



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**12.01.2005 Bulletin 2005/02**

(51) Int Cl.7: **F25D 21/00**

(21) Application number: **04103090.9**

(22) Date of filing: **30.06.2004**

(84) Designated Contracting States:  
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR**  
**HU IE IT LI LU MC NL PL PT RO SE SI SK TR**  
Designated Extension States:  
**AL HR LT LV MK**

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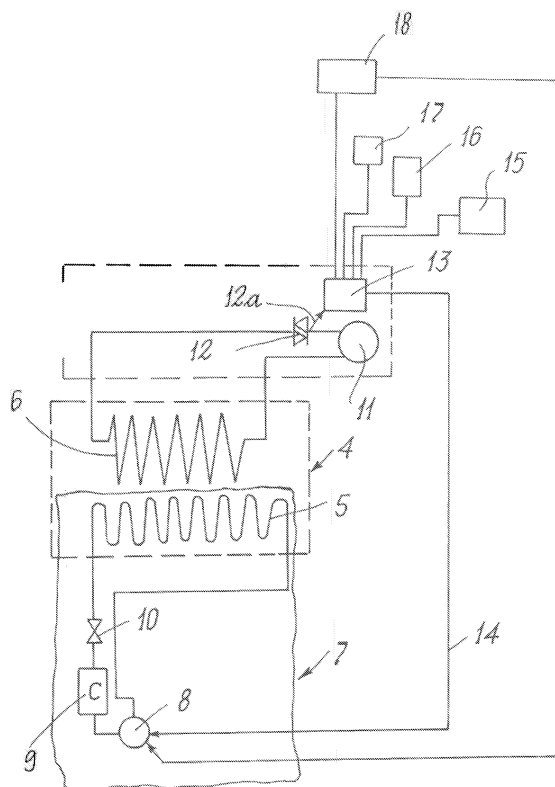
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(30) Priority: **09.07.2003 IT MI20031395**

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(54) **Refrigeration appliance with automatic time-determined defrost**

(57) A refrigeration appliance (refrigerator, freezer and the like), comprising an evaporator (5), a compressor (8) and electrical defrost means (6) for said evaporator (5), in which a microprocessor (13) is present, associated with time measurement means (15, 18) providing the microprocessor (13) with data relative to the functioning of the compressor (8) for the purpose of obtaining from said data a percentage operation of the compressor (8) and an indication of the predicted commencement of defrost (Hdl), this indication being compared with one or more time bands with the purpose of advancing or delaying if necessary the effective commencement of the next defrost so that it takes place within the established time band.



**FIG. 1**

## Description

**[0001]** The present invention relates to a refrigeration appliance with automatic time-determined defrost for containing food, drinks, liquid or solid substances etc.

**[0002]** Refrigeration appliances with automatic defrost systems known colloquially as no-frost refrigerators have long been available. In this type of refrigerator a film of ice forms on the evaporator, usually positioned in the conditioned temperature compartment in contact with the air present in the compartment, due to condensation and subsequent freezing of the moisture present in the air within the compartment. The formation of this ice film prejudices heat transfer between the conditioned environment and the evaporator, so reducing the efficiency of the refrigeration cycle.

**[0003]** No-frost refrigerators present an automatic defrost system based on the activation of an electrical resistance element in heat transfer contact with the evaporator.

**[0004]** The defrost resistance element is activated manually or automatically by electronic devices which control the operating time of the compressor. A new defrost cycle is normally carried out when the total time for which the compressor has operated reaches a predetermined value, for example 8 hours. These 8 hours can evidently be reached over quite different time periods, for example because periods of operation are interrupted by periods of non-operation. Assuming for example that the compressor operates for 50% of the time, a defrost operation will be automatically performed every 16 hours.

**[0005]** The duration of the effective defrost cycle can also be controlled, for example on the basis of the power of the resistance element or the size of the evaporator. In all cases defrosting requires a considerable quantity of electrical energy. For example, just the defrost cycle for a common domestic refrigerator consumes of the order of 250 kWh annually.

**[0006]** In many European countries, night consumption of electrical energy is encouraged to better balance the load on the network energy system. The price of energy is often much lower within these time bands, and often falls to just one quarter of the price during peak hours. For example, in many countries a lower tariff is applied between 10 p.m. and 6 a.m.

**[0007]** As already stated, in traditional automatic defrost systems, defrosting can take place at any moment, and hence at times at which the electrical energy cost is at its highest.

**[0008]** The technical aim of the present invention is therefore to provide a device and process for the night-time defrosting of refrigerators which enable the starting time of the defrost cycle to be optimized, by advancing it or delaying it with respect to the time based on the use of the refrigerator (and hence of the compressor), so that the defrost cycle takes place at least partly during the hours of low energy tariff.

**[0009]** Further characteristics and advantages of the invention will be more apparent from the description of a preferred but non-exclusive embodiment of a night-time defrosting device and process for refrigerators, illustrated by way of non-limiting example in the accompanying drawings, in which:

Figure 1 is a schematic plan view of a refrigeration circuit in accordance with the present invention; and Figure 2 is a flow diagram showing the defrosting control process of the present invention.

**[0010]** With reference to said figures, a refrigerator compartment contains an evaporator unit 4, comprising a substantially hairpin-type evaporator 5 in heat transfer contact with the air present in the compartment and conveyed towards the evaporator 5 by a fan V. A refrigerant fluid flows through the evaporator, with which a suitably sized conventional resistance element 6 is in heat transfer contact. The evaporator 5 forms part of a conventional refrigeration unit 7, comprising a compressor 8, a condenser 9 and a throttle valve 10. The resistance element 6 is connected to a current source 11 and to a static switch 12 (triac), the output 12a of which is controlled by a microprocessor 13. The microprocessor 13 hence controls the opening/closure of the static switch 12 and also, via the line 14, the starting/stopping of the compressor 8 of the circuit of the refrigeration unit 7.

**[0011]** The microprocessor 13 is suitable for making calculations, and is connected to a clock 15, to a timer 18, to a dynamic memory unit 17 and to a static memory unit 16.

**[0012]** The static memory unit 16 stores information regarding the value of preset parameters such as the operating time  $T_r$  required of the defrosting resistance element 6 if this time is not determined by the operation of the bimetallic switch associated with the evaporator, the total operating time  $T_s$  of the compressor 8 after which defrosting is required (8 hours in the example), and the maximum time  $T_{dmax}$  between two consecutive defrost operations (50 hours in the example).

**[0013]** The defrost time comprises both the operating time  $T_r$  of the resistance element and the time required for the compressor to annul the overheating of the environment caused by the resistance element 6 itself; in the example the sum of these two times is quantified as 3 hours. In the example there is only one time band of low tariff electrical energy during the day, this being assumed to be from 10 p.m. to 6 a.m.

**[0014]** The defrost process controlled by the microprocessor takes place as follows with reference to Figure 3:

- S1: reading from the static memory 16 the values of  $T_{dmax}$  (maximum time between two successive defrosts),  $T_s$  (maximum total compressor operating time between two successive defrosts), relative to parameters set in the factory, and of which the value

is optimized to obtain efficient refrigerator operation.

- S2a: executing a defrost procedure by activating the resistance element via the static switch 12, and deactivating the compressor on activation of the resistance element 6. 5
- S2b: reading the current time and date from the clock 15 and assigning the value read from the clock 15 to a variable Od (variable indicating the moment, in terms of the time and date, of termination of the defrost procedure), and storing this value in the dynamic memory 17. 10
- S3: zeroing a variable Tc, provided by the timer 18 and indicating the compressor operating time, zeroing a variable Td, again provided by the timer 18 and indicating the time passed since the last defrost, and zeroing a variable Hd, stored in the dynamic memory 17 and indicating the moment at which the defrost procedure is scheduled to commence. 15
- S4: reading the variables Tc and Td from the timer 18, and which are continuously updated by this latter. 20
- S45: checking whether the value of Td is greater than 3 hours (3 hours is only a sample value. In fact it represents a sampling time, prior to which no prediction is made on the presumed defrost commencement time. This value can be optimized at will). If greater than 3 the procedure executes S5, i.e. the prediction procedure commences, otherwise it waits and repeats S4. 25
- S5: calculating the value of a variable Tp equal to  $(T_d/T_c) \cdot (T_s - T_c)$ ; the variable defined in this manner is a prediction, made on the basis of a percentage utilization of the compressor ( $T_d/T_c$ ), of the time which will pass before the compressor has operated for a total time equal to  $T_s$  (in this example  $T_s = 8$  hours). 30
- S6: reading the time and date of the last defrost stored in the dynamic memory 17 as Od, adding it to Tp and hence determining the time and date predicted for the next defrost cycle and storing this in the dynamic memory 17 as the value of the variable Hd1. 35
- S7: determining the value of the variable Hd2 as the sum of the time and date read from the clock and the preset parameter Tdmax, then storing this in the dynamic memory 17 to hence determine the moment of the next defrost on the basis of the preset maximum time between two consecutive defrosts. 40
- S8: comparing the values of Hd2 and Hd1 and determining the earlier, to establish and hence choose which of the two moments of defrost is closer in time. 45
- S9a/S9b: assigning to the parameter Hd the value determined by the comparison made at point S8. 50
- S10: checking whether the value of Hd lies (end values included) between 10 p.m. and 3 a.m., i.e.

whether the commencement of the defrost cycle is scheduled within the low tariff band. This band does not extend until 6 a.m. as the defrost cycle is scheduled to last 3 hours at most. If it lies therebetween, the procedure executes S11, otherwise it executes S12. (The times representing the ends of the band are evidently provided by way of example, and can be varied according to the case in point).

- S11: reading the current time and date from the clock 15 and verifying that they are equal to Hd, i.e. whether it is time for defrosting. If they are equal, the procedure executes S2a/S2b, otherwise it executes S4 to continue the cycle.
- S12: checking whether the value Hd lies between 3 a.m. and 2 p.m. If it lies therebetween, S13 is executed, otherwise S16.
- S13: checking whether the value Hd1 (variable calculated on the basis of compressor switch-on) has been chosen for the value Hd, in which case S14 is executed, otherwise S15.
- S14: checking whether the value of Tc is greater than or equal to Ts, i.e. whether the compressor has already operated for more than Ts hours. If less, S4 is executed, if greater S15 is executed.
- S15: setting a parameter Hd at 3 a.m. and executing S17, hence anticipating the defrost cycle.
- S16: setting a parameter Hd at 10 p.m. and executing S17, so delaying the moment of commencement of the defrost cycle; if  $Hd1 < Hd2$  the moment of commencement of the defrost cycle is delayed to the required extent, by making the compressor operate for more than the scheduled time Ts, then activating it as soon as within the low tariff band.
- S17: reading the current time and date from the clock 15 and verifying that these are equal to the Hd values set during the preceding steps, then executing S2a/S2b, i.e. the defrost cycle, if the verification is positive; if negative, S4 is effected.

**[0015]** Modifications and variants are possible, in addition to those already stated; for example the parameters Tdmax, Ts, Tr can have different values, suitable for a particular environment or apparatus. The said parameters can be decided each time, so that they become variables (for example  $T_s(T_d)$ ), determined automatically by the microprocessor 13 according to the values of other variables, such as the number of openings of the door 2f, the ambient temperature, atmospheric humidity, etc. The time Tp for which the defrost resistance element operates can be preset or determined by the (bimetallic) temperature switch present on the evaporator 5.

**[0016]** In the same manner the calculation of the time and date effected in S5 for the next defrost cycle can be based on more complex calculation algorithms with a greater number of variables, such as ambient temperature, atmospheric humidity or the number of openings of the door 2f.

[0017] In addition,  $T_d/T_c$  can be checked downstream of S5 to determine if equal to 1, i.e. that the compressor 8 has operated for the entire time following defrost; if  $T_d=T_c=T_s$  (8 hours) the calculation is not made and defrosting takes place as soon as time  $T_s$  is reached. This could indicate abnormal refrigerator operation or particular conditions such as a semi-open door.

[0018] In this case certain checks can be made to exclude malfunction. For example continuous operation of the compressor 8 for a lengthy period could be due to the fact that fast freezing has been requested manually, the fact that ambient temperature has changed abnormally, the fact that the door has been recently opened, the fact that settings of the refrigerator thermostat have been changed, or other factors.

[0019] In the case of anomalies such as a slightly open door or an inexplicable temperature rise, a buzzer can sound or any other visual or acoustic signals be provided.

[0020] The clock 15 can be set manually by the user or be of radio-controlled automatically set type.

[0021] The low tariff band can be different from that from 10 p.m. to 6 a.m. There can also be more than one time band (of low tariff or otherwise) within which defrost is allowed to take place.

[0022] A preferred embodiment has been illustrated, however others can be devised using the same inventive concept.

compared with a predetermined value, the earlier of the two being chosen as the time to activate the next defrost

4. A refrigeration appliance as claimed in claim 3, **characterised in that** the chosen earlier value is compared with one or more time bands to examine the convenience of attributing this chosen earlier value to one or other band in order to advance or delay if necessary the effective commencement of the next defrost so that this takes place within the established time band.

## Claims

1. A refrigeration appliance (refrigerator, freezer and the like), comprising an evaporator (5), a compressor (8) and electrical defrost means (6) for said evaporator (5), **characterised by** comprising a microprocessor (13) associated with time measurement means (15, 18) providing the microprocessor (13) with data relative to the functioning of the compressor (8) for the purpose of obtaining from said data a percentage operation of the compressor (8) and an indication of the predicted commencement of defrost ( $Hd1$ ), this indication being compared with one or more time bands with the purpose of advancing or delaying if necessary the effective commencement of the next defrost so that it takes place within the established time band.
2. A refrigeration appliance as claimed in claim 1, **characterised in that** the percentage is calculated as the time of operation of the compressor ( $T_c$ ), divided by the total time ( $T_d$ ) formed by the sum of the time of operation of the compressor ( $T_c$ ) plus the time of non-operation of the compressor.
3. A refrigeration appliance as claimed in claim 1, **characterised in that** the value of the indication of the predicted commencement of defrost ( $Hd1$ ) is

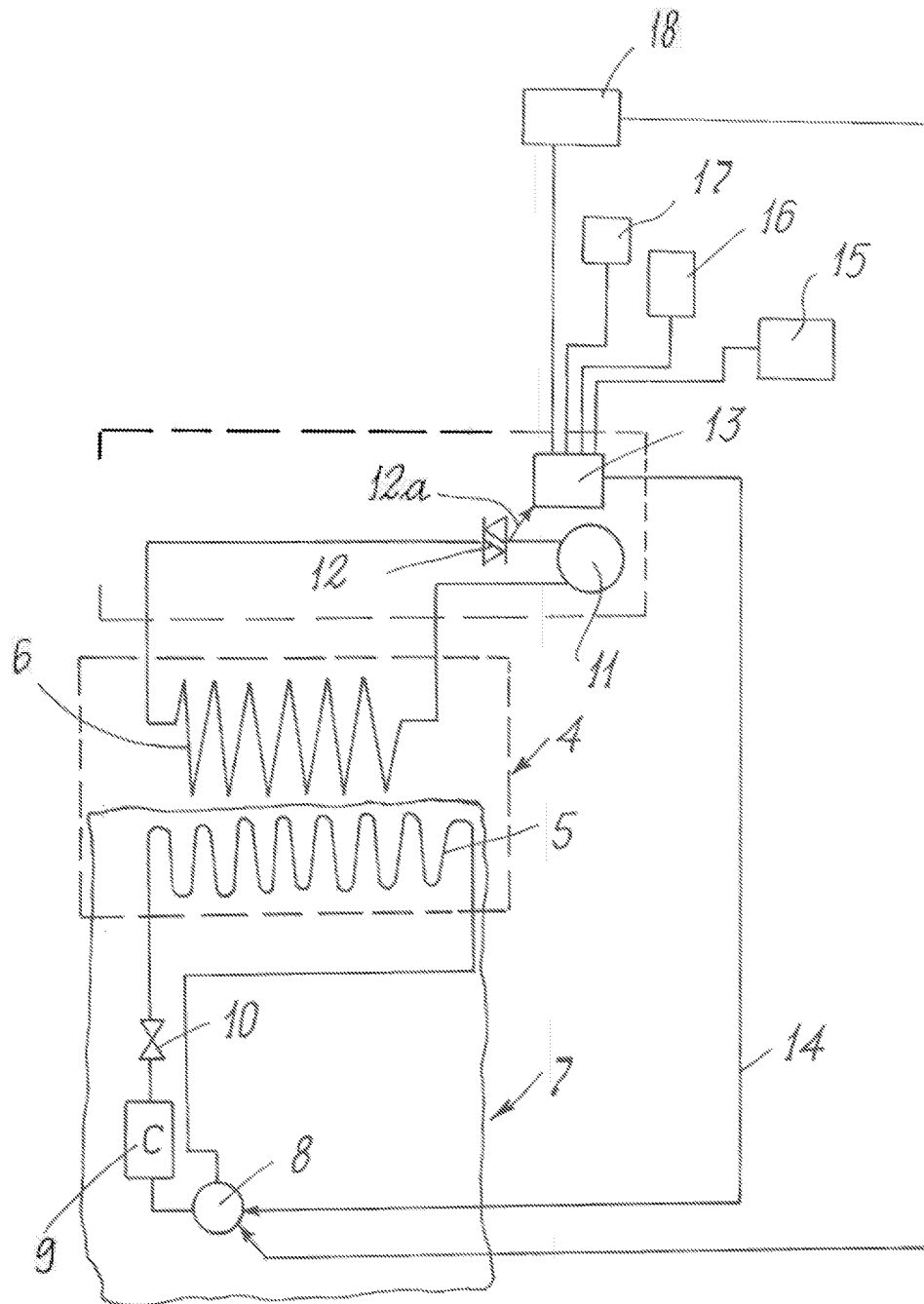
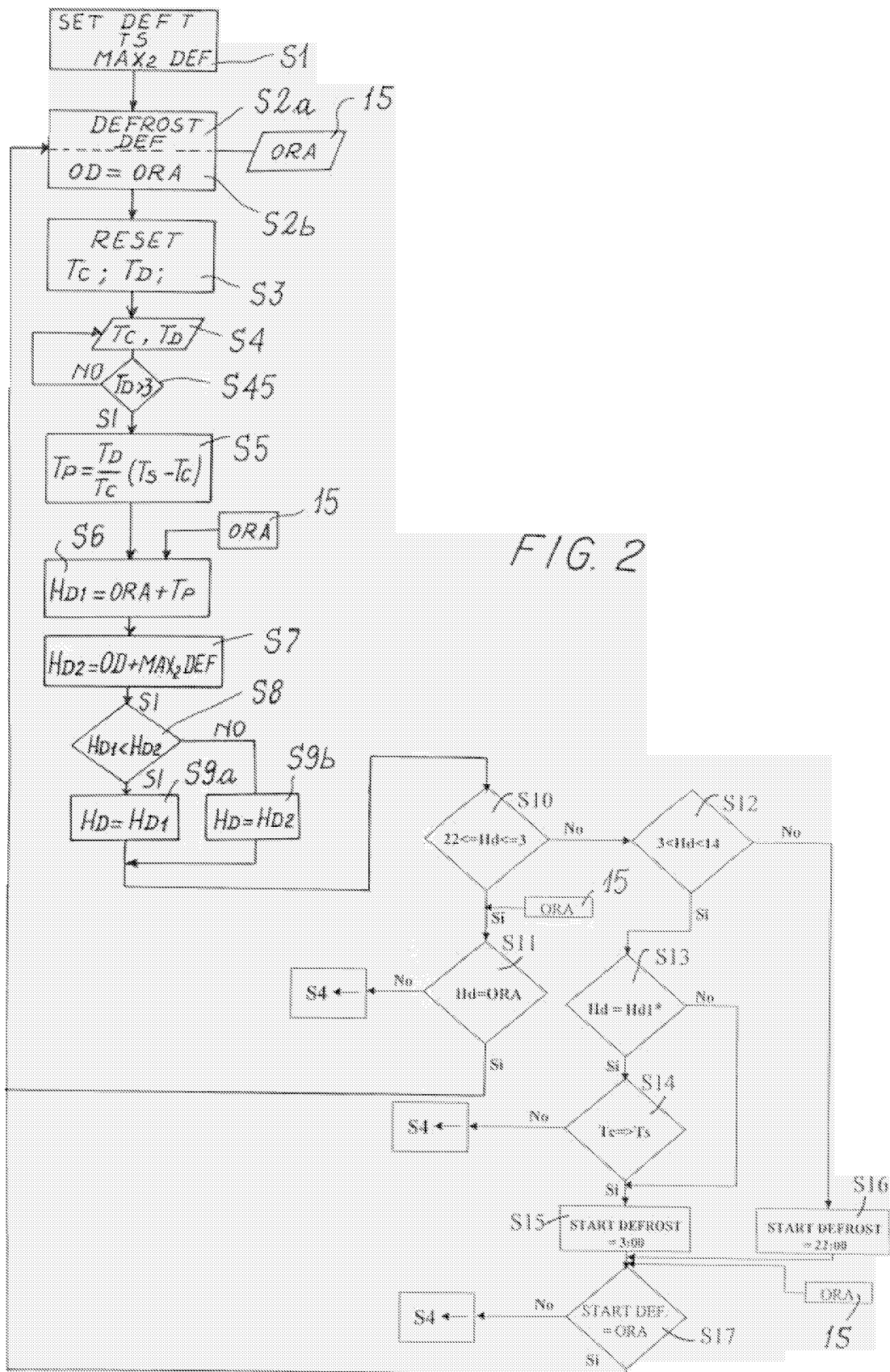


FIG. 1





European Patent  
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Application Number  
EP 04 10 3090

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                |                                                      |                                              |
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| Place of search<br>Munich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                | Date of completion of the search<br>12 November 2004 | Examiner<br>Salaün, E                        |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>D : document cited in the application<br/>L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p> |                                                                                                                                                                                |                                                      |                                              |

EPO FORM 1503 03.82 (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.  
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