

**(12) STANDARD PATENT**  
**(19) AUSTRALIAN PATENT OFFICE**

(11) Application No. **AU 2011252057 B2**

- (54) Title  
**Customized control of the thermal comfort of an occupant of a building**
- (51) International Patent Classification(s)  
**F24F 11/00** (2006.01)
- (21) Application No: **2011252057** (22) Date of Filing: **2011.05.11**
- (87) WIPO No: **WO11/141506**
- (30) Priority Data
- |                |                   |              |
|----------------|-------------------|--------------|
| (31) Number    | (32) Date         | (33) Country |
| <b>1053752</b> | <b>2010.05.12</b> | <b>FR</b>    |
- (43) Publication Date: **2011.11.17**  
(44) Accepted Journal Date: **2015.01.15**
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- (56) Related Art  
**US 5762265**  
**US 6145751**  
**EP 2123986**  
**US 5674007**  
**US 5170935**

(12) DEMANDE INTERNATIONALE PUBLIÉE EN VERTU DU TRAITÉ DE COOPÉRATION EN MATIÈRE DE BREVETS (PCT)

(19) Organisation Mondiale de la Propriété  
Intellectuelle  
Bureau international



(10) Numéro de publication internationale  
**WO 2011/141506 A1**

(43) Date de la publication internationale  
17 novembre 2011 (17.11.2011)

PCT

(51) Classification internationale des brevets :  
F24F 11/00 (2006.01)

(21) Numéro de la demande internationale :  
PCT/EP2011/057601

(22) Date de dépôt international :  
11 mai 2011 (11.05.2011)

(25) Langue de dépôt : français

(26) Langue de publication : français

(30) Données relatives à la priorité :  
1053752 12 mai 2010 (12.05.2010) FR

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(81) États désignés (sauf indication contraire, pour tout titre  
de protection nationale disponible) : AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,  
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,  
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,  
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,  
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,  
NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD,  
SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,  
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) États désignés (sauf indication contraire, pour tout titre  
de protection régionale disponible) : ARIPO (BW, GII,  
GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG,  
ZM, ZW), eurasien (AM, AZ, BY, KG, KZ, MD, RU, TJ,  
TM), européen (AL, AT, BE, BG, CH, CY, CZ, DE, DK,  
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,  
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,  
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, ML, MR, NE, SN, TD, TG).

Publiée :

— avec rapport de recherche internationale (Art. 21(3))

[Suite sur la page suivante]

(54) Title : CUSTOMIZED CONTROL OF THE THERMAL COMFORT OF AN OCCUPANT OF A BUILDING

(54) Titre : CONTRÔLE PERSONNALISÉ DU CONFORT THERMIQUE D'UN OCCUPANT D'UN BÂTIMENT

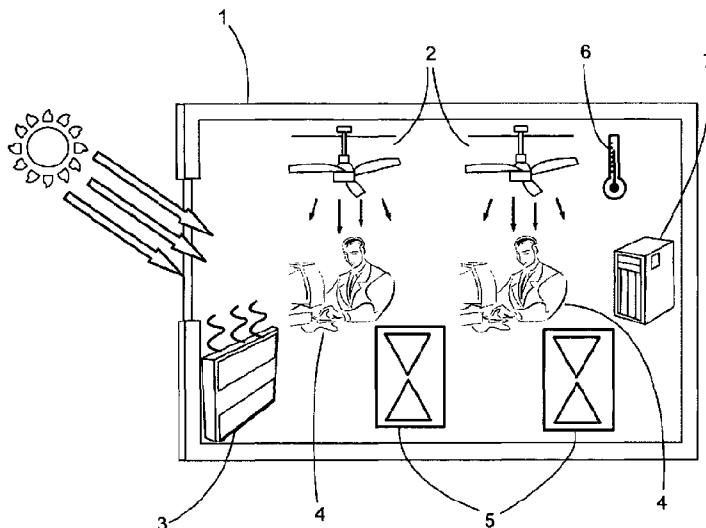


FIG.1

(57) Abstract : Method of controlling a heating and/or air conditioning and/or ventilation system (CVC), characterized in that it comprises the steps consisting in (12) - calculating a theoretical thermal comfort parameter (PMValgo) for at least one occupant of at least one zone of a building on the basis of at least one parameter specific to the occupant such as his metabolism (met) and/or his clothing (clo) and controlling a heating and/or air conditioning and/or ventilation system (CVC) in such a way that the theoretical thermal comfort parameter converges to a predefined thermal comfort range corresponding to a satisfactory comfort, (17) - correction of at least one parameter specific to the occupant if the occupant's actual thermal sensation is not satisfactory.

(57) Abrégé : Procédé de contrôle d'un système de chauffage et/ou climatisation et/ou de ventilation (CVC), caractérisé en ce qu'il comprend les étapes consistant à : (12) - Calculer un paramètre de confort thermique théorique (PMValgo) pour au

moins un occupant d'au moins une zone d'un bâtiment à partir d'au moins

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- avant l'expiration du délai prévu pour la modification des revendications, sera republiée si des modifications sont reçues (règle 48.2.h))

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un paramètre propre à l'occupant comme son métabolisme (met) et/ou sa vêtue (clo) et contrôler un système de chauffage et/ou climatisation et/ou de ventilation (CVC) de sorte que le paramètre de confort thermique théorique converge vers une plage de confort thermique prédéfinie correspondant à un confort satisfaisant, (17) - Correction d'au moins un paramètre propre à l'occupant si la sensation thermique réelle de l'occupant n'est pas satisfaisante.

## Customized control of the thermal comfort of an occupant of a building

The invention concerns a method of controlling a heating and/or ventilation and/or air-conditioning (HVAC) system and a heating and/or ventilation and/or air-conditioning system employing such a method. It also relates to  
5 a medium containing software implementing such a method. Finally, it also concerns a building equipped with such an HVAC system.

The most widespread way of controlling a heating/ventilation/air-  
10 conditioning (HVAC) system generally utilizes as the main control parameter the temperature of the air present in a certain closed space occupied by persons called "occupants". In this control method, the manager or the occupant determines fixed set point values of the temperature and the air speed required of the HVAC system and the  
15 HVAC system is controlled so as to achieve those set point values. Such a control method proves highly unsatisfactory for achieving satisfactory comfort of the occupants of a building.

To improve on these widespread methods, more sophisticated control  
20 methods further base the control of an HVAC system on a more complex approach taking into account two parameters specific to an occupant of a building, the metabolic rate (met), which represents the heat production of the human body ( $1 \text{ met} = 58 \text{ W/m}^2$ ), and the clothing (clo), which represents the thermal insulation of the clothes ( $1 \text{ clo} = 0.155 \text{ K} \cdot \text{m}^2/\text{W}$ ).  
25 Such an approach generally uses the so-called Fanger thermal sensation model and calculates a theoretical occupant comfort index known as the Predicted Mean Vote (PMV) based on four environmental parameters, the temperature of the internal air ( $T_a$ ), the air speed ( $V_a$ ), the mean radiant temperature ( $T_r$ ) and the relative humidity (RH), and the two parameters  
30 specific to an occupant referred to above, the metabolic rate (met) and the

clothing (clo). This more refined approach thus makes it possible to take better account of thermal phenomena important to an occupant of a building, notably by taking into account parameters specific to an occupant and a set of environmental parameters influencing the thermal sensation  
5 of the occupant.

Even systems based on this second approach have numerous drawbacks, however, including the following:

- 10       - they use average values for a given area of a building, in which all occupants are deemed to experience the same thermal comfort;
- 15       - they are based on simplified and coarse hypotheses in respect of the parameters specific to the occupants, for which a constant value is chosen, the same for all occupants of the same thermal area, possibly varying with the season: this application of the method, which ignores the specifics of each person in terms of morphology, usual clothing, metabolic cycle, does not take into account the differences between the thermal sensations of the different occupants; a standard of comfort is imposed on all and  
20       nobody has personalized control of their own comfort;
- 25       - they do not always take into account the presence and the feelings (which are personal and subjective) of more than one occupant in each thermal area;
- 30       - they use linearized comfort indices, based on an hypothesis of constant parameters (met; clo), such as the index V in the document US5170935;
- they require costly computer resources to implement complex optimization calculations intended to cause the thermal sensation calculated by the algorithm to tend toward the actual thermal sensation of the occupant, sometimes necessitating a

long step of regular calibration, like the solution described in the document US5170935.

Accordingly, a general object of the invention is to propose an enhanced  
5 solution for the control of an HVAC system that removes some or all of the drawbacks referred to above.

To be more precise, the aim of the invention is to achieve some or all of  
the following objects:

10

A first object of the invention is to propose a solution for controlling an HVAC system that takes account of the comfort of different occupants in each thermal area of the same building.

15 A second object of the invention is to propose a solution for controlling an HVAC system that does not require excessively complex and costly computer means, regardless of the number of occupants of the building.

To this end, the invention provides a method of controlling a heating  
20 and/or ventilation and/or air-conditioning (HVAC) system, characterized in that it comprises the steps of:

– Calculation of a theoretical thermal comfort parameter (PMValgo)  
for at least one occupant of at least one area of a building on the  
basis of at least one parameter specific to the occupant, such as  
25 their metabolic rate (met) and/or their clothing (clo), and controlling  
a heating and/or ventilation and/or air-conditioning (HVAC) system  
so that the theoretical thermal comfort parameter converges toward  
a predefined thermal comfort range corresponding to a satisfactory  
level of comfort,

- Correction of at least one parameter specific to the occupant if the real thermal sensation of the occupant is unsatisfactory.

5 The correction consists in the modification of one or more parameters specific to the occupant without modifying other elements of the calculation.

10 The invention also relates to a computer medium containing a computer program executing the steps of the method described above of controlling a heating and/or ventilation and/or air-conditioning (HVAC) system.

15 The invention further relates to a heating and/or ventilation and/or air-conditioning (HVAC) system comprising a heating and/or air-conditioning device and/or a ventilation device, one or more sensors for measuring at least one environmental parameter, control means comprising actuators enabling modification of the operating conditions of the HVAC system as a function of at least one calculated set point value, characterized in that it comprises means for taking into account the real thermal sensation of at least one occupant and means for implementing the control method  
20 described above.

The invention further relates to a building characterized in that it incorporates a heating and/or ventilation and/or air-conditioning system employing the control method described above.

25

The invention further relates to a man-machine interface of a heating and/or ventilation and/or air-conditioning (HVAC) system including means for entering the real thermal sensation of an occupant of a building.

The man-machine interface may offer the possibility of entering, from six different thermal sensation levels, three "hot" levels and three "cold" levels and/or may include the display of at least one suggestion for improving the comfort of an occupant and/or the display of environmental parameter values and/or the display of the value of a theoretical comfort parameter and/or the display of the energy consumption and/or the display of the stable or transient state of the HVAC system.

The invention is more particularly defined by the claims.

These objects, features and advantages of the present invention will be set out in detail in the following nonlimiting description of one particular embodiment given with reference to the appended figures, in which:

Figure 1 shows diagrammatically a thermal area of a building including an HVAC system of one embodiment of the invention.

Figure 2 represents a man-machine interface (MMI) of the HVAC system of this embodiment of the invention.

Figure 3 represents diagrammatically an algorithm employed by the HVAC system control method of this embodiment of the invention.

Figure 4 represents, for this embodiment of the invention, the evolution in time over a winter day of environmental parameters, the real PMV of an occupant and the PMV calculated by the algorithm associated with this occupant.

Figure 5 represents in detail, for this embodiment of the invention, the evolution of these parameters in the graph (PMV, Ta) on intervention of an occupant via the MMI, corresponding to the time t1 in figure 4.

- 5 The embodiment of the invention described defines an HVAC system comprising an individual ventilation system 2 combined with a heating and air-conditioning system 3 (the latter two functions may instead be separated), suitable for a tertiary building 1, and more generally for any enclosed space, such as a vehicle, a dwelling, etc. The operation of the
- 10 heating/ventilation/air-conditioning (HVAC) system is controlled by a device based on hardware and/or software on the basis of control parameters such as the temperature (Ta) and the air speed (Va), enabling action on thermal and/or airflow actuators, not represented, to define the chosen operation of the heating, ventilation and air-conditioning system.
- 15 The device includes measurement sensors 6 connected to computer means 7 for implementing the steps of an HVAC system control method to be described hereinafter.

According to an essential feature of the invention, the HVAC system

20 further includes means for taking into account the real thermal sensation of the occupants, notably through means enabling an occupant 4 to intervene. In the chosen embodiment, these means are based on a man-machine interface 5 personal to each occupant 4 of the building 1, by means of which they enter the thermal sensation they are experiencing

25 from a plurality of predefined choices, the result of which is transmitted to the computer means 7 for them to take it into account.

Figure 2 represents an example of a man-machine interface (MMI) 5 in the form of a housing comprising control buttons and a screen for the display

30 of information such as environmental parameters, energy consumption,

and the evaluation of the thermal comfort of the occupant achieved by controlling the HVAC system. This man-machine interface 5 offers an occupant 4 the choice of six different thermal sensations distributed around the central value corresponding to the required comfort. Thus an occupant can indicate that they are hot, very hot or too hot or that they have a sensation of cool, cold or too cold. The man-machine interface 5 enables them to enter this simply by pressing one of the six control buttons 8 offering the six choices defined above. Alternatively, the man-machine interface may take the form of a touch-sensitive screen or an application on their computer or a portable object such as a telephone. Note that the occupant does not do anything if they are satisfied with their thermal comfort.

In the chosen embodiment, controlling the thermal comfort of an occupant is based on the Fanger model referred to above. This model defines seven levels of thermal sensation corresponding to a comfort index (PMV) and a predicted percentage dissatisfied (PPD) by their thermal comfort.

PMV	PPD	Associated thermal sensation
+3	100%	Very hot
+2	76.8%	Hot
+1	26.1%	Warm
0	5%	Neutral
-1	26.1%	Cool
-2	76.8%	Cold
-3	100%	Very cold

The so-called neutral thermal sensation, for which the thermal comfort index PMV takes a zero value, corresponds to the optimum comfort.

A PMV in the range  $]-0,5; +0,5[$ , corresponding to class B of thermal comfort as defined in ISO 7730, generates a maximum of 10% of persons dissatisfied by their thermal comfort. This comfort range, often recommended, is the target of the control algorithm. Any other comfort

range, whether or not defined in the ISO 7730 standard, may likewise be envisaged.

Accordingly, the HVAC system of this embodiment of the invention uses a  
5 man-machine interface 5 comprising six control buttons corresponding to  
the six thermal sensations around the neutral value aimed for, as defined  
by the Fanger model. Any other choice enabling quantification of the  
thermal sensation of the occupant may naturally be envisaged instead.

10 The invention relates to a method of controlling an HVAC system as  
defined above which therefore takes into account the real thermal  
sensation of each occupant of the building. The real thermal sensation is  
thus defined as that felt directly by an occupant, which they can evaluate  
15 qualitatively and associate with a real thermal comfort deduced directly  
from their real thermal sensation. This method of controlling an HVAC  
system is based on the calculation of a theoretical comfort parameter with  
the aim of bringing it as close as possible to the real theoretical comfort  
experienced in order to obtain pertinent and effective control of the HVAC  
system.

20

To this end, the control method uses values of the parameters specific to  
an occupant, the metabolic rate (met) and the clothing (clo), which are  
initialized on the basis of predefined hypotheses. These initial values may  
depend on the season, the type of activity in the room, the habits of the  
25 occupants, etc. However, according to the concept of the invention, at  
least one of the parameters specific to an occupant is modified, corrected,  
if the occupant indicates, by actuating a button of the MMI, that their real  
thermal sensation is departing from the neutral value aimed at.

Figure 3 represents the algorithm employed by the method of this embodiment of the invention of controlling the HVAC system of a building, which applies to each occupant of the building, which is divided into thermal areas per occupant. These different thermal areas of the building  
5 may correspond to separate rooms or to different areas of the same space each having a terminal for control of the interior temperature, for example in non-partitioned offices of the "open space" type.

In a first step 10, the two parameters specific to an occupant, the  
10 metabolic rate  $met$  and the clothing  $clo$ , according to the chosen calculation model, are initialized to a predefined value, as explained above. These initial values may depend on the occupants, the season, etc.

15 In a second step 11, the four parameters representing the interior ambience at the level of the occupant used in the Fanger model, the interior air temperature  $T_a$ , the mean radiant temperature  $T_r$ , the air speed  $V_a$  at the level of the occupant, the relative humidity  $RH$ , are measured in the thermal area concerned, or alternatively deduced by a calculation  
20 model. To this end, the HVAC system includes one or more suitable sensors 6 situated in each controlled area of the building. The measurements obtained can optionally be corrected by calculation models.

25 In a third step 12, the thermal comfort parameter  $PMV$  associated with the occupant is calculated, in the manner defined by the prior art Fanger model, on the basis of the two parameters specific to the occupant and the four environmental parameters, as outlined above. This thermal comfort parameter is therefore a theoretical comfort parameter denoted  $PMV_{algo}$ .  
30 It is calculated for each occupant of the building.

In a fourth step 13, a control unit calculates set point values ( $Ta\_set$ ;  $Va\_set$ ) for the HVAC system of each area of the building so that the PMV<sub>algo</sub> associated with each occupant converges toward a comfort range defined as above, with minimum energy consumption.  $Ta\_set$  calculated by this control unit is common to all the occupants of the same thermal area, whereas  $Va\_set$  can in the case of an individual ventilation system be different for each occupant. To this end, the method uses a known control process that enables the values of the environmental parameters of the area concerned to be modified by action on various actuators modifying the operation of the HVAC system to converge toward the set point values.

In a fifth step 14, the control unit verifies if the environmental conditions of the thermal area concerned have reached a stable state, i.e. if the control mechanism used has enabled convergence toward the defined set point values. The convergence time of this transient phase corresponds to the time constant of the system. Throughout this time, the HVAC system is in a transient state, which may be indicated by a message such as "in processing" displayed on the man-machine interface. Such a state indicates to an occupant that the environmental conditions are changing and that even if they are experiencing a sensation of discomfort at the present time, they may not intervene on the system and must be patient.

When the above convergence terminates, the HVAC system leaves its transient state for a stable state. In such a situation, the occupant has the possibility in a sixth step 15 of indicating that their thermal comfort is not satisfactory, via the man-machine interface 5 described above. This is reflected in a thermal comfort input parameter PMV<sub>mml</sub> of the control method, the value of which differs from the theoretical comfort index

PMValgo calculated before, and which corresponds to an estimate of the real thermal comfort of the occupant. It will therefore be called, by an abuse of language, the real thermal comfort parameter.

- 5 If the occupant is satisfied with their level of comfort, the control method repeats the preceding steps 11 to 14 at a predefined frequency. If the occupant indicates that their comfort is not satisfactory, the control method then executes the following additional steps:
- 10 A seventh step 16 consists in calculating the error between the theoretical comfort parameter PMValgo calculated before and the real comfort parameter PMVmmi representative of the actual thermal sensation of the occupant.
- 15 In an eighth step 17, the HVAC system considers that the foregoing difference stems from an error as to the non-verifiable hypotheses made as to the parameters specific to the occupant, and effects a calculation for correction of at least one of these parameters so that a new calculation of the thermal comfort parameter PMValgo by the Fanger model, as effected
- 20 in the third step 12, gives a result for the theoretical thermal comfort parameter PMValgo conforming to the real comfort of the occupant, i.e.  $PMValgo = PMVmmi$ , and this coincidence of PMValgo and the PMV experienced by the occupant continues, even after future variations in the temperature and/or the air speed that will thereafter make it possible to
- 25 return to the comfort range.

In the chosen embodiment, the control method modifies only the metabolic rate parameter  $met$  to a new value  $met^*$  that will be referred to as the resultant metabolic rate and leaves the clothing parameter  $clo$  unchanged.

- 30 The metabolic rate parameter is chosen as the adjustment personal

parameter because it depends more particularly on the occupant, varies greatly according to the person, their age, sex, corpulence, height, health, etc., whereas the clothing parameter  $clo$  is more linked to the season and to the climate than to the occupant. The method could however be implemented instead by modifying only the clothing parameter  $clo$  or by modifying only these two parameters  $met$ ,  $clo$ . In all cases, although the new parameters specific to the occupant taken into account by the algorithm, in this embodiment  $met^*$  and  $clo$ , are probably different from the real parameters specific to the occupant, these adjustment parameters make it possible to arrive at the equality  $PMValgo = PMVmmi$  and to preserve a very good coincidence between  $PMValgo$  and the comfort  $PMV$  experienced by the occupant following the variations in temperature and/or air speed enabling a return to the comfort range.

The new metabolic rate value  $met^*$  is obtained by an iterative method using the following arithmetical series:  $met_{p+1} = met_p + p$ , where the initial value  $met_0$  corresponds to the value existing before actuation of the MMI by the occupant and  $p$  corresponds to a step the sign of which takes account of the fact that the  $PMV$  is an increasing function of  $met$ . For example,  $p = 0.01 * \text{sign}(PMVmmi - PMValgo(met_n))$ . On each step, a new value  $PMValgo(met_p)$  of the thermal comfort is obtained. This iterative process is continued until a thermal comfort value  $PMValgo \approx PMVmmi$  is reached. When this value is reached, the new metabolic rate value  $met^*$  metabolic rate is fixed, so that the following corresponding relationship is obtained:  $PMValgo = PMVmmi = PMV(met^*)$ .

In this embodiment of the invention, the HVAC system employs a ninth step 18 that consists in detecting excessive demands by an occupant. To this end, it verifies if the new parameter specific to the occupant remains within a predefined reasonable range. Accordingly, if the new metabolic

rate value  $met^*$  leaves a predefined range  $[met_{low} ; met_{high}]$ , it is considered that what the occupant is requesting is excessive. This is indicated to them via the man-machine interface and the control method retains the old metabolic rate value  $met$ . Otherwise the new value  $met^*$  replaces the old value. Moreover, in the event of excessive demands, an automatic system may be generated and proposed to the occupant via the man-machine interface. This suggestion can relate to the clothing of the occupant, for example, proposing that they take off or put on a jacket. It can also consist in an alert concerning their energy consumption. In such a case of excessive demands, it is up to the occupant to act; the control method does not change their parameters.

At the end of this step, the HVAC system control method continues and repeats the above steps starting from the second step 11. If the metabolic rate value  $met$  has changed, the value of the theoretical comfort index  $PMValgo$  also changes and the method controls the system to modify its initial stable state in order for the theoretical thermal comfort parameter to return to the predefined comfort range.

In parallel with the steps of the control method described above, the control method thus employs additional steps of interaction with each occupant of the building, as touched on above. Accordingly, in the event of discomfort, an occupant can act on the control of the HVAC system via the man-machine interface during a step 22, when the system has reached a stable state, as indicated above. Thereafter, following intervention of the occupant on the control of the HVAC system in the step 22, a suggestion can be put to them in a step 23 in the case of an excessive demand on their part. Otherwise, the HVAC system will modify its operation taking account of the real thermal sensation of the occupant and will converge

toward a new stable state in which the thermal comfort will satisfy the occupant.

The foregoing control method has naturally been illustrated by way of  
5 example. It could, without departing from the concept of the invention, be applied for some areas of a building, or even for some only of its occupants. Moreover, it has been applied to a system comprising a heating and air conditioning device and an individual ventilation device, which is advantageous for obtaining the optimum personalized comfort. It  
10 could however be applied with no heating or air-conditioning device for a system dedicated to summer or winter, for example. Similarly, in a simplified version, it could be implemented without controlling a ventilation device or alternatively for controlling only a ventilation device. Finally, the invention may further be implemented on any thermal system at least one  
15 of the parameters of which, such as the temperature, is controlled on the basis of a variable set point.

Moreover, the control method of the invention has been illustrated by applying it to the Fanger thermal model. It naturally remains applicable for  
20 any variant of that model or any other model that uses at least one parameter specific to an occupant of the building to calculate a parameter estimating the comfort of an occupant. Thus many simplifications are possible in application of the Fanger model. For example, the influence on the PMV of the relative humidity being low for temperatures close to a comfortable temperature (cf. ISO 7730), provided that its value remains  
25 within the recommended comfort range for the relative humidity [30%; 70%], its value may be chosen as constant, possibly at 50%, in temperature countries. The air speed is generally subject to a ceiling of 1 m/s to remain within the range of validity of the PMV/PPD model and to  
30 prevent drafts and thus localized discomfort.

Accordingly, the invention finally relies on the concept represented by the following two essential steps of the thermal system control method:

- 5        12 – Calculation of a theoretical thermal comfort parameter PMValgo for at least one occupant of at least one area of a building on the basis of at least one parameter specific to the occupant, such as their metabolic rate and/or their clothing, and controlling a heating and/or ventilation and/or air-conditioning (HVAC) system so that the theoretical thermal comfort parameter converges toward a
- 10        predefined comfort range corresponding to a satisfactory level of comfort,
- 17 – Correction of at least one parameter specific to the occupant if the real thermal sensation of the occupant is not satisfactory.
- 15        This second step 17 is to be understood as correcting only the parameter or parameters specific to the occupant, without modifying the other calculation parameters or how they are taken into account.

20        The control method defined as above enables the calculation of a theoretical thermal comfort parameter (PMValgo) for a plurality of occupants of the same area and then the execution of the correction step for at least one of the occupants of the area.

25        Figures 4 and 5 show an embodiment of the HVAC system control method described above during a winter day (ventilation system turned off), for an occupant characterized by their two specific parameters  $met_{real}$  and  $clo_{real}$  (which are unknown to the control algorithm) and their thermal sensation  $PMV_{real}$ .

In figure 4, the curves 30, 31 respectively represent the evolution over time of the theoretical thermal sensation  $PMV_{algo}$  and the real thermal sensation  $PMV_{real}$  of an occupant (both multiplied by 10 to enhance the readability of the graph), these two indices naturally being zero in unoccupied periods, i.e. the morning with  $t < t_0$  and the evening with  $t > t_2$ . The curves 32, 33, 34 respectively represent the evolution over time of the curves for the air temperature  $T_a$  and the mean radiant temperature  $T_r$  in the room and the external temperature  $T_{ext}$ .

- 10 The occupant arrives in the office in the morning at  $t=t_0$ , the HVAC systems being started up half an hour before this to provide them with satisfactory thermal comfort on their arrival. Until  $t=t_1$ , they nevertheless experience a thermal sensation  $PMV_{real} \approx -0,9$  while the control algorithm calculates for them a thermal sensation in the comfort range:  $PMV_{algo} \approx 0$ , this mismatch being explained by the fact that the difference between the real parameters specific to the occupant ( $met_{real}$ ;  $clo_{real}$ ) and those programmed in the control unit ( $met_0$ ;  $clo_0$ ).

- At the time  $t=t_1$ , they indicate via the MMI their feeling concerning their thermal sensation by actuating the "cold" button corresponding to  $PMV_{mmi} = -1$ . The system then reacts quickly and the temperature in the room rises toward a higher value, returning the real thermal sensation of the occupant to the comfort range, until they leave in the evening at the time  $t=t_2$ .

- 25 Figure 5 illustrates in more detail the correction mechanism implemented by the invention, in the graph ( $PMV$ ,  $T_a$ ). The relative humidity and the air speed are considered constant throughout the process:  $RH = 50\%$ ,  $V_a = 0.1$  m/s.

Just before the time  $t_1$ , the calculated theoretical thermal comfort parameter  $PMV_{algo_0}$  has the value 0 theoretically corresponding to satisfactory comfort for the occupant. This calculation is effected taking as hypotheses a metabolic rate parameter  $met_0 = 1.3$  and a clothing parameter  $clo_0 = 1$ . The ambiance parameters have the following values:  
 5  $T_a = 22\text{ }^\circ\text{C}$ ,  $V_a = 0.1\text{ m/s}$ ,  $T_r = 19.5\text{ }^\circ\text{C}$ ,  $RH = 50\%$ . The HVAC system is thus in a first stable state.

However, the occupant of the building has real specific characteristics  
 10 different from the hypotheses adopted by the calculation model:  $met_{real} = 1.1$  and  $clo_{real} = 0.75$ . It follows that the occupant is cold and is experiencing thermal discomfort, the real comfort index they are experiencing having the value  $PMV_{real_0} = -0.85$ : they then actuate the "cold" button on their man-machine interface. This induces evaluation of  
 15 the real thermal comfort parameter of the control method at a value  $PMV_{mmi} = -1$ .

The method then calculates a corrected metabolic rate value  $met^*$  that takes the value  $met^* = 0.94$ . For this value, the control method then  
 20 obtains a different and unsatisfactory value  $PMV_{algo_1}$  of the theoretical thermal comfort parameter that satisfies the condition  $PMV_{algo_1} = PMV_{mmi}$ . Consequently, the method modifies the set point values  $T_{a\_set}$  ( $V_{a\_set}$ , already at the minimum, is left constant at  $V_a = 0.1\text{ m/s}$ ) of the system as a function of this new metabolic rate parameter  $met^*$  so that the  
 25 comfort parameter  $PMV_{algo}$  converges toward the satisfactory value  $PMV_{algo_2}$ , close to zero. The change to the set point values of the HVAC system is reflected in concrete terms in an instruction to the heating actuator to increase the temperature of the interior air. In the final stable state, the ambiance parameters have the following values:  
 30  $T_a = 25.5\text{ }^\circ\text{C}$ ;  $V_a = 0.1\text{ m/s}$ ;  $T_r = 21\text{ }^\circ\text{C}$ ;  $RH = 50\%$

The specific parameters taken into account by the algorithm have the following values:  $met = 0.94$ ;  $clo = 1$ . These values are different from the real specific parameters, but give a very good estimate of the real thermal sensation  $PMV_{real_2}$  of the occupant.

Note that imposing beforehand a limit  $met_{low}=1$  in such a case would have made it possible to prevent reaching as high a heating temperature, synonymous with excess energy consumption.

Note that the concept of the invention thus makes it possible to converge toward a satisfactory level of comfort on the basis of an indication of the real comfort experienced by an occupant without actually knowing their specific thermal parameters: thus the method has succeeded in achieving the real thermal comfort of the occupier by modifying only the metabolic rate parameters so as to obtain thermal parameter values specific to the occupant  $met = 0.94$  and  $clo = 1$ , which nevertheless differ from their real parameters  $met_{real} = 1.1$  and  $clo_{real} = 0.75$ . The calculations effected show that the approach consisting in modifying only the metabolic rate value enables convergence toward a level of comfort close to the real level of comfort of the occupant over ranges of temperature and air speed typical of tertiary offices.

Thus the solution adopted achieves the objects of the invention and has the following advantages:

- It makes it possible to control the thermal comfort of the occupants of a building in a personalized manner, taking account of their real comfort;
- It is suited to simple and user-friendly implementation, not requiring excessively costly computer means.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge in Australia.

Claims

1. A method of controlling a heating and/or ventilation and/or air-conditioning (HVAC) system, characterized in that it comprises the steps of:

Calculation of a theoretical thermal comfort parameter (PMValgo) for at least one occupant of at least one area of a building on the basis of at least one parameter specific to the occupant, such as their metabolic rate (met) and/or their clothing (clo), and controlling a heating and/or ventilation and/or air-conditioning (HVAC) system so that the theoretical thermal comfort parameter converges toward a predefined thermal comfort range corresponding to a satisfactory level of comfort,

Correction of at least one parameter specific to the occupant if the real thermal sensation of the occupant is not satisfactory.

2. The control method according to claim 1, characterized in that the step of correcting at least one parameter specific to the occupant includes only the correction of one or more parameters specific to the occupant in the calculation of the theoretical thermal comfort parameter for the occupant.

3. The control method according to claim 1 or claim 2, characterized in that the at least one area contains a plurality of occupants, in that the step of calculating a theoretical thermal comfort parameter (PMValgo) is carried out for each of the occupants, and in that the correction step is carried out for at least one of the occupants.

4. The control method according to claim 3, characterized in that it includes a step of automatic initialization of the at least one parameter specific to the occupant when the control method is started up.
5. The control method according to any one of the preceding claims, characterized in that the at least one parameter specific to the occupant is their metabolic rate (met) and/or their clothing (clo).
6. The control method according to any one of the preceding claims, characterized in that it includes a step of entry via a man-machine interface of the real thermal sensation of the occupant to obtain a value of a real thermal comfort parameter (PMV<sub>mmi</sub>).
7. The control method according to claim 6, characterized in that the step of entry via the man-machine interface of the real thermal sensation of the occupant is prohibited if the heating and/or ventilation and/or air-conditioning (HVAC) system is in a transient state of convergence toward a stable state.
8. The control method according to claim 6 or claim 7, characterized in that it includes a step of correcting at least one parameter specific to the occupant so that the heating and/or ventilation and/or air-conditioning (HVAC) system is controlled so as to lead to its convergence toward a new stable state in which the theoretical thermal comfort parameter converges toward the predefined comfort range corresponding to a satisfactory level of comfort whilst obtaining a real thermal comfort satisfying the occupant.
9. The control method according to any one of the preceding claims, characterized in that it includes a step of measuring and/or estimating

environmental parameters and taking these measurements and/or estimates into account to calculate the theoretical thermal comfort parameter (PMValgo).

10. The control method according to any one of the preceding claims, characterized in that the step of calculating the theoretical thermal comfort parameter (PMValgo) uses the Fanger method based on the interior air temperature ( $T_a$ ), the mean radiant temperature ( $T_r$ ), the air speed ( $V_a$ ), the relative humidity (RH), the metabolic rate (met) and the clothing (clo).

11. The control method according to claim 10, characterized in that the step of correcting at least one parameter specific to the occupant consists in modifying only the metabolic rate (met).

12. The control method according to any one of the preceding claims, characterized in that it includes an additional step of comparing the corrected value (met\*) of the at least one parameter specific to the occupants with a predefined range ( $[met_{low}; met_{high}]$ ), the situation being judged excessive if this value is outside the range, the value of the parameter specific to the occupant (met) not being modified in any such situation.

13. A computer medium containing a computer program executing the steps of the method according to any one of the preceding claims of controlling a heating and/or ventilation and/or air-conditioning (HVAC) system.

14. A heating and/or ventilation and/or air-conditioning (HVAC) system comprising a heating and/or air-conditioning device and/or a ventilation device, one or more sensors for measuring at least one environmental

parameter, control means comprising actuators enabling modification of the operating conditions of the HVAC system as a function of at least one calculated set point value, characterized in that it comprises means for taking into account the real thermal sensation of at least one occupant and means for implementing the control method according to any one of claims 1 to 12.

15. The heating and/or ventilation and/or air-conditioning (HVAC) system according to claim 14, characterized in that the means for taking into account the real thermal sensation of at least one occupant comprise a man-machine interface.

16. The heating and/or ventilation and/or air-conditioning (HVAC) system according to claim 15, characterized in that the man-machine interface offers the possibility of entering one of six different thermal sensation levels, comprising three "hot" levels and three "cold" levels, and/or in that it includes the display of at least one suggestion for improving the comfort of an occupant and/or in that it includes the display of environmental parameter values and/or in that it includes the display of the value of a theoretical comfort parameter and/or in that it includes the display of the energy consumption and/or in that it includes the display of the stable or transient state of the HVAC system.

17. A building, characterized in that it incorporates a heating and/or ventilation and/or air-conditioning system employing the control method according to any one of claims 1 to 12.

18. The building according to claim 17, characterized in that it takes into account the real thermal sensation of all its occupants.

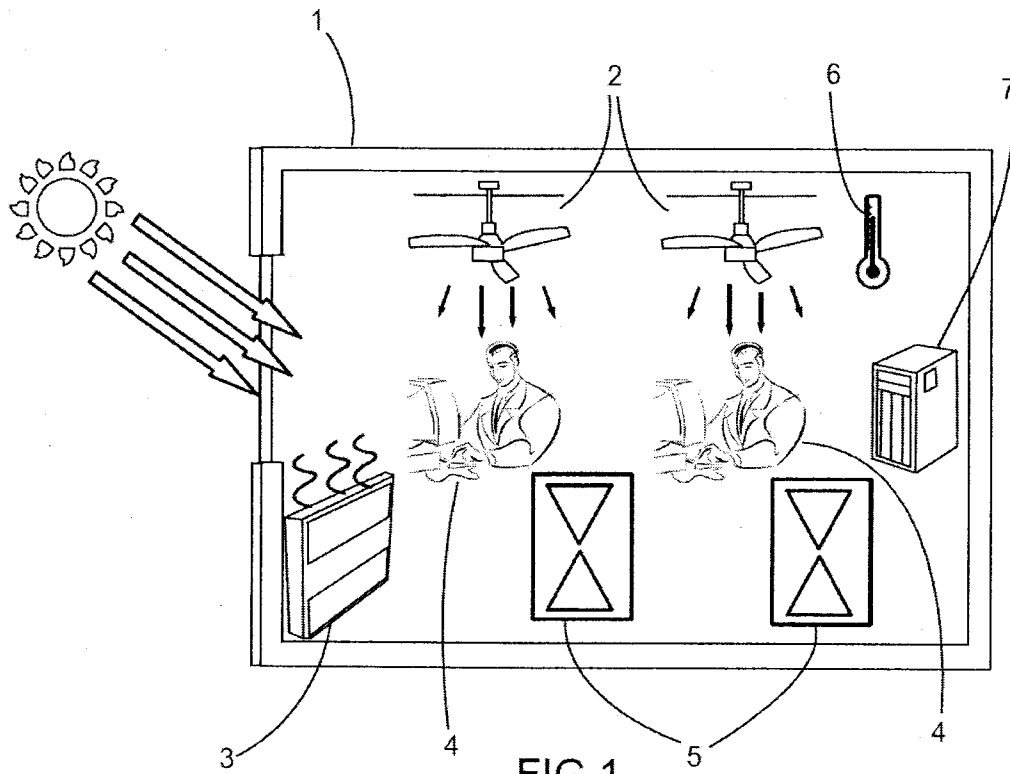


FIG.1

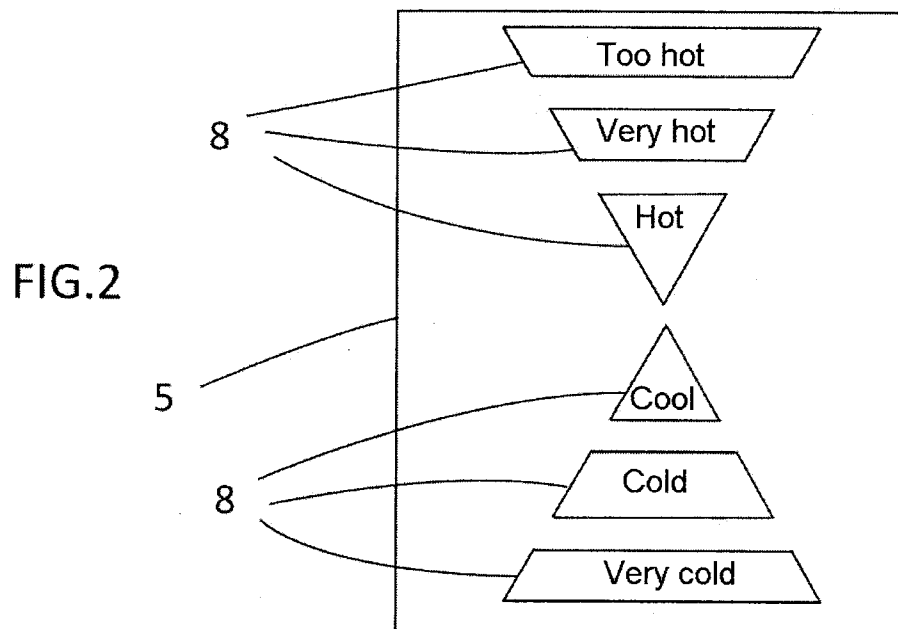


FIG.2

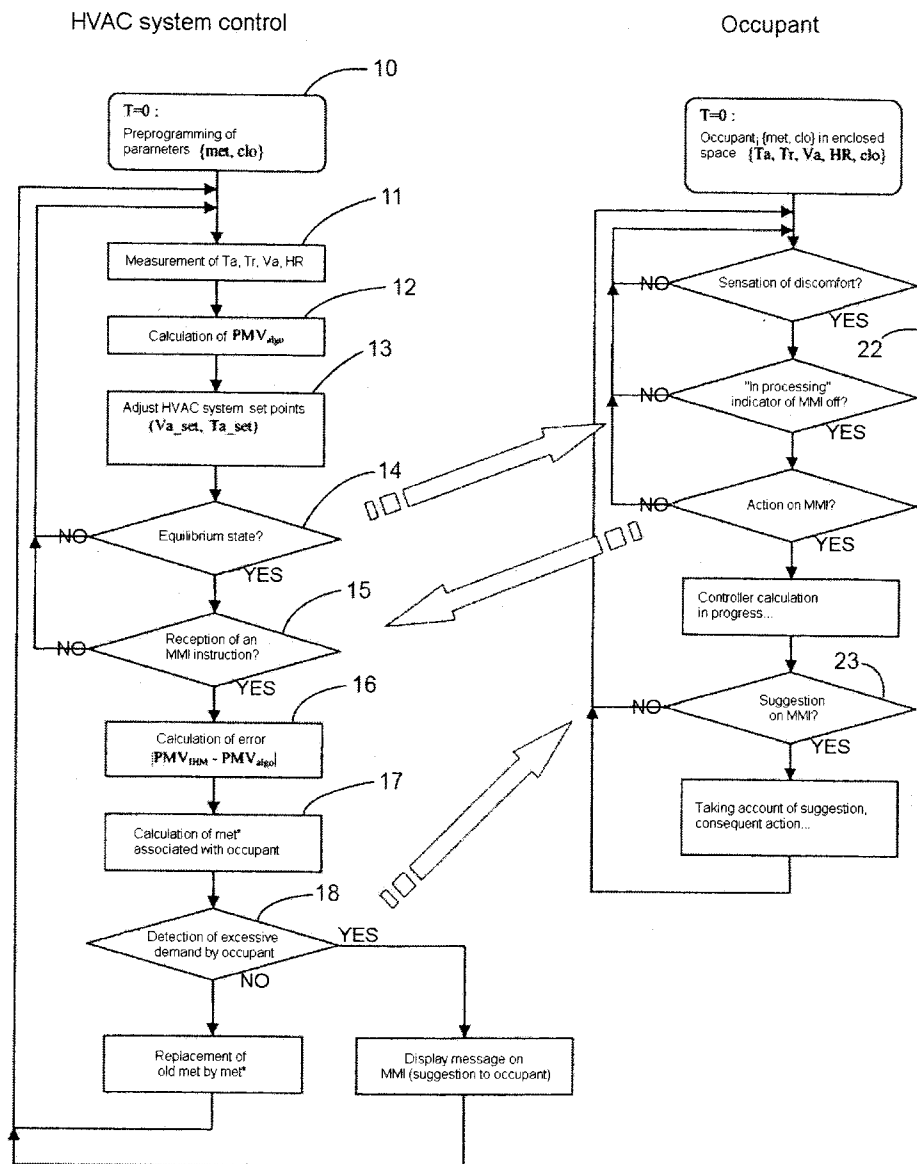


FIG.3

