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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 April 2006 (20.04.2006)

PCT

(10) International Publication Number
WO 2006/041418 A1

(51) International Patent Classification:
F28F 13/12 (2006.01) ***F24F 7/10*** (2006.01)

(21) International Application Number: PCT/TR2005/000039

(22) International Filing Date: 31 August 2005 (31.08.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/618,122 14 October 2004 (14.10.2004) US

(71) Applicants and
(72) Inventors: KILKIS, Birol [TR/TR]; TEKNOLOJI PLAZA ESKI BUYUKDERE CAD. OZCAN SOK. NO: 23 LEVENT, 34416 ISTANBUL (TR). **MANAS, Alphan** [TR/TR]; TEKNOLOJI PLAZA ESKI BUYUKDERE CAD. OZCAN SOK. NO: 23 LEVENT, 34416 ISTANBUL (TR).

(74) Agent: DESTEK PATENT INC.; TOPHANE ORTAPAZAR CAD. NO: 7 OSMANGAZI, 16040 BURSA (TR).

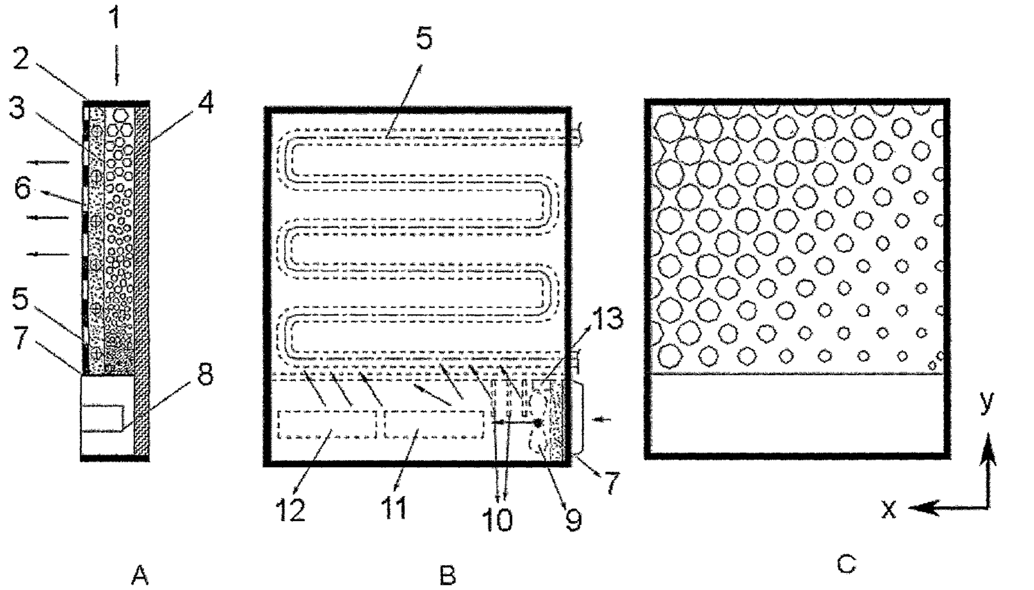
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *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.

(54) Title: COMPOSITE HYBRID PANEL, OR BUILDING ELEMENT FOR COMBINED HEATING, COOLING, VENTILATING AND AIR-CONDITIONING



(57) Abstract: An invention of composite, hybrid radiant/forced and natural convection, integrated, sandwiched, multi-role panel (1) optimally integrates heating, cooling, ventilating, air-conditioning, thermo-electric effect, energy recovery, and energy storage functions at very moderate operating temperatures such that it can directly utilize renewable and waste energy resources having very low exergy. The composite hybrid panel or building element (1) having a diffuser layer (2) that is thermally conductive, a porous layer (3) providing uniform air diffusion, a thermal insulation layer (4) simply attached or embedded or integrated to a building wall ceiling, floor or stands alone for indoor space partitioning purposes.

WO 2006/041418 A1

COMPOSITE HYBRID PANEL, OR BUILDING ELEMENT FOR COMBINED HEATING, COOLING, VENTILATING AND AIR-CONDITIONING

BACKGROUND – FIELD OF INVENTION

This invention relates to composite, integrated, sandwiched, multi-role, hybrid radiant-convective panel or building element, which optimally integrates heating, cooling, ventilating, air-conditioning functions and any other indoor function like air pressure control, thermo-electric effect, energy recovery, and energy storage functions at very moderate temperatures such that it can directly utilize renewable and waste energy resources with very low exergy.

BACKGROUND – DESCRIPTION OF PRIOR ART

Heating, ventilating and air-conditioning (HVAC) systems have to satisfy three primary comfort functions, namely heating and cooling, humidity control, and ventilation. These functions are usually delegated to either a central forced convection air-conditioning system, or unitary air-conditioners, or hydronic heating/cooling systems (like convective fan-coils or radiant panels). **In turn, in existing building technology walls, ceilings, and floors are non- HVAC functional, except acting like radiant panels or carrying ducts or chilled beams. On the other hand, radiant panels or chilled beams alone cannot control indoor humidity and cannot satisfy latent thermal loads. They can only satisfy sensible thermal loads.**

Building elements, walls, ceilings and floors may be more cost effective and energy efficient if they are directly used for HVAC and other indoor functions and satisfy both sensible and latent loads.

In particular, forced convection air-conditioning through a single duct system compromises the efficiency and comfort functions, which are not truly compatible and sometimes contradictory. Ducts of a central air-conditioning system spanning the entire building are expensive and they are energy, premium space, and material intensive, they need frequent, if not continuous maintenance and inspection for indoor air quality reasons for human health and other functional requirements like clean rooms, hospitals, schools etc, to name a few.

On the other hand, available terminal units of existing technology, whether air or hydronic, primarily function by either thermal convection or radiation, whereas optimum human comfort precisely requires a radiant convective split of 60% by 40%, of which, none of the existing HVAC systems can provide.

Hydronic systems like radiators or radiant panels are more energy distribution efficient but cannot handle latent loads without a secondary air system. For example, a recent DOE (Department of Energy) study classifies ceiling panel cooling as the most energy efficient system (DE-AC01 -96CE23798) but requires a secondary air system in order to satisfy latent loads (humidity control of indoor air).

Conventional HVAC systems are designed to use high-exergy energy resources, commonly fossil fuel based, at very low-exergy efficiency, like 6%. When these systems are attempted to be coupled with low-exergy renewable or waste energy resources, HVAC equipment and terminal units need to be either over sized or resource temperature need to be conditioned, or both, each of which are costly penalties and often diminish the environmental and exergetic advantages of utilizing renewable and waste energy resources. In other words, conventional HVAC systems, which fundamentally remained unchanged for over a century are incompatible with low-exergy renewable and waste energy resources and require substantial equipment over sizing and/or conditioning of the resource temperature with boilers, heat pumps, and chillers. As a result, these energy resources will not economically and rationally substitute fossil fuels unless a new HVAC system is introduced, which may directly utilize them. The only heating and cooling system that can be directly coupled to low-exergy energy resources without any penalty is radiant panel system. However, radiant panel systems cannot handle latent loads like humidity control and a secondary system needs to be introduced to the same indoor space to satisfy latent loads. The so-called hybrid HVAC system is a co-location of at least two different types of heating and a cooling system like a radiant panel and a convective system like a condensing type fan-coil in the same indoor space.

Although the hybrid HVAC system seems to be a possible candidate for better utilization of low-exergy renewable and waste energy resources, it can only optimize the equipment over sizing and temperature conditioning instead of eliminating these costly measures, which diminish major advantages of low-exergy energy resources. For example even after using design and sizing optimization tools developed by the Inventor, a fan-coil and radiant panel combination using 45°C waste water for space heating requires 60% equipment over sizing and a boiler to peak the resource temperature from 45°C to 55°C. This example shows that whichever engineering ingenuity and mathematical tools are employed, the feasibility of coupling conventional HVAC systems directly with low-exergy energy resources is quite limited and remains uneconomical.

Conventional HVAC technologies worldwide encounter four major problems:

1- They cannot directly couple with low-exergy energy resources without impairing performance of other green components and without substantial economic and technical penalties.

2- They cannot actively control radiant/convective heat transfer split for maximum human comfort.

3- Installation, operation, and maintenance are costly and energy and occupied space intensive.

4- They require uncomfortably low condensation temperature of humid air in order to control the indoor air humidity. This renders generally a re-heat process and reduces the coefficient of performance (COP) of heat pumps and chillers.

About 90% of HVAC systems use central forced-air distribution, which is the least economical and exergetically most inefficient system. On the other hand, technologies mainly emerging in Europe like chilled beams and similar radiant systems cannot handle latent (humidity control) loads without an additional conventional system.

The apparatus of this invention overcomes these problems mentioned above by combining all HVAC functions into a single terminal unit that can directly couple with low-exergy energy resources. This invention houses all HVAC elements in it or this invention may also be used with any central HVAC system, heat pump system or central heating or cooling system as an n efficient and multi-role terminal unit without housing any HVAC element like dehumidifier etc.

SUMMARY

In accordance with the present apparatus of invention, which is a composite hybrid radiant and convective panel takes the hybrid HVAC concept one big step further and combines different and essential radiant and convective components of HVAC physically into a composite, single terminal unit for total human comfort, and any other building functions and eliminates the four major problems of conventional HVAC system. The same system may equally be effective for animal shelters, greenhouses and storage buildings, libraries, and museums. The invention comprises a thermally active and hydrodynamically porous diffuser plate, which acts as both a radiant and forced/natural convection heat

exchange surface and a latent air diffusion surface for total comfort service from such a single surface. This surface is encased in a wall, ceiling or floor panel, encased in an office cubicle partition, or embedded to a section of the building structure or any building element. Heating and cooling of the air diffusing into the indoor space from the composite hybrid panel can be pre-conditioned in a central system or by the panel itself by hydronic pipes or electric cables (heating only) or thermo-electric effect wires (cooling only) or any combination of all these placed behind the porous diffuser plate. These cables, wires, pipes also heat or cool the diffuser plate surface to make it a radiant panel surface at the same time. Conversely pre-conditioned air may also make the diffuser plate surface thermal radiation-wise active without pipes, wires, or electric cables. In summary, diffusing air is heated or cooled and humidity conditioned by different systems in a part of the same encasement or air is pre-conditioned by other external systems outside the encasement. The thermal mass of apparatus stores heat or cold thus shaves-off the peak sensible thermal loads. It may also incorporate a building exterior integrated feature, which collects energy. The same encasement of the apparatus may also house other sanitary, comfort and utility functions like air filtering, air sanitization, ionization, air-pressure control, indoor lighting, electrical power supply lines and or bus-bars, plumbing pipes, internet, wired or wireless communication systems.

The invention also comprises an apparatus and method for dynamically optimum operation control for minimum cost and maximum efficiency, and an operation control algorithm for different objective functions.

Objects and Advantages

Accordingly, besides the objects and advantages of the composite hybrid radiant/convective panel described in my above patent, several objects and advantages of the present invention are:

- to provide HVAC and other indoor functional walls, ceilings and floors in existing building technology,
- to provide HVAC cheaper than a central, forced-convection system with ducts and reduce its disadvantages of occupying cost-premium indoor space and material and energy intensive capital and operating costs,
- to provide intuitive hybrid HVAC system to optimally satisfy all objective and subjective human comfort requirements in a dynamically optimum cost and maximum energy and exergy efficiency,

- to provide intuitive hybrid HVAC system, which can handle latent loads without a separate air system,
- to provide a hybrid HVAC system that can directly utilize low-exergy energy resources, which otherwise are wasted
- to provide a new hybrid HVAC system such that renewable energy resources may economically and rationally substitute fossil fuels,
- A unified, single apparatus to provide all building functions as necessary,
- A unified, single apparatus that can operate stand-alone (by itself) or can be optimally modulated into other conventional systems.

DRAWING FIGURES

In the drawings, closely related figures have the same number but different alphabetic suffixes.

Fig 1A shows cross sectional side view of the innovative composite hybrid panel (in wall position for demonstration purposes) having three layers and a decorative, porous, hybrid radiant, forced/natural convection functional cover.

Fig 1B shows front view of a preferable embodiment with heating and/or cooling elements of innovative wall panel (surface porosity not shown). The geometry of the composite hybrid panel may be any suitable geometry like rectangle, square, parallelogram, circular, oval etc.

Fig. 1 C shows front sectional view of a preferable embodiment of a porous layer of innovative wall panel, where the degree of porosity, thus air-flow resistance changes both in lateral and transverse directions in order to compensate the asymmetric air intake and fan location (porosity holes not to scale in the figure).

Fig 2A shows cross sectional side view of the innovative composite hybrid panel without diffuser layer and heating and/or elements.

Fig 2B shows front view of the preferable embodiment of hybrid wall panel without heating and or cooling elements (no pipes, cables or wires).

Fig 3A shows cross sectional side view of the innovative splittable composite hybrid panel when the air intake and conditioning-filtering etc duct is separated.

Fig 3B shows front view of the innovative splittable composite hybrid panel without air duct.

Fig 3C shows an embodiment of an air duct splittable from composite hybrid panel.

Fig 4 shows an embodiment of breathing system composed of placing two composite hybrid panels (in this case wall panels for demonstration purposes) while one of two includes a diffuser layer and the other does not.

Fig 5 shows an example application for completely Green, Innovative Building HVAC Technology using a heat pump.

Fig 6 shows an example application of completely Green, Innovative Building HVAC Technology using heat pipes.

Fig 7 shows an algorithm of control apparatus that optimizes the load split PR.

Reference Numerals in Drawings

1. Composite hybrid panel (shown in wall position)
2. Air diffuser
3. Porous layer
4. Thermal insulator (preferably from recycled organic material)
5. Heating and or cooling element
6. Decorative and porous front cover
7. Air filter
8. Air duct
9. Fan
10. UV Lamps
11. Air humidifier unit
12. Dehumidifier unit (preferably liquid desiccant)
13. Sensors
14. Wind Turbine
15. Solar Photovoltaic Cells
16. Solar Water Panel
17. Ground Source Heat Pump (GSHP)
18. Electric battery
19. Hydronic Circuit
20. Desiccant de-humifier and cooler
21. TES (Thermal Energy Storage)
22. Seasonal Energy Storage System (ground heat exchange coils)
23. Capillary tubes

DESCRIPTION – Figs. 1A and 1B – Preferred Embodiments

A preferred embodiment of the composite hybrid panel **1** of the present invention is illustrated in Fig 1A and Fig 1B. As shown in Fig 1A, the innovative composite hybrid panel **1** comprises three layers **2, 3, 4** and a decorative, porous, and other functional front cover **6**. From the front cover, the composite hybrid panel surface exchanges heat with the indoor space by thermal radiation and natural thermal convection. At the same time, conditioned air is diffused to the indoor space through the pores of the panel surface, thus establishing a forced convection heat transfer. Diffuser **2**, which is air diffusing and thermally conducting layer of any porous material like stainless steel wool made from metal scrap or metal waste from any machine shop and then treated with anti-bacterial agents like silver-based anti-microbial agent or any other environmentally friendly antibacterial material. It also houses hydronic tubing or capillary tubes for heating and or cooling or electrical heating cable, electrical mat or thermo-electric cooling wire or wire mat **5.** Hydronic tubing (like thermoplastic tubing) or piping (like any metal pipe) or any capillary tubing is preferably made from fossil fuel by products or any other recycled or suitable scrap material. This layer **2** enhances heat transfer to/from the panel surface and helps o maintain a uniform surface temperature for even thermal radiation and convection. The porous layer **3** is made from any material; preferably, recycled or inverse engineered product like spray glued wood chips or shredded auto tires with pre-engineered variation of its degree of porosity in three dimensions in order to provide uniform air diffusion to the room over the entire panel surface. An analytic or numerical model determines the porosity and size distribution in all dimensions (height, width, depth). This porous layer may have a constant width (thickness) like shown in the relevant figures or may have a variable thickness in order to facilitate the uniformity of air diffusion. For example, this layer may taper along the height of the panel. Back and side thermal insulation preferably from recycled organic material with fire-resistant properties **4** minimizes energy losses. The composite hybrid panel **1** is preferably framed by recycled, environment safe, chemical free wood profiles and it is simply attached to the building wall. All material is fire-resistance compliant. Total panel thickness is typically and preferably, 6 inch (15 cm). Composite hybrid panels **1** may be combined and interconnected with each other or other building panels and plumbing elements with air and hydronic connectors. A dynamically active control apparatus controls all indoor functions.

As shown in Fig 1B, a heating and or cooling element **5** may be placed into the diffuser **2** of the innovative composite hybrid panel **1**. The heating and or cooling element **5** can be for example PEX tubing for warm or cold fluid circulation or electrical heating wires, electric mats, or thermo-electric effect (cooling) wires or mats. The shape and type of the heating element do not limit the scope. The important point is heating or cooling the panel surface when required with a dynamically controlled system (see fig 7). The fan **9** inhales or brings fresh air into the air duct **8.** Location, type, capacity, number and dimensions of the fan **9** used in the panel can be altered or changed. Fans may be located symmetrically or asymmetrically in any number, in any type or a combination of types and at any level of the panel and or in the air duct. The air filter **7** typically electrostatic type strains the air introduced to the air duct **8**. The UV lamps **10** clean and disinfect the air. A humidifier **11** and dehumidifier **12** can be placed into the air duct to control air relative humidity of the diffusing air for maximum human comfort and required levels. The arrows in fig 1B shows the typical directions of air circulation from air duct **8** to diffuser **2** and porous layer **3** in a uniform pattern. Because of the location of the fan(s) **9**, a sample position shown in fig 1B, air diagonally moves and advances from air duct **8** to porous wall **3** and -if exists- to diffuser **2**. Therefore the pores of the porous layer can be accordingly arranged, in this sample case diagonally, which is in a manner that the smallest pore is the nearest to the fan **9** and pores are less populated **in** order to increase the airflow resistance in this region.

Figure 2A shows the innovative composite and hybrid panel without heating or cooling pipes or electric cables/wires. This arrangement establishes a passive composite hybrid panel or building element structure, which is a part of the invented continuous air breathing system. Passive and active panels continuously breathe air except at off periods of the system if an on-off control is used. The preferable control apparatus and algorithm (fig 7) is a dynamic, temperature and airflow modulated control by varying the radiant/convective split and fluid temperatures. Side sectional view of this passive panel (in wall position) is displayed in fig 2B. The passive panel exhausts the air from the indoor space in a project-suitable manner or feeds it to re-circulation. The configuration shown in fig 2B for a passive panel may also be used for active panel configuration if the panel surface temperature control is also going to be accomplished by the conditioned air diffusing to the room through the panel pores.

Figures 3A to C show a splittable composite hybrid panel where the panel **1** and the air duct **8** can be separated for any reason like maintenance, repair or mounting. The splittable composite hybrid panel **1** may also be separately marketed if it will be serviced by a separate central system. In another case, a single air duct **8** may service a plurality of composite hybrid panels **1** with conditioned air, electricity, hot water or heating or cooling.

Fig 4 shows the air breathing system composed of mutually located panels **1**. In this system, one of the panels has diffuser layer and heating and or cooling elements, which is named active panel. The other panel is called passive panel, as it does not include diffuser and heating and or cooling elements. Passive panel is used only for air exhaust, energy recovery and other indoor functions desired at that indoor location.

While active wall exhales fresh, conditioned air into indoors, passive wall inhales. The connecting pipe **23** at the bottom in fig 4 shows a case where capillary tubes are used to bring liquid desiccant fluid from the active panel air duct **8** and to charge it at the passive panel air duct using the reclaimed (recovered) heat at the passive panel from the warm exhaust air and return the charged desiccant fluid back to active panel air duct **8** for continuing its dehumidifying function.

Figs. 5 and 6 – Applications of Preferred Embodiments

As shown in fig 5, in the heating mode, if the energy is derived from warm water, a water to air heat exchanger heats the incoming air, and the remaining energy in the warm water circulates through typically PEX tubing of heating element **5**, typically and preferably 0.75 inch (13 mm) in diameter. Tube spacing is determined according to the required thermal capacity. If the energy is derived from warm air, like from a solar air collector, the exchanger becomes air to water. Heat exchangers may be in every floor or tiny flat plate heat exchangers can be incorporated into the air duct of each composite hybrid radiant/forced and natural convection panel **1**. The advantage of the latter is that one type of fluid circulates in the system. Heating or cooling elements **5** transfer heat to/from the indoors through the decorative front cover **6**, which acts as a radiant panel surface. Radiant panel surface temperature, which controls the radiant and natural convection heat transfer at the entire panel surface is adjusted with respect to thermal loads by the fluid temperature circulating through the heating or cooling elements, or the electrical power of the electrical cables, mats or wires, or diffusing air temperature or both. Air diffusing through the thermal energy storing air diffuser **2** is further heated or cooled before entering the indoor space by the heating or cooling elements –if present. Air diffusion provides the forced convection component and satisfies all the latent thermal loads (humidity control). A dedicated control algorithm precisely maintains the best radiant/convective split for human comfort. A similar composite hybrid panel **1** without air diffuser **2** and heating element **5** is mounted on preferably an opposite side of the indoor space like the opposite wall if panels are located at walls, in order to to draw air from indoors and to deliver it back for re-circulation or exhaust all or part of it. This is the "passive" composite hybrid panel. Composite hybrid panel **1** may be serviced by a flexible mini-duct system to deliver externally conditioned air-to-air duct **8**. Air passes through a re-usable electrostatic, plasma, ionic, or HEPA air filter **7**, pass through UV lamps for sterilization and then diffuses through the porous layer **3**. A pre-filter may also be used at the upstream of the fan. This invention can be directly coupled with a cluster of other green energy components like wind turbines (WT) **14**, solar photovoltaic (PV) arrays **15**, solar water panels **16**, ground source heat pumps (GSHP) **17**, and energy storage systems **22** (fig 3). Any combination of such a cluster derives a completely green building technology and can eliminate fossil fuel dependency. When a GSHP **17** is coupled to the composite hybrid panel system **1**; it provides heat (in winter) from or rejects heat (in summer) to the ground, which also provides seasonal (long-term) energy storage. Hydronic circuit **19** conditions the ventilation air, provides energy to the composite hybrid panel tubing of the heating or cooling elements **5**, and activates liquid desiccant de-humidifier and air cooler **20**. WT **14** provides green electricity and incorporates batteries. Composite hybrid panel **1** itself is short-term thermal energy storage medium due to its relatively large thermal mass. A medium-term TES **21** shaves-off the peaks of the load and the green energy supply, and further shaves-off the demand. Solar water panels **16** deliver additional heat. Due to decreased, coincident loads, all green components have minimal size and peak performance. A further application of the invention is shown in fig 7, where heating element **5** directly transfer heat from/to the ground by the use of capillary tubes. Composite hybrid panel **1** may also be integrated into a Trombe wall section on the outside or incorporate phase change materials for energy storage. Other plumbing and building control and energy supply elements may be pre-engineered and pre-fabricated into these panels too, depending upon the need and production options to be marketed.

As a preferred embodiment, the composite hybrid panel **1** operates with a heat pump and satisfies the total sensible indoor space comfort load by radiant and convective components of heat transfer from its porous surface **6**.

In this patent, the load split is defined by the symbol *PR*, which needs to be optimized continuously in order to minimize the cost of the system. An optimum sensible load split control apparatus was invented which continuously optimizes *PR* by continuously calculating the indoor sensible comfort load q. In cooling, q is negative and in heating q is positive by sign convention.

$$PR = C'|q| \qquad (1)$$

Here *PR* is the optimum, instantaneous sensible load split between the radiant and convective components of the composite hybrid panel 1, depending upon the instantaneous total sensible load q. In Equation 1, the absolute value of q is used. C' is a performance characteristic constant:

$$C' = -\frac{C_{hp}}{C_1}\frac{a}{\left(xC_p M^{x-1}\right)} \qquad (2)$$

In Equation 2, x is -1.5 C_{hp} is the life-cycle-cost of the heat pump coupled to the composite hybrid panel system whose life-cycle cost factor is C_p. M is the design spacing of the hydronic tubing, or electric cables, or thermo-electric function wires **5** in the hybrid composite panel 1. a is a constant between 0.001 and 7.0. C_1 is constant depending upon the fluid temperature required from the heat pump. The control apparatus is schematically shown in Figure 7.

As a sample application, the control apparatus continuously monitors the mean radiant temperature t_{mr}, average dry-bulb air temperature of the indoor space t_a, and *AUST* (Area weighted uncontrolled indoor surfaces of the indoor space). Using these values, the outdoor temperature and the heat overall load loss (gain in cooling) U of the indoor space. Control is based on two steps. The first step modulates the temperatures of the diffusing air and fluid temperature depending upon the magnitude of q. The second step determines *PR*, which means how much of the sensible load is going to be satisfied by the radiant surface compared to the total sensible load. Thus, *PR* is a ratio. If the optimum *PR* needs to adjust the fluid temperatures, they are adjusted accordingly. If t_a, t_{mr}, or *AUST* are not in acceptable ranges, then the optimum solution is re-adjusted. Fan speeds are also controlled and adjusted.

One another important feature of these active and passive composite hybrid panels is that the indoor air pressure in every zone may be independently adjusted for premium human comfort. For example, when the outdoor air pressure is low, migraine headaches are aggravated in certain people. In such cases, an indoor pressure conditioning may reduce or even eliminate these symptoms. Positive pressurization of indoors on a zone-by-zone basis is also very important for homeland security. If an outside CBR risk evolves, positive pressurization of the building is possible. If and indoor CBR risk evolves, the risk can be isolated by adjusting the indoor air pressures of each zone independently. Active panel "exhales" and passive panel "inhales." This breathing system spread over the entire large surface area of the panel generates a uniform indoor environment and surrounding. Without any passive panel, the invention relies on air exfiltration from the conditioned indoor space. The same invention may also embed air ionizing technique or plasma filtration method. In air ionization air is ionized in a controlled manner in the active panel, and pollutants are collected on the passive panel. On the passive panel, decorative cover is replaced periodically. Because the airflow is slow, dust problem in indoors are generally minimized by this invention.

Another important application of these active and passive panels is that, the same invention may be applied to floors, ceilings, roofs, attic panels, or indoor partitioning walls in part or whole of the invention. For example, the same invention may be used for office cubicles to generate local/personal microenvironment climate, lighting and hub for electronic components, computers etc. This invention may be applied to any kind of building like but not limited to residential, commercial, industrial, etc. The same invention may be used in ground transportation and sea vessels and aircrafts with the exception in this case that these hybrid composite panels **1** may have no outside connection. The same invention may also be employed in spacecrafts where energy is limited and human comfort is a premium especially in emergency cases: in an emergency, the use of energy can be minimized in the composite hybrid panel **1** simply switching to radiant mode only.

All passive and active panels, ceiling, or even floor panels may incorporate artificial lighting elements over a wide surface area in particular but not limited to new low temperature, low energy, and closer to natural day lighting type lighting fixtures such as LED or similar lamp devices. Low intensity lighting over a larger surface area is more energy efficient and closer to natural lighting. These fixtures may be color and intensity variable in order to emulate a complete cycle of day lighting. In particular, this emulation may be useful in aircraft and spacecraft cabins to minimize the rapid earthly time zone changes to emulate the usual 24 hour cycle for astronauts in spacecrafts.

In particular but not limited to hybrid floor panel version, this invention may be used in other functions and applications like but not limited to animal shelters or pens, sport facilities (like outdoor tennis courts in winter), outdoor applications for cafes, greenhouses, public areas, restaurants, zoos, warehouses, controlled climate pharmaceutical and electronics buildings, storage rooms, hospitals, schools, offices, apartments, micro-climate control systems etc.

Another important application of these active and passive panels may be in museums or libraries to generate temporary or permanent display areas with zone control and independent HVAC application such that museum personnel, patrons, and artifacts books etc are maintained in an environment with maximum benefits without any compromise. For example in a library of old books and manuscripts, the air temperature must be low, while the humans must be thermally comfortable. Due to the dual control nature of the composite hybrid panel such that radiant surface temperature and the flowing air temperature can be independently controlled, the air temperature is kept minimal while human thermal comfort requirements are satisfied by the radiant heat transfer component of the composite hybrid panel **1**.

This Invention may also be coupled, integrated, and made compatible and able to integrate with new building construction technologies like building, panels for walls, floors, and roofs. The invention may be embedded into such building panels too.

This Invention may also incorporate natural ventilation through outdoors with a controlled or pre-engineered degree of porosity/permeability of outdoor air. Exhaust of air may be accomplished at the passive panel in a similar fashion. This combination eliminates ducts for indoor air ventilation requirements. These panels may have additional air filter layers for outdoor air.

Advantages

Further objects and advantages are enumerated below.

1. As a key feature, this technology operates at very moderate temperatures, so that it can be directly coupled to low-exergy energy resources such as solar, waste, and ground heat. This complete compatibility eliminates the conventional HVAC plants, terminal units, and associated energy losses, may increase the exergetic efficiency from about 15% to 80%, and proportionally eliminates environmental degradation.
2. This technology improves the HVAC thermal efficiency by about 12% points and reduces heating and cooling loads by up to 40%. Fossil fuel dependence may be reduced by up to 90%, and electrical power demand is reduced by about 85%.. The combined result is a substantial decrease in oil and gas dependency and increased energy security.
3. Engineering calculations show that capital cost may up to 70% cheaper, operating and maintenance costs may be up to 80% cheaper, when compared to central air-conditioning systems, after correcting the latter figure for the desiccant cooler.
4. This technology can significantly enhance economical and technical feasibility of using heat pumps, solar water heating panels, and wind turbines. For example, if a ground source heat pump is used with this invention, its COP increases typically by 40%, which offsets additional investment and operating costs, and adds positive impact on the environment. If wind energy drives the GSHP, the system becomes completely green as shown in fig 5. Even if only solar water panels are used, the overall installation cost will compete with conventional

HVAC systems, when increased solar panel efficiency is also factored-in. This reveals that solar panel water heaters in building heating and cooling can become perfectly economical even with today's solar panel technology, when they are coupled with the invention. Therefore, this invention provides a huge market and energy savings potential in solar building sector too. The same is also true for micro and district CHP (Combined Heat and Power) and CCHP (Combined Cold Heat and Power) systems.

5. Better indoor air distribution and circulation improve comfort. Anti-microbial properties of this technology help to sustain a healthier and mold free indoor environment.
6. Because the conditioned airflow rate is reduced by about 50% and complete zoning is possible, the bio-terror risk in a 15-m indoor radius decreases in similar proportion.

7. The building sector will significantly save energy and fossil fuel with the proposed technology and saved fossil fuels will be allocated to uses that are more rational.
8. Higher exergy and energy efficiency of the invention will contribute to improvement of the environmental quality and sustainability. H

Commercialization/Market Potential

The invention is a complete package of integrated, composite hybrid radiant/forced and natural convection heat transfer wall panel for hybrid HVAC, which can be directly coupled to renewable or waste energy sources. This is an important step for environmental issues and energy economy. The invention has its own dedicated dynamic control apparatus (fig 7) and optimization algorithm, which makes the invention also adaptable and affordable. The invention may also be coupled to several other green component cluster options as typically shown in fig 5 and fig 6, in order to suit every need, building type, geographic location, and energy market.

Because a simple shop technology and a waste material supply are sufficient, production investment shall be minimal and attractive. With a combination of strong commercial and industrial interest among homeowners, contractors, and decision-makers, and ease of manufacturing, commercialization of the proposed technology is feasible and will be seamless with the HVAC market.

Conclusion, Ramifications, and Scope

An invention of composite, integrated, sandwiched, multi-role composite radiant wall panel optimally integrates heating, cooling, ventilating, air-conditioning, thermo-electric, energy recovery, and energy storage functions at very moderate temperatures such that it can directly utilize renewable and waste energy resources having very low exergy. The same panel may also modularly integrate or connect with/to other building functions, plumbing functions, electric/electronic functions, and indoor air pressure control functions. The above-mentioned functions may all be present or only some of these functions may be present. The panel may be completely opaque, completely transparent, or semi-transparent. Direct compatibility with low-exergy energy resources eliminates costly equipment over sizing and resource temperature conditioning associated with conventional HVAC systems. Significant implications are the cost effective utilization of abundantly available low-exergy energy resources in all types of buildings, consequential substitution of fossil fuels in the building industry, and proportional reduction of harmful emissions on a macro scale, overall cost reduction of buildings, cost and thermally, exergetically effective energy conserving building envelope. This invention optimally combines radiant and convective heat transfer and collectively maximizes all human comfort requirements by integrating HVAC functions with all other building functions into a single element in energy efficient, economically effective, innovative, single-source manners. More uniform, mold-free, and healthier indoor air distribution and complete zoning capability improves the indoor air quality, human comfort, and reduces risks of airborne CBR agents (Chemical, Biological, and Radiological) from homeland security perspectives. This system is easy to install, operate, and maintain both in existing and new buildings. A simple shop using 100% recyclable waste material and fossil fuel by-products can manufacture the composite hybrid panel structure. In a typical house this system can reduce HVAC loads by 40%, increase overall thermal efficiency by 12% points, improve exergetic efficiency from 15% to 80%, eliminate fossil fuel dependency by 90%, and reduce bio-terror risk. The investment cost will be 70% cheaper and the operating cost will be one-fifth when waste heat is used. The composite hybrid wall panel may replace conventional boilers, furnaces, and chillers at the plant level, bulky air-conditioning ducts and terminal HVAC units at the terminal level, adds a desiccant cooling system at an intermediate level, and precisely embeds radiant and connective heat transfer at the 60% by 40% split, that may also be adjusted with an innovative control algorithm. Ground source heat pumps (GSHP), solar panels (SP), and wind turbines (WT) may mutually enhance their attributes with the invention. This invention primarily targets walls, which have the same heating and cooling effectiveness.

Claims

1. A composite hybrid panel or building element (1) which may be functional mainly in building HVAC and other possible industrial applications which involve thermal radiation, convection and air conditioning characterized by comprising a front cover (6) which is simultaneously a thermally radiating and both forced and naturally convecting surface, a porous layer (3), which provides uniform air diffusion.
2. A composite hybrid panel or building element (1) of claim 1 further comprising a thermally conductive diffuser layer (2).
3. The composite hybrid panel (1) of claim 2 wherein said diffuser layer (2) is preferably composed of stainless steel wool from metal scrap or other recycling materials.
4. A composite hybrid panel or building element (1) of claim 1 further comprising a thermal insulator layer (4), preferably made from recycled organic material with fire resistant properties simply attached to a building wall, ceiling or floor or simply acting as a partition used like in office cubicles.
5. The composite hybrid panel (1) of claim 1 wherein said porous layer (3) is preferably composed of glued wood chips and/or auto tires or other recycled materials.
6. The composite hybrid panel (1) of claim 1 further comprises heating and or cooling elements (5) hydronic pipes, either electric cables or thermo-electric effect wires.
7. The composite hybrid panel (1) of claim 1 further comprises an electrostatic, ionic, plasma or HEPA air filter (7) and/or UV lamps (10).
8. The composite hybrid panel or building element (1) of anyone of the preceding claims wherein said panel (1) has a ventilation, a combined forced and natural convection heating and cooling, a thermal radiation heating and cooling, and air-conditioning functions all of which may co-exist or any one of them or some of them in any combination may exist at any time of operation, depending upon the optimum operating conditions and indoor demand.
9. The composite wall or building panel typically embedded on a green HVAC system comprising wind turbines (WT), solar photovoltaic arrays, solar water panels, ground source heat pumps (GSHP), a TES, a hydronic circuit and energy storage system characterized in that: wherein said GSHP provides heat (in

winter) from or rejects heat (in summer) to the ground and seasonal energy storage, activate said desiccant cooler, said TES shaving off the peaks of thermal loads and the green energy demand, said solar panels being deliver additional heat characterizing in that said hydronic circuit being conditioning ventilation air, provide energy to said composite hybrid panel tubing.

10. The composite wall or building panel of claim 8 characterizing in that said panel (1) comprises heating element (5) directly transferring heat from/to the ground by the use of heat pipes.
11. The composite hybrid panel (1) of anyone of the preceding claims said porous (3) layer said front cover (6) and said thermal insulator (4) layer establish a passive panel.
12. The composite hybrid panel (1) of anyone of the preceding claims said porous layer (3) said thermal (preferably organic) insulator layer (4) and said air diffuser layer (2) establish an active panel.
13. Two composite hybrid panels (1) of anyone of the preceding claims said porous layer (3), and said air diffuser layer (2) and without the said thermal insulator layer (4), arranged back to back that establish a stand-alone two directional active panel system for indoor partitioning, both or any of the composite hybrid panels may also involve LED or similar lighting elements on the panel surface and/or electric power and/or electronic data transfer lines and/or bus bars.
14. A method of the composite hybrid panel or building element of claim 1 wherein said porous layer (3) and said thermal insulator layer (4) establish a passive panel and said porous layer (3), said thermal insulator layer (4) and said air diffuser layer (2) establish an active panel characterizing in comprising: placing said passive panel at preferably opposite facing side of said active panel so as to provide a continuously breathing system that said passive panel inhales and said active panel exhales during operation periods.
15. A method for using the composite hybrid panel or building element embedded on air ionizing technique characterizing in that air is ionized in a controlled manner on the said active panel, and pollutants are collected on the said passive panel.
16. A method for using the composite hybrid panel or building element embedded on changing the fan speeds of the said active panel, the said passive panel characterizing in that air pressure is adjusted in a controlled manner.

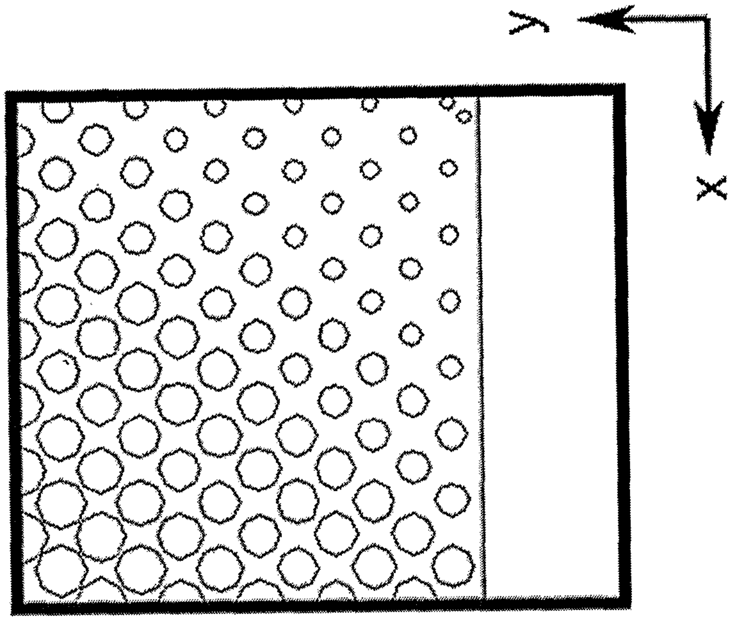


Fig 1C

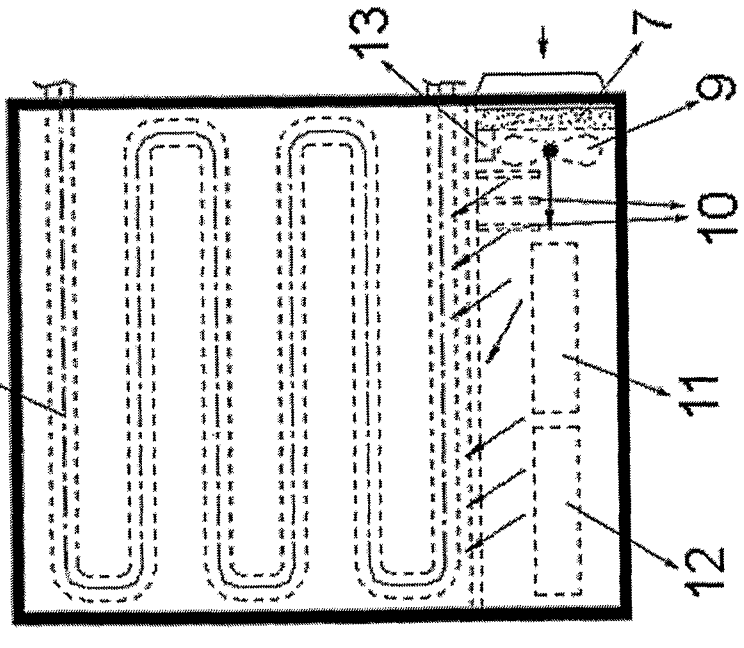


Fig 1B

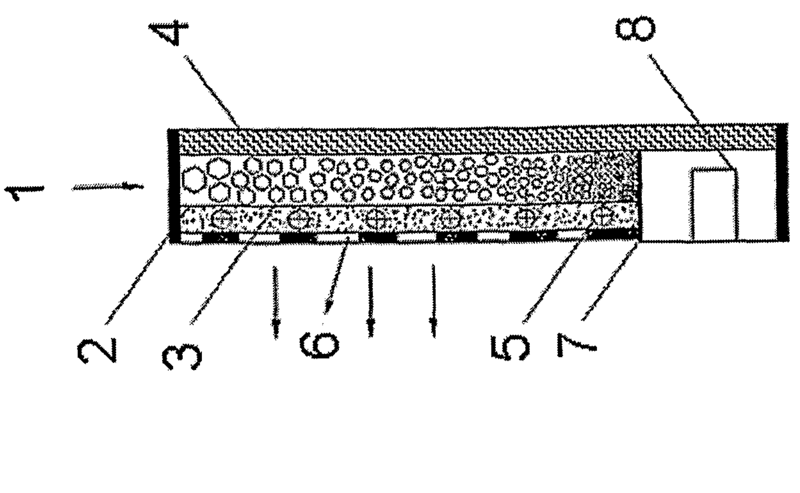


Fig 1A

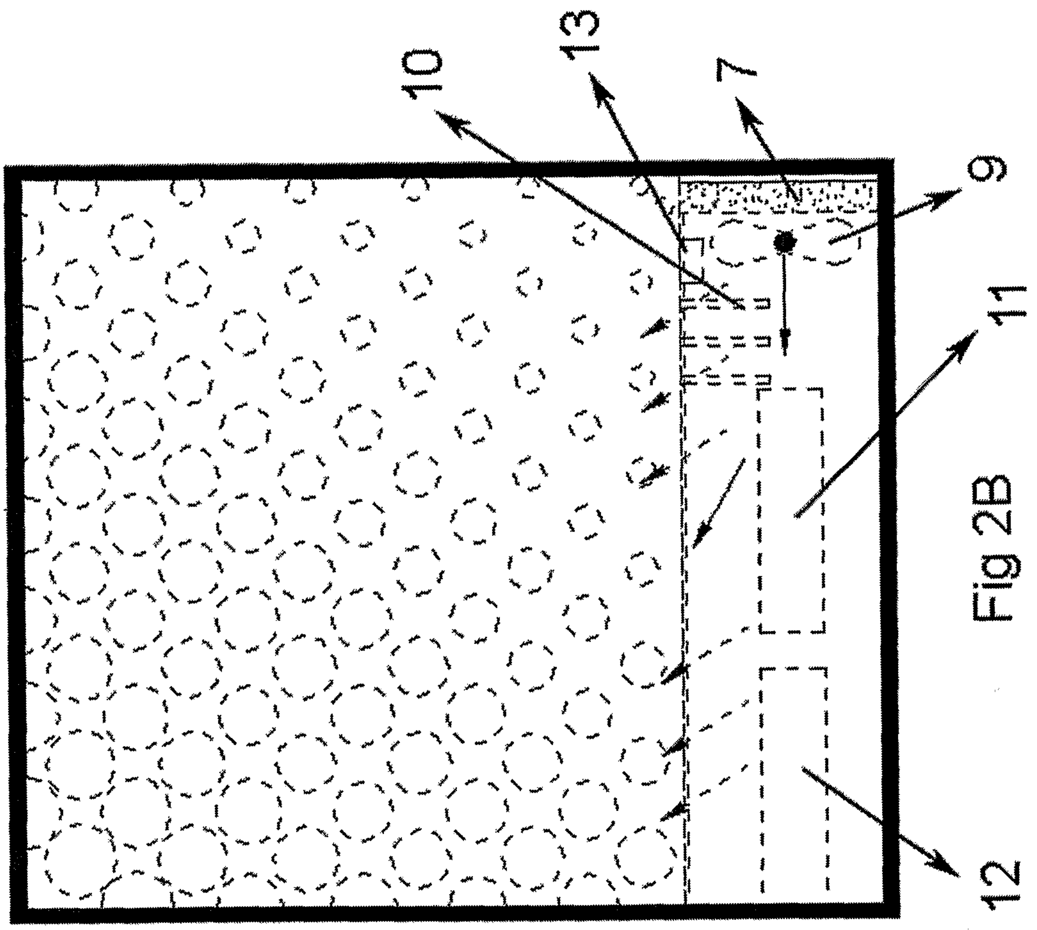


Fig 2B

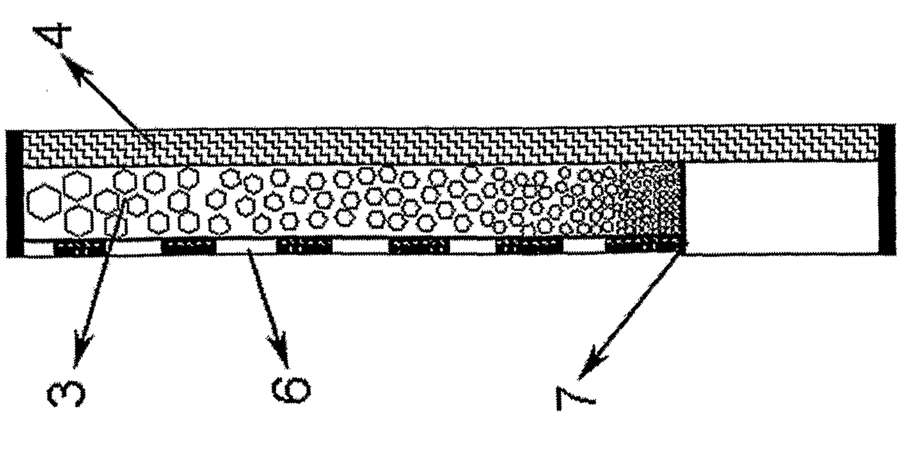


Fig 2A

3/7

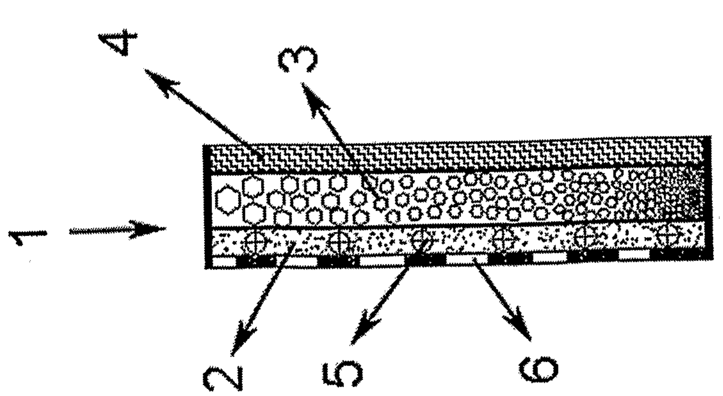


Fig 3A

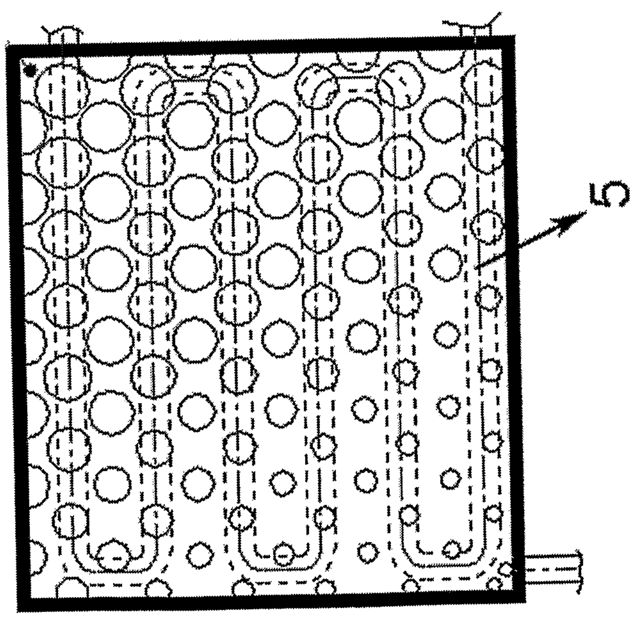


Fig 3B

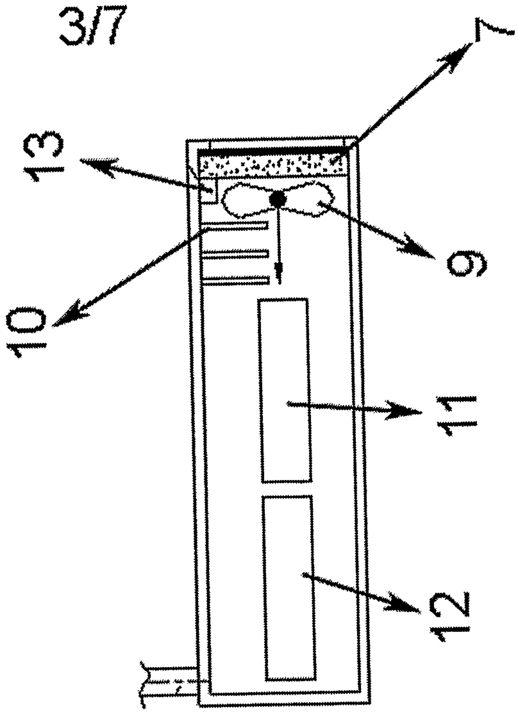


Fig 3C

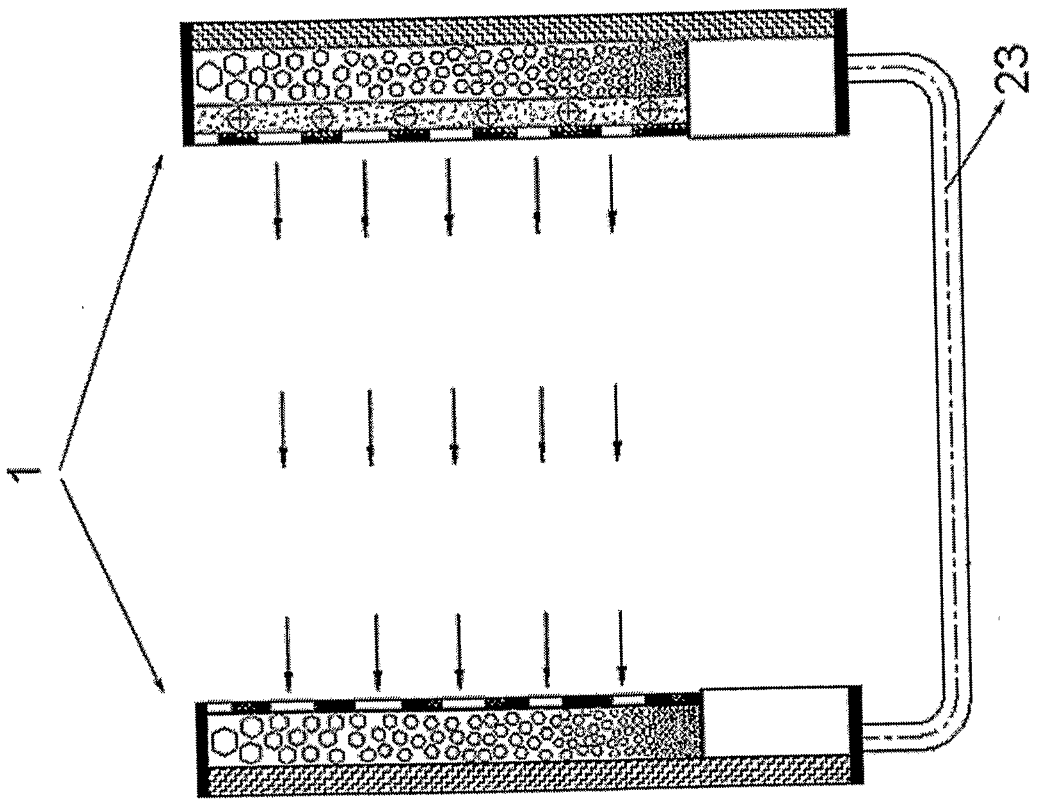


Fig 4

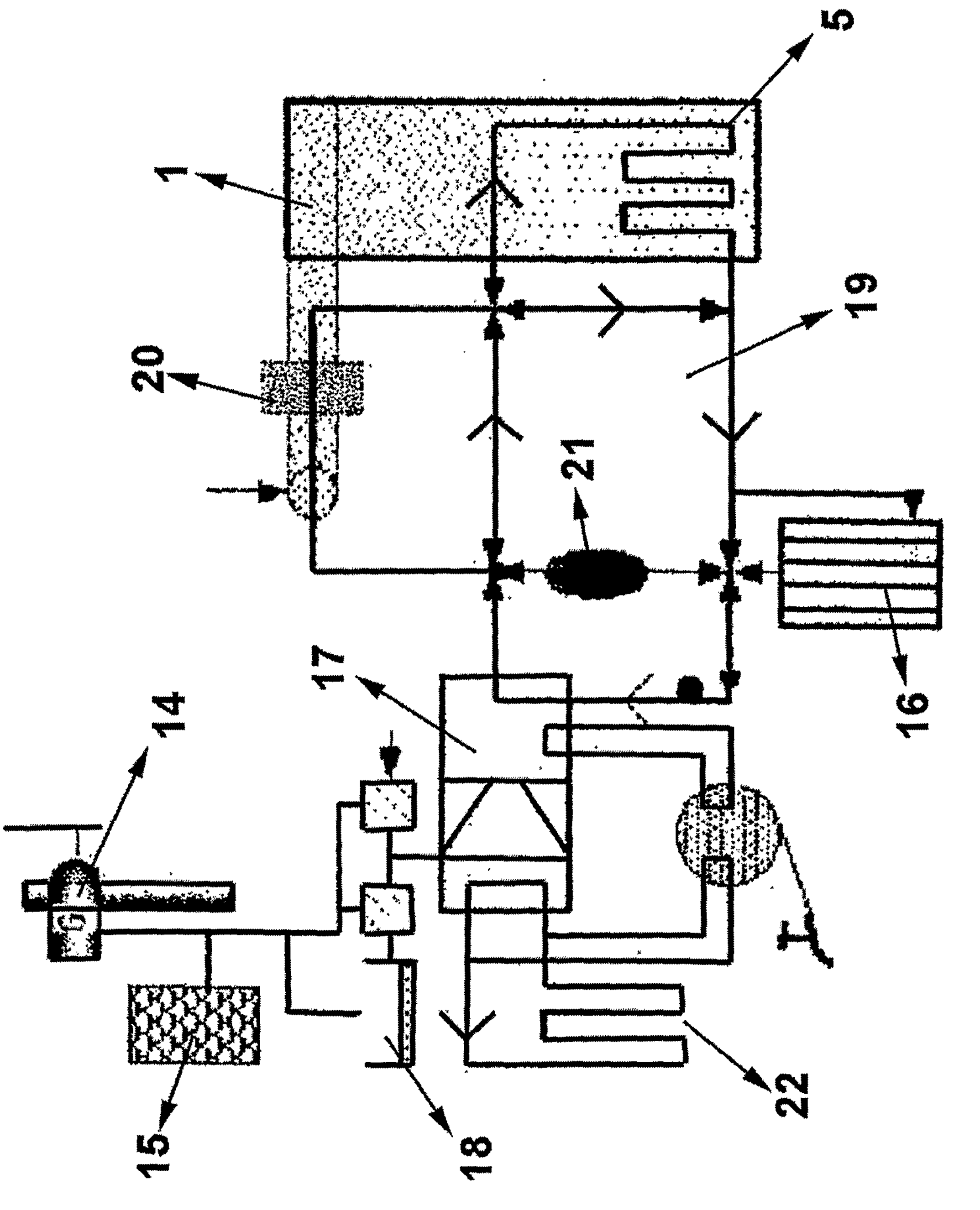


Figure 5

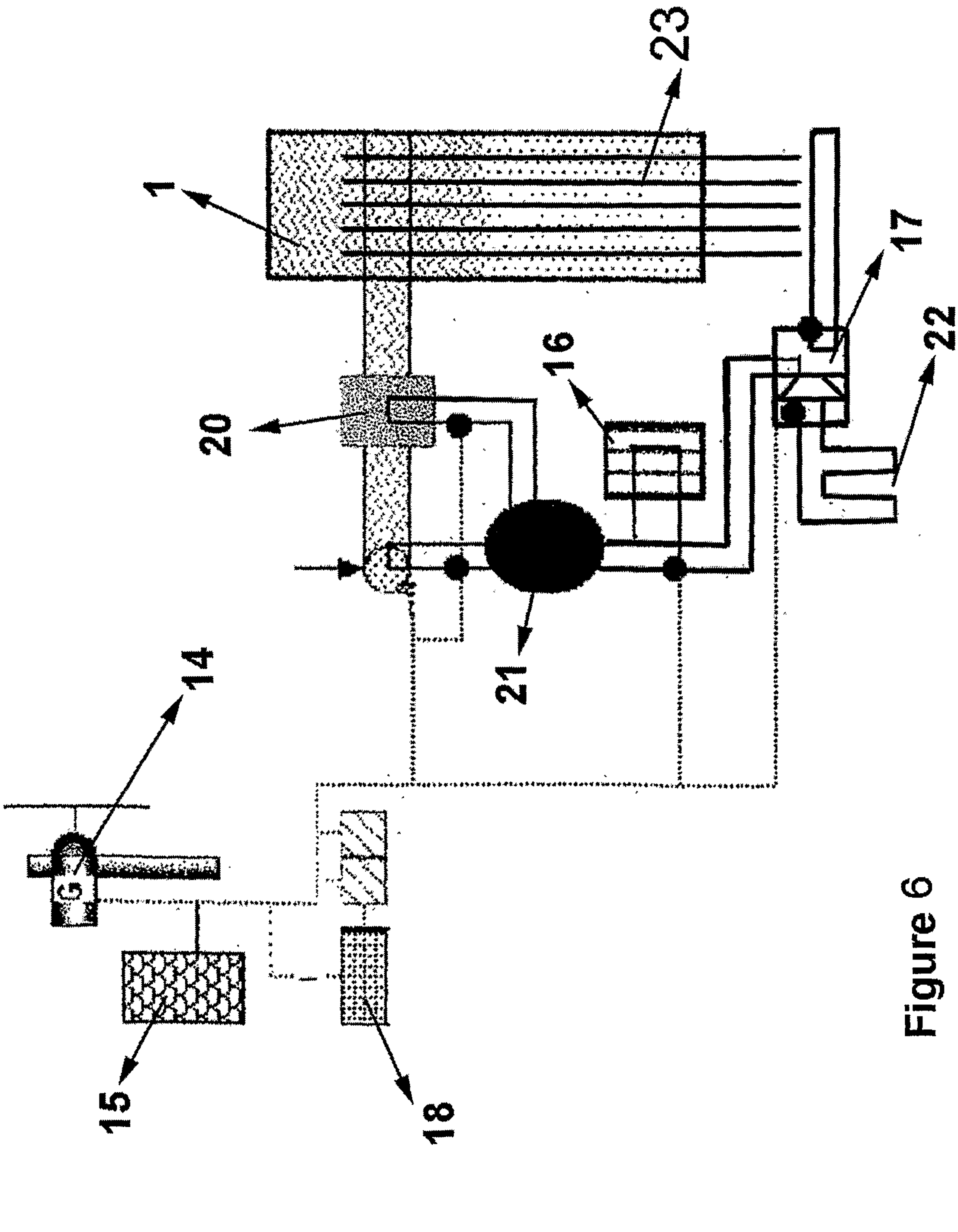


Figure 6

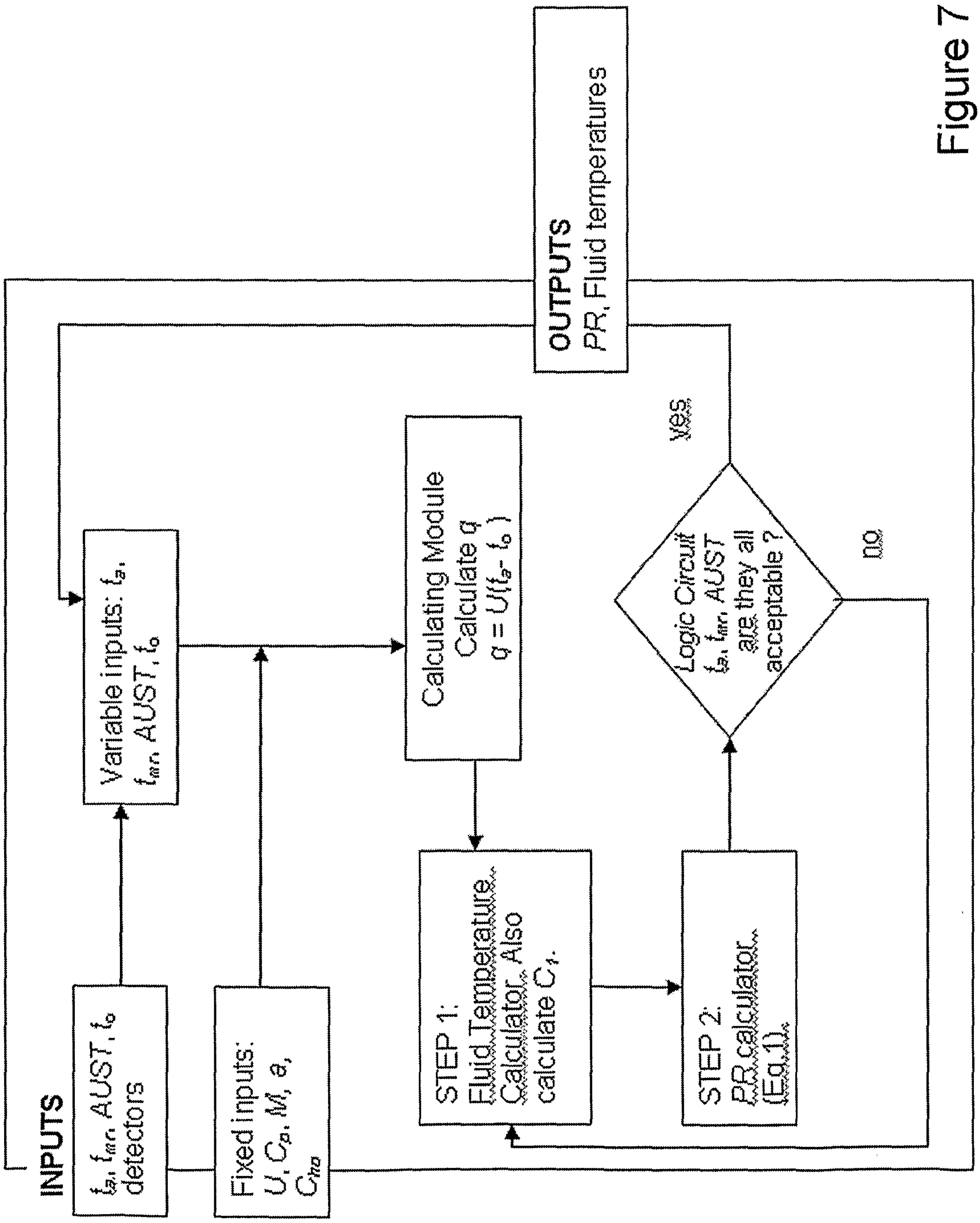

INPUTS
t_a, t_{mr}, AUST, t_o detectors
Fixed inputs: U, C_p, M, a, C_{ha}
Variable inputs: t_a, t_{mr}, AUST, t_o
Calculating Module Calculate q $q = U(t_a - t_o)$
STEP 1: Fluid Temperature Calculator. Also calculate C_1.
STEP 2: PR calculator (Eq.1).
Logic Circuit t_a, t_{mr}, AUST are they all acceptable ?
yes
no
OUTPUTS PR, Fluid temperatures

Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2005/000039

A. CLASSIFICATION OF SUBJECT MATTER
F28F13/12 F24F7/10

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)
F28F F24F

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2 988 980 A (TSCHUDIN HANS R) 20 June 1961 (1961-06-20) column 4, line 57 - column 5, line 30; figures 2-4	1-3,5,8, 11,12 4
A	US 2 751 198 A (RAPP GEORGE M) 19 June 1956 (1956-06-19) claim 1; figures 1-5	1-8, 10-16
A	US 2 251 663 A (DARBO HOWARD H) 5 August 1941 (1941-08-05) claim 11; figure 5	1-8, 10-16
Y	DE 195 00 670 C1 (H. KRANTZ-TKT GMBH, 51465 BERGISCH GLADBACH, DE) 8 February 1996 (1996-02-08) figure 2	4

-/--

[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 document 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	Date of mailing of the international search report
1 February 2006	23/02/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rosborough, J

INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2005/000039

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 207 718 A (ATLAS AIR PTY. LIMITED) 7 January 1987 (1987-01-07) figure 5	7

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 9

1.
Expressions such as "typically" have no limiting effect on the scope of a claim, ie. the features following any such expression are to be regarded as entirely optional.
As it is unclear which features are rendered optional by the expression "typically" in line 1 (ie. the extent of the features which are covered by said expression is not clear), the application does not meet the requirements of Article 6 PCT.

2.
It is not clear what is meant by the term "hydronic".

3.
It is not clear which "composite wall or building panel" is being referred to by the term "the composite wall or building panel" (line 1).

4.
The terms "the ground and seasonal energy storage"; "said desiccant cooler"; "said hydronic circuit" and "said composite hybrid panel tubing" lack an antecedent.

5.
It is not clear what is meant by the expression "said TES shaving off the peaks of thermal loads and the green energy demand, said solar panels being deliver additional heat".

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2005/000039

Box 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.: 9
   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:
   see FURTHER INFORMATION sheet PCT/ISA/210

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 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:

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 an additional fee, this Authority did not invite payment of any additional fee.

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.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/TR2005/000039

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2988980	A	20-06-1961	NONE	
US 2751198	A	19-06-1956	NONE	
US 2251663	A	05-08-1941	NONE	
DE 19500670	C1	08-02-1996	NONE	
EP 0207718	A	07-01-1987	NONE	