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(54) **Control method for controlling a tumble laundry drier for drying wool laundry**

(57) A control method for controlling a tumble laundry drier (1) for drying wool laundry (5); the control method includes the steps of: loading the wool laundry (5) into a drum (3) of the tumble laundry drier (1); feeding a stream of drying air into the drum (3); rotating the drum (3) at a first rotation speed (n_1) greater than a second rotation speed (n_2) at which centrifugal acceleration of the inner surface of the drum (3) equals gravitational acceleration, so the wool laundry (5) is pressed by centrifugal force against the inner surface of the drum (3), as opposed to dropping inside the drum (3); and cyclically stopping rotation of the drum (3) by zeroing the rotation speed (n) and then re-accelerating the drum (3) back to the first rotation speed (n_1) to rearrange the wool laundry (5) inside the drum (3).

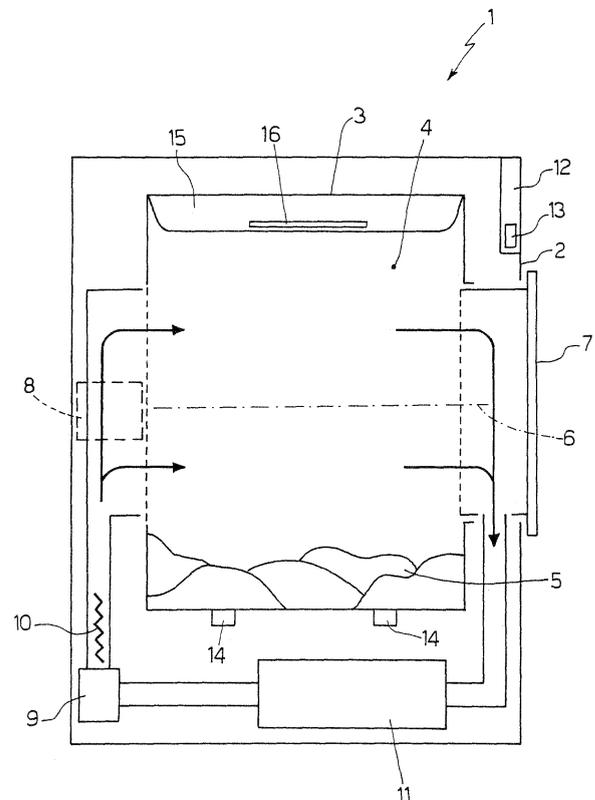


Fig.1

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DescriptionTECHNICAL FIELD

[0001] The present invention relates to a control method for controlling a tumble laundry drier for drying wool laundry.

BACKGROUND ART

[0002] Drying woollens poses serious difficulties, on account of the tendency of woollens to felt, thus resulting in irreparable damage. Felting of woollens is caused by overheating the wool, and by the woollens rubbing against the inner surface of the drum or against other woollens.

[0003] Felting of woollens caused by overheating can be prevented by simply reducing and accurately controlling heating of the woollens during the drying process.

[0004] To prevent rubbing-induced felting of woollens, most commercial driers feature an extra mechanical component (so-called "rack") which supports the woollens in a fixed position inside the drum during the drying cycle. In other words, in the rack, the woollens are supported in a fixed position inside the drum, so the warm air flows over the surface of the wool with no mechanical movement of the woollens. Examples of a drying rack for drying stationary woollens are described in US2006096120A1 and US2004118012A1.

[0005] Drying woollens in a rack, however, results in uneven drying, in that, at the end of the drying process, the woollens are perfectly dry on the outside, but still relatively damp on the inside. Furthermore, the rack represents an extra cost for the customer, and is also cumbersome and therefore difficult to store when not in use. Finally, using a rack, the relative humidity of the woollens cannot be measured during the drying cycle, to stop the drying cycle when the humidity of the woollens reaches a given value. Consequently, using a rack, the drying cycle must be of constant predetermined duration, regardless of the actual weight and initial humidity of the woollens.

DISCLOSURE OF INVENTION

[0006] It is an object of the present invention to provide a control method for controlling a tumble laundry drier for drying wool laundry, and which is designed to eliminate the aforementioned drawbacks, is cheap and easy to implement, and, in particular, provides for drying wool laundry quickly with no felting of the wool.

[0007] According to the present invention, there is provided a control method for controlling a tumble laundry drier for drying wool laundry, as claimed in the accompanying Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a schematic side view of a tumble laundry drier implementing a control method for drying wool laundry in accordance with the present invention;

Figure 2 shows a graph of the rotation speed of a revolving drum of the Figure 1 tumble laundry drier during a wool drying cycle.

PREFERRED EMBODIMENTS OF THE INVENTION

[0009] Number 1 in Figure 1 indicates as a whole a laundry drier comprising a casing 2 resting on a floor on a number of feet. Casing 2 supports a revolving laundry drum 3, which defines a drying chamber 4 for the laundry 5 to be dried, rotates about a horizontal rotation axis 6 (in alternative embodiments not shown, rotation axis 6 may be tilted or vertical), and has a front access opening closed by a door 7 hinged to a front wall of casing 2. Drum 3 is rotated by an electric motor 8, and is fed through with a stream of drying air fed into drum 3 by a centrifugal fan 9 and heated by a heating device 10.

[0010] During operation, fan 9 produces a stream of dry air that is fed to heating device 10 and then into drum 3 through a perforated back of the drum. After contacting laundry 5, the dry air flows out of drum 3 to a condenser 11, in which it is cooled to condense the laundry moisture contained in it. For which purpose, condenser 11 is fed through with cooling air drawn in from outside tumble laundry drier 1; and the dry air from condenser 11 is drawn in again by fan 9.

[0011] It should be pointed out that condenser 11 is referred to here purely by way of example in connection with one embodiment of the present invention, and may be omitted in the case of an exhaust-type tumble laundry drier 1 (i.e. in which the hot drying air from drum 3 is exhausted directly to the outside).

[0012] The rotation speed of electric motor 8, which rotates drum 3 about rotation axis 6, is controlled by an electronic control unit 12, which receives the input commands from the user of tumble laundry drier 1. More specifically, electronic control unit 12 performs a wool drying cycle specially designed for felt-free drying wool laundry 5.

[0013] First of all, during the wool drying cycle, electronic control unit 12 controls heating device 10 to reduce heating of the drying air and hence the temperature of wool laundry 5 to well below the felting temperature of the wool.

[0014] During the wool drying cycle, electronic control unit 12 also controls electric motor 8 to rotate drum 3 about rotation axis 6 at a variable rotation speed n. More specifically, when designing tumble laundry drier 1, a ro-

tation speed n_2 is determined at which centrifugal acceleration of the inner surface of drum 3 equals gravitational acceleration (i.e. 1 g). Rotation speed n_2 is easily calculated using the following equations:

$$n = 60 * \omega / 2\pi$$

$$a = \omega^2 * r$$

were :

- n is the rotation speed of drum 3 measured in radians/second;
- ω is the rotation speed of drum 3 measured in revolutions/minute;
- a is the centrifugal acceleration of drum 3;
- r is the radius of drum 3.

[0015] During the wool drying cycle, drum 3 is rotated at a constant rotation speed n_1 greater than rotation speed n_2 at which centrifugal acceleration of the inner surface of drum 3 equals gravitational acceleration, so wool laundry 5 is pressed by centrifugal force against the inner surface of drum 3, as opposed to dropping inside drum 3. In addition, during the wool drying cycle, rotation of drum 3 is stopped cyclically by zeroing rotation speed n , and drum 3 is re-accelerated back to rotation speed n_1 to rearrange wool laundry 5 inside drum 3. In other words, keeping wool laundry 5 pressed against the inner surface of drum 3 by centrifugal acceleration greater than gravitational acceleration (i.e. by a centrifugal force greater than the gravitational force) eliminates (or at least greatly reduces) mechanical stress on wool laundry 5 caused by wool laundry 5 dropping and tumbling inside the rotating drying drum 3. At the same time, to avoid uneven drying of wool laundry 5, wool laundry 5 is rearranged cyclically inside drum 3 by cyclically stopping drum 3 for about 2 seconds (generally about 1-3 seconds).

[0016] To effectively rearrange wool laundry 5 during the wool drying cycle, and so achieve uniform drying of the wool, while at the same time preventing excessive mechanical stress of the wool, rotation of drum 3 should be stopped cyclically every 5-15 minutes and, preferably, about every 10 minutes.

[0017] In a preferred embodiment, rotation speed n_1 is about 70 rpm (revolutions per minute) and, more generally, ranges between 65 and 75 rpm, for a drum 3 of 575 mm in diameter. In connection with the above, it is important to point out that, to allow for tolerances and, particularly, to avoid excessive movement of wool laundry 5 as drum 3 rotates, rotation speed n_1 must not be too close to rotation speed n_2 . On the other hand, rotation speed n_1 must not be too far from rotation speed n_2 , to

avoid excessive mechanical stress of wool laundry 5 caused by high centrifugal acceleration.

[0018] In a preferred embodiment, at each cyclic stop in rotation of drum 3, rotation speed n of drum 3 is decreased/increased with a deceleration/acceleration of about 20-35 revolutions/second² (i.e. drum 3 needs about 2-3 seconds to decelerate/accelerate from 70/0 rpm to 0/70 rpm). These deceleration/acceleration values of drum 3 are important by greatly reducing rubbing (and so preventing felting) of wool laundry 5 during deceleration/acceleration of drum 3.

[0019] In a preferred embodiment, electronic control unit 12 determines the position of wool laundry 5 inside drum 3, and stops drum 3 so that, when drum 3 is stopped, wool laundry 5 is at the bottom of drum 3. This prevents wool laundry 5 from dropping inside drum 3 when the drum is stopped, and so further reduces mechanical stress of wool laundry 5. More specifically, drum 3 has three lifters 15, each with a sensor 16 for sensing the presence of wool laundry 5; and electronic control unit 12 determines the lifter/s 15 contacting wool laundry 5, and stops drum 3 so that, when drum 3 is stopped, the lifter/s 15 contacting wool laundry 5 is/are in a low position (for example, by commencing stoppage of drum 3 when the lifter/s 15 contacting wool laundry 5 is/are about 120° upstream from its/their lowest position).

[0020] Figure 2 shows a graph of rotation speed n of revolving drum 3 during the wool drying cycle. As shown in Figure 2, during the wool drying cycle, rotation speed n is kept substantially constant at rotation speed n_1 greater than rotation speed n_2 , and drum 3 is stopped cyclically.

[0021] Electronic control unit 12 is connected to a humidity sensor 13 to measure the relative humidity of wool laundry 5 during the wool drying cycle. Humidity sensor 13 comprises a pair of electrodes 14 contacting wool laundry 5 inside drum 3 to measure the resistance/conductivity of wool laundry 5, and uses the resistance/conductivity of wool laundry 5 to determine the humidity of wool laundry 5. Electronic control unit 12 stops the wool drying cycle when the electric resistance/conductivity between the two electrodes 14 is above/below a resistance/conductivity threshold (i.e. the humidity of wool laundry 5 is below a humidity threshold). Preferably, to decide stoppage of the wool drying cycle, the resistance/conductivity measured between the two electrodes 14 immediately after a cyclic stop in rotation of drum 3 is compared with the resistance/conductivity threshold.

[0022] In connection with the above, it is important to point out that, immediately after a cyclic stop in rotation of drum 3, wool laundry 5 has just been rearranged, so the measured resistance/conductivity between the two electrodes 14 better reflects the actual humidity of wool laundry 5 as a whole. In other words, the actual humidity of wool laundry 5 as a whole is better (i.e. more accurately) determined by measuring the resistance/conductivity between the two electrodes 14 immediately after a cyclic stop in rotation of drum 3.

[0023] Wool drying cycle as described above has numerous advantages, by being cheap and easy to implement in a standard tumble drier (no additional components, other than those normally featured in a modern tumble drier are required), and by enabling careful (i.e. felt-free) but nevertheless effective drying of wool laundry. More specifically, determining the end of the drying cycle on the basis of the measured humidity (i.e. electric resistance/conductivity) of the laundry to be dried, the wool drying cycle as described above minimizes mechanical stress of the wool laundry (i.e. eliminates undue mechanical stress caused by a longer than necessary drying cycle), is effective (i.e. at the end of the drying cycle, the wool laundry is as dry as necessary), and is efficient (i.e. the drying cycle wastes no electric energy) regardless of variations in the weight and initial humidity of the wool laundry to be dried.

Claims

1. A control method for controlling a tumble laundry drier (1) for drying wool laundry (5); the control method comprising the steps of:

loading the wool laundry (5) into a drum (3) of the tumble laundry drier (1);
 feeding a stream of drying air into the drum (3);
 and
 rotating the drum (3) about a rotation axis (6) at a variable rotation speed (n);
 the control method being **characterized by** comprising the steps of:
 rotating the drum (3) at a first rotation speed (n_1) greater than a second rotation speed (n_2) at which centrifugal acceleration of the inner surface of the drum (3) equals gravitational acceleration, so the wool laundry (5) is pressed by centrifugal force against the inner surface of the drum (3), as opposed to dropping inside the drum (3); and
 cyclically stopping rotation of the drum (3) by zeroing the rotation speed (n) and then re-accelerating the drum (3) back to the first rotation speed (n_1) to rearrange the wool laundry (5) inside the drum (3).

2. A control method as claimed in Claim 1, wherein the first rotation speed (n_1) ranges between 65 and 75 rpm for a drum (3) of 575 mm in diameter.
3. A control method as claimed in Claim 2, wherein the first rotation speed (n_1) is about 70 rpm for a drum (3) of 575 mm in diameter.
4. A control method as claimed in Claim 1, 2 or 3, wherein, at each cyclic stop in rotation of the drum (3), the rotation speed (n) of the drum (3) is decreased/in-

creased with a deceleration/acceleration of about 20-35 revolutions/second².

5. A control method as claimed in any of Claims 1 to 4, wherein rotation of the drum (3) is stopped cyclically every 5-15 minutes.
6. A control method as claimed in Claim 5, wherein rotation of the drum (3) is stopped cyclically every 10 minutes.
7. A control method as claimed in any of Claims 1 to 6, wherein, at the stop stage, the drum (3) is stopped for about 1-3 seconds.
8. A control method as claimed in Claim 7, wherein, at the stop stage, the drum (3) is stopped for about 2 seconds.
9. A control method as claimed in any of Claims 1 to 8 and comprising the further steps of:

measuring the electric resistance/conductivity between two electrodes (14) contacting the wool laundry (5) inside the drum (3); and
 stopping the drying cycle when the electric resistance/conductivity between the two electrodes (14) is above/below a resistance/conductivity threshold.

10. A control method as claimed in Claim 9, wherein, to decide stoppage of the drying cycle, the resistance/conductivity measured between the two electrodes (14) immediately after a cyclic stop in rotation of the drum (3) is compared with the resistance/conductivity threshold.
11. A control method as claimed in any of Claims 1 to 10, and comprising the further steps of:
- determining the position of the wool laundry (5) inside the drum (3); and
 stopping the drum (3) so that, when the drum (3) is stopped, the wool laundry (5) is at the bottom of the drum (3).
12. A control method as claimed in Claim 11, wherein the drum (3) has a number of lifters (15), each with a sensor (16) for sensing the presence of the wool laundry (5); and the control method comprises the further steps of:

determining the lifter/s (15) contacting the wool laundry (5); and
 stopping the drum (3) so that, when the drum (3) is stopped, the lifter/s (15) contacting the wool laundry (5) is/are in a low position.

13. A control method as claimed in Claim 12, and comprising the further step of commencing stoppage of the drum (3) when the lifter/s (15) contacting the wool laundry (5) is/are about 120° upstream from its/their lowest position.

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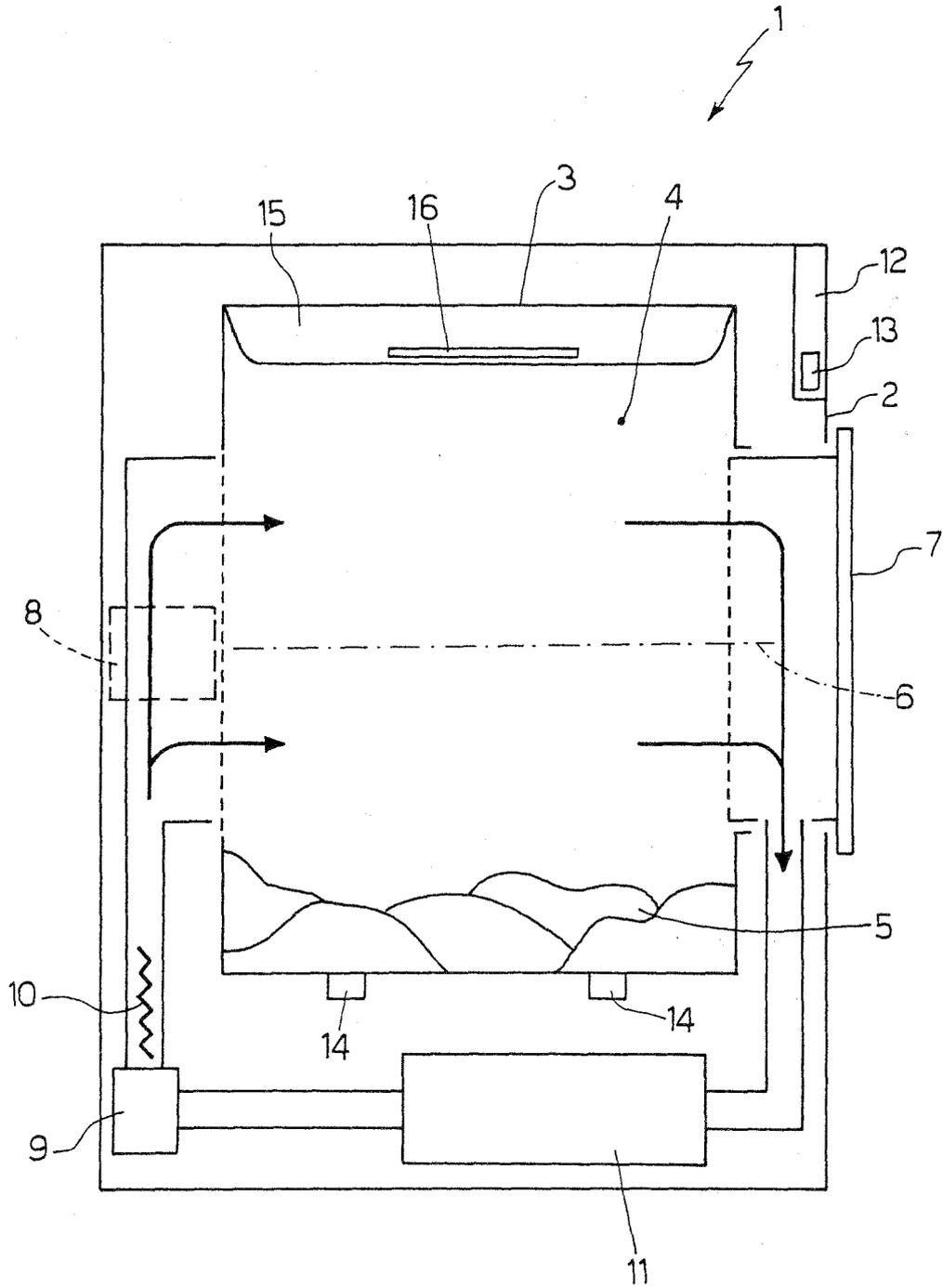


Fig.1

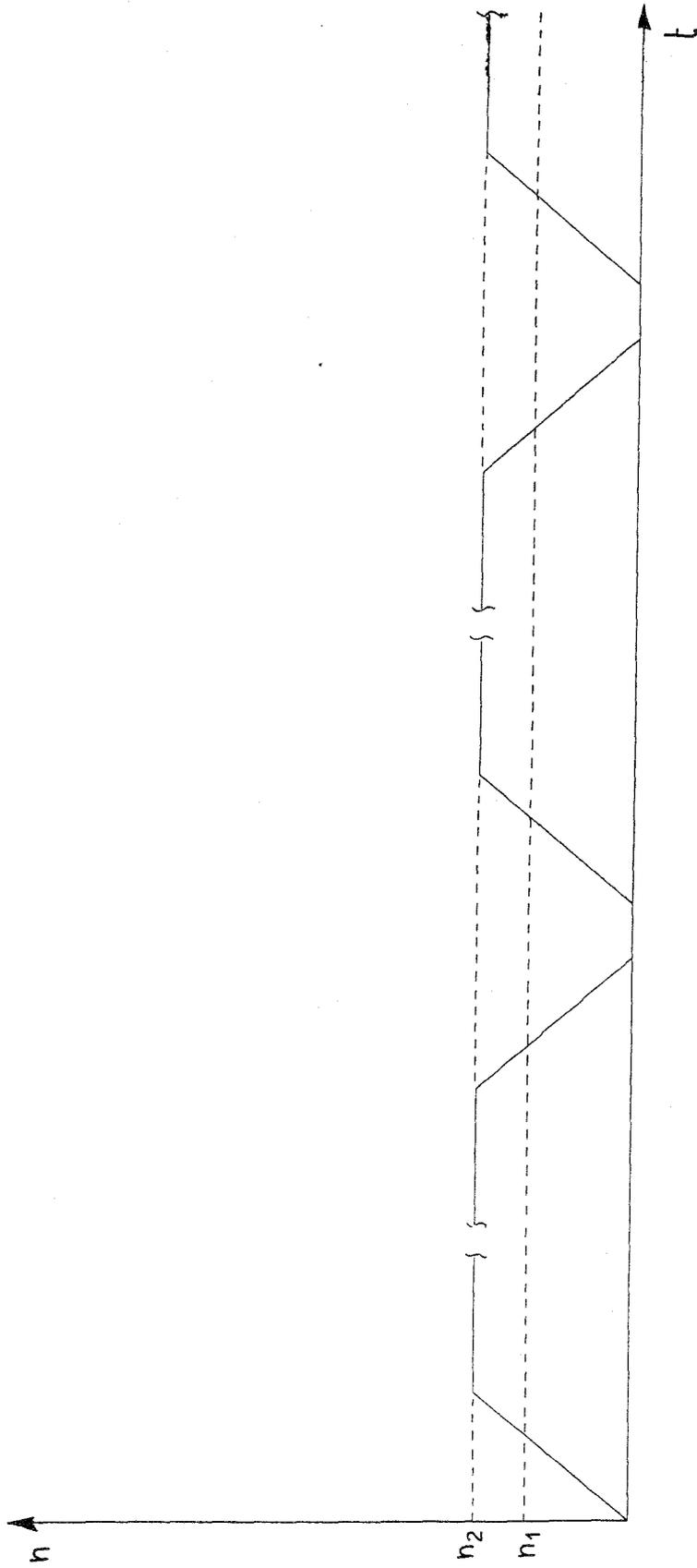


Fig.2



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
Munich		15 November 2007	DIAZ, M
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 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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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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