(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 September 2011 (01.09.2011)

PCT

(10) International Publication Number
WO 2011/103615 A1

(51) International Patent Classification:
F24F 5/00 (2006.01) *E04H 1/00* (2006.01)
E04C 2/30 (2006.01) *E04H 3/00* (2006.01)
E04B 1/00 (2006.01) *E04H 9/00* (2006.01)

(21) International Application Number:
PCT/AU2011/000181

(22) International Filing Date:
21 February 2011 (21.02.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2010900777 24 February 2010 (24.02.2010) AU

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: 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) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (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).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: HEATING AND COOLING SYSTEM AND METHOD

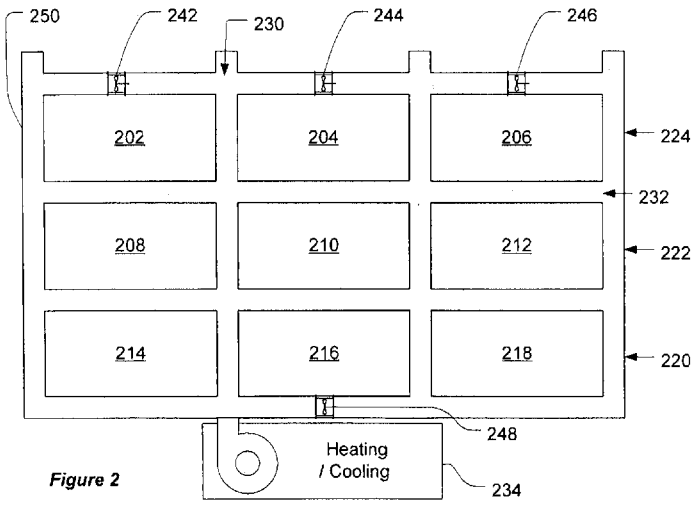

Figure 2

(57) **Abstract**: There is described a building (200) including two or more building units (202 to 618). The building units include a structure defining at least one room having an interior volume. The building includes a an external envelope (250) enveloping and being spaced from the structure defining the room(s) to define an air circulation zone (230)separate from and external to the interior volume. The building (200) also includes a mechanism (234) configured to heat and/or cool the air circulation zone to control the temperature in the internal volume by heating and/or cooling the structure defining the rooms. A heating and cooling method are also described.

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Heating and Cooling System and Method

Field of the invention

The present invention relates to a building, and its components and to methods of heating and/or cooling a building. It will be convenient to describe the preferred embodiment in connection with heating and cooling high rise buildings, of the type that include a plurality of buildings units in their construction, but the present invention should not be considered to be limited to that exemplary application.

Background of the invention

Most modern buildings employ some form of heating or cooling to keep the interior spaces of the building at a temperature that is suitable for the building's use. Typically this involves keeping the building's occupants comfortable. However, heating and cooling of buildings, especially high rise buildings, can use large amounts of energy and requires complex equipment.

One of the first central heating schemes was the ancient Roman system termed a "hypocaust", which involved burning a fire to generate heat and passing the combustion products (e.g. flue gasses and smoke) of the fire underneath a floor of a room and then up a series of chimneys built into the walls of the room, thereby heating the walls of the room. These systems requires specialised floor structures and wall configurations, had no ability to vary the temperature of the heating achieved, and could not additionally perform cooling.

Modern buildings often use forced air heating and cooling which have ventilation ducts that are coupled to heating and/or cooling systems, to force air of a desired temperature into a room. Such systems are typically referred to as heating, ventilation and air conditioning systems (HVAC systems).

Other heating solutions also exist, for example, water based systems such as hydronic or steam heating systems that circulate heated water through a network of pipes through one or more radiators located at selected positions in the building. As the hot

fluid is circulated around the system, heat radiates into the room being heated via the radiators thereby warming them.

In some instances, typically residential, underfloor or in-floor heating can be used. These systems typically include a mesh or grid of either pipes circulating water or electrical heating elements within or under a floor. These systems are typically quite energy efficient and operate at low temperatures. However, they have significant disadvantage in the case that maintenance needs to be carried out on some part of the heating system which is embedded in the floor.

As an alternative to these systems, particularly in residential applications where individual dwellings may require full control over their own heating and cooling requirements, heating and cooling may be performed on a residence by residence basis. For example, reverse cycle air conditioning may be fitted to each individual unit or residence in a residential high rise building. This allows the occupants to control their own heating and cooling. However, each individual residence has the burden of maintaining their system, and high energy efficiency of each system in a building may not be attained.

Accordingly, it would be advantageous to provide an alternative heating and cooling arrangement for use in buildings.

Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment or any form of suggestion that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

Summary of the invention

The present disclosure describes a building including: an interior volume defined by a floor, ceiling and at least one wall, an air circulation zone, outside the interior volume; and means to conduct heat between the interior volume and the air circulation zone.

In one aspect there is provided a building including two or more building units, the building units including structure defining at least one room having an interior volume; an external envelope defining an outside of the building, and an air circulation zone, within the envelope, that is separate from the interior volume. At least part of the structure defining at least one room is configured to transmit heat between the room's interior volume and the air circulation zone. The building also includes a mechanism configured to heat and/or cool the air circulation zone to control the temperature in the internal volume by heating and/or cooling the structure defining the rooms.

Preferably at least part of one of the floor, ceiling or wall has a relatively high heat conductivity to enhance heat conduction between the interior volume and the air circulation zone.

Most preferably the building additionally includes means for controlling the temperature of air in the air circulation zone. The mechanism for heating and/or cooling the air circulation zone can be an air heater or air cooler. Heating and cooling can be performed by any practical means, these can be active heating, such as: electrical; combustion based heating; passive heating such as solar, geothermal heating or the like. Similarly cooling can be active; (refrigeration); or passive (e.g. circulation of a cooling fluid through a cool body of water etc.)

In preferred embodiments heating and/or cooling is not performed by air exchange between the air circulation zone and the interior volume of the room.

The air circulation zone can have air flow control means, for example, one or more fans, blowers, louvers, diffusers, diverters, baffles, seals, or other active or passive flow control devices etc, to control circulation of air in the zone.

In some embodiments the means to conduct heat between the interior volume and the air circulation zone will simply be a portion of a wall, floor or ceiling separating the interior volume and the air circulation zone. In this case the portion of a wall can have heat conduction properties chosen to conduct heat at a predetermined rate or to store heat. For example the heat conduction region can include a phase change material or

other heat storage device. Such embodiments can be advantageous in stabilising the internal temperature of the interior of the room.

The building units may be assembled from pre-fabricated sub-assemblies or preferably are prefabricated. Prefabricated units may, or may not require on-site finishing, fit-out, or like processes to complete the building.

The building preferably includes an insulating structure located outwardly from the air circulation zone and adapted to thermally insulate the air in the air circulation zone. The insulating structure or envelope can be formed at least in part by an external wall of the building.

The structure defining the external envelope of the building can be spaced from the structure defining at least one room to define a part of an air circulation zone of the building.

Preferably the building can be constructed from a plurality of building units, wherein each building unit defines a respective portion of the interior volume of the building. One or more building units can include an external wall structure spaced apart from an internal wall thereof to thereby define a portion of building's envelope and air circulation zone. The building units can be located within the building such that gaps between each building unit exist, and which can form part of the circulation zone.

The air circulation zone can be coupled to one or more ducts, pipes or other air flow control devices that are outside the envelope of the building,

In another aspect there is provided, a building including: an external envelope; at least one room having by a floor, ceiling and at least one wall defining an interior volume. At least part of the floor, ceiling and/or wall is spaced apart from the external envelope of the building and defines a gap therebetween in which air can circulate. The building includes a heat conducting structure adapted to conduct heat between air in a gap and the interior volume of the room. Preferably the building is constructed from a plurality of building units positioned in a predetermined manner. The building units can be arranged such that a gap is provided between adjacent building units. The gaps can extend such

that it forms a contiguous air circulation zone comprising similar gaps between adjacent building units and/or the external envelope of the building.

The external envelope of the building can be formed by the façade of the building. Preferably the envelope is largely sealed to minimise or prevent air leakage from the air circulation zone. Most preferably air is recirculated through said air circulation zone.

Most preferably the building additionally includes means for controlling the temperature of air in the air circulation zone. The means for controlling the temperature of air can be an air heater or air cooler. Heating and cooling can be performed by any practical means as discussed above.

It is also preferable that no air is exchanged between the air circulation zone and the interior volume of the room.

In some embodiments the heat conducting structure can be at least a portion of a wall, floor or ceiling separating the interior volume and said gap. In this case the portion of a wall, floor or ceiling can have heat conduction properties chosen to conduct heat at a predetermined rate or to store heat. For example the heat conducting structure can include a phase change material or other heat storage device. Such embodiments can be advantageous in stabilising the internal temperature of the interior of the room. The structure can be a wall of the room or building unit.

The buildings can be formed by a self supporting building unit. The building can include a plurality of interconnected building units.

In another aspect there is provided a method of adjusting the temperature of a room including: circulating air through a zone abutting the room such that heat is transferred between air within the room and the circulating air. The method can include: heating and/or cooling the circulating air. In some embodiments the method includes recirculating the air through a heating and/or cooling system to control the temperature of the circulated air.

Preferably the method includes maintaining separation between air within the room and the circulating air.

In a further aspect the present invention provides a panel structure for a building unit. The panel structure has first and second surfaces and includes; at least one structural layer; at least one sound insulating layer; and at least one heat transmission path between the first and second surfaces.

Preferably the sound insulating layer has a high thermal conductivity. Preferably the sound insulating layer provides an insulating effect using constrained layer damping.

A structural layer and sound insulating layer can form adjacent layers in the structure. Alternatively one or more additional layers can lie between the structural layer and sound insulating layer.

The structural layer can include a metal or other rigid sheet-like skin. It can also include structural bracing elements, e.g. purlins or the like.

Preferably the metal skin is sheet like and structurally self supporting. It can additionally be formed with corrugations, ridges or other forms to increase rigidity. Preferably the structural layer is the outermost layer of the structure.

Preferably the layers of the panel structure are bonded together, e.g. using an adhesive, welding or the like. Some layers can be mechanically attached to other layers, e.g. using screws, rivets etc.

The panel structure can include an internal lining layer having one surface that defines one of the first or second surfaces of the panel structure.

Preferably the structural layer is highly thermally conductive. To achieve this it can be made from metal. The sound insulating layer can be a polymer layer, e.g a visco-elastic membrane. The internal lining can be, for example, formed of plaster board, plywood or other suitable sheet like material for lining an interior surface of a building.

The panel structure can additionally include a heat absorption layer. For example a layer capable of storing heat, such as a layer including a phase change material.

The panel structure can be formed in discrete panel segments, or alternatively formed continuously.

The panel structure can comprise a portion of any one or more of a floor, ceiling or wall of a building unit.

The heat transmission path between the first and second surfaces can be provided by transferring heat through the layers of the panel structure. Alternatively one or more thermal transmissive elements can be included in the panel structure to transfer heat from one surface (or adjacent one surface) thereof to the other. The thermally transmissive elements can be conductive elements that substantially traverse the thickness of the panel structure.

The invention also provides a building unit including any one or a wall, floor or roof that includes a portion formed from a panel structure as described herein.

The invention also provides a building including: at least one room, said room being defined by at least a floor and one or more surfaces, wherein at least part of said floor and one or more surfaces being formed from a panel structure as described herein.

The building can further include an air circulation zone air outside the room, but inside the building in which air is circulated such that is transferred through the panel structure between air in the room and the circulating air to thereby regulate the temperature of the air in the room.

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude further additives, components, integers or steps.

Brief description of the drawings / figures

Illustrative embodiments of the present invention will now be described by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figure 1 shows a simplified embodiment of the present invention, implemented in a one room building;

Figure 2 shows a schematic illustration of a second building made in accordance with an embodiment of the present invention;

Figure 3 shows a further embodiment of the present invention in a three storey building;

Figure 4 illustrates an exemplary wall construction usable in a building unit assembly in an embodiment of the present invention;

Figure 5 illustrates cut-away view through a junction between four units of the type illustrated in Figure 4;

Figure 6A shows a schematic side view of further embodiment of the present invention in a three storey building; and

Figure 6B shows a schematic top view of the building of figure 6A.

Detailed description of the embodiments

The applicant's earlier filed International patent application PCT/AU2009/001236 describes a system and method for constructing a building made from a plurality of building unit assemblies. These building unit assemblies essentially comprise a self supporting pre-fabricated building unit which comprises a floor, walls and roof which together define an interior space of the building. Each building unit has one or more structural support frame segments attached to it. These building unit assemblies can be joined together in various different ways to form a building, for example, high rise buildings can be constructed by stacking a plurality of building unit assemblies on top of

one another such that vertically aligned structural frame segments are aligned and connected the structural frame segments of an adjacent assembly to form the structural frame of the building. Typically, when a building is constructed in accordance with our earlier patent application a column zone is defined around each of the building units. This column zone typically extends throughout the whole building to provide a network of interconnected voids. For example, column zones occur horizontally between storeys and vertically between horizontally neighbouring aligned building units. The present inventor has identified that these column zones can be used to provide central heating and or cooling to the interior of the building units within the building by circulating temperature controlled air through them. Heat can be transferred into and/or out of the interior of the building units through part (or all) of the walls, floor and/or ceiling of the building units. Such a system can thus heat and/or cool the occupied space of the building through its structure simply and comfortably.

Figure 1 illustrates a simplified building that illustrates this principle of operation. Figure 1 illustrates a building 100 having in it a first wall 102 which defines an interior volume 104 of the building 100. A second wall 106 is also provided to define an exterior envelope of the building. Between the interior wall 102 and the exterior wall 106 a cavity or gap 108 is defined which forms an air circulation zone. The building 100 is also provided with a heating and/or cooling system 110 which is used to heat or cool air which is passed through the cavity 108. Optionally, an air circulation fan 112 can be provided in the cavity 108 to re-circulate the heating or cooling air around the cavity 108.

Preferably, the internal wall and external wall are of different construction and the internal wall 102 of the building 100 is constructed such that it has a high thermal conductivity or high ability to store heat (such as can be achieved with a phase change material) to thereby efficiently exchange heat between the internal volume 104 of the building and the air circulating in the cavity 108. It is also preferable that the external wall 106 is well insulated to prevent heat exchange between the environment and the air in the cavity. In the embodiment illustrated in Figure 1, the air in the cavity 108 is recirculated through the heating and cooling system 110 to maintain temperature of the heating and cooling air.

Heating and cooling of the air can be performed in any practical manner. For example cooling can be performed using mechanisms including, but not limited to, refrigeration, evaporative cooling, heat exchange with a passively cooled fluid, thermoelectric cooling etc.. Heating can also be performed using a wide variety of mechanisms including, but not limited to, combustion of a fuel such as gas, oil, coal, wood; solar heating; geothermal heating etc.

In an example residential implementation, in winter (or in areas with low external temperature) the interior of the building units will have a desired temperature of between 16 and 20 degrees Celsius. To achieve this, air circulating in the cavity will typically need to be heated to a temperature between 30 and 60 degrees Celsius. In summer (or in areas with high external temperature) the interior of the building units will have a desired temperature between 21 and 26 degrees Celsius. To achieve this air circulating in the cavity will typically need to be cooled to a temperature between 7 and 11 degrees Celsius. Some local heating or cooling can additionally be used by occupants to further adjust the temperature of the unit to their requirements. Other temperature ranges can also be used depending on the implementation, external temperature, heat storage properties of materials, heat conduction properties and other factors.

In this embodiment, by circulating air around the cavity and transferring heat through the surfaces of the building unit, the entire interior surface effectively becomes a radiator for the heat (either into or out of the interior of the building unit).

Figure 2 illustrates a more complex embodiment of the present invention. In this embodiment, the building 200 includes a plurality of building units 202,204,206 through to 218. The building units 202 through to 218 are arranged in three levels 220 to 224. Between horizontally adjacent building units e.g. 202 and 204, 208 and 210, 214 and 216 there is a vertically extending column zone e.g. 230. Between vertically adjacent building units e.g. building unit 202 and building unit 208, unit 204 and unit 210, unit 206 and unit 212 there is a horizontally extending zone 232. As in the previous embodiment, a heating and/or cooling device 234 is provided. Flow control devices are also provided within the column zones, e.g. air circulation means, e.g. in the form of fans 242, 244, 246 and 248.

In this embodiment, the outer envelope of the building e.g. 250, which will generally comprise the façade of the building, its foundations or lower floor and its roof, is substantially sealed and defines a volume within the building. The inhabitable interior volume of the building units 202 through to 218 are defined by their respective walls, floor and ceiling. Thus defining an air circulation zone through the network of column zones 230, 232 into which heating and/or cooling air can be provided in the manner described above.

As described in the previous embodiment, the thermal properties of the walls of the individual building units e.g. 202 are chosen carefully to provide the desired level of heat exchange of between the interior of the building units and the heating or cooling air circulating within the spaces 230,232, without mixing of air between them.

Figure 3 shows a more detailed embodiment of a multistorey building made in accordance with the present invention. In this example, the building illustrated 300 is constructed in accordance with our earlier filed PCT application (PCT/AU2009/001236). In this regard, the building 300 is comprised of a plurality of building unit assemblies e.g. 302. Building unit assemblies 302 include a building unit 304 and a plurality of associated structural frame segments 306 and 308. Building unit assemblies which are on the outside of the building have façade elements e.g. façade segment 310, mounted to them. The top side of the building 300 is also provided with a roof which may additionally be formed in segments attached to the building units or formed separately to the building unit assemblies. As is illustrated, a building unit assembly which is on a corner of a building will include façade segments on two or more sides. An example of this is shown in building unit 312 which has a forward facing façade e.g. 314 which has three windows and a sidewards façade element 316 which is shown only in side view.

The building unit assemblies 304 to 304D are stacked on top of one another such that their structural frame segments are aligned and support the building. Using this construction technique, column zones e.g. zone 320, are provided between neighbouring building units (e.g. 304 and building unit 304a). Similarly, horizontally extending column zones e.g. 322 exist between vertically adjacent building units such as building unit 304 and building unit 304b. In practice, the façade segments of the

building will be produced with a small gap e.g. 10mm between them to allow for manufacturing tolerances. These gaps are sealed e.g. with a flexible and/or compressible seal attached to the façade segments or by sealing with a sealing compound after positioning of the building unit units. These seals e.g. 324 prevent air leakage through the gaps between neighbouring façade elements 310,310a to provide a sealed outer perimeter of the building 300. In this preferred embodiment, the façade units 310 are preferably made using an insulated system, for example, aluminium framed and glazed assemblies, composite aluminium, glass reinforced concrete or fibre cement panels, precast concrete, timber or folded metal cladding.

To better control air flow paths around the column zones 320 and 322 seals can also be located within the column zones between neighbouring building units. In this example, seals 326 and 328 are provided between pairs of vertically adjacent building units 304a and 304b, 304c and 304d. Similar seals e.g. 334 and respectively, can be provided between the outer ceiling of building unit 304a and its corresponding roof segment 330 and between the outer floor of building unit 304d and a corresponding section of either floor or foundation of the building 332. Seals 334 and 336 also control air flow around the column zones of the building.

The building 300 is additionally provided with a heating or cooling system 340 to provide hot and/or cold air into the column zones 320,322 and air circulating fans 342 to circulate the air through the column zones. In use, the fan 342 will circulate air around the column zones as defined by arrows 344a, b and c. Air does not flow into the column zones between vertically adjacent building units 304a, 304c and 304d or above and below building units 304a and 304b respectively due to the position of seals 326,328,334 and 336. Thus it can be considered that building units 304,304b and 304e are predominately heated and/or cooled by active circulation around its outside whereas other than the sidewalls of building units 304a,304c and 304d, passive heating and cooling needs to take place as no air is circulated past their ceilings or floors. Of course, different air flow patterns can be implemented with or without the use of seals. It is also possible to put active ventilation controls such as a controllable louvers, additional fans or other airflow control devices at any point within the column zones to achieve a desired air flow pattern.

Figure 4 shows a cross-sectional view through one side of a building unit which can advantageously be used in an embodiment of the present invention. As will be appreciated the other side of the building unit will be of the same construction. The construction of the building unit illustrated in Figure 4 can provide good thermal contact between air circulation zone in which heating or cooling air is circulated, and the interior of the building unit. Moreover, the construction illustrated in Figure 4 provides good acoustic isolation between the outside of the building unit and its inside, thus facilitating good sound isolation between units in buildings constructed of multiple building units. High fire ratings for these building units may additionally be achieved.

In Figure 4 there is shown cross sectional view through a portion of the side wall, floor and ceiling of a building unit. The building unit 400 includes three main sub-assemblies namely, a wall assembly 402, a roof assembly 404 and flor assembly 406. These assemblies are generally of a layered construction and include a structural layer (e.g. a layer including an relatively strong skin and possibly also separate structural supporting elements), and one or more lining layers. The structural layer is typically on the external side of the panel, but need not be.

The wall assembly 402 is formed from a panel structure that includes:

A top and bottom angle section 408 and 410, which extend longitudinally for substantially the whole length of the building unit 400. The angle sections 408 and 410 can be made from 3mm or 4mm steel.

An outer metal skin 412, which can be made from, e.g. 1.8mm sheet steel, and is welded along its top and bottom edges to the angles 408 and 410.

A plurality of ribs 414 spaced along the length of the building unit 400. These ribs can be e.g. 75mm Z-purlins set at 400mm centres along the length of the building unit 400 and welded to the sheet 412 and angles 408 and 410.

An inner wall lining 416, which can be made from 13 or 16 mm plasterboard or like material that is glued to the inner wall of the outer skin 412. Advantageously the wall lining 416 is fire rated and bonded to the skin 412. A sound insulating material is

applied between the wall lining and skin to achieve the acoustic requirements, e.g. through a system of constrained layer damping. Most preferably, this layer is also thermally conductive to assist in heat transfer through the structure. Additionally, phase change material can be incorporated into the panel structure, e.g. as an additional layer or incorporated into the plaster board etc. to store heat for later dissipation either into the interior of the unit or circulating air.

The roof assembly 404 is a similar panel structure to the wall and includes:

A longitudinally extending angle section 418, which extend longitudinally for substantially the whole length of the roof assembly 404. The angle section 418 can be made from 3mm or 4mm steel.

An outer metal skin 420, which can be made from, e.g. 1.6mm sheet steel, and is welded along its longitudinal edges to the angles 418.

A plurality of ribs 422 spaced along the length of the building unit 400. These ribs can be e.g. 100mm Z-purlins set at 600mm centres along the length of the building unit 400 that are welded to the sheet 420 and angle 418.

The ceiling of the roof structure, is lined on its inside e.g. with one or more layers of 13 or 16mm plasterboard 424. The lining can be mechanically fastened to the inside of the ceiling with fasteners, e.g. screws or the like. Typically these will need to be attached after assembly of the building unit.

The floor assembly 406 is of similar construction to the roof assembly 404, and includes:

A longitudinally extending angle section 426, which extends for substantially the whole length of the floor assembly 406. The angle section 426 can be made from 3mm or 4mm steel.

An outer metal skin 428, which, for example, can be made from 1.6mm sheet steel, and is welded along its longitudinal edges to the angles 246.

A plurality of ribs 430 spaced along the length of the building unit 400. These ribs 430 can be e.g. 200mm Z-purlins set at 600mm centres along the length of the building unit 400 and welded to the sheet 428 and angle 426.

The inside floor of the assembly can be formed from a suitable sheet material 432, which can be a sheet of 22mm particleboard, and attached in a suitable manner, e.g. by gluing to the purlins with adhesive or mechanical fastening.

The panel structures described herein can either be formed in discrete panels segments and assembled to form the respective wall, floor or roof assembly, or formed continuously. Moreover the floor and roof panel structure can also include an acoustic isolation layer to further reduce transmission of sound through these panels.

As previously discussed, the building units form part of a building unit assembly and also include structural support segments in the form of externally mounted columns (not shown on this diagram) which structurally support the building unit.

Figure 5 shows a partial cross-sectional view through the neighbouring corners of four building units of the type illustrated in Figure 4. On the right hand side of figure 5 there is illustrated a vertically aligned pair of building units "Unit 1" and "Unit 2" which are shown in solid lines. A laterally adjacent pair of vertically aligned building units "Unit 3" and "Unit 4" are illustrated in dotted lines. The structural frame segments of the building unit assemblies are not illustrated for clarity.

In this arrangement the building unit assemblies, Units 1 to 4, are positioned such that there is a column zone entirely surrounding them from each of their neighbours. This gap is assured in construction using the techniques described in our earlier PCT patent application. In this example a 25mm zone 501 extends laterally between the building unit assemblies forming neighbouring storeys of the building. A vertically extending column zone 502 is provided between horizontally neighbouring building unit assemblies. This gap is 20mm when measured between the external wall purlins (414 from figure 4) of neighbouring building unit assemblies, but is larger (170mm) when the purlin depth is considered.

Flow control structures, in the form of seals can be placed between adjacent building units to define the air circulation zone. For example a vertically extending seal can be placed between the columns of neighbouring units, or directly between its walls. Similarly, a horizontally extending seals can be positioned between vertically adjacent units.

Figure 6A and 6B illustrate another embodiment of the present invention, in side and top view respectively. In this embodiment, the building 600 includes a plurality of building units 602 and 602.1 to 618 and 618.1. The building units are arranged vertically in three levels, and horizontally in two rows.

Between horizontally adjacent building units e.g. 602 and 604, 608 and 610, 614 and 616 there is a vertically extending column zone e.g. 630. Between vertically adjacent building units e.g. building unit 602 and building unit 608, unit 604 and unit 610, unit 606 and unit 612 there is a horizontally extending zone 632. As in the previous embodiment, a heating and/or cooling device 634 is provided. Flow control devices are also provided within the column zones, e.g. air circulation means, e.g. in the form of fans 644 and 648.

In this embodiment, the outer envelope of the building e.g. 648, which is generally defined by its façade does not define part of the air circulation zone. Instead the building contains a series of seals 660 to 670 extending vertically between horizontally adjacent units that assist in defining the air circulation zone, and a series of horizontally extending seals 650 between the building units of neighbouring storeys. In effect the seals 650 and 660 to 670 restrict the air circulation zone to the network of column zones 630, 632 between building units. means that only the internal walls of the units 602, 602.1 to 616 to 616.1 are used for heating and/or cooling the internal volume of the units.

As described in the previous paragraphs, as heating or cooling air circulates through the column zones heat will be transferred to, or from, the interior of the building unit through its walls, floor and ceiling. The interior of the room is thus heated by either connection or radiating heat into the room. Or alternatively, heat is transferred out to the column

zones by conversion or radiation to cool the room. As noted above, the construction of the building units illustrated in Figure 4 can provide good thermal contact between heating and cooling air circulating in the column zones in and the interior of the building units. Moreover, the construction illustrated in Figure 4 and air gap provided by the column zones between neighbouring building units provides good acoustic isolation between neighbouring building units. High fire ratings for these building units may additionally be achieved.

It will be understood that the invention disclosed and defined in this specification extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various alternative aspects of the invention.

The claims defining the invention are as follows:

1. A building including:

two or more building units, the building units including structure defining at least one room having an interior volume;

an external envelope defining an outside of the building, and an air circulation zone, within the envelope, that is separate from the interior volume, wherein at least part of the structure defining at least one room is configured to transmit heat between the room's interior volume and the air circulation zone; and

a mechanism configured to heat and/or cool the air circulation zone to control the temperature in the internal volume by heating and/or cooling the structure defining the rooms.

2. A building as claimed in claim 1 which further includes heating or cooling means to control the temperature of air in the air circulation zone.

3. A building as claimed in any one of the preceding claims wherein there is no exchange of air between the interior volume and the air circulation zone.

4. A building as claimed in any one of the preceding claims wherein at least one of said building units includes a façade structure carried on an outside thereof, said façade structure forming a portion of the external envelope of the building in use.

5. A building as claimed in any one of the preceding claims wherein the external envelope is insulated to minimise heat exchange between air in the air circulation zone and an external environment.

6. A building as claimed in any one of the preceding claims, which further includes a flow control system to control the air flow within the air circulation zone.

7. A panel structure for a modular building unit, said panel structure having first and second surfaces and including;

at least one structural layer;

at least one sound insulating layer; and

at least one heat transmission path between the first and second surfaces.

8. A panel structure as claimed in claim 7 wherein either or both of the sound insulating layer and structural layer has a high thermal conductivity.

9. A panel structure as claimed in either of claims 7 or 8wherein the sound insulating layer provides a sound insulating effect using constrained layer damping.

10. A panel structure as claimed in any one of claims 7 to 9 wherein the structural layer and sound insulating layer form adjacent layers in the panel structure.

11. A panel structure as claimed in any one of claims 7 to 10 wherein one or more additional layers lie between the structural layer and sound insulating layer.

12. A panel structure as claimed in any one of claims 7 to 11wherein the structural layer includes a metal skin.

13. A panel structure as claimed in any one of claims 7 to 12wherein the structural layer includes structural bracing elements.

14. A panel structure as claimed in either one of claims 12 or 13wherein the metal skin is sheet-like and structurally self supporting.

15. A panel structure as claimed in either one of claims 12 or 14 wherein the metal skin includes corrugations, ridges or other forms to provide rigidity to the metal skin.

16. A panel structure as claimed in any one of claims 7 to 15 wherein the layers of the panel structure are bonded or mechanically fixed to other layers.

17. A panel structure as claimed in any one of claims 7 to 16 wherein the panel structure additionally includes a heat absorption layer.

18. A panel structure as claimed in claim 17 wherein the heat absorption layer includes a phase-change material.

19. A panel structure as claimed in any one of claims 7 to 18 wherein the panel structure comprises a portion of any one or more of a floor, ceiling or wall of a pre-fabricated building unit.

20. A building as claimed in any one of claims 1 to 6 wherein at least a portion of the structure defining at least one room is formed from a panel structure as claimed in any one of claims 7 to 19.

21. A method of adjusting the temperature of a room forming part of a building as claimed in any one of claims 1 to 7, the method including:

circulating air through an air circulation zone abutting the room such that heat is transferred between air within the room and the circulating air.

22. A method as claimed in claim 21 wherein the method includes:

heating and/or cooling the circulating air.

23. A method as claimed in either of claims 21 or 22 which includes:

recirculating the air through a heating and/or cooling system to control the temperature of the circulated air.

24. A building as claimed in any one of claims 1 to 6 wherein a structure defining the external envelope of the building is spaced from the structure defining at least one room to at least partially define the air circulation zone of the building.

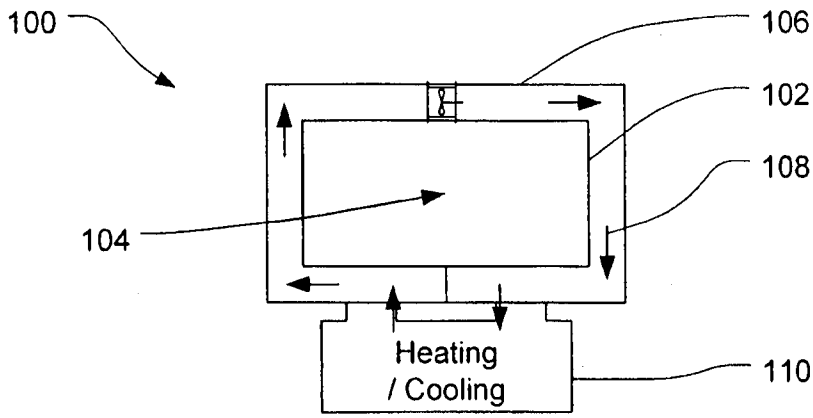


Figure 1

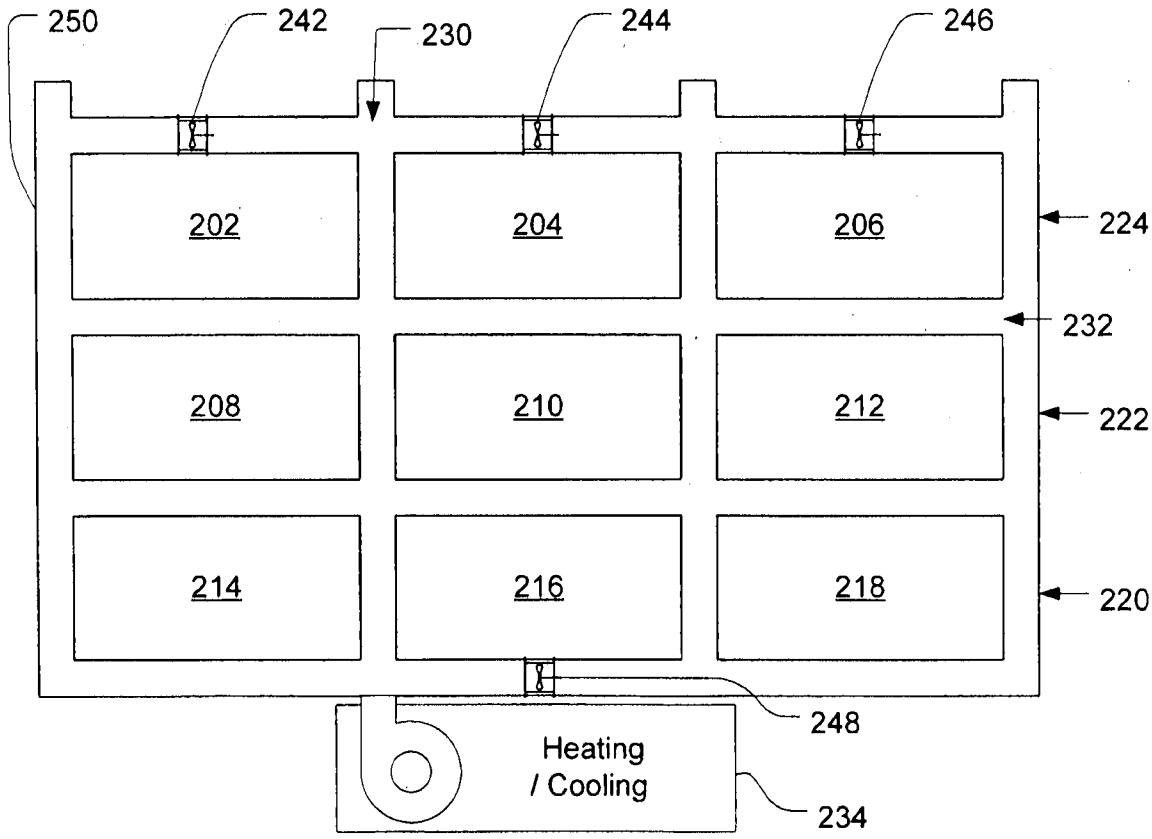
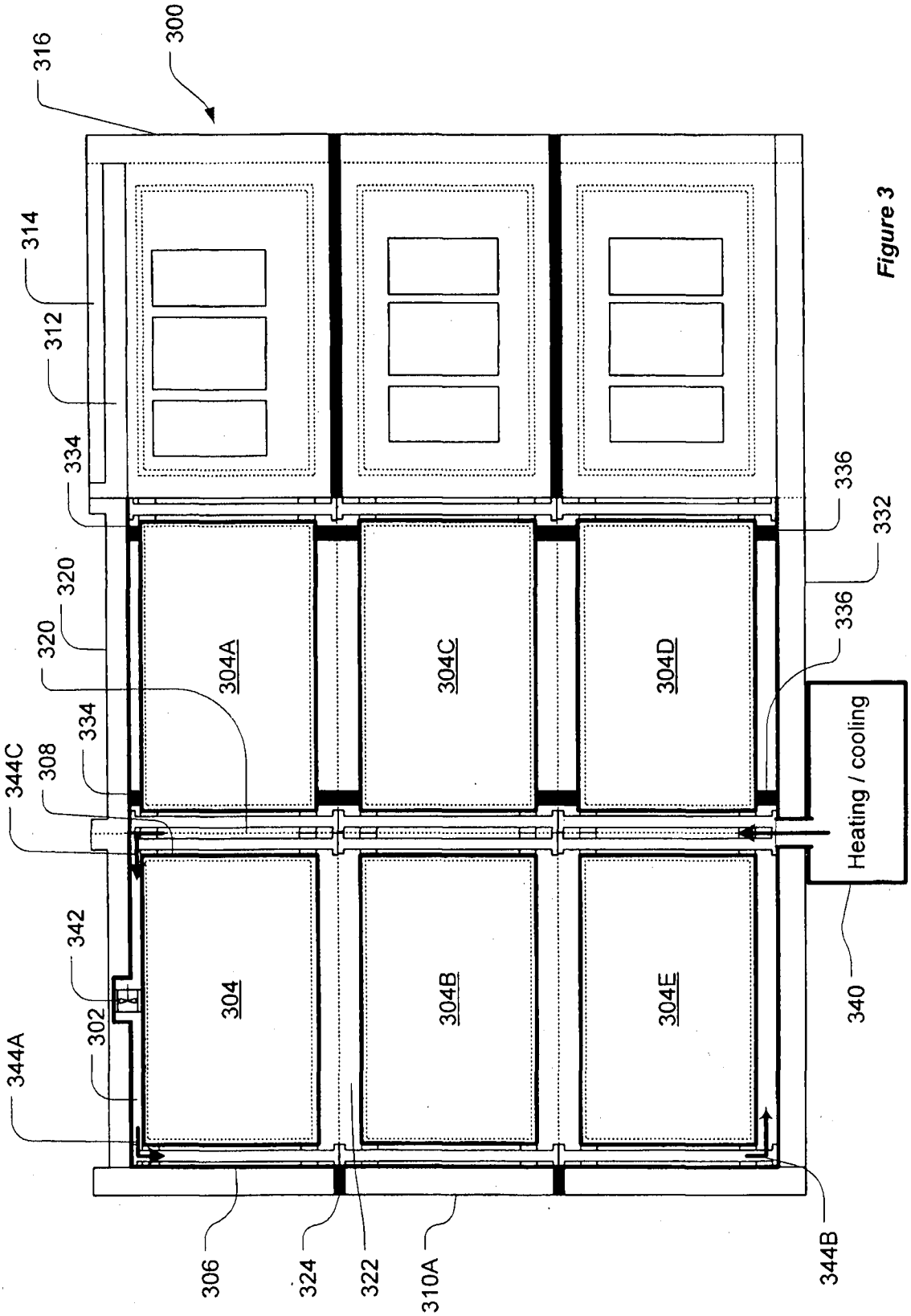


Figure 2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304A
304C
304D
334
308
344C
342
302
344A
304
304B
304E
306
324
322
310A
344B
336
332
336
Heating / cooling
340

Figure 3

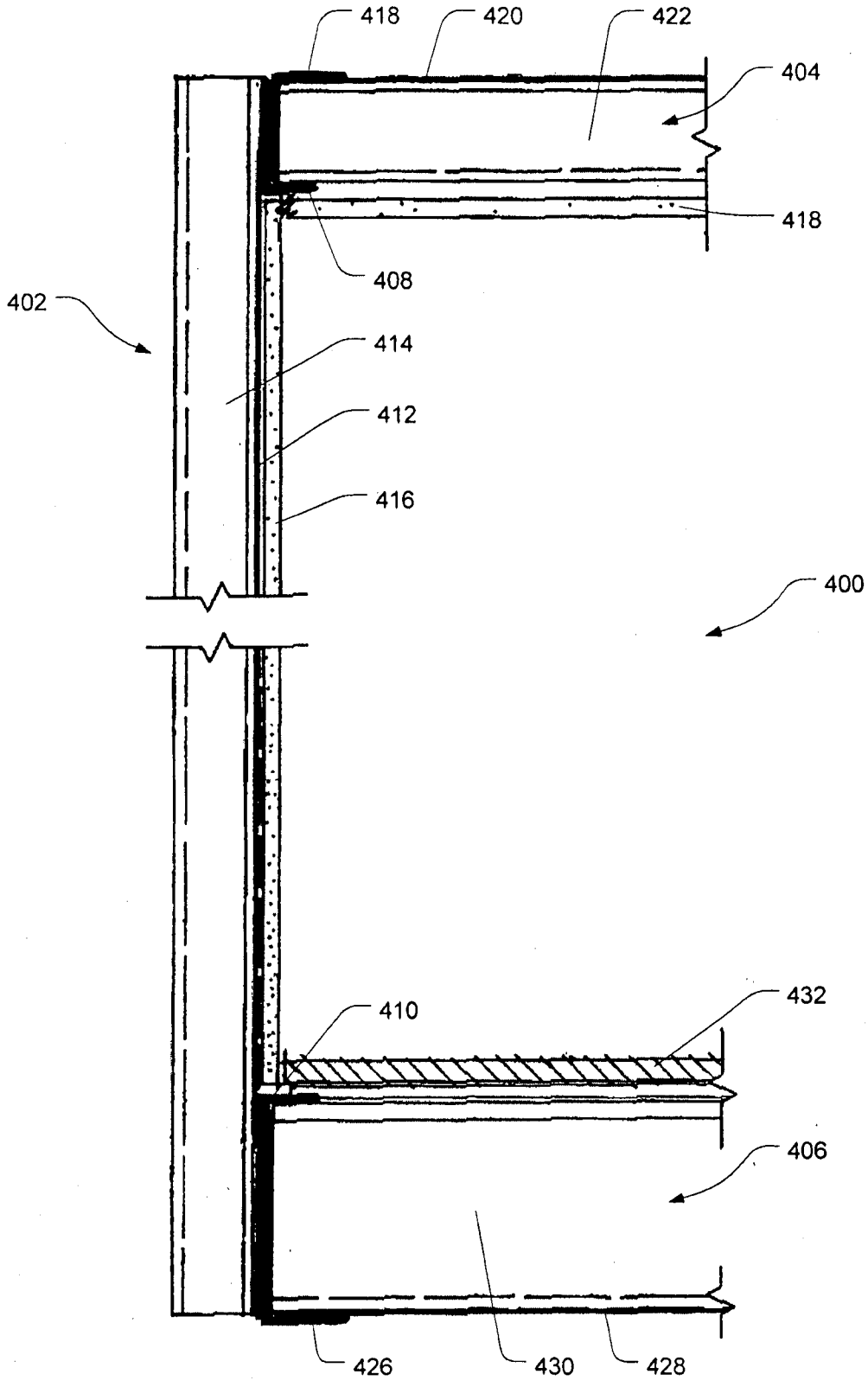
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Figure 4

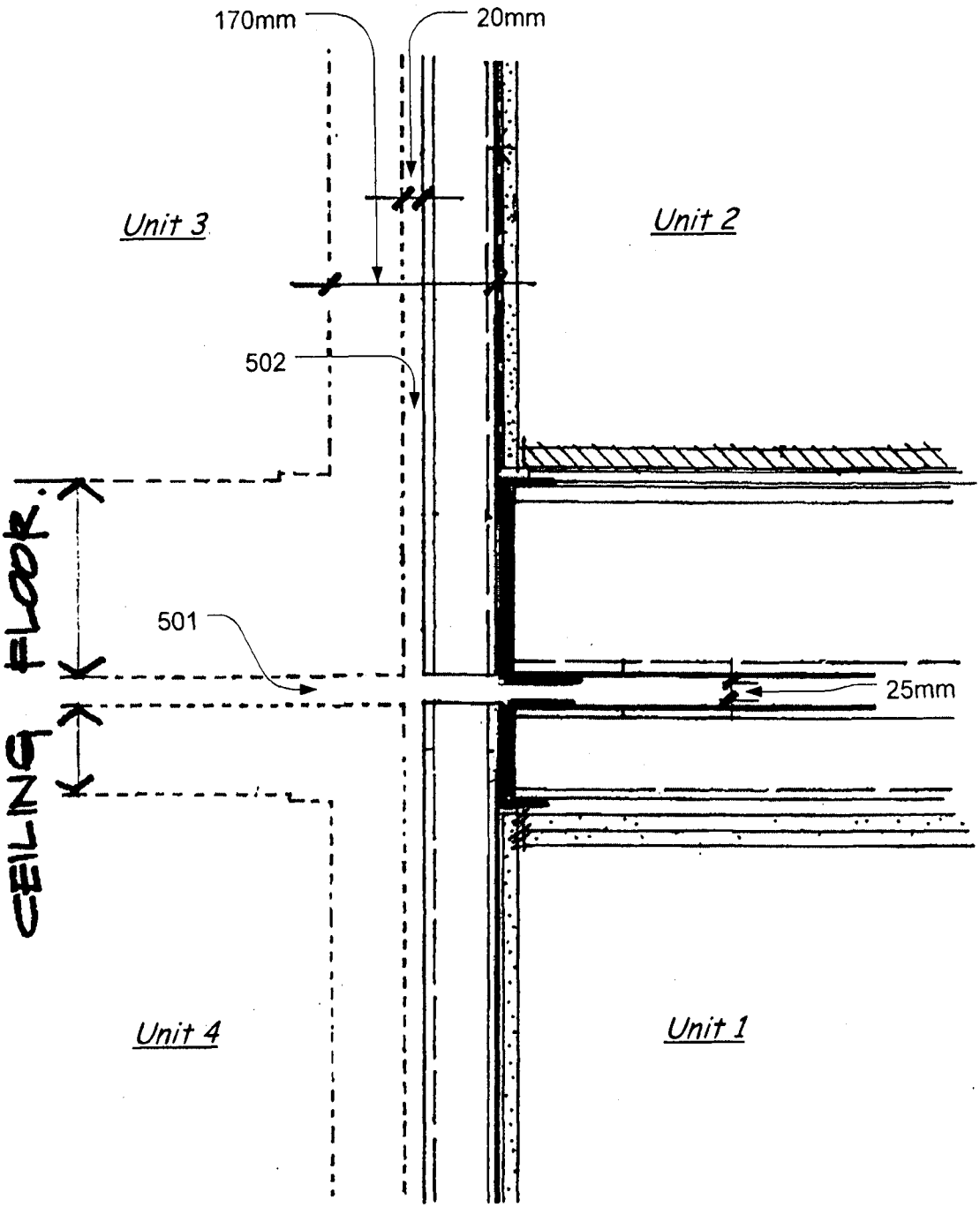
170mm
20mm
Unit 3
Unit 2
502
FLOOR
501
25mm
CEILING
Unit 4
Unit 1

Figure 5

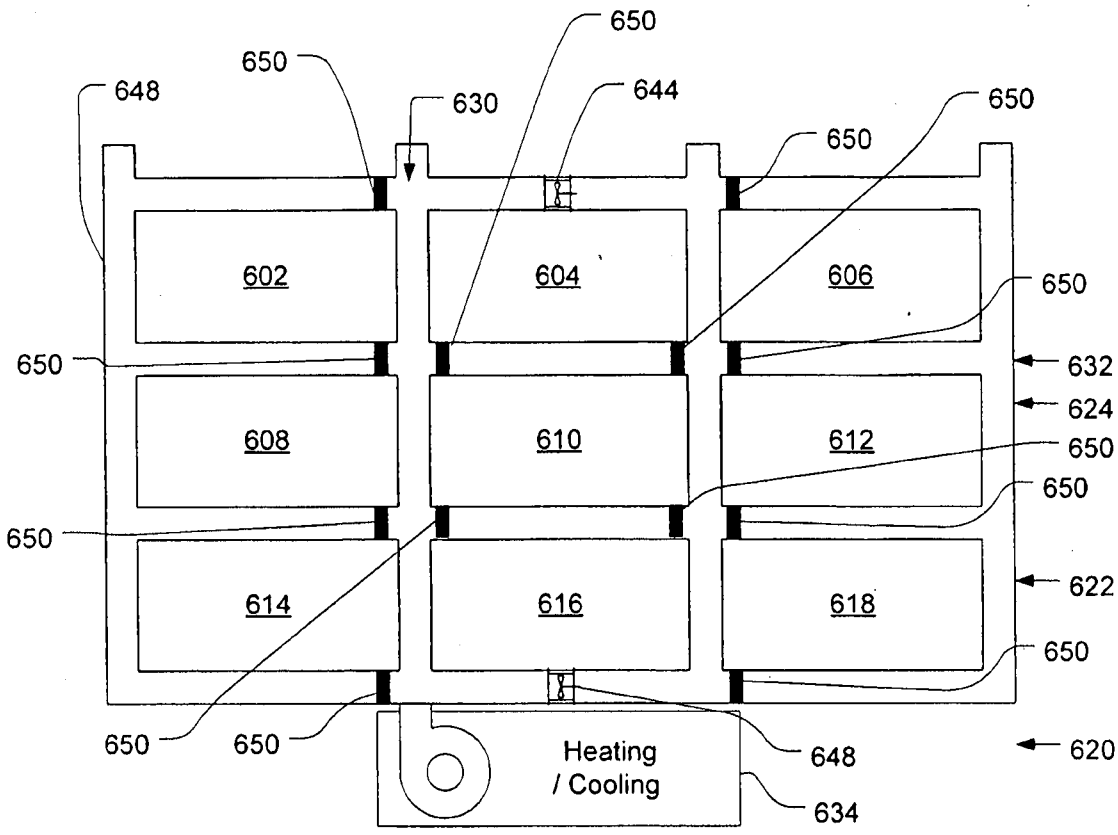

Figure 6A

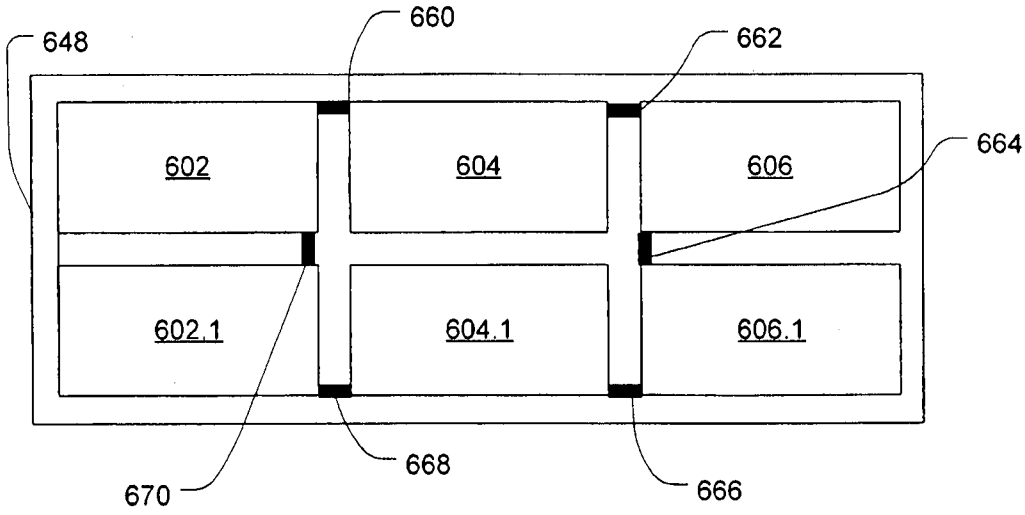

Figure 6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000181

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

F24F 5/00 (2006.01) *E04C 2/30* (2006.01) *E04B 1/00* (2006.01) *E04H 1/00* (2006.01)

E04H 3/00 (2006.01) *E04H 9/00* (2006.01)

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)

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

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPOQUENET: EPODOC/WPI- IPC Marks F24F5/00, F24F7/10, E04B1/LOW, E04H1/LOW, E04H3/LOW, E04H9/LOW, E04C2/30 with Key Words DOUBLE_WALL+, GAP+, CAVIT+, SPAC+, HEAT+, COOL+, AIR_CONDITION+, AIR INTERNAL, INSIDE, EXTERNAL, OUTSIDE, TEMPERATURE, CONTROL+, ADJUST+, MAINTAIN+, AIR_CIRCULAT+, AIR_GAP?

GOOGLE PATENT: Word Search BUILDING, ROOM, DOUBLE, WALL, CAVITY, GAP, AIR, HEAT, COOL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan JP 06-212713 A (CHIYOU SEIGEN) 2 August 1994 See IPDL machine translation; figure http://www4.ipdl.inpit.go.jp/Tokujitu/PAJdetail.ipdl?N0000=60&N0120=01&N2001=2&N3001=H06-212713	1-6, 21-24
X	Patent Abstracts of Japan JP 2008-185324 A (MIYAZAKI MASAYASU) 14 August 2008 See IPDL machine translation; figures http://www4.ipdl.inpit.go.jp/Tokujitu/PAJdetail.ipdl?N0000=60&N0120=01&N2001=2&N3001=2008-185324	1, 2, 4-6, 21-24

[X] Further documents are listed in the continuation of Box C [X] See patent family 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 application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
16 May 2011

Date of mailing of the international search report
17 MAY 2011

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000181

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan JP 2003-120957 A (FUKUCHI KENSO KK) 23 April 2003 See IPDL machine translation; figures http://www4.ipdl.inpit.go.jp/Tokujitu/PAJdetail.ipdl?N0000=60&N0120=01&N2001=2&N3001=2003-120957	1, 2, 4-6, 21-24
A	Patent Abstracts Of Japan JP 2002-194828 A (KAKUDAI KENCHIKU SEKKEI KENKYUSHO KK) 10 July 2002 See abstract; figure	1-6, 21-24
A	Patent Abstracts of Japan JP 2000-204774 A (TAKUBO KOGYOSHO KK) 25 July 2000 See abstract; figs	1-6, 21-24
A	JP 08-135037 A (FUKUBI KAGAKU KOGYO KK) 28 May 1996 See English abstract retrieved from EPODOC database	1-6, 21-24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000181

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box A

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-6, 21-24

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000181

Supplemental Box A
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claim groups 1-6, 24 and 21-23 are directed to a building and a method of controlling the temperature of the building, said building including: two or more building units, the building units including structure defining at least one room having an interior volume; an external envelope defining an outside of the building, and an air circulation zone, within the envelope, that is separate from the interior volume and a mechanism configured to heat and/or cool the air circulation zone to control the temperature in the internal volume. It is considered that an air circulation zone within the envelope that is separate from the interior volume and a mechanism configured to heat and/or cool the air circulation zone to control the temperature in the internal volume comprises a first distinguishing feature.

- Claims 7-19 and 20 are directed to panel structure for a modular building unit and a building comprising said panel, the said panel structure having first and second surfaces and including; at least one structural layer; at least one sound insulating layer; and at least one heat transmission path between the first and second surfaces. It is considered that least one heat transmission path between the first and second surfaces comprises a second distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

Each of the abovementioned groups of claims has a different distinguishing feature and they do not share any feature which could satisfy the requirement for being a special technical feature. Because there is no common special technical feature it follows that there is no technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a priori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2011/000181

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member
JP	6212713	NONE
JP	2008185324	NONE
JP	2003120957	NONE
JP	2002194828	NONE
JP	2000204774	NONE
JP	8135037	NONE

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX