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Your Reference: 1990/1822/P/GB

25 March 2014

Dear Sir/Madam

PATENTS ACT 1977: PATENTS RULES 2007
NOTIFICATION OF GRANT: PATENT SERIAL NUMBER:GB2464271

1. I am pleased to tell you that your patent application number GB0818313.9 complies with the requirements of the Act and Rules, and that you are therefore granted a patent (for the purposes of Sections 1-23 of the Act) as from the date of this letter.

2. Grant of the patent is expected to be announced in the Patents Journal on 23 April 2014. In accordance with section 25(1), the patent will be treated for all later sections of the Act as having been granted and as taking effect on that date. The patent specification will be published on the same date, and you will receive the Certificate of Grant for your patent shortly afterwards. If you would also like a copy of your granted specification, this will be freely available from our website at www.ipo.gov.uk/p-find-publication.

3. **Renewing your patent** – IMPORTANT – To keep your patent in force, you must pay the Office an annual renewal fee:

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(iv) If any renewal fee is not paid by the due date, a further six months is allowed in which to pay the fee, however additional fees will be payable one month after the due date. Information on the current renewal fees can be found on our website at www.ipo.gov.uk/p-renew.

(v) An example - For a patent filed on 17 October 2004, the first renewal fee would be due for payment on 31 October 2008. The fee could be paid in advance from 1 August 2008. Subsequent renewal fees would be due on 31 October annually. The first free month of the late payment period would end on 30 November 2008 and if no payment was received by 30 April 2009 the patent would cease.

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Yours faithfully

SEAN DENNEHEY
DIRECTOR OF PATENTS

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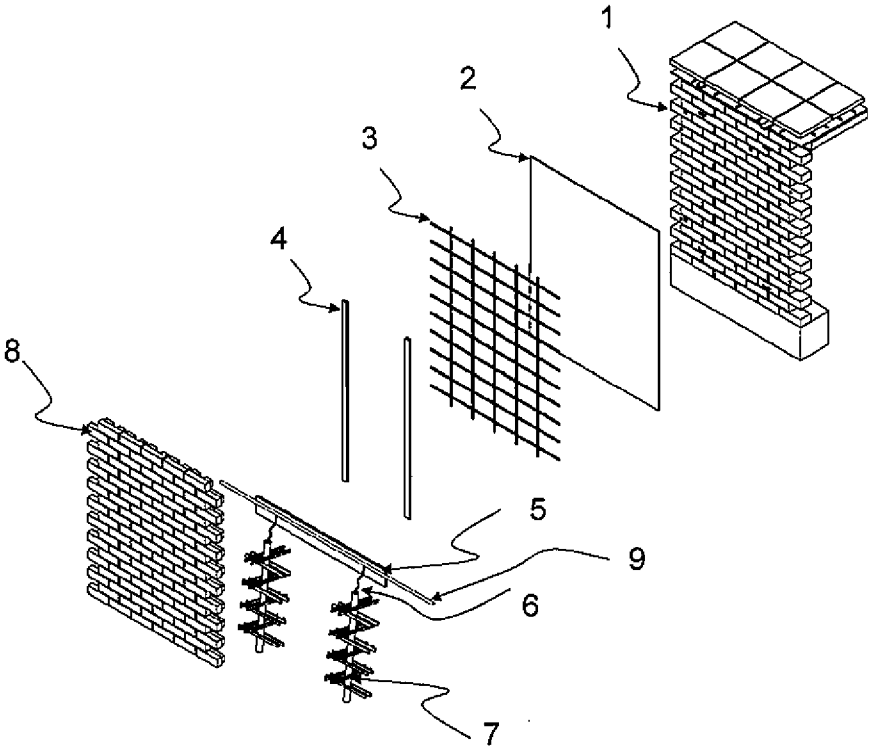

Figure 1

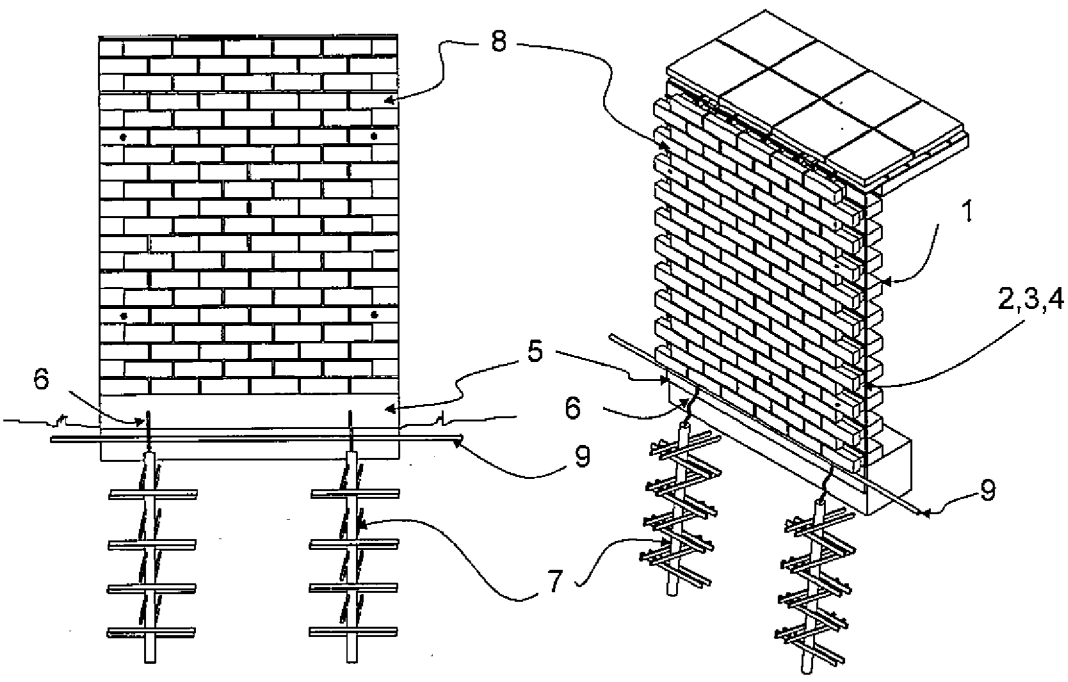

Figure 2

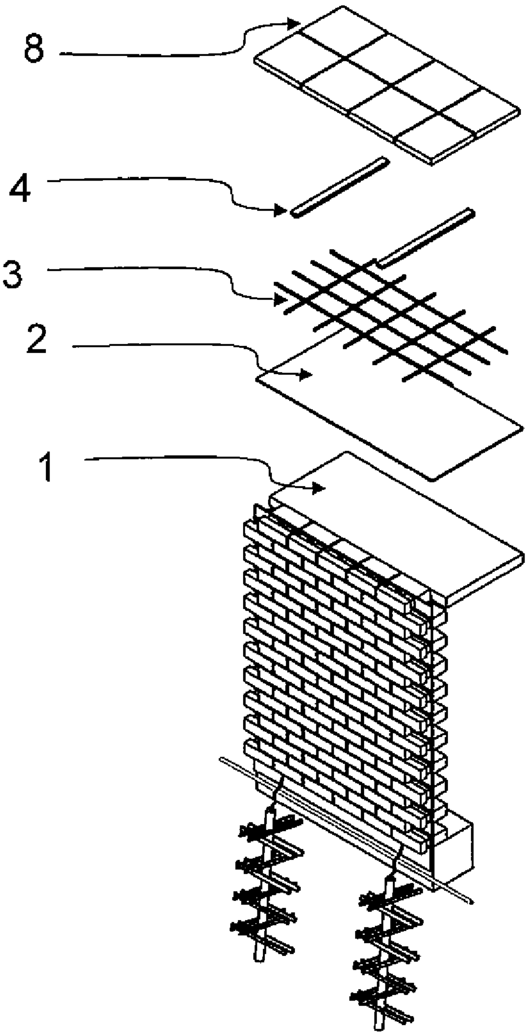

Figure 3

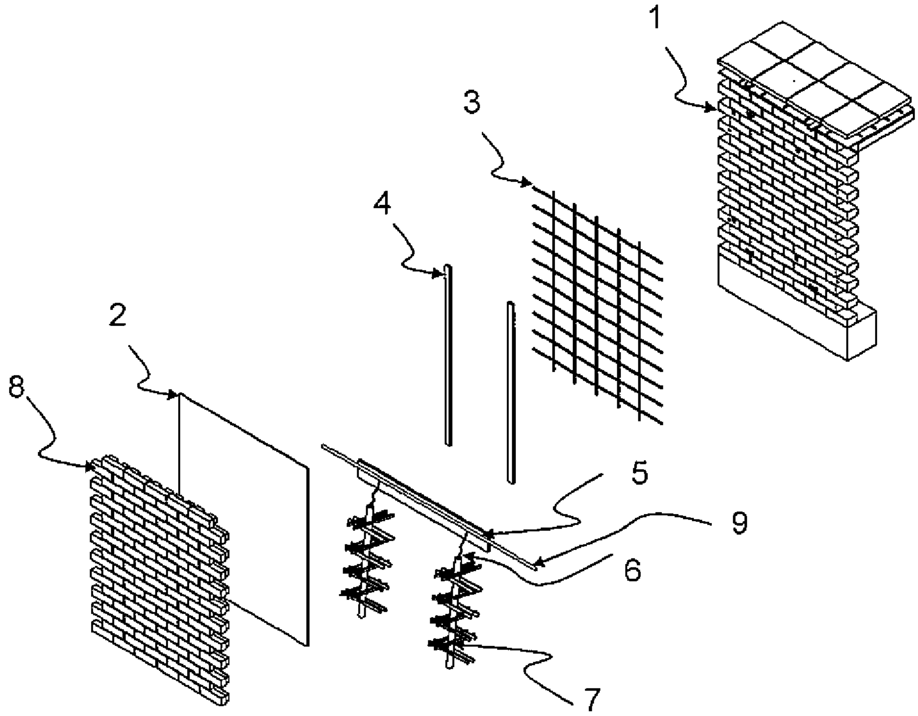

Figure 4

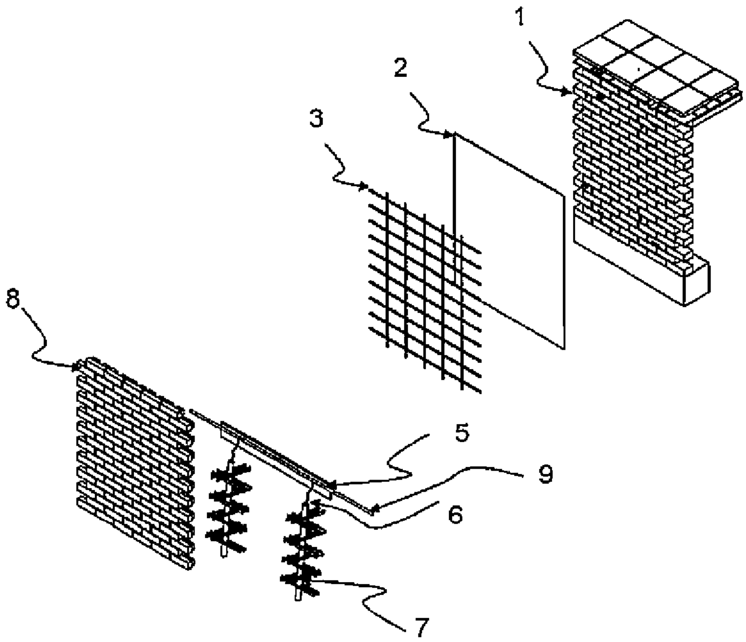

Figure 5

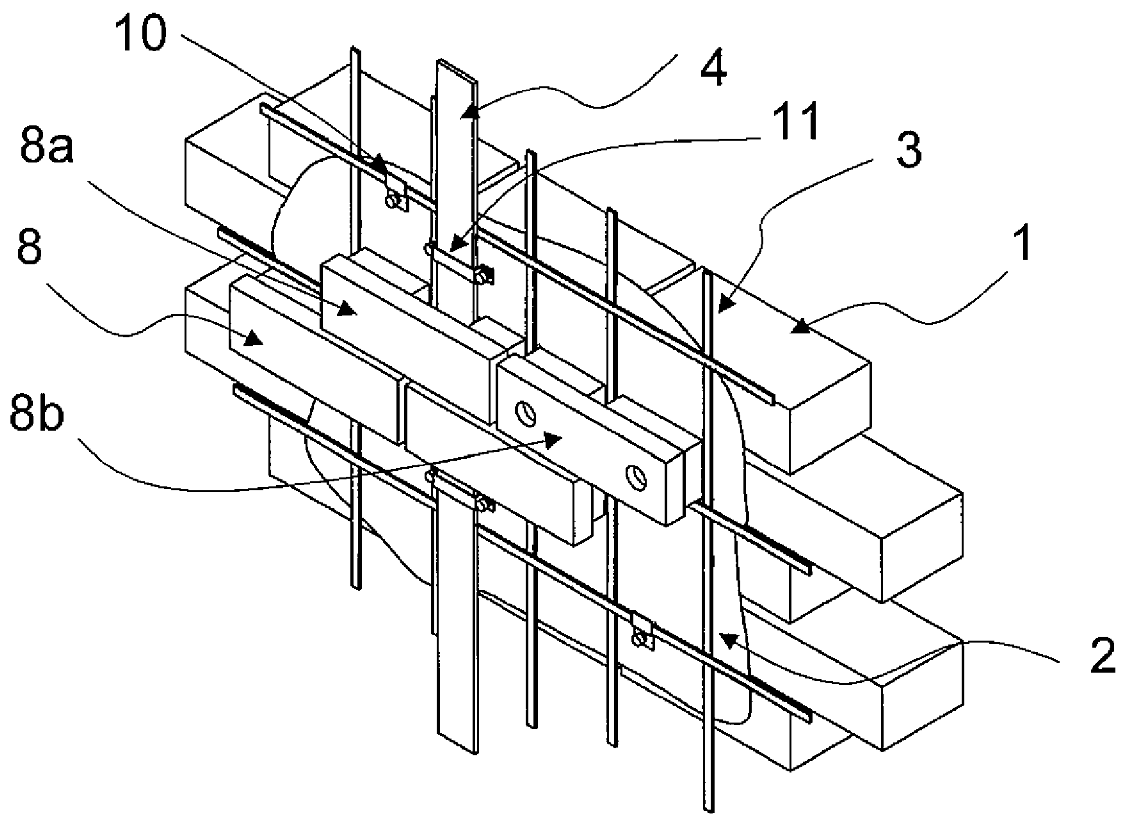

Figure 6

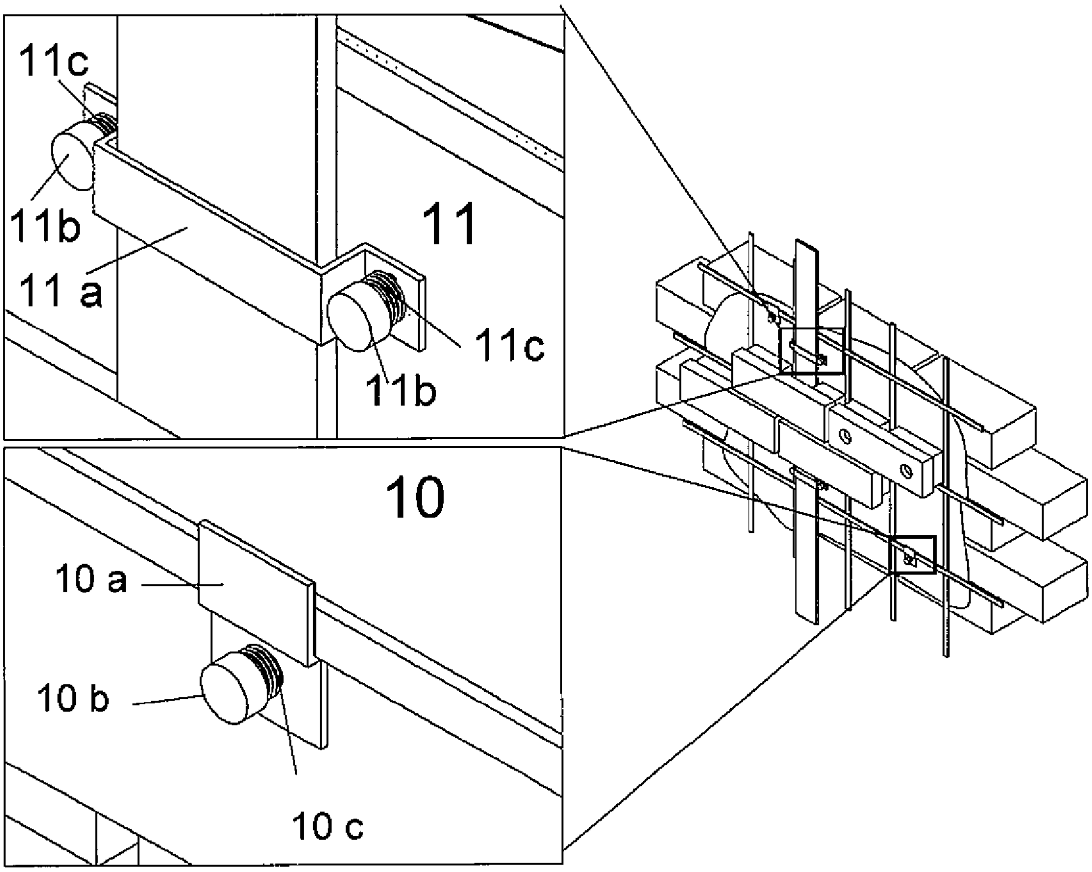

Figure 7

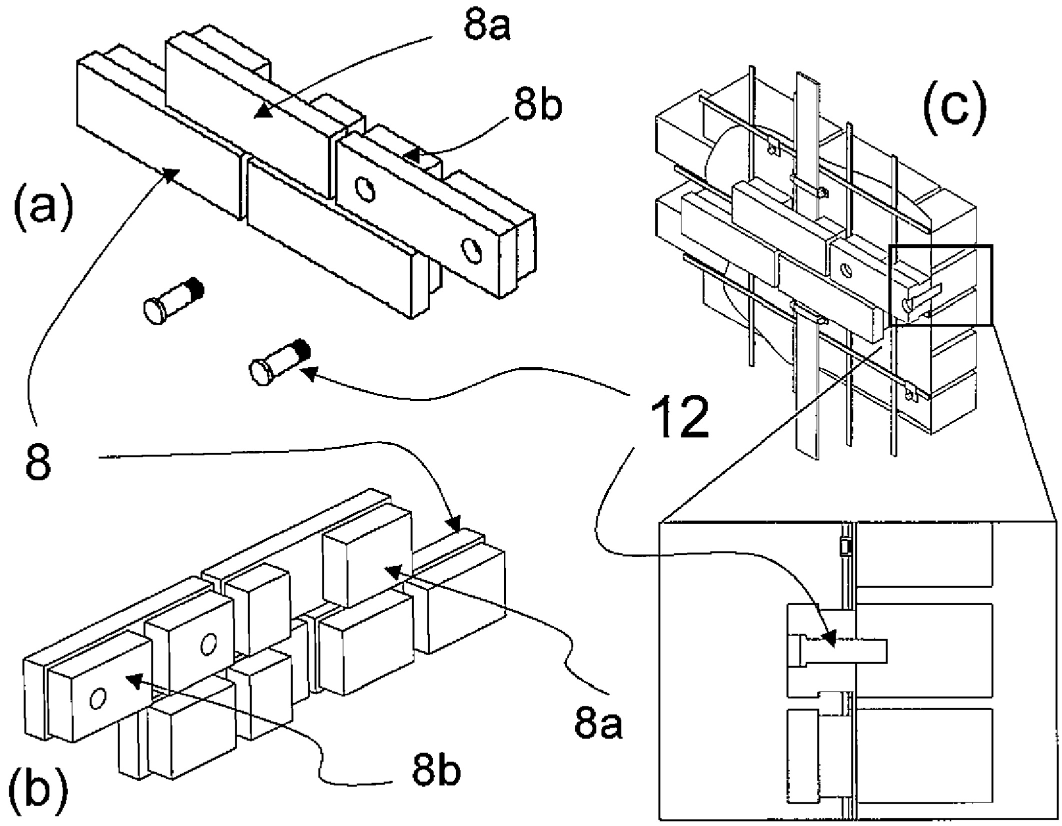

Figure 8

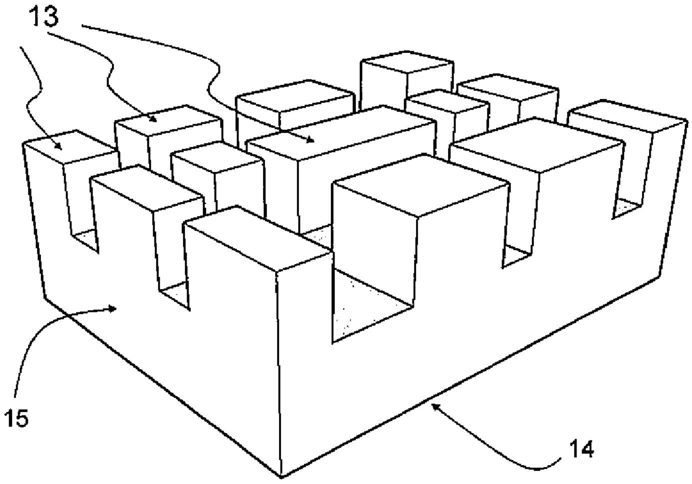

Figure 9

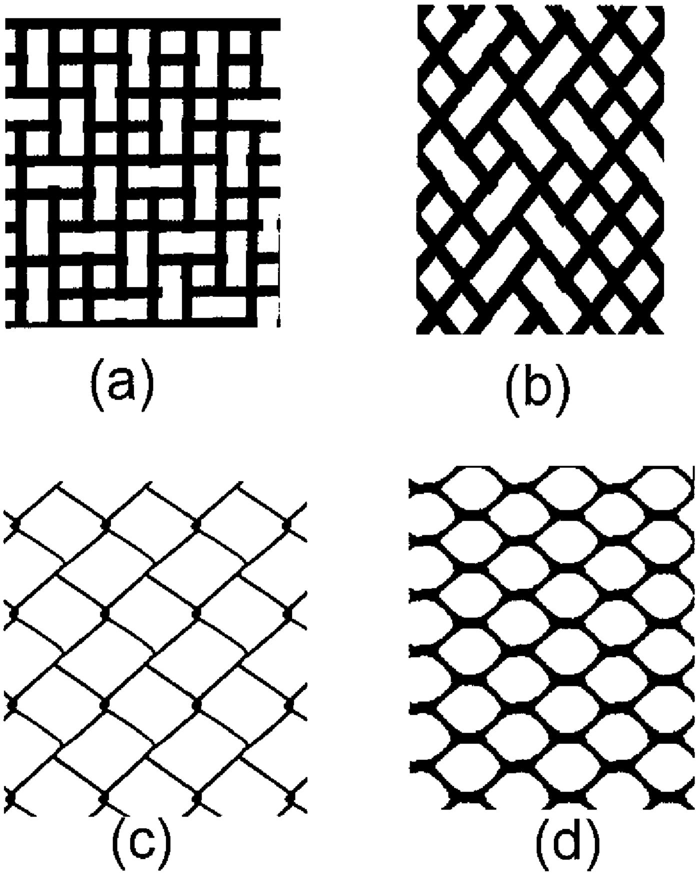

Figure 10

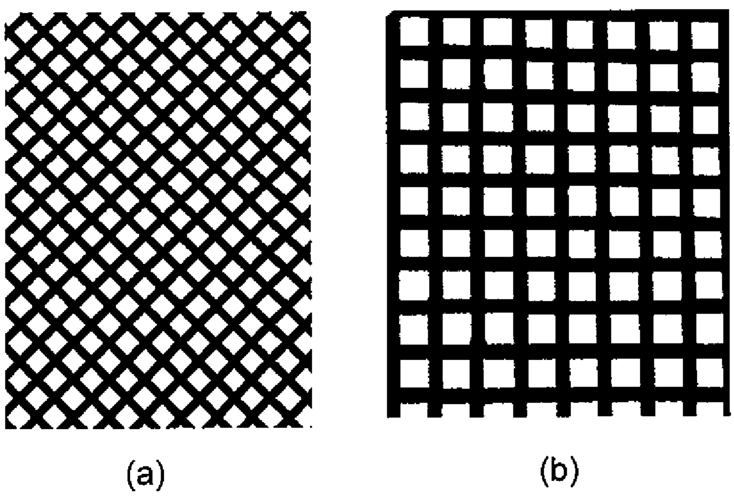

Figure 11

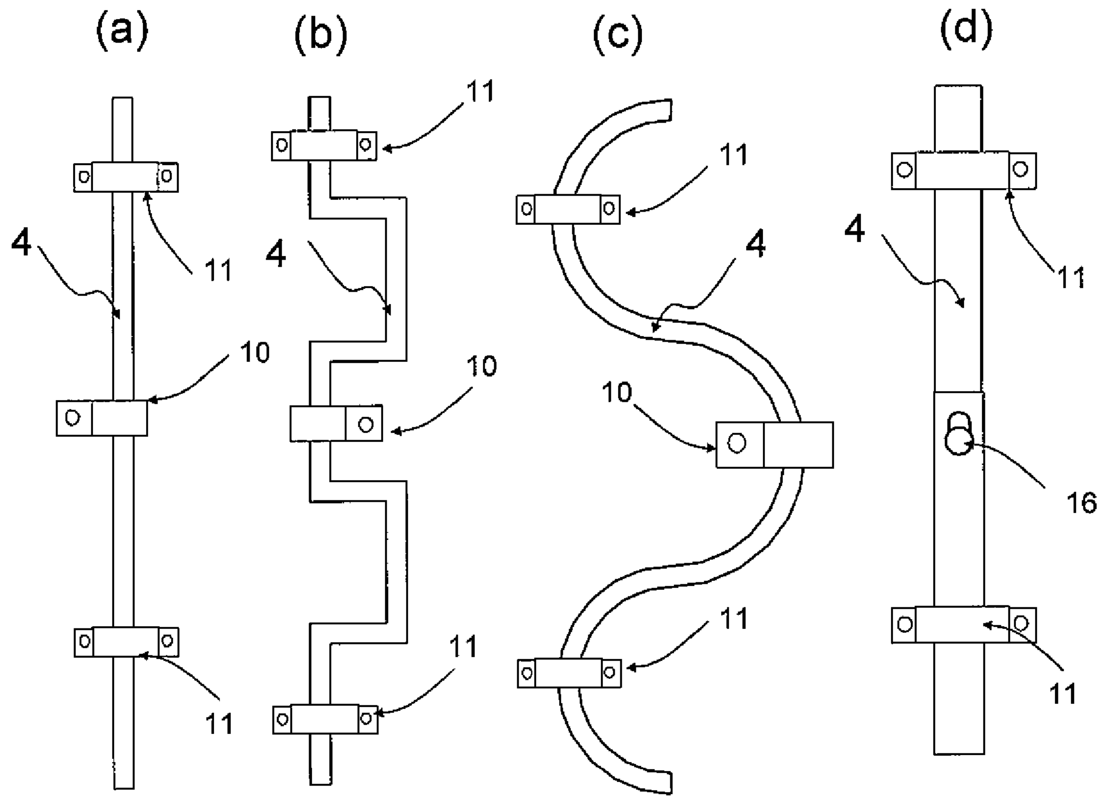

Figure 12

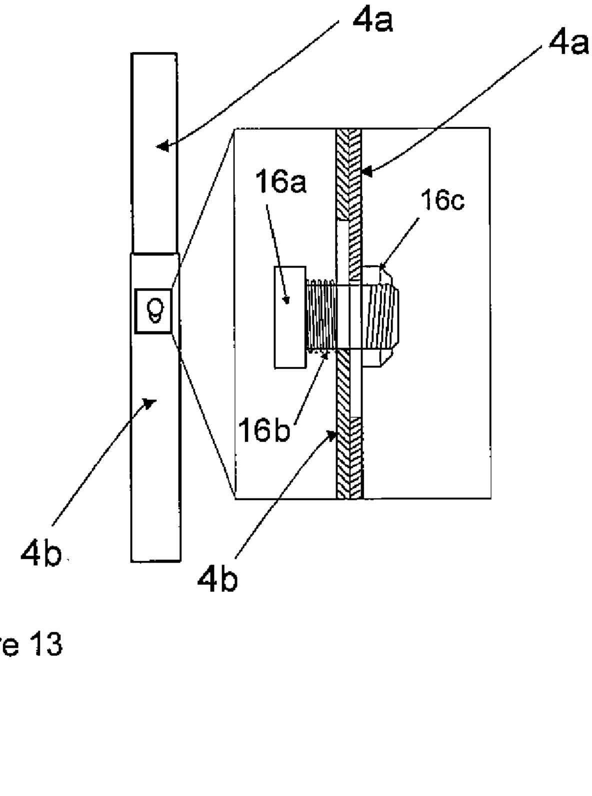

Figure 13

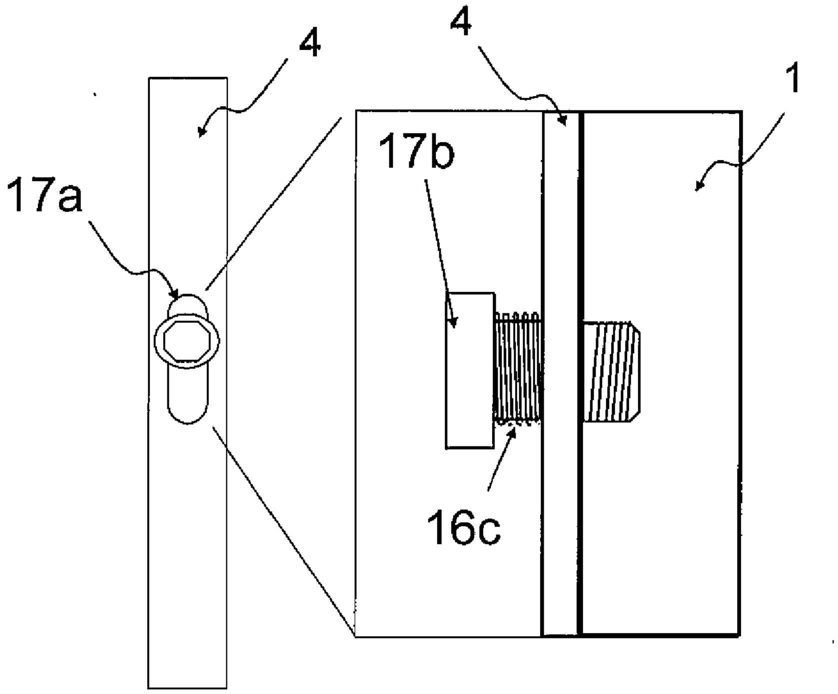

Figure 14

Title - Temperature Regulation System for Buildings

This invention relates to a temperature regulation system for buildings, and in particular to a system for conductive heat transfer between ground and the envelope of a building.

The general concept of transferring heat from the envelope of a building to the ground in summer and from the ground to the building in winter is known.

For instance, US4,433,720 describes the concept of using a thermal conductor grid in thermal contact with the wall of a building having a thermal conductivity greater than that of the wall. At least one thermal probe is directly connected to the thermal conductor and extends into the earth adjacent the building wall to a depth wherein the earth exhibits a substantially constant temperature. This is claimed to enable natural heat flow between the thermal conductor grid and the thermal probe.

However, the above-mentioned patent and the current state-of-the art does not solve many problems associated with the implementation of this concept.

The encasing of a thermal conductor grid in an inorganic plaster of ceramic material to cover the grid and maintain a traditional look for the building would cause a significant problem since the thermal expansion coefficients of the thermal conductor grid and the plaster would be expected to be different, causing short life to the plaster layer and the need for continuous maintenance. Also, the current state of the art does not solve problems associated with integrating the thermal conductor grid into existing buildings since fixing of the thermal grid to the building could cause damage due to thermal expansion and contraction. The usefulness of a metal rod as a thermal probe is limited by the external area of such a rod (2π x $Radius \times Length$), resulting in limited heat conduction between the ground and the probe.

The current state of the art is also not applicable to concrete buildings with flat roofs, nor does solve the problem of fitting the thermal conductor to a wall to allow direct contact and thermal conductivity whilst still allowing relative grid movement as a result of changes in temperature.

Also there is a problem in maintaining a traditional look and at the same time installing the conductive components. In most cases, buildings are covered externally by bricks or natural stones, which makes it difficult to introduce a conductive layer to the walls or to the roof of existing buildings without damaging their aesthetic appearance or reducing the building's reliability and structural stability due to movement of the conductive layer relative to the rest of the building.

There has now been devised a temperature regulation system for incorporation into a building, which overcomes or substantially mitigates disadvantages associated with the prior art.

Thus, according to a first aspect of the invention, there is provided a temperature regulation system for incorporation into a building structure, between internal and external leaves that define a cavity in the envelope of the building, the system comprising at least one thermally conductive element connected to ground temperature through at least one thermal probe extending into the earth adjacent to the building to a depth wherein the earth exhibits a substantially constant temperature, enabling the natural thermal flow of heat between the conductive element and the ground, wherein external leaf comprises cladding provided with voids, arranged such that the voids are formed about the the conductive element is mounted within the cavity in such a way that it can move due to thermal expansion and contraction.

The temperature regulation system of the invention may maintain the building into which it is incorporated at relatively constant temperature. This is achieved by transferring the heat from the envelope of the building to the ground in summer and transferring the heat from the ground to the envelope of the building in winter through the conductive element. The system utilises thermally conductive elements connected to ground, whilst maintaining reliable structure and stability in the building by allowing the thermally conducting layer to move, due to thermal expansion and contraction, relative to the internal and external leaves between which it is positioned.

By the “envelope” of the building is meant in this context the structures that constitute the boundary between the interior of the building and the external environment, ie the external walls and roof(s) of the building.

The temperature regulation system according to the invention may further comprise a heat reflective layer attached to the cavity-facing side of the internal or external leaf of the envelope, to reflect heat towards the thermally conductive element. Such a heat reflective layer may comprise a metallic or metallised, or other suitably heat reflective, foil. For use in hot climates, such a heat reflective layer will be mounted on the internal leaf of the envelope, ie to reflect heat away from the interior of the building. In cold climates, the heat reflective layer will be mounted on the cavity-facing side of the external leaf, to reflect heat towards the interior of the building.

The thermally conductive element may comprise a grid or mesh mounted on the cavity-facing side of the internal leaf. Mounting of the grid or mesh may be by means of mechanical fasteners that allow relative movement of the grid or mesh due to thermal expansion and contraction.

In some embodiments, the grid or mesh allows for localised distortion and deformation due to thermal expansion and contraction.

In some embodiments, the area of the grid or mesh, at maximum operating temperature, is equal to or less than the area of the internal leaf on which it is mounted, to allow for thermal expansion and contraction.

The grid or mesh may comprise a regular array of metallic rods arranged horizontally and vertically.

Alternatively, the grid or mesh may comprise a sheet having a regular array of perforations. The perforations may have a wide variety of shapes, but may typically be square, rectangular, rhomboidal, circular or oval.

In many embodiments, the thermally conductive element further comprises at least one heat conductor which is in contact with the grid or mesh and is fastened to the cavity-facing side of the internal leaf by the means of a fixing system that allows relative movement of the heat conductor due to thermal expansion and contraction. Such a heat conductor may have an irregular shape or pattern that allows for localised distortion and deformation due to thermal expansion and contraction. Alternatively, the heat conductor may consist of two or more hollow beams having a telescopic coupling to permit coaxial sliding due to thermal expansion and contraction. Such coaxially sliding beams may be urged into close contact by a spring-loaded mechanical fastener.

The system may include a thermal skirt which couples the thermally conductive element to the at least one thermal probe. Such a skirt may be attached to the at least one thermal probe via link conductors.

To enhance thermal conductivity from the probe to the earth, the or each thermal probe may comprise a metal shaft that having additional conductors arranged transversely thereto. Alternatively, the or each thermal probe may have an irregular surface.

The thermally conductive components of the system, ie the mesh or grid, heat conductors, thermal probes, link conductors etc, will generally be made of materials having good thermal conduction properties. Typically, such materials include metals, and in particular ferrous metals, such as iron and steel. Components such as mechanical fasteners and the like may be manufactured from, or at least partially coated with, thermally insulating material, to prevent thermal conduction in undesirable paths. For instance, in hot climates, the mechanical fasteners by which the thermally conducting element is mounted on the internal leaf may be so constructed, to prevent unwanted conduction of heat into the internal leaf.

Where mechanical fasteners are used to hold components of the thermally conductive element in position, the fasteners are preferably such that they permit movement of those components due to thermal expansion or contraction. Typically, the fasteners comprise brackets by which the components are retained. The brackets may be urged into close engagement with the components, eg by compression springs mounted about the shafts of bolts, screws or the like by which the fasteners are fixed in position (usually on the internal leaf of the structure).

To exchange heat with the thermally conductive parts of the system, a fluid pipe may be attached to the conductive element.

According to a second aspect of the invention, there is provided a building incorporating a temperature regulation system according to the first aspect.

The temperature regulation system may be incorporated into the building at the time of construction of the building, in which case the internal and external leaves may be the internal and external leaves of a cavity wall.

Alternatively, the temperature regulation system may be incorporated into the building subsequent to its construction, ie the system may be added to an existing structure. In such a case, the internal leaf may be the original external wall or roof of the building and the cladding layer of building elements is constructed adjacent to, or applied to, the original external wall or roof.

At least some of the building elements of the cladding may have a hole to enable them to be fastened mechanically to the original external wall of the building.

In certain embodiments, the cladding layer is constructed of building elements having on the cavity-facing side thereof a plurality of protrusions that can be mechanically removed to create a cavity of the desired form to accommodate the thermally conductive element. Such building elements are of particular utility in the invention, and so in a third aspect of the invention there is provided a generally cuboidal building element, one major face of which is defined by a plurality of protrusions that can be selectively removed to create a void of desired form.

The cladding elements may be manufactured from a wide variety of natural and synthetic materials. Typically, however, the cladding elements will be manufactured in such a way that at least their external face will mimic the appearance of conventional building materials, such as brick and stone.

The invention will now be described in greater detail, by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic and exploded view of principal components of a first embodiment of the temperature regulation system according to the invention (omitting for the sake of clarity surrounding elements, the ground etc);

Figures 2(a) and 2(b) are respectively a front elevation and perspective view of the temperature regulation system of Figure 1 in an assembled condition;

Figure 3 is an exploded view of components of the temperature regulation system for a slab-covered roof of buildings;

Figure 4 is a view similar to Figure 1, of a second embodiment of the temperature regulation system, for use in a cold climate;

Figure 5 is a view similar to Figure 1 of a third embodiment of the temperature regulation system, in which relatively large heat conductors present in the first and second embodiments are omitted;

Figure 6 is a detailed fragmentary view of the temperature regulation system of Figures 1 and 2;

Figure 7 shows on an enlarged scale regions of Figure 6, illustrating the method by which components of the temperature regulation system are fixed in place;

Figures 8(a), 8(b) and 8(c) are schematic views illustrating the method of attachment of external cladding elements forming part of the temperature regulation system according to the invention;

Figure 9 is a perspective view of a cladding element that can be used in the temperature regulation system according to the invention;

Figures 10(a), 10(b), 10(c) and 10(d) are partial plan views of four embodiments of a thermal grid that can be used in the temperature regulation system according to the invention;

Figures 11(a) and 11(b) are views similar to those of Figure 10, of two alternative forms of thermal grid;

Figures 12(a), 12(b), 12(c) and 12(d) show examples of four different heat conductors that may be utilised in the temperature regulation system according to the invention, and ways in which the heat conductor may be attached to an internal wall;

Figure 13 shows a partial view of the heat conductor of Figure 12(d), with an enlarged sectional view of an associated fixing mechanism; and

Figure 14 is a view similar to Figure 13, of an alternative fixing mechanism.

Referring first to Figure 1, a first embodiment of a temperature regulation system according to the invention comprises several principal components.

The reference numeral (1) indicates the original wall of an existing building or the internal leaf of a cavity wall for new buildings. A relatively thin thermal reflective layer (2) is included which can be used to reflect heat towards a thermal grid (3). In order to improve heat conductivity relatively large heat conductors (4) are attached to the thermal grid (3). Both the thermal grid (3) and heat conductors (4) are attached to a conductive skirt (5) which preferably extends below the ground level. Link conductors (6) link the skirt (5) to thermal probes (7) that have the form of thermally conductive rods extending into the ground. The thermal probes (7) carry small external crossbars to increase the effective surface area of the probes (7) for improved thermal contact and transfer with the ground.

An external layer of cladding elements (8), for example natural stones or bricks, is attached to the structure to maintain the traditional appearance and improve the reliability of the system by allowing thermal expansion and contraction of the system. This is achieved by the provision of voids on the internal side of the cladding elements (8) to allow for such movement, as described in more detail below. A fluid pipe (9), for example a water pipe, may be attached to the system (in the illustrated example, adjacent to the skirt (5)), to exchange heat with the conductive components of the system.

The fully assembled system is shown in Figures 2(a) and 2(b), from which surrounding construction elements and the ground on which the structure is built are omitted for clarity.

Figure 3 illustrates how a similar system can be integrated into the structure of a roof. Components of the system are identified by the same reference numerals as for the embodiment described in relation to Figures 1 and 2. A thermal grid (3) of the roof is attached to the thermal grid of the walls, and the heat conductors (4) of the roof are attached to the corresponding heat conductors of the wall. This improves heat conductivity from the roof to the walls and then to the ground. As for the external cladding of the wall, external roof slabs (8) are designed with voids on their undersurface to allow relative movement of the thermally conductive elements. Where the roof has a solid fence, it might be impractical to attach the thermal grid of the roof to the thermal grid of the walls. In such a case, the heat conductors (4) may simply transfer heat from the roof to the ground through the walls. As used in the remainder of this document, the word 'wall' means a segment of an enclosure (ie vertical wall or roof), unless indicated otherwise.

For use in extremely cold climates, the heat reflector (2) can be placed between the external layer of cladding elements (8) and the thermally conductive elements (3,4), to improve the internal temperature by reflecting heat inwards towards the internal side of the building. Such an arrangement is illustrated in Figure 4.

In some embodiments, the heat reflector (2) and/or heat conductors (4), as in Figures 1 and 2, may be dispensed with, for example to reduce cost. The feasibility of this may depend on the type and size of the thermal grid (3). For example, using large beams of high density grid may reduce the need for the reflective layer (2) and the heat conductors (4). A system in which the heat conductors are omitted is shown in Figure 5.

A detailed fragmentary view of the temperature regulation system of Figures 1 and 2 is shown in Figure 6. This illustrates the features that provide mechanical and thermal stability and reliability to the system. The thermal reflector (2) is attached to the original or internal wall (1) by the means of a suitable fixing means, for example adhesive, bolts or screws. The thermal grid (3) is attached to the original or internal wall (1) by the means of a fixing system that allows relative movement in the thermal grid (3) caused by thermal expansion and contraction. The large heat conductors (4) may be welded to the grid and attached to the wall by the means of a suitable fixing system which allows for thermal expansion and contraction. The external cladding elements (8) may be made from traditional brick, natural stone, wood, metal or any other natural or artificial material. The cladding elements (8) have voids on their internal side (illustrated most clearly in Figures 8 and 9, as described below) to allow the thermally conductive components (3,4) to move without damaging the external cladding layer or reducing the stability of the original internal wall. For the external cladding layer, different types of external building blocks can be used. For example, in Figure 6 a first element 8a is a normal brick with voids on its internal face to allow for relative movement of the conductive components. The element 8a may be attached to adjacent elements by a suitable binding material such as cement. A second element 8b is attached with bolts or screws passing through holes in the element 8b, to increase the stability of the external layer and reduce its thickness. Holes in such elements could be closed with a suitable cap of the same material or mortar of the same colour to improve the appearance of the completed system.

Figure 7 shows on an enlarged scale examples of fixing systems for the grid (3) and the thermal conductors (4), that allow movement relative to the internal wall and external cladding. Both fixing systems are interchangeable. For example, the fixing system of the grid (3) consists of a bracket (10a), a bolt (10b) and a spring system (10c). Similarly, the heat conductor (4) is attached to the wall by a fixing system that consists of a bracket (11a), two bolts (11b) and two spring system (11c). This allows the conductors (4) to be attached to the heat reflector and the wall with considerable force but at the same time to allow relative movement due to heat expansion and contraction. For use in a hot climate, the fixing systems (10,11) may be made from low conductivity material or from a metallic material with a layer of insulation on the internal side, to reduce heat conduction to the internal wall.

Figures 8(a), 8(b) and 8(c) show in greater detail exemplary cladding elements, and the manner in which they are attached to the rest of the system. Figures 8(a) and 8(c) are views from the external side, whilst Figure 8(b) is a view of the internal side of the elements. The voids formed in the internal side of the elements are clearly visible, and Figure 8(c) also shows a sectional view illustrating how the elements with holes may be fastened to the original or internal wall.

Figure 9 shows an example of a universal building block (14) that may be used to simplify the construction of the external cladding layer. The face of the building block (14) that, in use, is the inwardly directed surface is formed with protrusions (13) that, in the embodiment illustrated, constitute approximately one half of the thickness of the building block (14). These protrusions (13) can be broken off or otherwise removed mechanically to create a required pattern of voids on the internal face of the building block (14) in order to accommodate the grid (3) or thermal conductors (4) positioned behind the building block (14). As an alternative to the production of a universal block that can be adapted to fit the underlying components, it may also be possible to produce a dedicated impression for any specific grid pattern for mass production. Different versions with different patterns of protrusions and/or holes for screws or bolts can also be produced, depending on the original building and the shape of the thermal grid (3) and the heat conductors (4). The protrusions may also be added to the main body of a building block in the manner of spacers, eg using mechanical fasteners or binding material, to allow the building block to be fastened to the original or internal wall with the desired pattern of voids to accommodate the thermal grid (3) and the heat conductors (4).

Figures 10(a)-(d) show examples of different thermal grid patterns that may compensate for the thermal variation in temperature. This is done in local deflection parallel to the wall by allowing localised movement and distortion. This configuration allows the use of thick materials for the thermal grid, and may eliminate the need for use of the larger heat conductors (4). Where complete thermal grid patterns are used, such as those illustrated in Figure 11, it becomes important to compensate for heat expansion and contraction by using thin material and allowing spaces at the end of the wall for expansion and contraction. In such a case, the size of the pattern should be calculated to prevent interference between the thermal grid (3) and the internal wall and external cladding layer.

Figures 12(a)-(d) show examples of different shapes of heat conductors (4) that may be attached to the thermal grid (3) and the internal wall (1) using the two types of fixing systems (10,11) that were described above in relation to Figure 7. Figure 12(a) shows a normal heat conductor beam that will expand and contract through its full length. Such a beam could be welded to the thermal skirt (5) and be allowed to expand or contract from the opposite direction. This will make it difficult to attach to the roof heat conductors. To solve this problem other versions (Figures 12(b),(c) and (d)) can be used. The embodiments shown in Figures 12(b) and 12(c) are solid beams made from a single piece of conductor that compensate for thermal expansion and contraction through localised deformation. The embodiment of Figure 12(d) is a heat conductor that consists of several hollow beams of differing dimensions that slide telescopically inside each other coaxially. The beams are maintained in close contact by a bolt (16a), a spring mechanism (16b) and a nut (16c) that allow relative movement with thermal conductivity, as illustrated in Figure 13. The embodiments of Figures 12(b), 12(c) and 12(d) may be welded to the thermal skirt (5) and to the heat conductors on the roof to transfer heat.

Finally, Figure 14 shows a fixing system for fastening heat conductors (4) to the external side of the internal wall (1) using a bolt (17b) which is positioned within a slot (17a) in the conductor. A spring system (17c) is utilised to improve the heat conduction and allow relative movement due to thermal expansion and contraction. The bolt (17b) may be made from, or encased in, a thermal insulation material to reduce heat conduction to the internal wall in a hot climate.

Claims

1. A temperature regulation system for incorporation into a building structure, between internal and external leaves that define a cavity in the envelope of the building, the system comprising at least one thermally conductive element connected to ground temperature through at least one thermal probe extending into the earth adjacent to the building to a depth wherein the earth exhibits a substantially constant temperature, enabling the natural thermal flow of heat between the conductive element and the ground,

wherein the external leaf comprises cladding provided with voids, arranged such that the voids are formed about the conductive element in such a way that the conductive element can move due to thermal expansion and contraction within the voids.

2. A temperature regulation system according to Claim 1, which further comprises a heat reflective layer attached to the cavity-facing side of the internal or external leaf of the envelope.

3. A temperature regulation system according to Claim 1 or Claim 2, wherein the thermally conductive element comprises a grid or mesh mounted on the cavity-facing side of the internal leaf by mechanical fasteners that allow relative movement of the grid or mesh due to thermal expansion and contraction.

4. A temperature regulation system according to Claim 3, where the grid or mesh allows for localised distortion and deformation due to thermal expansion and contraction.

5. A temperature regulation system according to Claim 3, where the area of the grid or mesh, at maximum operating temperature, is equal to or less than the area of the internal leaf on which it is mounted, to allow for thermal expansion and contraction.

6. A temperature regulation system according to Claim 3, wherein the grid or mesh comprises a regular array of metallic rods arranged horizontally and vertically.

7. A temperature regulation system according to Claim 3, wherein the grid or mesh comprises a sheet having a regular array of perforations.

8. A temperature regulation system according to Claim 5, wherein the perforations are square, rectangular, rhomboidal, circular or oval.

9. A temperature regulation system according to any one of Claims 3 to 8, wherein the thermally conductive element further comprises at least one heat conductor which is in contact with the grid or mesh and is fastened to the cavity-facing side of the internal leaf by the means of a fixing system that allows relative movement of the heat conductor due to thermal expansion and contraction.

10. A temperature regulation system according to Claim 9, wherein the heat conductor has an irregular shape or pattern that allows for localised distortion and deformation due to thermal expansion and contraction.

11. A temperature regulation system according to Claim 9, where the heat conductor consists of two or more hollow beams having a telescopic coupling to permit coaxial sliding due to thermal expansion and contraction.

12. A temperature regulation system according to Claim 11, wherein the coaxially sliding beams are urged into close contact by a spring-loaded mechanical fastener.

13. A temperature regulation system according to any preceding claim, which further comprises a thermal skirt which couples the thermally conductive element to the at least one thermal probe.

14. A temperature regulation system according to Claim 13, wherein the thermal skirt is attached to the at least one thermal probe via link conductors.

15. A temperature regulation system according to any preceding claim, wherein the or each thermal probe is a metal shaft that having additional conductors arranged transversely thereto to enhance thermal conductivity from the probe to the earth.

16. A temperature regulation system according to any one of Claims 1 to 14, wherein the or each thermal probe has an irregular surface to enhance thermal conductivity from the probe to the earth.

17. A temperature regulation system according to any preceding claim, wherein at least one fluid pipe is attached to the conductive element to exchange heat.

18. A temperature regulation system according to Claim 9, wherein the fixing system is a spring-mounted bracket system.

19. A temperature regulation system according to Claims 9-18, wherein the thermally conductive element and the at least one heat conductor have separate fixing systems.

20. A building incorporating a temperature regulation system according to any preceding claim.

21. A building as claimed in Claim 20, wherein the cladding comprises a layer is of building elements and at least some of the building elements have a hole to enable them to be fastened mechanically to an external wall of the building.

22. A building as claimed in Claim 20 or 21, wherein the cladding is constructed of building elements having on the cavity-facing side thereof a plurality of protrusions that can be mechanically removed to create a cavity of the desired form to accommodate the thermally conductive element.

23. A temperature regulation system substantially as hereinbefore described.