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(54) Title: MODULAR CONSTRUCTION SYSTEM

(57) Abstract: A modular construction system is described. The system includes blocks (1) composed of structural slabs (4) and spacers (5), with the spacers (5) being arranged to form orthogonal and diagonal cavities (6, 7) extending within the blocks (1). When a number of blocks 1 are combined, the cavities combine to extend across blocks. Reinforcing members in the form of joists (8) can be located within the cavities, together with fastening members, to secure the construction. The principal system components may be manufactured from second-grade and/or reclaimed wood-based products and the like, to provide an inexpensive construction material. Additional cladding members or fascias can be mounted to the slabs (4), to alter aesthetic appearance or to provide functional properties such as insulation.



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MODULAR CONSTRUCTION SYSTEM

The present invention relates to a modular construction system, primarily for use in construction of buildings and the like.

5 Several types of modular construction systems are known, intended for simplifying the task of construction of buildings. The use of a modular system can accelerate construction, due to the modular nature of components, and such systems are more or less suitable for construction by
10 relatively unskilled personnel. Further, the manufacture and production of the components themselves is generally intended to be relatively straightforward, since one or more basic shapes can be mass-produced and used in a wide range of construction projects.

15 However, known modular construction systems suffer from a number of disadvantages. Conventional modular systems are generally made from largely solid modules, which while providing strength for individual modules may be difficult to secure together without requiring the use
20 of mortar, cement or the like, which generally require specialist skills. Further, the installation of services and conduits into the building may require the creation of access points by chasing or other more complex construction techniques. Typically, such modules can be more or less
25 filled with concrete to which vertical or horizontal steel reinforcement can be added; other modules are made from

wood but are not so reinforced.

In addition, many conventional modular systems are relatively costly to produce and can be relatively heavy and so difficult to handle before and during construction.

5 Adobe, bricks and concrete blocks are known to have limitations in resisting storms, earthquakes and comparable sources of damage and destruction. In this context, braced timber construction has proved more satisfactory in some regards (International Decade for Natural Disaster
10 Reduction. Newsletter 'Stop Disasters', numbers 18, 25. Geneva, IDNDR).

Building often requires the use of mortar and other wet mixes that create problems during construction and delay completion. A further disadvantage of wet
15 construction is that once the wet mix has set, buildings cannot be modified other than by demolition, which is wasteful of resources (United Nations Conference on the Environment, 1992, 'Agenda 21'. New York, UN Department of Public Information, pp 206-214) and negatively affects the
20 quality of the urban environment (European Commission, 1992, 'Green Book', Luxembourg, Director General for the Environment, chapters 5-6).

Another problem is that the erection of buildings in general, and especially wet construction, requires
25 specialised and rare skills. This conflicts with the call for increased participation by people in the construction

of their own homes (United Nations, 1988, 'Global strategy for shelter', UN General Assembly). With regard to building services such as electricity, water, and gas supplies, conventional building construction is difficult to adapt to
5 the competing needs of protection for the services and access for maintenance, and the changing requirements of technology. Concerning repair and alterations, buildings in general and homes in particular are often difficult to repair, alter or extend.

10 It is among the objects of embodiments of the present invention to provide an improved modular construction system.

According to a first aspect of the present invention, there is provided a modular construction system comprising
15 blocks that may be assembled to form structures, the blocks each comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, wherein when assembled the voids of one or more blocks define at least one continuous cavity along at
20 least two axes of the one or more blocks for receiving at least one reinforcing member.

Thus, the present invention provides blocks which are relatively light due to the voids, and which may thus be handled and manipulated relatively easily, and yet may be
25 reinforced and connected together by means of reinforcing members within the voids. Although conventional modular

systems may make use of modules having cavities or voids therein, these are individual isolated cavities used for lightness or for forming structural members along a single axis; the provision of continuous cavities of the present invention allows reinforcing members to extend between individual blocks in multiple directions so improving strength and connections between blocks and of the structure as a whole. In certain embodiments of the invention, connections may be provided in diagonal as well as orthogonal directions. Further, the voids and cavities are located within the blocks of the present invention, between the paired slabs, thereby concealing the reinforcing members.

In addition, the continuous cavities of the present invention may also be used for accommodation of services and conduits such as electrical cables or water conduits and the like; this is not possible with conventional modular systems that lack interconnected cavities, and in particular multidirectional interconnected cavities.

Further, the blocks of the present invention may be assembled 'dry', that is without the use of wet construction materials. This makes the blocks more suitable for assembly by relatively unskilled labourers. Of course, wet materials such as adhesives may also be used if desired.

Preferably the cavity is defined by the voids of a

plurality of blocks; more preferably the cavity extends substantially continuously through the blocks. That is, the cavity is generally 'open', as opposed to a 'closed' cavity extending through a fixed number of blocks. This arrangement allows reinforcing members to extend along several blocks, so improving the connections and reinforcements between blocks, as well as permitting the cavity to be extended as the blocks are assembled.

Preferably the cavity is defined between the spacers of the blocks.

Preferably the spacers are encircled by the voids; that is, the spacers are completely surrounded by the voids. This allows cavities to extend in a plurality of directions around the spacers.

A plurality of cavities may be defined; these are preferably interconnected with one another, and may lie along different axes of the blocks, or may lie along parallel axes of the blocks. A combination of parallel and different axes may also be used.

Preferably cavities extend along a plurality of axes of the blocks, conveniently at least three axes, and more preferably at least four axes. In preferred embodiments of the invention, the cavities extend along both orthogonal axes of the block (for example, left/right, and up/down) and along both diagonal axes of the block. The orthogonal and diagonal axes of the block are preferably, but not

necessarily, spaced at 45 degree angles from one another. Preferably the cavities are all interconnected. Preferably the cavities are of modular dimensions; this allows common reinforcing members to fit into any of the cavities. In certain embodiments of the invention, orthogonal cavities are of twice the width of diagonal cavities and of those cavities at the edges of blocks. This allows a single reinforcing member to fit into the diagonal cavities, while two reinforcing members that are paired will fit into orthogonal cavities. Edge cavities of two blocks may combine to form standard orthogonal cavities, or an edge cavity of a single block may be closed with a single reinforcing member.

A block may further define a cavity extending perpendicular to the block; that is, along the axis extending between the paired slabs. The cavity may conveniently be defined by means of a void provided within the spacer, or may be defined outside the spacer. In certain embodiments of the invention, the perpendicular cavity may be created in use, for example, by drilling a hole connecting the outside faces of the paired slabs. Thus, in preferred embodiments of the invention, the blocks define cavities extending in five axes within which reinforcing members may be received.

Preferably the blocks define a regular shape. Conveniently the blocks are generally quadrilateral in

shape, and preferably square or rectangular. This construction allows blocks to be easily assembled into a regular pattern, and further permits a regular, repeating pattern of spacers and voids to be created, which in turn
5 leads to a regular arrangement of cavities.

Preferably each block comprises a plurality of spacers; preferably also the spacers are regularly arranged within each block. The number of spacers within each block may vary depending on the size of the blocks; in certain
10 embodiments of the invention, four spacers will be provided within generally square blocks, however it will be apparent that square blocks may be used in combination with for example rectangular blocks having a greater number of spacers arranged in the same regular formation.

15 The spacers are preferably generally octagonal in shape; this provides a number of flat faces against which reinforcing members may rest along each of four axes (two orthogonal, and two diagonal). However, any convenient shape may instead be used. For example, spacers may be
20 cylindrical, square or other quadrilateral, or cruciform, among others. In certain embodiments of the invention, blocks or similar constructions may be used as spacers between slabs or between pairs of blocks to form larger blocks.

25 Preferably the slabs are formed of a cuttable material; conveniently a material derived from wood or the

like. The use of a cuttable material allows blocks to be produced in regular shapes but cut to conform to any desired irregular shape for constructional purposes. Conveniently the slabs are formed of materials that incorporate reclaimed or other low-grade wood material, such as used in products in which wood, similar fibrous and/ or other materials are compressed and/ or mixed with cement, plaster, glue and/ or other fillers and/ or binders and the like, such as oriented strand board (OSB), or are made of OSB or similar materials. The use of reclaimed or other low-grade wood materials allow the blocks to be produced relatively inexpensively, thus making them also suitable for production in developing regions of the world. Other materials may of course be used if desired, such as paper, including paper-based boards such as paperboards, 15 cardboards, pasteboards and the like; plastics; polymers; metals; concrete; stone; and the like. Any suitable rigid material may be used. Slabs may be of solid construction or may include cavities, corrugations, foams, cells, and the like, for lightness. 20

Preferably the system further comprises one or more reinforcing members for being received into the cavity of the blocks.

The reinforcing members may comprise joists for extending through a cavity. The joists may be in the form of I-beams or the like; such joists may also include webs 25

having apertures for receiving bolts or other fastening members such as ties, chains, straps or wires for fastening joists to other components of the system. These apertures may be oriented in orthogonal and/ or diagonal directions.

5 The joists are conveniently comprised of metal, wood, plastics, or any of the materials described above with reference to the slabs. Preferably the joists are dimensioned to fit both orthogonal and diagonal cavities; although in certain embodiments of the invention, distinct

10 orthogonal and diagonal joists may be provided.

The reinforcing members may comprise clamps for engaging with spacers. The clamps may comprise metal or plastics materials. The clamps may be used to engage with spacers of two or more blocks, and so connect the blocks.

15 The clamps may also be suitable for engaging with other reinforcing members, such as joists or other structural elements.

The reinforcing members may comprise bolts or other fastenings such as ties, chains, straps or wires; these may

20 be used to connect joists or other reinforcing members together. Alternatively, or in addition, bolts, screws, nails, staples, ties or wires may be used perpendicular to the cavities, to transmit forces and loads between reinforcing members, slabs, and spacers.

25 The reinforcing members may comprise straps or the like, for securing around spacers. The straps may comprise

plastics, metal, or fibre-based materials. The straps may further comprise locking members, such as bolts, clasps, clamps, ties or the like.

The various reinforcing members may be provided as a single type, or as a combination of any or all of the types described above.

Preferably the blocks further comprise engaging means for engaging adjacent blocks together. While the reinforcing members will permit engagement of blocks, additional engaging means may be used, primarily but not exclusively to allow engagement and registration of adjacent blocks prior to the inclusion of the reinforcing members in the structure. The engaging means preferably comprises corresponding protrusions and recesses provided on the blocks, preferably on the edges of the paired slabs. The protrusions and recesses may be in the form of tongue and groove formations, or the like.

Preferably the blocks further comprise securing means for securing adjacent blocks and/or reinforcing members together. The securing means may comprise screws, nails, staples, adhesive, or the like. The securing means may be used to secure the blocks to the reinforcing members; for example, where joists are provided, blocks may be screwed, nailed or stapled to the joists, so securing the blocks together.

In certain embodiments of the invention, the blocks

may further comprise non-structural layers. These layers may comprise any or all of cladding, insulation, waterproofing, soundproofing, and the like. The non-structural layers may comprise any suitable materials. The layers may be provided externally or internally of the structural slabs. Preferably at least one external layer is provided, since this permits an aesthetic layer to be included to provide a choice of surface finish and appearance of the blocks. The layers may be removable; for example, the layers may be secured to the structural slabs by means of studs or hooks and eyes or the like, so permitting layers to be added or removed as desired. These layers may also be used for positioning and aligning adjacent blocks; for example, layers may be slightly offset from the structural slabs, to provide a tongue and groove form offset.

The cavities that do not receive reinforcing members may be filled with materials that have a structural role, or with non-structural materials; for example, insulation, fire-retardant material, ballast, or the like. Granular, foam-based or other flowing mixes or materials are preferred, for example vermiculite, perlite, or the like, particularly for insulation, since such materials may simply be poured into the interconnected cavities.

Multiple blocks may be combined to form a building unit. For example, several blocks may be connected across

their shortest axis to provide a building unit several blocks deep. Alternatively, or in addition, several blocks may be connected along their height and/or width to provide a larger building unit. Each of these units may then be
5 combined to form a structure in the same way as individual blocks. Allowance may be made for expansion and contraction of the units. As mentioned above, blocks may be used as spacers between pairs of blocks to provide a larger, composite block.

10 Preferably the spacers and slabs are formed from separate components; alternatively, the blocks may be moulded as one-piece units. A further variation may be to produce single slabs having part-height spacers integrally formed thereon; two such integral units may then be secured
15 together (for example, by glue, nails, screws, bolts, ties or the like) to form a pair of slabs having full-height spacers therein.

The system may further comprise wedge-shaped blocks, allowing the connection of a plurality of blocks at angles
20 other than zero or ninety degrees. Other wedge-shaped members may instead or in addition be provided, which are not in the form of blocks.

According to a further aspect of the present invention, there is provided a block for use in a modular
25 construction system, the block comprising paired structural slabs and at least one spacer separating the paired slabs

to form a void therein, wherein the void defines at least one cavity along at least two axes of the block for receiving at least one reinforcing member.

According to a still further aspect of the present invention, there is provided a kit for forming structures, the kit comprising a plurality of blocks which may be assembled to form structures, the blocks comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, wherein when assembled the voids of one or more blocks define at least one continuous cavity along at least two axes of the block for receiving at least one reinforcing member; in combination with a plurality of reinforcing members.

According to a yet further aspect of the present invention, there is provided a structure comprising a plurality of blocks comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, wherein the voids of one or more blocks define at least one continuous cavity along at least two axes of the block for receiving at least one reinforcing member; and a reinforcing member received in the cavity.

According to a still further aspect of the present invention, there is provided a method of assembling a structure, the method comprising the steps of:

arranging a plurality of blocks in a structure, the blocks comprising paired structural slabs and at least one

spacer separating the paired slabs to form a void therebetween, such that the voids of one or more blocks define at least one continuous cavity along at least two axes of the block for receiving at least one reinforcing member; and

locating a reinforcing member within the continuous cavity to reinforce the structure.

These and other aspects of the present invention will now be described, by way of example only and without limitation, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic external view of a plurality of blocks forming a building unit of a construction system in accordance with an embodiment of the present invention;

Figure 2 shows a schematic internal view of the unit of Figure 1, showing the reinforcing members therein;

Figure 3 shows a side view of a block of the unit of Figure 1 showing slabs and octagonal spacers separating the slabs;

Figure 4 shows a sectional view of the block of Figure 3, taken along the line A-A showing orthogonal and diagonal cavities;

Figure 5 shows a side view of a modified block that may be used in the invention;

Figure 6 shows a sectional view of a building unit

including reinforcing joists in accordance with an embodiment of the invention;

Figure 7 shows a side view of a building unit including reinforcing joists in accordance with an embodiment of the invention;

Figure 8 shows a further sectional view of a building unit including reinforcing joists in accordance with an embodiment of the invention;

Figure 9 shows a sectional view of a building unit including reinforcing clamps in accordance with an embodiment of the invention;

Figures 10 and 11 show side and sectional views of a block for use in the invention showing edging;

Figures 12 and 13 show side views of blocks for use in the invention showing non-structural members such as cladding;

Figures 14 and 15 show schematic and side views of a building unit and a block respectively for use in the invention showing tongue and groove arrangements;

Figure 16 shows a side view of a block for use in the invention showing perpendicular reinforcing bolts;

Figures 17 and 18 show side views of a block for use in the invention showing the use of access spacers to allow access into the interior of the block;

Figures 19a to 19c are side views of blocks for use in the invention showing yet further cladding materials;

Figures 20a to 20c illustrate a use of the present system in the construction of a building;

Figure 21 shows the integration of services within the blocks of the invention;

5 Figure 22 shows a block including several different types of spacers which may be used in the present invention; and

Figures 23a and 23b illustrate a use of the present system in construction.

10 Aspects of the invention are intended to provide a modular construction system based on the use of fundamental units (blocks) which provide cavities extending between the blocks within which cavities a variety of reinforcing members may be received, to aid the assembly of blocks to
15 form building units. This basic concept is described and explained further below.

Referring first of all to Figures 1 and 2, these show schematic external and internal views of a construction system in accordance with an embodiment of the present
20 invention. The figures illustrate the basic system comprising a number of blocks 1 (Figure 1) interconnected by internal reinforcements 2 (Figure 2). One or more blocks forming a single unit strengthened by reinforcement is referred to as a building unit. Building units 3 (Figure 2)
25 are separated from one another by joints that allow for expansion and contraction, and are combined to form parts

of buildings.

Figures 3 and 4 show side and sectional views respectively of a single block of Figure 1. Each block consists of two or more structural slabs 4 and spacers 5. The structural slabs are connected by and spaced from one another by the spacers, which are located at regular intervals within the block. The relative location of the spacers defines a series of voids between the slabs, which in use combine to form a number of cavities; several voids combine to form one continuous cavity. Figure 4 shows the presence of orthogonal cavities 6, running vertically and horizontally, and diagonal cavities 7, running diagonally across the blocks. In this example, spacers are eight-sided, although different forms may be used as will be described below, and are attached to the structural slabs (eg by bonding).

Figure 5 shows a side view of a modified block that may be used with the invention. The modified block includes paired outer structural slabs and spacers as with the block of Figures 3 and 4, with a third slab located between the outermost slabs. This form of block allows a double skin construction, and may be produced simply by securing two conventional blocks together, or as a separately produced block. Thus, by inserting one or more intermediate slabs, multiple cavities may be produced.

Figures 6 to 9 show blocks including a variety of

reinforcing members that may be used with the present invention. As explained with reference to Figure 4, each block includes orthogonal 6 and diagonal 7 cavities. As shown in Figure 6, a single orthogonal joist 8 fits in the peripheral orthogonal cavity, while a pair of orthogonal joists 8 fits in the internal orthogonal cavities. Of course, in certain embodiments of the invention, a single size of orthogonal joist may be designed to fit within both peripheral and other orthogonal cavities, or a single joist of double width may be designed to fit intermediate orthogonal cavities as well as two adjacent peripheral orthogonal cavities. Diagonal joist 9 fits within a diagonal cavity. It will be appreciated that the Figure is illustrative only, and that various lengths and widths of orthogonal and diagonal joists may be used in a practical application. Further, joists may be cut to size during construction depending on the particular details of the construction.

Figure 7 shows a side view of a block having four layers of structural slab. A number of joists 8 are illustrated in the lower peripheral orthogonal cavities of the block. As shown in Figure 7, the joists 8 are shaped as I-beams with flanges 10 located adjacent the structural slabs. Webs 11 are shaped to receive orthogonal and diagonal connections; this can be seen most clearly in Figure 6, with portions of the webs 11 being angled to

allow for the insertion of bolts or other fasteners such as ties, chains or wires therethrough along the orthogonal or diagonal axes. The flanges abut the spacers, and transfer forces thereto. As seen in Figures 7 and 8, further types of reinforcing members referred to as bearing plates 12, 14 are mounted outside the cavities on the edges of blocks, and transmit forces to the edges of the structural slabs. Other versions of plates that are partially mounted outside cavities are illustrated by fillet plate 123 and bearing plate 124 shown on Figure 23a. Such fillet plates may be used to close ends of cavities, or may be attached to a packing plate 126 so as to locate it correctly in the positions shown, whilst different sizes of bearing plates are shown to support the wall and to close the upper end of the outer cavity. In Figure 8, bearing plates 12 have webs that match those of orthogonal joists, and extended flanges 13 (shown in Figure 7). Diagonal bearing plates 14 have webs that match those in diagonal joists, and flanges that are similar to those in orthogonal bearing plates. Orthogonal bearing plates are used on orthogonal sides of blocks, diagonal bearing plates are used where blocks are cut parallel to diagonal cavities (eg to suit roofs).

Figure 9 illustrates reinforcing members in the form of clamps. Clamps extend between spacers, and secure the spacers, and hence adjacent blocks, together. Possible clamp configurations include bolted orthogonal clamp 15,

bolted diagonal clamp 16, sprung orthogonal clamp 17 and sprung diagonal clamps 18. Bolted clamps are for permanent connections; sprung versions are for temporary connections (eg at exhibitions, when a structure may be subsequently
5 disassembled). Clamps provide a supplementary means of joining blocks by connecting selected spacers in adjacent blocks. Clamps may also be used for spot reinforcement. Clamps may also be used during assembly of blocks (eg prior to tying building units), or for locally connecting
10 building units to each other. Clamps may include pre-drilled holes or the like for receiving bolts or other fasteners such as ties or wires along orthogonal or diagonal axes.

Additional reinforcing members may also be used,
15 including orthogonal connector ring 19 and diagonal connector ring 20, both shown in Figure 9 and used to distribute forces between spacers of adjacent blocks and to permit further bolted or tied connections along orthogonal or diagonal axes. In addition, standard washers, nuts and
20 bolts, and ties or chains (not shown) may be used for assembly, ties and reinforcement, and for linking building units to each other and other parts of structures.

Referring now to Figures 10 and 11, these show side and sectional views of a block for use in the invention,
25 and illustrate edging 21. Edging 21 is intended for use where structural slabs are cut from modularly defined

larger slabs (eg slabs to which spacers have been attached), leading to loss of modular consistency due to the width of the kerf. Edging makes up for the loss, protects the edges of the structural slabs, and assists the uniform transmission of pressure. Edging may include corresponding protrusions and recesses, such as pyramid-shaped projections 22 and pyramid-shaped indentations 23 (not shown to scale) that, when locked under pressure, resist movement between blocks.

10 Figures 12 and 13 show a variety of non-structural members that may be incorporated into blocks. The Figures show interior cladding 24 consisting of cladding spacers 25 and interior faceplates 26. In this example, the thickness of a faceplate plus a cladding spacer equals half of the modular distance of two slabs plus one spacer. This allows for various facings to differ in thickness whilst maintaining the modular sizing of the blocks. Any differences in thicknesses may be compensated for by corresponding variations in the lengths of the cladding spacers. The void between these spacers, the faceplate and the slabs may be partially or entirely filled with non-structural intermediate layer 27 (eg a layer of sound insulation material that is perforated to allow for the passage of the spacers). Alternatively, a structural intermediate layer 28 may be used, in which case the layer 28 assumes the role of the cladding spacers. Other forms of

intermediate layer include vapour barrier 29, illustrated as being attached to the back of the interior faceplate, and breathing membrane 30. In the case of exterior cladding 31, modular constraints do not apply (other than at 5 internal corner returns, where claddings are cut). This allows exterior faceplates 32 to be irregular and thicker than interior faceplates, to have external insulation 33 and to include back ventilation 34.

Figures 14 and 15 illustrate samples of tongues 35 and 10 grooves 36, protecting and sealing joints between blocks. Tongues and grooves are formed by diagonally shifting intermediate layers in relation to the structural slabs. This allows arrangements to be selected that best suit the choice of materials for the intermediate layers (eg in the 15 case of seating a tongue made of harder material against a softer material, both materials being part of the intermediate layer). For some materials (eg structural intermediate layers), the functions of seal, cladding spacer, and intermediate layer are combined. Alternatively, 20 tongues and grooves, cuts with feathers or crosscuts with feathers may be formed within the edges of the structural slabs, so allowing the arrangement to be used without cladding or other non-structural layers.

Figure 16 shows a side view of a block including 25 perpendicular reinforcing bolts. The arrangement shown in the Figure is intended to illustrate how access is gained

to cavities in selected blocks during construction (eg to install reinforcements or building services) and after completion (eg to maintain, repair, renew, upgrade or extend building services). For accessing blocks, holes 37
5 in the centres of the spacers and in corresponding positions in the structural slabs allow bolts 38 to be passed through, while the outer slab is not bonded to the spacer. This enables the relevant blocks to be partly disassembled so as to provide access to a selected cavity
10 (eg in cases of prefabrication of fully serviced structural elements).

Referring now to Figures 17 and 18, these illustrate the use of modified access spacers 39 instead of those spacers previously described. Access spacers extend between
15 paired structural slabs or multiple thickness blocks, but are not bonded to the outermost pair of slabs. Such access spacers may of course be present in combination with conventional spacers that retain the slabs in the desired spatial relationship. Access spacers 39 correspond with
20 access holes 40 in structural slabs. Access spacers and structural slabs are bolted together using cup washers 41, which engage with the access holes. Where access spacers are not bonded to interior structural slabs, the correct position of the eight sides of the octagonal access spacers
25 is set by feather 42 engaging with saw cut 43. Use of access spacers facilitates removal/replacement of selected

structural slabs during construction. Prior to assembly, such selected slabs have any restraining edging removed for ease of access. Where access is required, the bolts and washers are removed, and the outermost slab removed from the assembly, so allowing access into the interior of the block. Figure 18 further illustrates interchangeable faceplates 44, with attached lock knobs 45 for engagement with rimmed washers 46. The lock knobs and rimmed washers enable the interchangeable faceplates to be pressed on and to be removed for repair, renewal or interchange. This allows cladding materials and faceplates to be easily changed even after construction, allowing for ready redesign of constructs. The lock knobs and/or rimmed washers may vary in depth with the thickness of intermediate layer 47, vary in strength with the weight of the cladding material, or vary in design with the location of the cladding (eg on ceilings).

An alternative means of retaining interchangeable faceplates is achieved by the provision of studs (not shown) on the cladding or faceplate. Such studs may be attached by a flat head to the inside face of external cladding, and engage with a circular opening in the outer slab of the block (for example, within a hole provided in the spacer and slab) to which the cladding is to be attached, the diameter of the opening being equal to a side of the square-shaped void within the spacer that is

attached to the slab and behind the circular opening, and next engages with the square void inside the spacer.

The stud engages by hooking into the space of the four corners of the void that extend beyond the circle. Such engagement is achieved either by compressible protrusions on the round stud (e.g., where the stud is made of a semi-hard plastic and is hollow inside) or by incorporating four springs inside the stud that compress when passing through the hole and expand upon entry in the void.

10 The process may be reversed by sharply pulling the external cladding, which may be done by attaching pull knobs or rings to removable parts of the cladding, or by inserting and turning a hook in the joint surrounding the removable section.

15 Figures 19a to 19c illustrate samples of alternative and interchangeable claddings. Where faceplates are omitted cladding spacers may also be omitted, or may be used for fixing alternative claddings (eg plasterboard 48 for interior use), render-on-mesh 49 or back-ventilated timber
20 lining 50 for external use. The figure illustrates vapour barrier 51 and insulation bats 52 placed in cavities between blocks (such blocks may be formed as composite blocks having hollow cores). In such blocks, ventilated cavity 53 may supplement the cavities provided between
25 removable exterior and interior claddings and the blocks and within the blocks themselves.

Figures 20a to 20c illustrate part of a building constructed using a system according to the present invention. To assemble blocks together into building units, the desired number of blocks are aligned using tongue and groove formations if present, and adjacent spacers may be clamped together to retain blocks in alignment. During construction, and/or after the blocks are in position, joists are inserted into the orthogonal and diagonal cavities formed between the blocks to strengthen and reinforce the building unit. Blocks may then be further secured to the joists, by nailing the structural slabs to the joists, or by the use of bolts, ties, chains or wires between joists and/or straps around spacers. This is illustrated in Figure 23a, which also illustrates that edge plates 118, bearing plates 124 and fillet plates 123 may close the open edges of a building unit. Multiple building units may then be secured together and built up into a building in the same way.

Referring to Figure 20b, showing a particular application of the construction system, roof tiles 54 are laid on roof battens 55 over sarking 56 on counter battens 57. These are supported by composite blocks having hollow cores 58 with vapour barrier, insulation bats and ventilated cavities as discussed with respect to Figure 19. Horizontally positioned blocks 59 are illustrated with cladding members in the form of floor plate 60,

intermediate layers 61, and ceiling plate 62. Building units are connected by two types of assembly wedges 63 and 64, which allow building units to be connected to one another at angles other than zero and ninety degrees. In 5 this example, the wedges shown are made of metal. The length and location of the wedges is determined by engineering considerations. The wedges are covered by slab cover plates where exposed. The wedges are bolted to the joists on the periphery, and through these through to the 10 other side, providing a tie connecting the outer walls, thus helping to counter the outwards thrust of the roof. In alternative embodiments of the invention, the wedges may be formed in the same manner as blocks, with spacers and structural boards. The wedges allow the joists and spacers 15 of conventional blocks to be secured thereto. The wedges, of which the types are suited to size and function of the building units, facilitate erection with on-site connections 65. The design allows ties 66 to be attached to wedges. Outer cladding surfaces may be secured to assembled 20 building units and to wedges by angle brackets 67. Any potential incompatibility of orthogonal and diagonal dimensions is overcome by the variable width of ridge 68.

Referring now to Figure 21, this illustrates integration of building services and equipment within 25 building units. Building service conduits of small diameter (eg telephone line 69) may be placed in the readily

accessed but narrow cavity between removable faceplates and structural slabs. Building services conduit 70 is in a cavity between structural slabs. Cavities also accommodate circular light fitting 71 and a light fitting faced with translucent panel 72.

Figure 22 illustrates a range of different types of spacer that may be used in connection with the present invention. Spacer 102 is generally octagonal, allowing joists to abut a face of the spacer in each direction. The spacer may be readily mass-produced from four separate identical components, and may include a void 103 through the centre thereof, to facilitate insertion of bolts and the like. The second form of spacer 104 is cylindrical, and may lack the central void, but in that case may be readily drilled to create such a void if desired. A further variant spacer 106 is generally square in profile with rounded corners. Like the circular spacer, this variant may be drilled to create a void if desired. The fourth variant spacer 108 is generally cruciform, and as with the octagonal spacer may be readily produced from four subunits to provide a central void if desired.

Finally, Figures 23a and 23b illustrate further the assembly of blocks to form structures, in this case a vertical wall secured to a lower foundation, and supporting flooring and a flat roof. Figure 23a is an enlarged view of sections of the whole assembly shown in Figure 23b. A

number of blocks 110 are vertically connected to form a wall by straps 112 looped around the spacers 114, with shear bolts 116 provided to help resist pressure exerted by straps at the corners of loops. Packing plates 126 allow support for perpendicularly-aligned blocks 120 that form a floor and flat roof, and that may be held in place by means of further bolts 122 through the spacers of the perpendicular blocks and the packing plates.

The bearing plate 124 shown in Figure 23a also allows much flexibility in the system. Fixed back to back, two units placed on edge may act as a beam supporting blocks with single, double or treble cavities on either side, or a single beam may act as a trimmer beam to the same formation. The depth of the beam may be increased or decreased by adding or deducting modules, or may be increased in thickness by increasing or decreasing the thickness of the web.

Where the modular thickness of the block is 100mm, and where the thickness of the web is a multiple of 25mm, the use of a number of beams will return the horizontally laid blocks to the 100mm module at regular intervals. Where at certain intervals a thinner web is used (eg a multiple of 22mm) but the regular spacing of the horizontally laid blocks is maintained, open joints will occur at those intervals, the joints being multiples of 3mm where the webs are multiples of 22mm. These open joints may be employed as

expansion joints defining building units, and allowing these units to expand and contract.

Similarly, by placing bearing plate-derived units on end, either back-to back or singly, they may be employed as
5 columns that support point loads such as beams and the like, and that allow for the horizontal expansion joints to be matched by corresponding vertical expansion joints. This aspect of the invention enables certain edges of building units to function as dilatation seams in the construction
10 of buildings.

Thus, it can be seen that the present invention provides a building system that combines readily-assembled units in the form of blocks with reinforcing members such as joists and clamps which securely and stably connect the
15 blocks. The system also allows for the inclusion of building services and the like within the construction. It also provides a system in which units that are assembled in the construction of buildings can be disassembled and reused, and which enables unskilled persons to contribute
20 towards the construction, repair, alteration or extension of their homes.

In certain embodiments, the invention may be used as a former to provide a formwork for concrete and related casting materials. The former may be removable and/or
25 dismantlable, or may be permanent if desired.

The invention achieves this in part by means of a

system comprising blocks that can be manufactured in a range of different sizes, and reinforcements, with optional extensions comprising edgings, claddings, tongues and grooves, access to cavities, lift-off sections and
5 faceplates, alternative claddings, assembly wedges and built-in building services and equipment. The blocks may be integrated with one, several or all the extensions, depending on materials, method of manufacture, cost and market, which vary with location. The invention is multi-
10 functional in that the blocks may be used to form walls, floors, ceilings, roofs, beams, corbels, columns, non-load bearing enclosures, partitions, screens, doors, panels, formers, containers, furniture, or any article of utility or ornament.

CLAIMS

1. A modular construction system comprising blocks that may be assembled to form structures, the blocks each
5 comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, wherein when assembled the voids of one or more blocks define at least one continuous cavity along at least two axes of the one or more blocks for receiving at least one
10 reinforcing member.

2. The system of claim 1, wherein the cavity is defined by the voids of a plurality of blocks.

15 3. The system of claim 2, wherein the cavity extends substantially continuously through the blocks.

4. The system of any preceding claim, wherein the cavity is defined between the spacers of the blocks.

20

5. The system of any preceding claim, wherein the spacers are encircled by the voids.

6. The system of any preceding claim, wherein a
25 plurality of cavities are defined.

7. The system of claim 6, wherein the plurality of cavities are interconnected with one another.

8. The system of claim 6 or 7, wherein the plurality
5 of cavities lies along different axes of the blocks.

9. The system of claim 6 or 7, wherein the plurality of cavities lies along parallel axes of the blocks.

10 10. The system of any preceding claim, wherein cavities extend along a plurality of axes of the blocks.

11. The system of claim 10, wherein cavities extend along at least three axes of the blocks.

15

12. The system of claim 10, wherein cavities extend along at least four axes of the blocks.

13. The system of claim 12, wherein cavities extend
20 along two orthogonal axes of the block and along two diagonal axes of the block.

14. The system of claim 13, wherein the various axes of the block are spaced at 45 degree angles from one
25 another.

15. The system of any preceding claim, wherein the cavities are of modular dimensions.

16. The system of any preceding claim, wherein each block further defines a cavity extending perpendicular to the block.

17. The system of claim 16, wherein the perpendicular cavity is defined by a void provided within the spacer.

10

18. The system of claim 16 or 17, wherein the perpendicular cavity is created in use.

19. The system of any preceding claim, wherein the blocks define cavities extending in five axes within which reinforcing members may be received.

20. The system of any preceding claim, wherein the blocks define a regular shape.

20

21. The system of claim 20, wherein the blocks are generally quadrilateral in shape.

22. The system of any preceding claim, wherein each block comprises a plurality of spacers.

25

23. The system of claim 22, wherein the plurality of spacers are regularly arranged within each block.

24. The system of any preceding claim, wherein the
5 spacers are generally octagonal in shape.

25. The system of any of claims 1 to 23, wherein the spacers comprise blocks located between slabs or further blocks.

10

26. The system of any preceding claim, wherein the spacers are comprised of a material selected from : wood or a material derived from wood including engineered woods such as block-board, plywood, structural building boards or
15 panels, other organic or inorganic fibrous tissue, or the like; paper, including paper-based boards such as paperboards, cardboards, pasteboards and the like; plastics; polymers; metals; concrete; stone.

20 27. The system of any preceding claim, wherein the slabs are formed of a cuttable material.

28. The system of claim 27, wherein the slabs are formed of a material derived from wood including engineered
25 woods such as block-board, plywood, structural building boards or panels, other organic or inorganic fibrous

tissue, or the like.

29. The system of claim 28, wherein the slabs are formed of materials that incorporate reclaimed or other
5 low-grade wood material.

30. The system of claim 29, wherein the slabs are formed of oriented strand board.

10 31. The system of any of claims 1 to 26, wherein the slabs are formed from a material selected from : paper, including paper-based boards such as paperboards, cardboards, pasteboards and the like; plastics; polymers; metals; concrete; stone.

15

32. The system of any preceding claim wherein the slabs include cavities, corrugations, foams, or cells.

20 33. The system of any preceding claim, further comprising one or more reinforcing members for being received into the cavity of the blocks.

34. The system of claim 33, wherein the reinforcing members comprise joists for extending through a cavity.

25

35. The system of claim 34, wherein the joists

comprise I-beams.

36. The system of claims 34 or 35, wherein the joists
comprise webs having apertures for receiving fastening
5 members for fastening joists to other components of the
system.

37. The system of any of claims 33 to 36, wherein the
reinforcing members are comprised of a material selected
10 from : wood or a material derived from wood including
engineered woods such as block-board, plywood, structural
building boards or panels, other organic or inorganic
fibrous tissue, or the like; paper, including paper-based
boards such as paperboards, cardboards, pasteboards and the
15 like; plastics; polymers; metals; concrete; stone.

38. The system of any of claims 33 to 37, wherein the
reinforcing members comprise clamps for engaging with
spacers.

20

39. The system of any of claims 33 to 38, wherein the
reinforcing members comprise fastening members, such as
bolts, chains, ties or wires.

25

40. The system of any of claims 33 to 39, wherein the
reinforcing members comprise straps or the like, for

securing around spacers.

41. The system of claim 40, wherein the straps further comprise locking members.

5

42. The system of any preceding claim, wherein the blocks further comprise engaging means for engaging adjacent blocks together.

10 43. The system of claim 42, wherein the engaging means comprises corresponding protrusions and recesses provided on the blocks.

15 44. The system of any preceding claim, wherein the blocks further comprise securing means for securing adjacent blocks and/or reinforcing members together.

45. The system of any preceding claim, wherein the blocks further comprise non-structural layers.

20

46. The system of claim 45, wherein the non-structural layers comprise any or all of cladding, insulation, fire-retardant, waterproofing, aesthetic layers, and soundproofing.

25

47. The system of claim 45 or claim 46 wherein the

non-structural layer is provided externally of the structural slabs.

48. The system of any of claims 45 to 47 wherein the
5 non-structural layer is removable.

49. The system of any preceding claim, wherein multiple blocks are combined to form a building unit.

10 50. The system of any preceding claim, wherein the spacers and slabs are formed from separate components.

51. The system of any preceding claim, further comprising wedge-shaped members.

15

52. The system of any preceding claim, further comprising a granular, foam-based, or flowing material located within at least one cavity.

20 53. A block for use in a modular construction system, the block comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therein, wherein the void defines at least one cavity along at least two axes of the block for receiving at least one
25 reinforcing member.

54. A kit for forming structures, the kit comprising a plurality of blocks which may be assembled to form structures, the blocks comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, wherein when assembled the voids of one or more blocks define at least one continuous cavity along at least two axes of the block for receiving at least one reinforcing member; in combination with a plurality of reinforcing members.

10

55. A structure comprising a plurality of blocks comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, wherein the voids of one or more blocks define at least one continuous cavity along at least two axes of the block for receiving at least one reinforcing member; and a reinforcing member received in the cavity.

56. A method of assembling a structure, the method comprising the steps of:

arranging a plurality of blocks in a structure, the blocks comprising paired structural slabs and at least one spacer separating the paired slabs to form a void therebetween, such that the voids of one or more blocks define at least one continuous cavity along at least two axes of the block for receiving at least one reinforcing

member; and

locating a reinforcing member within the continuous cavity to reinforce the structure.

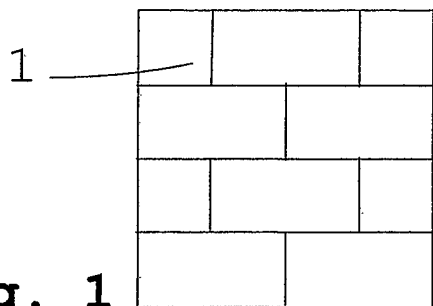


Fig. 1

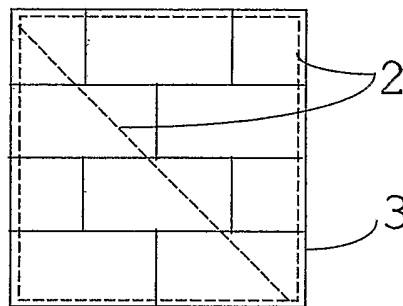


Fig. 2

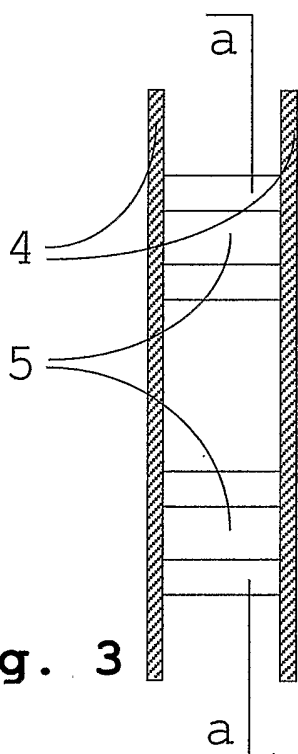


Fig. 3

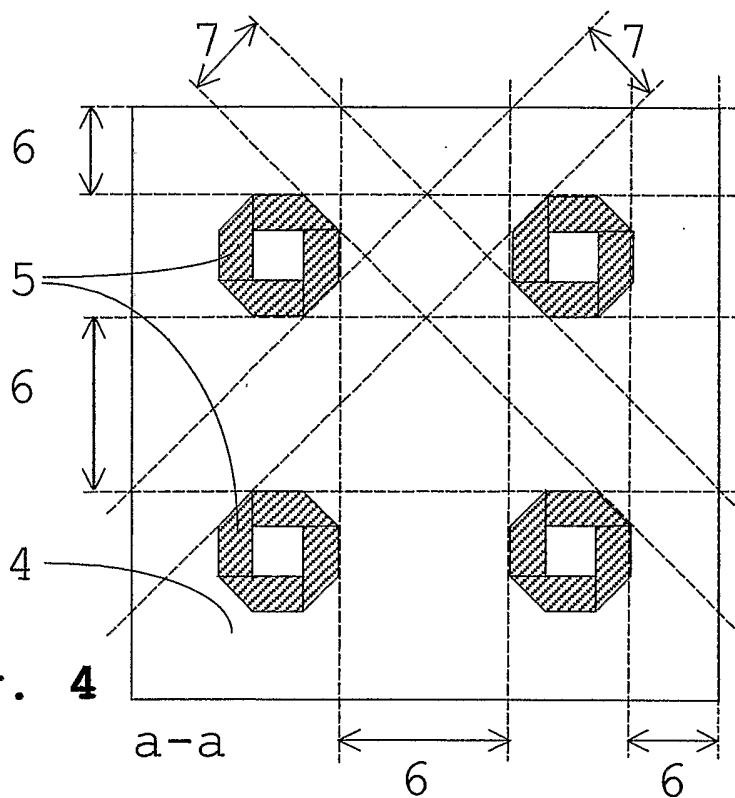


Fig. 4

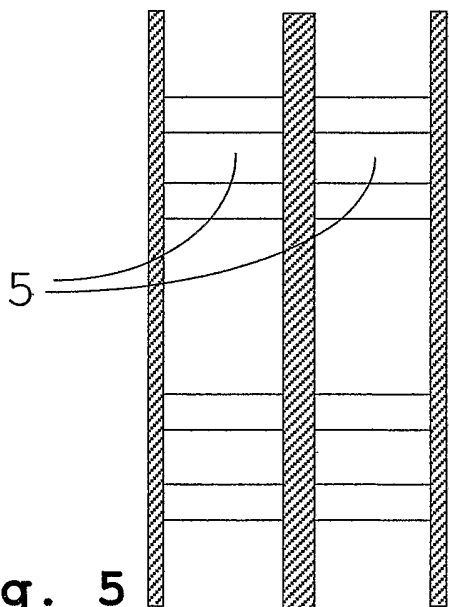


Fig. 5

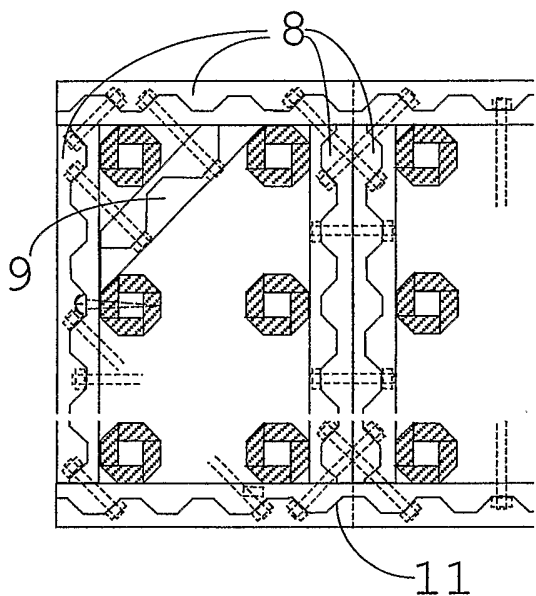


Fig. 6

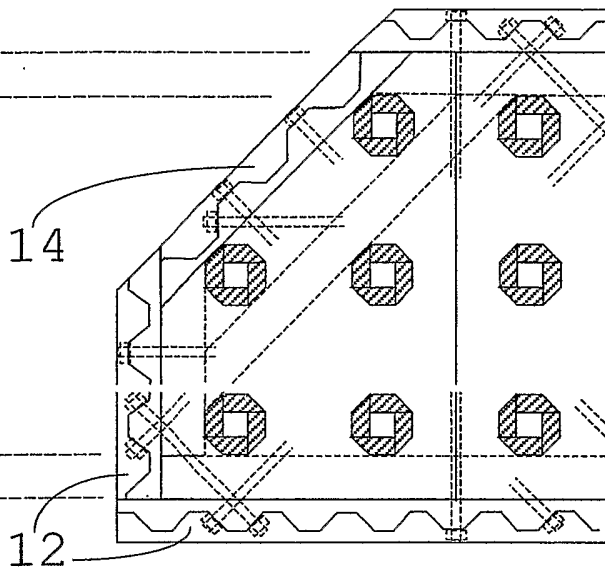


Fig. 8

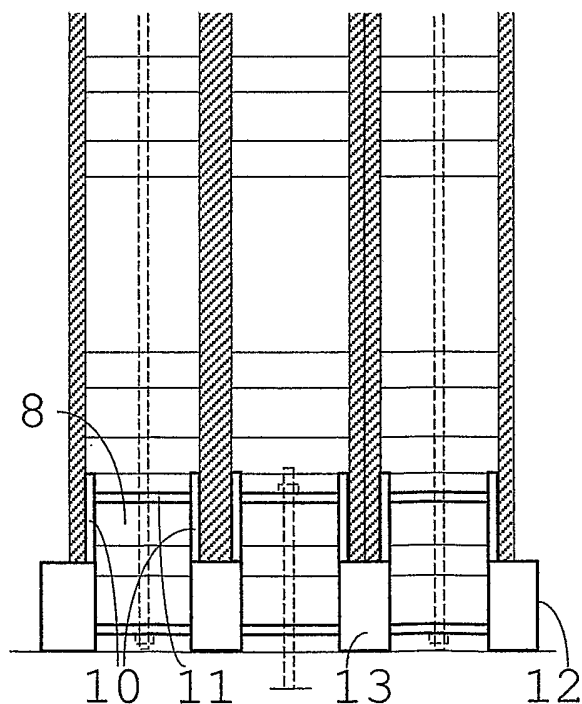


Fig. 7

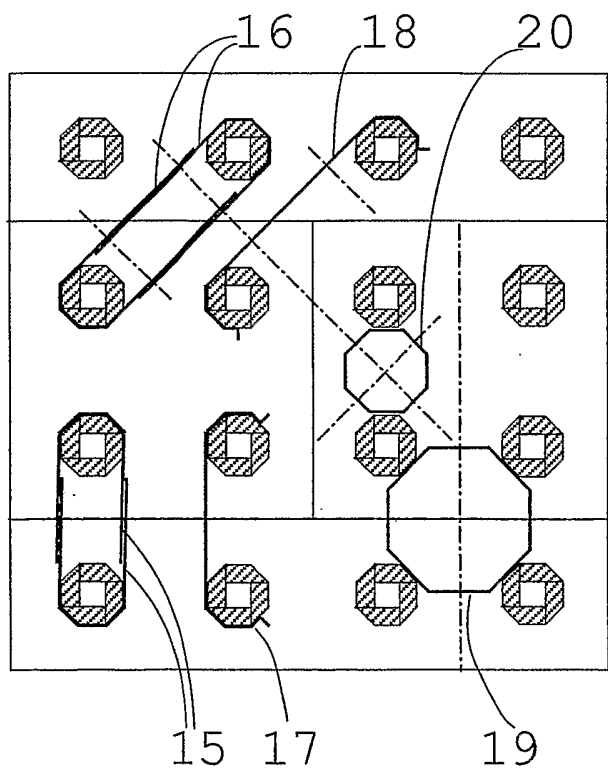


Fig. 9

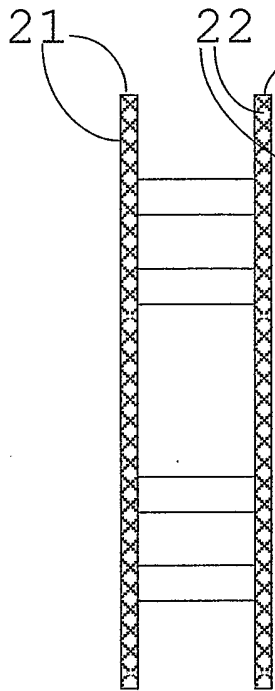


Fig. 10

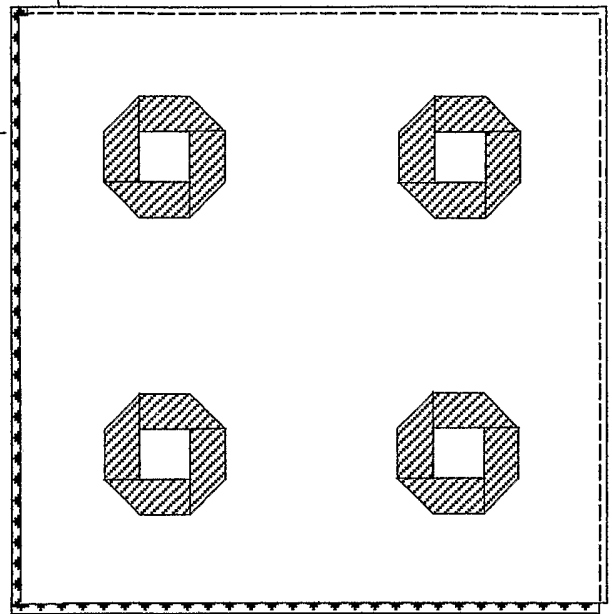


Fig. 11

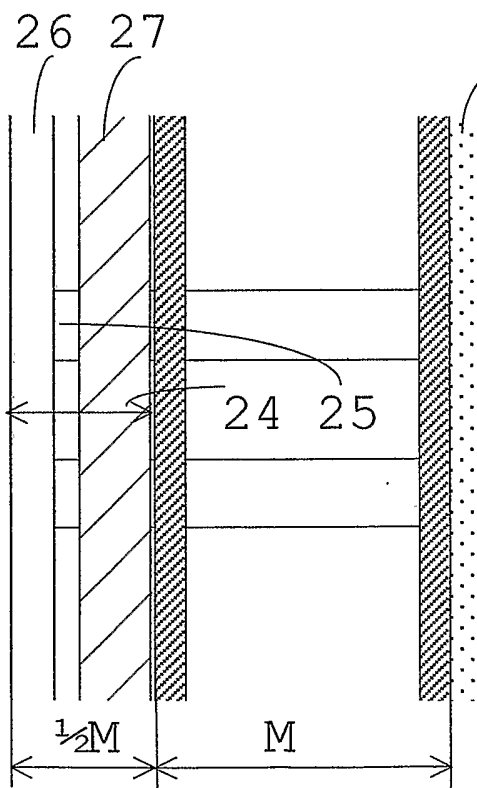


Fig. 12

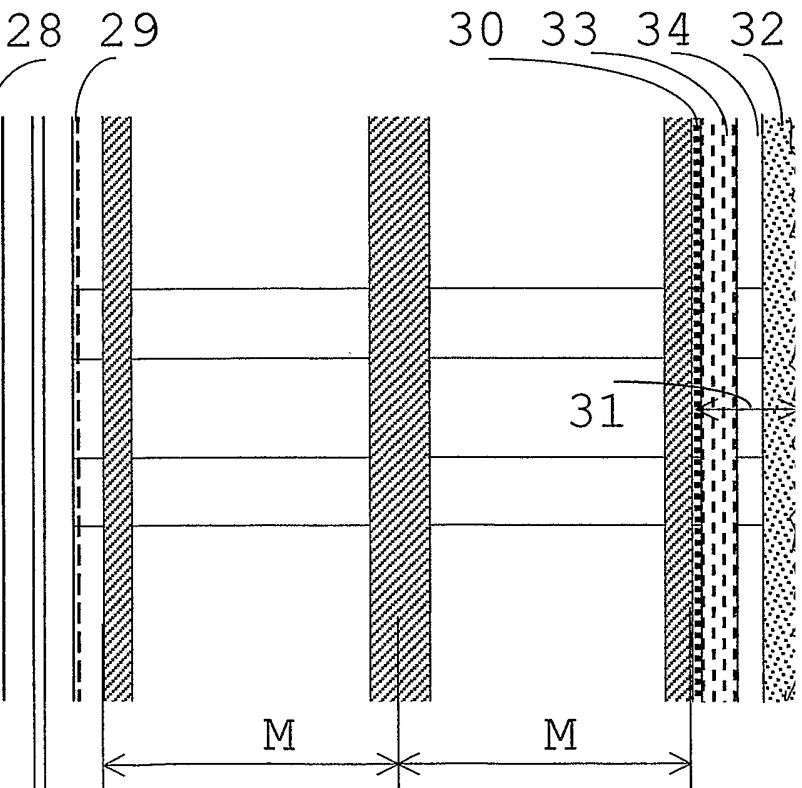


Fig. 13

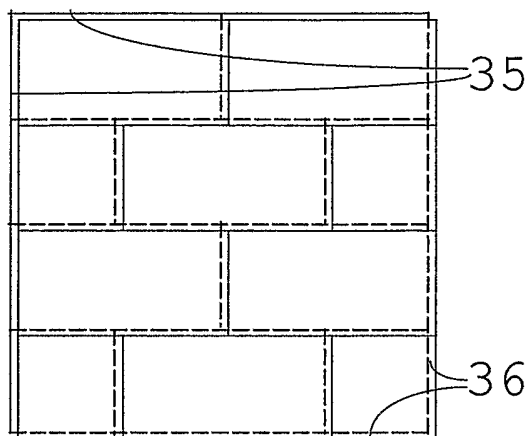


Fig. 14

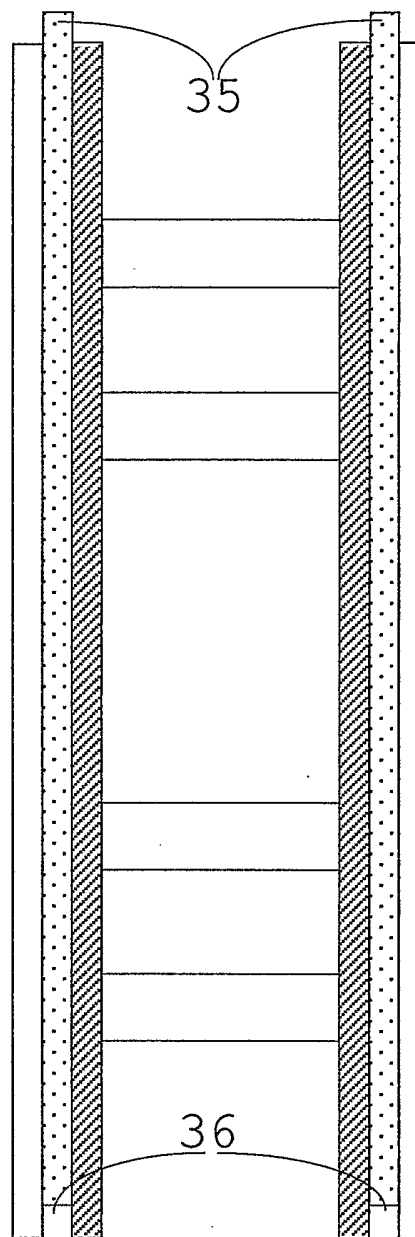


Fig. 15

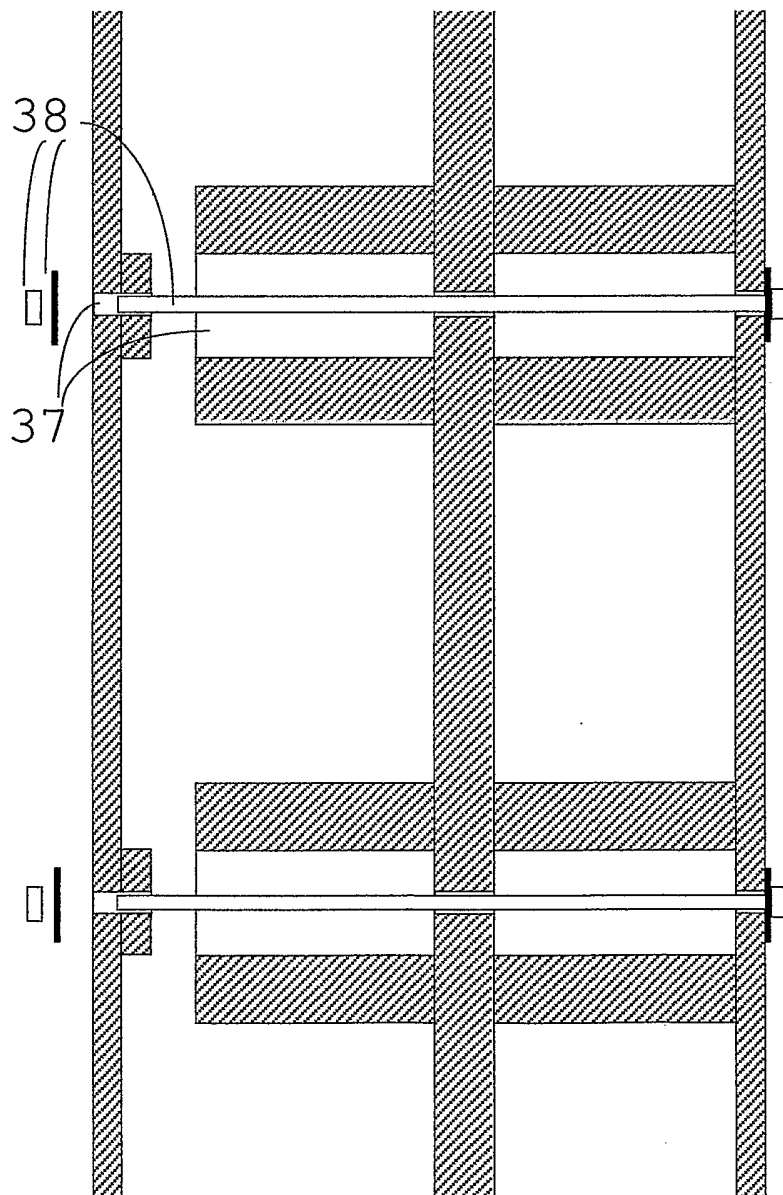


Fig. 16

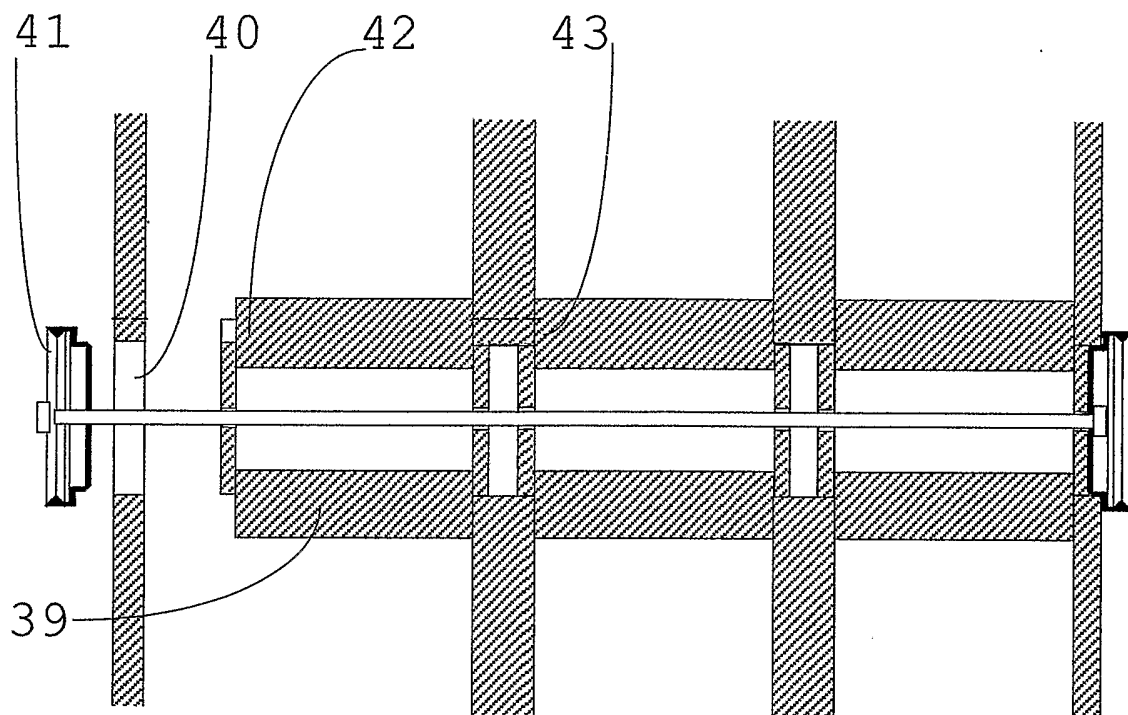


Fig. 17

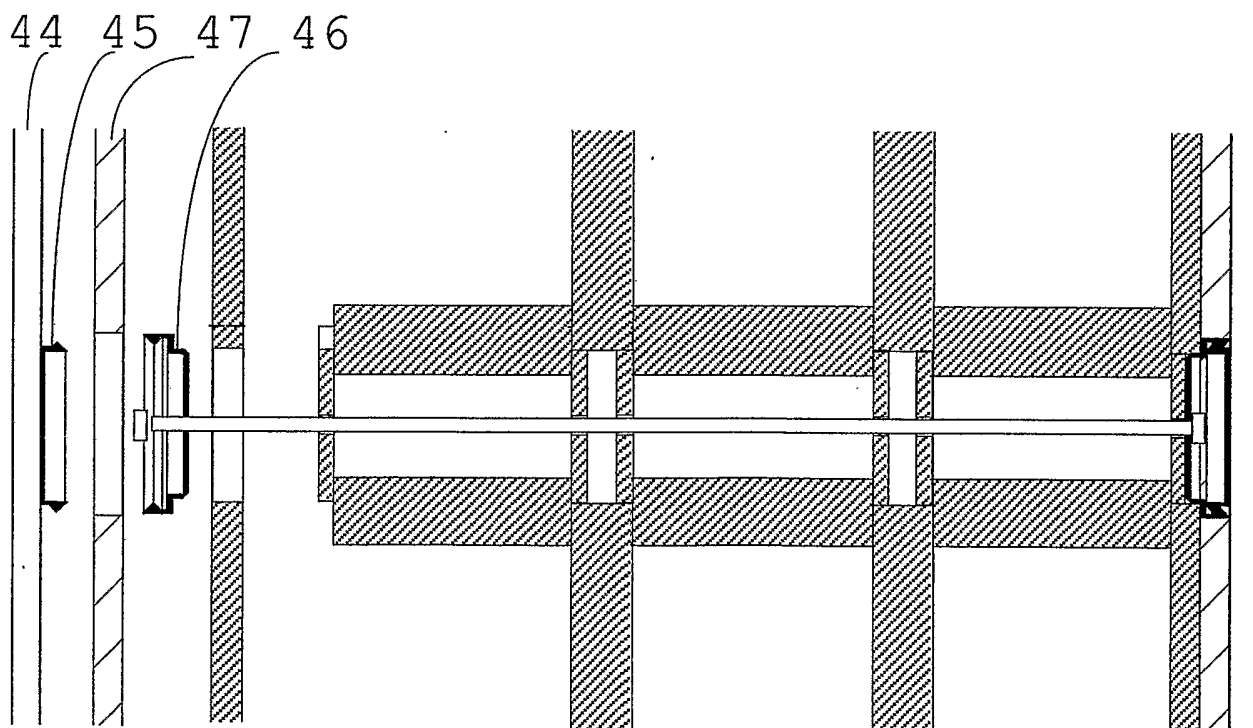
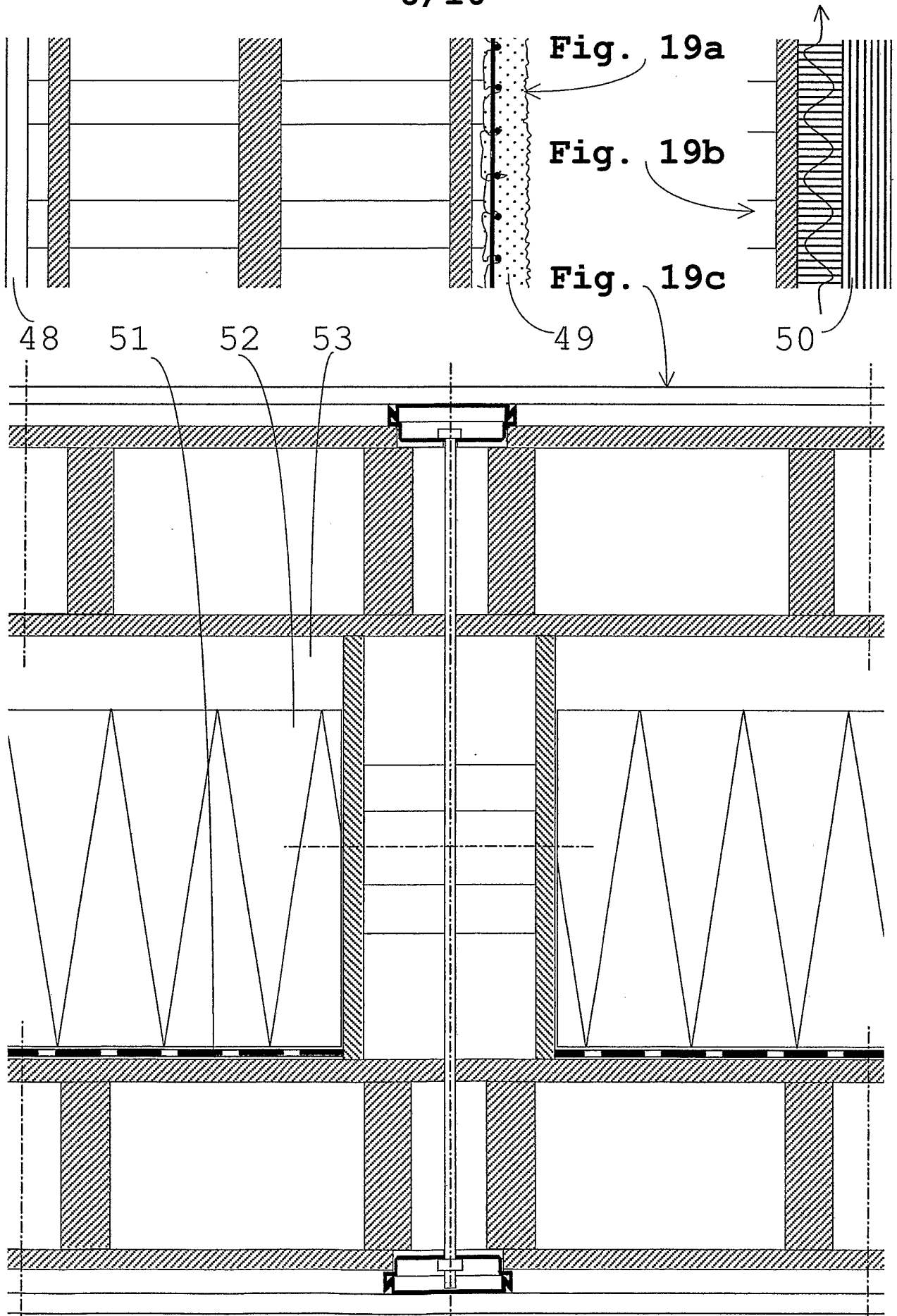
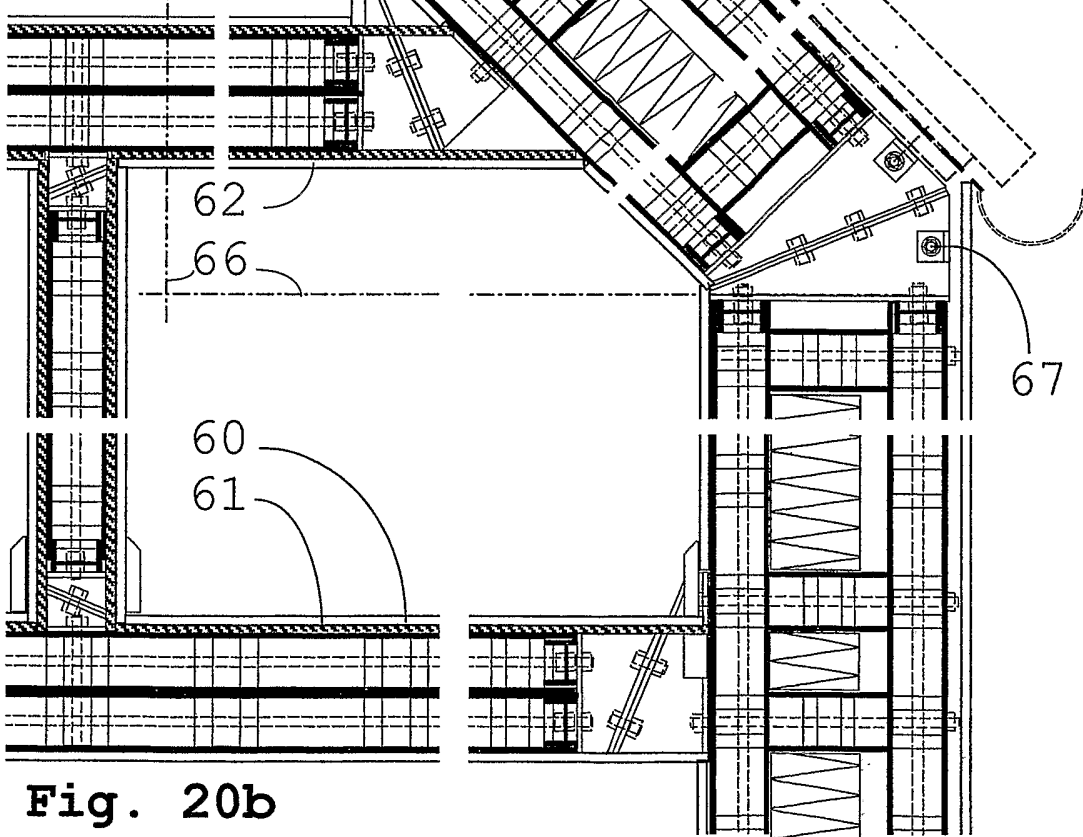
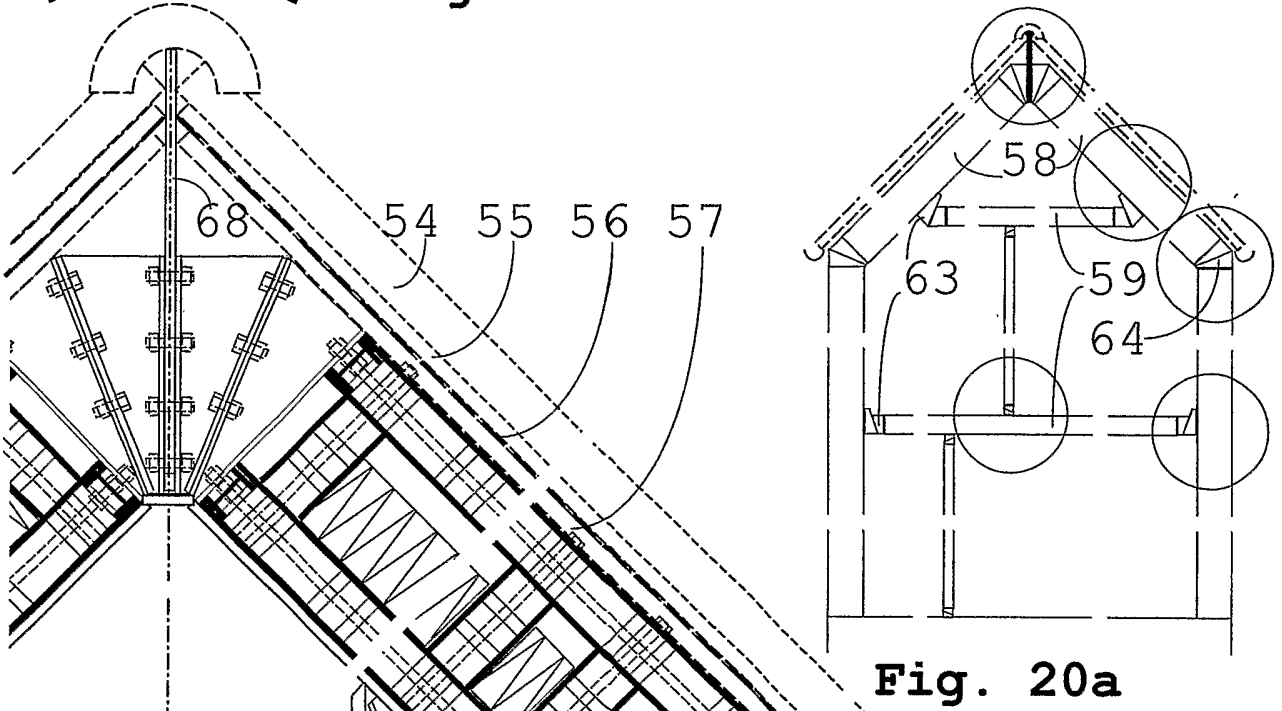
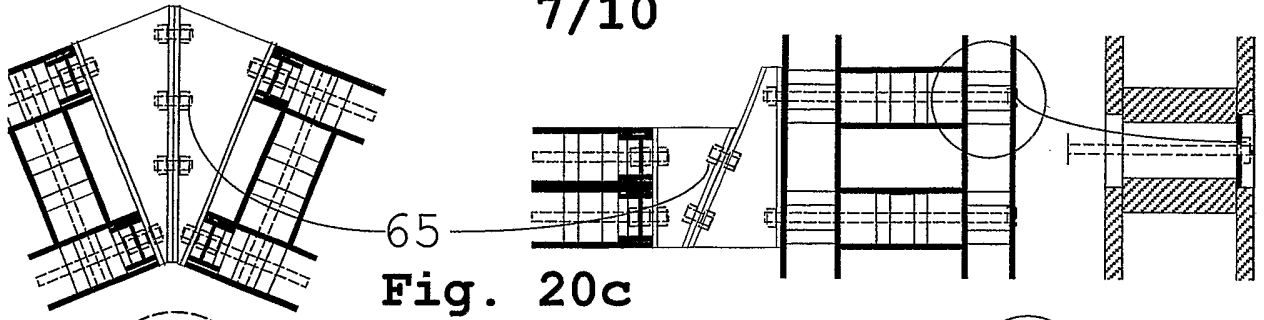


Fig. 18

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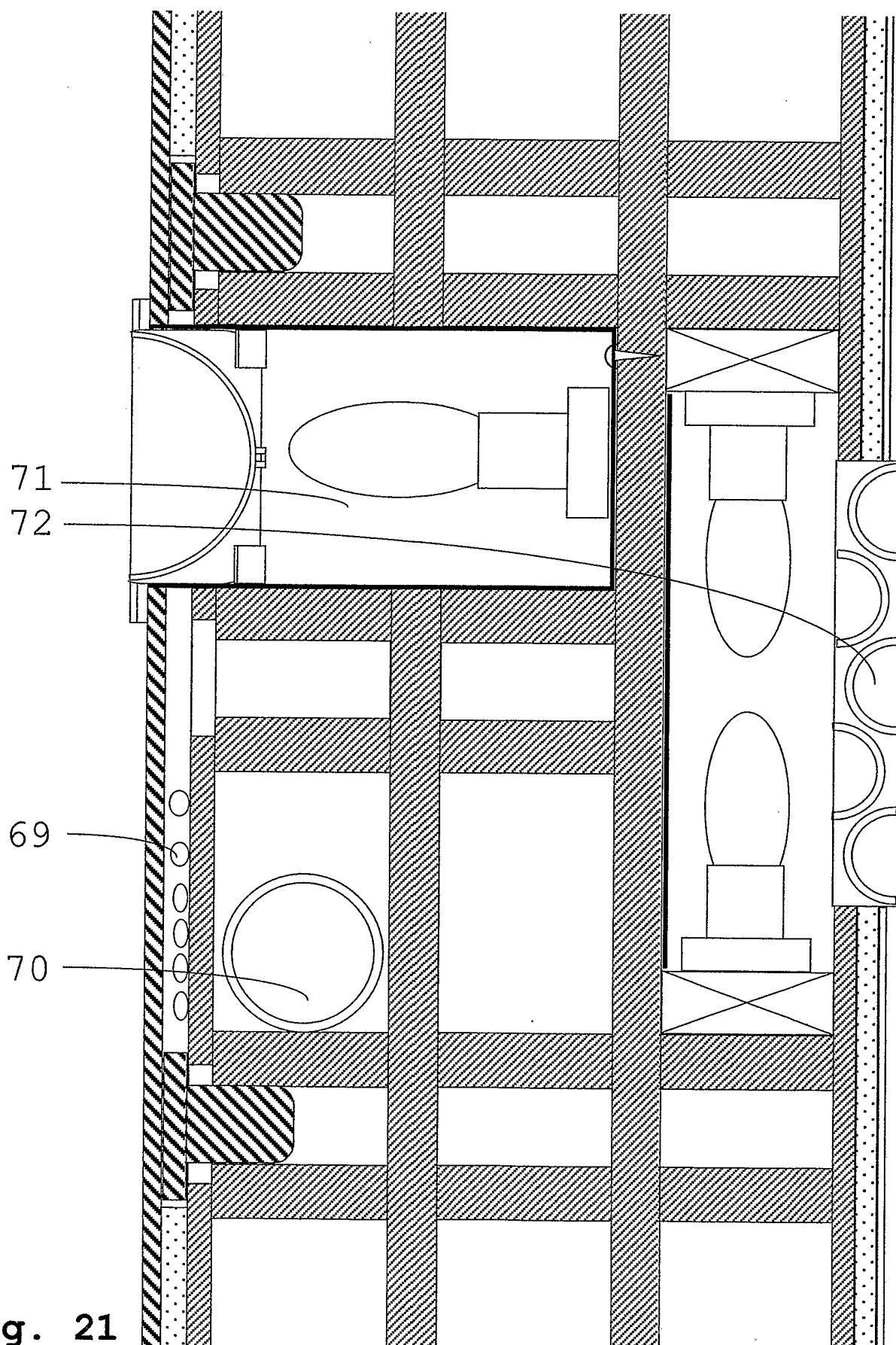


Fig. 21

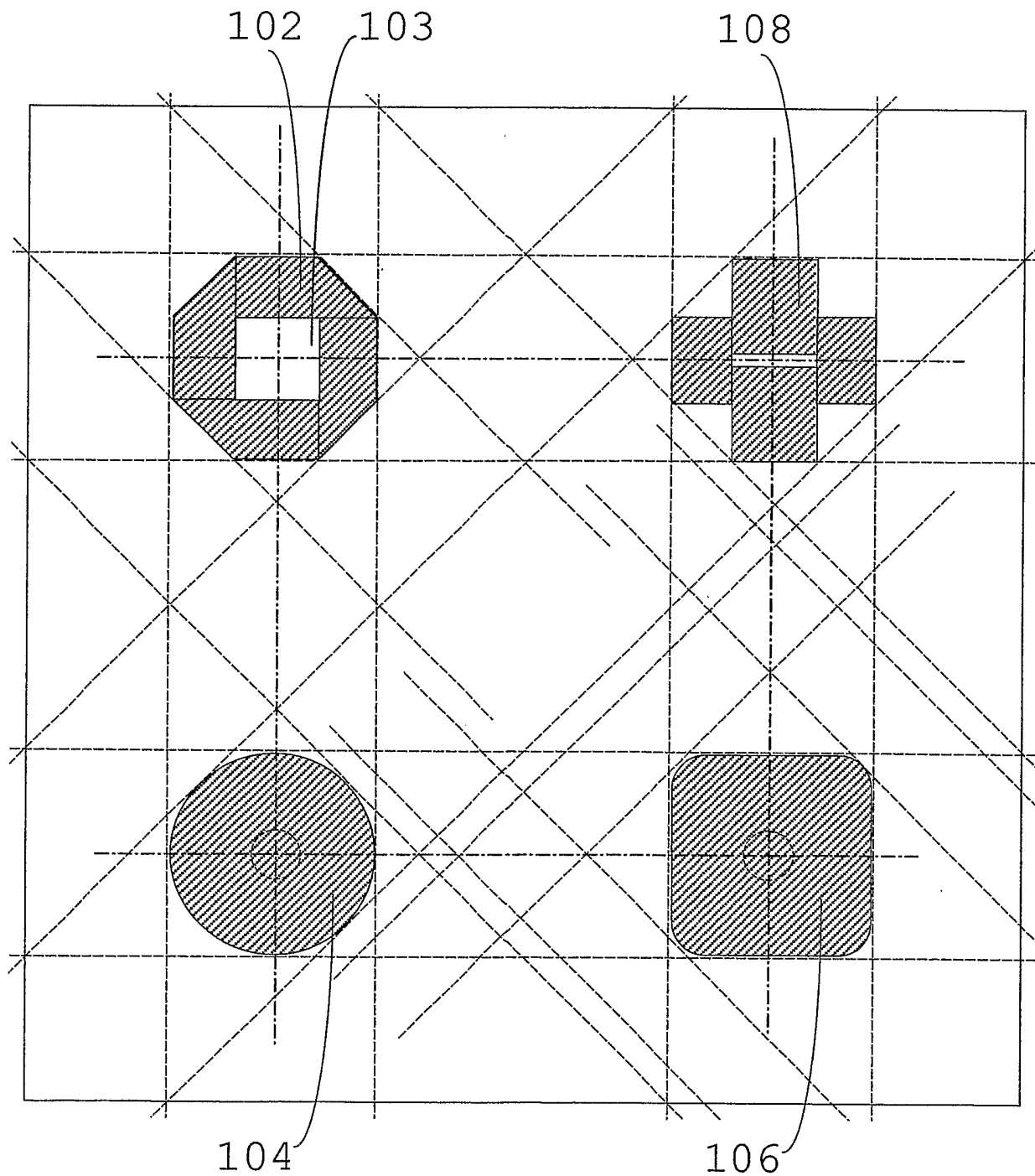


Fig. 22

