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(54) Liquid level sensor

(57) A sensor (1) for detecting the level of ink (10) in a chamber (9) in an ink jet printer, the sensor comprising: a polyimide sheet (2); a flexi-circuit formed on a first side of the polyimide sheet; a thermistor (3) mounted on the first side of the polyimide sheet in contact with the flexi-circuit, the other side of the sheet being arranged to form, in use, part of a wall of the chamber; wherein the amount of heat dissipated through the polyimide sheet and detected by the thermistor indicates the presence of absence of liquid adjacent to the sensor and hence provides level detection.

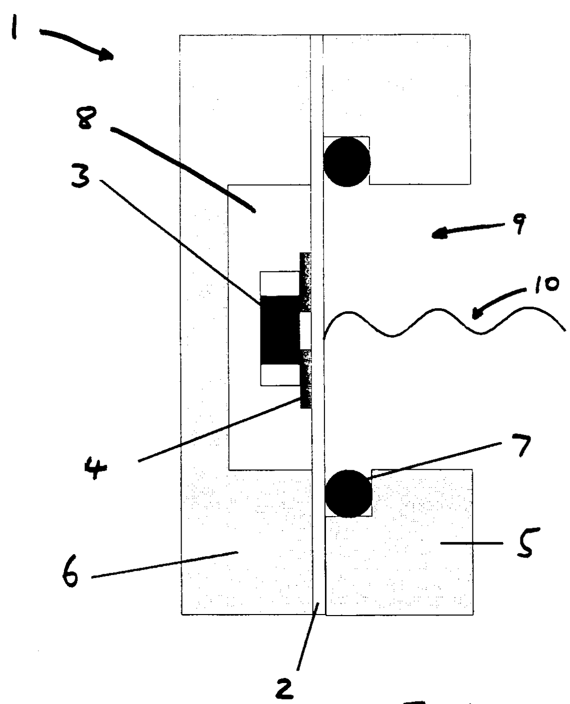

Fig 1

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Description

[0001] This invention relates to a liquid level sensor and, in particular, to a sensor for detecting the level of ink in a chamber in an ink jet printer.

[0002] It is known to be difficult to detect the level of a liquid in a very small chamber, for example one that is only 15 to 20 mm high.

[0003] For example, float sensors are unsuitable as there is insufficient depth for a float, especially when considering that the average density of the ink is 0.7 times that of water. Further, it is very difficult to detect accurately the very small vertical movements of the float.

[0004] Direct electrical measurements of the ink and/or air are unsuitable as the precise composition of the ink may be unknown or may vary. Accordingly, the conductivity of the ink is unknown and it is likely that different inks would have different conductivities. Therefore it is impossible to carry out accurate calculations. Further, the ink may be electrolised and therefore generate sediments which could block the ink jet nozzles. The quality of the ink is also reduced.

[0005] Capacitance measurements are temperature dependent and so very strict ambient conditions are required to obtain accurate readings. Further, when using such a small chamber, stray capacitance in the sensor wire may be larger than the capacitance which is being measured. Accordingly, the accuracy of such a detection system is compromised. The surface tension and capillary effects in a plate capacitive type sensor will also affect the accuracy of any measurements.

[0006] It is not practical to use optical methods for detecting the presence of the ink as the ink is formulated for maximum opacity and a very high surface affinity. Accordingly, a useful and accurate optical sensor would rely on hydrophobic surface treatments which can repel the ink even when the sensor has been immersed for a long period of time.

[0007] It could be possible to use heated thermistors to detect the ink level and the thermistors measure the change in heat dissipation of the thermistor between when they are immersed in ink and when they are suspended in air. Thermistors which have a good chemical compatibility and which can therefore safely be used are generally glass encapsulated. However, the disadvantage with this type of thermistor is that they exhibit a wide variation in initial resistance, temperature response and dissipation constant. Accordingly, to ensure a good level detection, the thermistor has to be driven hard and this results in a high surface temperature when the thermistor is suspended in air. However, the surface temperature is such that the ink quality can be adversely affected.

[0008] It is also known to use positive temperature coefficient thermistors, such as those having a "switch point" at a given temperature. These thermistors also have a high surface temperature which can adversely affect the ink quality.

[0009] In order to obtain a sufficient precision of the sensor, high accuracy thermistors can be used and these thermistors are typically epoxy coated beads with bare lead wires. This type of thermistor has problems of material compatibility and electrolysis of the ink. As with the thermistors described above, it is possible to enclose the device but this slows the response and unpredictably affects the heat dissipation the surroundings.

[0010] Thus, an object of the present invention is to provide a sensor which requires little or no calibration or set up procedure and which uses standard components to accurately and reliable denote the level of ink in a chamber in an ink jet printer.

[0011] According to the present invention, there is provided a sensor for detecting the level of ink in a chamber in an ink jet printer, the sensor comprising:

a polyimide sheet;
a flexi-circuit formed on a first side of the polyimide sheet;
a thermistor mounted on the first side of the polyimide sheet in contact with the flexi-circuit, the other side of the sheet being arranged to form, in use, part of a wall of the chamber;
wherein the amount of heat dissipated through the polyimide sheet and detected by the thermistor indicates the presence of absence of liquid adjacent to the sensor and hence provides level detection.

[0012] The thermistor may be a self heating thermistor such that sufficient bias current is supplied to the device so that it heats itself. The voltage across the device is then compared with the known voltage across the device when it is in air in order to determine whether the sensor is adjacent to the ink.

[0013] A second sensor may be used to monitor the ambient conditions in order to prevent thermal runaway and to control the heating power to the thermistor.

[0014] Extra copper may be used around one or both of the SMT (Surface Mount Technology) pads to increase heat dissipation and to help define a switching point as the level of the ink in the chamber varies. SMT pads are the small exposed copper areas of the flexi-circuit where solder is applied to form the connection between the device and the circuit.

[0015] The sensor may be held in contact with the ink by a clamp plate and may be sealed with an O-ring to ensure that none of the glues used in the lamination of the flexi-circuits is immersed in the ink.

[0016] There may be an air space above the sensor to prevent air currents disrupting the measurement.

[0017] A resistor may be provided to heat the thermistor so that the thermistor is used only for temperature measurement. The heat dissipation may therefore be defined by the copper connection between the devices and by the thickness of the polyimide film. These factors can be precisely and easily controlled.

[0018] Further, a closed loop control circuit may be used to drive the thermistor. Such a circuit can drive sufficient power into the resistor so that a given temperature rise, such as 10°C, above the ambient temperature is achieved. If the sensor is in air, this temperature rise should be achieved quickly, at which point the power will be reduced and stop heating the ink and surroundings unnecessarily. Alternatively, if the heat sensor is in ink, the drive circuit will fail to heat the thermistor sufficiently and will saturate at a defined power input level. In this case, the saturation point will indicate whether the sensor is in ink or in air.

[0019] The advantages of such an arrangement are that there will be a limited temperature rise which protects the ink from degradation and faster response time and increased noise margin at the detection point. Accordingly, a more accurate detection means is achieved.

[0020] Examples of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic cross sectional side view of an embodiment of the present invention.
Figure 2 is a schematic view of the thermistor mounting of Figure 1; and
Figure 3 is an alternative arrangement to that shown in Figure 2.

[0021] As shown in Figure 1, a sensor 1 is provided with a polyimide sheet 2 (preferably Kapton®) on one side of which is mounted a thermistor 3. The polyimide sheet is approximately 50 microns thick. The thermistor 3 is mounted on copper tracks 4 which form a flexi-circuit. In use, the sheet 2 is positioned so as to form part of a wall of an ink housing 5 and is held in place by a clamp plate 6. An O-ring 7 is provided to ensure a fluid tight seal between the ink housing and the polyimide sheet. An air space 8 surrounds the thermistor 3 to prevent air currents from disrupting the measurements. The polyimide sheet and the ink housing 5 form a chamber 9 in which ink can be stored. The level 10 of the ink is obviously variable, dependent upon the volume stored. The ink level can be detected by the sensor 1.

[0022] In Figure 2, the thermistor 3 can be seen mounted on the copper track 4 of the flexi-circuit. Electrical leads 11 are provided to power the thermistor. A nominal sensing level 12 is indicated at the same height as the copper track 4. This level could be different, depending upon the arrangement of the components.

[0023] In the alternative embodiment shown in Figure 3, an additional heating resistor 13 is located above the thermistor 3. Additional electrical leads 14 power the resistor 13.

[0024] The drive circuit 15, shown in Fig. 4, is a simple bridge 16 where the resistance (i.e. temperature) of a self heating thermistor 3 is compared against the resistance (temperature) of another device 17 which has such a high resistance that its self heating effect is very low. The bridge is unbalanced and biased so that the self heating thermistor 3 maintains a constantly lower resistance, and hence higher temperature, than the ambient measuring, non heating device 17. In this way, the maximum temperature rise of the sensor device can be controlled, irrespective of the heat dissipation to the surrounding environment. This prevents overheating and degradation of the ink.

[0025] Given that the maximum temperature excursion of the thermistor 3 is now limited, ink level changes are detected by measuring the "effort" (drive voltage to the bridge from the op-amp 18) required to achieve the temperature rise. A high drive voltage indicates more energy dissipated from the thermistor, implying the device must be cooled by the ink in the chamber.

Claims

1. A sensor for detecting the level of ink in a chamber in an ink jet printer, the sensor comprising:

   a polyimide sheet;
   a flexi-circuit formed on a first side of the polyimide sheet;
   a thermistor mounted on the first side of the polyimide sheet in contact with the flexi-circuit, the other side of the sheet being arranged to form, in use, part of a wall of the chamber;
   wherein the amount of heat dissipated through the polyimide sheet and detected by the thermistor indicates the presence of absence of liquid adjacent to the sensor and hence provides level detection.

2. A sensor according to claim 1, wherein the thermistor is a self heating thermistor such that sufficient bias current is supplied to the device so that it heats itself.

3. A sensor according to either claim 1 or claim 2, wherein a second sensor is provided to monitor the ambient conditions.

4. A sensor according to any one of the preceding claims, wherein extra copper is provided around one or both of the SMT (Surface Mount Technology) pads to increase heat dissipation and to define a switching point as the level of the ink in the chamber varies.

5. A sensor according to any one of the preceding claims, wherein the sensor is held in contact with the ink by a clamp plate and is sealed with an O-ring to ensure that none of the glues used in the lamination of the flexi-circuits is immersed in the ink.

6. A sensor according to any one of the preceding

claims, further comprising an air space above the sensor to prevent air currents disrupting the measurement.

7. A sensor according to any of one of the preceding claims, wherein a resistor is provided to heat the thermistor so that the thermistor is used only for temperature measurement.

8. A sensor according to any one of the preceding claims, further comprising a closed loop control circuit for driving the thermistor.

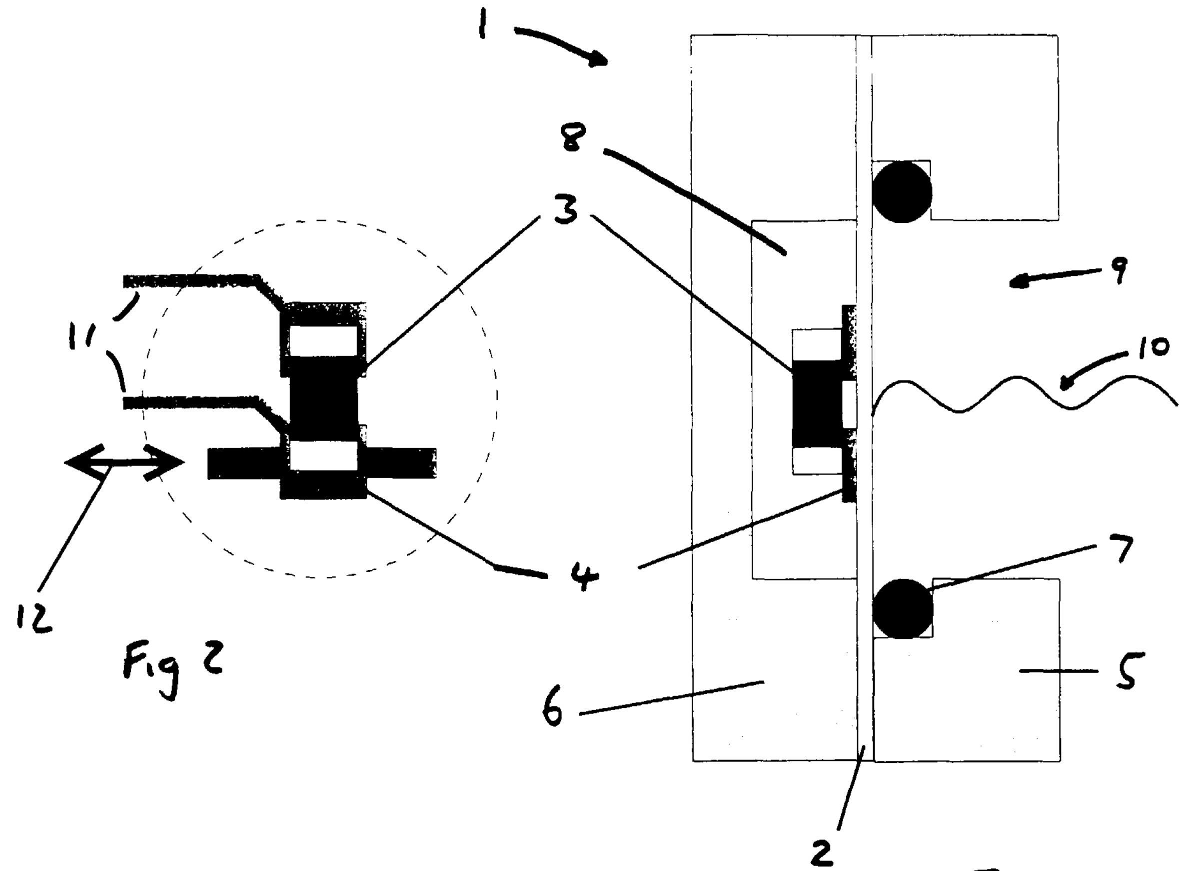

Fig 2

Fig 1

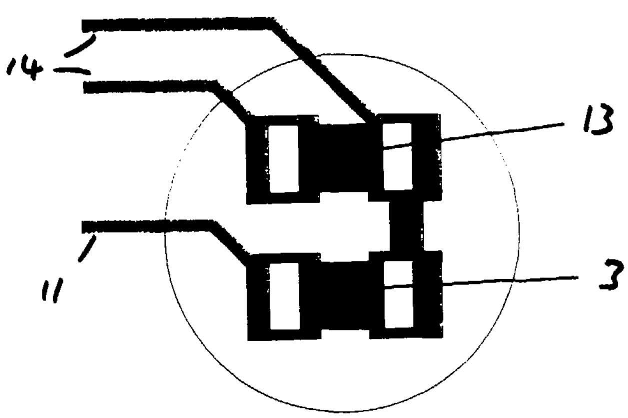

Fig 3

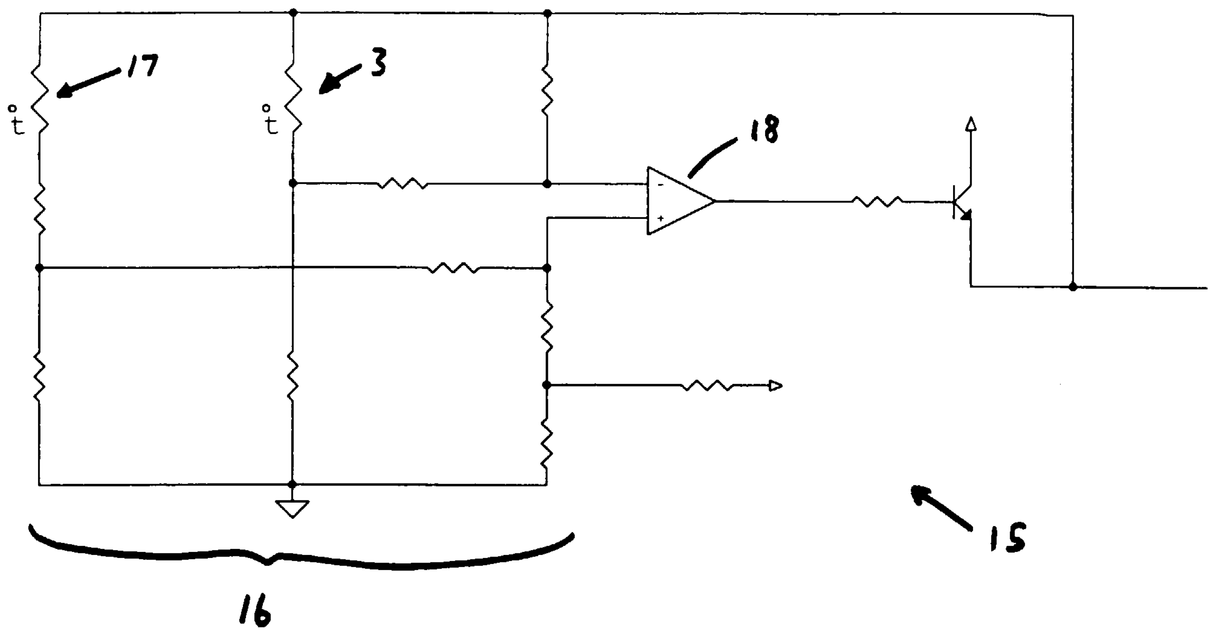

Fig 4

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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 6161

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 January 2000	Adam, E

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Application Number
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