(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 120 505 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.08.2001 Bulletin 2001/31

(51) Int Cl.[7]: **E04B 2/14**, E04B 2/42

(21) Application number: **01300709.1**

(22) Date of filing: **26.01.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **26.01.2000 GB 0001625**

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(54) A building block suitable for the construction of dry-stacking high performance masonry walls

(57) A pre-cast modular block 1 for construction of walls by dry-stacking comprises two outer walls 2 and two inner walls 3. Each outer wall 2 is connected to its adjacent inner wall 3 by cross-walls 4 defining voids 5. The inner walls 3 are connected by cross-walls 6 which define a void 7 and open-ended formations 8. V-shaped grooves 10 and 11 are provided in the cross-walls 5 and 6 respectively. The upper surfaces 12 of the outer walls 2 are below the level of the upper surfaces 13 and are provided with bosses 14 which at their tops are level with surfaces 13.

Vertical rebates 17 are provided in the outer walls 2 at each side edge thereof.

The bosses 14 provide for stability during dry-stacking of the bosses and serve to define horizontal bed joints, vertical joints being defined by the rebate 17.

Horizontal and vertical bands of reinforced concrete may be provided in the wall for stability thereof.

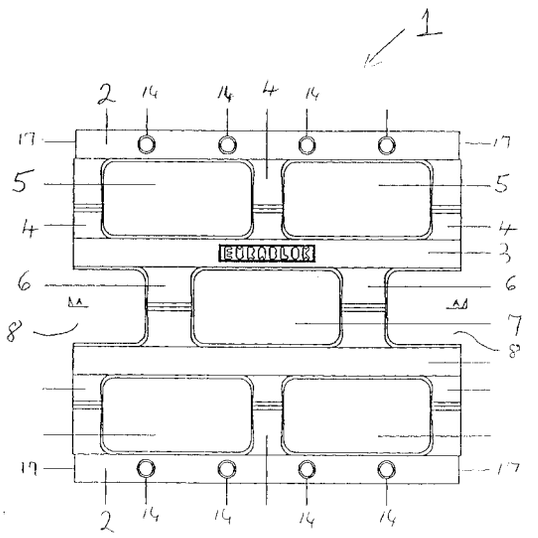

FIG. 1

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Description

[0001] This invention relates to a pre-cast modular building block suitable for the construction of dry-stacking high performance masonry walls.

[0002] Masonry walls are traditionally built from pre-cast modular blocks laid in courses on beds of wet mortar. Mortar is necessary to fill gaps between the blocks caused by dimensional inaccuracies in the blocks thus improving the stability to the wall and its load bearing capacity. The strength of the wall is dependant upon the strength and alignment of the blocks as well as the quality of the mortar, its control, mixing and usage.

[0003] Block laying on wet mortar is a time consuming and skilled trade. Regular checks have to be made on the horizontal, vertical and lateral alignments of the laid blocks during construction, the lateral strength of traditional wall panels is relatively low and is dependant upon the amount of perimeter support provided. The lateral strength may be increased by horizontal bands of steel reinforcement in the bed joints and/or providing vertical posts at intervals along the length of the wall.

[0004] A newly built panel of masonry is relatively weak for several days until the mortar has had time to set and achieve some of its tensile strength. During this initial period there is the risk of collapse in strong winds unless the wall is propped. Traditional masonry walls are also relatively brittle and deform and crack when subjected to forces for which they were not designed e.g. accidental impact, earth quakes, foundation settlement.

[0005] In cavity masonry wall construction metal ties are required to restrain the inner and outer skins of masonry. During construction one skin is built with wall ties projecting ready to be built into the bed joints of the other skin masonry. Personnel on site can accidentally injure themselves on the projecting ties.

[0006] It is an object of the present invention to obviate or mitigate the abovementioned disadvantages.

[0007] According to the present there is provided a pre-cast modular block comprising

(i) first and second outer walls transversely spaced from each other;

(ii) first and second inner walls provided between, and respectively adjacent to, the first and second outer walls and being transversely spaced therefrom and from each other, the upper surfaces of the inner walls being above those of the outer walls;

(iii) a first set of three cross-walls connecting the first inner and outer walls, and a second set of three cross-walls connecting the second inner and outer walls, the cross-walls of each set being provided one at each end of the block and one centrally thereof whereby two voids are defined between each adjacent pair of inner and outer walls, each of said first and second sets of cross-walls being formed with aligned V-shaped notches;

(iv) a third set of two cross-walls connecting the inner walls to each other, the two cross-walls of the third set being provided at the quarterpoints of the length of the block so that a void is defined between the inner walls of the block, said third set of cross-walls having an aligned set of V-shaped notches;

(v) a plurality of projections on the upper surfaces of the outer walls, the upper surfaces of the projections being level with the upper surfaces of the inner walls; and

(vi) vertical rebates in the outer walls at each side edge thereof.

[0008] Therefore, on plan, the modular pre-cast unit has three rows of hollow cores separated by four longitudinal walls. The outer rows of cores are divided by three cross walls located at the block ends and the mid point. The central row of cores is divided by two cross-walls located at the quarter points of the length. All the cross walls have aligned V-shaped notches.

[0009] The upper surfaces of the inner walls are "higher" than those of the outer walls and the latter surfaces have projections to the height of the inner walls. The side edges of each outer wall have vertical rebates.

[0010] The block's weight can easily be made to be within current repetitive handling recommendations (particularly since the V-shaped notches reduce the weight of the block) and the shape of the block provides an opening suitable for a one hand balanced lift.

[0011] The block of the invention is used in the construction of walls by dry stacking and eliminates the need for laying blocks on wet mortar beds. In any one course of the wall, the side edges of two adjacent blocks are in abutting relationship. The blocks in an upper course have lower surfaces of their inner walls of the blocks of the next lower course. The projections on the upper surfaces of the outer wall of one course abut against the lower surfaces of the outer walls of the blocks of the next upper course and keep the dry-stacked blocks stable during construction.

[0012] Alternate courses of masonry use overlaps of opposite hands to break the joints.

[0013] The controllable dimensional horizontal and vertical accuracy of the wall is thus achieved by alignment of the mating faces of the blocks and the shape of the block determines the bed joint and perpendicular joint widths and maintains them to exact tolerance limits. The depth of the bed joint is, of course, defined by the upper surface of the outer wall of a block of one course and the lower surface of the outer wall of the block of the upper course. In turn, this depth is defined by the distance between the upper surface of the outer wall and the lower surface of the inner wall of a block. Blocks may be produced with different values of this distance thus

giving the possibility of bed joints of different depth. Furthermore, in any one block, this distance may vary transversely of the block. The perpendicular joint width is defined by the rebates at the abutting side edges of adjacent blocks in one course.

[0014] The speed at which the blocks may be erected is, therefore, faster and may be carried out by certified trained labourers.

[0015] The wall as assembled incorporates cavities defined by the voids. There are no projecting cavity wall ties which could cause injury and building sites using the block of the invention can be expected to be tidier and cleaner making them safer than traditional sites.

[0016] Furthermore it is a feature of the invention that horizontal and vertical reinforcement may be provided in the assembled wall. For the purposes of horizontal reinforcement, a steel reinforcing bar or the like may be laid along the aligned V-shaped notches of the third set of cross-walls, i.e. those connecting the inner walls of the block. Reinforcing concrete may then be introduced around the bar to provide a horizontal band of reinforcement. The V-shaped grooves locate the longitudinal reinforcement and ensure the correct cover therefor.

[0017] Furthermore, the wall may be provided with vertical bands of reinforcement, again comprising a reinforcing bar (which will extend through vertically aligned voids of the assembled wall) embedded in concrete.

[0018] The horizontal and vertical bands of reinforcement will generally be provided at 1.2m intervals, the pattern being realigned to frame openings. The bands bond the blocks together and provide ductility and strength to the wall enabling the completed structure to be resistant to earthquakes, accidental damage, subsidence and lateral forces such as wind loads and thermal strain.

[0019] Insulation may be provided within the voids. The use of insulation materials within the voids, installed upon the completion of each "lift" (i.e. the blocks laid above one horizontal band and before construction of the next such band) or storey, provides thermal properties for the completed wall which are generally twice as good as traditionally insulated walls. The V-shaped notches allow the longitudinal continuity of insulation in the voids and also reduce the thermal bridge between the walls of the block.

[0020] Once the wall has been erected, the bed and vertical joints may be rendered. The render may involve use of a primer coat incorporating additives to provide high early strength and low water/cement ratios to minimise the amount of water involved thus allowing subsequent operations to proceed within hours. The render coats penetrate the controlled joint widths between the blocks to augment the stability and load bearing capacity of the wall.

[0021] Additives as described in the previous paragraph may also be incorporated in the concrete used for forming the horizontal and vertical bands of reinforcement.

[0022] The block can be cut to provide sub-modular length block components. In large volume production, the sub-modular units may be individually moulded by inserting a profiled splitting plate across the mould width. The block can also be cut to provide internal wall blocks comprising the outer row of cores together with their boundary walls. again, in large volume production, this partition block can be manufactured by inserting a solid spacer in place of the central row of core farmers. Pairs of corner units can be formed by removing the overlapping walls of the units to produce a combined unit with an overall plan dimension of one modular length by one-and-a-half modular lengths. Alternatively, handed corner blocks can be fabricated.

[0023] The invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a plan of a block in accordance with the present invention;

Figure 2 shows a section on the line A-A of the block of Fig 1;

Figure 3 shows a side elevation of a block;

Figure 4 shows an end elevation of a block;

Figure 5 shows a vertical section through a wall of stacked blocks;

Figure 6 shows a horizontal section through a wall of stacked blocks;

Figure 7 shows a typical arrangement of horizontal and vertical reinforced concrete cores in the front elevation of a single storey building;

Figure 8 shows a typical arrangement of horizontal and vertical reinforced concrete cores in the side elevation of a single storey building.

Figure 9 shows in horizontal section a typical detail of forming a lintel over an opening;

Figure 10 shows in horizontal section a typical cill detail; and

Figure 11 shows in horizontal section a typical jamb detail;

[0024] As shown Fig 1, a pre-cast concrete block 1 in accordance with the invention comprises two external longitudinal (rectangular) walls 2 parallel to, and transversely spaced from, two internal longitudinal (rectangular) walls 3 which are also transversely spaced from each other.

[0025] Each external longitudinal wall 2 is connected to the adjacent internal longitudinal wall 3 by a set of three cross-walls 4 positioned one at each end of the block and one at the centre point. These cross-walls 4 define two cavities 5 between each adjacent outer wall 2 and inner wall 3.

[0026] The two internal longitudinal walls 3 are connected together by a set of two internal cross walls 6 each provided at the quarter points of the block. These two walls 6 define, between the two inner walls 3, a single void 7 and two open-ended "notches" 8.

[0027] The four voids 5 and the void 7 are all of the same size. Furthermore when two of the blocks 1 are placed end-to-end, the adjacent open-ended "notches" 9 of the two blocks co-operate to define a similarly sized void 10 (see Fig 6).

[0028] The sides of the voids 5 and 7 taper allowing the cast block 1 to release itself from the mould in which it is manufactured (see the section of Fig 2).

[0029] The blocks are half bonded so that all of the voids are in vertical alignment.

[0030] As shown in Figure 4, the internal cross walls 5 are each formed with an upper V-shaped notch 10 that is symmetrical about the centre. The use of such shaped notches 10 reduces weight, locates reinforcement (see *infra*), allows for continuity of insulation and reduces the thermal connection between the longitudinal walls 2,3. Also as shown in Figure 4, the external cross walls 4 are provided with V-shaped notches 11. However, these notches are asymmetrical with their apices being closer to the inner wall 3 than the outer wall 2.

[0031] As also shown in Fig 4, the upper surfaces 12 of the outer walls 2 are below the level of the upper surfaces 13 of the inner walls 3. Provided on the upper surfaces 12 of the exterior walls 2 are equally spaced bosses 14 which at their tops are level with the upper surfaces 13 of the inner walls. The basal surfaces 15 of the outer walls 2 are flat and are level with the basal surfaces 16 of the inner walls 3.

[0032] Referring back now to Fig 1, it will be seen that the ends of the external walls 2 terminate just short of the outer end faces of the cross-walls 4 thereby defining vertical rebates 17.

[0033] The function of the bosses 14 and rebates 17 and the aforementioned will be described below.

[0034] Small numbers of the blocks may be made using a semi-dry concrete mix in individual moulds. These can be cast upside down, manually filled and tamped in, then tipped out to cure. The rebates 17, can be formed by fixing machined strips of material to the basic block mould. Large production runs would be manufactured in batches the right way up using an hydraulic press.

[0035] If desired, the block 1 may be moulded with a trademark, logo or other identification (e.g. block classification codes or block strength or grade data) provided, for example, in the upper surface 13 of an inner wall 3 or at any other suitable location such as moulded into the bosses 14.

[0036] The following procedure is used to assemble a wall comprised of the blocks with horizontal and vertical bands of concrete and steel reinforcement.

[0037] Initially, a first course of the blocks 1 is laid by positioning the blocks in end-to-end abutting relationship (as depicted in the plan view of Fig 6). It will be appreciated that, with the blocks so laid, the two adjacent "notches" 8 cooperate to define the void 9 additional to the voids 5 and 7 that are preformed in the block.

[0038] A horizontal band of reinforced concrete is then provided as follows. A steel reinforcing bar 19 is laid in the V-shaped notches 10 of the internal cross-walls 5 (see Fig 5) and is located in position by the notch. Concrete 20 is then cast into the voids 7 and 9 up to the level of the upper surfaces 13 of the inner walls 3 thus embedding the reinforcing bar 19 in the concrete with the required degree of "cover".

[0039] Subsequently the second course of blocks is laid stretcher-bond on the first course. Accurate vertical positioning and stability of the blocks of the second course are achieved by virtue of the lower surfaces 15 of the outer walls 2 of the upper blocks seating of the bosses 14 of the blocks in the first course. In this way it is also ensured that there is a horizontal "bed" 21 of constant width between the lower surfaces 15 of the outer walls of the blocks of the upper course and the upper surfaces 12 of the outer walls of the blocks of the lower course (see Fig 5). It will also be appreciated that, in any one course of blocks, there is a vertical joint 22 of constant spacing between any two adjacent blocks formed by the adjacent rebates 17 (see Fig 6).

[0040] Further courses of blocks 1 may then be laid to a level immediately below that at which it is desired to have a further horizontal band of reinforced concrete 20.

[0041] The stability of a "lift" of the stacked blocks is greater than traditional construction due to the height to width ratio and it is unlikely that temporary propping will be required to ensure stability during construction.

[0042] Thermal insulation 18 is now provided in the empty voids 5,7 and 8 of the courses that have been laid. The insulation may be installed in any convenient way, e.g. injected foam, blown mineral fibre, polymer beads or pre-formed insulation blocks. Longitudinal continuity of the insulation is ensured by the V-shaped notches 10 and 11.

[0043] A further course of blocks is then 1 laid and provided with a steel reinforcing bar 19 and concrete 20 as described for the first course. Depending on the type of insulation used in the lower courses, it may be necessary to install a thin waterproof sheet material for temporarily supporting the wet concrete as it cures.

[0044] The positioning of the horizontal bands of reinforced concrete will be a matter of design but, in the construction of a wall for a house, will generally be provided at foundation level, damp proof course level, window cill levels, at 1200mm intervals in plain wall panels, window and door opening lintel levels, floor and roof lev-

els. At every band of horizontal reinforced concrete, there is an opportunity to check and adjust the accuracy of the setting out and level of the stacked blocks. Shims 23 (not shown) may be inserted into the "bed" 21 between the blocks 1 to bring about the required adjustment prior to concreting.

[0045] In additional to the horizontal reinforcement, vertical reinforcement bands of reinforcement (comprised of a steel bar 24 embedded in concrete 25) may be provided at 1200mm centres in plain walls and around all window and door openings. The vertical reinforcement may extend from the foundations or a higher level to the roof. Typical arrangements of vertical and horizontal reinforcement in walls of a single storey building produced with the stacked blocks are shown in Figs 7 and 8.

[0046] The manner is which the vertical reinforcement is formed is as follows. After building up several courses of blocks 1 above a horizontal band of reinforcement 19, 20 and prior to provision of the insulation 18 and formation of the next horizontal band, a steel bar 24 is inserted downwardly through vertically aligned voids until it abuts against the previously installed horizontal band. Strips of any suitable material are then inserted down the vertically aligned voids (in which the bar 24 is provided) to act as shattering and the concrete 25 is poured around the bar 24.

[0047] Subsequently insulation 18 is installed as previously followed by construction of the next horizontal band of reinforcement 19,20.

[0048] Fig 9 is a detail showing a horizontal band of reinforcement 19,20 provided to increase the effective depth of a lintel 26 over an opening. More particularly, the rows of blocks immediately over the lintel may be provided with horizontal bands of reinforced concrete 19, 20 which provide additional strength to the lintel. The cross-section and/or number of the reinforcing bar(s) in this band of reinforced concrete may be selected as appropriate.

[0049] Fig 10 shows the use of a band of horizontal reinforcement immediately below a window cill 27.

[0050] Fig 11 shows the use of a vertical band of reinforcement 24, 25 adjacent a jamb 28.

[0051] The horizontal and vertical bands of reinforced concrete reinforced bands perform a number of roles. They provide lateral stability, especially of large panels of masonry, vertical restraint against wind uplift and horizontal shear and racking resistance for use in seismic and excessive wind locations. The reinforcing bands also provide longitudinal ties at corners and at floor deck, roof wall plate and wall intersections. They provide vertical reinforcement at corners and opening jambs. The reinforcement provides for lintels over openings, can increase the structures vertical load bearing capacity, and act as bearing beams and tie beams at floor and roof support levels.

[0052] When the blocks have been assembled as described, the joints are rendered externally and internally. The first coat of render may be a pre-gauged mix containing a waterproofing additive which also increases the tensile capacity of the render. The render coat penetrates and seals the bed and perpendicular joints, and adds to the vertical and lateral load bearing capacity of the finished wall. Subsequent coats of render are of traditional specification to suit local conditions.

[0053] The finished construction is suitable for domestic or commercial construction of external walls and internal partitions. The construction is also applicable, when additional reinforcing is installed, for retaining walls. The thermal properties of the completed wall system provide high-energy conservation, making the system applicable to construction in areas of extreme heat or cold. The contemplated structure is water resistant, thermally efficient and structurally stable.

Claims

1. A pre-cast modular block comprising

(i) first and second outer walls transversely spaced from each other;

(ii) first and second inner walls provided between, and respectively adjacent to, the first and second outer walls and being transversely spaced therefrom and from each other, the upper surfaces of the inner walls being above those of the outer walls;

(iii) a first set of three cross-walls connecting the first inner and outer walls, and a second set of three cross-walls connecting the second inner and outer walls, the cross-walls of each set being provided one at each end of the block and one centrally thereof whereby two voids are defined between each adjacent pair of inner and outer walls, each of said first and second sets of cross-walls being formed with aligned V-shaped notches;

(iv) a third set of two cross-walls connecting the inner walls to each other, the two cross-walls of the third set being provided at the quarterpoints of the length of the block so that a void is defined between the inner walls of the block, said third set of cross-walls having an aligned set of V-shaped notches;

(v) a plurality of projections on the upper surfaces of the outer walls, the upper surfaces of the projections being level with the upper surfaces of the inner walls; and

(vi) vertical rebates in the outer walls at each side edge thereof.

2. A block as claimed in claim 1 wherein the V-shaped notches of the third set of cross-walls are symmetrical.

3. A block as claimed in claim 1 or 2 wherein the V-shaped notches of the first and second sets of cross-walls are asymmetrical.

4. A wall comprised of dry-stacked blocks as claimed in any one of claims 1 to 3.

5. A wall as claimed in claim 4 incorporating horizontal and vertical bands of reinforced concrete.

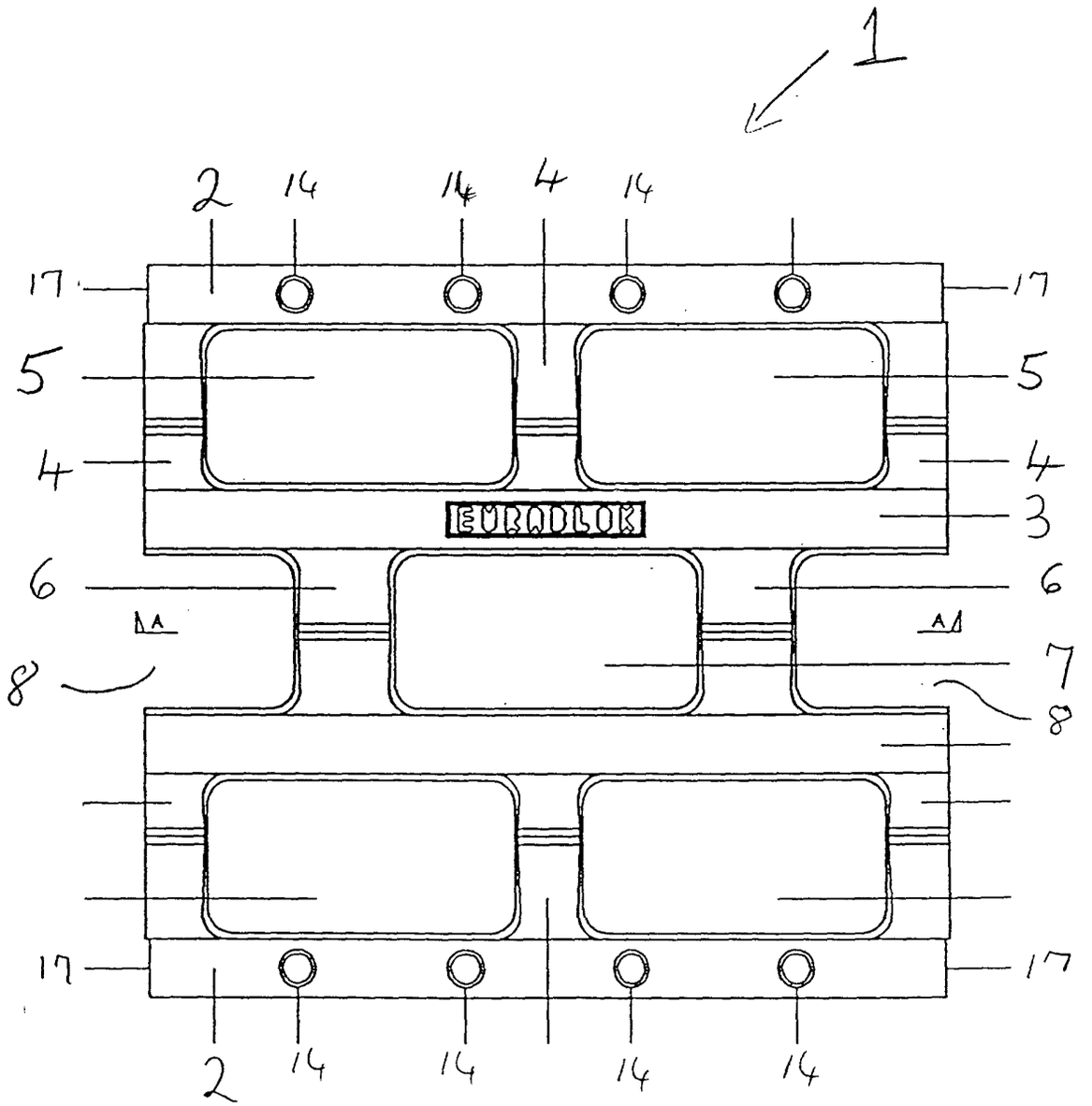

FIG. 1

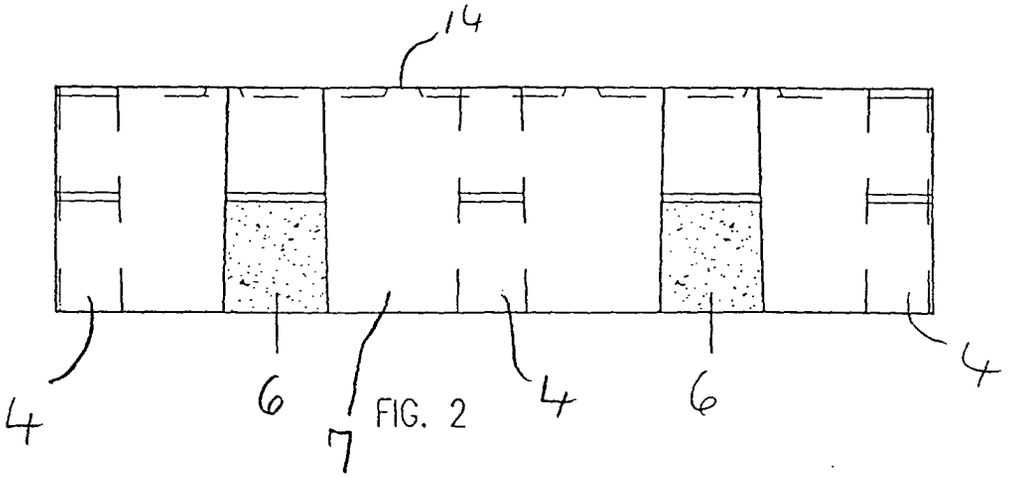

FIG. 2

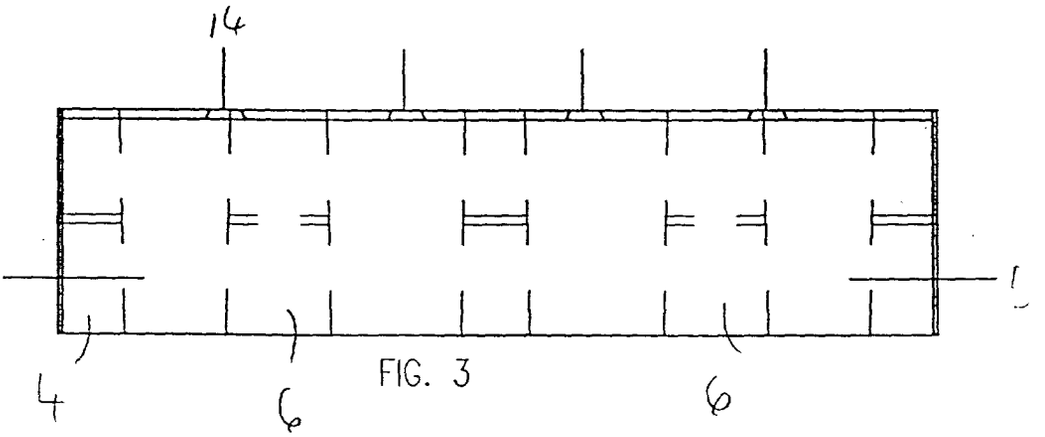

FIG. 3

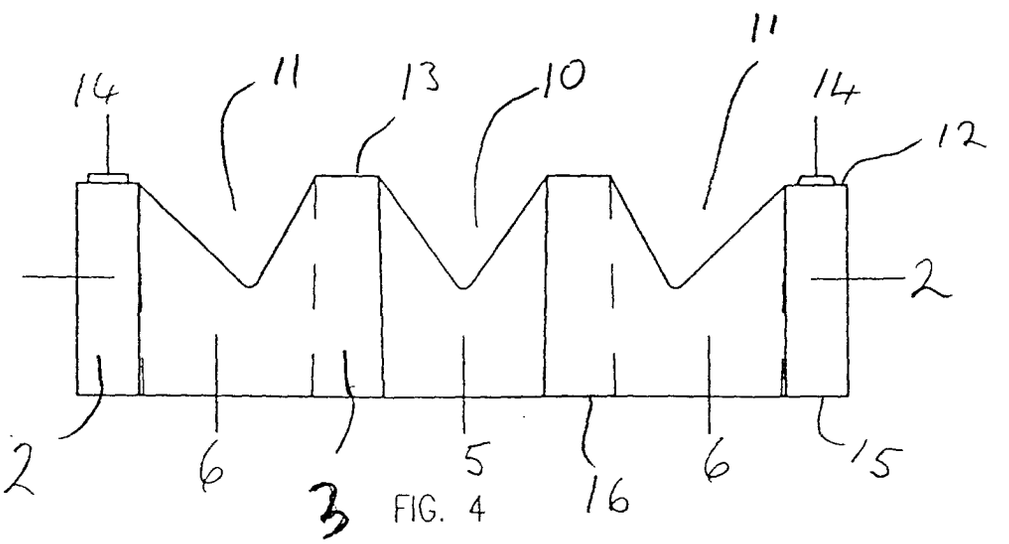

FIG. 4

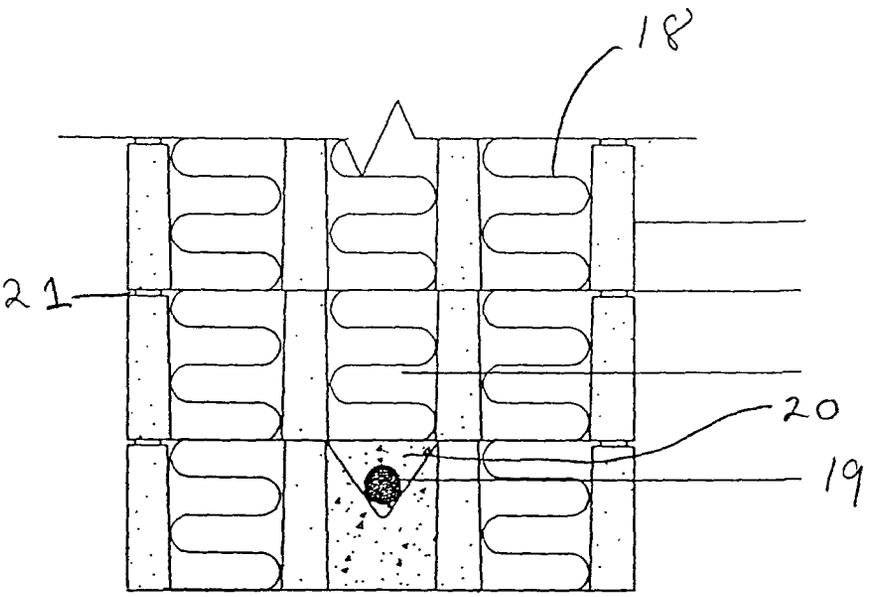

FIG 5

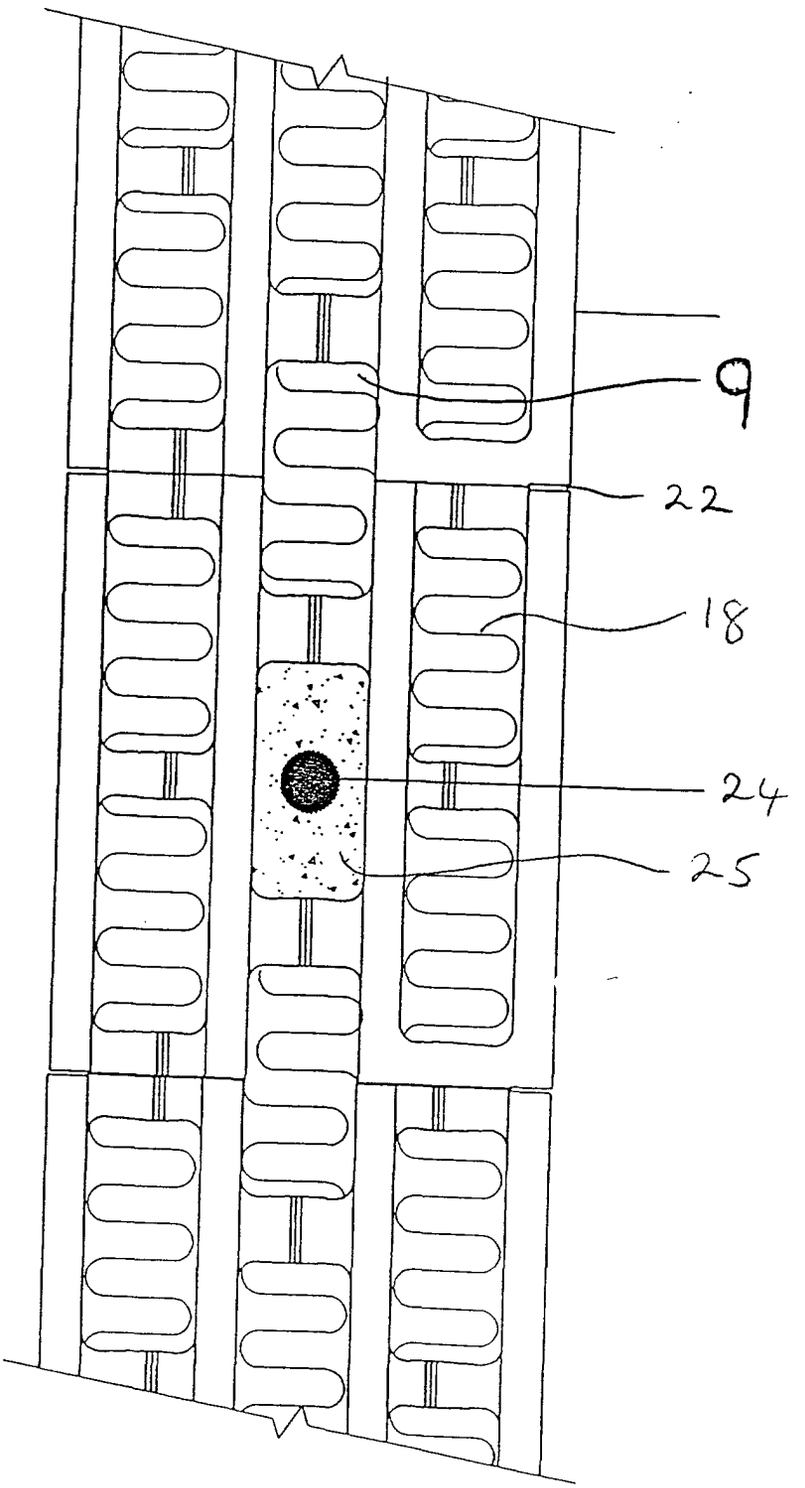

FIG 6

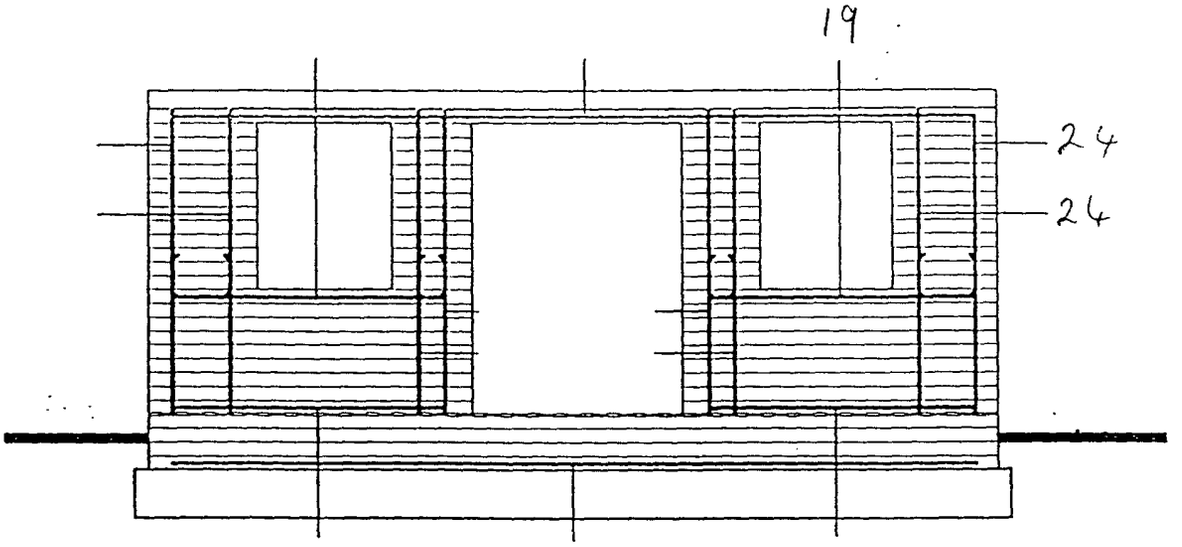

FIG 7

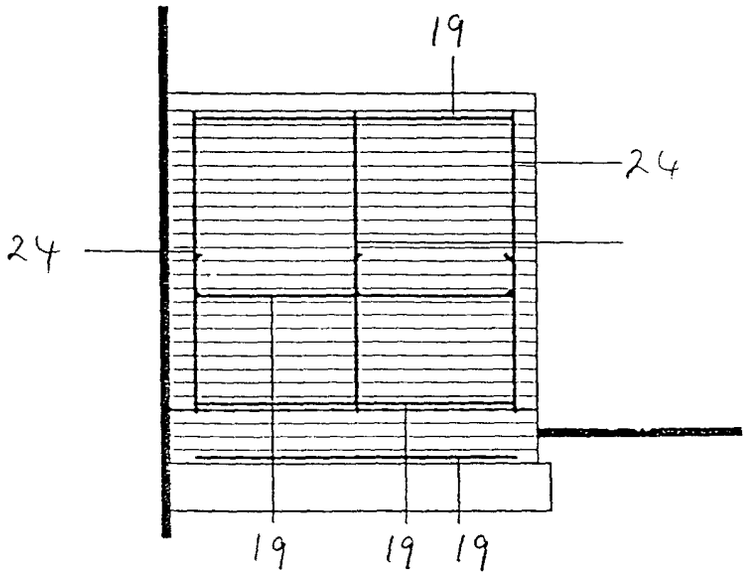

FIG 8

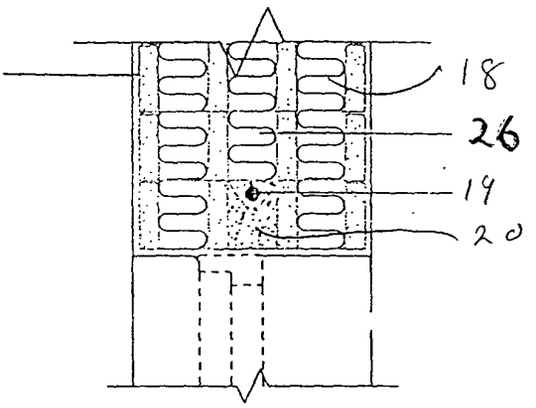

FIG 9

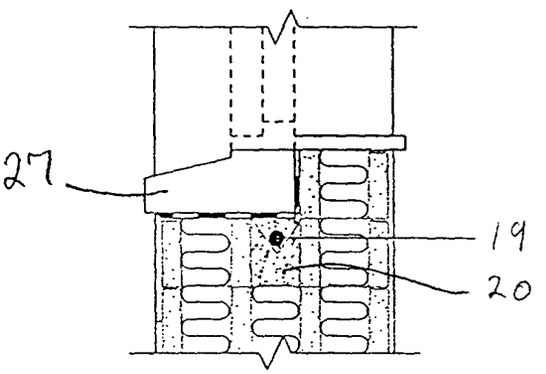

FIG 10

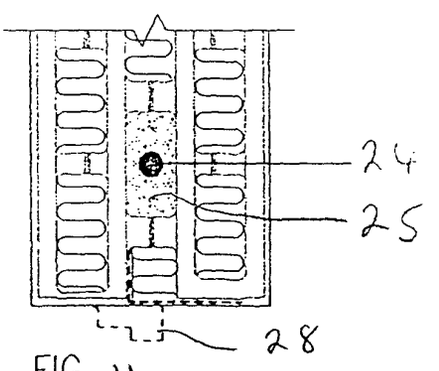

FIG 11