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(54) **Washing/drying machine or clothes dryer with drying air adjustment system**

(57) The present invention discloses a washing/drying machine or clothes drier comprising a control unit adapted to control the on/off phases of a fan, as well as an associated laundry drying method. According to the invention, said control unit is also adapted to adjust the rotation speed of said fan.

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Description

[0001] The present invention relates to a washing/drying machine or clothes drier according to the preamble of claim 1, as well as to a method for drying damp laundry according to the preamble of claim 9.

[0002] At present, washing/drying machines and clothes driers are known wherein laundry is dried through the combined action of a rotating drum, which contains said laundry, and of a blower, which blows warm air toward the laundry.

[0003] In the more common clothes driers sold on the market, the drum and the blower fan are both driven by one motor which, in order to reduce noise and improve efficiency, can be a three-phase motor.

[0004] Since the fan is directly coupled to the drum motor, the flow rate of the air flow generated by the fan depends on the rotation direction and speed of the drum.

[0005] In order to improve the drying efficiency, in some clothes drier available on the market the fan is driven by a dedicated asynchronous single-phase motor with shorted coil or with start capacitor; the choice of an asynchronous single-phase motor is the only known fan drive solution which has been adopted so far, due to its low costs, in washing/drying machines or clothes driers.

[0006] Since an asynchronous motor with shorted coil is capable of rotating at a fixed speed, which is given by the frequency of the supply voltage and by the number of turns of the inductor winding, the fan of known clothes driers generates an air flow being almost constant for its total operating time.

[0007] These known washing/drying machines and clothes driers suffer the drawback of not being capable of varying the air flow of the fan; consequently, they do not allow to optimize the drying cycle by acting on the air flow rate.

[0008] For the purpose of optimizing the drying cycle, and in particular of optimizing the efficiency of the drying system, the Patent US 4,549,362 describes an industrial clothes drier fitted with an air recirculating/mixing system; according to the invention, the machine comprises a control unit (11) which adjusts a valve system allowing to recirculate different percentages of warm air inside the drum.

[0009] These machines have some drawbacks as well, and do not allow to optimize the drying process; firstly, these valve systems are not very reliable and costly; secondly, these systems provide a constant flow of warm air, while the opening of the valves allows more air to enter from outside, thereby determining not only a reduction of moisture, but also a decrease in temperature.

[0010] With reference to known clothes driers using a single motor for driving both the drum and the fan, in 1983 a Patent (US 4,689,896) proposed a clothes drier fitted with a temperature control system adapted to maintain a constant temperature by varying the flow of air through a fan running at different speeds. The speed variation occurs mechanically through a system of pulleys. This system also suffers the drawback of a costly and unreliable mechanical system, and therefore cannot be used on an industrial scale.

[0011] According to the Patent EP 0 435 015, the machine performs drying phases wherein the air flow and/or the heating element are stopped for a certain time. This system suffers the drawback of a longer drying time.

[0012] The object of the present invention is therefore to solve the above-mentioned problems by providing a washing/drying machine or clothes drier allowing to optimize the drying cycle through a solution being reliable from both mechanical and control point of view.

[0013] Another object of the present invention is to provide a method for drying damp laundry, in particular laundry having previously been subjected to a washing and spinning process.

[0014] These and other objects are achieved by means of a washing/drying machine or clothes drier and a method for drying damp laundry incorporating the features of the annexed claims, which form an integral part of the present description.

[0015] Further objects and advantages will become apparent from the following detailed description and annexed drawings, supplied by way of non-limiting example, wherein:

- Fig. 1a shows a known washing/drying machine.
- Fig. 1b shows some technical details of the washing/drying machine of Fig. 1a.
- Fig. 1c shows some technical details of the washing/drying machine of Fig. 1a.
- Fig. 2 shows the progress over time of residual moisture in damp laundry being subjected to a drying cycle.
- Fig. 3a shows a block diagram of some components of a washing/drying machine according to a first embodiment of the invention.
- Fig. 3b shows a block diagram of some components of a washing/drying machine according to a second embodiment of the invention.
- Figs. 4a, 4b and 4c show the variation of the air flow rate according to three embodiments of the method being the subject of the present invention.

[0016] Fig. 1a illustrates a known washing/drying machine 1 which, in this explanatory and non-limiting example, is of the front-loading type; said machine has a front opening 2 used for placing laundry into a drum 3, the aperture of which can be closed by means of a door 4 incorporating with a glass 5.

[0017] Said washing/drying machine 1 has a control panel 6 comprising means 7 adapted to allow the user to select a wash and/or drying programme; in particular, such means can comprise one or more knobs 8, a number of push-buttons 9 and a display 10. By using said selection means 7, the user thus selects the wash and/or drying programmes that is considered to be the best for the laundry to be washed and/or dried; said drying pro-

grammes are preferably associated with a characteristic of the fabric of the damp laundry to be dried.

[0018] The information entered by the user is used by a control unit 11 which manages and controls the operation of the machine. To this end, the control unit 11 comprises a microcontroller 12 being able to receive, through suitable interfaces and electric connections:

- the results of the readings performed by sensors 21 being present in the machine,
- the information entered by the user through the control panel,
- the information contained in non-volatile memories (ROM, RAM, EEPROM, etc.) installed in the control unit 11 and containing data necessary for executing the wash and/or drying programmes.

[0019] To make all this possible, the control unit is preferably provided in the form of an electronic board on which a plurality of electronic circuits 13 are mounted or integrated, which allow to process the data received or sent by the microcontroller 12.

[0020] Based on the information received, the microcontroller 12 activates a main motor 17 which drives the drum 3, as well as a secondary motor 14 which drives a fan.

[0021] In known machines, the drying cycle comprises a series of clockwise and anticlockwise rotations of the drum 3 at speeds being lower than the satellization speed, i.e. the speed at which the centrifugal force has such an intensity that the laundry can make a full turn of the drum 3 while adhering to the walls of the same.

[0022] The drying cycle also comprises phases wherein a blower 22, shown in Fig. 1c, blows warm air inside the drum 3. The blower 22 essentially comprises a hollow body containing a heating element 23, typically a resistor, and a fan which, driven by a motor 14, generates a flow of air F arriving at the drum through a duct formed by the body of the blower 22.

[0023] Fig. 1b illustrates the tub 24 of the washing/drying machine 1 and the blower 22; in this embodiment, the rotation of the fan generates a flow of air which absorbs the thermal energy yielded by the heating element 23 and is then directed into the drum through a union 25 located between the blower and the gasket 15 surrounding the aperture 2 for loading the laundry.

[0024] Within said duct, between the fan and the union 25, there is a radiating element, typically a resistor, which yields thermal energy to the flow of air blown by the fan into the drum.

[0025] On the whole, in washing/drying machines or clothes driers the damp laundry is subjected to a drying process which can be subdivided, for simplicity's sake, into three main phases defined in Fig. 2 by the two points A and B of the curve.

[0026] Fig. 2 shows a Cartesian graph with the X axis indicating time and the Y axis indicating the percentage of residual moisture being present in the laundry to be dried. The graph refers to a drying cycle performed with constant air flow rate and temperature; the graph is not in scale and therefore no values are indicated, which are however known to those skilled in the art. In the time interval T1, the laundry to be dried is warmed up; during this phase, the residual moisture is almost constant or decreases slightly due to the air passing through the fabric and extracting water droplets from it.

[0027] In the time interval T2, immediately following the warm-up phase, the water remaining in the laundry is quickly released due to the effect of the dragging force exerted by the air passing through the fabric and due to evaporation; the percentage of residual moisture decreases quite rapidly. At the inflection point of the curve, indicated in Fig. 2 with the letter B, the residual moisture reduction speed falls abruptly; in fact, the laundry to be dried is in a condition wherein the reduction of moisture is due more by thermo dynamical effects than by mechanical effects (dragging force of the air passing through the fabric).

[0028] It is apparent from the above description that an optimum drying process should require a high flow of air rate in the time intervals T1 and T2, so as to increase the thermal energy yielded to the laundry to be dried in order to warm it up and remove the residual relative moisture, whereas a flow rate of air being too high would be useless, or even counterproductive, in the last drying phase, because the moisture to be removed is low and a high flow rate of air would not be saturated.

[0029] The remarks made so far about the rotation of the drum 3 and the processes to which the laundry is subjected during the drying cycle can be applied to a clothes drier as well. The technical differences between a washing/drying machine and a clothes drier are not mentioned herein, in that they are known to those skilled in the art and are not relevant for the purposes of the present invention.

[0030] According to the invention, in order to optimize the drying process the washing/drying machine or clothes drier comprises a control unit 11 adapted to control the on/off phases of a fan of a blower, as well as for adjusting the rotation speed of said fan; this allows to obtain different flow rates of air as necessary.

[0031] In a preferred and advantageous embodiment, the washing/drying machine or clothes drier comprises a first motor 17, in particular a three-phase motor, for driving a drum 3, and a second motor 14, preferably an electronic commutation motor, for driving the fan; the control unit 11, in addition to controlling the main motor 17, is also adapted to adjust the rotation speed of said second motor 14.

[0032] In the preferred case of a washing/drying machine or clothes drier wherein the drum 3 is driven by a three-phase motor and the fan is driven by an electronic commutation motor, both motors need a rectifier (19,19'), i.e. a circuit receiving the mains alternating voltage 20 (typically 220-230 V at 50 Hz in Italy) and outputting a direct voltage, as well as an inverter (18,18'), i.e. a circuit

receiving a direct voltage and outputting one or more alternating voltages.

[0033] With reference to Fig. 3a, the inverter 18 associated with the three-phase motor generates, on three output lines, three alternating voltages offset by 120 degrees, while the inverter 18' associated with the electronic commutation motor (which in the illustrated example is of the permanent magnet type) generates a square wave whose duty cycle is proportional to the rotation speed of the motor; the control of motors driven through electronic commutation is known and therefore will not be detailed any further, but it is clear that, depending on the type of motor chosen, the corresponding inverter will generate an appropriate number of voltages having suitable frequencies and shapes. Each inverter (18,18') receives a direct voltage generated by a respective rectifier (19,19').

[0034] According to the invention, the control unit 11 of the washing/drying machine or clothes driers controls both inverters (18,18') by defining the frequency of the output voltages, and consequently the rotation speed of the motors; it should be noted that, in the examples of Figs. 3a and 3b, the operation of the motor 14 is of the brushless type. The connection between the control unit 11 and the inverters (18,18') is preferably bidirectional, so that the control unit 11, besides transmitting commands to the inverters (18,18'), can also receive useful information from the inverters. Said information sent by the inverters (18,18') can refer to the torque required for keeping the drum in motion, to the current absorption of the motor, etc.

[0035] The washing/drying machine or clothes drier can be equipped, in a known manner, with sensors 21 whose readings provide information regarding the operating state of the machine; as an explanatory and non-limiting example, the washing/drying machine or clothes drier can be equipped with a tachometric sensor for measuring the rotation speed of the drum, a pressure switch for measuring the water level in the tub 24, or an air temperature sensor.

[0036] By means of the information received from the inverters (18,18') and/or said sensors 21, the control unit 11 controls the operation of the machine by adjusting the rotation speed of the drum 3 and of the fan 16 or by signaling any operation errors through the display 10 being present on the control panel 6 or through a buzzer.

[0037] It is clear that many changes can be made to the above-described washing/drying machines or clothes drier by those skilled in the art without departing from the scope of the present invention resulting from this description, the following claims and the annexed drawings.

[0038] In particular, for the purpose of reducing the costs while maintaining the same drying efficiency, a particularly advantageous solution is the one shown in Fig. 3b, wherein the motor 17 driving the drum 3 and the motor 14 driving the fan 16 use a common rectifier circuit 19.

[0039] Other variants can be obtained with different solutions employing variable speed motors controlled by an electronic control unit which, according to the invention, coincides with the control unit 11 of said washing/drying machine or clothes drier. In particular, the electronic commutation motor driving the blower fan can be a three-phase motor, a variable reluctance motor or a permanent magnet motor.

[0040] Washing/drying machines or clothes driers according to the invention, such as those described above by way of example, allow to implement an optimum method for drying damp laundry.

[0041] Said method for drying damp laundry can be used in a washing/drying machine or clothes driers fitted with a control unit 11 adapted to control the on/off phases of a fan of a blower, and in which an air flow generated by said fan and warmed up through a heating element 23 is directed into a drum containing said laundry; according to the invention the method provides, the rotation speed of said fan 16 to be adjusted through said control unit 11.

[0042] By varying the operating speed of said fan during the drying phases, it is possible to change the flow rate of the warm air blown into the machine.

[0043] Advantageously, the method according to the invention therefore comprises at least a first and a second drying phases, wherein the flow rate of said flow of air is different. Preferably, said first drying phase takes place at the beginning of said drying method and is characterized by a flow rate of air being higher than that of said second phase.

[0044] In other words, during the initial drying phase the method according to the present invention preferably comprises a phase in which the fan is driven at high speed, so that the air absorbs a large quantity of thermal energy from the heating element 23 and carries it into the drum. This phase, with the fan driven at high speed, allows to warm up the damp laundry rapidly.

[0045] According to the invention, after said first drying phase, which preferably can coincide with the time periods T1 and T2 of Fig. 2, the fan speed is then reduced. The use of a fan drive motor controlled through electronic commutation, together with the electronic control provided by the control unit 11 of the machine, allows to choose among different drying programmes. Following the first warm-up phase, the fan speed can then be gradually reduced, or the drying cycle can be subdivided into a plurality of time intervals wherein the fan speed is reduced.

[0046] Depending on the type of fabric of the laundry to be dried, e.g. cotton, wool, etc., it is also possible to provide for different optimal drying methods. To this end, the washing/drying machine or clothes drier according to the invention comprises means 7 adapted to allow the user to select a drying program. Such means comprise push-buttons 9, knobs 8 or menu items which can be displayed through the display 10 mounted on the machine control panel.

[0047] Preferably, the selection of the drying pro-

gramme takes place by choosing a characteristic of the fabric, e.g. the type of fabric or the degree of delicacy of the treated laundry.

[0048] In conclusion, depending on the type of laundry to be dried, the drying programme can comprise fan operating phases at different speeds, in particular a first phase at top speed and a last phase, which takes place during the final drying stage, wherein the flow of air generated by the fan is lowest.

[0049] It is also possible to employ other preferred drying methods wherein, for instance, said first drying phase is characterized by a flow rate of air being higher than that of said second phase, and by the fact that said first phase precedes said second phase.

[0050] Some preferred embodiment examples of the method according to the invention are presented in Figs. 4a-4c, which show by means of Cartesian graphs the flow rate variation occurring during the drying process.

[0051] In the embodiments of the drying method shown in Figs. 4a-4c, the air flow rate is rapidly increased up to a maximum value and then kept constant during a first drying phase having a duration t_{in} being necessary for warming up the laundry.

[0052] The duration of said phase depends on the loaded laundry, e.g. weight, fabric, etc., as well as on the size of the heating element of the blower and on the flow rate of air.

[0053] After this first phase, the flow rate of air is decreased either gradually (Fig. 4a) or in successive phases during which the flow rate is kept at a constant value for time intervals having a duration t_2 - t_n (Figs. 4b and 4c). In particular, as shown in Fig. 4b, the flow rate of air is reduced at each successive drying phase, whereas in the method embodiment of Fig. 4c there are a first phase and a second phase being repeated in succession; at each repetition, said flow rate of air is reduced during said first phase. The value of the flow rate of air during said second phase can be equal to or other than zero; Fig. 4c shows the case in which it is other than zero.

[0054] Other advantageous variants can be obtained by adjusting both the rotation speed of the fan and the temperature of the heating element 23; said adjustment of the heating element 23 can be achieved by controlling, through the electronic control unit of said washing/drying machine or clothes drier, a switch which disconnects said heating element 23 from the electric network.

[0055] By opening the switch in a known manner at time intervals defined by the control unit, it is possible to adjust the power drawn by said element, and consequently the thermal energy that the latter is capable of dissipating.

Claims

1. Washing/drying machine or clothes drier comprising a control unit (11) adapted to control the on/off phases of a fan (16) of a blower (22), **characterized in that** said control unit (11) is also adapted to adjust the rotation speed of said fan.

2. Washing/drying machine or clothes drier according to claim 1, **characterized in that** it comprises a first motor (17) for driving a drum (3) and a second motor (14) for driving said fan, and that said control unit (11) is adapted to adjust the rotation speed of said second motor (14).

3. Washing/drying machine or clothes drier according to claim 2, **characterized in that** said second motor (14) is an electronic commutation motor, in particular of the permanent magnet type.

4. Washing/drying machine or clothes drier according to claim 3, **characterized in that** said first motor (17) is of the asynchronous three-phase type.

5. Washing/drying machine or clothes drier according to claim 4, **characterized in that** said first and second motors use a common rectifier circuit (19).

6. Washing/drying machine or clothes drier according to one of the previous claims, **characterized in that** it comprises means (7) adapted to allow the user to select at least one programme for drying damp laundry.

7. Washing/drying machine or clothes drier according to claim 6, **characterized in that** said programmes are associated with a characteristic of the fabric of said laundry.

8. Washing/drying machine or clothes drier according to claim 6 or 7, **characterized in that** said drying programme comprises fan operating phases at different speeds.

9. Method for drying damp laundry in a washing/drying machine or clothes drier fitted with a control unit (11) adapted to control the on/off phases of a fan of a blower, and in which a flow of air generated by said fan and warmed up through a heating element (23) is directed into a drum (3) containing said laundry, **characterized in that** the rotation speed of said fan (16) is adjusted through said control unit (11).

10. Method according to claim 9, **characterized in that** said method comprises at least a first and a second drying phases wherein the flow rate of said flow of air is different.

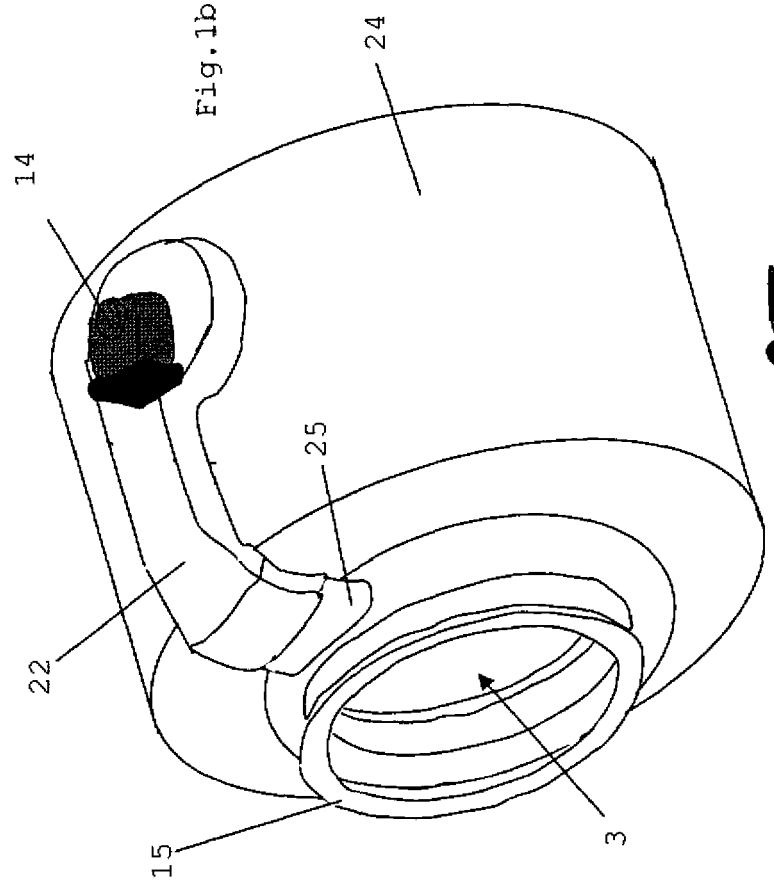
11. Method according to claim 10, **characterized in that** said first drying phase is **characterized by** a flow rate of air being higher that that of said second phase and in that said first phase precedes said second phase.

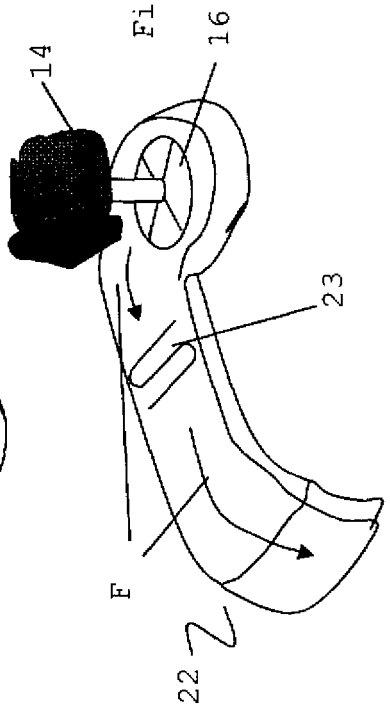
12. Method according to claim 11, **characterized in that** said first drying phase takes place at the beginning of said drying method.

13. Method according to claim 11, **characterized in that** said first and second phases are repeated in succession and that, at each repetition, the flow rate of said air flow is reduced during said first phase.

14. Method according to one of claims 9 to 12, **characterized in that** said flow rate of air is lowest during the final drying phase.

15. Method according to one of the previous claims, **characterized in that** it provides an adjustment of the thermal energy dissipated by said heating element (23).





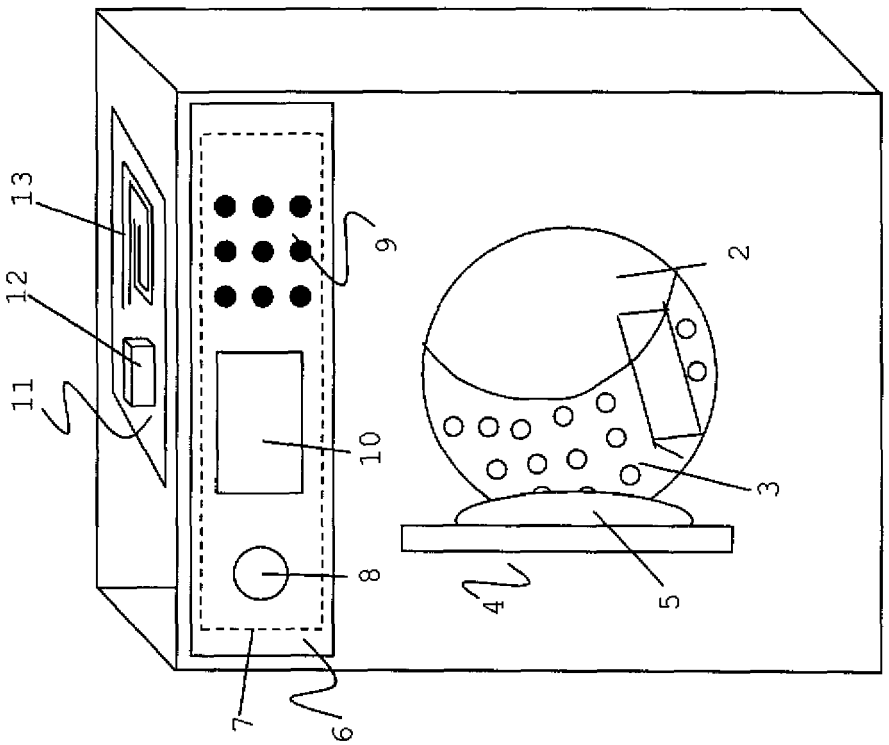


Fig.1a

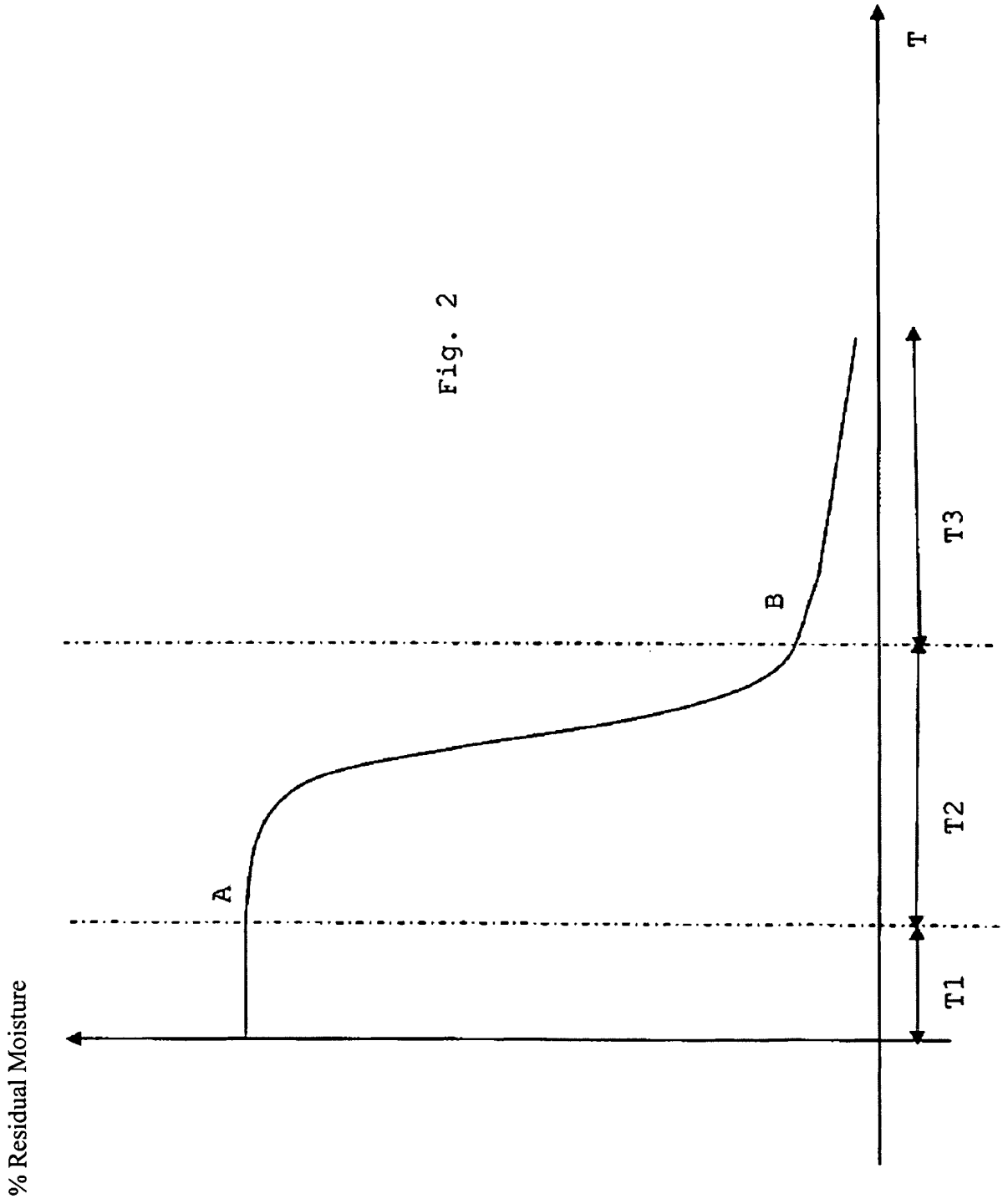


Fig. 2

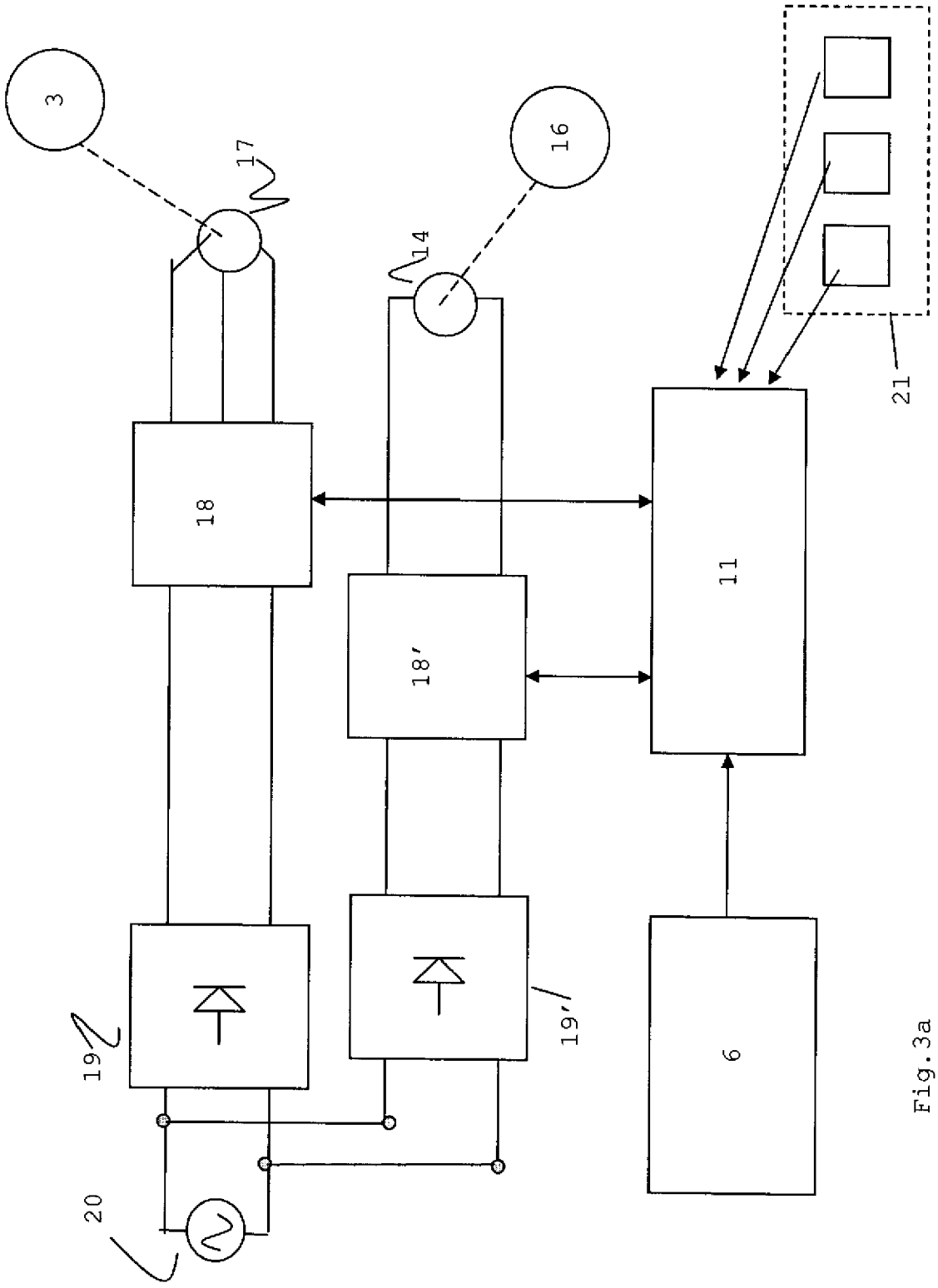


Fig.3a

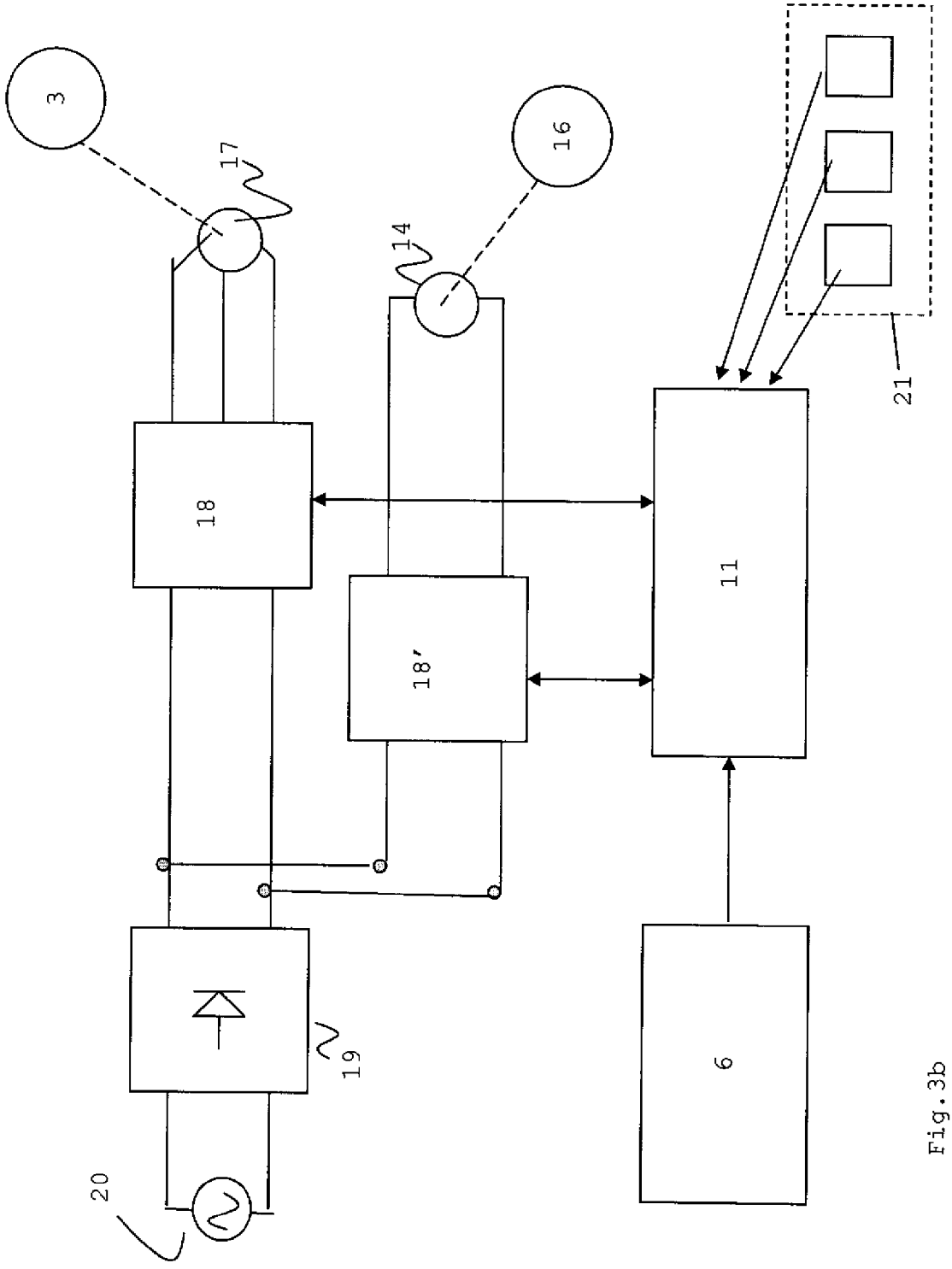


Fig.3b

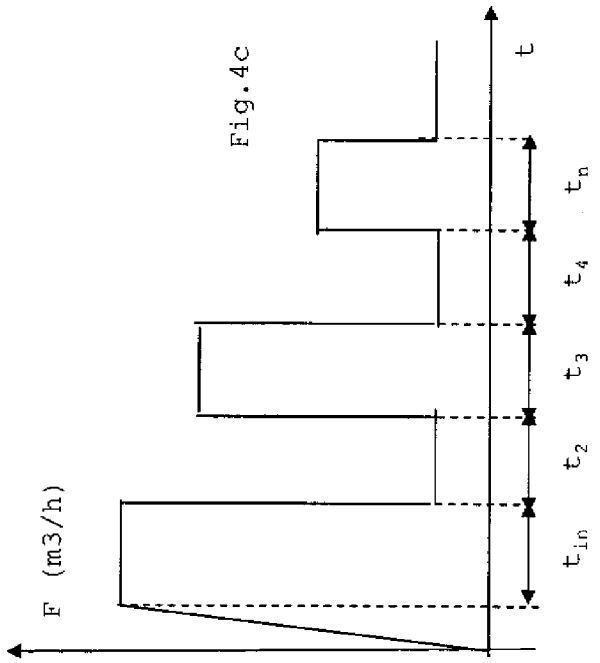


Fig.4c

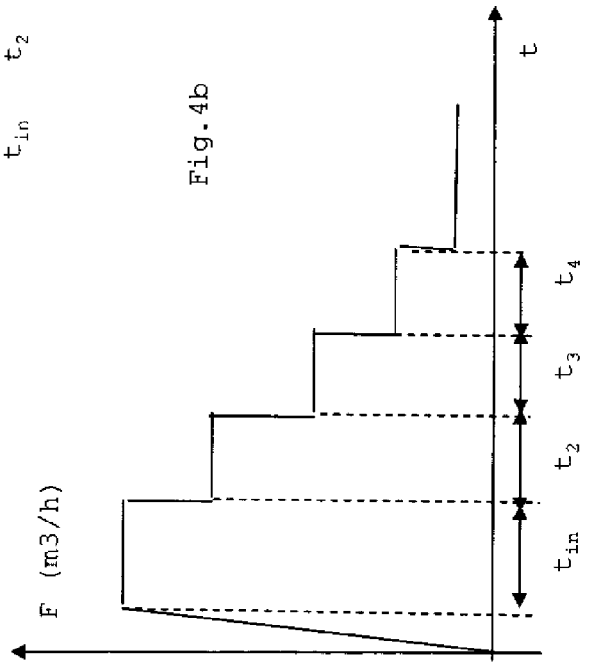


Fig.4b

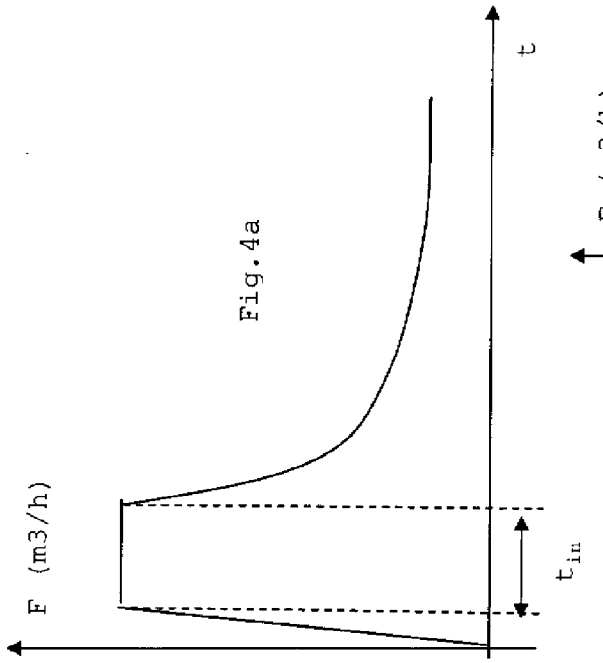


Fig.4a

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EUROPEAN SEARCH REPORT

Application Number
EP 05 11 1599

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 745 495 B1 (RIDDLE DOUGLAS ALLEN [US] ET AL) 8 June 2004 (2004-06-08) * abstract; figure 1 * * column 2, line 56 - line 61 * * column 3, line 17 - line 21 * * column 3, line 37 - line 42 * * column 3, line 61 - line 65 * * column 4, line 1 - line 4 *	1-15	INV. D06F58/28
A	WO 2004/059066 A (ARCELIK AS [TR]; AVCI SERDAL KORKUT [TR]; ALTINSU RAIF [TR]; GUELAY ER) 15 July 2004 (2004-07-15) * page 1, line 18 - line 20 * * page 4, line 29 - line 31 *	4,5	

TECHNICAL FIELDS SEARCHED (IPC)

D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 March 2007	FAYMANN, L

CATEGORY OF CITED DOCUMENTS

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06-03-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6745495 B1	08-06-2004	CA 2446359 A1	27-12-2004
WO 2004059066 A	15-07-2004	AU 2003298499 A1	22-07-2004
		EP 1581682 A1	05-10-2005
		TR 200502343 T1	22-01-2007

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4549362 A **[0008]**
- US 4689896 A **[0010]**
- EP 0435015 A **[0011]**