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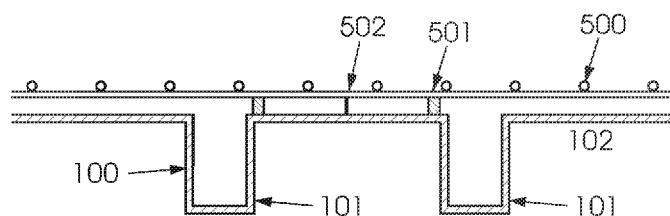


FIGURE 7a

(57) **Abstract:** Disclosed is a dimensionally adjustable self-supporting permanent formwork and support system, which comprises a formwork section with integral support means for the formwork section, with the formwork section comprising a plurality of formwork units (100) each of which comprises an elongate open-ended trough (101) having at least one operatively upper edge from which a flat section (102) extends, and with the formwork section, upon being provided with an upstanding perimeter rim, being locatable between end-supports to substantially close the open-ended troughs and support the formwork, and enable the formwork sections to be filled with a filler material to set in the formwork units and around the reinforcing members.



PERMANENT FORMWORK AND SUPPORT SYSTEM

FIELD OF THE INVENTION

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This invention relates to formwork or moulds used in the construction of reinforced concrete suspended slabs, staircases and beams.

BACKGROUND TO THE INVENTION

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Concrete in the wet or green state needs a mould or formwork to contain it while it is setting and hardening. Formwork is first assembled on a support structure to form a mould before reinforcement bars are placed on top or inside it and concrete is poured into the formwork, vibrated and allowed to set. Typically the formwork is made of steel panels that are clipped together, or from wood panels that have to be carpentered together. In general the formwork has to be greased to prevent concrete from sticking to it so that it can be reused multiple times.

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Steel panel formwork is made from modular units, thus requiring the reinforced concrete structure to be of certain dimensions, being a multiple of the modular units. Wooden formwork does not have this restriction but requires carpentry. For all reusable formwork, the formwork has a finite life before it has to be replaced, fixed or maintained. The greasing/oiling of the formwork as well as handling has a strong effect on the longevity of the formwork - if the concrete sticks to the formwork, it has to be pried or hammered away thus damaging the formwork. Repeated transport of the formwork between construction sites has a similar negative impact on its longevity.

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Reusable formwork has the following typical components and characteristics which are described in how it is deployed:

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- (a) A shoring or support system is deployed on the floor below. This shoring can be in the form of scaffolding, props, or supports.
- (b) The formwork is greased / oiled.
- (c) The formwork is placed and secured on top of the shoring system
- (d) The reinforcement is placed and tied together
- (e) The concrete is poured and vibrated.
- (f) After a prescribed period the formwork is stripped for reuse.
- (g) Some props or parts of the shoring system are left in place to support the still green concrete.

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(h) In multi-storey buildings the props/shoring system on the floors below has to remain in place to provide a load path to support the wet concrete and formwork in the upper floor slab immediately after it has been poured and until it has set.

- 5 A lot of time is needed to deploy and strip the formwork and shoring system. While in use the formwork and shoring system cannot be used elsewhere. The capital investment in formwork and shoring systems is significant for a construction company, and it also faces the ever present risk of theft of these systems, especially shoring components such as scaffolding.
- 10 To solve some of these problems two methods have evolved over the last several decades, namely:
- (a) Rib and block or lintel systems, and
 - (b) Permanent formwork (dating at least back to the 1960's).
- 15 Of particular interest to the present invention is permanent formwork. In typical permanent formwork, a mould is left with the concrete after it sets. It does not require greasing / oiling. But it does require shoring and support while the concrete is green. Since the formwork is left behind it is usually made of thin metal sheet.
- 20 Some initial permanent formwork was made of corrugated metal sheet (both galvanized and un-galvanized). The corrugation created stiffness so that workers can walk on it, and concrete could be poured, as it spans between supports. Over time the corrugated metal sheet with deeper corrugations were used, which stiffens permanent formwork. Such permanent formwork was referred to as steel deck, which was used both in reinforced concrete
- 25 construction, and in composite (steel and concrete) construction.

The steel deck cannot be of any depth. Whilst making the permanent formwork corrugation deeper does improve the overall stiffness of the steel deck, the steel deck is, with deeper corrugation, subject to local buckling, which renders such formwork useless. There is an

30 interplay between the stiffness of the formwork and local stability. To prevent local buckling, some products include local stiffeners. These stiffeners have to be deployed during construction of the formwork, which is a time-consuming process and requires quality control. It also introduces a further cost element to the construction process.

35 In general permanent formwork comes in strips that clip together along their length.

One further development is the use of part of permanent formwork as reinforcing for concrete. This has a potential problem in that the quality of the bond of concrete formwork steel sheet that is generally smooth and sometimes galvanized is questionable.

- 5 In all cases the concrete reinforcement does not interact with the permanent formwork. In all cases where the span is greater than about 2m, shoring support system is required for the permanent formwork.

SUMMARY OF THE INVENTION

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In accordance with this invention there is provided a dimensionally adjustable self-supporting permanent formwork and support system, which comprises a formwork section with integral support means for the formwork section,

- 15 with the formwork section comprising a plurality of formwork units each of which comprises an elongate open-ended trough having at least one operatively upper edge from which a flat section extends,

- 20 with each formwork unit being securable to an adjacent formwork unit for a plurality of the formwork units to be secured together by overlapping flat sections of adjoining formwork units and securing them to each other, with formwork units located at the operative sides of the formwork section being provided with upstanding rim to create the formwork section with a plurality of spaced-apart troughs joined by flat sections and bounded on its sides with rims,

- 25 with the formwork section providing a support surface for a spacer to support reinforcing members spaced apart from an operatively upper surface of the formwork section and substantially below the rim level of the formwork section, and securing means allowing at least one of the reinforcing members and the spacer to be secured to the formwork section operatively to provide integral support to the system;

- 30 with the formwork section, upon being provided with a upstanding perimeter rim, being locatable between end-supports to substantially close the open-ended troughs and support the formwork, and enable the formwork sections to be filled with a filler material to set in the formwork units and around the reinforcing members.

There is further provided for the end-support to comprise a double-layer brick wall, with the ends of the formwork section being supported on the operatively inner brick layer and the open-ended troughs being contained by the operatively outer brick layer.

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There is further provided for the system to include an optional external shoring system operatively supporting the formwork section at least whilst the filler material sets, operatively to provide a reinforced filler material support structure.

- 5 There is further provided for the securing means to comprise at least one tie.

There is further provided for the filler material to comprise concrete, and for the ties to include rebar lengths extending through the trough sections.

- 10 There is further provided for each formwork unit to comprise a set of two troughs each with a flat section extending from an operatively upper edge thereof, with the two trough and flat sections being longitudinally slidably adjustable relative to each other, operatively to adjust the length of the formwork unit.

- 15 There is still further provided for the flat sections of adjoining formwork units to be slidable over each other to adjust the distance between adjoining troughs, operatively to adjust the width of the formwork section.

- 20 There is also provided for the depth of the trough to be set as a multiple of standard height of a layer of brick and mortar, operatively to enable a selection of trough depth to match a desired number of rows of bricks and mortar between the flat section and the bottom of the trough, operatively to enable a formwork unit's flat sections and trough to be supported in a brick wall.

- 25 There is also provided for the overlapping flat sections of adjoining formwork units to be secured to each other by means any one or more of screws, rivets, seam welding or spot welding, or crimping.

- 30 A further feature of the invention provides for the formwork section to be provided with a mid-span support between the overlapping flat sections of adjoining formwork units and the reinforcing members extending above it, with the mid-span support comprising at least a plurality of spaced apart ties extending substantially in a line between the centre of the overlapping flat sections and the reinforcing members above it, operatively to support the mid-span between the troughs of two adjoining formwork units from deflection under the weight of filler material.

- 35 There is further provided for the formwork section to be provided with a mid-span support between the overlapping flat sections of adjoining formwork units and the reinforcing members

extending above it, with the mid-span support including a brace having a set two legs with a connecting portion between them, with one leg located in each trough on the sides of the overlapping flat sections, and the connecting portion extending between the upper ends of the legs over the mid-span and below the reinforcing members extending above the overlapping flat sections of adjoining formwork units, and with the connecting portion being secured by means of a tie to the overlapping flat section below it, operatively to support the mid-span between the troughs of two adjoining formwork units from deflection under the weight of filler material.

There is still further provided for the formwork section to be provided with a mid-span support between the overlapping flat sections of adjoining formwork units and the reinforcing members extending above it, with the mid-span support comprising a strip of mesh arranged vertically to support the reinforcing members extending above the overlapping flat sections, and being secured by means of ties to the overlapping flat section below it, operatively to support the mid-spans between the troughs of adjoining formwork units from deflection under the weight of filler material.

There is further provided for the support means to comprise one or more of scaffolding, props, or supports, alternatively self-spanning features of the formwork and support system.

These and other features of the invention are described in more detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of permanent formwork and support system according to the invention are described below by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a cross section of a prior art concrete slab system consisting of "T" beams;

Figure 2 is a perspective view and sections of several embodiments of permanent formwork according to the invention;

Figure 3 shows one important feature of the invention: the ability of the permanent formwork to telescope in and out along its length. A splice is shown;

Figure 4a is an end view showing how telescoping the permanent formwork against a brick wall can create an effective mould for pouring concrete;

- Figure 4b is a plan view of the permanent formwork shown in Fig 4a;
- Figure 5 shows how the permanent formwork can be adjusted in the width direction;
- Figure 6 refers to an embodiment of the invention where the height of the permanent deck is dictated by the specific application in which it applied, in this case by the height of the bricks and mortar;
- Figure 7 shows several embodiments of how top steel mesh can be supported and correctly spaced, as well as be used to support the horizontal part of the permanent formwork deck. This support can be used to stiffen and "strap" several troughs together;
- Figure 8 shows several other embodiments of how to strengthen and stiffen the horizontal flat portion of the permanent formwork;
- Figure 9 shows several embodiments of temporary shoring system. The system can be supported from the floor below, or itself suspended. The system can be made self-supporting in which case there is no need for shoring / support system;
- Figure 10 gives a way to make a beam which is stiffer and stronger part of the permanent formwork deck;
- Figure 11 shows a way to make a down-stand beam and have a continuous concrete slab above it;
- Figure 12 shows a way to make an up-stand beam and have it be continuous with the concrete slab;
- Figure 13 shows two embodiments of a beam's permanent formwork that requires shoring/support; and
- Figure 14 shows several embodiments of a beam's permanent formwork that is self-spanning and requires no shoring/support in its span.

DETAILED DESCRIPTION OF THE INVENTION

A concrete slab constructed according to the prior art is shown in Figure 1. This slab (3) is made of concrete (1) in repeated T-forms (4). Reinforcing (2) is placed in the base of each T-form, and steel mesh (5) is embedded in the concrete (1) of the slab (3). The slab (3) has to be supported by shoring during curing of the concrete, and the slab requires formwork within which the reinforcing (2) and mesh (5), before concrete is cast into the formwork to fill it.

The shape of the concrete slab (3) which incorporate the repeated T-form beams (4) is what is desired to be produced using the system of the invention.

Preferred embodiments of the invention are described below with reference to Figures 2 to 14 and include dimensionally adjustable self-supporting permanent formwork and support systems, each comprising a formwork section with integral support means for the formwork section. Each formwork section comprises a plurality of formwork units, with each formwork unit comprising an elongate trough having at least one operatively upper edge from which a flat section extends. Each formwork unit is securable to an adjacent formwork unit, thus enabling a plurality of the formwork units to be secured together to create the formwork section.

The formwork section provides a support surface for a spacer to support reinforcing spaced apart from an operatively upper surface of the formwork section. The securing means allows at least one of the reinforcing and the spacer to be secured to the formwork section. The formwork section, upon being provided with an upstanding perimeter rim, is fillable with a filler material to fill the troughs to set around the reinforcing. This thus provides a self-supporting reinforced filler material permanent formwork and support system.

An optional shoring system may be used to support the formwork section at least whilst the filler material sets.

The permanent formwork in this invention can be made up of various repeated units made of folded, bent or rolled thin sheet metal pieces, or a mixture of such units.

Figure 2(a) shows one embodiment of a fitted together and assembled permanent formwork made of several formwork units (100).

Figure 2(b) shows various embodiments of the repeated units (100). Also shown in Figure 2(b-5) is one embodiment that further separates the permanent formwork into a trough (101) and a flat section (102). The flat section can be corrugated as shown in Figure 2(b) to add stiffness to this section. These units, i.e. the trough (101) and flat section (102), can be mixed and matched or repeated as needed on the building site, as shown in Figure 2.

As shown in Figure 2(c) the units can be clipped together via a lip and clip mechanism (105), or can be screwed, riveted, welded, spot welded, or crimped together (106). The lip and clip mechanism's (105) main components are male and female parts that engage once pressed together. The lip-clip mechanism (105) can extend a portion or the full length of the permanent deck (the length of the deck is defined as perpendicular to the drawing in Figure 2(c)). Many

embodiments of the lip-clip mechanism are possible. Figure 2(b-6) shows a stand-alone clip (1012) made of spring steel that clips the lips of the permanent formwork 101.

5 A key aspect of the permanent formwork is its ability to be adjusted in one, two or three orthogonal directions: i.e. it is adjustable in the length and/or width and/or height directions.

As shown in Figure 3, the adjustment in the length direction is achieved by inserting one length of the permanent formwork repeat unit (101) into another and telescoping the repeat unit in the length direction (201) to the desired length. Figure 3 shows one repeat unit being inserted into another. For the sake of clarity of Figure 3, the inner unit has not been drawn to scale. In reality, 10 the formwork is made of thin sheets and will lie snugly one within the other. Once the desired length of the permanent formwork is reached, the two (or more) repeat units are spliced together by means of screws, rivets, seam welding or spot welding, or crimping (202). Two repeat units can be spliced (210) together by a short portion of the repeat unit. The length 15 adjustment (201) can be achieved by moving one or both pieces in the splice (210).

The importance of the permanent formwork to be adjustable in the length direction is to extend the permanent formwork until both ends engage with either bricks, beams or other vertical structural members forming part of the structure. This engagement provides a good enough 20 seal so that when concrete gets poured it is contained and does not pour out of the ends of the deck (100). One example, using bricks, is shown in Figure 4. The outer brick skin (1301) provides the concrete pour stop; the inner brick skin (1302) provides the end supports for the permanent formwork deck (100). The bottom of the trough (101) shown in Fig 4a rests on the top of the inner skin brick layer (1302) and abuts the inner surface of the outer skin brick layer 25 (1301). The inner skin brick layer (1302) is completed to underneath the flat horizontal piece (102) to ensure the permanent formwork (100) is supported along its entire end (1303), as shown in Fig 4b.

Adjustment in the width direction (301) is achieved by moving the troughs (101) one with 30 respect to the other. This in turn is achieved by either having narrower horizontal pieces (102), or in one embodiment shown in Figure 5, the horizontal pieces (102) are shifted horizontally in the transverse width direction (301) and overlap a protruding lip (302). The overlap of part of the lip (302) can occur on either one edge or on both edges of the horizontal piece (102). None, one, or every repeat unit can be shifted in the width direction (301), one with respect to the 35 other. Shifting many repeat units (100) with respect to each other can achieve a large increase in the overall width of the permanent formwork deck covering width. Once the desired width of

the permanent formwork is reached, the repeat units are spliced together by means of screws, rivets, seam welding or spot welding, or crimping (304). Note that there is a balance between having each horizontal piece (102) adjustable in the width direction (301), which comes at a cost of difficulty of installation. In one embodiment there will be a mixture of un-adjustable repeat units (100) and adjustable horizontal pieces (102), to limit the impact of this.

The importance of horizontal adjustment is to fully cover a given floor area in the width direction. The width adjustment in the permanent formwork allows for wide tolerances in the building and support of the floor system. The width adjustment (301) obviates the necessity to “plug holes/areas” created by un-adjustable permanent formwork. The width adjustment by means of the moveable horizontal pieces (102) does not have to be constant along the length of the deck—as long as the flat section (102) rests on the lip/flange (302) and can be attached to it this will be sufficient to make the formwork effective.

As shown in Figure 6, the vertical adjustment of the formwork (401) is achieved in the factory during the manufacturing process. The depth of the permanent formwork is dictated by the strength of the required reinforced concrete “T” beam’s strength and stiffness. The permanent formwork’s depth also determines the stiffness and strength of the formwork itself. In general the permanent formwork’s depth will be dictated by the type of construction. For example, if it is used with a brick wall support, then the depth of the formwork should be a multiple of the brick plus mortar height (402), as shown in Figure 6. The reason for this is that the horizontal portion of the permanent deck (403) should rest on bricks’ horizontal surfaces so that the brick laying lines are not disturbed and are thus properly support both the web and the flange of the deck to achieve a properly supported and reinforced concrete beam, as shown in Figure 6. When the permanent deck is used with steel beams, then its height (401) will be dictated by the steel beam’s dimensions and features.

Another key aspect of the present invention is to utilize the steel used as reinforcing in a typical reinforced concrete beam as a support system for the permanent steel formwork to support the wet concrete. For example, the horizontal portion of the permanent formwork deck can be supported when it is carrying the wet concrete by the steel reinforcement as shown in Figure 7.

Figure 7 shows several embodiments of the support of the mid span of the flat portion of the deck (102). The support is provided by the mesh (500) that is required in the concrete slab as

reinforcing and for shrinkage and creep control, and as wear or durability reinforcing. The concrete reinforcement needs to be spaced away from the formwork by a spacer (501).

As shown in Figure 7a at mid spaced and periodically along the length of the deck a tie (502) picks up the mid-span of the deck (102). As concrete is poured, the mid-span of flat portion of the deck (102) will deflect down, engage the tie (502), and transfer the load to the mesh (500), which in turn will transfer the load to the spacers (501) and to the stiff vertical portions of the trough (101). This effectively reinforces the flat section (102) against vertical deflection under weight of the concrete.

Another embodiment, shown in Figure 7b, consists of a "stool" (510) which is supported by the troughs (101). The stool, sized correctly, serves a second function: it positions the mesh (500) in the vertical direction (505) correctly (to engineer's drawings).

A modification to the stool is to change its shape to (515), as shown in Figure 7c. Here the stool is converted into a truss by connecting it to the mesh (500). Other configurations of the truss (515) are possible utilizing the stool as the mesh spacer and as one portion of the truss, while the steel mesh (500) is utilized as another portion of the truss.

Another embodiment of the support system of the span of the flat portion of the deck (100) is a vertical mesh (550) positioned vertically between the upper mesh (500) and the deck (102), as shown in Figure 7d. This mesh's function is to:

- (a) position the mesh (500) vertically in space (505);
- (b) support the flat span of the deck (102) via connections (502) when the concrete is poured and during construction;
- (c) connect the two verticals of the trough (101) to prevent the trough verticals from splaying open when the concrete is poured; and
- (d) stiffen the overall permanent formwork by connecting several troughs (101) together during construction.

The vertical mesh (550) connects to the reinforced mesh (500) at spaced apart intervals in the horizontal direction (555). The reinforced mesh (500) stabilizes the vertical mesh (550). The vertical mesh (550) locates the horizontal mesh (500) accurately in the horizontal direction (555). As shown in Fig 7d(i), the vertical mesh (550) can be bent into several profiles (570), shown edge on, schematically in Figure 6. The vertical mesh (550) can be attached to the deck at several points (503).

Not shown in the drawing in Figure 7 is how the stool (510), vertical mesh (550) and other support systems for the horizontal mesh (500) are positioned into the page, i.e. along the length of the deck 100. These support systems can be perpendicular to the length of the trough (101) or at any angle to the trough (101), along the length of the trough. The stool leg (511) can extend along the length of the troughs (101); alternatively one leg (511) of the same stool can extend into the page, while the other out of the page, as shown in Figure 7b. The vertical mesh (550) will be spaced into the page in the embodiment shown in Figure 7d. Neighbouring vertical meshes (550) can be configured continuously or in a checker pattern. The vertical spacer (550) has to be a mesh with large enough apertures to allow concrete to flow and set through it. Although a solid spacer is possible, the concrete has to be able to bind to it strongly enough to have no discontinuity in the concrete.

Figure 7e and 7e(i) also shows how the horizontal deck (102) can be folded and used as a spacer for the reinforcement mesh 500. The horizontal folded deck (102) can be the standard inverted box rib or IBR, or can be custom made into a unique shape.

Several other embodiments of how to strengthen and stiffen the horizontal flat portion of the permanent formwork is shown in Figure 8. It is possible that portions of the permanent formwork may be corrugated (700), as shown in Figure 8a, with the corrugation deep enough so as to render the formwork stiff enough not to need any support or aid to carry the wet concrete and construction loads. As shown in Figure 8a, the corrugation is in the flat portion of the permanent formwork (102). The corrugation profile rests on the lips of the troughs (101) and the corrugations span from trough to trough. The corrugation flattens out at the lips/walls of the troughs to allow for fastening. It is possible that the trough (101) and the horizontal corrugation piece (700) may be manufactured as one piece to form the repeat unit (100). It is also possible that the corrugation may be manufactured independently to the troughs and screwed to the lips of the troughs (101). The corrugation could be circular/sinusoidal, or folded into something similar to inverted box rib (IBR). The corrugated portion (700) can be manufactured in pieces for ease and lightness of installation with screws.

It is also possible that the flat portion of the permanent formwork may be reinforced with horizontal bars (710), as shown in Figure 8b. In this embodiment the horizontal bars (710) are attached to the horizontal portion of the permanent formwork via connections (711) (e.g. ties, cable ties, wires, welding, etc.). The connectors (711) have to attach in the span (to pick up the wet concrete loads) and near the vertical portions of the troughs (101).

Another aspect of the present invention is the temporary shoring system (800) used in conjunction with the permanent formwork, as shown in Figure 9. The temporary shoring system has to be positioned either underneath the splice area (210), or close to where the telescoping
5 decks attach. The shoring (800) has to support the outermost permanent formwork deck (100). Several shoring systems (800) might be required in the long span of the permanent formwork. Figure 9b shows the temporary formwork in span (longitudinal direction) and the shoring system (800) is shown in Fig 9a in section—transverse to the long direction of the permanent formwork (100). It is important to note that the temporary shoring system (800) can support
10 many troughs of (100).

In one embodiment, shown in Figure 9a, the shoring system (800) consists of a beam (801). In Figure 9a the beam is made of two lipped channels back to back. This beam is supported by two or more props (805) along the beam length. The props have to be adjustable vertically
15 (806) to support the permanent deck in a level or even pre-camber manner. The props are supported by the ground, a floor, a beam, or another support underneath.

Another embodiment of the temporary shoring system is shown in Figure 9b. In this embodiment the shoring system (850) includes a set of braces () which are connected to a
20 bottom bracket (855). At their other ends the braces () are each connected to a tube () which is provided with apertures proximate its open ends. Two adjacent sets of braces are connected to each other by means an inner tube (852) that is slidingly received with the open ends of the adjoining brace tubes (). The distance between two adjacent sets of braces () can be adjusted by telescopic movement of the inner tube () within the brace tubes (), in the width of the
25 permanent formwork direction (301). The telescoping action is achieved via holes (851) with pegs placed through the two brace tubes (). The inner tube (852) forms part of the telescope. The shoring system includes a bottom chord (853), of which the length can be set by adjusting a nut on a threaded rod, by means of a turnbuckle, or by means of a ratcheting cable mechanism (for example as used in the transportation industry to secure tarpaulins on trucks).
30 It is possible that the bottom chord may also be made of an inner pipe that is slidingly received within an outer pipe with holes and pegs, in a manner that is similar to the top chord (852) in construction. Only two units are shown in Figure 9b, but it is possible to repeat as many units as required in the direction of the width of the permanent formwork (301) - each unit slides into its neighbour and is secured via pegs in complementary shaped and sized holes (851).

This shoring system (850) can be supported by sliding in vertical props in underneath the bottom bracket (855) and then the vertical props can be adjusted vertically. The shoring system (850) can also be supported (870) by resting its ends (860) on supporting beams or walls found on either side of the slab. Slight pre-camber can be achieved by tightening the bottom chord (853) via a turnbuckle, ratchet, nut system, or jacking system. In this embodiment of the shoring (850), no contact is made with the floor or support below. This proves advantageous as it decouples the construction of any given floor system from the strength and/or stiffness of the floors below. This decoupling affords speed in construction.

It is possible and preferred that the permanent formwork troughs (101) be stiff enough to span their required distances without any shoring or support. Figure 9(c) shows how the troughs (101) can be made up of two lipped Z or C sections or purlins to form a steel structural section. The two steel sections can be clipped together, strapped together (178), bolted together or welded together. Each purlin can be light enough to be installed by only two men and assembled when on its supports. The main point is that no shoring or support is required in such instance.

A key part of this invention is that the vertical troughs (101) can be moved very close to each other and attached together (106), as show in Figure 10. Once longitudinal reinforcement is placed at the bottom and if necessary, in some cases in the top portion of the troughs (101) as well and once the concrete is poured and sets, two reinforced concrete beams have been created. The beams (1000) can be highly reinforced and can thus be stiffer and stronger than the regular repeated unit (100) of the slab system. These beams (1000) can support more load. Further these beams (1000) form a continuous, same-thickness structure with the suspended slab system (100).

A downward standing beam is shown in Figure 11. In this case the beam (1000), which is stiffer and stronger than the ribs formed by the troughs (101), is shown. If the beam is too deep, and/or if it is on the edge, a strap (1010) can be attached to the lips of the beam via attachments (1006). In general the straps (1010) can be narrow to allow pouring of concrete. The beam (1000) interacts with the repeated floor formwork (100) as above.

An upstand-beam formwork is shown in Figure 12. In this case, the beam (1000) which is stiffer and stronger than the ribs formed by the troughs (101), is shown. Inserts (such as wood, sheet metal) (1100) are inserted into the regular trough (101). The insert might have to be attached (1106). The vertical inserts extend upwards, and are strapped together at the top via a strap

(1110). The strap (1110) is narrow to allow for pouring and vibrating of concrete. The inserts and the straps can be one piece, or can be attached. If necessary, the inner insert (1100) can be fenestrated (1115) in order to allow poured concrete in the (100) area to be continuous with the concrete in the upstanding beam (1000).

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If the beam is too deep, and/or if it is on the edge, a strap (1010) can be attached to the lips of the beam by means of attachments (1006). In general the straps (1010) can be narrow to allow pouring of concrete. The beam (1000) interacts with the repeated floor formwork (100) as above.

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It is possible to create a beam (2000) either as a stand-alone as shown in Figure 13, or interacting with the slab permanent formwork. The permanent formwork (2010) of the beam (2000) can be made of several pieces, or one piece (1001 in Figure 11). The pieces can be a top hat (2011) as (101) of the permanent slab formwork, channels (2012) (either straight or lipped) as is shown in Figure 13, or a Z-section (2013) (either straight or lipped) also shown in Figure 13. The pieces are connected together via any one or more of welding, screwing, bolting, riveting (2005). A strap(s) (2015) can be used to tie the two lips of (2012) or (2013) together. The strap (2015) is attached via any one or more of screws, welding, rivets, bolts (2005). Once the concrete is set inside the permanent formwork (2000), the pieces that are outside the concrete can either be cut off, or bent towards the concrete beam. It is possible to have the lips of the top hat (2011) and the flanges of the channel (2012) directed into the concrete beam (2000) during the setup of the permanent formwork (2010).

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Figure 14 shows several embodiments of a stand-alone beam made up of thin sections (3020). The sections can be light enough as to be lifted into position by several men. The sections (3020) can be made of folded plate or be standard/custom made structural steel sections such as purlins. The various sections (3020) are bolted/riveted/welded screwed or attached (3106). The attachment can occur on site or in the factory. If each structural sub-component (3020) is lifted into position by hand the attachment will be made up in the air. In such a way a strong and stiff steel girder can be created. Such beams do not require shoring/support and can span appreciable distances. Reinforcing (3010) can be placed into the formed section. Concrete (3000) can be poured in; the concrete can then be vibrated from the inside or the outside. The concrete can be poured via fenestration in the section at the top flange(s). Pour stops made of thin metal sheet or wood (3027) can be added to the section to have concrete poured on top of the beams. The pour stops (3027) can be made telescoping in nature (length telescoping). Similar pour stops can be used on the ends of the beams. The beams can be designed as

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steel and reinforced concrete sections. The beams can support the permanent formwork deck (100). The features of the permanent formwork-deck can be introduced to the permanent formwork beams. The features of the permanent formwork beams can be introduced to the permanent formwork troughs (101). The construction loads can be carried only by the steel; the service loads can be carried either by the steel or by the steel and concrete beams. It is however not a requisite for the beams to be filled with concrete.

The present invention can also be used to cast not only suspended slabs, staircases, but also beams. The beams can form part of the suspended slab/ staircase system, or be stand alone.

A further advantage of the present invention is that the use of a permanent formwork to create effectively a permanent steel encased beam enables fire-proofing to be done much easier. The fire proofing of the steel beam may be done with bricks and mortar instead of expensive encasing methods or use of special and expensive paints, foams or chemicals. The use of bricks and mortar is easier and cheaper. It can be done by bricklayers, who would already be working on site, and using materials, which would also already be on site.

It will be appreciated that the embodiments of the invention described above is given by way of example only and are not intended to limit the scope of the invention. Modifications to the embodiments are possible further departing from the essence of the invention.

It is, for example, possible for the beam and the deck-trough permanent formwork to rest on masonry and steel support components. Spaces can be left open in the masonry to accommodate the permanent formwork deck-trough and/ or beam. The beams and deck-trough permanent formwork can be retrofitted to existing masonry walls by cutting fenestration opening in one of the skins of the masonry walls and resting the permanent formwork troughs/ beams on the created bottom ledges.

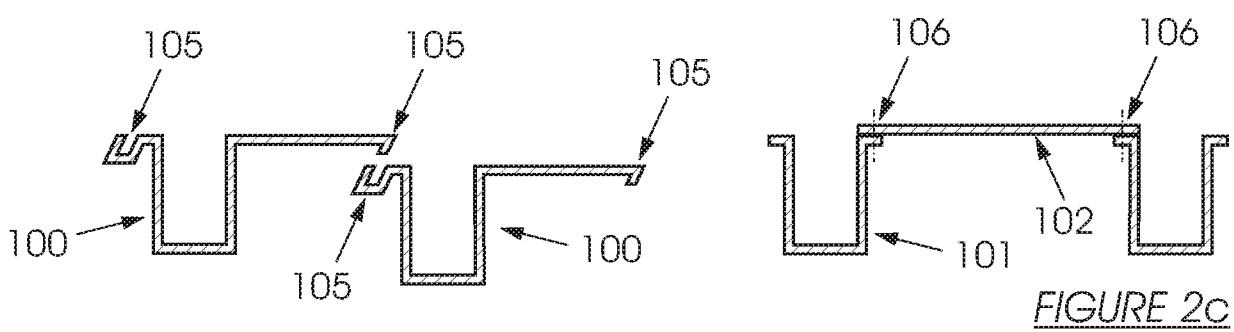
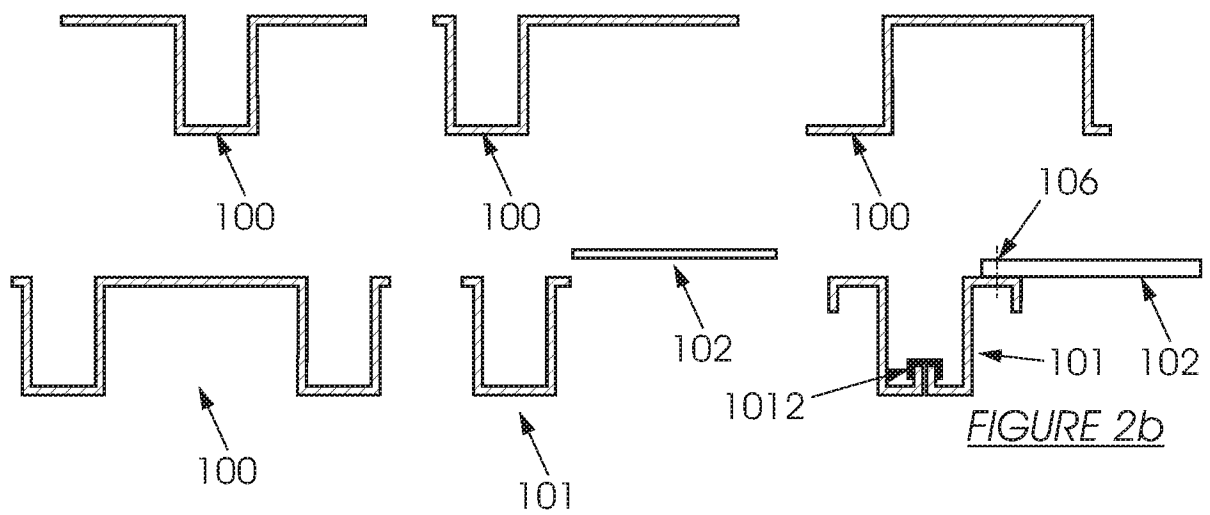
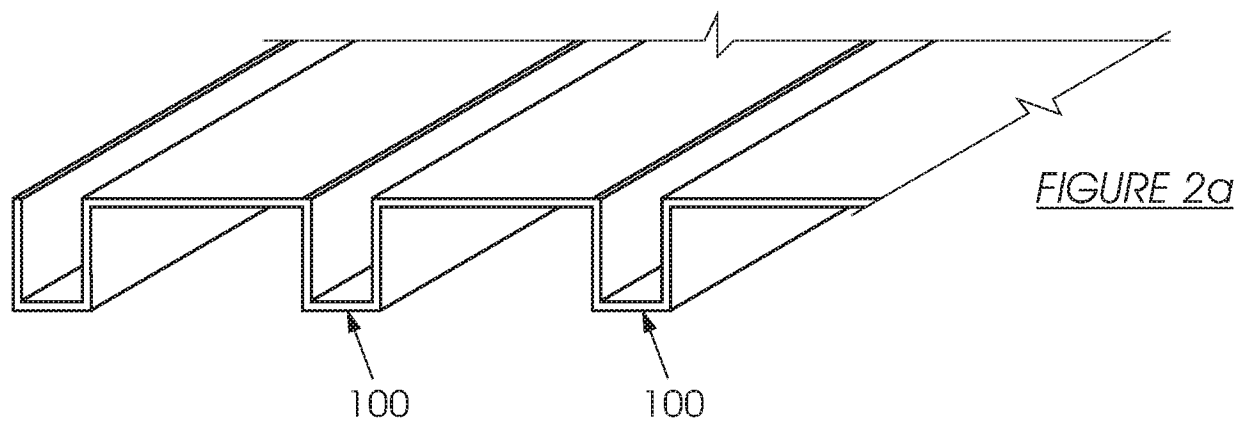
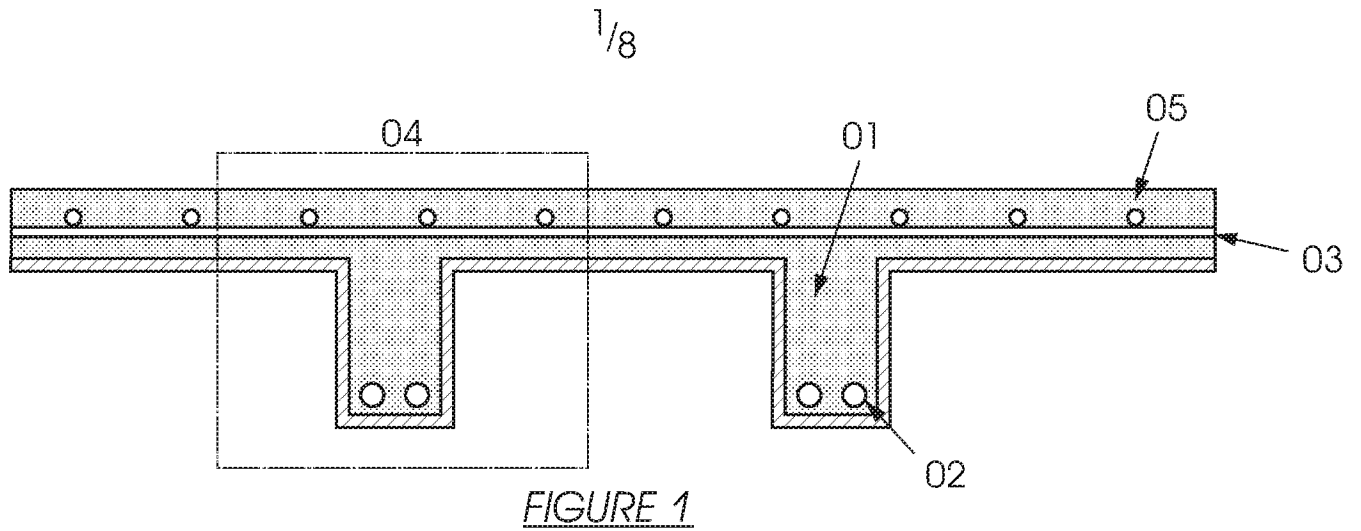
CLAIMS

1. A dimensionally adjustable self-supporting permanent formwork and support system,
5 which comprises a formwork section with integral support means for the formwork section,
with the formwork section comprising a plurality of formwork units each of which comprises an elongate open-ended trough having at least one operatively upper edge from which a flat section extends,
10 with each formwork unit being securable to an adjacent formwork unit for a plurality of the formwork units to be secured together by overlapping flat sections of adjoining formwork units and securing them to each other, with formwork units located at the operative sides of the formwork section being provided with upstanding rim to create the formwork section with a plurality of spaced-apart troughs joined by flat sections and bounded on its sides with rims,
15 with the formwork section providing a support surface for a spacer to support reinforcing members spaced apart from an operatively upper surface of the formwork section and substantially below the rim level of the formwork section, and securing means allowing at least one of the reinforcing members and the spacer to be secured
20 to the formwork section operatively to provide integral support to the system; and
with the formwork section, upon being provided with an upstanding perimeter rim, being locatable between end-supports to substantially close the open-ended troughs and support the formwork, and enable the formwork sections to be filled with a filler material to set in the formwork units and around the reinforcing members.
25
2. A system as claimed in claim 1 in which the end-support comprises a double-layer brick wall, with the ends of the formwork section being supported on the operatively inner brick layer and the open-ended troughs being contained by the operatively outer brick layer.
30
3. A system as claimed in claim 1 which includes an optional external shoring system operatively supporting the formwork section at least whilst the filler material sets, operatively providing a reinforced filler material support structure.
- 35 4. A system as claimed in claim 1 or 2 in which the securing means comprises at least one tie.

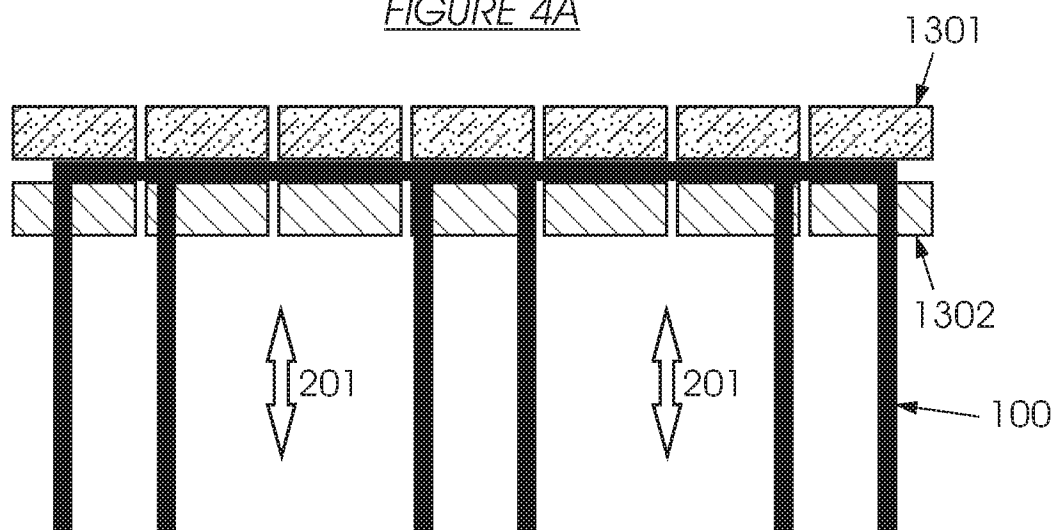
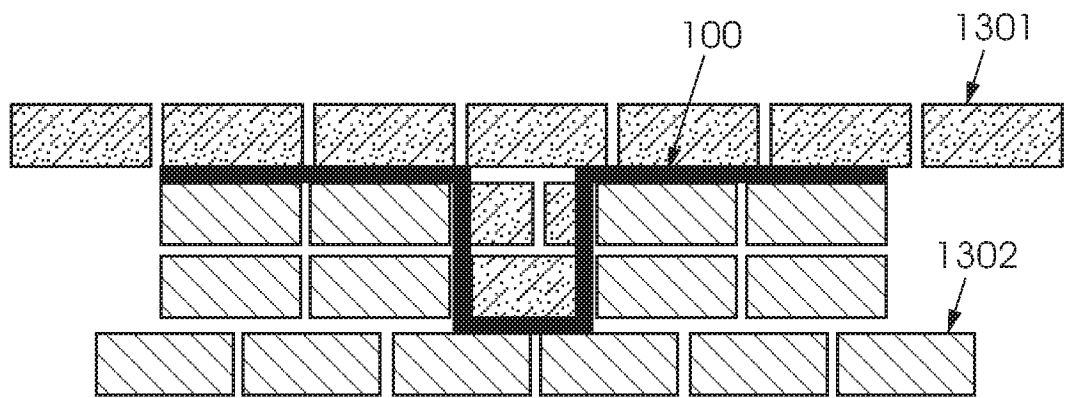
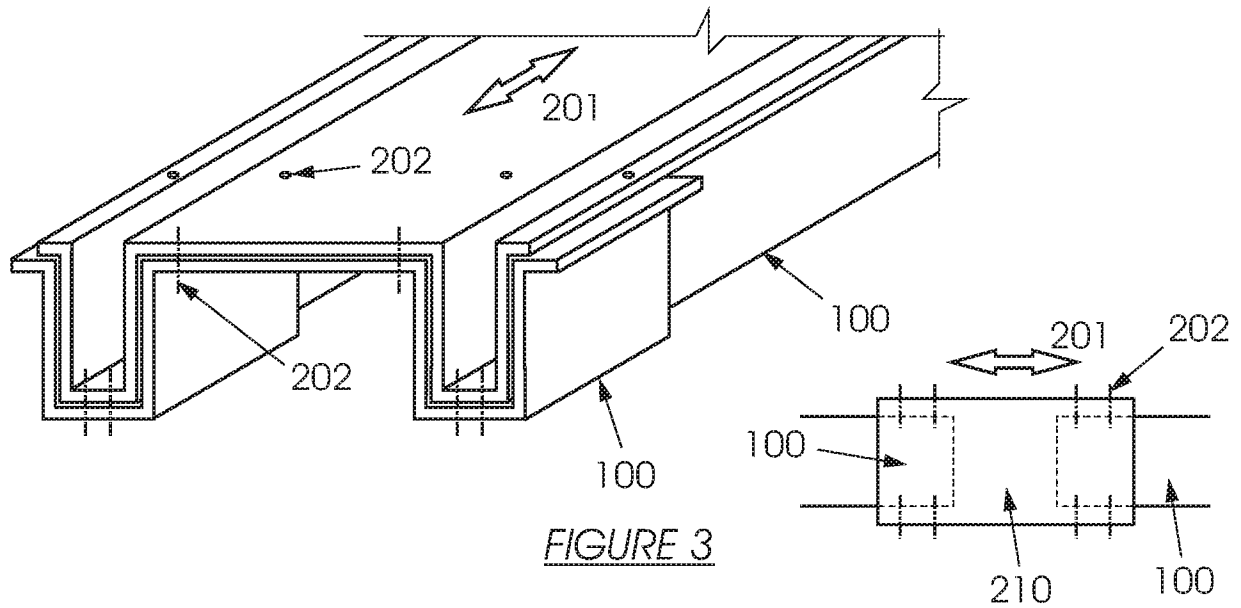
5. A system as claimed in claim 4 in which the filler material comprises concrete, and the ties include rebar lengths extending through the trough sections.
- 5 6. A system as claimed in any one of the preceding claims in which each formwork unit comprises a set of two troughs each with a flat section extending from an operatively upper edge thereof, with the two trough and flat sections being longitudinally slidably adjustable relative to each other, operatively to adjust the length of the formwork unit.
- 10 7. A system as claimed in any one of the preceding claims in which the flat sections of adjoining formwork units are slidable over each other to adjust the distance between adjoining troughs, operatively to adjust the width of the formwork section.
- 15 8. A system as claimed in any one of the preceding claims in which the depth of the trough is set as a multiple of standard height of a layer of brick and mortar, operatively to enable a selection of trough depth to match a desired number of rows of bricks and mortar between the flat section and the bottom of the trough, operatively to enable a formwork unit's flat sections and trough to be supported in a brick wall.
- 20 9. A system as claimed in any one of the preceding claims in which the overlapping flat sections of adjoining formwork units are secured to each other by means any one or more of screws, rivets, seam welding or spot welding, or crimping.
- 25 10. A system as claimed in any one of the preceding claims in which the formwork section is provided with a mid-span support between the overlapping flat sections of adjoining formwork units and the reinforcing members extending above it, with the mid-span support comprising at least a plurality of spaced apart ties extending substantially in a line between the centre of the overlapping flat sections and the reinforcing members above it, operatively to support the mid-span between the troughs of two adjoining
30 formwork units from deflection under the weight of filler material.
- 35 11. A system as claimed in any one of the claims 1 to 9 in which the formwork section is provided with a mid-span support between the overlapping flat sections of adjoining formwork units and the reinforcing members extending above it, with the mid-span support including a brace having a set two legs with a connecting portion between them, with one leg located in each trough on the sides of the overlapping flat sections, and

the connecting portion extending between the upper ends of the legs over the mid-span and below the reinforcing members extending above the overlapping flat sections of adjoining formwork units, and with the connecting portion being secured by means of a tie to the overlapping flat section below it, operatively to support the mid-span between the troughs of two adjoining formwork units from deflection under the weight of filler material.

12. A system as claimed in any one of the claims 1 to 9 in which the formwork section is provided with a mid-span support between the overlapping flat sections of adjoining formwork units and the reinforcing members extending above it, with the mid-span support comprising a strip of mesh arranged vertically to support the reinforcing members extending above the overlapping flat sections, and being secured by means of ties to the overlapping flat section below it, operatively to support the mid-spans between the troughs of adjoining formwork units from deflection under the weight of filler material.



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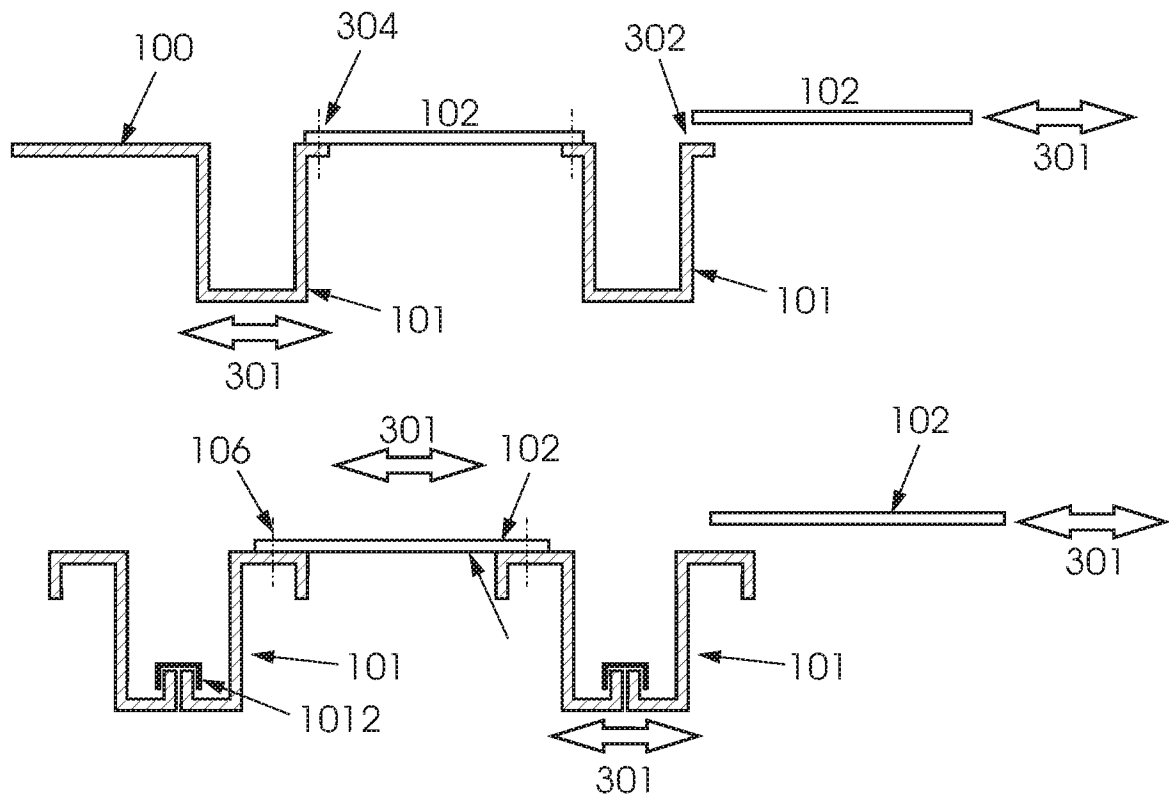


FIGURE 5

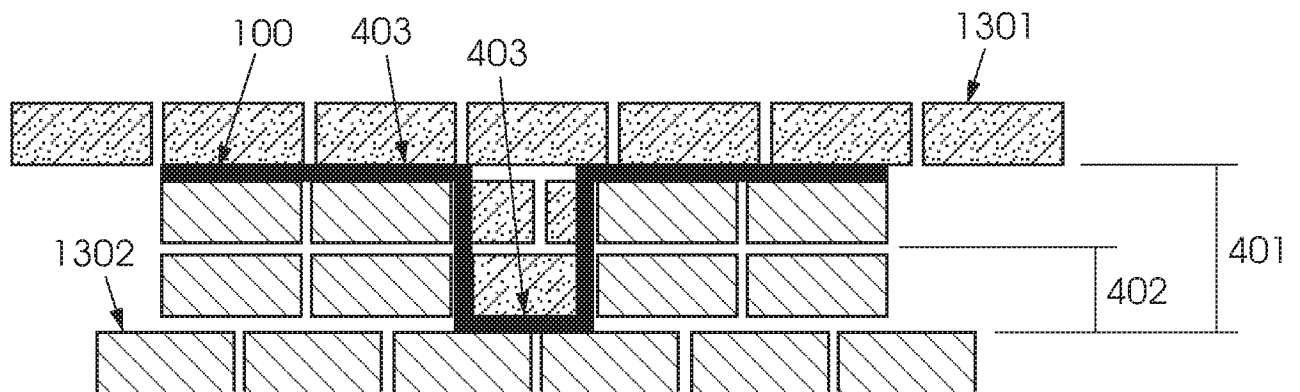


FIGURE 6

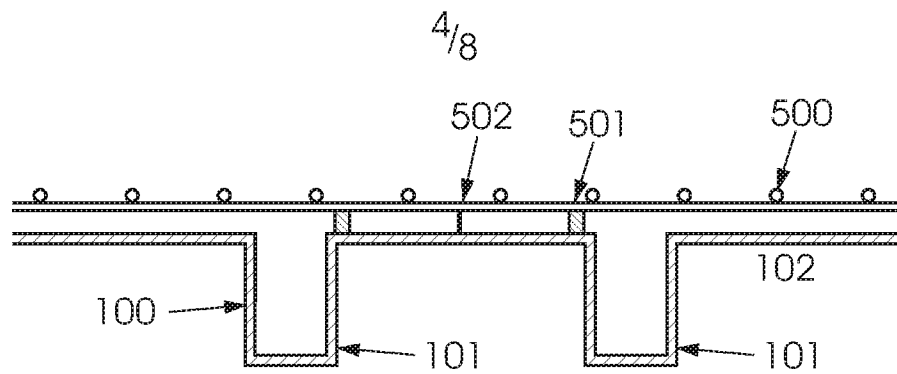


FIGURE 7a

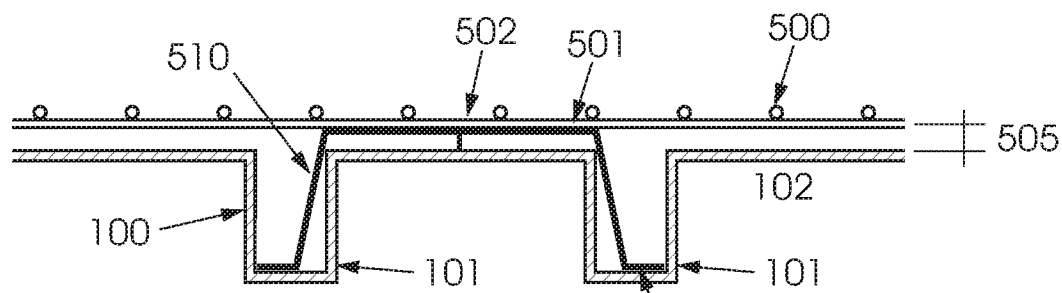


FIGURE 7b

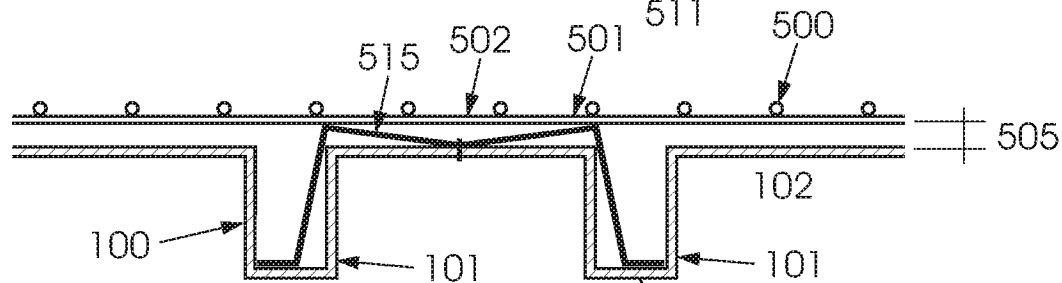


FIGURE 7c

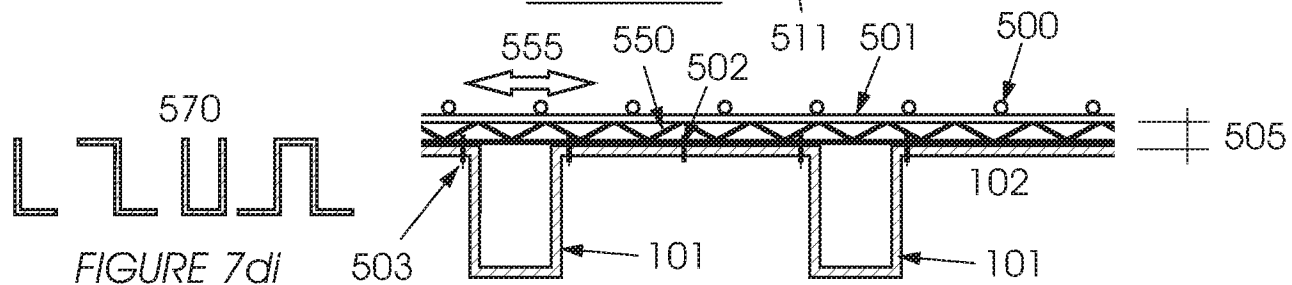


FIGURE 7d

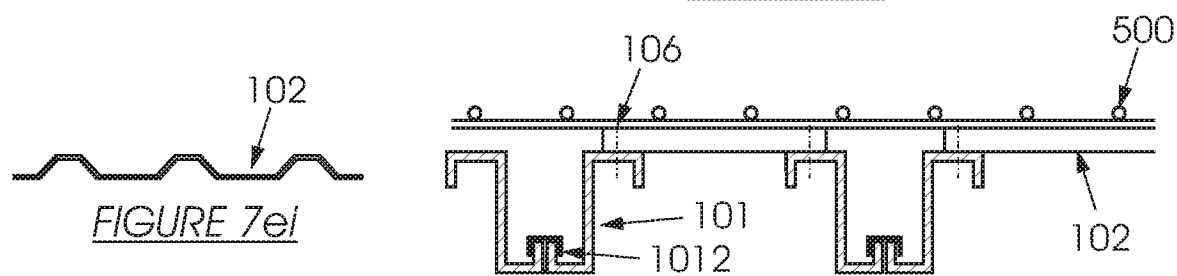


FIGURE 7e

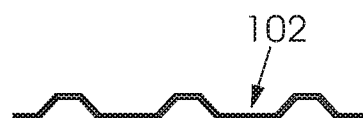
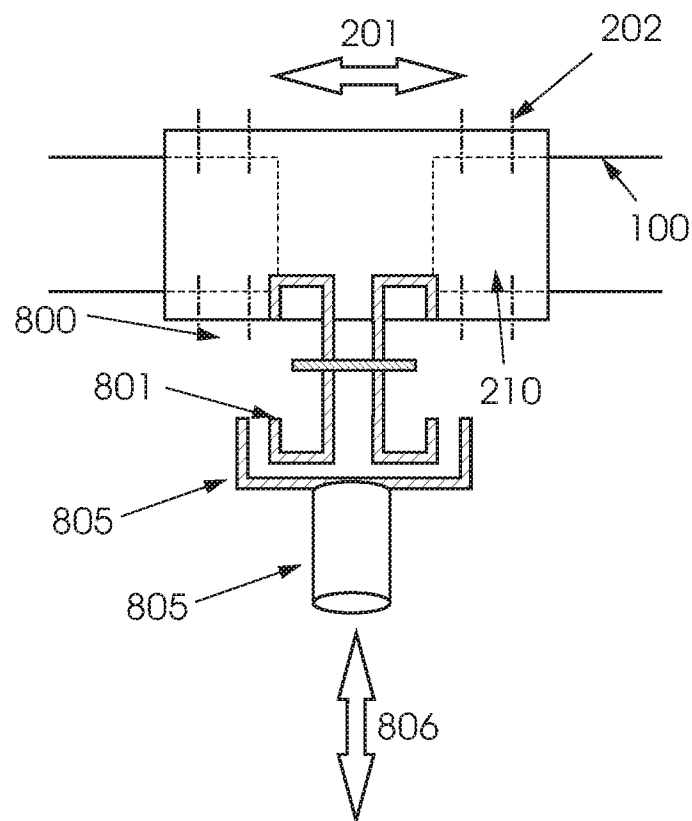
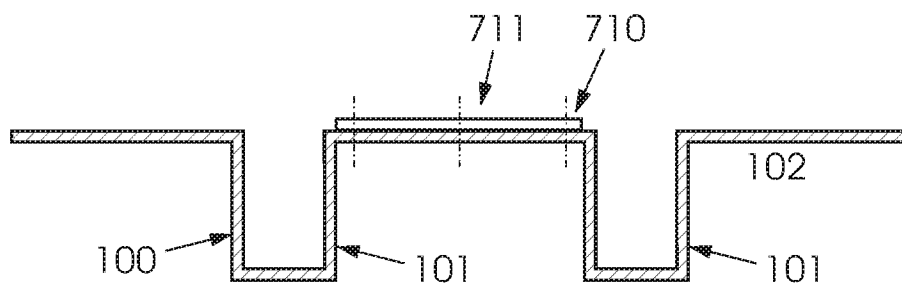
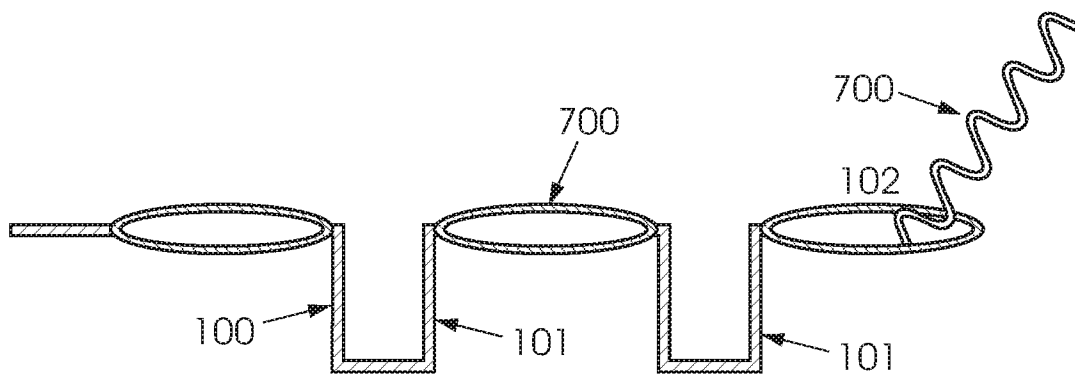


FIGURE 7e

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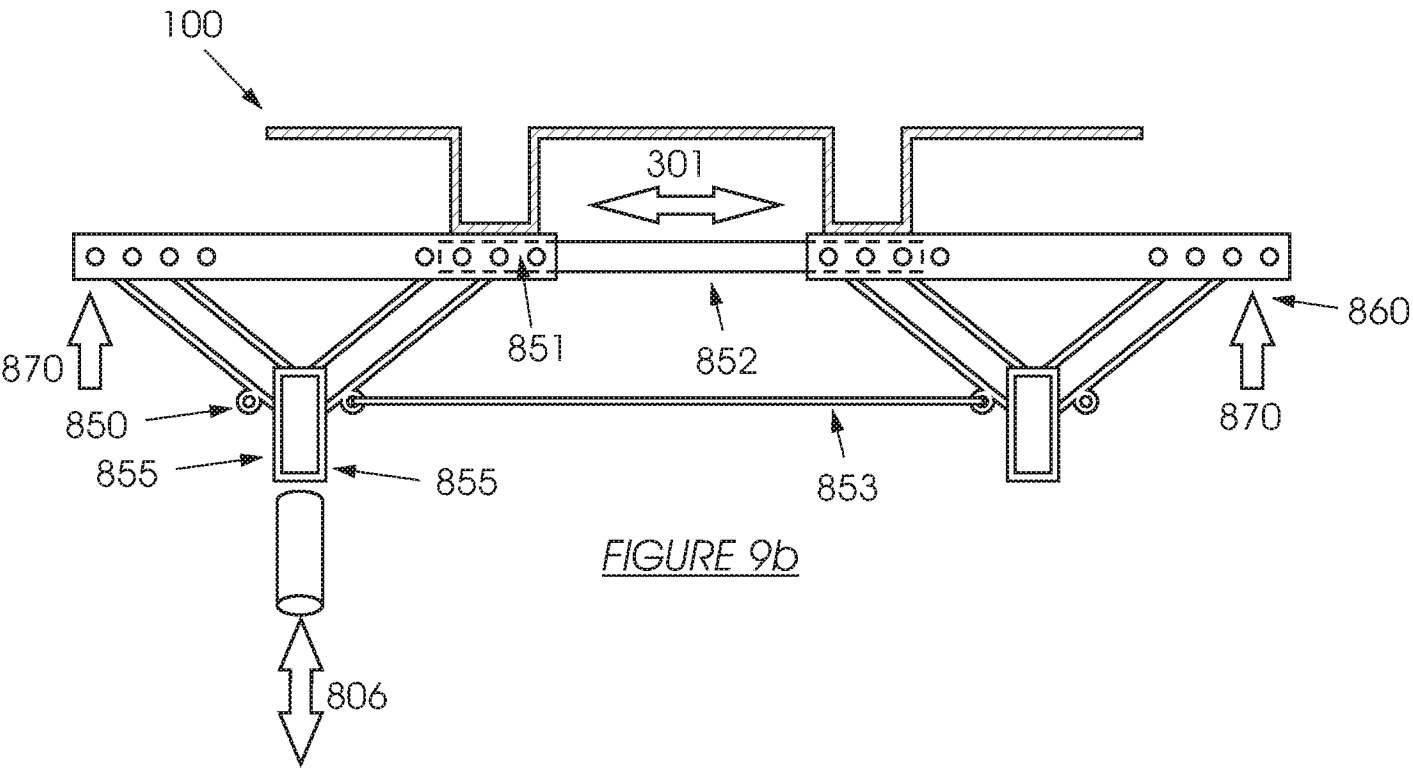


FIGURE 9b

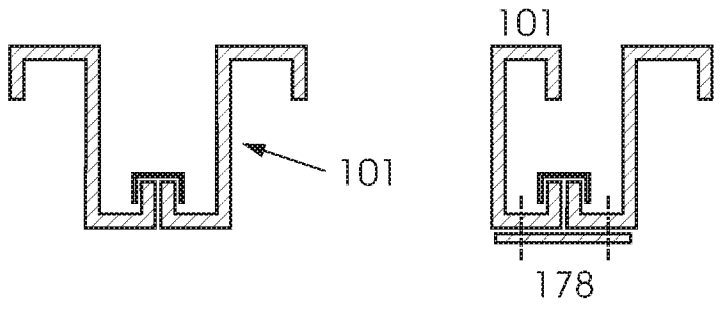
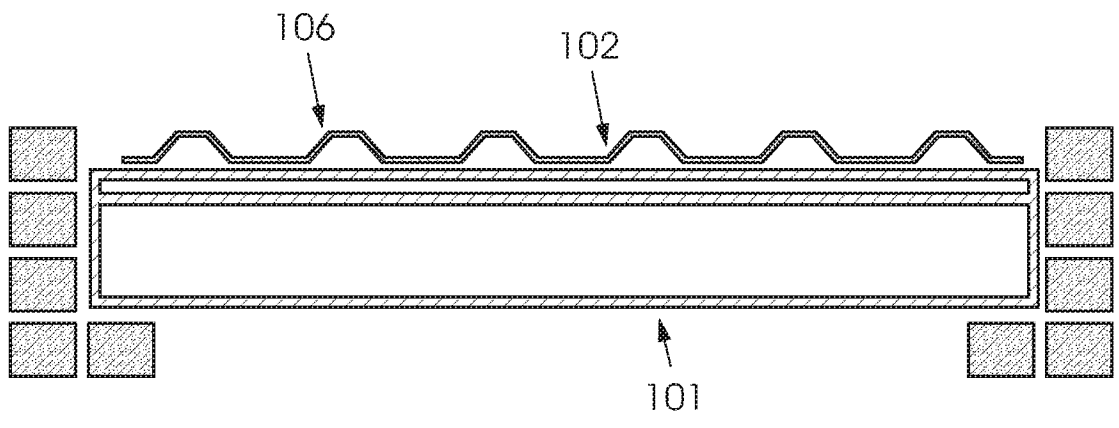


FIGURE 9c

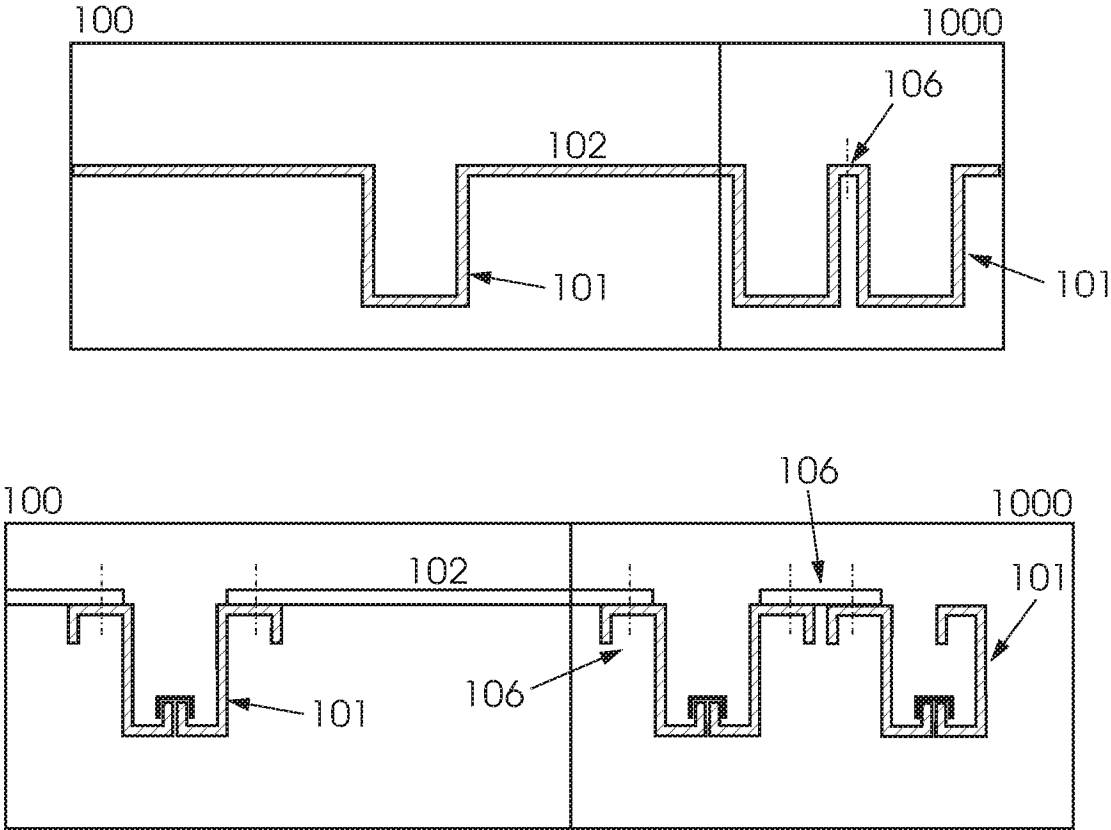


FIGURE 10

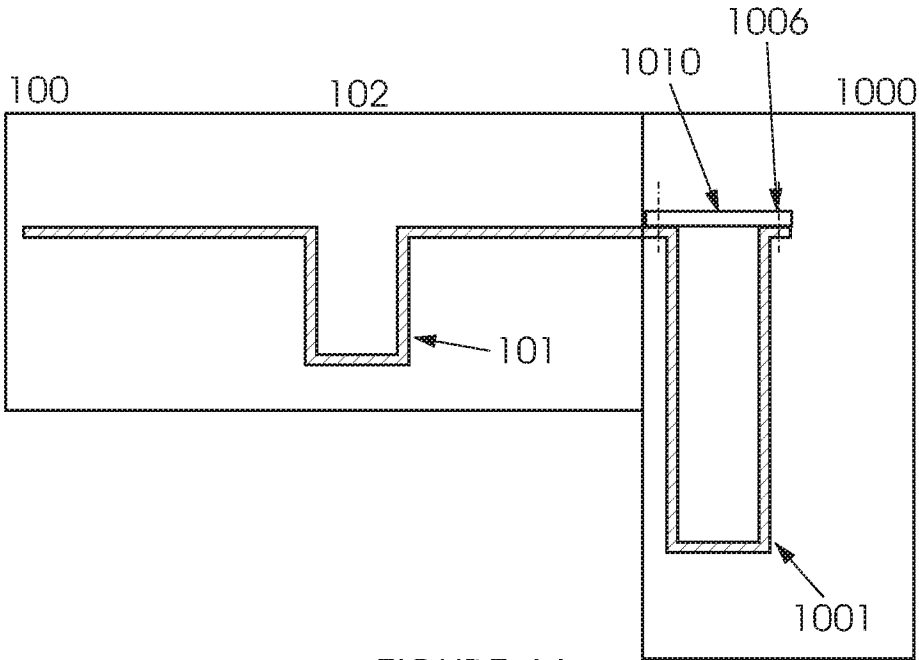


FIGURE 11

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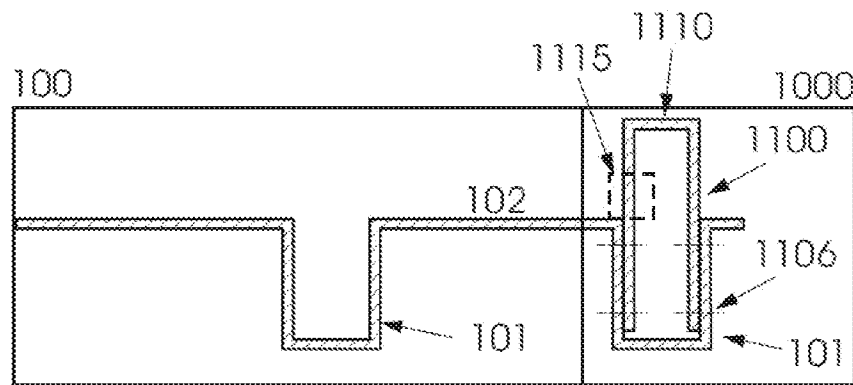


FIGURE 12

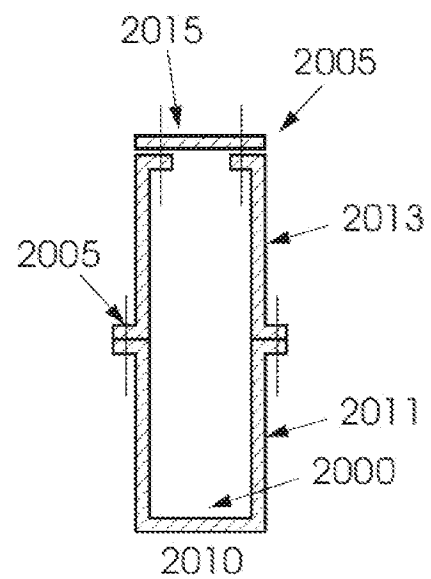
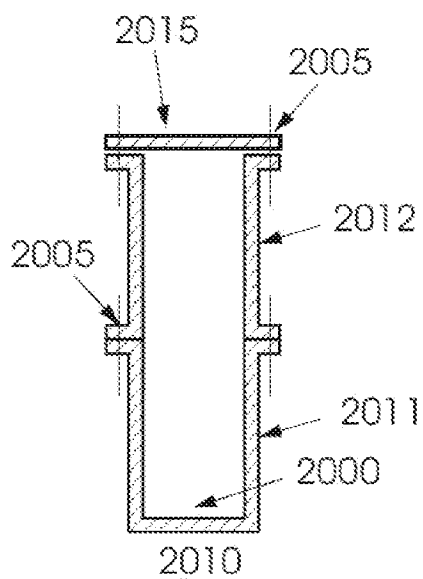


FIGURE 13

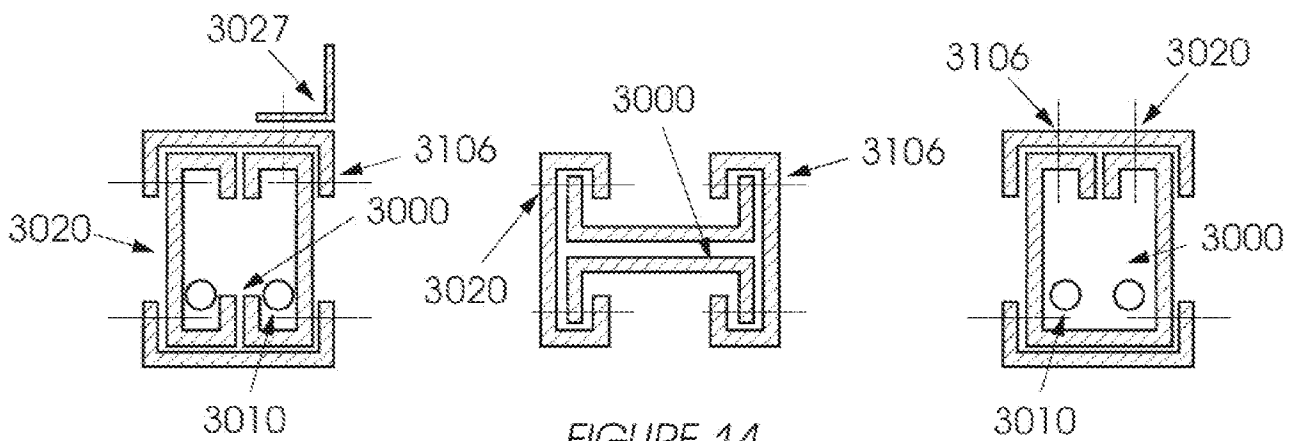


FIGURE 14

INTERNATIONAL SEARCH REPORT

International application No.

PCT / IB 2018/059344

A. CLASSIFICATION OF SUBJECT MATTER		
IPC: E04G 11/46 (2006.01); E04B 5/40 (2006.01); E04B 1/16 (2006.01); E04G 9/06 (2006.01); E04G 17/04 (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) E04B, E04G		
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) PATENW, PATDEW		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 20160145261 A (N I STEEL CO LTD [KR]; THE NAEUN STRUCTURAL ENG CO LTD [KR]) 20 December 2016 (20.12.2016) whole document, particularity [0030]	1 - 12
X	WO 2016183639 A1 (LIFTING POINT PRE-FORM PTY LIMITED) 24 November 2016 (24.11.2016) whole document, particularity page 14, lines 26 - 28	1 - 12
X	US 3113402 A (BUTLER DONALD H) 10 December 1963 (10.12.1963) whole document	1 - 12
X	KR 20100055759 A (LEE, CHANG NAM) 27 May 2010 (27.05.2010) whole document, particularity [0023]	1 - 12
☒ Further documents are listed in the continuation of Box C. ☒ 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 20 February 2019 (20.02.2019)		Date of mailing of the international search report 27 February 2019 (27.02.2019)
Name and mailing address of the ISA/AT Austrian Patent Office Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24-535		Authorized officer LACKNER S. Telephone No. +43 / 1 / 534 24-353

INTERNATIONAL SEARCH REPORT

International application No.

PCT / IB 2018/059344

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 20150090659 A (CHOI, WAN GYU, KIM, SOO CHANG, YOO, JIN OOH) 06 August 2015 (06.08.2015) whole document	1 - 12
A	DE 2503132 A1 (BASTGEN,ALOYS) 29 July 1976 (29.07.1976) whole document	1 - 12
A	JP 2010121271 A (NIKKEN BUILD:KK) 03 June 2010 (03.06.2010) whole document	1 - 12
A	JP 2004036292 A (TM GIKEN KK) 05 February 2004 (05.02.2004) whole document	1 - 12
A	JP H04149347 A (OTA KIZAI KK) 22 May 1992 (22.05.1992) whole document	1 - 12

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT / IB 2018/059344

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WO	A1	2016183639	CN	A	107849854	2018-03-27
			BR	A2	112017024905	2018-07-31
			EP	A1	3298216	2018-03-28
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			EA	A1	201792449	2018-05-31
			CA	A1	2985523	2016-11-24
			WO	A1	2016183639	2016-11-24
			AR	A1	108960	2018-10-17
			KR	A	20180011125	2018-01-31
			PH	A1	12017502091	2018-05-07
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			US	A1	2018155886	2018-06-07
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