highlights flow rates at which the pumping rate needs adjustment. If a particular flow rate shows a need for adjustment, the installer adjusts the speed of the pump 2 at that flow rate and the control program linearly interpolates new pump speed values for a variable band either side of the adjusted speed.

The configuration interface 43 also allows the operator to set a start-up delay until a predetermined volume of water has entered the shower tray 27.

In use, a person enters the shower and turns on the shower unit by switching on the electric shower unit or turning the mixing valve of a non-electric shower unit to an on position. The control program executing continuously on the microcontroller 7 identifies an input signal from the flow sensors 4 or 5 and 6 when the shower is turned on. The start-up software control module is called which compares values of volume of water delivered into the shower measured by timers 13 against a predetermined start-up volume of water stored in the memory of the microcontroller 7. When the timers 13 measure a volume of water equal to the start-up volume of water stored in the memory, the voltage control means software control module (VCMSCM) for the pump motor is called and executes on the microcontroller 7 generating a pulse width modulated duty cycle control signal which applies a voltage to the pump motor via a MOSFET. The pulse width modulated duty cycle control signal depends on the water inlet flow rate which is also calculated by the timers 13 which convert the digital signal of the flow sensors 4 or 5 and 6 into a water inlet flow rate. The water inlet flow rate recorded by the timers 13 is compared by the VCMSCM to a default table of pulse width modulated duty cycle versus inlet flow rate and the VCMSCM selects the PWM duty cycle associated with the measured water inlet flow rate. The water inlet flow rate is continuously monitored in real time and any adjustments are made as and when required by the VCMSCM to maintain the balance between water in and water out of the shower unit.

As the person continues to shower, the values of the signals generated by the A/D converter 41 are monitored by the mains voltage compensating software control module executing on the microcontroller 7. These values are monitored in order to identify any variation in the AC mains

input voltage. The compensating software control module monitors values recorded by the A/D converter 41 and compares them against pre-recorded values stored on the memory of the microcontroller 7 to identify exception values which fall outside an envelope of acceptable values. In the event of such exception values, the compensating software control module modifies the PWM signal being applied to the pump motor to compensate for the variation in the mains voltage. Otherwise, the transformer output is unregulated and the percentage variation in the mains voltage would be mirrored in the transformer's output voltage which affects the pump motor speed by the same amount.

When the person turns the shower off, the control program executes a pump shutdown software control module which gradually ramps the pump motor speed down via the PWM signal when the water inlet flow stops as identified by the flow sensors 4 or 5 and 6. The pump shutdown software control module also monitors the load current on the pump 2 and compares this value to a predetermined threshold value stored in the memory of the microcontroller 7. The pump shutdown software control module shuts the pump 2 down when the load current equals or is less that the predetermined threshold current value. The control program has a pump reactivating software control module for briefly reactivating the pump a number of minutes, for example ten minutes after the pump 2 is switched off in response to the water inlet flow stopping. This removes any runoff water from shower curtains and the like. The pump 2 is reactivated for a short period of time in the range of 10 to 45 seconds.

Variations and other modifications can be made without departing from the scope of the invention defined in th appended claims.

CLAIMS

1. A system for controlling the rate of a pump (2) on a water drainage outlet (3) of a water dispensing unit, the system comprising means for measuring the water inlet flow rate of an inlet water supply to the water dispensing unit and means for controlling the rate of the pump (2) on the water drainage outlet (3) based on the measured water inlet flow rate.

2. A system as claimed in claim 1, wherein the means for controlling the rate of the pump (2) comprises a means for controlling a voltage applied to an electric motor of the pump (2).

3. A system as claimed in claim 2, wherein the means for controlling the voltage applied to the electric motor sets a pump rate which substantially equalises the water inlet flow rate of the water dispensing unit and the water outlet flow rate of the pump (2).

4. A system as claimed in claim 2 or claim 3, wherein the means for controlling the voltage applied to the pump motor is a microcontroller (7) with a control program running thereon.

5. A system as claimed in any one of the preceding claims, wherein the means for measuring the water inlet flow rate comprises at least one flow sensor (4, 5, 6) in communication with the inlet water supply.

6. A system as claimed in claim 5, wherein the at least one flow sensor (4, 5, 6) generates a digital signal containing information in relation to the water inlet flow rate.

7. A system as claimed in claim 6, wherein the digital signal generated by the at least one flow sensor (4, 5, 6) is transmitted to a timer of the microcontroller (7).

8. A system as claimed in claim 7, wherein the timer calculates a water inlet flow rate.

9. A system as claimed in any one of claims 4 to 8, wherein the microcontroller (7) has a pulse width modulator (9) for applying a pulse width modulated signal to the pump motor.

10. A system as claimed in any one of claims 4 to 9, wherein the control program monitors signals received from the at least one flow sensor (4, 5, 6) and generates a pulse width modulated control signal to be applied to the pump motor based on these flow sensor signals.

11. A system as claimed in any one of claims 4 to 10, wherein two flow sensors (5, 6) are in communication with the microcontroller (7).

12. A system as claimed in any one of claims 5 to 11, wherein the at least one flow sensor (4, 5, 6) is a turbine flow sensor.

13. A system as claimed in any one of claims 4 to 12, wherein the microcontroller (7) has a user configuration interface (43).

14. A system as claimed in any one of claims 9 to 13, wherein a pulse width modulation PWM carrier frequency is in the range of 7 to 9 KHz.

15. A system as claimed in any one of claims 4 to 14, wherein the microcontroller (7) has a memory (41) and an A/D converter (141) and the microcontroller (7) stores a table of acceptable values for an A/D converter (141) in the memory (41).

16. A system as claimed in claim 15, wherein the memory (41) of the microcontroller (7) has at least one set of default tables containing empirical values of pulse width modulated duty cycle versus inlet flow rate.

17. A system as claimed in any one of the preceding claims, wherein the system has means for delaying the start-up of the pump (2) until a predetermined volume of inlet water has passed the inlet water measuring means.

18. A system as claimed in any one of the preceding claims, wherein the system has means for compensating for variation in AC mains input voltage.

19. A system as claimed in claim 18, wherein the compensating means monitors values from the analogue to digital converter (141) of the microcontroller (7).

20. A system as claimed in any one of the preceding claims, wherein the system has means for shutting down the pump (2) in response to measuring a threshold pump operating current value.

21. A system as claimed in claim 20, wherein the pump operating current shutdown threshold value is stored in the memory (41) of the microcontroller (7).

22. A system as claimed in any one of the preceding claims, wherein the system has means for briefly reactivating the pump (2) a number of minutes after the pump (2) is switched off in response to the water inlet flow stopping.

23. A water dispensing unit having a water supply means (28, 31, 32) and a water retaining means (27) having a water drainage outlet (3) and a pump (2) on the water drainage outlet (3), the water dispensing unit having a system for controlling the rate of the pump (2) on the water drainage outlet (3) of the water dispensing unit, the system comprising means for measuring the water inlet flow rate of the water supply means to the water dispensing unit and means for controlling the pump (2) on the water drainage outlet (3) based on the measured water inlet flow rate.

24. A water dispensing unit as claimed in claim 23, wherein the means for controlling the pump (2) comprises a means for controlling a voltage applied to an electric motor of the pump (2).

25. A water dispensing unit as claimed in claim 24, wherein the means for controlling the voltage applied to the electric motor of the pump (2) sets a pump rate which substantially equalises the water inlet flow rate of the water supply means and the water outlet flow rate of the pump (2).

26. A water dispensing unit as claimed in any one of claims 23 to 25, wherein the water dispensing unit is a shower unit, the water supply means is a shower head (26) supplied with water and the water retaining means is a shower tray (27).

27. A control program executable on a microcontroller (7) for controlling the rate of a pump (2) on a water drainage outlet (3) of a water dispensing unit, the control program having a software control module for reading signals from water inlet flow rate measuring means and a software control module for controlling the pump (2) on the water drainage outlet (3) based on the signals read from the water inlet flow rate measuring means.

28. A control program as claimed in claim 27, wherein the software control module for controlling the pump (2) comprises means for controlling a voltage applied to an electric motor of the pump (2).

29. A control program as claimed in claim 28, wherein the software control module for controlling the voltage applied to the pump motor sets the rate of the pump (2) so that the water inlet flow rate of the water dispensing unit and the water outlet flow rate of the pump (2) are substantially equal.

30. A control program as claimed in any one of claims 27 to 29, wherein the control program comprises a start-up software control module reading values from timers of the microcontroller (7) and comparing them to a required pre-set start-up volume of inlet water prior to initiating the pump (2).

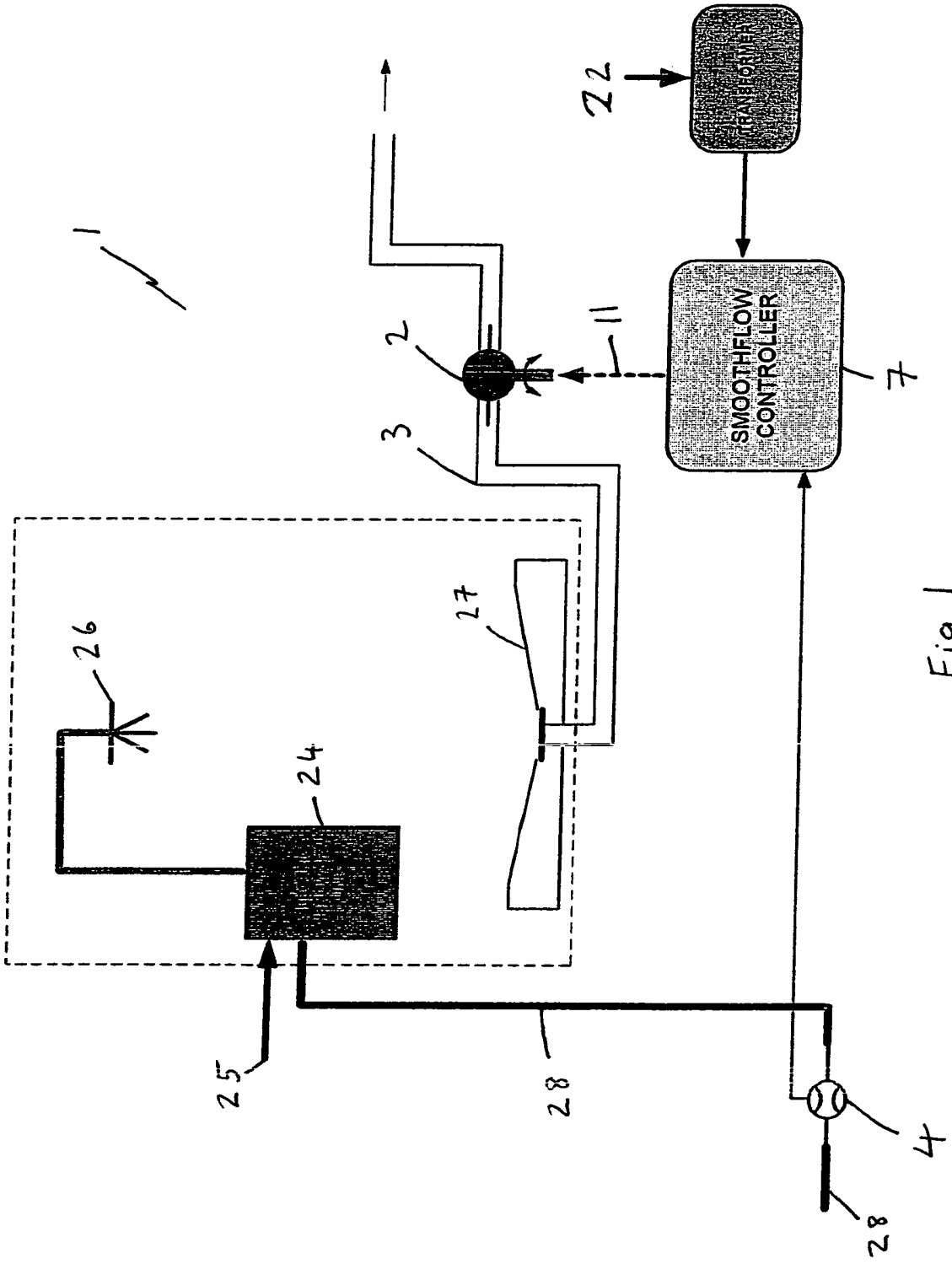
31. A control program as claimed in any one of claims 27 to 30, wherein the control program has a compensating software control module executing on the microcontroller (7) for reading values from the A/D converter (141) and for determining exception values outside an accepted envelope of values and in response to identification of exception values modifying the pulse width modulated signal being applied to the pump motor to compensate for the exception values.

32. A control program as claimed in any one of claims 28 to 31, wherein the control program has a pump shutdown software control module for gradually ramping the pump motor speed down via a PWM signal when the water inlet flow stops and monitoring the load current on the electric motor of the pump (2) for shutting the pump (2) down when the load current falls below a predetermined threshold value.

33. A control program as claimed in any one of claims 28 to 32, wherein the control program has a pump reactivating software control module which has means for identifying a pump shut down condition, means for counting a predetermined period of time and means for initiating the voltage control means to run the pump (2) for a short duration of time.

34. A system as claimed in any one of claims 1 to 22, substantially as hereinbefore described with reference to and as show in the accompanying drawings.

35. A water dispensing unit as claimed in any one of claims 23 to 26, substantially as hereinbefore described with reference to and as show in the accompanying drawings.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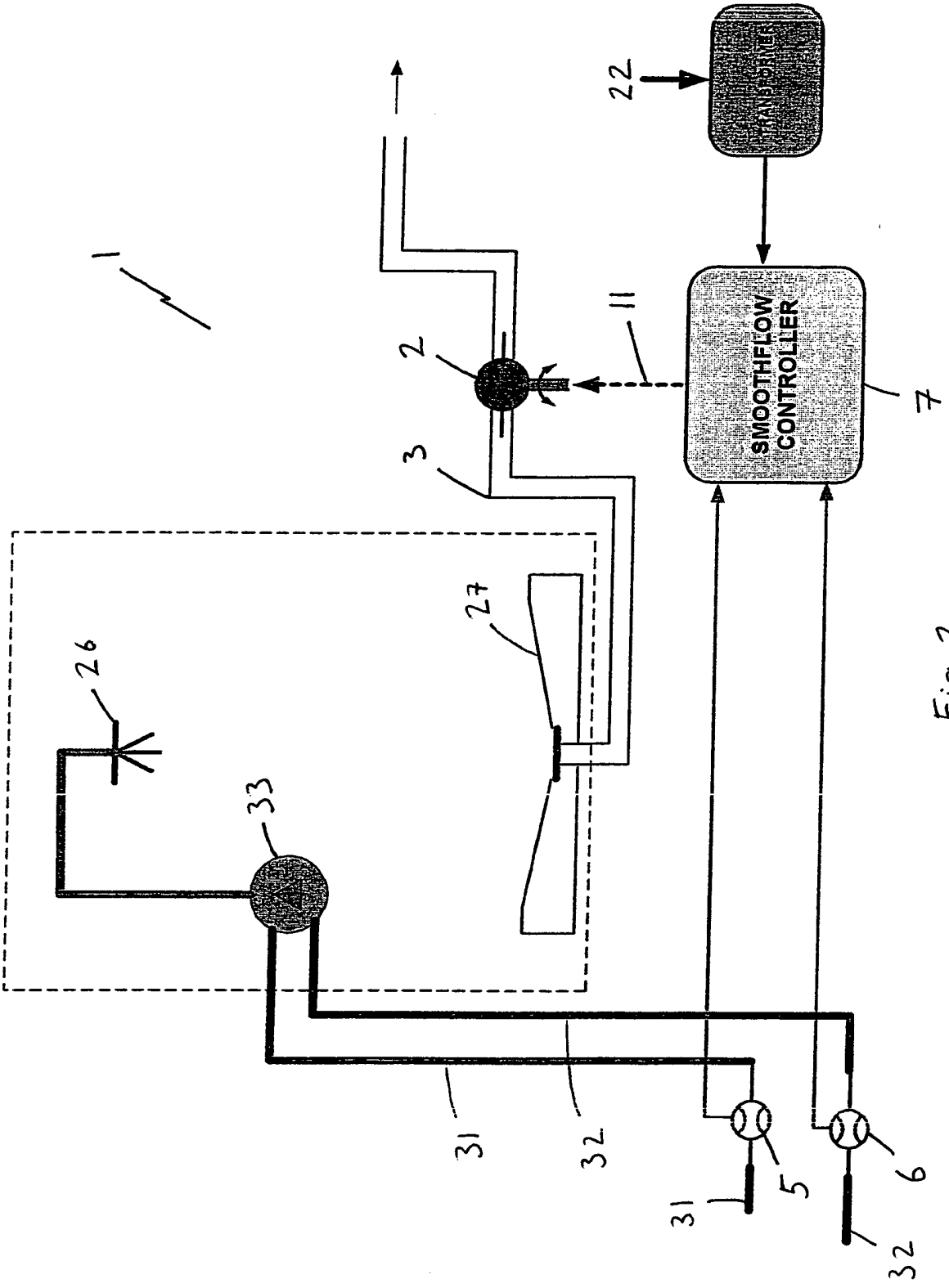
TRANSFORMER
SMOOTHFLOW CONTROLLER

Fig 1


1
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TRANSPOWER
SMOOTHFLOW CONTROLLER
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Fig 2

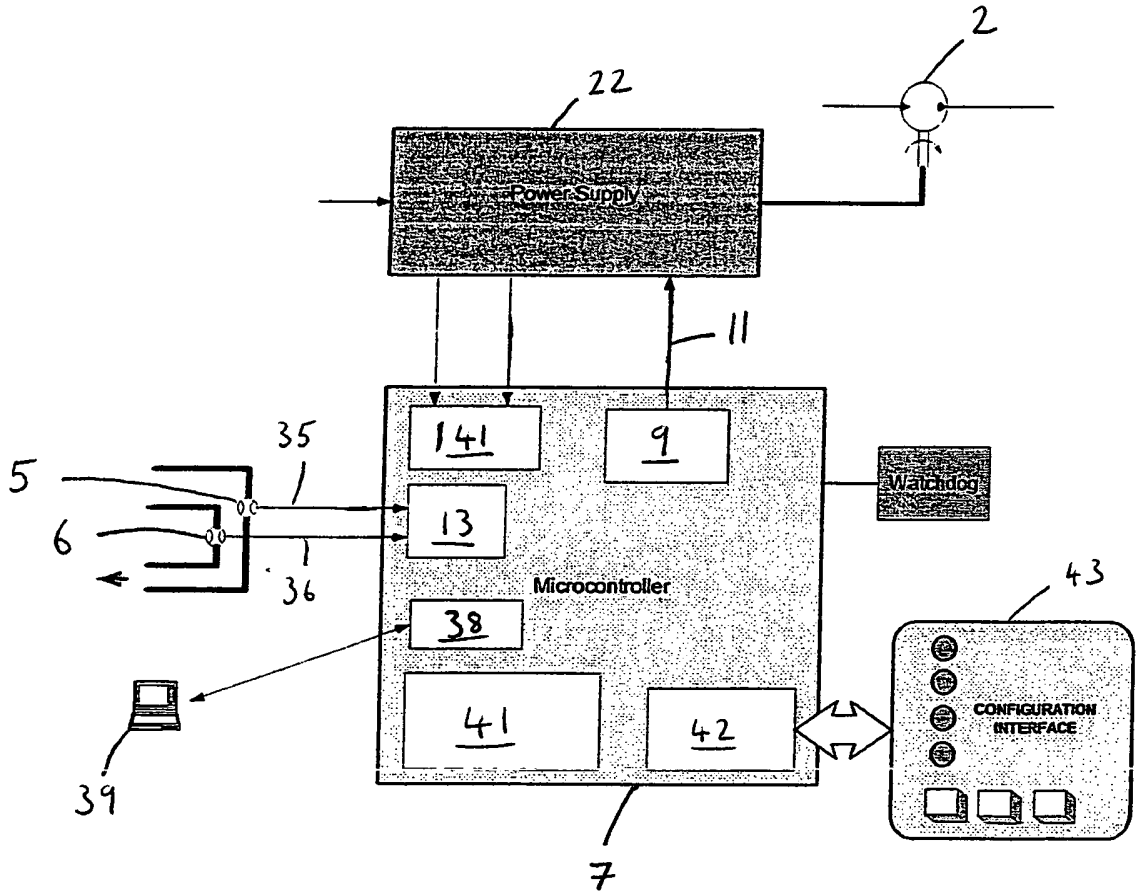
2
22
Power Supply
11
141
9
Watchdog
35
5
13
6
36
Microcontroller
43
38
41
42
CONFIGURATION INTERFACE
39
7

Fig 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/004290

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B49/06 F04D15/00 A47K3/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B F04D A47K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 276 541 A (ANTONI HAROLD NIKOLAS * GONTAR) 5 October 1994 (1994-10-05) the whole document page 6, paragraph 3	1-35
X	GB 2 355 653 A (* MACRO MARINE LIMITED) 2 May 2001 (2001-05-02) the whole document page 6, paragraph 2	1-35
X	US 5 458 185 A (MIZUNO ET AL) 17 October 1995 (1995-10-17) the whole document column 5, line 19 - line 44; figure 7	1-35

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 August 2006	22/08/2006

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2006/004290

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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