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(54) **Dry-cleaning washing machine with infrared gas detector**

(57) Household dry-cleaning washing machine comprising a tub (10) wherein a perforated drum (12) to store clothes is rotating and a closed circuit (14) to let a solvent like decamethylcyclopentasiloxane (D5) circulating in an air stream across the drum. The circuit comprises a condenser (16), a heater (18) and a fan (20). At least a gas sensor (22) is provided to detect the solvent concentra-

tion in air, as well as to deliver a relevant data to an electronic device (38) to control the machine.

The gas sensor (22) is an infrared device (IR) which is positioned outside the closed air circuit (14) and is connected therewith, in such a way that the gas solvent may be made to circulate along an optical path (28) wherein the solvent flows by absorbing IR energy.

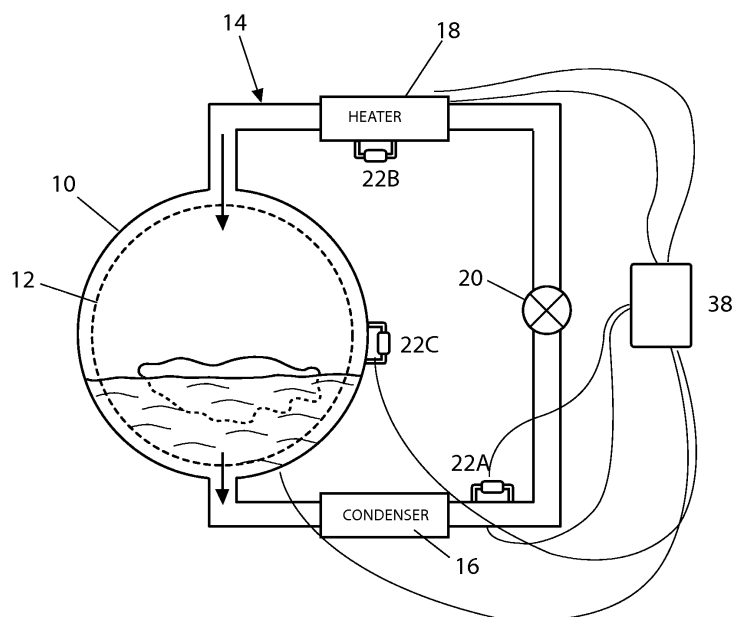


FIG. 1

Description

[0001] The present invention relates to a dry-cleaning washing machine, i.e. a washing machine wherein a non-aqueous, lipophilic fluid as the solvent or solution for cleaning is used.

[0002] Decamethylcyclopentasiloxane (D5) is a washing fluid already used in the field of the industrial and commercial laundry, where the safety control by expert personnel is easier and normally made. Its introduction in household machines is just about to be implemented, as the use of said fluid is more dangerous in a domestic environment.

[0003] D5 is a lipophilic liquid having a non-negligible vapour pressure. Knowing the concentration in air of D5 is of the essence for many reasons. Firstly, to appropriately design the washing/drying circuit and to adopt programs for unforeseeable events. Moreover, to guarantee that flammable/explosion limits are not reached and exposure limits are not exceeded. Many different systems can be foreseen for measuring D5 in air; in principle anything that is giving a physical/chemical and measurable change can be used for that purpose.

[0004] Unfortunately, D5 is not well known and just few solutions have been partly investigated.

[0005] WO 01/94686 discloses a system for controlling a drying cycle in a drying apparatus by using a gas sensor capable of sensing the concentration of lipophilic fluid vapour in the drying apparatus drum. Various categories of sensors are reported as non-limiting examples, like reactive sensors, physical property sensors, absorption sensors, as well as a combination of sensors. However, no teaching is given concerning a definite, practical application of the sensor in a washing machine, particularly a household washing machine. Indeed, the application of said sensors involves fouling problems, particularly for siloxanes that have a particular tendency to leave a sticky or greasy residue on surfaces.

[0006] JP 5277287 discloses a dryer which uses a hydrocarbon solvent. The solvent flows in a closed circuit which essentially comprises the drum containing the clothes, a condenser, a heater and a fan. A gas concentration detector is positioned at the inlet of the condenser and controls an intake valve and an exhaust valve of the circuit in order to eliminate the danger of an ignited explosion of the vaporized solvent. Said solution suffers of the same fouling problems already mentioned, because the detector is directly positioned inside the solvent circuit.

[0007] Scope of the present invention is not only to implement a security system for a household dry-cleaning washing machine based on the control of the gas solvent concentration, but also to keep the user timely informed about the program development.

[0008] Another scope of the invention is to propose an improved embodiment of a household dry-cleaning washing machine wherein the fouling problem of the gas concentration sensor is substantially solved.

[0009] These and other objects of the invention are reached in a household dry-cleaning washing machine according to the claims of this patent.

[0010] Features and advantages of the invention will be better understood from the following description, given as a non-limitative example, with reference to the enclosed drawings, in which:

- Figure 1 shows schematically a dry-cleaning washing machine according to the present invention;
- Figure 2 shows schematically a sensor device to be applied to a dry-cleaning washing machine like that in Figure 1;
- Figure 3 shows an alternative solution with respect to that represented in Figure 1.

[0011] A dry-cleaning washing machine is substantially provided with a tub 10, in which a perforated drum 12 is assembled to rotate and to contain the clothes, and with a closed circuit 14, in which the tub 10 is included and a solvent like decamethylcyclopentasiloxane (D5) is made to circulate in an air stream. See, Figure 1.

[0012] The circuit 14 comprises a condenser 16, a heater 18 and a fan 20. At least a gas sensor 22 is also associated to the circuit 14 in order to detect the gas concentration therein, and to allow the control of the drying degree as well as of the safety operative conditions.

[0013] According to the present invention, said gas sensor 22 is an IR gas detector, which is positioned outside the circuit 14 to avoid fouling problems. For light in the infrared (IR) region, it is known that D5 has a simple and strong absorption spectrum, in which the height of the peaks are directly related to D5 concentration. As a consequence, once known a standard calibration curve, the actual concentration can be easily assessed.

[0014] The gas sensor 22 is connected with the circuit 14 through an inlet 24 and an outlet 26, in such a way that the gas solvent may be extracted from the circuit and made to circulate along an optical path 28, after that the gas solvent is newly introduced into the circuit 14. An IR source 30 and an IR detector 32 are positioned at opposed ends of the optical path 28. The IR source emits energy in the range of D5 absorption bands, and this energy is absorbed by D5 along the optical path and revealed by the IR detector. See, Figure 2.

[0015] A pumping device 34 may be provided for maintaining the desired gas flow inside the gas sensor 22; however, said pumping device can be omitted in the case the detector is operating at a fixed position, until the gas can freely move inside the optical path.

[0016] Advantageously, the gas sensor 22 is enclosed in a thermostatic system 36 for keeping the optical path 28 and the pumping device 34 at a given temperature.

[0017] Another feature of the invention is represented by the use of a plurality of gas sensors 22, in order to ensure not only the control of the drying degree during the whole development of the operative cycle but also the best safety conditions for the user. In this connection,

a first gas sensor 22A is positioned near the condenser 16 to verify its regular functioning, and a second gas sensor 22B is associated to the heater 18 which is the point of the circuit having the highest temperature. A third gas sensor 22C is positioned near the charging opening of the tub 10 where a possible danger situation may occur for the user.

[0018] All the gas sensors 22 are connected with an electronic control device 38 of any known type, which processes the data coming from the sensors and issues the necessary inputs to drive the dry-cleaning washing machine. Preferably, the gas sensors 22 are selectively fed and their signals are continuously processed.

[0019] Alternatively, only one IR sensor 22 may be used (Fig. 3) with only one gas pumping device 34. In this case, the gas sensor is connected through a multi-way valve 40 with the ducts 24 to draw the gas from the circuit 14 at the selected points of the same. The multi-way valve 40 is selectively operated by the control device of the machine in a known way. Only one return duct 26 connects the IR gas sensor 22 to the circuit 14 to reintroduce the gas into the same.

[0020] The advantages of the present invention may be summarized as follows. A real-time measurement of D5 concentration in the gas phase is obtained. A direct measurement of concentration is made, instead of a derived measurement as using other sampling techniques. A miniaturization of sensors is possible, so as a real kind of sensor may be applied to the machine.

Claims

1. Household dry-cleaning washing machine comprising a tub (10) wherein a perforated drum (12) to store clothes is rotating and a closed circuit (14) to let a solvent like decamethylcyclopentasiloxane (D5) circulating in an air stream across the drum; the circuit comprises a condenser (16), a heater (18) and a fan (20); at least a gas sensor (22) is provided to detect the solvent concentration in air, as well as to deliver a relevant data to an electronic device (38) to control the machine, **characterized in that** said at least a gas sensor (22) is an infrared device (IR) which is positioned outside the closed air circuit (14) and is connected therewith, in such a way that the gas solvent may be made to circulate along an optical path (28) wherein the solvent flows by absorbing IR energy.
2. Household dry-cleaning washing machine according to claim 1, **characterized in that** the IR device is connected with the circuit (14) by means of at least an inlet duct (24) and an outlet duct (26).
3. Household dry-cleaning washing machine according to claim 1, **characterized in that** the IR device comprises an IR source (30) and an IR detector (32)

which are positioned at opposed ends of the optical path (28), the IR source emits energy in the range of D5 absorption bands, and this energy is absorbed by D5 along the optical path and revealed by the IR detector.

4. Household dry-cleaning washing machine according to claim 1, **characterized in that** the optical path (28) is contained in a thermostatic system to keep the same at a given temperature.
5. Household dry-cleaning washing machine according to claim 1, **characterized in that** a pumping device (34) is associated with the optical path (28) to maintain the desired gas flow.
6. Household dry-cleaning washing machine according to claim 1, **characterized in that** the IR device is connected through a multi-way valve (40) with a plurality of ducts (24) to draw the gas from the circuit (14) at the selected points of the same, as well as with a duct (26) to reintroduce the gas into the circuit.
7. Household dry-cleaning washing machine according to claim 1, in which a plurality of gas sensors (22) are used, **characterized in that** a first gas sensor (22A) is positioned near the condenser (16) to verify its regular functioning, a second gas sensor (22B) is associated to the heater (18) which is the point of the circuit having the highest temperature, and a third gas sensor (22C) is positioned near the charging opening of the tub (10) where a possible danger situation may occur for the user.
8. Household dry-cleaning washing machine according to claim 5, **characterized in that** said gas sensors (22A, 22B, 22C) are selectively fed and their signals are continuously processed by the electronic control device (38).

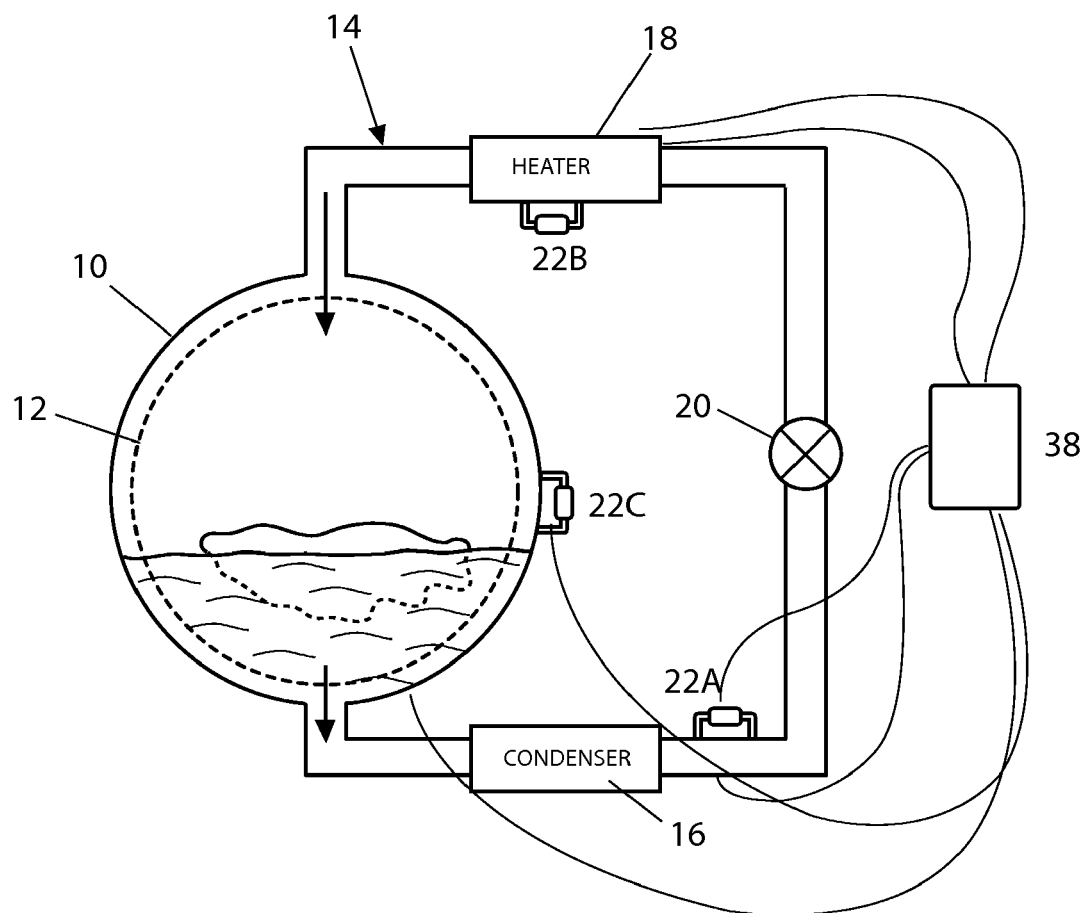


FIG. 1

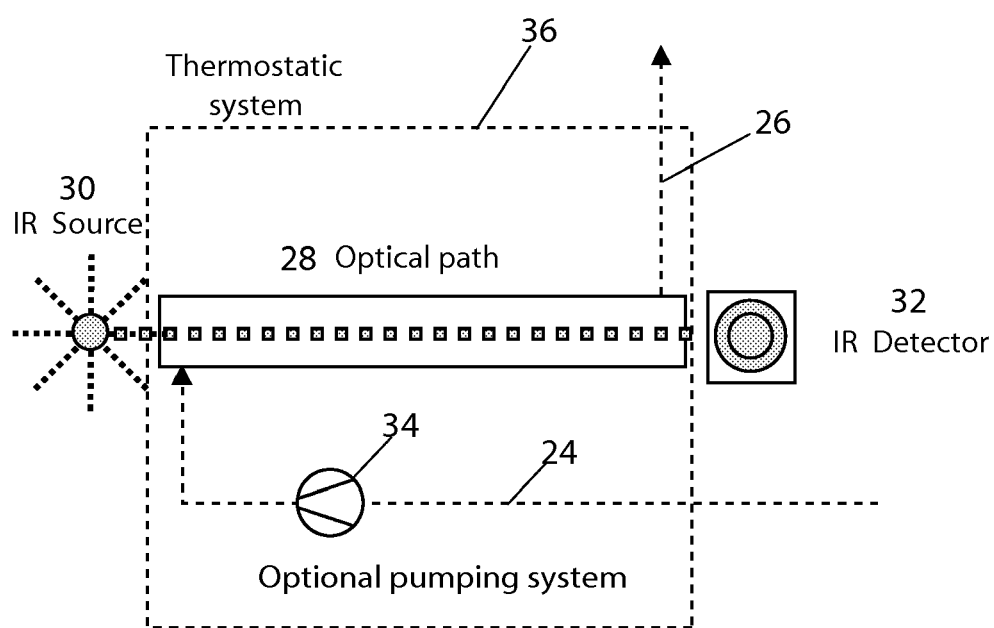
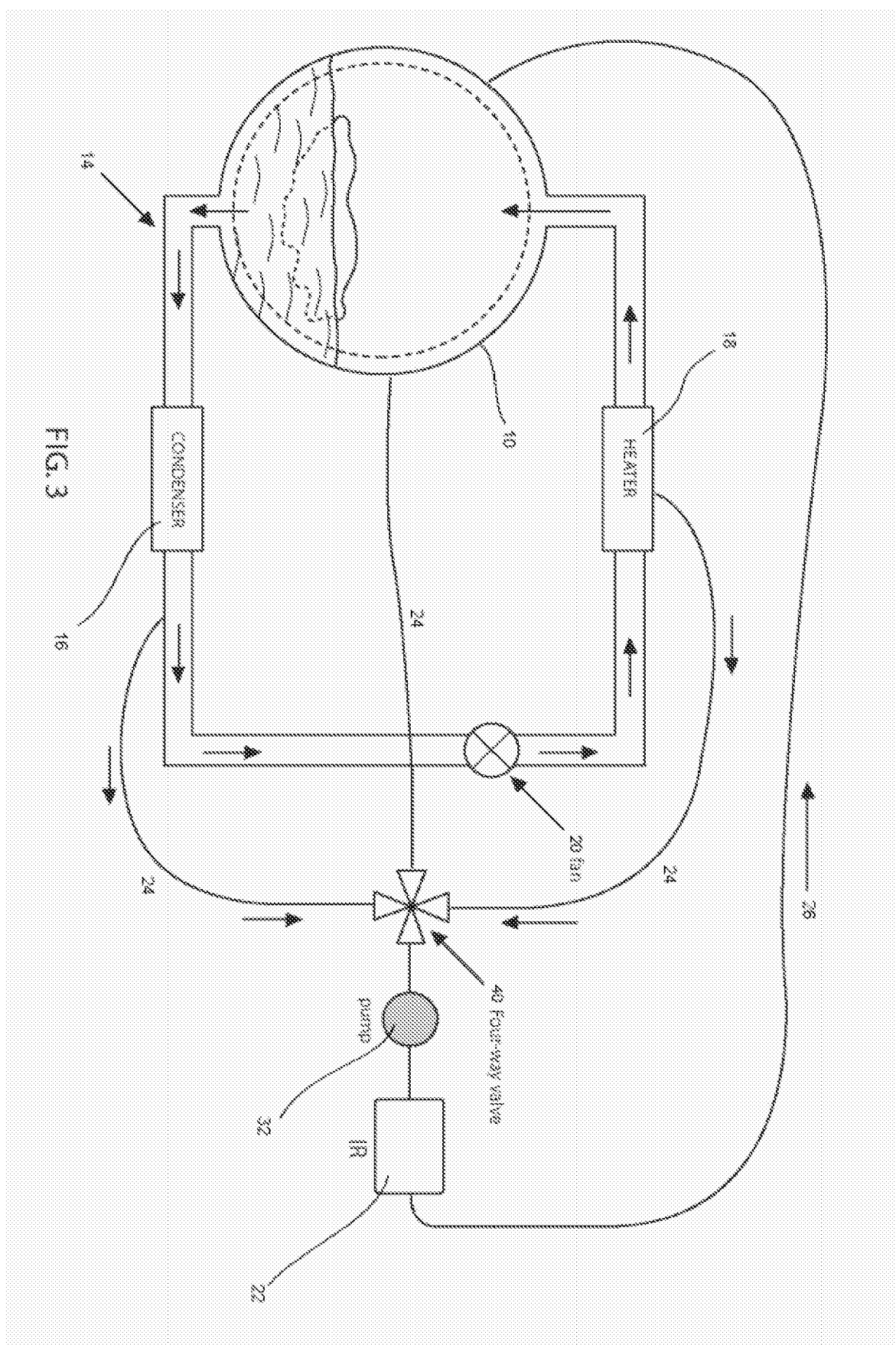


FIG. 2





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 10 2542

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 July 2007	Examiner Norman, Pia
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03/82 (P04/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 10 2542

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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