(19) Europäisches Patentamt
European Patent Office
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(11) **EP 2 458 066 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.05.2012 Bulletin 2012/22

(51) Int Cl.:
D06F 58/02 *(2006.01)* ***D06F 58/24*** *(2006.01)*

(21) Application number: **10192681.4**

(22) Date of filing: **26.11.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) **Closed cycle dryer**

(57) A closed cycle dryer comprises a heating unit used to heat the air that is blown in a rotating drum and a condensing unit upstream the heating unit comprising an air-cooled heat exchanger where the hot and humid air downstream the drum is contacting a first side of wall, a second side of said wall of the heat exchanger being contacted by flowing air at ambient temperature. At least a portion of the wall of the heat exchanger is provided with holes where a portion of the hot and humid air can be exhausted.

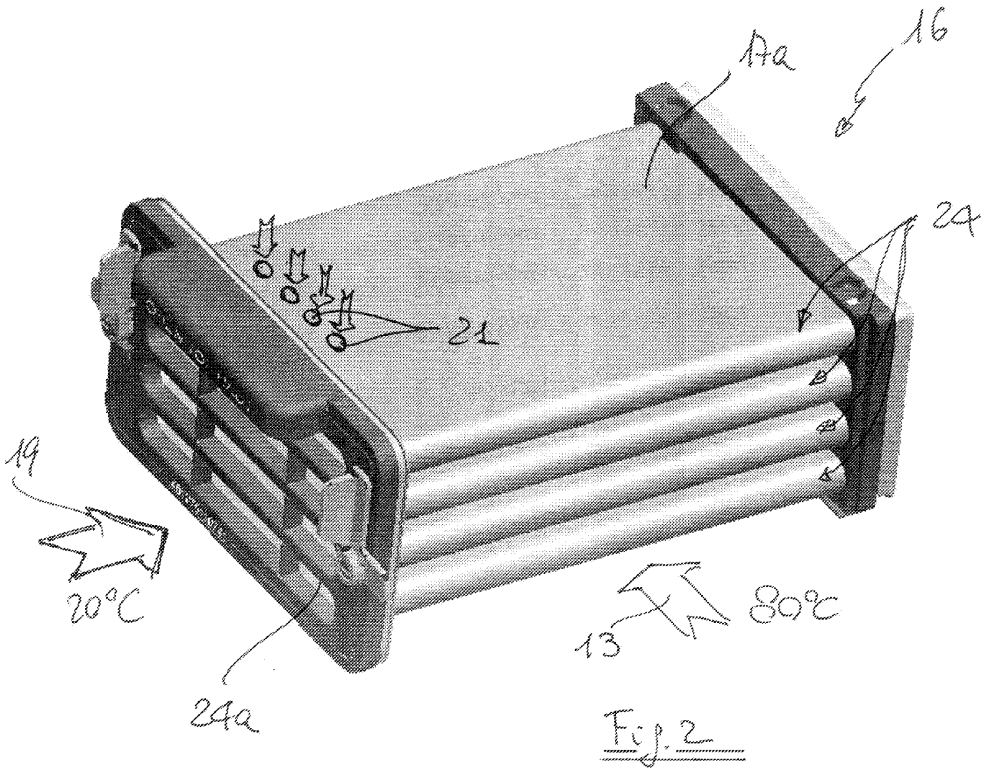


Fig. 2

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Description

[0001] The present invention relates to a closed cycle dryer comprising a heating unit used to heat the air that is blown in a rotating drum and a condensing unit upstream the heating unit comprising an air-cooled heat exchanger where the hot and humid air downstream the drum is contacting a first side of a wall, a second side of said wall of the heat exchanger being contacted by flowing air at ambient temperature. The present invention relates also to washing-drying machine in which the laundry can be washed and then dried in the same appliance. With the term "wall" referred to the heat exchanger we mean the heat exchanging surface which may comprises actually several tubes or plates.

[0002] In this kind of domestic dryer for drying laundry (after washing and spinning thereof) the condensing unit is used to remove moisture which condenses on the first side of the exchanging surface and is collected in a water reservoir or container. In such dryers the process air runs in a closed loop. The thermal connection to the ambient air takes place through the wall of the heat exchanger. Process air and cooling air are not mixed.

[0003] It is well known the importance of providing the customers with appliances which are very efficient in order to reduce energy consumption. This is particularly true for dryers where all the components of the appliance, particularly the heater, require a high level of energy compared to other appliances.

[0004] It is therefore an object of the present invention to provide a closed cycle air-condensing dryer which has better performance in term of energy saving.

[0005] The applicant has discovered a simple way of reducing energy consumption of around 2% or more without impacting adversely other performance characteristics of the appliance. Moreover the solution according to the invention has also other advantages since it decreases the drying cycle time and increases the condensation efficiency by about 11 % and 15% respectively.

[0006] The above object and further advantages are reached thanks to the features listed in the appended claims.

[0007] According to the invention, at least a portion of the heat exchange surfaces is provided with holes through which a controlled portion of hot and humid air coming from the rotating drum can be exhausted.

[0008] Further advantages and features according to the present invention will be disclosed in the following detailed description, provided as a non limiting example, with reference to the attached drawings in which:

- figure 1 is a schematic view of a closed cycle dryer according to the invention;
- figure 2 is a perspective view of a component used in the dryer of figure1;
- figure 3 is a top view of the component of figure 2 according to a second embodiment of the invention; and
- figure 4 is a table showing the results of the invention compared to a known dryer.

[0009] With reference to the drawings, with 10 is indicated the rotating drum of a closed cycle dryer which is fed in 10a with hot air downstream a heater 12. The still hot and humid air is exhausted in 10b from the drum 10 and, after a filter 18, is blown by a fan 14 though a condensing unit 15 provided with an air-cooled heat exchanger 16. The dry and cooled air 22 is then re-circulated to the drum 10. The heat exchanger 16 presents a wall 17 having two sides. A first side 17a is contacted by the hot and humid air 13 coming from the drum 10 while a second side 17b is contacted by air 19 at ambient temperature.

[0010] Process and ambient air are divided by the walls of the heat exchanger where condensation takes place.

[0011] According to the invention, the wall 17 is provided with holes 21 though which a portion of the hot and humid air (and therefore a not-condensed portion of the water vapor) can be directly exhausted to the ambient. Already condensed vapor (liquid) can also be exhausted and will be re-evaporated on the cooling side of the heat exchanger. Condensing and re-evaporating on the cold side will be in a zero energy balance. By using a predetermined number and diameter of holes 21 allows adjusting condensation efficiency, energy consumption and drying time. With the given holes the adjustment of the mentioned values are fixed. Not condensing completely the steam leads to an improvement of drying time and energy consumption.

[0012] In figure 2 it is shown a detail of the air-cooled heat exchanger 16 where the exchange surface or wall 17 is defined by a plurality of flattened and stacked tubes 24 where a defined distance between each couple of tubes is maintained. The heat exchanger 16 is of the removable type for cleaning purposes. In the example shown in figure 2, four tubes are used and only the upper tube is provided with circular holes 21. Such holes are preferably located sidewise near the end 24a of the tube 24 which is close to the cooling air entrance indicated with reference 26.

[0013] The number and dimension of the holes can vary in a quite broad range, but good results have been obtained by providing each tube 24 with from 2 to 15 holes having a diameter from 2 to 8 mm for a total cross section area comprised between 1 and 2 cm^2.

[0014] Through holes 21 in the heat exchanger 16 hot and humid air and condensed water can be sucked helping by re-evaporation to condense steam. Moreover process air can be exhausted out of the circulation pattern without condensing due to the presence of enough heated up air on the cold side of the heat exchanger.

[0015] The direct effect of providing the heat exchanger with holes 21 can be viewed in figure 4 which referrer to the same closed cycle dryer, one without holes (prior art) and the other with holes. It is clear how the simple use of holes in the heat exchanger wall can provide ad-

vantages in terms of time cycle reduction (from 135 minutes to 120 minutes), condensation efficiency (from 84 to 71%, bearing in mind that lower condensation efficiency leads to shorter drying time and smaller energy consumption), and energy consumption (from 0,546 kW/kg to 0,536 kWh/kg).

[0016] In figure 3 it is shown a second embodiment where the holes 21 can be opened and closed by the customer with levers 30 (acting as rotating locks) that are mounted on each flattened tube or plate 24. If the customer opens the holes 21 the process is accelerated and the condensation is reduced and also the energy consumption as well. With the levers 30 the holes 21 can be opened or closed to adjust humidity that will be lead out to ambient.

[0017] Instead of manual adjustment of the lever 30, the dryer can be provided with an electronic control for automatically adjusting the total free area of the holes 21 depending on the drying cycle chosen by the user and by the actual working condition of the appliances (for instance load of laundry, water content thereof, ambient temperature etc.).

[0018] A porous material or a kind o filter can be inserted into the holes 21 in order to avoid lint entering the cold air flow and accumulate on the cold air flow side.

Claims

1. A closed cycle dryer comprising a heating unit (12) used to heat the air that is blown in a rotating drum (10) and a condensing unit (15) upstream the heating unit comprising an air-cooled heat exchanger (16) where the hot and humid air (13) downstream the drum is contacting a first side (17a) of wall (17), a second side of said wall (17) of the heat exchanger being contacted by flowing air (19) at ambient temperature, **characterized in that** at least a portion of said wall (17) is provided with apertures (21) where a portion of the hot and humid air can be exhausted.

2. A closed cycle dryer according to claim 1, wherein said air-cooled heat exchanger (16) presents a plurality of flattened tubes (24) in which ambient air is adapted to flow, the outside surface of said tubes (24) being in contact with the hot and humid flowing air.

3. A closed cycle dryer according to claim 2, wherein the hot and humid hot air is flowing in a direction substantially crossing the direction of ambient air, or in a counter flow or in a parallel flow.

4. A closed cycle dryer according to claim 2 or 3, wherein said flattened tubes (24) are stacked.

5. A closed cycle dryer according to any of claims 2 to 4, wherein the apertures (21) are provided close to a first end of tubes (24) where ambient air is entering.

6. A closed cycle dryer according to any of claims 2-5, wherein a device (30) is provided for adjusting the free area of the apertures (21).

7. A closed cycle dryer according to claim 6, wherein such device is a lever (30) pivoting on the flattened tube (24) and adapted to close/open the apertures (21) thanks to rotation thereof.

8. A closed cycle dryer according to any of the preceding claims, wherein the total area of the apertures (21) is comprised between 1 and 2 cm^2.

9. A closed cycle dryer according to any of the preceding claims, wherein the apertures (21) are provided with a porous material in order to filter lint.

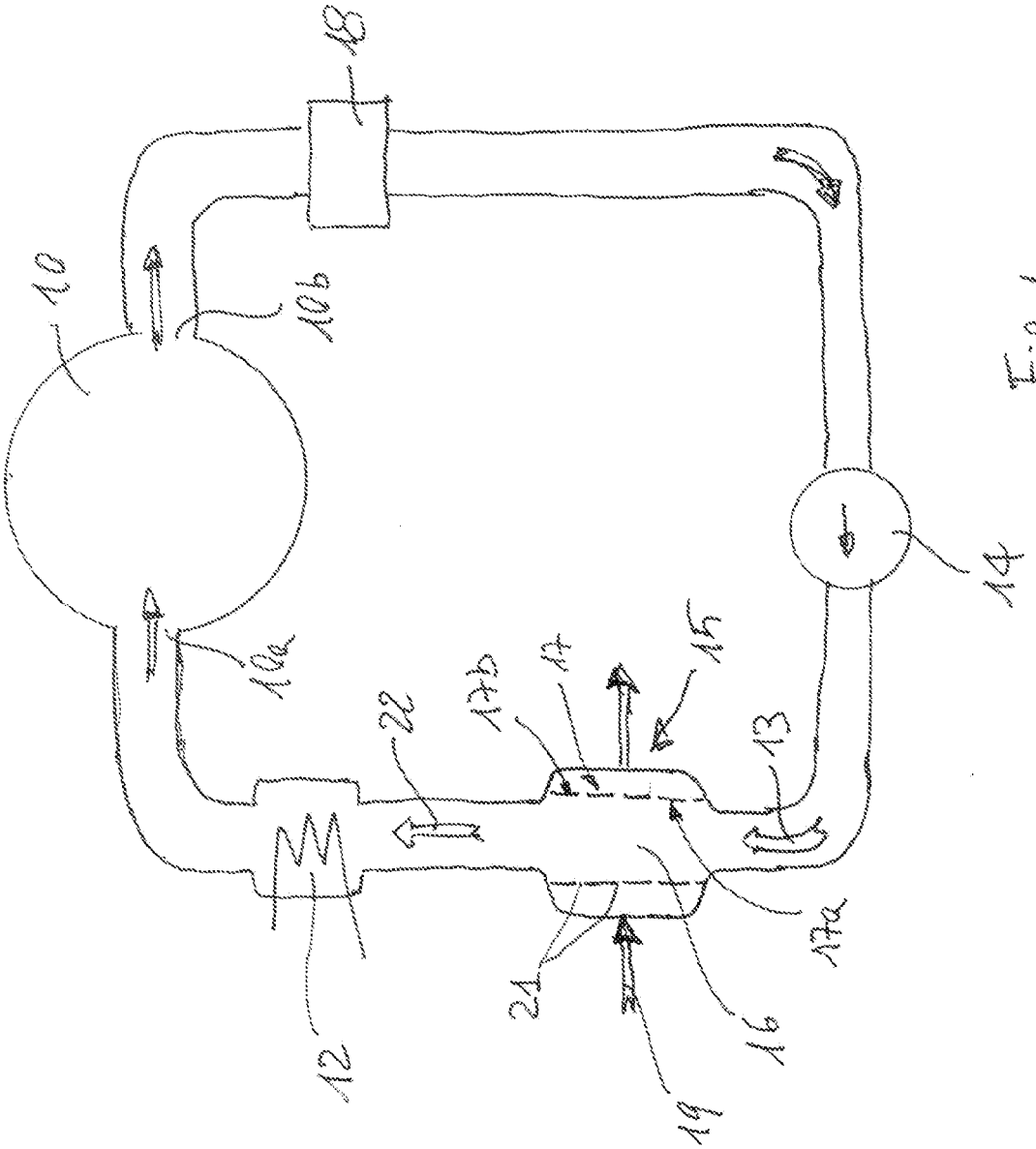


Fig. 1

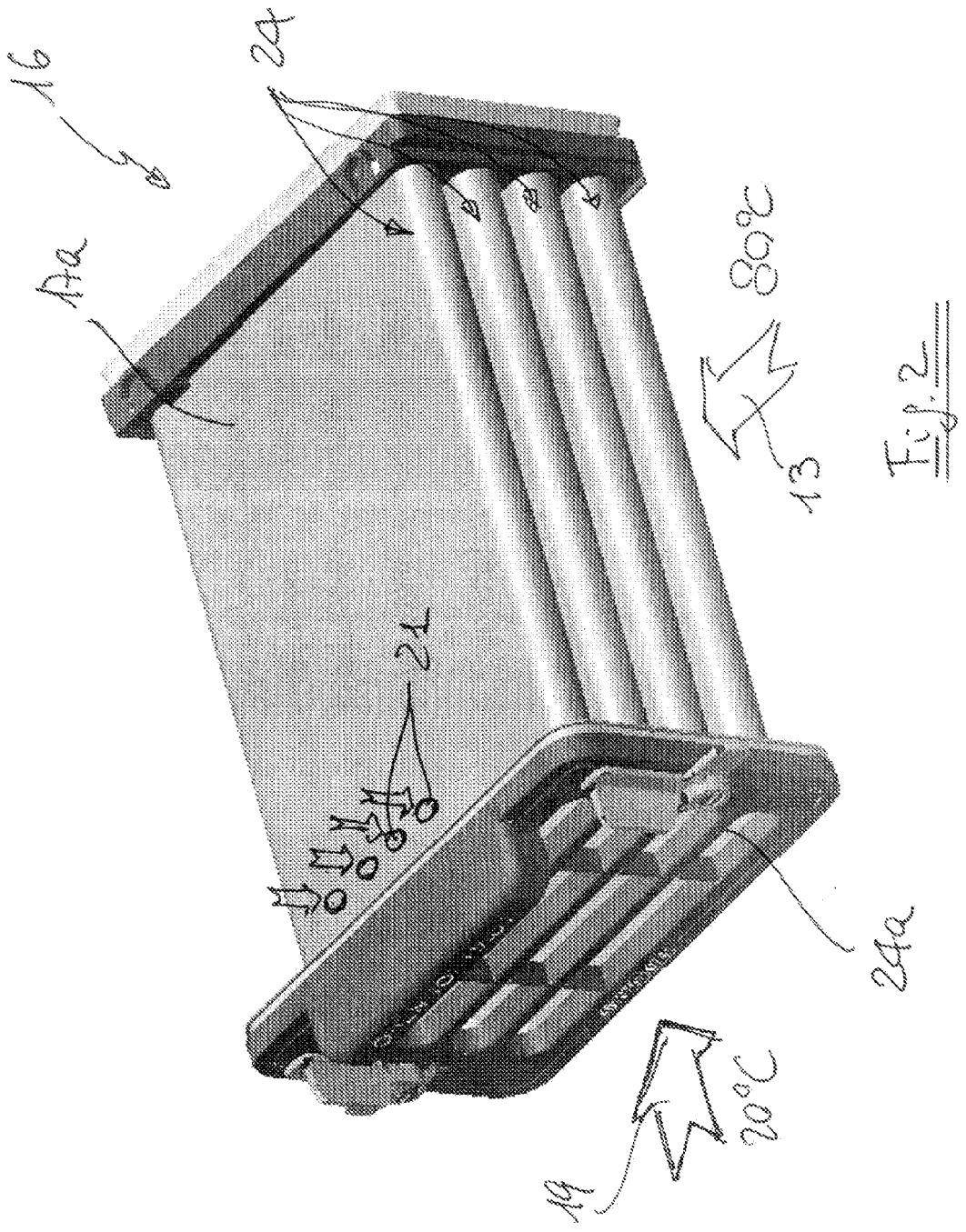


Fig. 2

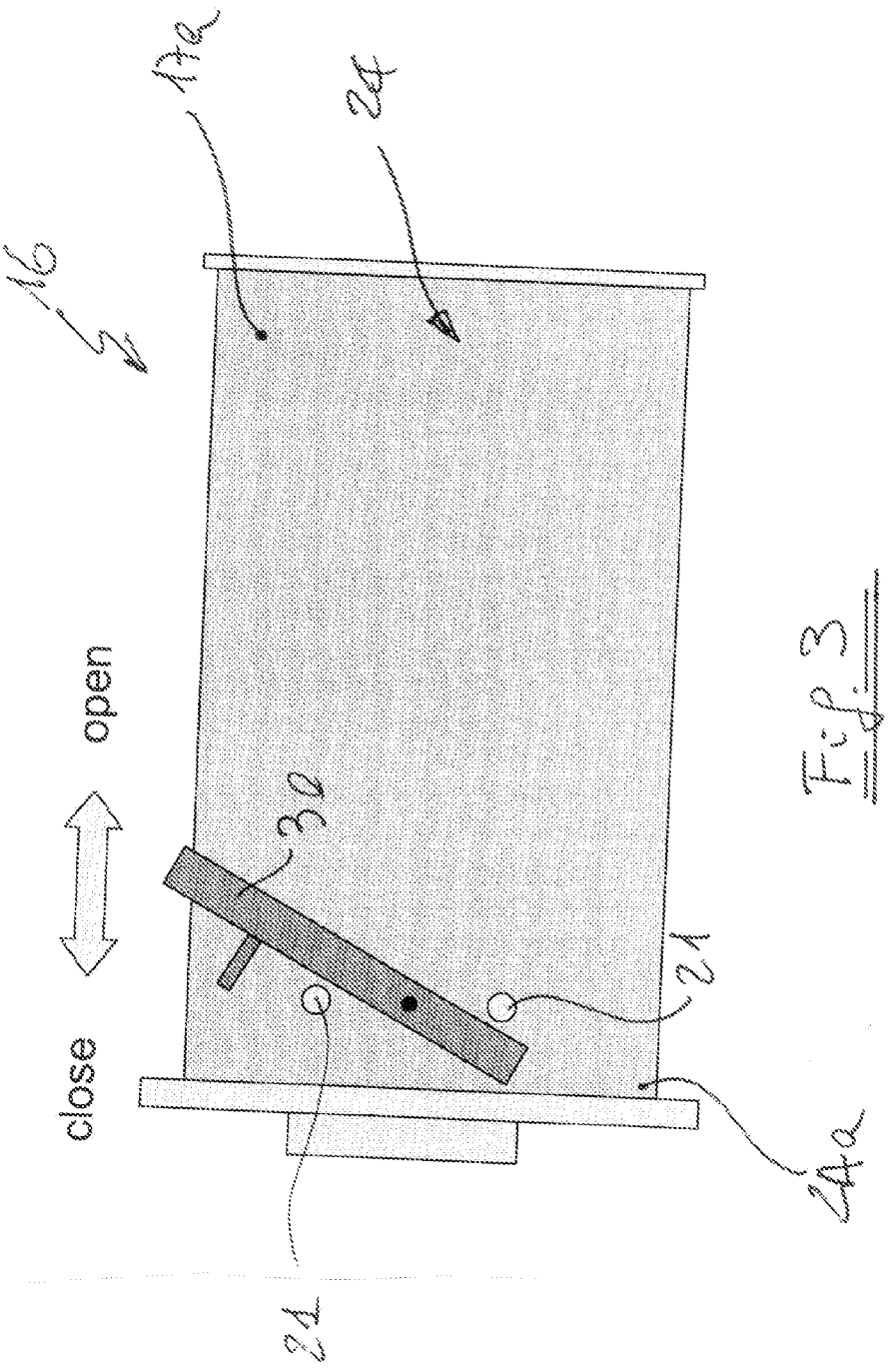


Fig. 3

Power (W)	Load (kg)	Voltage (V)	Program	Energy (kWh)	Time (min)	Condens-ation (%)	Energy/kg load kWh/kg
3000	9	230	cup dry	4,99	140	85	0,5544
3000	9	230	cup dry	4,87	128	86	0,5411
3000	9	230	cup dry	4,9	132	84	0,5444
3000	9	230	cup dry	4,89	140	82	0,5433
				without holes			
				mean values	**135**	**84**	**0,546**
3000	9	230	cup dry	4,82	120	71	0,5356
3000	9	230	cup dry	4,83	121	71	0,5367
				with holes			
				mean values	**120**	**71**	**0,536**

Values are evaluated according IEC standard

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 10 19 2681

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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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
Munich	4 April 2011	Spitzer, Bettina

CATEGORY OF CITED DOCUMENTS

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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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04-04-2011

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