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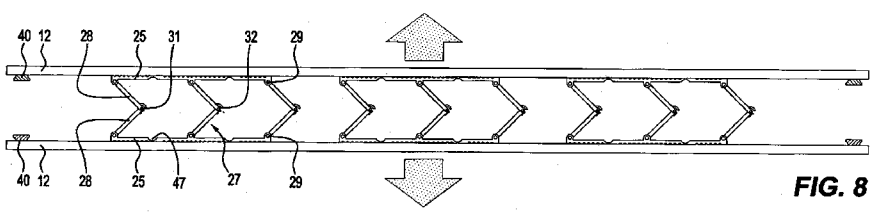

FIG. 8

(57) Abstract: A prefabricated formwork system comprising two parallel surfaces and a collapsible mechanism joining the two surfaces, wherein the collapsible mechanism moves between being collapsed and expanded to allow separation of the surfaces to expand the system from a collapsed position to an expanded position, wherein the system includes a lock to lock the system in the expanded position to maintain separation of the surfaces to form a formwork structure.

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PREFABRICATED FORMWORK SYSTEM

The present invention relates to a prefabricated formwork system for use in creating building constructions and engineering structures. The system in a particular form includes a panel. The invention also relates to an interlocking system for interlocking prefabricated formwork panels.

BACKGROUND OF THE INVENTION

Prefabricated formwork panels are fast replacing traditional methods of constructing concrete buildings. The on-site pouring of concrete using prefabricated formwork panels is preferred to prefabricated concrete tilt slabs, particularly in low-rise buildings, as prefabricated formwork panel systems provide greater versatility and accuracy in creating a wall as well as in accommodating building services within the panels. There is furthermore less expense in transporting prefabricated formwork panels than concrete slabs as they are lighter, not being filled with concrete until after erected on-site, and hence more panels can be transported in a single delivery compared with the transportation of concrete slabs.

Prefabricated formwork panels can be quickly erected and joined on-site, reinforced and then filled with liquid concrete to form permanent internal and external walls, including load bearing walls. These panels can be ready made with internal and external wall finishes, such as cement sheet or plasterboard, and can also be pre-fabricated with insulating layers.

In the quest for lowering construction costs and construction time, formwork systems are being developed to make the construction process more efficient and more economical while maintaining a high quality product.

SUMMARY OF THE INVENTION

According to the present invention there is provided a prefabricated formwork system comprising two parallel surfaces and a collapsible mechanism joining the two surfaces, wherein the collapsible mechanism moves between being collapsed and expanded to allow separation of the surfaces to expand the system from a collapsed position to an expanded position, wherein the system includes a lock to lock the system in the expanded position to maintain separation of the surfaces to form a formwork structure.

In one embodiment the formwork structure formed is a panel and in a preferred embodiment, the collapsible mechanism allows variable separation

between the panel surfaces and is specifically a hinged mechanism. In a preferred embodiment, the mechanism has opposing fixing plates, each for fixing to an inside of one of the surfaces, and a rotatable linkage hinged between the fixing plates to vary the separation of the surfaces and allow expansion and collapse of the formwork panel. The rotatable linkage is defined by at least two trusses linked together through a rotatable joint such as a hinge pin. The trusses at the rotatable joint include interlocking parts that forms one embodiment of the lock. The parts interlock to fix expansion of the collapsible mechanism once the surfaces have been set to a desired separated distance. In a specific embodiment the interlocking parts are resilient and clip together to provide the collapsible mechanism with a self-locking feature.

An embodiment of the invention includes a collapsible mechanism comprising opposing fixing plates and at least two rotatable linkages between the fixing plates, and preferably, three or more rotatable linkages that when expanded form side-by-side box trusses. The fixing plates can be glued to the surfaces, fastened using techniques such as screws, rivets, etc., or fixed to the surface using any conventional fastening technique. The number of collapsible mechanisms provided between the surfaces will be dependent on the structural strength and integrity required of the formwork panel.

The fixing plates in one embodiment may include a notch to receive a pin joint when the panel is collapsed such that the collapsed mechanism is clip locked into a collapsed state. From the collapsed state to full extension, the rotatable linkage extends through 0°- 180°.

In an embodiment of the invention the lock comprises at least one spacer, and preferably multiple spacers, to maintain separation of the surfaces. The spacers are insertable within the collapsible mechanism to maintain separation of the wall surfaces. Where the rotatable linkages form box trusses, the spacers are inserted within the box trusses. The spacers are preferably provided in a selection of spacer widths for maintaining different widths of panel expansions. For example, the wall panel can be fully expanded, half expanded or a quarter expanded, or anywhere inbetween, and appropriate spacers are provided for each extent of expansion.

The spacers are in one embodiment defined by two inter-clipping parts that snap fit together using a bead and groove clip lock arrangement to form a spacer.

Where expansion is maintained by the self-locking feature of the collapsible mechanism as described above, the interlocking parts of the rotatable linkage is able to maintain separation at variable expansion widths.

In one embodiment the surfaces are wall sheets, such as cement sheet, plasterboard, plastics board, metal sheet or screen. In another embodiment the surfaces may be a frame or a screen adapted to be attached to wall sheets. In further embodiments the surfaces may be structures other than walls, including indoor and outdoor slabs, beams, columns, multipurpose planks filled with concrete, stair structures and applicable to many other building construction and structural engineering possibilities.

The formwork panel created by the system may include an insulation layer and/or a fire rated layer adjacent to one or both sheets and an outer sheet covering the insulation/fire-rated layer.

In an expanded form the formwork panel is substantially hollow between the surfaces. To create a finished structure the panel may be in-filled using a suitable material. The in-fill material is typically one having flowable characteristics, including viscous and liquid forms, typically wet concrete. In another form the in-fill material may be insulation in the form of foam that can wet poured or inserted dry between the surfaces. In yet another embodiment a structural panel may be created without using any in-fill material but leaving the panel hollow.

To join together the wall formwork panels, one embodiment describes a female coupling stud provided along one side edge of the wall formwork structure that interlocks with a complementary male coupling stud provided along an edge of another structure. The male and female coupling studs have biased interlocking profiles that snap lock together when the male/female studs are coupled. The male and female studs are, in one embodiment, in extruded form made of metal or plastics. The male and female coupling studs are attached to their respective structures by clipping or sliding a channel in the stud profile onto a complementary profile guide provided along the inside of each structure wall surface.

In accordance with another embodiment of the present invention there is provided an inter-wall structure locking system comprising a male coupling stud having two fixing plates for fixing at side edges of two spaced wall surfaces of a first wall structure; and a female coupling stud having two fixing plates for fixing at side edges of two spaced wall surfaces of a second wall structure;

wherein the male and female coupling studs comprise biased interlocking profiles that clip together to join the first and second wall structures.

In accordance with yet another embodiment of the invention there is provided an interlocking system for interlocking prefabricated formwork structures having separated parallel surfaces, comprising retaining clips mounted on opposing inside edges of the structure surfaces of two structures to be joined, and a coupling stud for locating between the structures to be interlocked, the coupling stud having flanges that each engage a retaining clip to interlock the prefabricated formwork structures.

The retaining clips preferably have fixing faces for fixing the clips to the inside of each structure surface and a hooked lip extending outwardly from the fixing face and directed to open towards an edge of the structure for receiving the interlocking flange on the coupling stud. The clip is resilient so to expand slightly on insertion of the stud flange but to subject the stud flange to a retaining force to maintain engagement therewith.

The coupling stud is typically an elongate “H” or “I” profile stud having four flanges that each engage with clips positioned on opposing inner surfaces of each adjacent structure that the interlocking system joins. The stud can be in extruded form or can be in pieces shorter in length than the length of a structure side so that multiple coupling studs can be spaced along a side length of a structure.

In accordance with yet another embodiment of the invention there is provided a method of forming a structure using a prefabricated formwork system as described above, comprising:

expanding the prefabricated formwork system to a desired width between the parallel surfaces;

locking the expansion using a lock;

erecting the expanded and locked prefabricated formwork system by mounting the prefabricated formwork system in a base track; and

joining the prefabricated formwork system to other prefabricated formwork systems to form a larger structure.

In addition the above method may also include the steps of reinforcing the formwork system and pouring in-fill material between the surfaces. The method may include inserting vertical and horizontal reinforcement in the wall formwork structure before pouring concrete and/or running service cables through the wall formwork structure before pouring concrete.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, wherein:

Figure 1 is an isometric view of a prefabricated formwork system in a collapsed state, in accordance with an embodiment of the present invention;

Figure 2 is a partial side isometric view of the prefabricated formwork system of Figure 1;

Figure 3 is an isometric view of a prefabricated formwork system in an erected state with one wall sheet removed for clarity;

Figure 4 is an enlarged view of the prefabricated formwork system as illustrated in Figure 3;

Figure 5 is a side view of a prefabricated formwork system similar to that illustrated in Figure 3;

Figure 6 is a front sectional view taken at section A-A of Figure 5;

Figure 7 is an end view of a prefabricated formwork system in a collapsed state;

Figure 8 is a partial end view of a prefabricated formwork system being expanded;

Figure 9 is an end view of a prefabricated formwork system in an expanded state;

Figure 10(a) is a partial end view of a prefabricated formwork system expanded to half its maximum expansion width;

Figure 10(b) is a partial end view of a prefabricated formwork system expanded to only one quarter of its maximum expansion width;

Figure 11 is an end view of a prefabricated formwork system erected using spacers according to a first embodiment;

Figure 12 is an end view of a prefabricated formwork system erected using spacers of a second embodiment;

Figure 13 is a partial end view of a prefabricated formwork system partially expanded and erected using spacers of a third embodiment;

Figure 14 is a prefabricated formwork system of yet another expansion width and using spacers of a fourth embodiment;

Figures 15(a) and 15(b) illustrate separately opposing surfaces of a prefabricated formwork system provided with an interlocking system in accordance with an embodiment of the invention;

Figure 16(a) is an end view of a prefabricated formwork system in an expanded state showing the clips of the interlocking system illustrated in Figures 15(a) and 15(b);

Figure 16(b) is a plan view of two erected panels of the prefabricated formwork system joined together using the interlocking system illustrated in Figures 15(a) and (b); and

Figures 17(a), 17(b) and 17(c) illustrate another embodiment of a prefabricated formwork system and are respectively a plan view of a the system in a compressed state, a plan view of the system in an expanded state and an end view of the system in an expanded state.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Several embodiments of a prefabricated formwork system are illustrated in the drawings and described herein. The prefabricated formwork system creates a formwork panel suitable for a variety of uses in building construction and engineering structures including internal and external walls, structural walls and partitions, indoor and outdoor floor and ceiling slabs, beams, columns, multipurpose planks filled with concrete, stair structures, and any other type of formwork structure. For the purpose of describing a preferred embodiment of the invention, the example described herein refers to a prefabricated formwork panel for a wall. However, it is understood, as described above, that the prefabricated formwork system has a much wider application.

It is also understood that the term 'panel' used herein describes a basic two surface structure formed using the prefabricated formwork system. It is understood the system can form more complex structures that may not be necessarily described as a 'panel' but may incorporate panel characteristics. One such example is of a column 60 illustrated in Figures 17(a) to 17(c).

The embodiments illustrated show a wall formwork panel 10 having two parallel surfaces 12, and specifically wall surfaces, and a collapsible mechanism 20 joined between the two wall surfaces. The collapsible mechanism 20 allows separation and collapse of the wall surfaces relative to each other in order to expand and contract the wall formwork panel 10 between a collapsed position and an extended position, and in use from a collapsed position to an extended position whereby insulation and/or concrete can be filled between the wall surfaces.

To maintain wall surface separation, the system may either use a spacer insert, or may employ a locking mechanism on the collapsible

mechanism to lock the system in an expanded condition. In the illustrations shown, a spacer 50 is insertable between the wall surfaces when expanded to maintain separation of the wall surfaces.

Figures 1 and 2 illustrate a formwork panel 10 in a collapsed position. The collapsible mechanism 20 located between the wall surfaces 12 is in its most collapsed state in these Figures, which in this condition allows the formwork panel to be suitably stored and transported while occupying only a minimum amount of space. This is unlike known formwork systems or prefabricated panels where the width of the prefabricated panel or formwork is the same as the final, installed width. In that example of known systems, a truck load of panels being transported to site may include a maximum of 20 to 30 panels. By comparison, a truck load of formwork panels of the present system in a collapsed state may include 200 to 300 formwork panels 10, where the panels are only expanded once on site.

As the formwork panel 10 can form a load bearing wall or a non-load bearing wall, the wall surfaces will differ depending on wall requirements and whether the walls are to be exterior or interior walls. In the most common instances the wall surfaces 12 will be wall sheets such as cement sheet, plasterboard, metal sheet or plastics board, composite material, laminated sheet or the like. The wall surfaces may also be a screen-type surface having large or small apertures where the screen may itself be attached to yet another exterior surface or may form the outer surface which then can be rendered or finished off appropriately. The wall formwork panel can be suitably used for interior of exterior walls.

The collapsible mechanism 20 fixed between the insides 13 of the wall surfaces 12 allow the wall surfaces 12 to collapse to a minimum separation distance defined by the width of a fully collapsed mechanism, and to expand to a maximum width separation defined by the width of the mechanism 20 in its extended state. The separation of the wall surfaces 12 can be variable in that separation will vary at any point in the expansion process from the minimum separation distance to the maximum distance. In one embodiment spacers may be provided to limit separation to less than the maximum separation, as discussed below.

Figure 2 illustrates the collapsible mechanism 20 in its collapsed state. Figures 3 and 4 illustrate a wall formwork panel 10 in an expanded state but with one wall surface removed in order to improve clarity in the drawing. The collapsible mechanism may take the form of a single, large collapsible

mechanism positioned centrally between the two wall sheets, or as illustrated in the attached embodiments the collapsible mechanism may comprise a number of smaller collapsible mechanism units 20 arranged in arrays and positioned, generally symmetrically, to ensure minimum deflection of the wall surfaces during expansion of the panel. In Figures 3 and 4 the mechanisms 20 are grouped in an upper band 21 middle band 22 and lower band 23 wherein each band has approximately nine collapsible mechanisms 20.

Each collapsible mechanism 20 has a fixing plate 25 which is adapted to be secured to the inside 13 of one of the wall surfaces 12. Any known fastening technique can be used to fasten fixing plate 25 to the inside of the wall surface including adhesive or screwing/rivetting using mechanical fasteners. In the embodiment illustrated in Figures 3 and 4 the fixing plates 25 are serrated to make them suitable to being glued to the inside 13 of the wall surface.

A rotatable linkage 27 is pinned between fixing plates 25 and it is that rotatable linkage 27 that can be rotated and folded onto itself to collapse the formwork panel 10 or allowed it to be expanded. The rotatable linkage is defined by two trusses 28 that are each pinned by a short pin 29 to one opposing fixing plate 25 on opposite sides of a separation gap 30. Trusses 28 are in turn hinged at their other ends to each other through a long pin 31, which forms a rotatable joint. The trusses at the long pin 31 joint include interlocking parts in the form of stops 32 which creates a self-locking mechanism on the collapsible mechanism to limit hinge rotation only within a range of rotational movement, and specifically between 0°- 180°, and to fix the collapsible mechanism 20 in an expanded condition.

In its simplest form the collapsible mechanism has the above described features, namely two fixing plates, one for fixing to the inside of each wall surface, and a rotatable linkage pinned therebetween where the rotatable linkage has a central pin to allow trusses of the rotatable linkage to be folded on themselves. To promote stability more than one rotatable linkage 27 is pinned between fixing plates 25, and such an arrangement can be seen in Figures 7, 8 and 9 which shows two wall surfaces 12 having three sets of collapsible mechanisms 20 spanning therebetween wherein each collapsible mechanism has opposing fixing plates 25 and three rotatable linkages pinned therebetween to form two side-by-side box trusses 33.

Figure 7, which illustrates a wall formwork panel 10 in its collapsed position, shows trusses 28 folded onto each other. Figure 8 illustrates the

expansion of the rotatable linkage 27 from a collapsed position towards an erected position that is illustrated in Figure 9 where maximum separation 30 of the wall surfaces is achieved. From the collapsed state to full extension, the rotatable linkage extends through 0°- 180°.

The collapsible mechanism 20 along the fixing plates 25 includes notches 47 adapted to receive the pin joints of rotatable linkages 27 at long pin 31 and so provide a more compact and flush collapsed panel structure, as best illustrated in Figure 7. The inter-engagement of the notches 47 and rotatable linkage 27 at the lower pin 31 can be made to display some resilience and provide a clip locking effect when the panel is fully collapsed. This can be useful during storage and transportation to prevent unintentional wall panel separation and ensure the panels stay folded/collapsed. Also as illustrated in Figure 7, opposing profile guides 40 for receiving coupling studs 36, 38, are brought together to lie flush against each other in a collapsed condition.

To achieve maximum compaction of the collapsible mechanism 20 and panel stability, the collapsible mechanism may include multiple levels of rotatable linkages 27 that are arranged in a staggered relationship in a vertical direction. For example, referring to the systems shown in Figure 4 and Figure 5, the panel is illustrated having three units of box truss-style collapsible mechanisms along a width of the panel, but also provided with two or three levels of fixing plates 25 and rotatable linkages 27 in a vertical direction to form a larger complex collapsible mechanism.

Accordingly, the complex collapsible mechanism 20 as illustrated in Figures 4 and 5 includes five spaced fixing plates 25 that are spaced in a vertical direction, where three of the vertically spaced fixing plates are arranged one above the other and adapted to be fixed to one wall surface (the “left hand fixing plates” 25a), and the two opposing vertically spaced fixing plates 25 are arranged one above the other and adapted to be fixed to an opposing wall surface (the “right hand fixing plates” 25b). The right hand fixing plates 25b are staggered from the left hand fixing plates 25b so that they are arranged directly horizontally opposite the space between any two of the left hand fixing plates 25a.

This means that the trusses 28 extending from the fixing plates are also arranged in a staggered formation in the collapsible mechanism 20 and as illustrated in Figure 5. Long pins 31 are used to join the bottom corner of one truss to the upper corner of another truss and the five trusses of the illustrated

embodiment are joined in this manner so as to pivot along an X-axis as illustrated in Figure 5.

Any number of combinations of fixing plates 25 and rotatable linkages 27 may be used to form a collapsible mechanism, complex or simple, to achieve a stable formwork panel structure.

Figure 6 taken along section A-A of Figure 5 illustrates the left hand wall surface 12 as illustrated in Figure 5 and this sectional drawing only shows the parts of the collapsible mechanisms 20 that are fixed to the left hand wall surface, namely right hand fixing plates 25b and associated rotatable linkages. Referring to Figures 5 and Figures 6 it can be seen that the upper band 21, middle band 22 and the lower band 23 each includes collapsible mechanisms 20 in an array of three groups across, where each collapsible mechanism is fixed to the wall surface 12 in Figure 6 by three fixing plates 25 (middle band), or two fixing plates 25 (lower and upper bands).

The trusses 28 include apertures 34, which in Figures 4 and 5 are shown as pairs of apertures for each truss 28. These apertures are to increase the lightweight nature of the collapsible mechanisms and may also provide guides for horizontal reinforcement rods inserted prior to concrete pouring, although reinforcement rods may also be guided inbetween sets of collapsible mechanisms.

Figure 3 illustrates how the formwork panel 10 is erected on site. Panel 10 is mounted on a base track 15 that is fixed to a surface by mechanical fasteners, such as bolts, adhesive or any other known means. Base track 15 is a U-shaped channel on which formwork panel 10 is mounted. The inner wall surfaces 12 of panel 10 include retaining clips 16 fixed thereto into which flanges of the base track 15 are clipped and engage to erect the formwork panel.

Similar to the base track 15, there may also be provided an overhead track (not shown) that will maintain correct alignment of the wall panel and form framework of the overarching structure.

Figures 15(a), 15(c),16(a) and 16(b) illustrate one embodiment of an interlocking system for joining together prefabricated formwork panels as well as joining base tracks and overhead rails to the panels. The interlocking system comprises retaining clips 16 mounted on opposing edges of the inner surface 13 of two panels 12 to be joined, and a coupling stud 18 for locating between the panels to be interlocked with the retaining clips 16. The coupling stud 18

has flanges 19 that each engage a retaining clip to interlock the prefabricated formwork panels together.

Coupling stud 18 is illustrated in Figure 16(b) in plan view and forms a "H" or "I" profile where each extremity of the "H" or "I" is an interlocking flange 19. Coupling stud 18 is an elongate member that can be an extrusion the length of the side of a panel, or can be made of shorter pieces so that several studs 18 are spaced along the length of a panel edge. In the embodiment shown, the coupling stud 18 is a "H" profile that has been roller formed into a shape having four interlocking flanges to be received into respective four clips 16.

The gauge of the coupling stud 18 material may vary according to the application and namely the strength and integrity of the structure to be constructed. In some cases the coupling stud 18 may comprise regular I-beams commonly used on construction sites.

Retaining clips 16 are fixed along the inner edge of the panel surface that is to be joined. Figures 15(a) and 15(b) each illustrate opposing wall surfaces 12a and 12b of a typical formwork panel 10. Retaining clips 16 are positioned around the entire rectangular periphery of the wall surfaces so that the panel 10 can be interlocked with panels/other structures to the sides of panel 10 and to tracks/panels/other structures below and above panel 10. Other structures can include corner panels, solid structures such as brickwork, or any other structure to which a panel may need to be attached in building construction or structural engineering applications.

The retaining clips 16 on wall surfaces 12a and 12b alternate with respect to the opposing positions of the wall surfaces so that when coupled through a collapsible mechanism 20, the retaining clips on one inner surface do not overlap with the retaining clips on the other surface. This is so that in the collapsed panel condition, the panel will collapse to a minimum possible thickness that is only as thick as the greater of the folded collapsible mechanism or the clip 16 thickness.

As illustrated in Figure 16(a), each retaining clip 16 has a hooked lip 48 extending outwardly from a fixing face 49 where the hooked lip 48 is directed to open towards an edge of the panel for receiving an interlocking flange 19 on the coupling stud 18. The clip is resilient so to expand slightly on insertion of the stud flange but to subject the stud flange to a retaining force to prevent detachment of the interconnection. The clips 16 are fixed to the inner face of the wall surface by known means including rivets, screws, adhesive or any other suitable means.

Another embodiment of an inter-panel locking system is illustrated in Figure 3, which shows coupling studs 36, 38 provided along each side edge 17 of the panel 10. One coupling stud is a female coupling stud 36 while the other is a male coupling stud 38 and together the coupling studs allows one wall formwork panel 10 to be joined to another panel 10 by interlocking the male and female coupling studs together.

The female and male studs 36, 38 have complementary interlocking profiles that are also biased to cause a snap lock when the male and female studs are coupled, similar to a simple buckle engagement. The male and female coupling studs in the embodiment illustrated are extruded from metal or plastics and are attached to their respective panel sides by clipping or sliding a channel 39 provided on the female and male coupling studs onto a complementary profile guide 40 provided along the inside 13 of each panel wall surface 12. Profile guides 40 may be adhered or mechanically fastened to the inside 13 of the wall surface 12.

Figures 11, 12 13 and 14 illustrates in plan view the interlocking profile nature of the coupling studs 36, 38 and the attachment of each coupling stud to the wall surface 12.

The profile of the female coupling stud 36 is substantially U-shaped having hooked ends 37. The hooked ends 37 include a ramped surface 41 that assists in guiding the male coupling stud into an interlocked relationship. The hooked ends 37 terminate in an inwardly facing free end that once interlocked with the male coupling stud catches on a corresponding flange 43 on the male stud and prevents detachment of the coupling studs.

The male coupling stud 38 has a leading face 42 flanked by ramped surfaces 44 that correspond to the ramped surfaces 41 of the female coupling stud to encourage inter-engagement. Flange 43 adjacent to the ramped surfaces 44 provides a neck 45 of male coupling stud 38 in which the hook ends 37 of the female coupling stud 36 can come to a rest.

The relationship between the female and the male coupling studs is biased to ensure secure interlocking therebetween. In particular, the separation of the hooked end 37 of the female coupling stud are biased to slightly displace during the connection process with the male coupling stud. The ramped surfaces 41 of the female coupling stud 36 slide along the corresponding ramped surfaces 44 and the male coupling stud 38 until the hooked ends 37 clear the diverging ramped surfaces 44 to resiliently contract towards each other at neck 45.

The far right diagram in each of Figures 11, 12, 13 and 14 illustrate a female coupling stud 36 and a male coupling stud 38 in an interlocked relationship. The formwork panels 10 as illustrated in Figures 11, 12, 13 and 14 illustrate a panel with female and male coupling studs at opposing side edges 17.

The coupling studs "buckle" together to also act as spacers to keep the wall surfaces separated before and during in-filling of concrete.

Figures 7, 8 and 9 illustrate the expansion process in erecting a wall formwork panel 10. The panel 10 is stored and transported in the contracted position as illustrated in Figure 7. Once on site, the wall surfaces 12 of the panel 10 are pulled apart until the collapsible mechanisms 20 are fully extended, which defines the maximum separation of wall surfaces 12 and hence the maximum thickness of the wall formwork panel. In order to maintain separation of the wall surfaces and prevent the wall surfaces from caving inwardly during the concrete pouring process, spacers 50 are inserted between the wall surfaces 12.

Spacers 50 can be made in a variety of forms where the primary function of the spacer is to prevent collapse of the wall surfaces. The spacers may constitute the coupling studs 18, 36 and 38, or additional inserts in between the surfaces.

Two examples of spacers 50 used to maintain maximum separation of wall surfaces 12 are illustrated in Figures 11 and 12. Figure 11 illustrates a so-called H spacer 52 whereas Figure 12 illustrates a so-called X spacer 54. Both the H and X spacers 52, 54 are inserted in the box trusses 33 formed by the collapsible mechanisms. As illustrated towards the far right of Figures 11 and 12, the H and X spacers are of a two-part form each having two spacer parts 52a, 52b and 54a and 54b, which clip together to form the H spacer or the X spacer. By providing the spacers 52 and 54 as two separate components that can be clipped together, the spacer parts can be provided in a more compact form thereby reducing storage and transportation space.

The H and X spacers each have four arms 55 extending from a central hole 56 where the arms 55 act as cross braces across the box trusses to maintain the separation gap 60 of the formwork panel 10. The hole 56 in the spacers can receive reinforcement rods or service parts. The spacers parts 52a and 52b and 54a and 54b, clip together through bead and groove interconnections as illustrated in Figures 11 and 12.

Figures 8, 10a and 10b illustrate different expansion widths capable with the wall formwork panel 10. The different expansion widths allow the formwork panels 10 of varying thickness to be constructed with the use of corresponding spacers. For example, Figure 9 illustrates full expansion of the formwork panel, then Figure 10a illustrates half expansion of the panel whereas Figure 10b illustrates approximately a quarter expansion of the panel.

These degrees of expansion may be desired in certain applications where thinner walls may be desirable, such as with internal dividing walls that need not be load bearing. With appropriate spacers the separation distance illustrated in Figures 10a and Figures 10b may be maintained.

Figures 13 and 14 illustrate similar variable expansion where Figure 14 shows a contraction to the full expansion of Figure 9, and Figure 13 shows an even still greater contraction. Spacers 50 illustrated towards the right of Figures 13 and 14 are specifically designed to maintain the separation of collapsible mechanisms 20 at the part-extensions illustrated in Figures 13 and 14. Spacers 50, are also in two-part form and are clipped together with four arms 55 that expand alongside linkage trusses 28 to brace the trusses to prevent the wall surfaces 12 from collapsing. Spacers 50 in Figures 13 and 14 are somewhat arrow shaped to follow the profile of the linkage trusses which also prevents the wall surfaces 12 from separating because the head 57 of the arrow shaped spacers 50 acts a stop to prevent full extension of the rotatable linkages 27.

The prefabricated formwork system can be used in a variety of configurations to form a variety of structural shapes. The basic building block starts with a panel having two parallel surfaces joined by a collapsible mechanism. From this starting point more complex structures can be created.

One such example is illustrated in Figures 17(a), 17(b) and 17(c), which shows a column 60 made from the prefabricated formwork system. The column is made by layering four of the above 'building block' panels one adjacent the other to form a substantially square cross-sectioned structure. Figure 17(a) illustrates a collapsed column, while Figure 17(b) illustrates an expanded column prepared for in-filling. Figure 17(c) illustrates in end view of the column 60.

As illustrated the column includes four layers of collapsible mechanisms 20 located between five parallel surfaces 12. The open sides of column 60 are capped by side sheets 62. The entire column is then mounted on an

appropriate base then reinforced and in-filled, typically with concrete, to form a strong structure capable of bearing loads.

Once the erected prefabricated structure is fully erected at its desired expansion, depending on desired wall thickness, and mounted to base track 15 with appropriate spacers inserted, if any, cabling and reinforcement can then be inserted between the wall surfaces 12.

The type of reinforcement that can be inserted includes horizontal reinforcement that may be inserted through the apertures 34 of trusses 28 or between the bands 21, 22, 23 of collapsible mechanisms in the panel. Vertical reinforcement can also be inserted between the collapsible mechanisms and/or through the collapsible mechanisms and through the holes 56 in spacers 50. The collapsible mechanisms provide some longitudinal and horizontal stiffness, depending on formation, but reinforcement bars are useful for added stability and stiffness

Once all of the reinforcement has been inserted and services run between the wall surfaces 12, the wall formwork panel can be prepared to take its final form as a wall. This may be by pouring concrete between the wall surfaces to fill the space between the wall surfaces and to surround the collapsible mechanisms 20 and any reinforcements and services within the concrete. Alternatively, insulation material may be filled between the wall surfaces to form an interior wall having no load bearing characteristics.

Insulation and/or fire retardant sheets may also be provided on the exterior of the formwork panel 10. For example, the wall surfaces may be made of a composite board adjacent to which is placed a layer of insulating board which is in turn overlaid by an exterior sheet that will form one of the outer sides of the final wall. The outer surface may be painted, rendered, or finished as desired.

The present wall formwork panel provides a marked advantage in transportation and storage costs of formwork panels. Not only are the panels able to be compacted down to a minimum thickness to allow for a greater number of panels to be transported but there is no dead load on each panel that as there is with existing prefabricated panels and formwork structures. Because the panels are lighter fewer labourers are required to erect the panel and there is no need for lifting cranes and associated elaborate safety procedures. The process of erecting the panels is fast, does not require skilled labour and results in a wall panel having the required structural integrity as stipulated by building codes.

It will be understood to persons skilled in the art of the invention that many modifications may be made without departing from the spirit and scope of the invention.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS:

1. A prefabricated formwork system comprising two parallel surfaces and a collapsible mechanism joining the two surfaces, wherein the collapsible mechanism moves between being collapsed and expanded to allow separation of the surfaces to expand the system from a collapsed position to an expanded position, wherein the system includes a lock to lock the system in the expanded position to maintain separation of the surfaces to form a formwork structure.

2. The prefabricated formwork system as claimed in claim 1, wherein the collapsible mechanism is partially expandable to allow variable separation between the panel surfaces, and the lock locks the variable separation of the panel surfaces.

3. The prefabricated formwork system as claimed in claim 1 or 2, wherein the lock comprises interlocking parts on the collapsible mechanism that allow the system to lock in an expanded position.

4. The prefabricated formwork system as claimed in any one of the preceding claims, wherein the collapsible mechanism has opposing fixing plates, each for fixing to an inside of one of the surfaces, and at least one rotatable linkage hinged between the fixing plates.

5. The prefabricated formwork system as claimed in claim 4, wherein the rotatable linkage has at least two trusses linked together through a rotatable joint.

6. The prefabricated formwork system as claimed in any one of the preceding claims, wherein the lock comprises one or more spacers insertable between the surfaces to lock the system in an expanded position.

7. The prefabricated formwork system as claimed in claim 6, wherein the spacers comprise a selection of spacer widths for maintaining different widths of panel expansions.

8. The prefabricated formwork system as claimed in claim 6 or 7, wherein the spacers are sized to insert within the collapsible mechanism.

9. The prefabricated formwork system as claimed in claim 6, 7 or 8, wherein the spacers include two inter-clipping parts that snap fit together to form a spacer.

10. An interlocking system for interlocking prefabricated formwork structures having separated parallel surfaces, comprising retaining clips mounted on opposing inside edges of the structure surfaces of two structures to be joined, and a coupling stud for locating between the structures to be interlocked, the coupling stud having flanges that each engage a retaining clip to interlock the prefabricated formwork structures.

11. The interlocking system claimed in claim 10, wherein the retaining clip is resilient and has a hooked lip extending outwardly from the structure surface and directed to open towards an edge of the structure for receiving the interlocking flange on the coupling stud.

12. The interlocking system claimed in claim 10 or 11, wherein the coupling stud is an elongate “H” or “I” profile stud having four flanges that each engage clips positioned on opposing inner surfaces of each adjacent structure.

13. An inter-panel locking system comprising a male coupling stud having two fixing plates for fixing at side edges of two spaced surfaces of a first structure; and a female coupling stud having two fixing plates for fixing at side edges of two spaced surfaces of a second structure; wherein the male and female coupling studs comprise biased interlocking profiles that clip together to join the first and second structures.

14. A method of forming a structure using a prefabricated formwork system as claimed in any one of claims 1 to 9, comprising:

expanding the prefabricated formwork system to a desired width between the parallel surfaces;

locking the expansion using a lock;

erecting the expanded and locked prefabricated formwork system by mounting the prefabricated formwork system in a base track; and

joining the prefabricated formwork system to other prefabricated formwork systems to form a larger structure.

15. The method claimed in claim 14, including:
reinforcing the formwork system then pouring in-fill material between the surfaces.

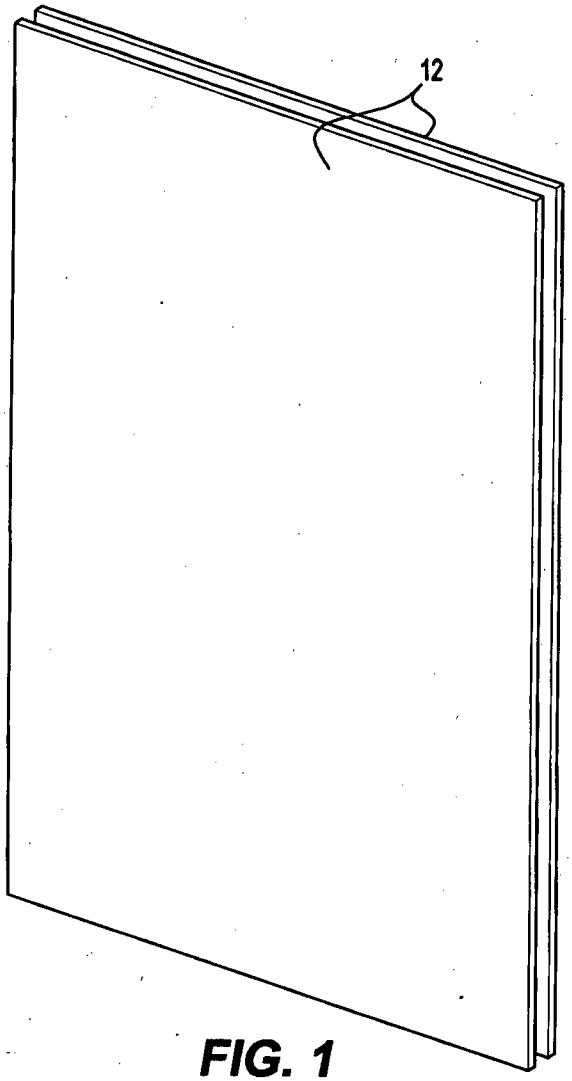

FIG. 1

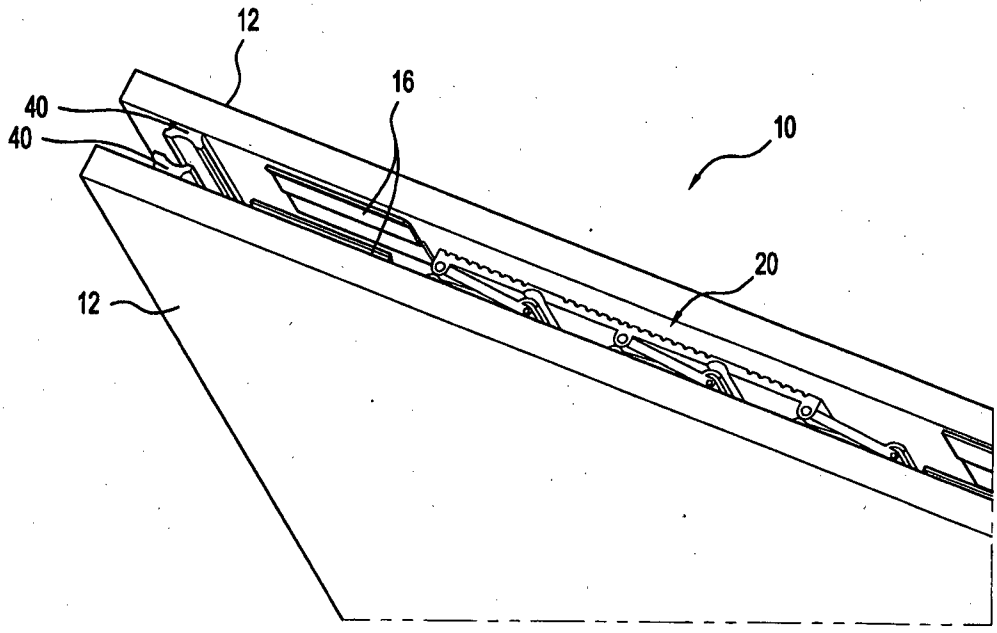

FIG. 2

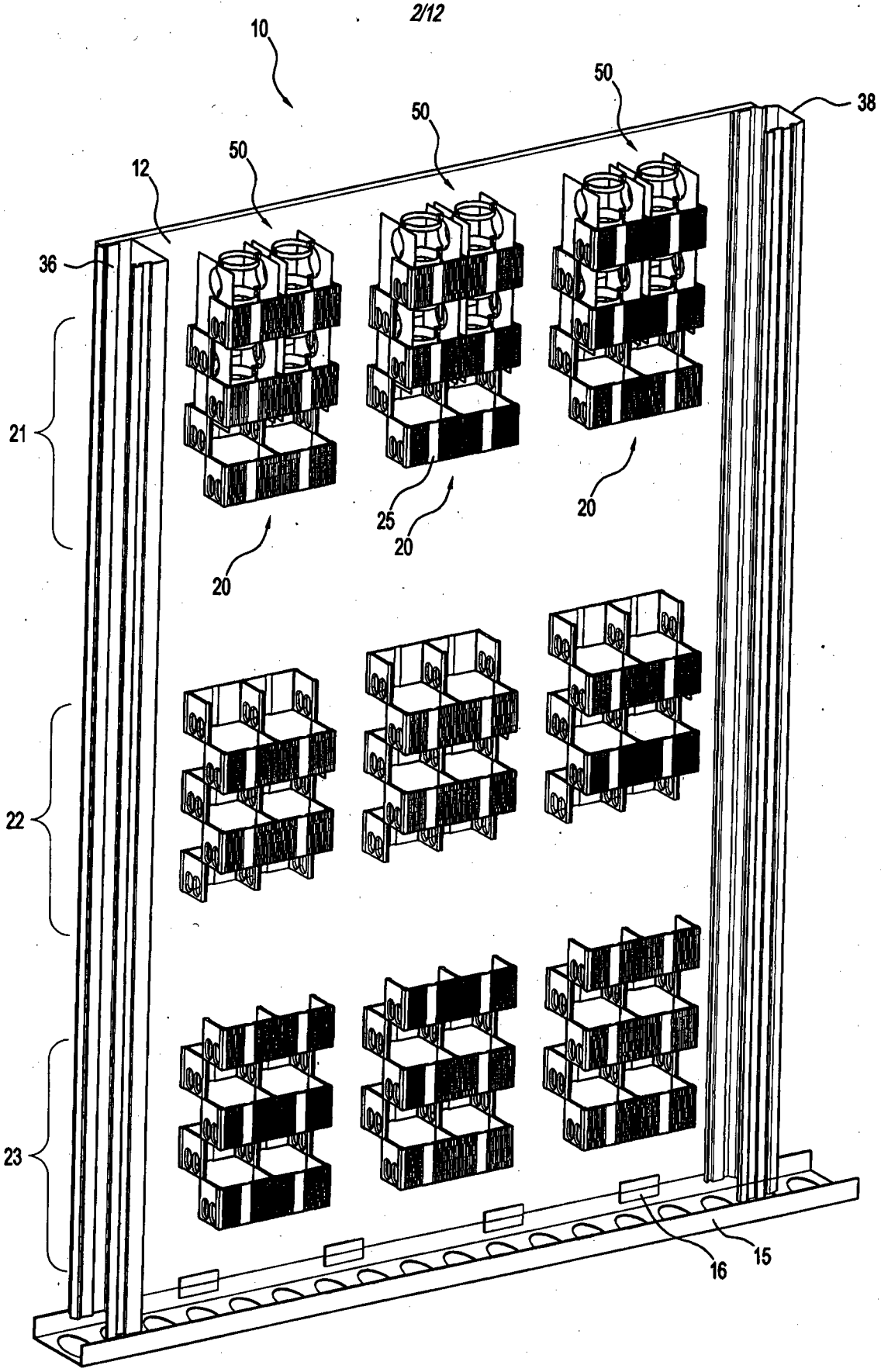

FIG. 3

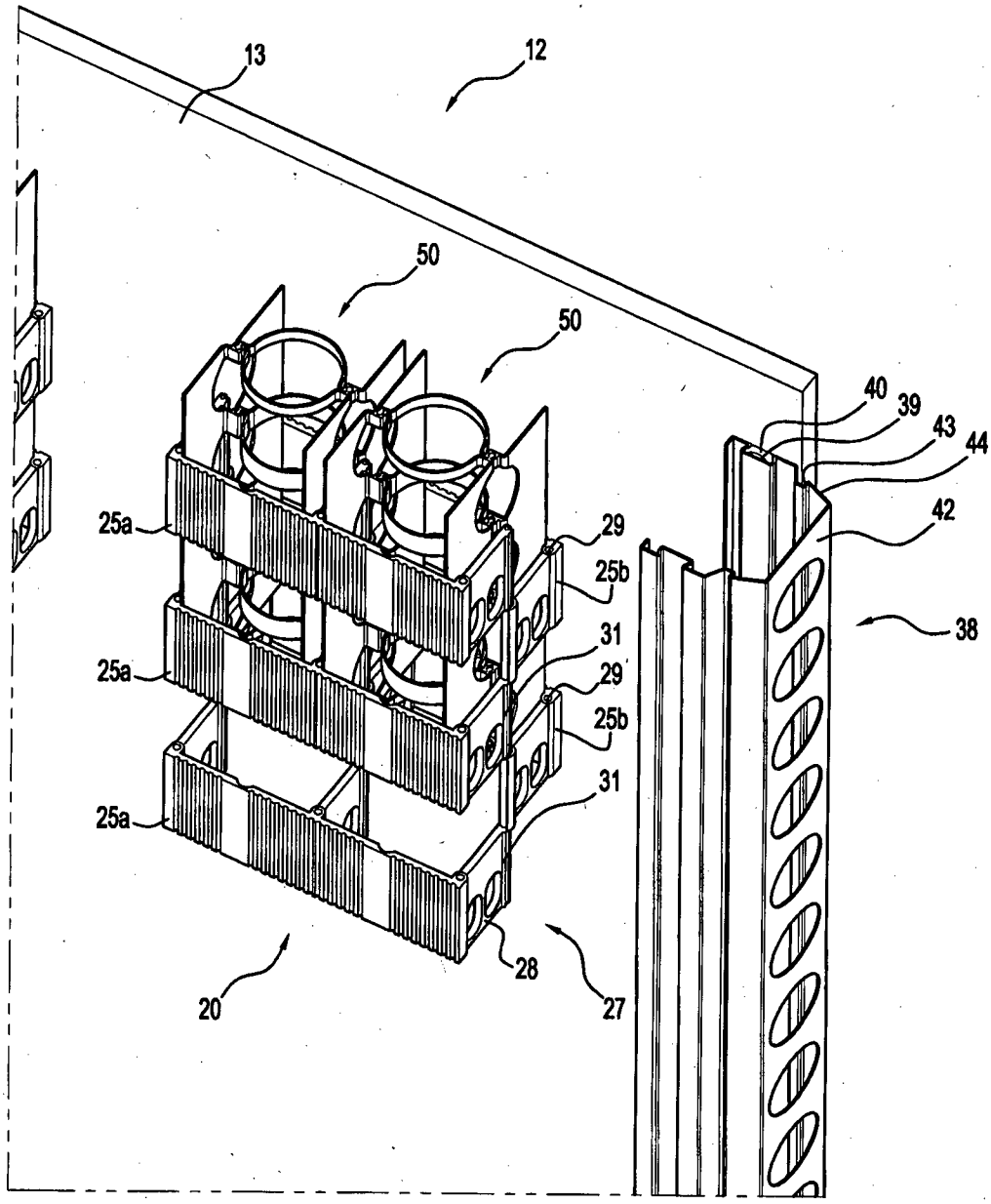

FIG. 4

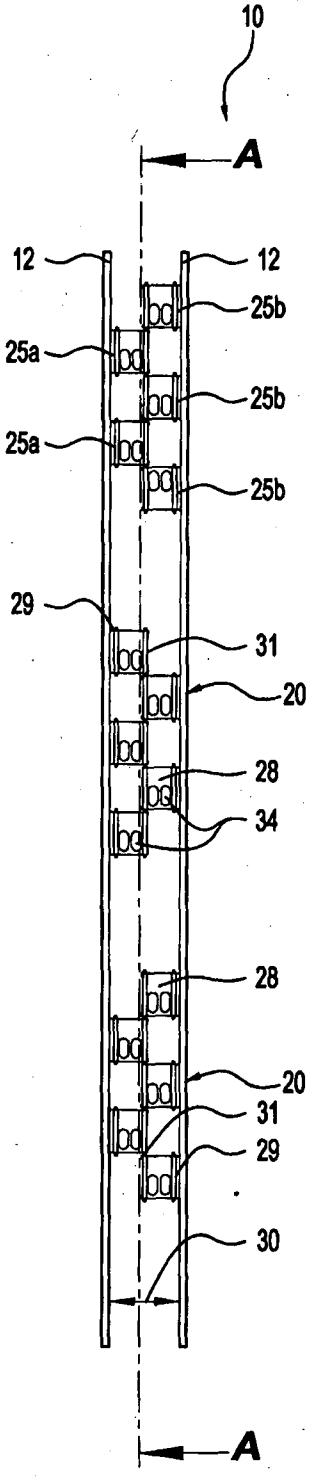
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FIG. 5

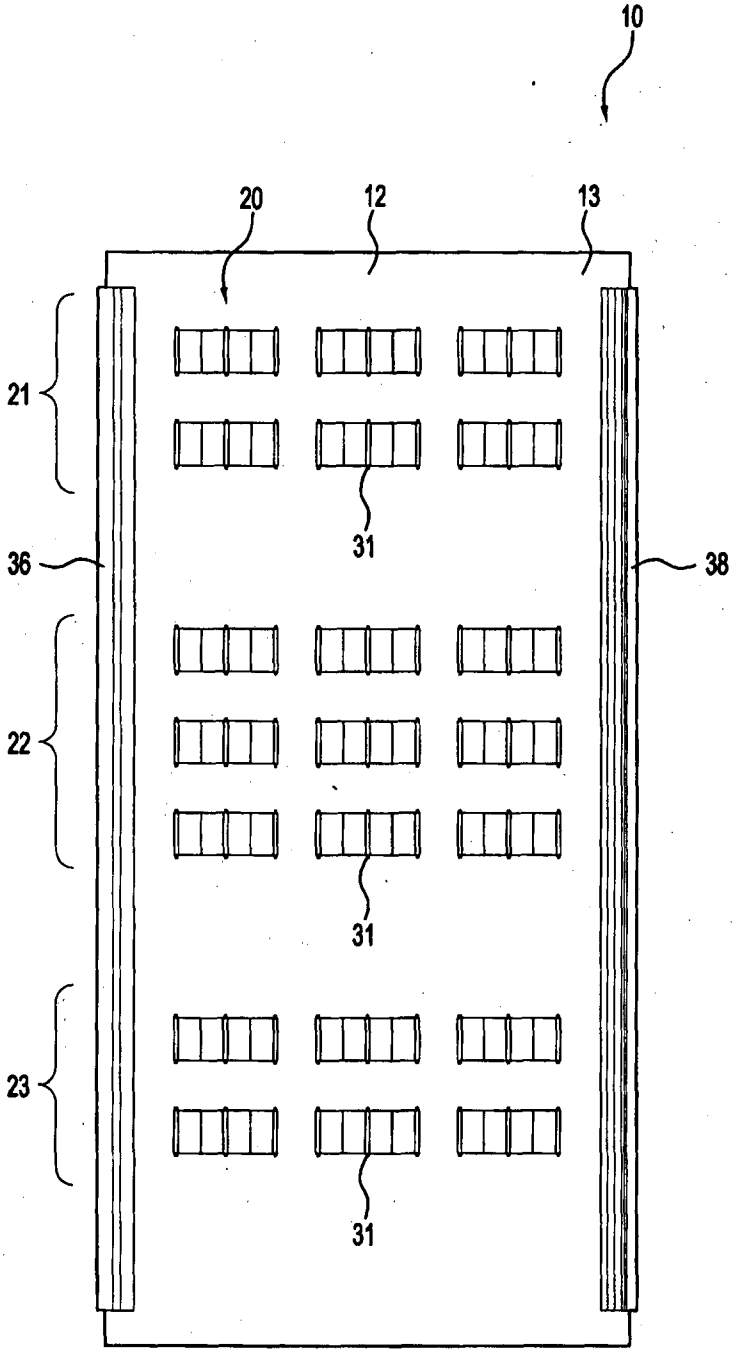
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FIG. 6

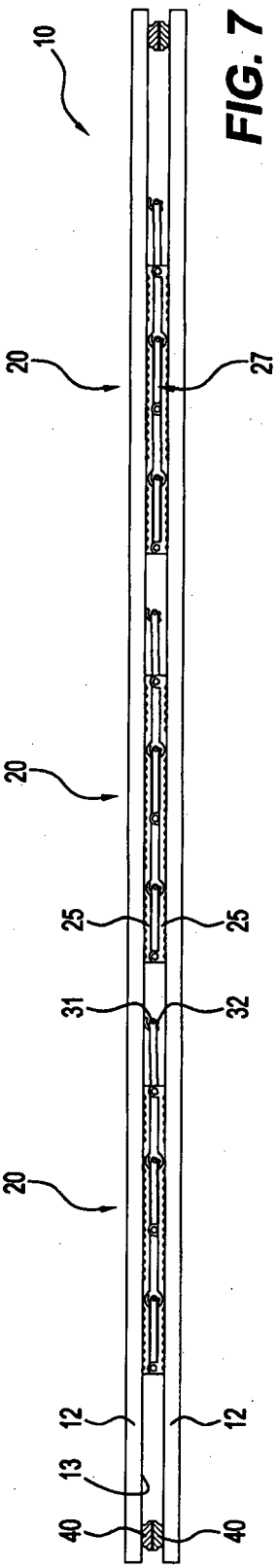

FIG. 7

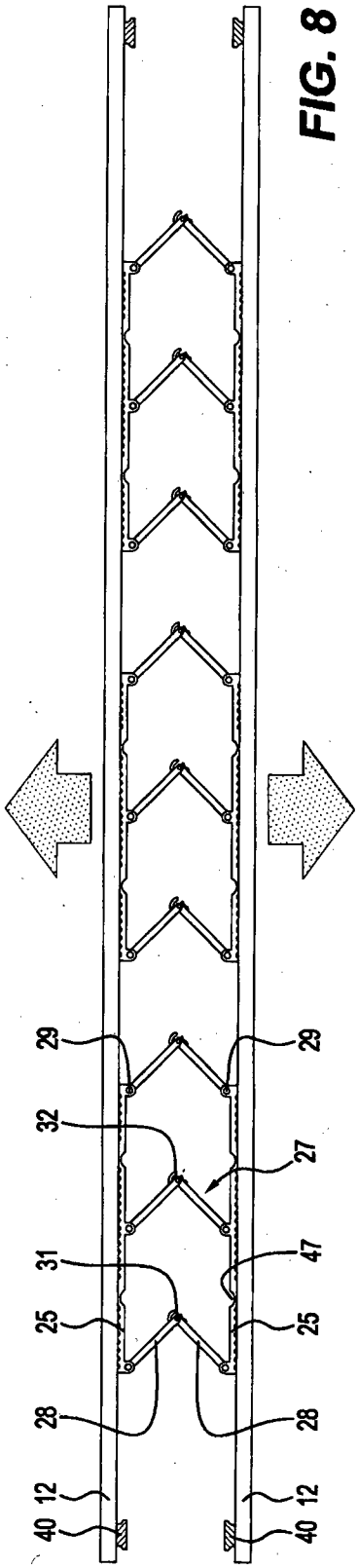

FIG. 8

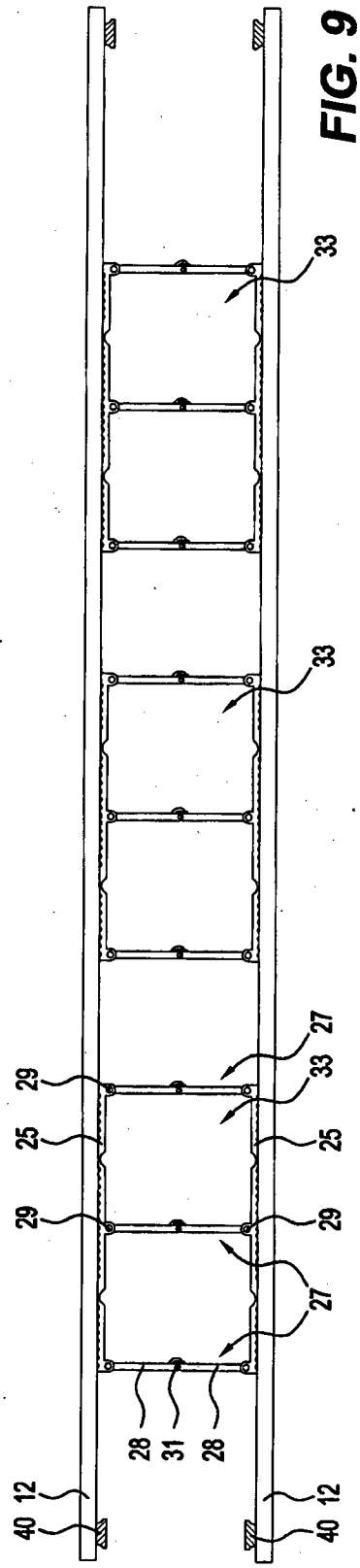

FIG. 9

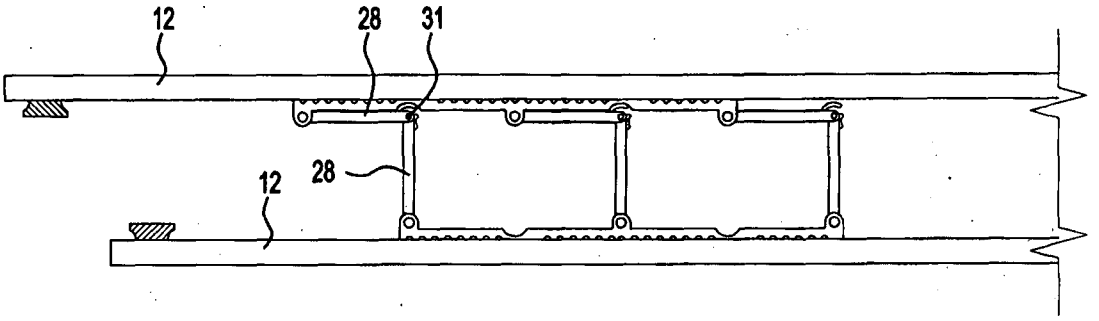

FIG. 10 (a)

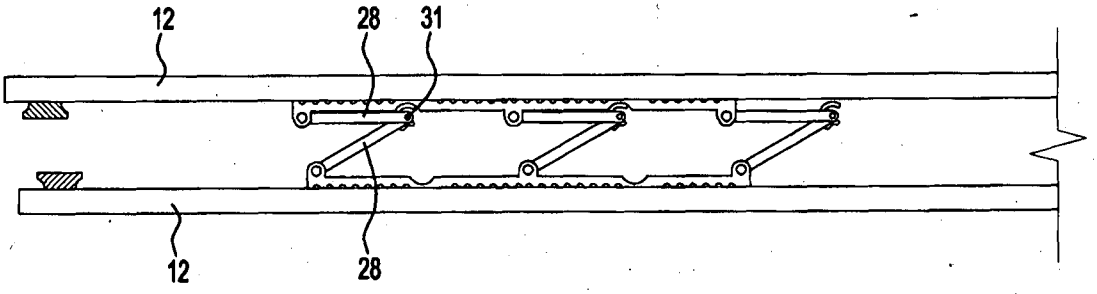

FIG. 10 (b)

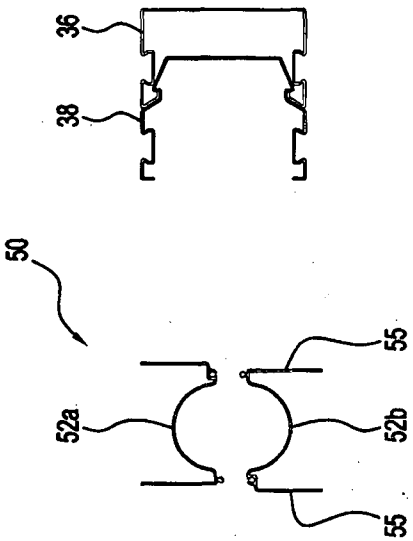
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FIG. 11

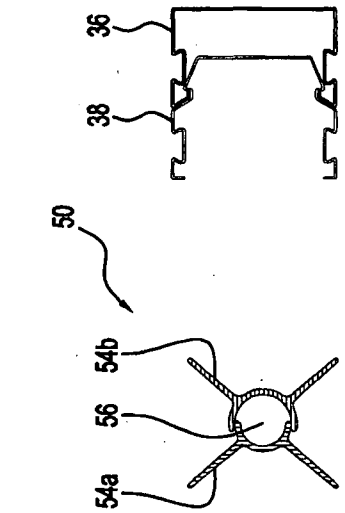
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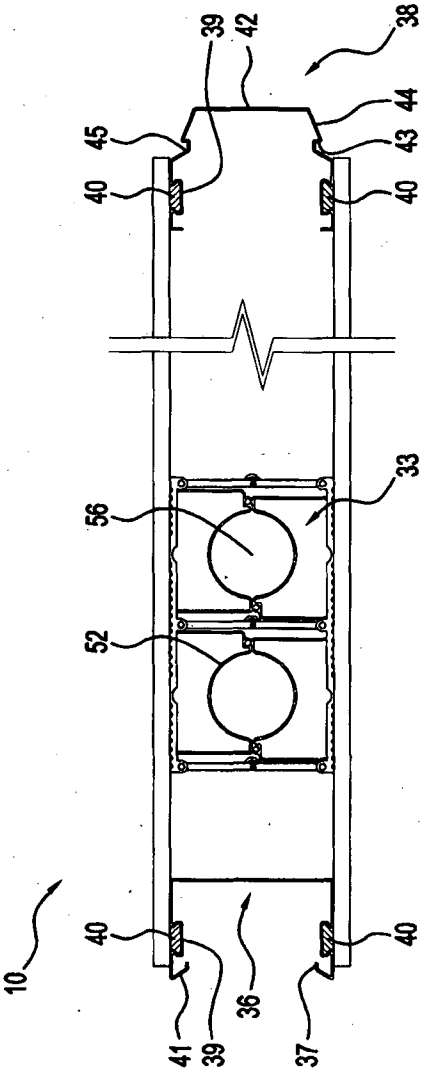
FIG. 12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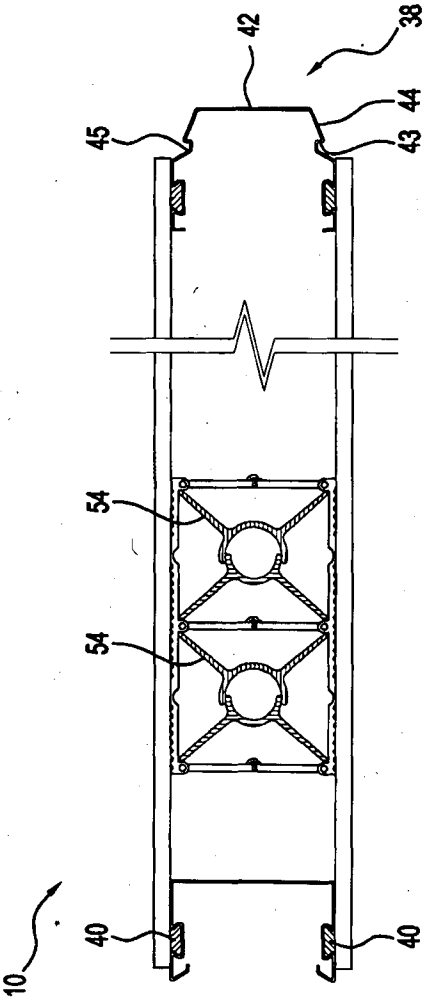
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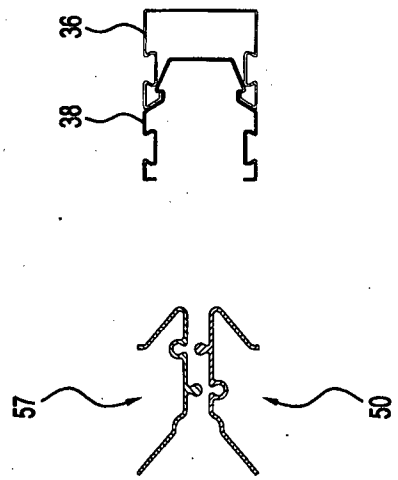


FIG. 13

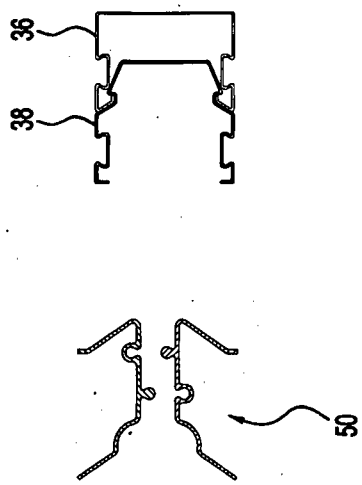
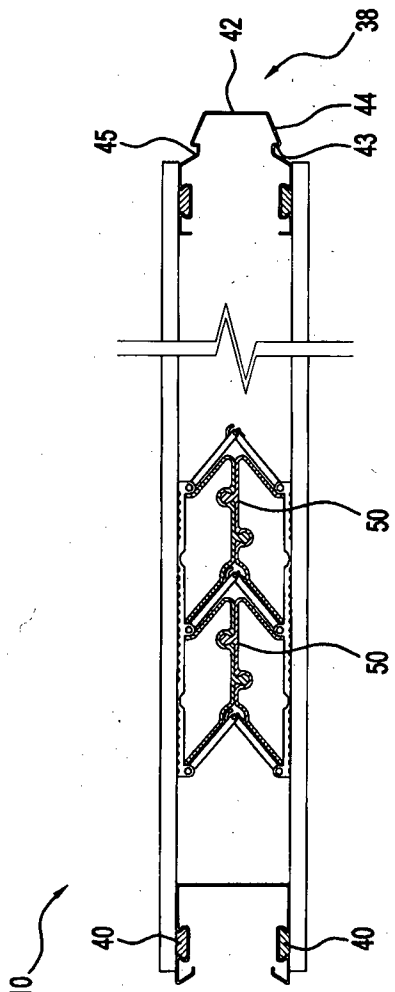
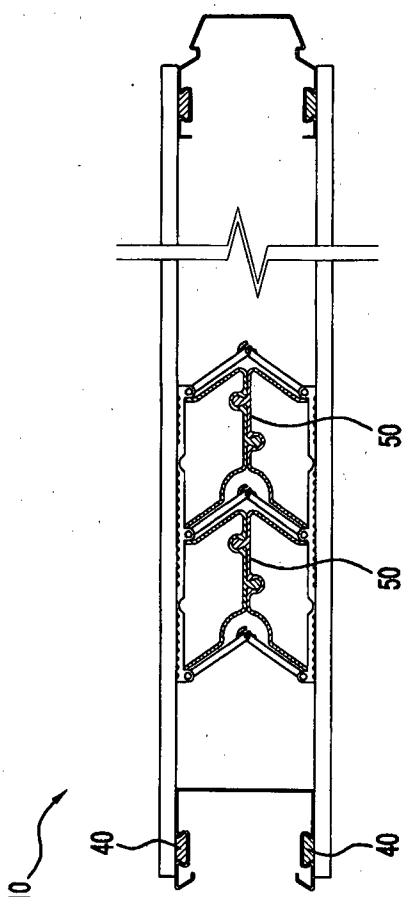


FIG. 14





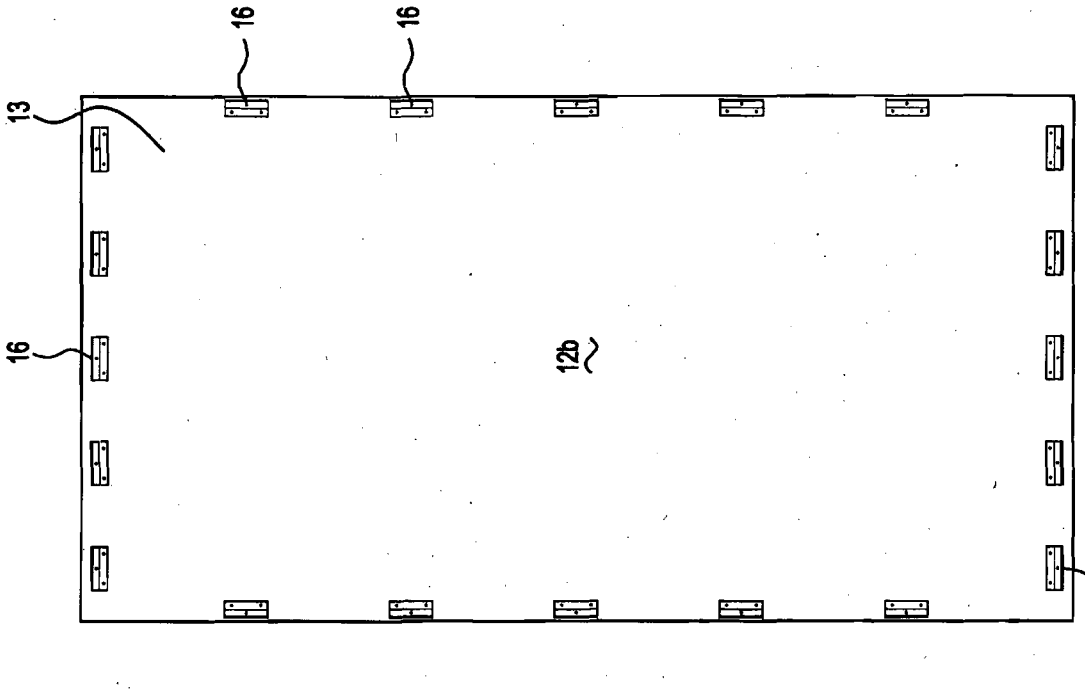


FIG. 15 (b)

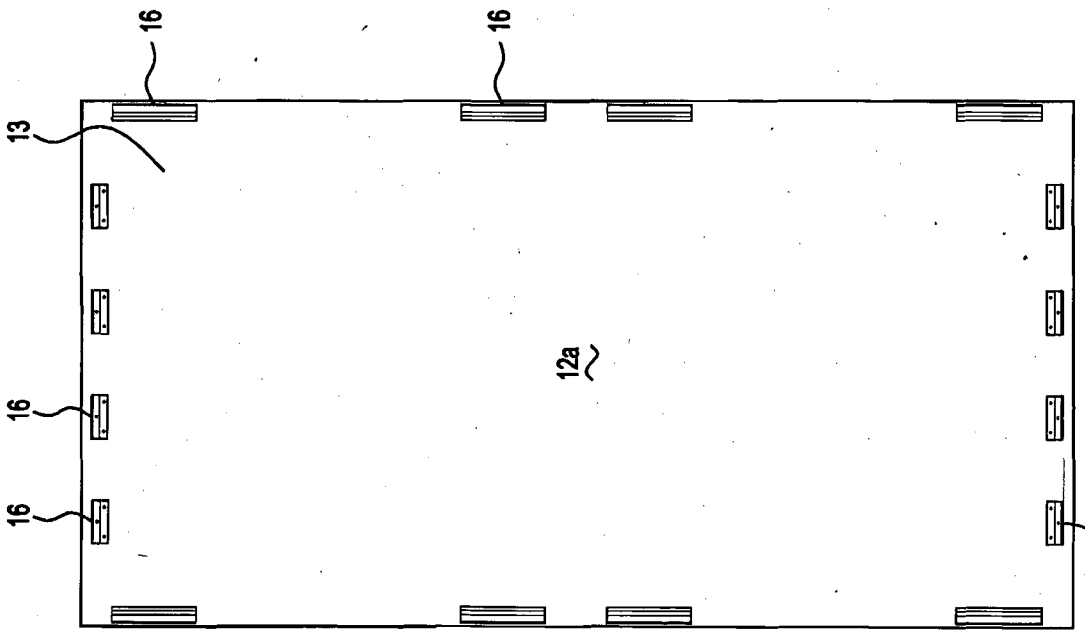


FIG. 15 (a)

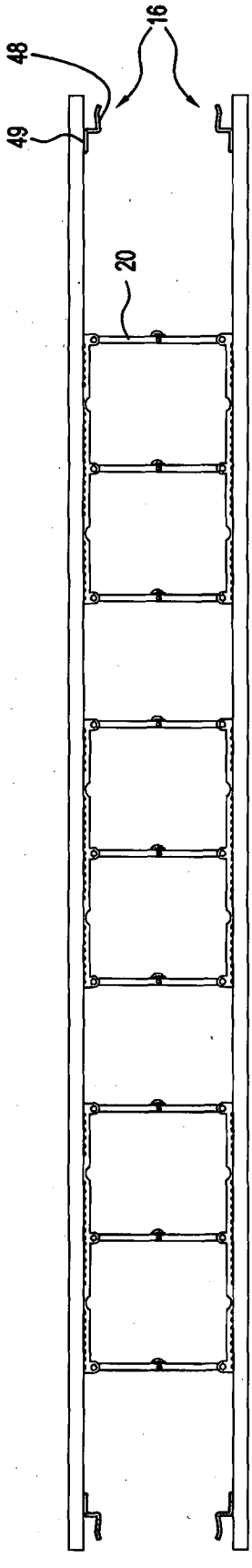


FIG. 16 (a)

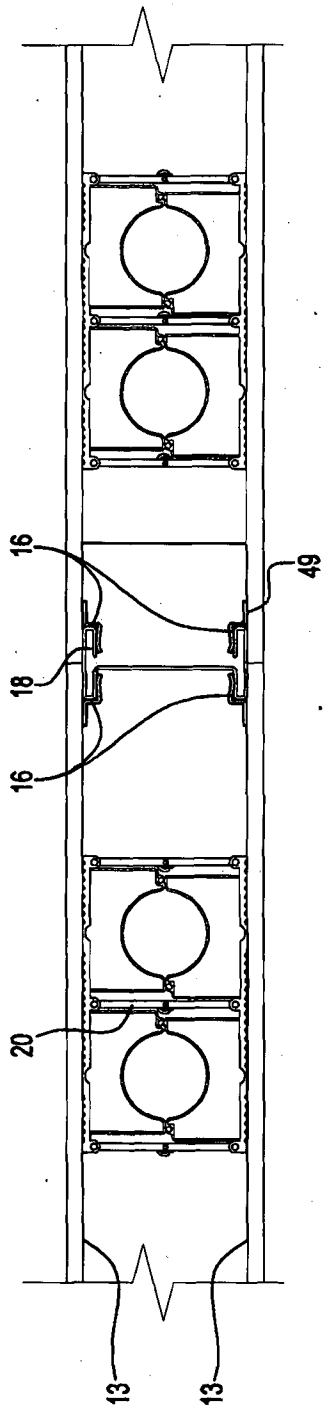


FIG. 16 (b)

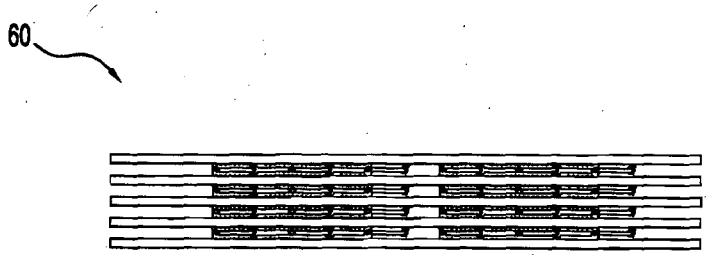


FIG. 17 (a)

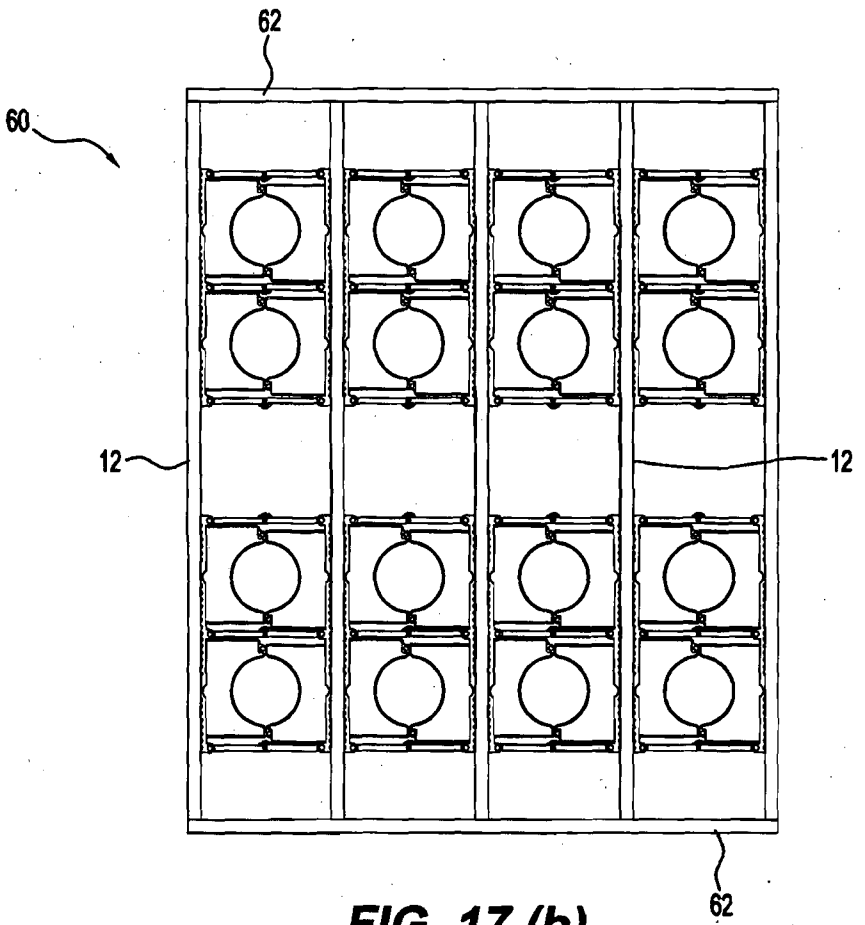


FIG. 17 (b)

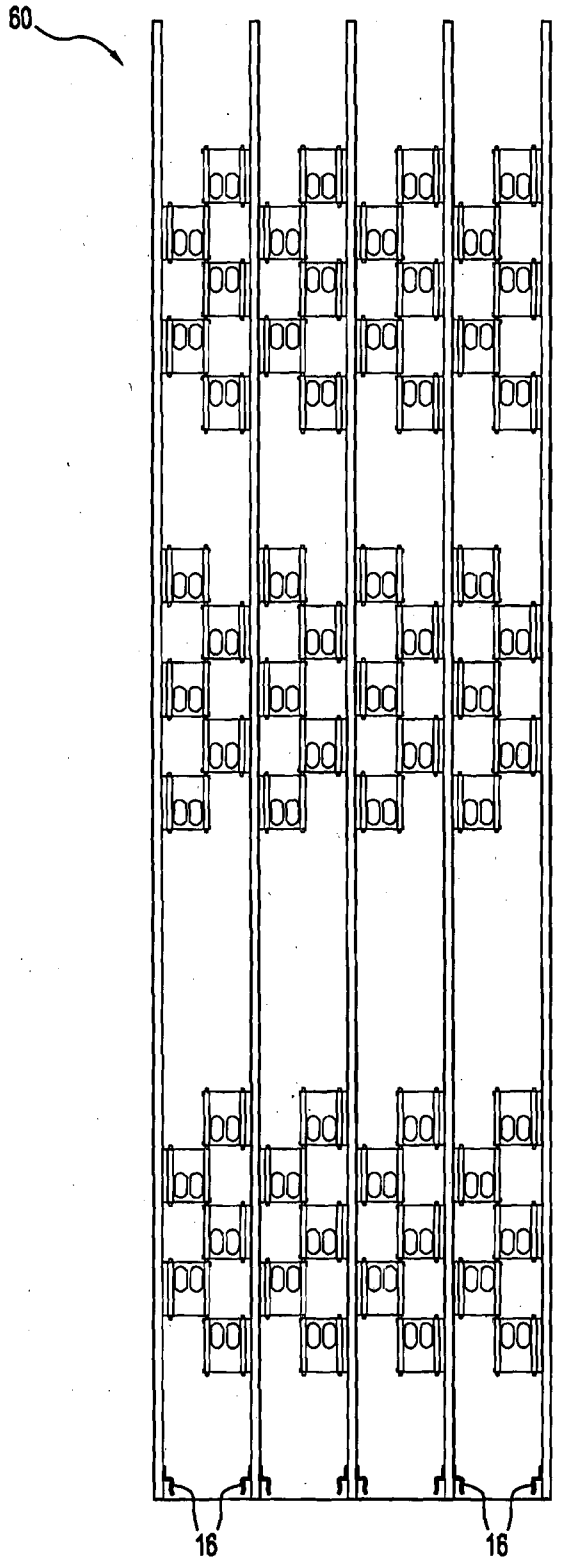


FIG. 17 (c)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000404

A. CLASSIFICATION OF SUBJECT MATTER

E04B 2/86 (2006.01) E04G 9/08 (2006.01) E04G 17/06 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 July 2012	20 August 2012
Name and mailing address of the ISA/AU	**Authorized officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au Facsimile No.: +61 2 6283 7999	Ritesh Thatte AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832645

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2012/000404**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/0103609 A1 (WOSTAL et al.) 03 June 2004 Abstract, paragraph 9 and figures 1-4	1, 3-9, 14-15
X	US 7082731 B2 (PATZ et al.) 01 August 2006 Abstract and figures	1, 2, 4-9
X A	US 4884382 A (HOROBIN) 05 December 1989 Figures 1-4 as above	10-12
P,X	AU 2011100636 A4 (BUILDING SOLUTIONS PTY LTD.) 07 July 2011 Fig 1A	10-12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000404

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

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

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

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

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

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

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

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-12, 14-15

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

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

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

☒ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of: **Box III**

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

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-9 and 14-15 are directed to a prefabricated formwork system. The feature of a collapsible mechanism joining two surfaces which can move between collapsed and expanded position is specific to this group of claims.

- Claims 10-12 are directed to an interlocking system. The feature of retaining clips mounted on opposing inside edges of surfaces to be joint and a coupling stud having flanges that each engage a retaining clip is specific to this group of claims.

- Claim 13 is directed to an inter-panel locking system. The feature of a male coupling stud and a female coupling stud, wherein the male and female coupling studs comprise biased interlocking profiles that clip together to join the first and second structures is specific to this group of claims.

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

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2012/000404**

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

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 2004/0103609 A1	03 Jun 2004	CA 2428765 A1	02 Jun 2004
		US 2004103609 A1	03 Jun 2004
		US 6915613 B2	12 Jul 2005
		US 2005108963 A1	26 May 2005
		US 7347029 B2	25 Mar 2008
US 7082731 B2	01 Aug 2006	US 2004040240 A1	04 Mar 2004
		US 7082731 B2	01 Aug 2006
		US 2006260240 A1	23 Nov 2006
US 4884382 A	05 Dec 1989	US 4884382 A	05 Dec 1989
AU 2011100636 A4	07 Jul 2011	None	

End of Annex

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