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(54) Washing machine with a continous water level sensor

(57) A washing machine having a continuous water level (CWL) sensor connected to a microprocessor comprises a comparator which compares the value from the CWL sensor with a predetermined threshold value, such comparator acting independently and/or in parallel with the microprocessor. In case of total or partial failure of the microprocessor, the above system guarantees that the water level in the tub does not go under or upper the minimum and maximum value respectively.

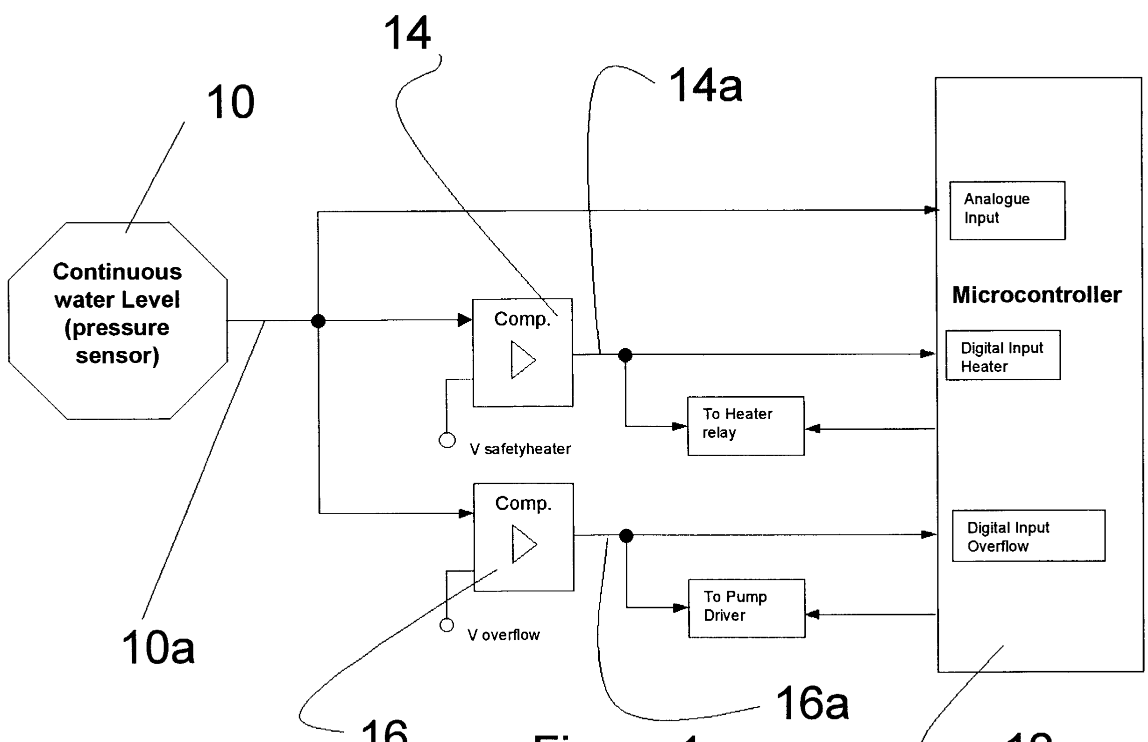

Figure 1

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Description

[0001] The present invention relates to a washing machine having a continuous water level (CWL) sensor connected to a control unit including a microprocessor. With the term "washing machine" we mean all kinds of domestic appliances for washing laundry and for washing dishes as well. As far as laundry-washing appliances are concerned, the present invention can be used for horizontal, vertical and tilted axes machines.

[0002] Modern washing machines use a CWL sensor that is able to monitor continuously the water level inside the tub.

[0003] CWL is a sensor able to convert the pressure applied to the sensor (that is proportional to the water level in the tub) into an electrical signal. There are few different types of CWL. Today the most common type is piezoresistive pressure transducer, membrane displacement sensor and inductive displacement device.

[0004] The piezoresistive pressure transducers are for instance produced and sold by Motorola, Honeywell, Sensym, and they are designed for wide applications. This kind of sensor combines a sensitive implanted strain gauge with advanced bulk micromachine technique, thin film metalisation and bipolar processing in order to provide an accurate high level analog output (voltage) that it is proportional to the applied pressure.

[0005] Membrane displacement sensors are produced for instance by Huba. This kind of CWL sensor is conceived as a low cost device for domestic appliances (particularly dishwashers). It is a displacement device where the deflection of a rubber membrane which results from the pressure acting on it, it is measured by a piezoresistive force sensor (Wheatstone bridge) obtained above an alumina substrate (by "Thick Film" technology) and on the same substrate the signal conditioning interface is also realized (by SMD technique). The sensor is temperature compensated and amplified for providing an analog voltage output.

[0006] Inductive displacement sensor are produced for instance by ELBI / Bitron. This kind of sensor is conceived as a low cost device for domestic appliances. It is an inductive displacement device (sensitive devise) using an inductance coil circuit measuring the deflection of the rubber membrane (by a metal pivot connected with the rubber membrane), that results from the pressure acting upon it.

[0007] The above known sensors combine a sensitive device with a microprocessor integrated in the same package to provide an accurate high level analog output that it is proportional to the applied pressure. The CWL sensor can be provided with the following different output types or it can be provided with multiple type of output: frequency, analog voltage output, PWM (pulse width modulation).

[0008] Washing machines are usually provided with electrical heater for heating tap water loaded in the machine in order to improve washing results. Such heaters (electrical resistances) are designed for working in a fully submerged condition. The demand of water saving (as a consequence of energy saving) has prompted appliance producers to design washing machines which use a reduced amount of water in each washing cycle. This water reduction increases the risk of heater failure, i.e. a damage to the heater which can also cause risk of fire. It is well known in the art that a heater failure occurs when the water in the tub or in the water circuit of the washing machine decreases under a certain level. When the water decreases under a certain level the heater becomes totally or partially dry and, as a consequence, inside the heater the temperature increases rapidly and the life of the heater is dramatically reduced.

[0009] Another risky situation can occur when the water level in the tub increases above a certain level. This situation is known as "overflow" and it can cause a spilling of water outside the washing machine.

[0010] Normally in a washing machine the heater and the discharge pump are operated by the control unit of the machine to which dedicated pressure switches (of the type on/off and calibrated for certain fixed levels of water) are connected.

[0011] The control unit of washing machine using a continuos water level (CWL) sensor comprises usually a microprocessor or equivalent control system electronic device that is connected with the CWL sensor in order to allow the control unit to use the correct amount of water and consequently to achieve better performances and to optimize energy consumption.

[0012] The use of a continuous water level sensor in combination with pressure switches (which provide for instance signals as far as minimum and maximum water levels are concerned) is certainly preferable from the point of view of safety, but it is quite expensive. For cost reasons it is preferred to use only one technology, i.e. a technology based on pressure switches only or a technology based on a CWL sensor only.

[0013] In the case a CWL sensor is used, the control unit is not 100% safe since its microprocessor, in case of total or partial failure, cannot guarantee that the water level does not go under or upper the minimum and maximum value respectively.

[0014] The main object of the present invention is to provide a washing machine that can operate the heater independently from the microprocessor of the control unit in order to guarantee the heater reliability and safety. Another object of the present invention is to provide a washing machine that can operate the discharge pump independently from the microprocessor in order to prevent water overflow.

[0015] According to the invention, such problem is solved thanks to the features reported in the appended claim.

[0016] In order to guarantee a certain performance the applicant has developed a technical solution for washing machines using a CWL sensor able to guarantee also the reliability of the heater and to prevent the overflow in case a fault of the control unit or its microprocessor occurs.

[0017] The invention will be described below, with reference to the attached drawing, in which:

- figure 1 shows schematically a block diagram of a portion of the control circuit of a washing machine using a CWL sensor, in which the CWL sensor has one analogue output;
- figure 2 shows a block diagram according to a second embodiment of the invention, in which the CWL sensor has a PWM or square-wave output and an analogue output;
- figure 3 shows a block diagram according to a third embodiment of the invention, in which the CWL sensor has only a square-wave PWM output;
- figure 4 shows a block diagram according to a fourth embodiment of the invention, in which the CWL sensor has a square-wave frequency output
- figure 5 shows an electronic circuit according to the invention and used to operate the drivers for the electrical heater and for the discharge pump; and
- figure 6 shows the output characteristic of a typical CWL sensor, which is able to provide an analogue voltage output proportional to the applied pressure.

[0018] According to the present invention, a CWL sensor 10 is normally operated with pipeline connection that it is connected with air trap device (not shown) that it is connected with the tub (not shown). The CWL sensor 10 can be assembled in order to be in direct contact with the media (water) without any pipeline. CWL sensor can be also assembled directly on the printed circuit board (PCB) to reduce the harness cost, and it can be of a very simple type (basic pressure transducer) where an addition amplifier is required to be operated by the microprocessor and comparators.

[0019] According to the invention, the simple and low cost electronic circuit connected to the CWL sensor 10 and to the microprocessor 12 is able to operate directly the drivers of the heater and of the discharge pump even if a microprocessor fault occurs.

[0020] With reference to figure 1, the control circuit comprises two comparators, respectively 14 and 16, with fixed thresholds acting independently and in parallel with the microprocessor 12. The voltage output 10a of the CWL sensor 10 connected with the microprocessor 12 is connected in parallel with the two comparators 14 and 16. The comparator outputs 14a and 16a are able to operate independently or in parallel with the microprocessor 12. Therefore, in case of failure of the microprocessor 12, the comparators 14 and 16 can drive the heater and/or the discharge pump independently from the microprocessor. The first comparator 14 compares the output value 10a of the CWL sensor 10 with a fixed threshold 14b related to a minimum water level for a safe function of the heater.

[0021] The second comparator 16 compares the output value 10a of the CWL sensor 10 with a fixed threshold 16b related to a maximum water level above which the discharge pump is switched on. The fixed thresholds (voltage references) are characteristics of each washing machine.

[0022] Figure 2, in which for the same or similar components the same reference numerals are used, shows the control circuit where the continuous water level sensor 10 has two outputs. In addition to the analogue output 10a, a square-wave output 10b is directly connected to the microprocessor 12 by pulsed width modulation PWM digital output signal (typically a timer event counter). The second output 10a is, as in the embodiment of figure 1, an analog output (voltage) connected to the comparators 14 and 16.

[0023] Figure 3 shows a block diagram similar to figure 1 where the continuous control of the water level through the CWL sensor is performed with a single output. A square-wave PWM output 10b of the sensor 10 is directly connected to the microprocessor 12 by PWM digital output and this signal is integrated by means of a resistor and a capacitor 22 which together perform the function of an integrator 24 in order to obtain analog signal 26 (voltage) to be connected with the comparators 14 and 16. This solution is normally used with PWM signals or could be used with high frequency signals.

[0024] Figure 4 shows a block diagram similar to figure 3 where the continuous control of the water level through the CWL sensor is performed with a single output. A square-wave frequency output 10b is directly connected to the microprocessor digital input and this signal is also connected with a device 28 usually called frequency to voltage converter (for example a component known with the name LM2907 manufactured by National Semiconductor). This electronic component 28 is able to provide a voltage signal proportional to the input frequency. This voltage output signal is connected with the comparators 14 and 16.

[0025] Figure 5 shows an example of the electronic circuit used to operate the driver for the heater and for the pump. It is based on dual voltage comparators using the LM393 component that it is an 8-pin integrated circuit and it is a very popular component with inside two open collector comparators that is sensible to the applied input voltage.

[0026] The first comparator (component LM 393 U1A in figure5) is used for checking the "Level 0". A fixed voltage is established by a voltage divider connected to the inverter (-) inputs. When the voltage coming from the continuos water level (CWL) sensor, that it is connected with the non inverting comparator (+) input, is under the fixed voltage value applied on the inverter input, the output of the comparator is low, and this means that the output voltage is equivalent to the GND.

[0027] In the case the voltage coming from the continuous water level (CWL) sensor increases its value and this voltage value is above the fixed reference voltage, an output comparator commutation is expected. In fact the output switches to high, and this means that the output voltage is equivalent to the VCC voltage. This information is able to operate directly the heater relay (heater is switched off) independently from the decision taken by the microprocessor.

[0028] The second comparator (LM 393 U1B in figure 5) is used for checking the condition of "Overflow". The above behavior of the component LM 393 U1A is substantially identical for the LM 393 U1B component that is used to operate the discharge pump driver. The only difference is the required different reference fixed voltage value, obtained by the voltage divider, connected to the inverter (-) inputs of the comparator. This reference voltage value has to be higher than the previous reference voltage value applied to the inverter input of the LM 393 U1A comparator.

[0029] Even if in the present description reference is made to certain specific water level values, on the same basic principle other defined water levels could be defined and used different from a water level linked to a safe function of the heater and to a water overflow prevention.

Claims

1. Washing machine having a continuous water level (CWL) sensor connected to a control unit including a microprocessor or the like, **characterized in that** the control unit comprises comparator means suitable for comparing the value from the CWL sensor with a predetermined threshold value, such comparator means acting independently and/or in parallel with the microprocessor.

2. Washing machine according to claim 1, comprising a water heater, **characterized in that** said comparator means comprises a comparator suitable for comparing the value of the CWL sensor with a threshold value indicative of a condition in which the water heater is submerged and for driving the water heater only if the value from the CWL sensor is higher than the threshold value.

3. Washing machine according to claim 1, comprising a discharge pump, **characterized in that** said comparator means comprises a comparator suitable for comparing the value of the CWL sensor with a threshold value indicative of a water overflow and for driving the discharge pump if the value from the CWL sensor is higher than the threshold value.

4. Washing machine according to claims 2 and 3, **characterized in that** said comparator means comprises a first comparator suitable for comparing the value of the CWL sensor with a first threshold value indicative of a condition in which the water heater is submerged and for driving the water heater only if the value from the CWL sensor is higher than the first threshold value, and a second comparator suitable for comparing the value of the CWL sensor with a second threshold value indicative of a water overflow and for driving the discharge pump if the value from the CWL sensor is higher than the second threshold value.

5. Washing machine according to claim 4, **characterized in that** the CWL sensor has an analogue output.

6. Washing machine according to claim 5, **characterized in that** the analogue output is connected to the microprocessor through three parallel connections, the first one being a direct connection, the other two including the interposition of the first and of the second comparator.

7. Washing machine according to claim 4, **characterized in that** the CWL sensor has a PWM or square-wave output.

8. Washing machine according to claim 7, **characterized in that** the PWM or square-wave output is connected to the microprocessor through three parallel connections, the first one being a direct connection, the other two including the interposition of the first and of the second comparator and of a integrator device between the CWL sensor and the two comparators.

9. Washing machine according to claim 4, **characterized in that** the CWL sensor has two output, a first one being a PWM or square-wave output connected directly to the microprocessor, a second one being an analogue output connected indirectly to the microprocessor with the interposition of the comparators.

10. Washing machine according to claim 4, **characterized in that** the CWL sensor has a square-wave frequency output.

11. Washing machine according to claim 10, **characterized in that** the square-wave frequency output is connected to the microprocessor through three parallel connections, the first one being a direct connection, the other two including the interposition of the first and of the second comparator and of a frequency to voltage converter between the CWL sensor and the two comparators.

12. Washing machine according to any of the preceding claims, **characterized in that** the CWL sensor is a device able to convert the water level into an electrical signal.

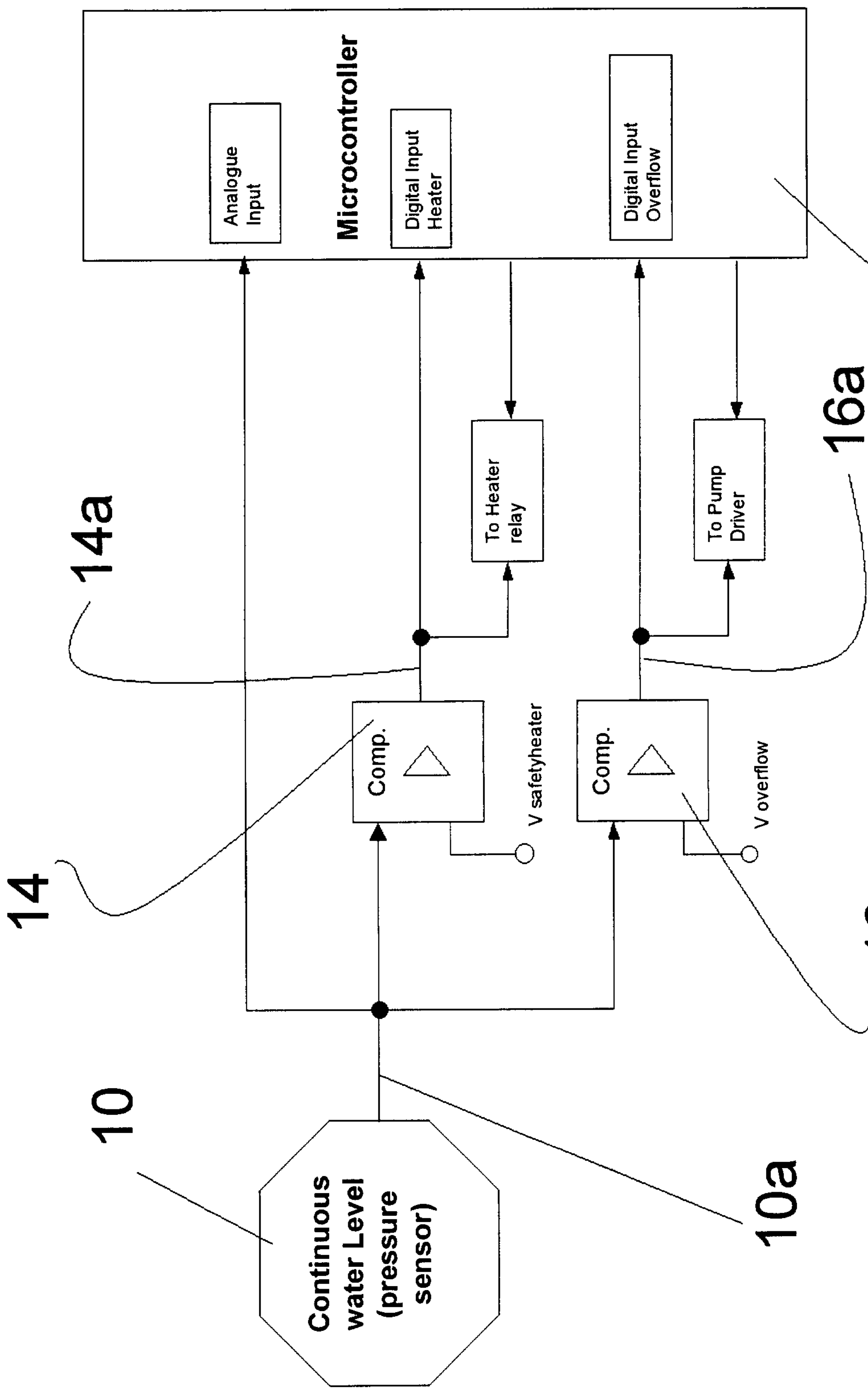

Microcontroller
Analogue Input
Digital Input Heater
Digital Input Overflow
12
To Heater relay
To Pump Driver
14a
16a
Comp.
Comp.
V safetyheater
V overflow
14
16
10
10a
Continuous water Level (pressure sensor)

Figure 1

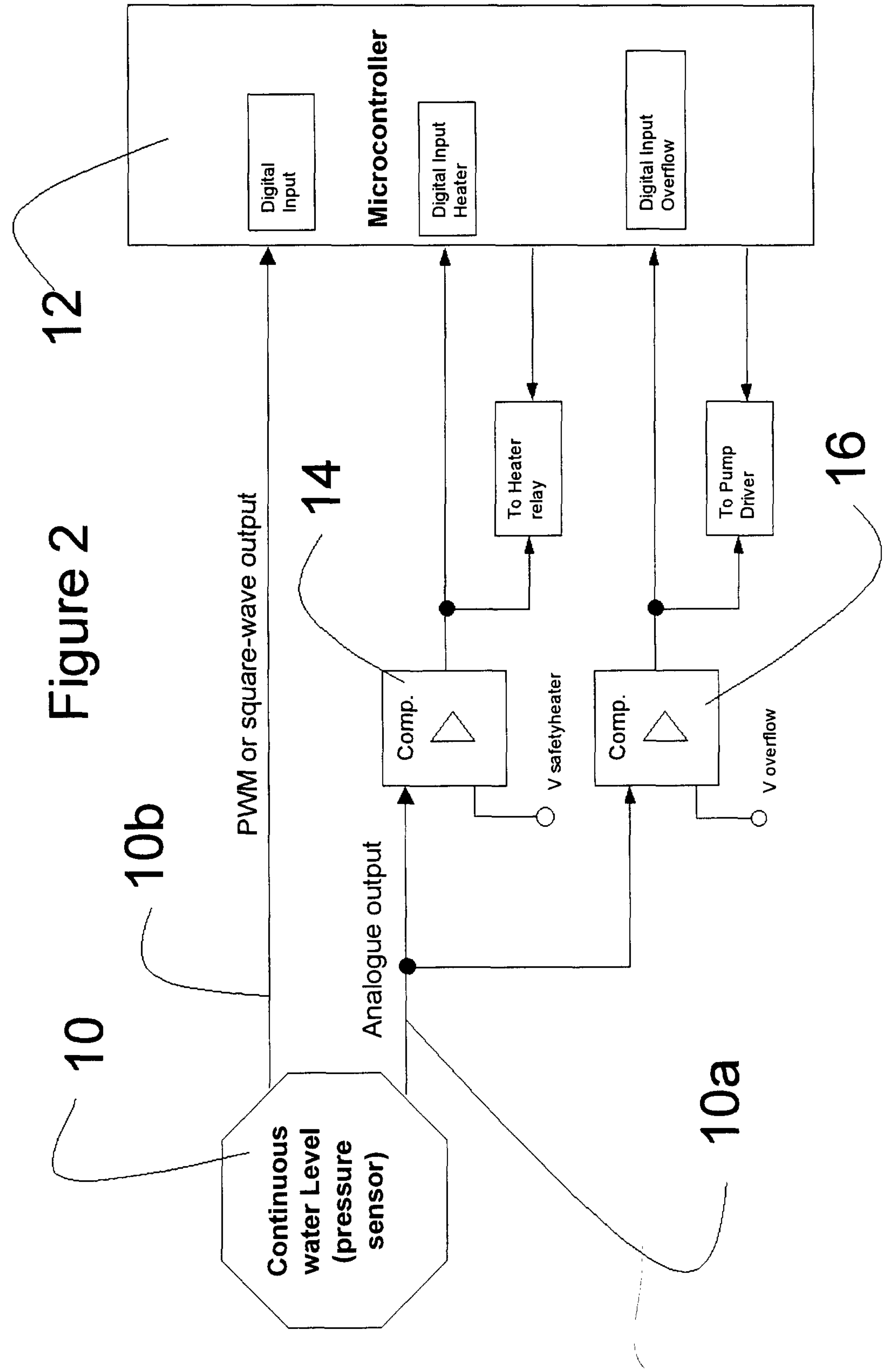

12
Microcontroller
Digital Input
Digital Input Heater
Digital Input Overflow
PWM or square-wave output
14
To Heater relay
To Pump Driver
16
Comp.
V safetyheater
Comp.
V overflow
10b
Analogue output
10
Continuous water Level (pressure sensor)
10a

Figure 2

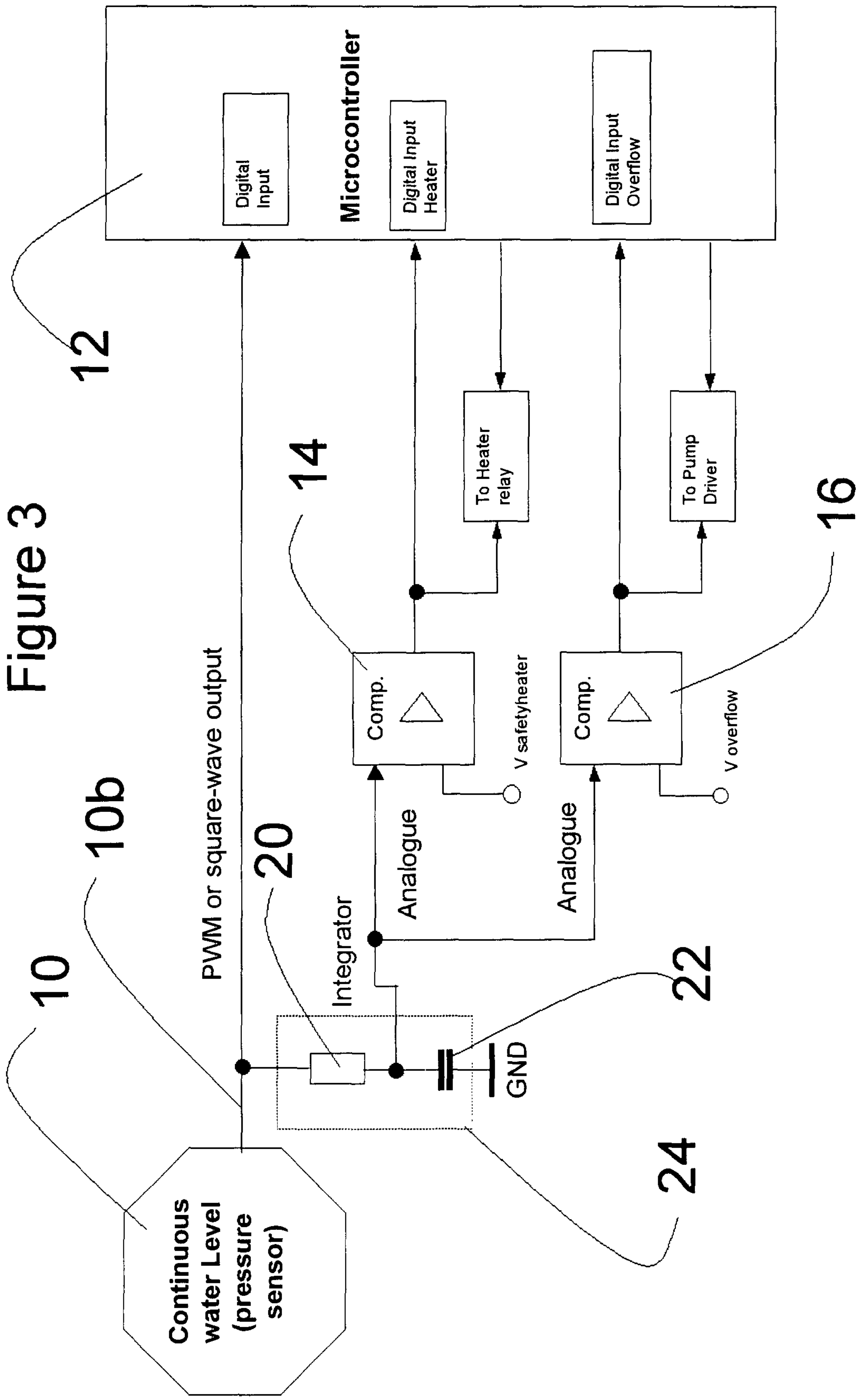

Microcontroller
Digital Input
Digital Input Heater
Digital Input Overflow
12
14
16
To Heater relay
To Pump Driver
Comp.
Comp.
V safetyheater
V overflow
Analogue
Analogue
PWM or square-wave output
Integrator
10
10b
20
22
24
GND
Continuous water Level (pressure sensor)

Figure 3

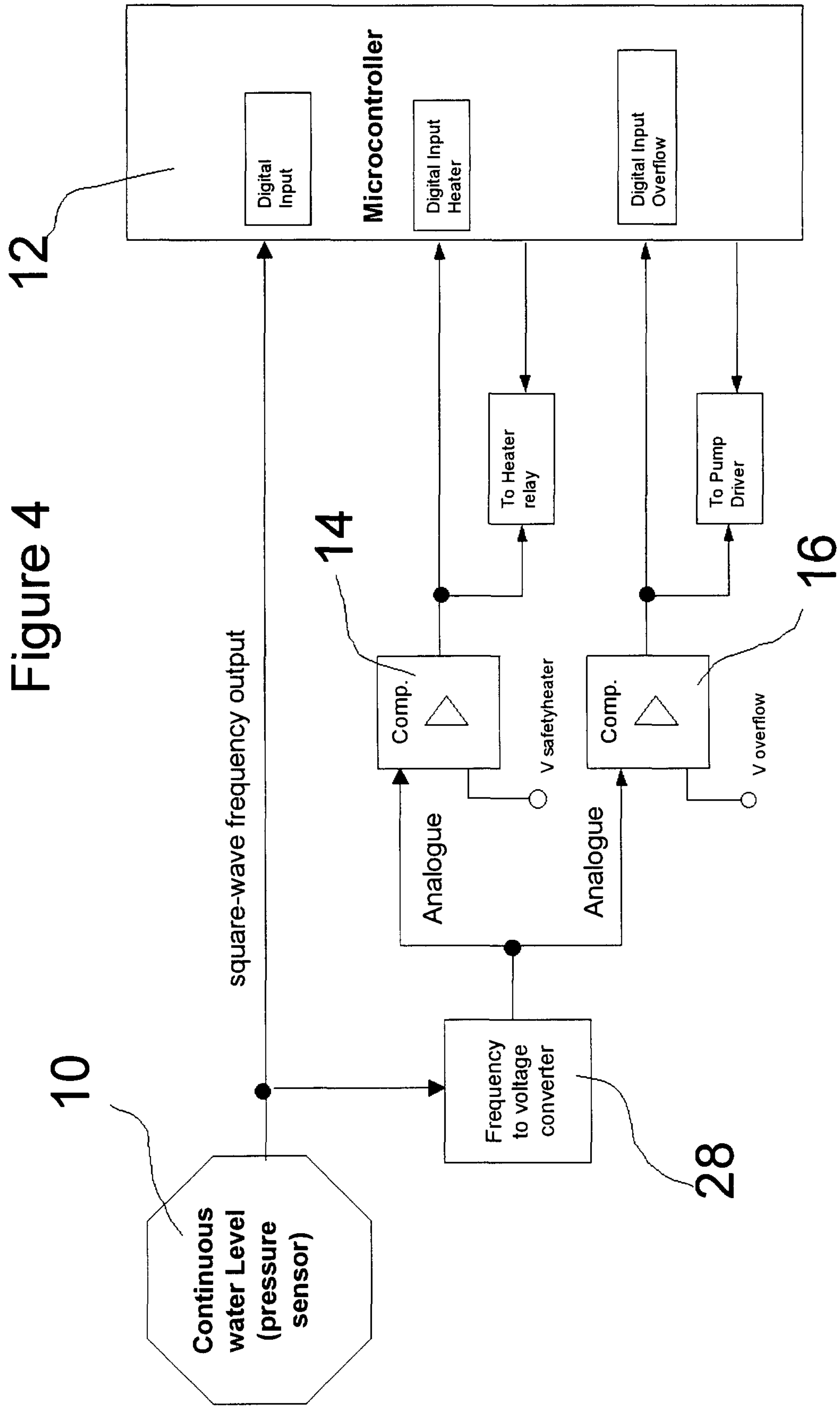

12
Microcontroller
Digital Input
Digital Input Heater
Digital Input Overflow
To Heater relay
To Pump Driver
14
16
Comp.
Comp.
V safetyheater
V overflow
square-wave frequency output
Analogue
Analogue
10
Continuous water Level (pressure sensor)
Frequency to voltage converter
28

Figure 4

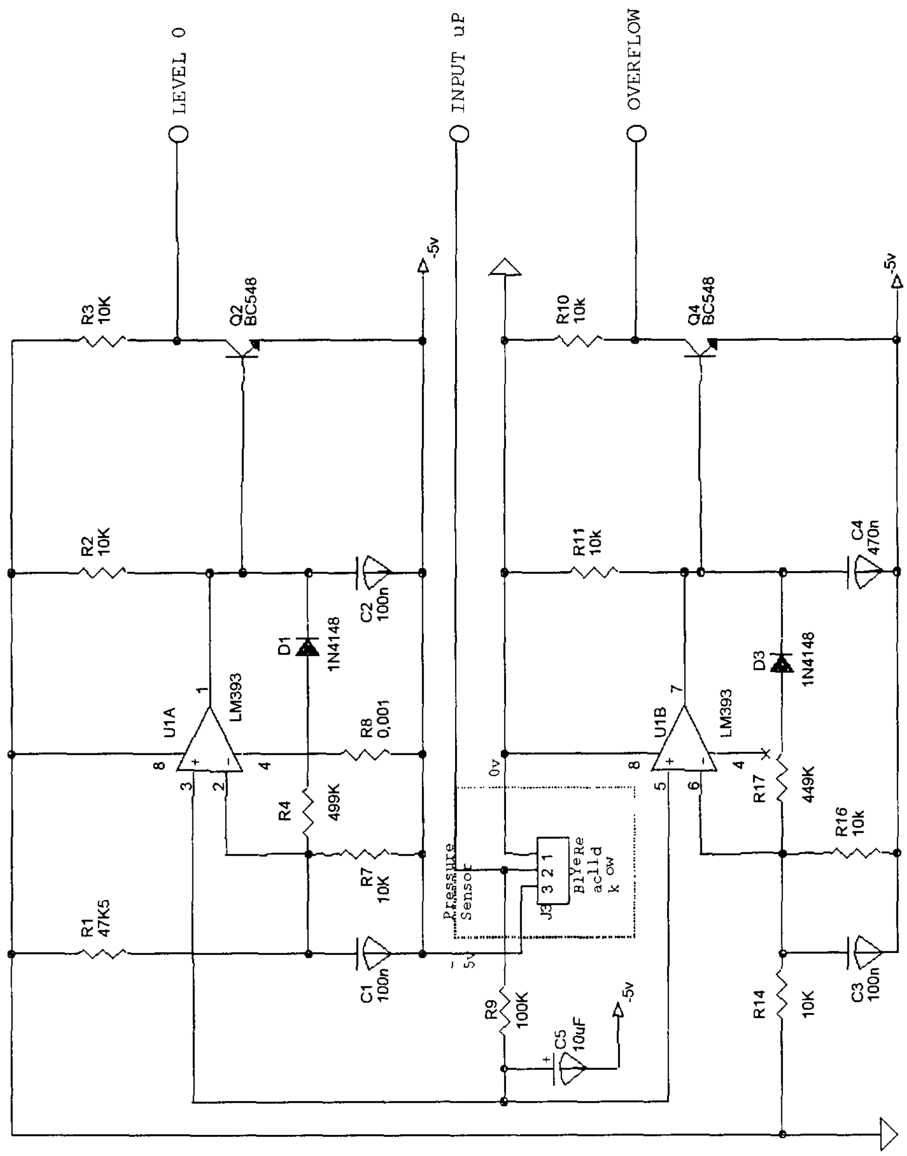
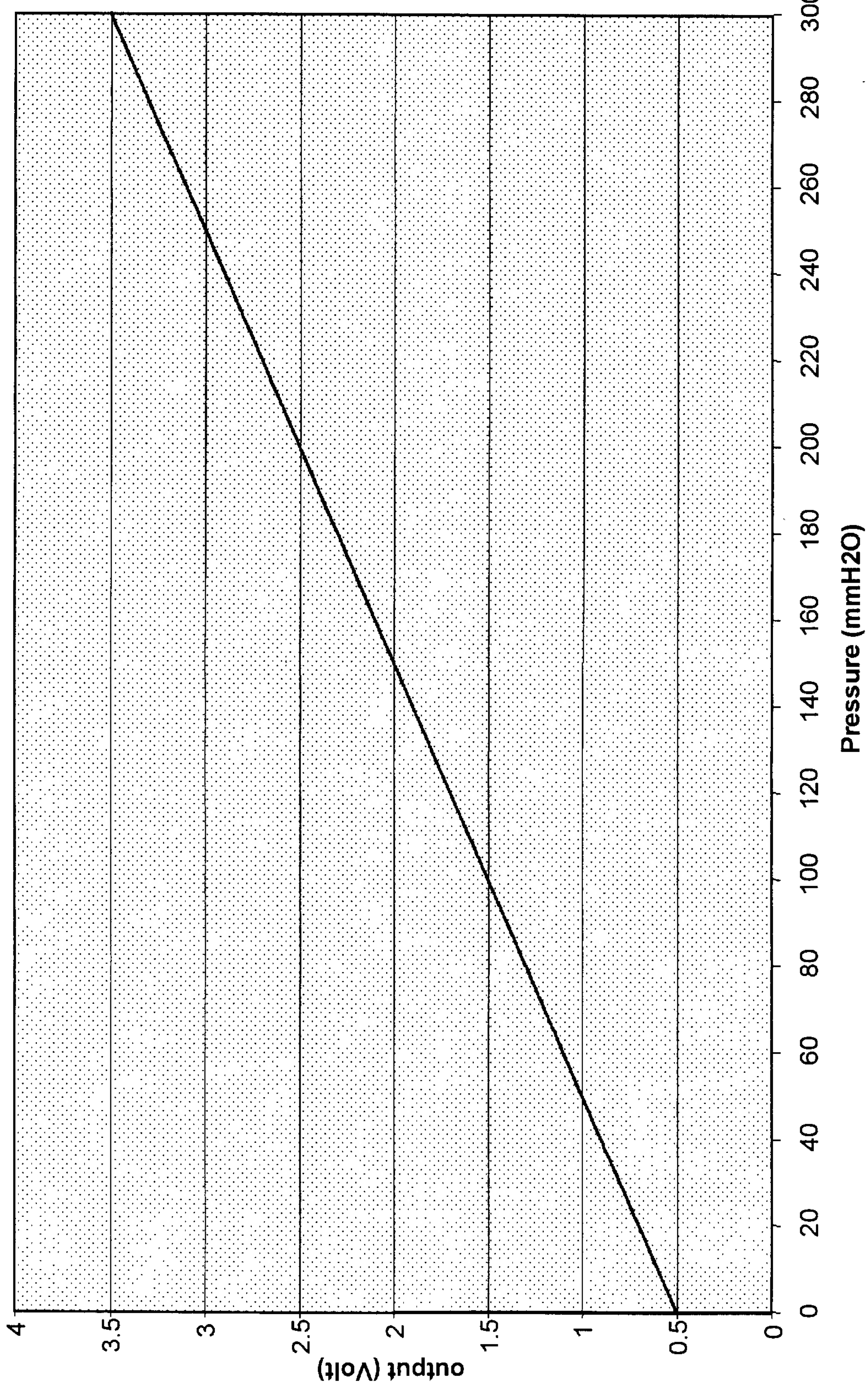

LEVEL 0
INPUT uP
OVERFLOW
R3
10K
Q2
BC548
-5v
R10
10K
Q4
BC548
R2
10K
C2
100n
D1
1N4148
U1A
LM393
R8
0,001
R4
499K
R7
10K
R1
47K5
C1
100n
R9
100K
C5
10uF
R11
10k
C4
470n
D3
1N4148
U1B
LM393
R17
449K
R16
10k
R14
10K
C3
100n
Pressure
Sensor
J3
0v

Figure 5

Figure 6


output (Volt)
0
0.5
1
1.5
2
2.5
3
3.5
4
Pressure (mmH2O)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 12 6605

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	GB 2 070 648 A (MIELE & CIE GMBH) 9 September 1981 (1981-09-09) * abstract paragraph *	1,12	D06F39/08 A47L15/42
A	DE 15 85 767 A (KIENINGER & OBERGFELL) 29 July 1971 (1971-07-29) * claim 1; figure *	2	
A	DE 40 29 544 A (BOSCH-SIEMENS HAUSGERÄTE GMBH) 19 March 1992 (1992-03-19) * abstract; figures *	3	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

D06F
A47L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 June 2001	Courrier, G

CATEGORY OF CITED DOCUMENTS

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