METHOD AND APPARATUS FOR CONTROLLING AN INTERNAL ENVIRONMENT

Abstract: Rectangularly related wall or window panels (10-13) of a building are hollow and water is constantly circulated through their interiors so that the heat of a panel (10-13) subjected to direct sunlight is dissipated at panels (10-13) in the shade. The panels (10-13) can additionally be connected via valve (28) with a heat exchanger (19) external to the building or the heat or coolness of the water in panels (10-13) can be stored at a heat score (21) or a cool store (22) for later use either in the panels (10-13) themselves or in an internal heat exchanger (20). Additionally the stores (21, 22) can be connected together at (30) for transfer of heat between them. In a modification the fluid being circulated is air and the arrangement is such that suction is applied to double glazing so as to maintain a near vacuum therein.
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
"METHOD AND APPARATUS FOR CONTROLLING AN INTERNAL ENVIRONMENT".

The present invention relates to a method and apparatus for controlling the internal environment of a normally sealed enclosure for human or animal occupation and which is normally exposed to sunlight. By "normally sealed" is meant that any windows of the enclosure are not intended to be opened and any doors are not intended to be left open for any length of time, or that movement of air into or out of the enclosure when doors are opened is limited by a double-door arrangement on the air-lock principle. The invention is principally applicable to buildings but its application to other kinds of enclosure, such as vehicles, is also envisaged. By "normally exposed to sunlight" is therefore meant that the enclosure is an out-door one but temporary shielding from direct sunlight is not excluded, as in the case of a railway vehicle passing through a tunnel.

The way in which modern office buildings are constructed has accentuated a problem which is inherent in all buildings, but which has been tolerable, or at least manageable, in the case of traditional buildings of brick, stone or concrete with relatively small window areas. Modern structures with very large windows and/or relatively thin cladding have a particular problem in dealing with internal heat gain due to the exposure of large wall areas to direct sunlight. Such buildings normally have sealed windows both for safety reasons and to permit air conditioning. As more and more electrical equipment is used, such as computers, printers and copying machines, so the problem of internally generated heat increases, placing further demands on the air conditioning apparatus. Even in temperate climates the problem ceases to be one of heating the building, except in abnormal weather conditions, but becomes that of disposing of excess heat. The necessary refrigerating apparatus is costly, noisy and consumes large amounts of energy.

Current techniques for limiting interior heating by direct sunlight include massive insulation and the use of reflective window glass and/or wall cladding. Such "mirror" buildings are such a nuisance to their surroundings by emitting blinding light and radiating heat that they are actually outlawed in some countries.
The present invention offers a more environmentally friendly solution requiring a minimum of energy input, which can itself be derived, or largely derived, from the sun.

An object of the invention is to provide an economical and effective way of controlling an internal environment having none of the drawbacks of current techniques and requiring relatively very little energy input.

The use of fluidised fenestration to extract the heat from direct sunlight has already been proposed for example in my earlier patent publications WO83/01103 and WO95/04006. There the principal object was to protect the interior of a building from the penetration of solar radiation, but the problem of what to do with the heat thus obtained was not addressed except to suggest that it might be stored for later use in heating the building. In practice in the case of a large modern building in a warm or temperate climate this would result in an excess of stored heat unless special measures were adopted for dissipating it.

The present invention proceeds from the realisation that at any given moment during the day more of the envelope of a building is in shade than is exposed to direct sunlight. If the heating caused by direct sunlight is transferred to all shaded areas of the envelope the dissipation of heat from the entire building will normally be more than sufficient to offset heat gain from localised direct sunlight. The building as a whole will achieve a stable equilibrium temperature at a level comfortable for human occupation. A fluidised system permits that both hot fluid and cold fluid can be stored, so that under exceptional conditions either the heat or coolness of the envelope can be offset by using the stored fluid, for example in interior heat exchangers. Less energy will be required to effect displacement of the fluid around the building or to and from the stores than is currently consumed by air conditioning or cooling equipment, so that energy bills will be reduced as well as damage to the environment.

In accordance with one aspect of the present invention there is provided apparatus for controlling the internal environment of a normally sealed enclosure for human or animal occupation and which is normally exposed to sunlight, the enclosure comprising hollow, fluid-filled exterior surface elements such that fluid within a said element will be warmed by incident solar energy, the elements being distributed around the enclosure and their
interiors being interconnected and means being provided for displacing the fluid from one of said elements while subjected to direct sunlight to all of the remaining elements so that heat obtained from the sun by fluid while in said one element will be dissipated while passing through a said element or elements currently in the shade.

In a preferred embodiment the enclosure is a building for human occupation and the said elements constitute a major proportion of the wall area of the building.

The said elements may comprise hollow transparent or translucent windows and may comprise hollow opaque wall components.

The fluid may be gaseous and the said elements may be, or comprise, double-glazed windows, circulation of the gas around the elements being by means of a pump associated with each element which serves to maintain a near vacuum in the interior of said element.

Alternatively the fluid may be a liquid and such as water or an aqueous solution.

Any one or group of said elements may be selectively communicable with thermal storage means whereby fluid at a selected temperature may be stored and means may be provided for selectively communicating the thermal storage means either with any one or group of said elements or with heat exchange means in the interior of the enclosure whereby air within the enclosure may be selectively heated or cooled.

The thermal storage means may comprise a liquid reservoir through which fluid from said one or group of said elements can be conducted to exchange heat with liquid in the reservoir and the reservoir is preferably connected to the heat exchange means by a liquid circuit independent of the fluid circuit associated with said elements.

The heat exchange means may comprise a hollow internal partition, ceiling or floor of the enclosure.

In accordance with another aspect of the present invention there is provided a method of controlling the internal environment of a normally
sealed enclosure for human or animal occupation and which is normally exposed to sunlight, the method comprising displacing a fluid around the enclosure through hollow external surface elements of the enclosure such that heat obtained by the fluid while passing through one or more of the elements currently subjected to direct sunlight will be dissipated while the fluid is passing through one or more of the elements currently in shade.

When the method is for controlling the internal environment of a normally sealed building for human occupation the fluid may be displaced through hollow window and/or wall elements which constitute at least a major proportion of the external wall area of the building.

Each said element may comprise a double-glazed window and the method may comprise applying suction to the space between inner and outer panes of each window to maintain a near vacuum within each element.

If the fluid is a liquid it may be selectively communicable with a thermal reservoir whereby liquid at a selected temperature may be stored and later communicated with heat exchange means in the interior of the enclosure whereby air within the enclosure may be heated or cooled.

A preferred embodiment of the invention will now be described by way of non-limitative example with reference to the accompanying drawings, in which:

Figure 1 schematically illustrates four hollow wall panels of a building, and

Figure 2 is a diagram of the incorporation of the panels of Figure 1 in a system including two fluid stores.

A building (not shown) has four rectangularly related walls at least the greater proportion of the area of each of which is taken up by hollow panels 10, 11, 12 and 13 facing respectively north, south, east and west. These panels may be wholly or partially transparent or translucent to act as windows or may be opaque cladding, and of course any given wall of the building may be made up of plural panels of which some are transparent and others not. If the building is in the northern hemisphere the panel 10 will receive virtually no direct sunlight, the panels 12 and 13 will
receive direct sunlight in the morning and in the evening respectively, while the panel 11 will receive direct sunlight obliquely and chiefly at mid-day. Thus at any time during the day a greater proportion of the total area of the panels will be in shade than in direct sunlight. Pipework 14 and 15 connects the interior of each panel 10-13 with the interior of all of the others. A pump 16 circulates water simultaneously through all of the panels. While passing through a panel currently subjected to direct sunlight the water will be heated more than it is heated while passing through the panels in shade, but because of the constant circulation of the water its temperature remains remains generally constant as heat is dissipated by all of the panels. Thus the temperature of a sealed room bounded by the panels will remain comfortable for human occupancy. At the same time heat generated within the room, for example by electrical equipment, will be collected by the water and distributed to all of the panels for dissipation exteriorly of the building.

Flow of the water through all of the panels 10-13 is controlled by distribution manifolds 17 and 18. Valves in these manifolds can be actuated selectively to connect the interiors of the panels additionally to a heat store 21 or a cool store 22. Each of these stores 21 and 22 is a heat exchanger enabling water in a separate circuit 23,24 to be either heated or cooled by the water from the panels 10-13. This separate circuit selectively connects the stores 21 and 22 via three-way valves 25, 26, and 27 to a heat exchanger 20 positioned within the room bounded by panels 10-13 or with a heat exchanger 19 positioned outside the building. For circulation of water in this second circuit to the internal heat exchanger 20 a second pump 31 is provided. Additionally a three-way valve 28 enables the water within panels 10-13 to circulate to the external heat exchanger 19 and a three-way valve 29 selectively directs water from the panels 10-13 either to the heat store 21 or the cool store 22. Each of the three-way valves 25-29 is of a kind which permits communication between only two of its three ports at one time.

Thus by suitable adjustment of the valves 25-29 surplus heat of the water circulating through the panels 10-13 can be dissipated externally of the building by the heat exchanger 19 or can be stored in the store 21. At night the coolness of the water circulating through the panels 10-13 can be stored by the store 22. When the interior of the room requires additional heat, as in the early morning, the heat store 21 can be connected to the
internal heat exchanger 20. Alternatively if the interior of the room requires additional cooling, as during the height of the day, the internal heat exchanger can be connected to the cool store 22.

A heat pump 30 controls communication between the stores 21 and 22. This valve is opened if, for example, heat within store 21 rises excessively so that the heat store 21 is cooled sufficiently to bring down the temperature of the water circulating through the panels.

The operation of all of the valves, i.e. those of the manifolds 17,18 and the three-way valves 25,26,27,29 and 30 will be under the control of temperature sensing means (not shown) positioned within the building, which will respond to temperature variations within the building by suitably adjusting the valves to bring the internal temperature of the building back to a pre-selected temperature. The valves may also be under the control of timer means (not shown) which will suitably adjust the valves according to anticipated conditions during the day and night. Thus control of the internal environment of a building may be fully automatic and under the control of a computer (not shown) which will ensure that the room temperature does not fluctuate excessively during the day in response to fluctuating external external temperatures.

Where the panels 10-13 are, or include, window components liquid in the first circuit passing through the panels may contain dye, micro-balloons or the like to enhance thermal absorption according to the teachings of my earlier patent publications. The use of a second circuit 23,24 is advantageous in that the relatively more expensive fluid passing through the panels does not have to be used in internal heat exchangers or radiators.

The internal heat exchanger 20 may take the form of a conventional radiator or it may be an internal component of the building, such as a hollow partition, ceiling or floor.

The preferred embodiment of the invention is described as utilising water as the fluid, which has advantages such as high thermal absorption, incompressibility and the relative ease of maintaining it in a sealed circuit or detecting leaks. However the use of gasses such as air is not ruled out at least for some applications. It is desirable to provide a
vacuum between inner and outer panes of a double-glazed window to prevent heat migration, but it has proved impossible in practice to maintain a reliable seal. In a system in which the space between the panes is subjected to continuous suction a near-vacuum can be reliably maintained despite a minor leakage of the seal caused, for example, by weather damage or expansion or contraction of frame elements.

Although only one pump 16 is exemplified as the means for displacing liquid between the panels 10-13 it is envisaged that a plurality of low-capacity solar powered pumps would be included in the first circuit positioned to take maximum advantage of sunlight. In this way the control of the internal environment of the building would make no energy demands whatsoever.

Clearly the greater the proportion of the wall area of the building which is represented by the panels 10-13 the more effective the system will be in dissipating heat received on the sunlit side, but a lesser advantage will be obtained even if the panels 10-13 are merely fluidised windows all mutually connected. The invention takes advantage of the natural phenomenon that in the case of all objects on the face of the earth heat loss is equal to heat gain over time and that temperature fluctuations are always temporary. The aim of the invention is to smooth such fluctuations so as to maintain a comfortable internal environment irrespective of the subjection of different surface areas of the building to direct sunlight at different times of the day, and to do so without high energy consumption or other adverse effects such as reflection or the need to use excessive mass in the construction of the building.
CLAIMS:

1. Apparatus for controlling the internal environment of a normally sealed enclosure for human or animal occupation and which is normally exposed to sunlight, the enclosure comprising hollow, fluid-filled exterior surface elements such that fluid within a said element will be warmed by incident solar energy, characterised in that the elements (10-13) are distributed around the enclosure and their interiors are interconnected and means (16) is provided for displacing the fluid from one of said elements (10-13) while subjected to direct sunlight to all of the remaining elements (10-13) so that heat obtained from the sun by fluid while in said one element (10-13) will be dissipated while passing through a said element or elements (10-13) currently in the shade.

2. Apparatus as claimed in claim 1, characterised in that the enclosure is a building for human occupation and the said elements (10-13) constitute a major proportion of the wall area of the building.

3. Apparatus as claimed in claim 2, characterised in that the said elements (10-13) comprise hollow transparent or translucent windows.

4. Apparatus as claimed in claim 3, characterised in that the fluid is gaseous and the said elements (10-13) are double-glazed windows, circulation of the fluid around the elements being by means of a pump associated with each element which serves to maintain a near vacuum in the interior of said element.

5. Apparatus as claimed in any one of claims 1-3, characterised in that the said elements (10-13) comprise hollow opaque wall components.

6. Apparatus as claimed in any one of claims 1-3 or 5, characterised in that the fluid is a liquid.

7. Apparatus as claimed in claim 6, characterised in that the liquid is water or an aqueous solution.

8. Apparatus as claimed in any one of the preceding claims, characterised in that any one or group of said elements (10-13) is selectively communicable with thermal storage means (21,22) whereby fluid at a selected
temperature may be stored and wherein means (25-29) is provided for selectively communicating the thermal storage means (21,22) either with any one or group of said elements (10-13) or with heat exchange means (20) in the interior of the enclosure whereby air within the enclosure may be selectively heated or cooled.

9. Apparatus as claimed in claim 8, characterised in that the thermal storage means (21,22) comprises a liquid reservoir through which fluid from said one or group of said elements (10-13) can be conducted to exchange heat with liquid in the reservoir and wherein the reservoir (21,22) is connected to the heat exchange means (20) by a liquid circuit independent of the fluid circuit associated with said elements (10-13).

10. Apparatus as claimed in claim 8 or claim 9, characterised in that the heat exchange means (20) comprises a hollow internal partition, ceiling or floor of the enclosure.

11. A method of controlling the internal environment of a normally sealed enclosure for human or animal occupation and which is normally exposed to sunlight, characterised in that the method comprises displacing a fluid around the enclosure through hollow external surface elements (10,13) of the enclosure such that heat obtained by the fluid while passing through one or more of the elements (10-13) currently subjected to direct sunlight will be dissipated while the fluid is passing through one or more of the elements (10-13) currently in shade.

12. A method as claimed in claim 11 for controlling the internal environment of a normally sealed building for human occupation, characterised in that the fluid is displaced through hollow window and/or wall elements (10-13) which constitute at least a major proportion of the external wall area of the building.

13. A method as claimed in claim 11 or claim 12, characterised in that each said element (10-13) comprises a double-glazed window and wherein the method comprises applying suction to the space between inner and outer panes of each window to maintain a near vacuum within each element (10-13).

14. A method as claimed in claim 11 or claim 12, characterised in that the fluid is a liquid which is selectively communicable with a thermal
reservoir (21,22) whereby liquid at a selected temperature may be stored and later communicated with heat exchange means (20) in the interior of the enclosure whereby air within the enclosure may be heated or cooled.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F24F5/00 F24J2/04

According to international Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F24F F24J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Further documents are listed in the continuation of box C. X Patent family members are listed in annex.

* Special categories of cited documents:
  *A* document defining the general state of the art which is not considered to be of particular relevance
  *E* earlier document but published on or after the international filing date
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