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(54) Modular building

(57) A modular building is made of prefabricated modules (10), which each form a module volume and which are arranged in at least an upper and a lower floor level with a horizontal module distance (NZ) between adjoining module volumes. The modules (10) are interconnected by a plurality of connecting devices (60), which each cooperate with four modules (10A-10D), consisting of two modules in the lower floor level and two modules in the upper floor level. Each module (10) is prefabricated with a plurality of vertical sectional elements (30, 32), which each have a length exceeding the height of the module volume. For each connecting device (60), two upper vertical sectional elements, each belonging to one of the two upper modules, stand via the connecting device on two lower vertical sectional elements, each belonging to one of the two lower modules. The connecting devices (60) are provided with positioning elements (66, 68), which cooperate with the two upper and the two lower vertical sectional elements to position them relative to each other in the horizontal plane.

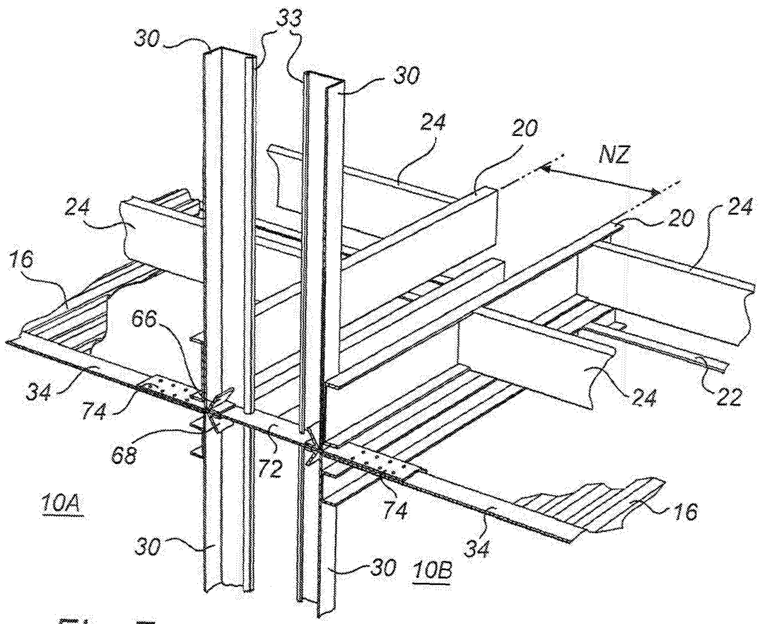

Fig. 7

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Description

Field of the Invention

[0001] The invention relates generally to the field of modular buildings. More specifically, the inventive concept relates to modular buildings of the type built of a plurality of prefabricated volume modules, preferably light-weight modules made of sheet-metal sections. The invention also relates to a method of manufacturing such a building and also a prefabricated module for this purpose.

[0002] The invention makes it possible to manufacture such modular buildings using so-called light-weight construction engineering (in contrast to traditional building constructions) and industrially prefabricated light-weight modules that require a small number of mounting operations at the building site.

Background Art

[0003] WO 91/05118 discloses a modular building of the above type comprising a skeleton or frame construction consisting of vertical columns and horizontal bars and beams which are joined to each other in a torsionally rigid manner in joints of the frame construction. The larger the building, the higher construction requirements are placed on the rigidity of the frame of the building. Both horizontal forces (wind forces) and vertical forces (payloads and dead weights) are transferred to the frame construction. The existence of and the demand for such torsionally rigid joints cause a great technical problem, in particular to solve all the rigidity requirements that are placed on a modular building, especially torsionally rigid joints where different materials, forces and functions meet.

[0004] SE 9404111-8, with the same inventor as the present application, discloses a modular multistorey building which, with respect to force take-up, is divided into (i) an inner zone, which takes up vertical forces and comprises columns with the volume modules suspended therefrom on several floor levels and which essentially does not take up any lateral forces acting on the building, and (ii) a façade zone, which is arranged immediately outside the inner zone and takes up lateral forces for lateral stabilisation of the inner zone and hence the entire building. The façade zone comprises a plurality of façade panel elements which are distributed along the outside of the inner zone and vertically oriented perpendicular to the façade of the building. In this solution, use is thus not made of horizontal beams as included in prior-art frame constructions. The payloads and dead weights of the modules are distributed over and taken up by the columns in the inner zone while most of the horizontal wind forces acting on the building are taken up by the façade panel elements arranged perpendicular to the façade in the façade zone outside the inner zone. A drawback of this prior-art technique is that the necessary size and cost of the horizontally stabilising façade zone quickly increase as the number of floor levels in the building increases. In addition, the solution involving a special façade zone is not quite satisfactory.

[0005] WO 03/093593, with the same inventor as the present application, discloses a modular building which like the building according to SE 9404111-8 has a plurality of vertical module-supporting columns. Volume modules made of sheet-metal sections are supported by the columns in two or more floor levels. The volume modules are prefabricated with two frame edge beams which are stronger than said sheet-metal sections and which are each horizontally extended along an upper end wall edge of the volume module. In the embodiment illustrated, the frame edge beams are mounted in upper roof beams and arranged in the same plane as these. The frame edge beams are on the one hand linearly connected to frame edge beams of adjoining modules on the same floor level and, on the other hand, connected to the columns so that the horizontal position of the frame edge beams relative to the columns is fixed. In manufacture, first the columns for the first floor level are mounted. After that the prefabricated volume modules on the first floor level are mounted by the means of already mounted frame columns, the frame edge beams of adjoining modules on the first floor level being linearly connected to each other. Then the process is repeated by mounting the columns for the next floor level and, after that, mounting on these the modules of the second floor level. In the embodiments shown, the modules are supported by the columns so that they are vertically loaded essentially only by their dead weight and payloads. The stronger frame edge beams included in the volume modules, like the vertical frame columns separate from the modules, consist of steel girders, such as rolled steel.

Summary of the Inventive Concept

[0006] An object is to provide an alternative modular building system of the type stated by way of introduction.

[0007] A special object is to provide a modular building which is quick, inexpensive and effective to manufacture and mount and which requires a reduced number of operations at the building site and a reduced number of components for mounting.

[0008] According to the inventive concept, a modular multistorey building is provided, comprising

a plurality of prefabricated modules, which each form a module volume and which are arranged in at least an upper and a lower floor level with a horizontal module distance between adjoining module volumes in each floor level, said building being characterised in that

the modules are interconnected by a plurality of connecting devices, which each cooperate with four modules, consisting of two modules in the lower floor level and two modules in the upper floor level,

each module is prefabricated with a plurality of vertical sectional elements, which each have a length exceeding the height of the module volume,

for each connecting device, two upper vertical sectional elements, each belonging to one of the two upper modules stand via the connecting device on two lower vertical sectional elements each belonging to one of the two lower modules, and

each connecting device is provided with positioning elements, which cooperate with the two upper and the two lower vertical sectional elements to position them relative to each other in the horizontal plane.

[0009] In conformity with the building according to WO 03/093593, the modules included in the building are preferably prefabricated as "light-weight modules" of sheet-metal sections.

[0010] The term "module" does not relate in the first place to a normally closed volume, but rather a constructionally and initially open room or framework of sectional elements without side walls. The volume of the module ("module volume") can be considered to be defined by geometric surfaces (imaginary walls). Each module can be adjusted completely to the desired building shape and function and can especially constitute a room or part of a room together with adjoining modules in the same floor level. Thus, the modules can be provided with wall-forming vertical panel elements, at the factory and/or at the building site, depending on the planning of the rooms.

[0011] The "prefabricated modules" are prefabricated with at least their vertical sectional elements and top and bottom constructions joined by the same. The prefabrication includes preferably, but not necessarily, also many other elements, such as panel material, infill, etc.

[0012] By "prefabricated" is meant the state of the module when being positioned at the building site. Normally as many components as possible can be prefabricated at the factory, but it is also conceivable that certain parts are mounted later, both before and after positioning of the modules.

[0013] The connecting devices can be designed in many ways within the scope of the inventive concept. Each connecting device can be formed as an integral unit or be made of several parts which are assembled at the building site in connection with the mounting of the modules. For example, at least some of the positioning elements of the connecting devices may consist of separate parts which are mounted at the building site. It is also possible to form each connecting device of a lower part which interconnects the lower modules and an upper part which interconnects the upper modules, the upper and the lower part being interconnected horizontally in a suitable manner, for instance using a female-male configuration.

[0014] An advantage of the multistorey building according to the inventive concept is that it can be manufactured without using separate strong columns since vertical forces appearing in the building can be taken up directly by the vertical sectional elements of the modules.

[0015] A further advantage of the building according to the inventive concept is that the prefabricated modules can be interconnected at the building site with few mounting operations and with few components.

[0016] A special advantage of the building according to the inventive concept is that interconnection of the modules can be carried out with a plastic cover or the like still on the modules, thereby preventing undesirable rain leakage into the interconnected modules or at least significantly reducing such leakage.

[0017] The vertical sectional elements of the modules have several functions:

(i) In each individual module, the vertical sectional elements of the module work as construction elements for vertical joining of the top and bottom of the module, which means that additional vertical elements need not be included in the module for this purpose.

(ii) In the completed building, the vertical sectional elements work as elements taking up vertical forces, for take-up and transfer of vertical forces on the one hand from the module in which each vertical sectional element is included and, on the other hand, from superposed modules, whereby additional elements taking up vertical forces need not be included in the building for this purpose.

(iii) Owing to the length of the vertical sectional elements exceeding the height of the volume of the modules, the vertical sectional elements in the completed building will also form vertical spacers between the floor levels. This ensures that there is a vertical distance between the module volumes in adjoining floor levels, that is a vertical distance between the geometric bottom plane of the volumes below and the geometric floor plane of the volumes above. To this end, each vertical sectional element can have an upper extension or a lower extension to form said vertical spacers, or most preferred both an upper extension and a lower extension. There is thus an impact noise reducing gap in the vertical direction between the module volumes of the modules.

[0018] The modules may comprise, in addition to the above-mentioned vertical sectional elements, additional vertical elements, such as sections and/or panel elements, which do not satisfy all the above-mentioned functions.

[0019] The vertical sectional elements included in the modules may consist of, for instance, U sections, square sections or tubes. Preferably, the vertical sectional elements are sheet-metal sections, most preferred sheet-metal sections of high-strength steel. The thickness can be 1-4 mm, preferably less than 3 mm, and most preferred in the range 2.5-2.0 mm.

[0020] Like the vertical sectional elements, the connecting devices have several functions and can be considered multifunctional devices:

(i) A first function of the connecting devices is that by means of their positioning elements, they provide "passive" positioning in the horizontal plane of the upper modules relative to the lower modules, so that in the completed building the vertical sectional elements of the upper modules are reliably kept in the correct horizontal position in alignment with the vertical sectional elements of the lower modules. Thus, vertical forces can safely be passed down from the upper vertical sectional elements to the lower vertical sectional elements.

(ii) A second function of the connecting devices is that during the actual mounting of the building they can help to perform "active" module positioning in the horizontal plane. To this end, the positioning elements of the connecting devices can have guide surfaces, such as wedges, cones, inclined surfaces, convex surfaces or the like, which during the interconnection can cooperate with the vertical sectional elements to ensure active lateral guiding of the same. In a preferred embodiment, this active module positioning can take place in two steps. In a first step, active positioning of modules takes place in a lower floor level when the connecting devices are applied to already erected modules in this lower floor level. In a second step, active positioning takes place when the modules in the floor level above are mounted on the applied connecting devices. It will be appreciated that the degree of "active positioning" depends on how exactly the modules are arranged initially.

(iii) A third function of the connecting devices is that they function as transition elements in the vertical direction between the vertical sectional elements of the modules. Vertical forces from the vertical sectional elements of the upper modules are transferred via the intermediate connecting devices down to the vertical sectional elements of the lower modules. Vertical loads appearing in the building, originating mainly from the dead weights and payloads of the modules, can thus be transferred by the vertical sectional elements without these forces causing any moment of force in the joints that must be taken up by the connecting devices.

(iv) A fourth function of the connecting devices is that they function as horizontal distance or positioning elements between adjoining modules in the same floor level. A modular building according to the inventive concept has, as is known per se from WO 03/093593, "free" neutral zones in the horizontal direction between the volumes of adjoining modules in the same floor level. By varying the horizontal extent of the connection devices, the width of these neutral zones can easily be varied. As an example, a standard dimension of the neutral zone of, for instance, 300 mm can easily be increased to another dimension, such as 600, 900 or 1200 mm, by using corresponding connecting devices of different lengths. The floor dimensions of the building can thus easily be varied and the neutral zones can, depending on their width, be used for different functions and installations.

(v) A fifth function of the connecting devices is that each connecting device functions as a common platform for adjoining modules which rest on the connecting device, so that exact and similar levels of the floor can be obtained in these adjoining modules. This solves in an efficient and simple way a structural engineering problem which traditionally is very difficult to solve.

[0021] The construction can be implemented so that the connecting devices are effectively held in place due to the vertical load exerted on them by superposed modules standing on the connecting devices. Thus, the number of mounting steps at the building site can be reduced.

[0022] The connecting concept according to the invention makes it possible to provide a construction in which the connecting devices constitute the only "loose" construction elements to form the joints. The vertical sectional elements taking up vertical forces are included in the prefabricated modules and all connecting functions in the joints can be implemented with the connecting devices. Additional elements can also be mounted at the building site, especially panel elements (such as trapezoidal plates) over horizontal neutral zones between the modules.

[0023] The "passive" and "active" positioning functions of the connecting devices as described above comprise preferably at least passive positioning in all directions in the horizontal plane. Alternatively, the positioning may concern only limited horizontal positioning, for instance positioning which ensures that a horizontal minimum distance is maintained between adjoining modules.

[0024] To provide the "active" positioning or guiding during the actual mounting, the positioning elements of the connecting devices can preferably be formed with guiding surfaces, such as wedges, pyramids, cones, angled plates or the like.

[0025] Each connecting device can be formed as a completed unit comprising the positioning elements, in which case the connecting device is first mounted on two lower modules to connect and position them relative to each other, after which two upper modules are mounted on the connecting device. As an alternative, each connecting device can be made of several parts. In a preferred embodiment, a connecting device can be formed on the one hand of a horizontal distance element, which rests on the vertical sectional elements of the lower modules and supports the vertical sectional elements of the upper modules and, on the other hand, a number of separate positioning elements which are mounted on the horizontal distance element afterwards, that is at the building site during the assembly of the modules.

[0026] In one embodiment, the positioning elements of the connecting devices cooperate with the vertical sectional elements of the modules by at least some of the positioning elements being inserted into the ends of the vertical sectional elements. This results in a "smooth" construction by the positioning elements being concealed in the completed connection while at the same time the actual mounting will be simple since all connection can take place with vertical mounting.

[0027] In a preferred embodiment, each connecting device comprises at least two upper and two lower positioning elements, which are each inserted into one of the two upper and two lower vertical sectional elements, respectively. In other embodiments, a plurality of positioning elements can be used to position each vertical sectional element and, as will be described below, one and the same positioning elements can cooperate with both upper and lower vertical sectional elements.

[0028] As stated above, the vertical sectional elements of the superposed modules stand via the connecting devices on the vertical sectional elements of the subjacent modules. In a particularly preferred embodiment of the connecting devices, which is particularly suited to take up the existing vertical loads, each connecting device comprises a horizontally extended, plate-shaped element, which forms a horizontal spacer to maintain said horizontal module distance between the module volumes and which has an upper side supporting the two upper vertical sectional elements and an underside which is supported by the two lower vertical sectional elements. This solution provides a strong and stable construction which does not cause any moment of force in the connecting device.

[0029] It is preferred for the vertical sectional elements to comprise at least four vertical corner sections arranged along the vertical corner edges of the module. The vertical sectional elements may also comprise vertical central sections arranged centrally on two opposite sides of the module, whereby two adjoining modules can thus be interconnected at their corners as well as between the corners.

[0030] In an embodiment which makes it possible to place rectangular modules in different directions in the horizontal plane, each module has, in addition to its four vertical corner sections, four vertical central sections arranged in pairs centrally on two opposite long sides of the module, the central sections in each pair having a mutual horizontal distance corresponding to said horizontal module distance.

[0031] As mentioned above, the connecting means are adapted to transfer vertical loads between the floor levels and position the modules in the horizontal plane. To maintain a correct horizontal position of the modules when the building is subjected to wind loads, it is preferred for the connecting devices to also cooperate with the modules so that combined "traction and compression beams" are formed in the building. In a preferred embodiment, each module is further prefabricated with a plurality of upper horizontal sectional elements, here referred to as connecting sections, which are positioned above the geometric top plane of the module volume, and each connecting device engages two such connecting sections, each belonging to one of two adjoining modules, to transfer horizontal forces in the building in the longitudinal direction of the connecting sections. The connecting sections interconnected by the connecting devices serve to form, in each floor level, combined "traction and compression beams" in interconnected modules to transfer horizontal forces between the connecting sections in the longitudinal direction of the same.

[0032] The engagement between the connecting devices and the connecting sections may comprise screw joints, such as self-tapping screws, and/or the engagement can be formed by extensions of the connecting device having downwardly projecting engaging portions and the upper horizontal sectional elements of the lower modules being formed with recesses or the like, in which the downwardly projecting portions are inserted and engage. The engaging portions can consist of, for instance, a plurality of punched bulges and depressions. Particularly the system can be made without using bolts and rivets.

[0033] In a preferred embodiment, the engagement between the connecting devices and the connecting sections of the modules is performed by the positioning elements of the connecting devices, which positioning elements will have a double function: (i) horizontal positioning of the vertical sectional elements and (ii) transfer of horizontal traction and compressive forces between the connecting sections.

[0034] Preferably, the four vertical sectional elements and the two upper connecting sections, with which a given connecting device cooperates, form a common geometric vertical plane. In this embodiment, preferably also the upper connecting sections of the modules have end portions which extend inwards over the upper ends of the vertical sectional elements. Thus, each connecting device will rest on two vertical sectional elements via two such end portions. This embodiment also allows that at least some of the positioning elements of the connecting devices are adapted to provide, while at the same time performing the horizontal positioning of the vertical sectional elements of adjoining modules, also said engagement between the connecting devices and the connecting sections for transferring horizontal forces in the building.

[0035] These and other embodiments are defined in the claims.

Description of a Preferred Embodiment

[0036] The above and other advantages, features and preferred embodiments will now be described in more detail with reference to the accompanying drawings.

Fig. 1 is a schematic perspective view of an embodiment of a module formed as a light-weight module, with certain components removed.

Fig. 2 is a schematic exploded view of a modular building made of four modules according to Fig. 1, interconnected by connecting elements according to Figs 4A and 4B.

Fig. 3 illustrates schematically how vertical forces are passed down through vertical sectional elements of the modules in a modular building.

Figs 4A and 4B illustrate in perspective from above and from below, respectively, a first embodiment of the connecting device.

Fig. 5 is an exploded view from above, in perspective, of a joint between four modules, comprising a connecting device according to Figs 4A and 4B.

Fig. 6 is a perspective view from below of the joint in Fig. 5.

Fig. 7 is a perspective view from above of the joint in Figs 4 and 5 in the assembled state, sectioned in the vertical plane A-A in Figs 8 and 10.

Fig. 8 is a cross-sectional view of the joint in Fig. 7 taken in the vertical plane B-B in Fig. 9.

Fig. 9 is a cross-sectional view of the joint in Fig. 7 taken in the vertical plane A-A in Figs 8 and 10.

Fig. 10 is a broken-away top view of the joint in Fig. 7.

Fig. 11 is a schematic view from above of a floor level in a building, comprising eight interconnected modules, of which two are rotated through 90 degrees.

Figs 12A-12D correspond to the marked circles A-D in Fig. 11 and illustrate on a larger scale a relative orientation of interconnected vertical sectional elements.

Figs 13A and 13B are perspective views from above and from below, respectively, of an extended embodiment of a connecting element.

Fig. 14 is a perspective view from above in the form of an exploded view of a joint between four modules, comprising a second embodiment of a connecting device.

Figs 15A and 15B are vertical sections of the connecting device in Fig. 14.

Figs 16A and 16B illustrate a first embodiment with separate positioning elements in the form of yokes.

Fig. 17A and 17B illustrate a second embodiment with separate positioning elements in the form of plates.

Description of Embodiments

[0037] With reference to the accompanying drawings, different embodiments will now be described.

[0038] Reference is first made to Fig. 1, which illustrates a volume module generally designated 10. The construction, function and manufacture of the module 10 can largely be performed in accordance with that described in the above-mentioned WO 03/093593, as will be described below. However, the module 10 differs from prior art mainly in respect of the parts of the module which cooperate with or are included in the joints of the building and which take part in the transfer of vertical forces and horizontal forces.

[0039] The module 10 is prefabricated preferably at a place other than the building site, thereby allowing the use of the advantages of the factory as regards rational handling of materials, quality and efficiency. At the building site, the modules are put in place by a crane. The modules can be customised at the factory and be provided with the necessary components. Since the entire inner mounting of infill and installation components can also take place at the factory, high-technological and accuracy-demanding operations can take place within the controllable environment of the factory. They can thus be equipped as sanitary modules, residential modules etc.

[0040] The faces of the modules 10, that is the two long sides and the two short sides or end walls, can be opened so that a completed room can be built from one or more modules 10, depending on where wall elements are mounted on the modules. Such wall elements can be mounted at the factory and/or mounted at the building site.

[0041] In the preferred embodiment, the module 10 has a rectangular horizontal cross-section according to Fig. 1. In the shown example, which is not limiting, the volume of each module has the dimensions 3.6 m * 7.8 m. This does not include what is referred to below as "neutral zones" between the volumes of the modules 10 (see designation NZ in the Figures). The height of the module is in the example shown 3 m. More generally, the volumes of the modules can, for instance, have a width B and a length $L = N * B$.

[0042] The volume of the module 10 is defined by the following geometric planes: the two vertical side planes, the two vertical end wall planes, a horizontal top plane 12 and a horizontal bottom plane 14. As mentioned above, the vertical planes can be more or less closed by means of joists and/or panel material. As will be described below, parts of the module extend outside these planes, which define the "volume" of the module.

[0043] The top plane 12 and the bottom plane 14 are normally closed by panel elements 16, of which broken away parts are shown schematically in the form of trapezoidal plate. This trapezoidal plate is used to transfer horizontal forces. It should be noted that these panel elements 16 also constitute part of said "sheet-metal sections" of the module and are thus preferably included in the prefabricated module, especially the bottom plate.

[0044] In the shown embodiment, the module 10 is made of sheet-metal sections (beams/joists/battens/ panel elements/trapezoidal plates). The sheet-metal sections preferably have a material thickness of 1-4 mm, preferably less than 3 mm, and most preferred less than 2 mm, or 2 mm. The material is preferably high-strength steel for the vertical sectional elements and connecting sections that will be mentioned below.

[0045] More specifically, the module 10 comprises in the shown embodiment the following sheet-metal sections:

- two horizontal top sections 18 and two horizontal bottom sections 20, which together define the geometric top plane 12 of the module, the geometric bottom plane 14 of the module as well as two opposite geometric side planes of the module;
- a plurality of top battens 22 and bottom battens 24 (see Fig. 5), which are supported by the top sections 18 and the bottom sections 20, respectively, and are extended in the top plane 12 and the bottom plane 14, respectively;
- four vertical sectional elements 30 (below referred to as corner sections 30), which are arranged at the vertical corner edges of the module 10 outside said geometric side plane;
- four vertical sectional elements 32 (below referred to as central sections 32), which are arranged in pairs centrally on two opposite long sides of the module 10 and outside said geometric side plane;
- two upper horizontal sectional elements 34 with wings (below referred to as connecting sections; Fig. 5), which are fixedly mounted in the module at a level above the geometric top plane 12 in the same vertical plane as the vertical corner sections 30; and
- two further upper horizontal sectional elements 35 with wings (below referred to as connecting sections), which are fixedly mounted at a level above the geometric top plane in the same vertical plane as the vertical central sections 32, as shown in Fig. 1. The connecting sections are, like the vertical sectional elements, preferably made of high-strength steel.

[0046] In addition, depending on design and planning of rooms, end wall and side joists can be arranged, as well as sections for mounting of such end wall joists, side joists, insulation etc. Moreover wall panels, such as plasterboard, fibreboard and particle board, can be mounted on the long sides and end wall sides.

[0047] To provide improved load take-up capacity, the legs of the here U-shaped vertical sectional elements 30, 32 are further provided with inwardly bent edges 33, as illustrated in Fig. 7. Alternatively, the vertical sectional elements can have a different shape, such as a square profile.

[0048] The vertical sectional elements 30, 32 of the module 10, which comprise the four vertical corner sections 30 and the four vertical central sections 32, each have a vertical upper extension 36 (Fig. 8), which extends a distance upwards past the geometric top plane (in this embodiment 20 mm) to form vertical spacers between the floor levels of the building. The floor structure of the superposed modules will thus be positioned at a vertical distance from the ceiling structure of the subjacent modules, thereby preventing them from resting directly on each other.

[0049] As shown in Fig. 5, the horizontal connecting sections 34 are aligned with the vertical corner sections 30 and form together with these a "frame" in the form of an inverted U around the geometric top plane 12 of the module volume 10 and its two geometric side planes. Correspondingly, the centrally positioned connecting sections 35 and the vertical central sections 32 form two "frames" outside the geometric plane of the module, as illustrated schematically in Figs 1 and 2. Thus, the vertical sectional elements 30, 32 are positioned in the neutral zones of the building. In this embodiment, the length of the connecting sections 30 and 32 is selected so that each connecting section is fitted between the extensions 36 of two vertical sectional elements.

[0050] In the shown embodiment, the connecting section 34 has substantially the same height as the extensions 36 of the corner sections (see Figs 5 and 8), so that a connecting element 60, when mounted according to Figs 5-10, vertically abuts against both the extensions 36 of the vertical sectional elements and the upper side of the connecting section 34.

[0051] Furthermore, in the shown embodiment the vertical sectional elements 30, 32 also have shorter lower extensions which extend a distance downwards past the geometric bottom plane.

[0052] Reference is now made to Figs 4A and 4B, which illustrate a first embodiment of a multifunctional connecting device 60 for connecting light-weight modules 10 according to Fig. 1 to form a completed building according to Figs 2 and 3. In this embodiment, the connecting device 60 is also made of sheet metal, preferably high-strength steel, and has the shape of a U profile provided with wings 62. The base of the U constitutes a plate-shaped element 64 which forms the tip of the connecting device 60. The plate-shaped element 64 supports on its upper side two upper positioning elements 66, which are positioned at a predetermined horizontal distance from one another, corresponding to the width of the neutral zones NZ of the building. As shown in Fig. 4B, two lower positioning elements 68 are arranged on the underside of the plate-shaped element 64, straight below the upper positioning elements 66. While connecting the modules to each other at the building site, the positioning elements 64 and 66 are inserted into open ends of corresponding vertical sectional elements 30, 32 to position them in exact alignment with each other. To this end, the positioning elements 64, 66 are preferably formed with one or more guide surfaces 70, which facilitates the mounting of both the connecting devices 60 and the modules which are to be placed on the connecting devices 60.

[0053] In the embodiment in Figs 4A and 4B, each positioning element 66, 68 is made of a bent metal sheet which is fixedly connected to the plate-shaped element 64. Other embodiments with more guide surfaces are conceivable, such as cones, pyramids or the like.

[0054] The connecting device 60 has a central portion 72 positioned between the positioning elements 66, 68 and two opposing extensions 74. The extensions 74 are provided with means which allow the extensions to be brought into engagement with the connecting sections 34 of the modules, as will be described below. In this embodiment, these means consist of screw holes 76, for receiving preferably self-tapping screws 80 (see Fig. 9) in connection with mounting. The length of the two extensions 74 of the connecting device 60 is selected with regard to how far the connecting devices 60 are to extend over the connecting sections 34 and how great horizontal forces are to be transferred by the connecting device 60. In this embodiment, the extensions 74 are substantially of the same length as the central portion 72.

[0055] As illustrated in Figs 13A and 13B, the length of the central portion 72 of the connecting device 60 can be varied, thus making it possible to easily vary the width of the neutral zone NZ. In one and the same building, it is also conceivable to use several different types or sizes of connecting elements 60, if neutral zones of different widths are desired at different places in the building depending on the planning of rooms and the installations.

[0056] The U profile of the connecting device 60 is preferably dimensioned according to the outer dimensions of the upper connecting sections 34, 35 of the modules 10, so that the connecting device 60 in connection with mounting encloses the connecting section 34, 35 as shown in cross-section in Fig. 8. As a result, the connecting device 60 will also have the function of serving as a sideways positioning element, that is guiding of the modules in the lateral direction, perpendicular to the longitudinal direction of the connecting device 60. This is particularly preferred if the modules 10, when being set up, are not fully aligned with each other and possibly have a certain skewness. By applying the connecting devices 60, such skewness can be effectively eliminated.

[0057] With reference to Figs 2, 3 and 5-10, a method will now be described for manufacturing a modular building by means of light-weight modules 10 according to Fig. 1 and connecting elements 60 according to Figs 4A and 4B.

[0058] First a foundation will be made at the building site, here schematically shown in the form of plinths 90 on the ground 100 (Fig. 3). A first set of connecting elements 60 are then arranged on these plinths. In the schematic embodiment shown in Fig. 2, four light-weight modules 10A-10D are to be mounted, two lower modules 10A and 10B and two upper modules 10C and 10D. The marked circle C in Figs 2 and 3 represents a joint between these four modules and corresponds to the construction shown in Figs 5-10.

[0059] To support the two lower modules 10A and 10B, a total of twelve lower connecting elements 60' are used in this embodiment. It will be appreciated that these twelve lowermost connecting elements 60' in the building can have a significantly different appearance from that of the connecting elements 60 which are positioned centrally in the building. Thus, they can basically consist of only the plate-shaped element 64 and the upper positioning elements 66. It will also be appreciated that the connecting elements which are positioned along the sides of the building can possibly be made shorter since they are not used to connect adjoining modules to each other.

[0060] In the next step of the mounting, the two lower modules 10A and 10B are put in place by a crane, the downwardly open ends of the vertical sectional elements 30, 32 of the modules 10A, 10B receiving the upper positioning elements 66 of the already mounted connecting devices 60', whereby the lower modules 10A, 10B are positioned correctly both horizontally and vertically. When the lower modules 10A, 10B thus have been positioned, they usually do not have to be secured in the vertical direction, although this is of course possible.

[0061] With the modules 10 put in place, a neutral zone NZ exists between horizontally adjoining modules 10, which zone in the completed building can be bridged in a suitable manner in ceiling and/or floor if adjoining modules 10 are to be connected to each other. In particular, the connection of the ceiling elements of the modules may effectively help to stabilise the building. The interconnection of the floors of the modules makes it possible to form larger rooms.

[0062] In the next step of the mounting, twelve connecting elements 60 are mounted on the now set-up lower modules 10A, 10B, which is done by the lower positioning elements 68 being guided down into the upwardly open ends of the extensions 36 of the vertical sectional elements 30, 32, thereby making it possible to obtain additional positioning of the lower modules 10A, 10B.

[0063] When the four central connecting devices 60 in Fig. 2 are mounted, not only the vertical extensions 36 of the vertical sectional elements 30, 32 are taken up in the U profiles of the connecting devices 60, but also the upper connecting sections 34, 35 of the lower modules 10A, 10B, as well be best seen in Fig. 8, whereby the extensions 74 of the connecting devices 60 allow effective lateral positioning of the modules 10.

[0064] Depending on the design of the connecting devices 60, it is now possible as a next step to secure the extensions 74 of the connecting devices 60 in the upper connecting sections 34 of the modules 10, here by means of screw joints 80, so that horizontal traction and compressive forces can be transferred in the longitudinal direction of the connecting devices 60 between the thus linearly interconnected connecting sections 34.

[0065] As one of many alternatives to such screw joints, the connecting devices 60 and the connecting sections 34 can be formed with horizontally cooperating gripping means, such as projecting portions and corresponding depressions/recesses, so that this linear engagement is automatically achieved by the connecting devices 60 being mounted on the lower modules 10A, 10B. In such an embodiment, practically no vertical joint is required since the superposed modules 10C, 10D will effectively hold the connecting devices 60 in place.

[0066] With this second layer of connecting elements 60 now in place, the modules of the second floor level (here represented by the modules 10C and 10D) can be put in place by a crane, the same guiding principle being used as in the mounting of the lower modules 10A, 10B. The vertical sectional elements 30, 32 of the upper modules 10C, 10D will rest directly on the upper side of the connecting devices 60.

[0067] This mounting principle can be repeated to reach the desired height of the building, as shown for illustration purposes with a three-storey building in Fig. 3.

[0068] A special advantage offered by the invention is that the above-described interconnection of the modules can take place with a plastic cover or the like still on the modules, whereby it is possible to eliminate undesirable leakage of rain or at least significantly reducing such leakage.

[0069] When the modules are delivered from the factory, they are normally covered with plastic or the like. When the modules in the lower floor level are to be mounted, this can be done without necessitating removal of the leakage-protecting plastic cover. When the connecting devices 60 are then to be mounted on the set-up modules, this can also take place without removing the plastic cover. The connecting devices 60 can simply be pressed down in the plastic cover, which then is either torn over a limited area adjacent to the vertical sectional elements, or is kept intact if sufficiently "loosely" mounted on the module. Since no separate columns for take-up of vertical loads are required in the construction, there will be no leakage problems in mounting of such columns for subsequent floor levels either.

[0070] In the completed building, vertical forces originating from the dead weights and payloads of the modules are taken up essentially only in the vertical sectional elements 30, 34 of the modules 10, as indicated by force arrows in Fig. 3. In particular, no forces are transferred to special additional columns between the modules. This is a special advantage as regards the requirement for strength of the construction elements included. Since the vertical loads do not generate any moment of force in the joints, but are passed straight down into them, basically all construction elements can be made of sheet metal, preferably high-strength steel, if required. It should be particularly noted that the plate-shaped elements 64 of the connecting device 60 need not take up any moment of force generated by vertical forces, but only have to transfer the vertical forces linearly from the upper to the lower vertical sectional elements 30, 32.

[0071] A further advantage of moment of force not being generated in the joints is that the width of the neutral zone can very easily be varied by changing the central portion 74 of the connecting devices 60, as illustrated by examples in Figs 13A and 13B. Such an increase of the width of the neutral zone does not cause an increasing moment of force to arise in the joints of the building.

[0072] Regarding vertical forces, it should also be noted that the top plane/ceiling construction 12 of the lower modules 10A, 10B is positioned at a vertical distance from the bottom plane/floor construction 14 of the upper modules 10C, 10D, whereby the modules 10 basically do not exert vertical loads on each other, only via their vertical sectional elements 30, 34.

[0073] In the completed building, as is known from the above-mentioned WO 03/093593, the connecting sections 34, 35, interconnected by the connecting devices 60, of the modules 10 take up horizontal traction and compressive forces originating from, for instance, wind loads on the building. An advantage of the present inventive concept is, however, that the upper connecting sections do not have to be made in the form of strong steel girders and also that the upper connecting sections do not have to be mounted in the longitudinal light-weight sections as described in WO 03/093593, which gives advantages both in prefabrication at the factory and in mounting at the building site.

[0074] A module 10 according to the embodiment illustrated normally has a floor surface of about 27 m^2 or more, if extended. By combining two or more modules, they can be adjusted to optional plannings of rooms. Depending on the selected planning of rooms, stabilisation can take place in different ways, reference being made to WO 03/093593 for further details in this respect. This document also describes how modular buildings of the type intended by the present application can be provided with special frame stabilising elements, and also in this respect reference is made to WO 03/093593 for further details and options.

[0075] The interconnecting concept described above also makes it possible to interconnect modules which are placed in different directions. As an illustrative example, reference is now made to the plan view in Fig. 11, which shows eight interconnected rectangular modules 10_1-10_8 in a floor level. The six modules 10_1-10_6 are oriented in a first direction with their long sides interconnected, as marked in the circles A and B. The two remaining modules 10_7-10_8 are mounted perpendicular to the others, the module 10_7 being connected to the two modules 10_5 and 10_6, as marked in the circles C and D. Figs 12A-D illustrate schematically how the vertical sectional elements 30/32 of the modules are oriented inside the four circles A-D. In the cases A and B, the interconnection conforms with the above-described embodiment. In the cases C and D, particular, specially designed connecting devices may be required since connecting devices 60 according to Figs 4A and 4B cannot be made to intersect directly in the same vertical plane. Such a specially designed connecting device can have, for instance, the shape of a cross, a T or be formed as a purely plate-shaped element without vertical sides.

[0076] The inventive concept makes it possible to manufacture modular multistorey buildings with very flexible surface sizes, although the building technique is basically "modular". The rectangular modules 10 can easily be extended beyond the corner sections 30 by extending the top sections 18 and the bottom sections 20. In the other direction, the surface size can easily be varied by adjusting the size of the connecting devices 60, as illustrated in Figs 13A and 13B. With the stringent requirements that are currently placed on functional dimensions and which vary from area to area and from country to country, this flexibility makes it possible to satisfy the requirements without influencing the modular systematics and the production. The industrial output target with standard volumes can be maintained.

[0077] Reference is now made to Fig. 14 which is a schematic exploded view in perspective of an alternative embodiment of a connecting device 160.

[0078] This embodiment differs from the previous embodiment by the horizontal connecting sections 34 of the modules 10 being extended (at reference numeral 37) inwards over the upper ends of the vertical sectional elements 30 (and preferably also the ends of the vertical central sections 32). The extensions 37 are provided with a plurality of through holes 39 inside the area which corresponds to the cross-section of the vertical sectional elements 30. The connecting device 160 is shorter than the connecting device 60 in Figs 4A and 4B and is provided with a plurality of positioning elements 166 adapted to be received in the holes 39 in order to linearly interconnect the connecting sections 34. The positioning elements 166, here in the form of conical studs, will thus have the three functions of (i) positioning the lower vertical sectional elements in the horizontal plane, (ii) positioning the upper vertical sectional elements in the horizontal plane relative to the lower sectional elements, and (iii) linearly interconnecting the connecting sections 34. The advantage of this embodiment is on the one hand that mounting will be quicker and can be carried out with fewer operations and, on the other hand, that the completed construction will be smoother since no special connecting means, such as the screws 80, will be required outside the vertical sectional elements 30. However, it will be appreciated that the embodiments can be combined, for instance by also using screws 80 or the like in the embodiment in Fig. 14. As is evident from Figs 15A and 15B, which are cross-sectional views of the embodiment in Fig. 14, the two upper vertical sectional elements 30 each stand on the upper side of an extension 37 of a connecting section 34.

[0079] In Fig. 14, the studs are preferably fixedly mounted, such as welded, in the connecting device 166, which thus is an integral unit during mounting. In alternative embodiments, the connecting device may consist of a plurality of separate parts which will not be joined until in the interconnection of the modules. Two examples of this are illustrated in Figs 16A and B as well as in Figs 17A and B. In these two examples, the positioning elements of each connecting device consist of four yokes 266 and four toothed plates 366, respectively, which in the interconnection of the modules 10 are inserted into corresponding openings in the plate-shaped elements of the connecting device.

[0080] As regards the shape of the connecting device, it can be U-shaped, as shown in the examples, or only a plate-shaped element. It is also possible to combine these embodiments by using a thicker plate-shaped element which abuts against the lower vertical sectional elements and which is then enclosed by a less thick "hat profile" to stabilise the plate-shaped element, especially in the neutral zone.

Claims

1. A modular multistorey building comprising
a plurality of prefabricated modules (10), which each form a module volume and which are arranged in at least an upper and a lower floor level with a horizontal module distance (NZ) between adjoining module volumes in each floor level, **characterised in that**
the modules (10) are interconnected by a plurality of connecting devices (60; 160), which each cooperate with four modules (10A-10D), consisting of two modules in the lower floor level and two modules in the upper floor level,
each module (10) is prefabricated with a plurality of vertical sectional elements (30, 32), which each have a length exceeding the height of the module volume,
for each connecting device (60; 160), two upper vertical sectional elements, each belonging to one of the two upper modules, stand via the connecting device on two lower vertical sectional elements, each belonging to one of the two lower modules, and
each connecting device (60; 160) is provided with positioning elements (66, 68; 166; 266; 366), which cooperate with the two upper and the two lower vertical sectional elements to position them relative to each other in the horizontal plane.

2. A building as claimed in claim 1, wherein the modules (10) are prefabricated as light-weight modules of sheet-metal sections, preferably of high-strength steel for the vertical sectional elements.

3. A building as claimed in claim 2, wherein said sheet metal has a thickness of 1-4 mm, preferably less than 3 mm, and especially in the range of 2.0-2.5 mm.

4. A building as claimed in any one of the preceding claims, wherein the positioning elements (66, 68; 166; 266; 366) of the connecting devices (60; 160) cooperate with the vertical sectional elements (30, 32) of the modules (10) by at least some of the positioning elements (66, 68; 166; 266; 366) being inserted into the ends of the vertical sectional elements.

5. A building as claimed in any one of the preceding claims, wherein each connecting device (60) comprises at least two upper and two lower positioning

elements (66, 68), which are each inserted into one of the two upper and two lower vertical sectional elements, respectively.

6. A building as claimed in any one of the preceding claims, wherein at least some of the positioning elements (66, 68; 166; 266; 366) of the connecting devices are provided with guide surfaces to perform active positioning of the vertical sectional elements (30, 32) when the modules (10) are interconnected by the connecting devices.

7. A building as claimed in any one of the preceding claims, wherein each connecting device (60) comprises a horizontally extended, plate-shaped element (64), which forms a horizontal spacer to maintain said horizontal module distance (NZ) between the module volumes and which has an upper side supporting the two upper vertical sectional elements and an underside supported by the two lower vertical sectional elements.

8. A building as claimed in any one of the preceding claims, wherein the vertical sectional elements of each module (10) comprise four vertical corner sections (30) arranged along the vertical corner edges of the module (10).

9. A building as claimed in any one of the preceding claims, wherein the vertical sectional elements of each module (10) comprise vertical central sections (32) arranged centrally on two opposite sides of the module (10).

10. A building as claimed in claims 8 and 9, wherein each module (10) is rectangular in cross-section and has four such central sections (32) arranged in pairs centrally on two opposite long sides of the module, the central sections (32) in each pair having a mutual horizontal distance corresponding to said horizontal module distance (NZ).

11. A building as claimed in any one of the preceding claims,
wherein the volume of each module is defined at the top by a geometric top plane (12) and at the bottom by a geometric bottom plane (14), and
wherein the vertical sectional elements (30, 32) of each module have upper extensions (36) which extend up past the geometric top plane (12) to form vertical distance pieces which hold the bottom plane (14) of the upper modules (10C, 10D) at a vertical distance from the top plane (12) of the lower modules (10A, 10B).

12. A building as claimed in any one of the preceding claims,
wherein the module volume of each module (10) is defined at the top by a geometric top plane (12) and at the bottom by a geometric bottom plane (14), and wherein the vertical sectional elements (30, 32) of each module (10) have a lower extension which extends down past the geometric bottom plane (12) of the module (10) to form a distance piece which holds the bottom plane (14) of the upper modules (10C, 10D) at a vertical distance from the top plane (12) of the lower modules (10A, 10B).

13. A building as claimed in any one of the preceding claims,
wherein the volume of each module is defined at the top by a geometric top plane (12),
wherein each module (10) further is prefabricated with a plurality of upper connecting sections, which are positioned vertically above the geometric top plane of the module volume, and
wherein each connecting device engages two such connecting sections, each belonging to one of two adjoining modules, to transfer horizontal forces in the building in the longitudinal direction of the connecting sections.

14. A building as claimed in claim 13, wherein the four vertical sectional elements (30; 32) and the two upper connecting sections (34; 35) with which a given connecting device (60) cooperates form a common geometric vertical plane.

15. A building as claimed in claim 13 or 14, wherein at least some of the upper connecting sections (34) have end portions (37) which extend inwards over the upper ends of the vertical sectional elements (30; 32), so that each connecting device (160) rests on two vertical sectional elements via two such end portions.

16. A building as claimed in claim 15, wherein at least some of the positioning elements (166; 266; 366) of the connecting devices (160) are adapted to provide, while at the same time they provide said horizontal positioning of the vertical sectional elements of adjoining modules, also said engagement between the connecting devices (160) and the connecting sections (34) for transferring horizontal forces in the building.

17. A building as claimed in claim 13, wherein said engagement between the connecting devices and the connecting sections of the modules comprises screw joints (76, 80).

18. A building as claimed in claim 13, wherein, to provide said engagement between the connecting devices and the connecting sections of the modules, the connecting devices have downwardly extending engaging portions and said connecting sections (34; 35) have recesses or the like in which said downwardly extending engaging portions engage.

19. A building as claimed in any one of claims 3-18, wherein the connecting sections (34) of the modules (10) are made of sheet metal, preferably of high-strength steel.

20. A building as claimed in claim 19, wherein the connecting sections (34) of the modules (10) are made of sheet metal with a thickness of 1-4 mm, preferably less than 3 mm, and especially in the range of 2.0-2.5 mm.

21. A method for manufacturing a modular building with at least a first and a second floor level, from a plurality of modules prefabricated of sheet metal, which each define a module volume and have a plurality of vertical sectional elements (30, 32) with a length exceeding the height of the module volume, said method comprising
placing a number of said modules to form the first floor level, with a horizontal module distance (NZ) between adjoining module volumes;
mounting a plurality of connecting devices on the vertical sectional elements of the modules in the first floor level to connect and position said modules relative to each other in the horizontal plane, and
placing a number of said modules on the mounted connecting devices to form the second floor level, with a horizontal module distance (NZ) between adjoining module volumes;
in the completed building, each connecting device cooperating with four modules (10A-10D), consisting of two modules in the first floor level and two modules in the second floor level, and
for each connecting device (60; 160), two upper vertical sectional elements, each belonging to one of the two upper modules, standing via the connecting device on two lower vertical sectional elements, each belonging to one of the two lower modules, and
each connecting device (60; 160) being provided with positioning elements (66, 68; 166; 266; 366), which cooperate with the two upper and the two lower vertical sectional elements to position them relative to each other in the horizontal plane.

22. A prefabricated module for use in a modular multi-storey building as claimed in any one of claims 1-20, which module forms a module volume and is prefabricated with a plurality of vertical sheet-metal sectional elements (30, 32), which each have a length exceeding the height of the module volume so that in the completed building there is a vertical distance between module volumes in adjoining floor levels.

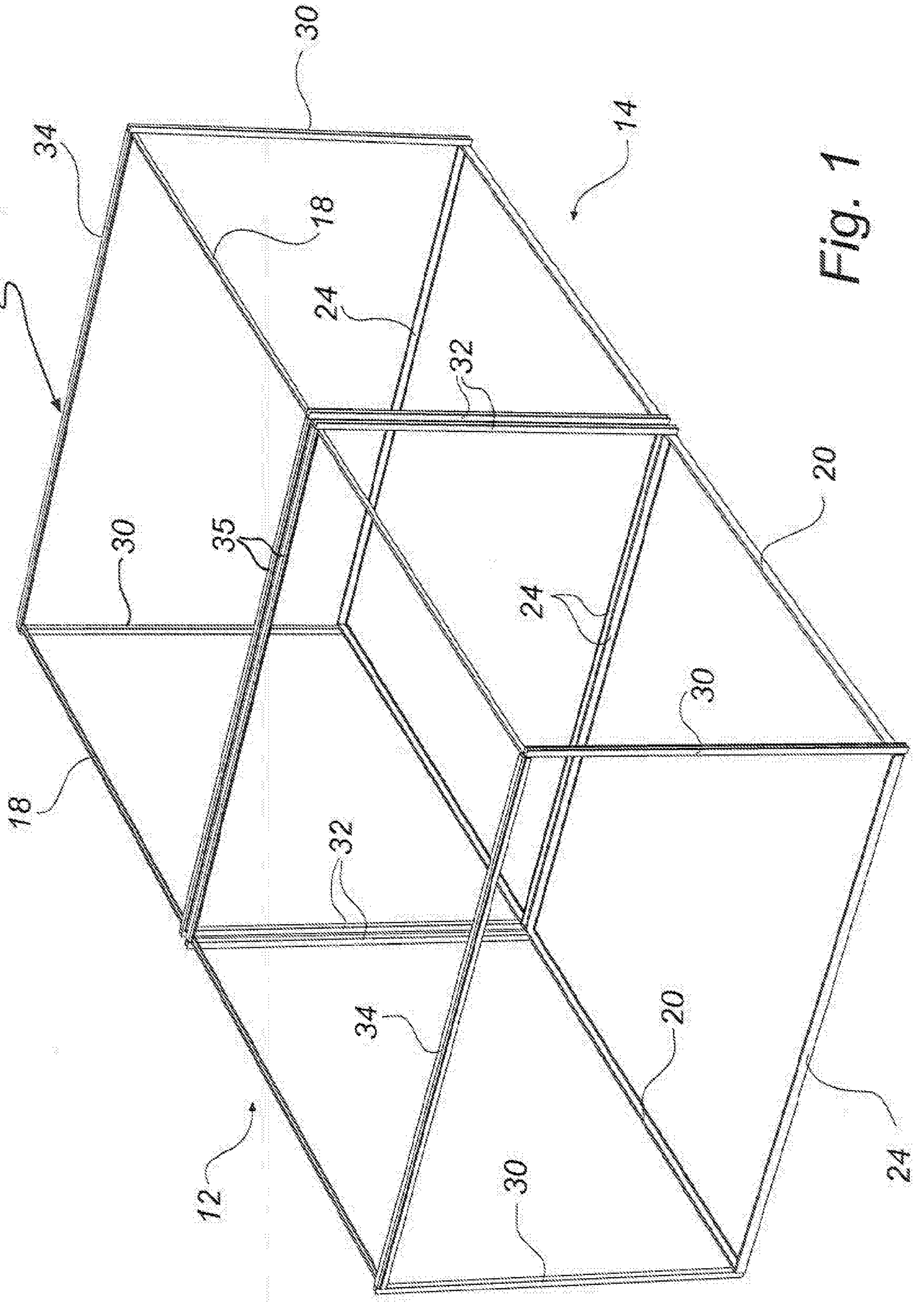


Fig. 1

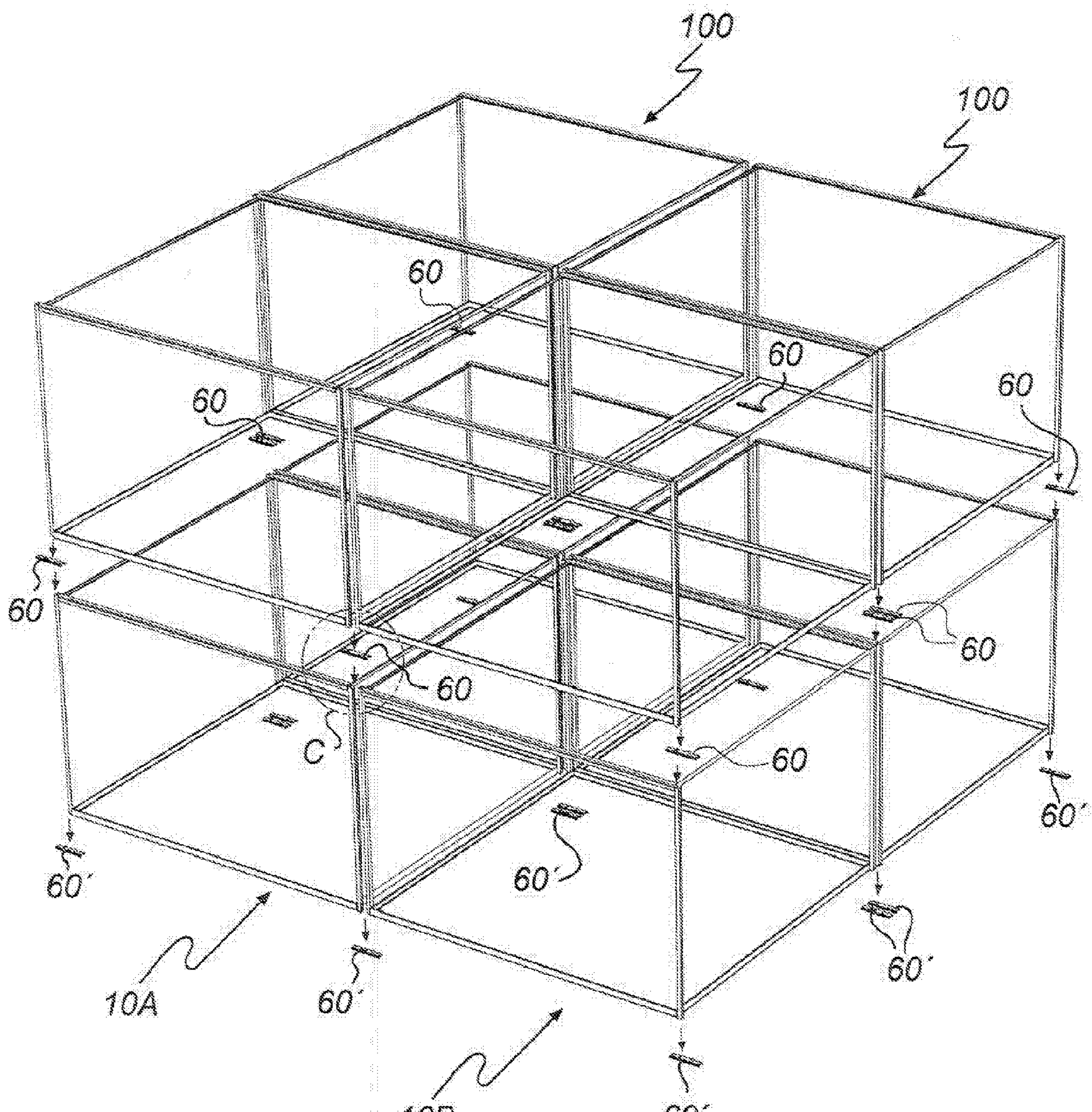


Fig. 2

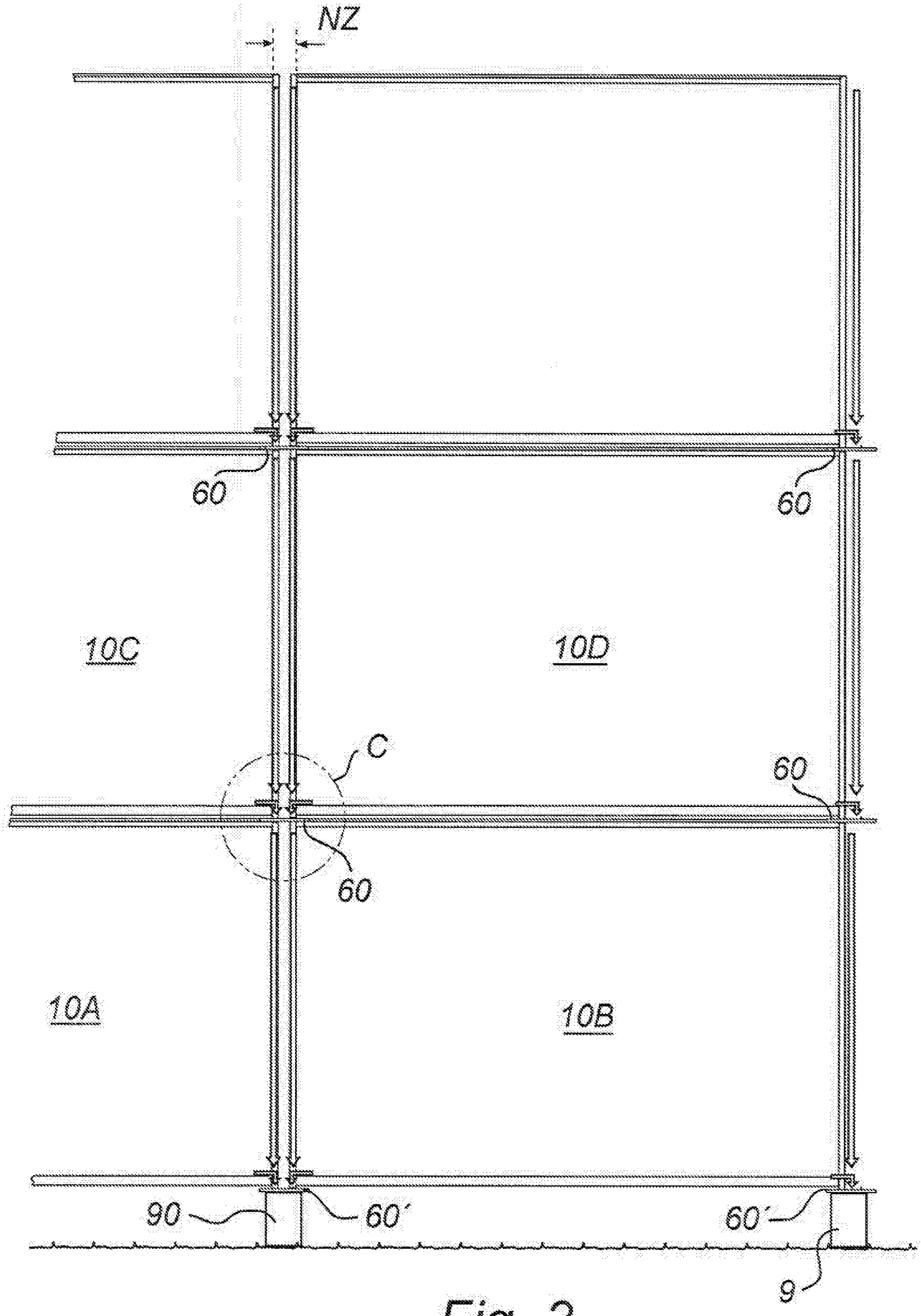


Fig. 3

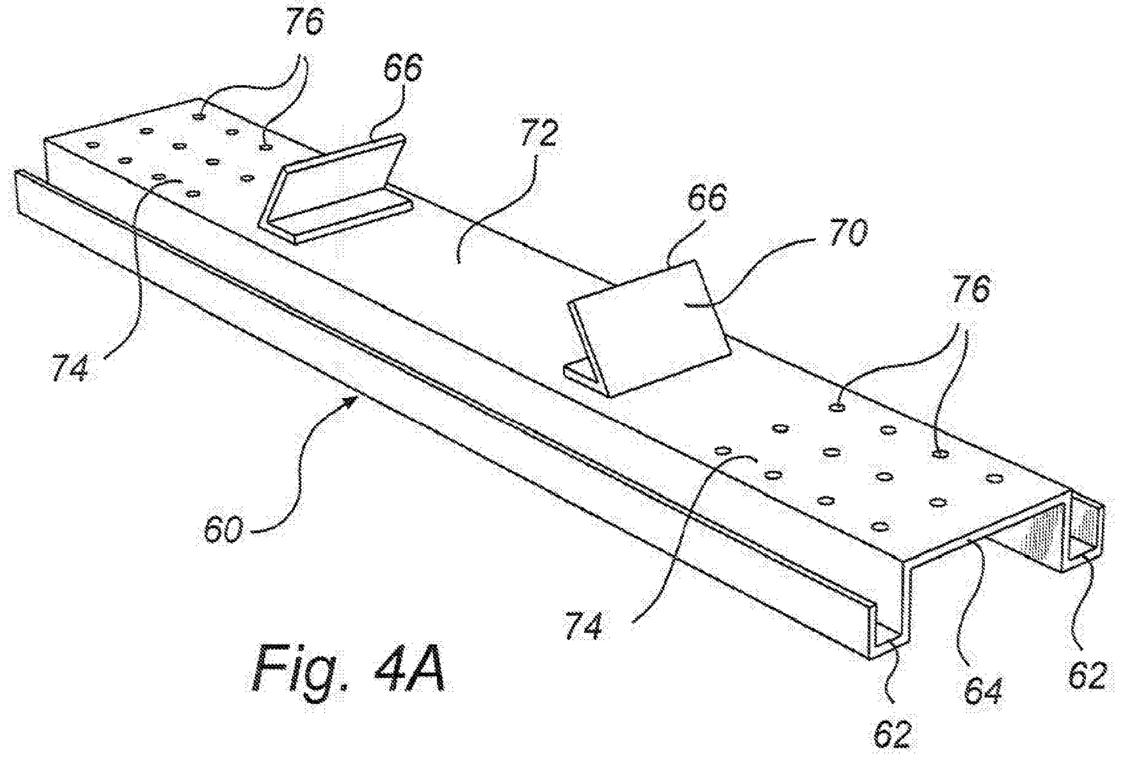


Fig. 4A

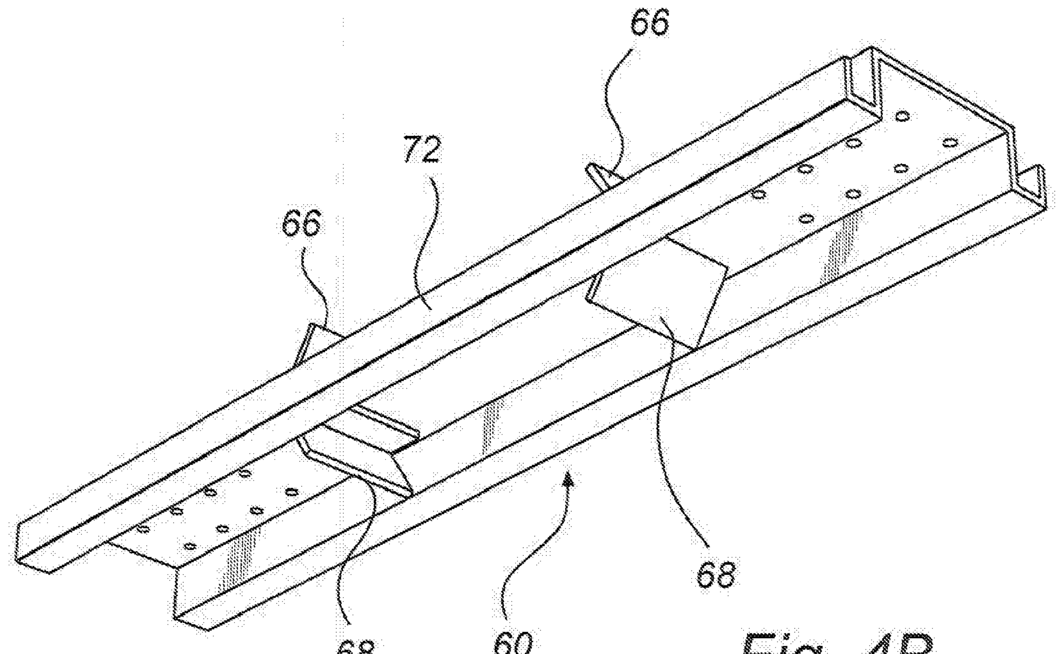
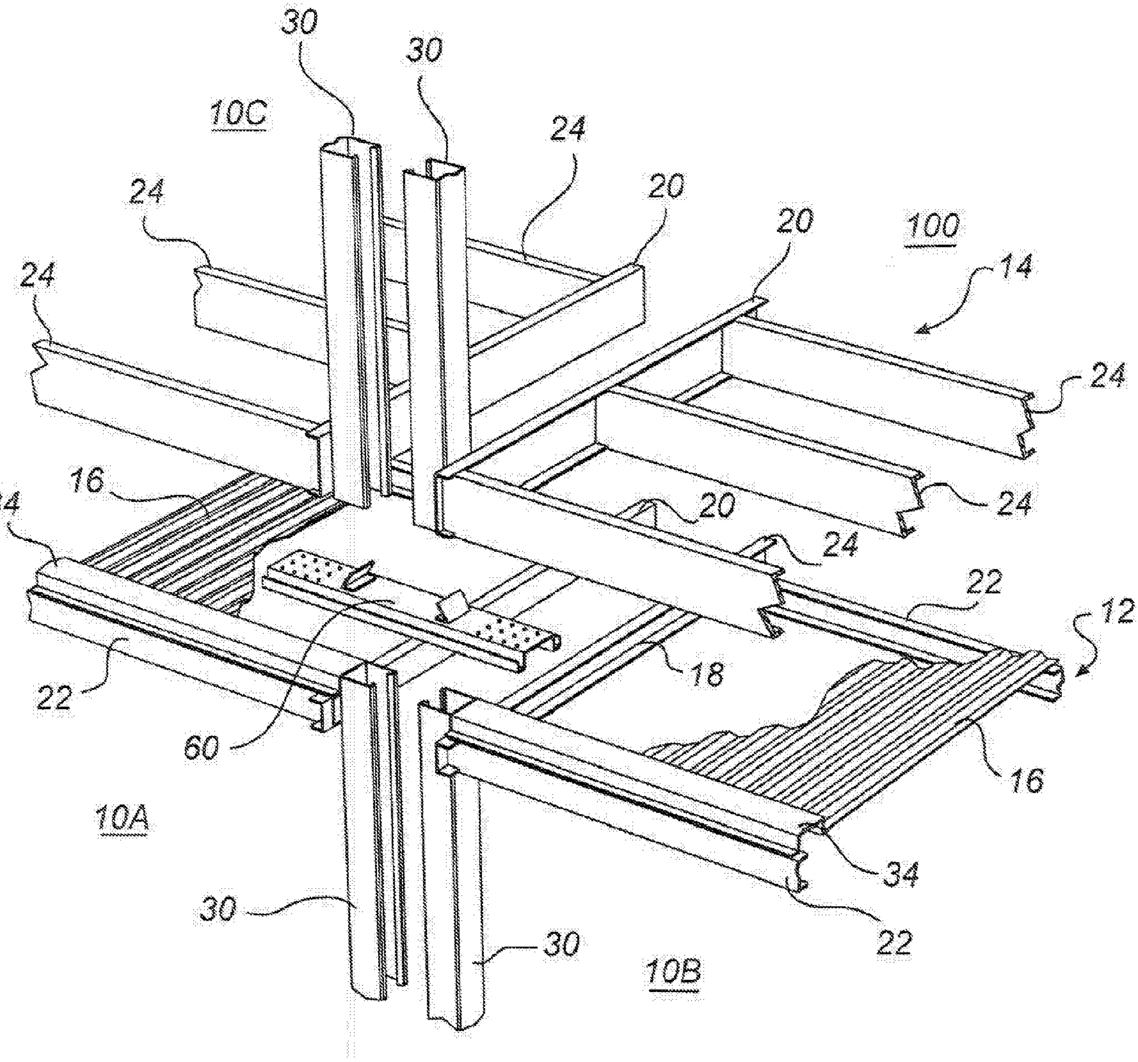


Fig. 4B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30
10C
24
24
20
20
100
14
24
24
16
34
24
20
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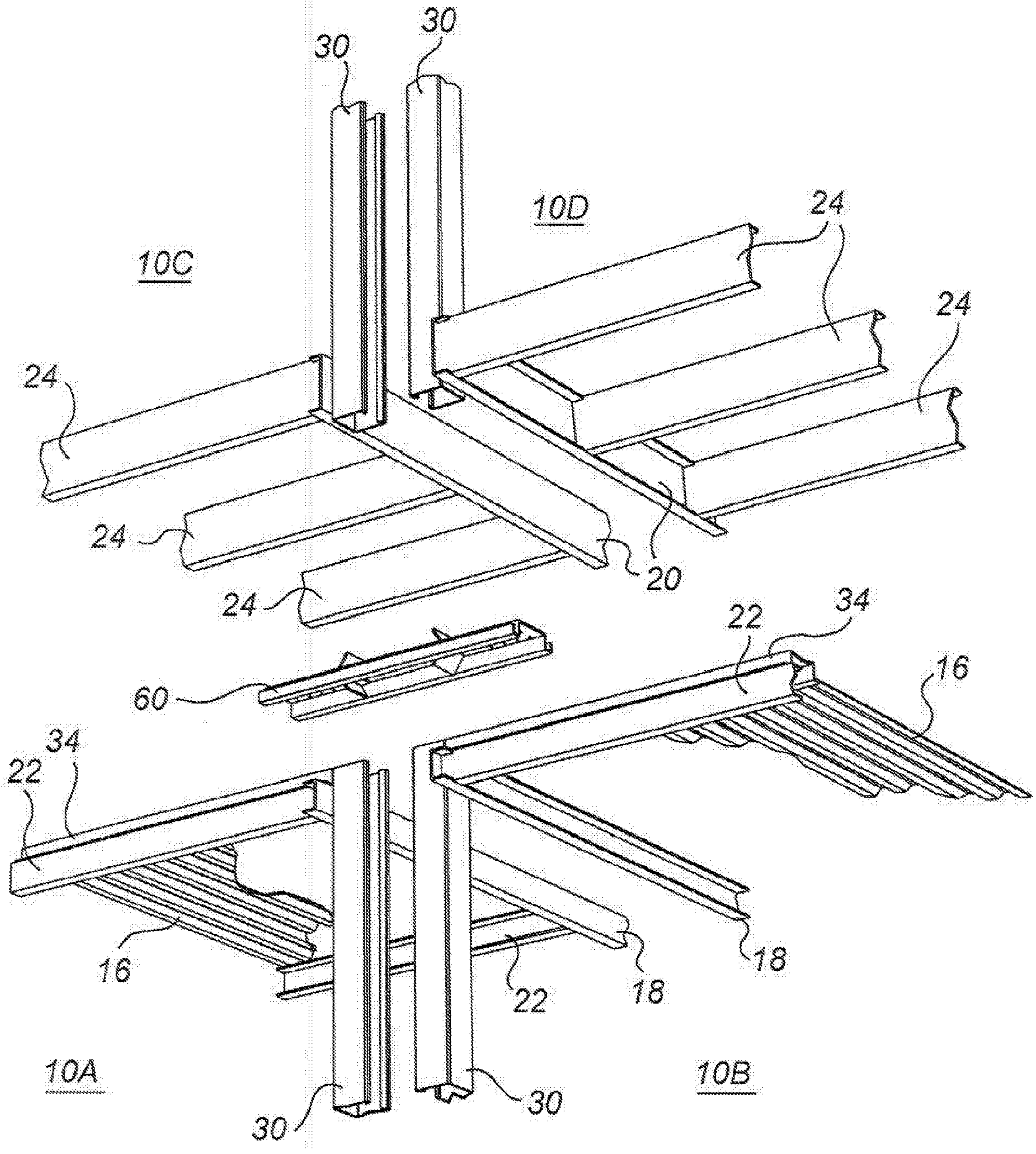
22
12
18
22
60
16
10A
34
30
22
30
10B

Fig. 5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10C
10D
24
24
24
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22
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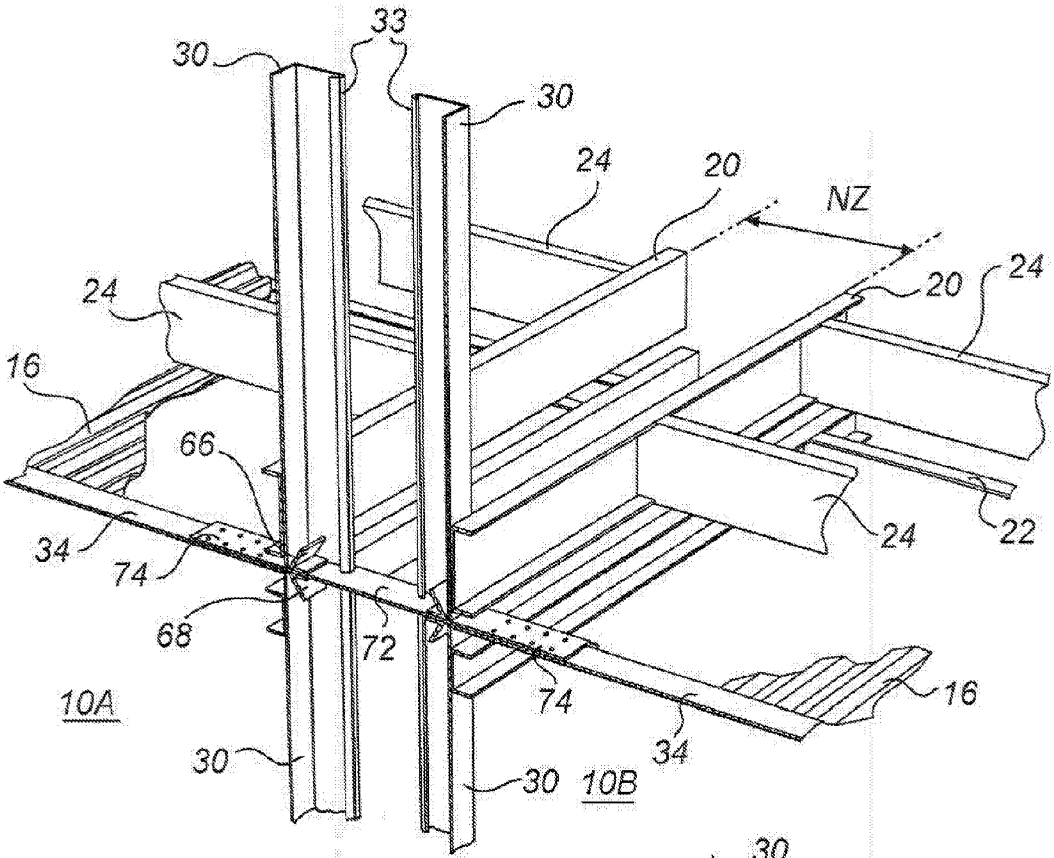
10A
10B
30
30

Fig. 6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33
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30
24
20
NZ
20
24
24
16
66
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74
68
72
74
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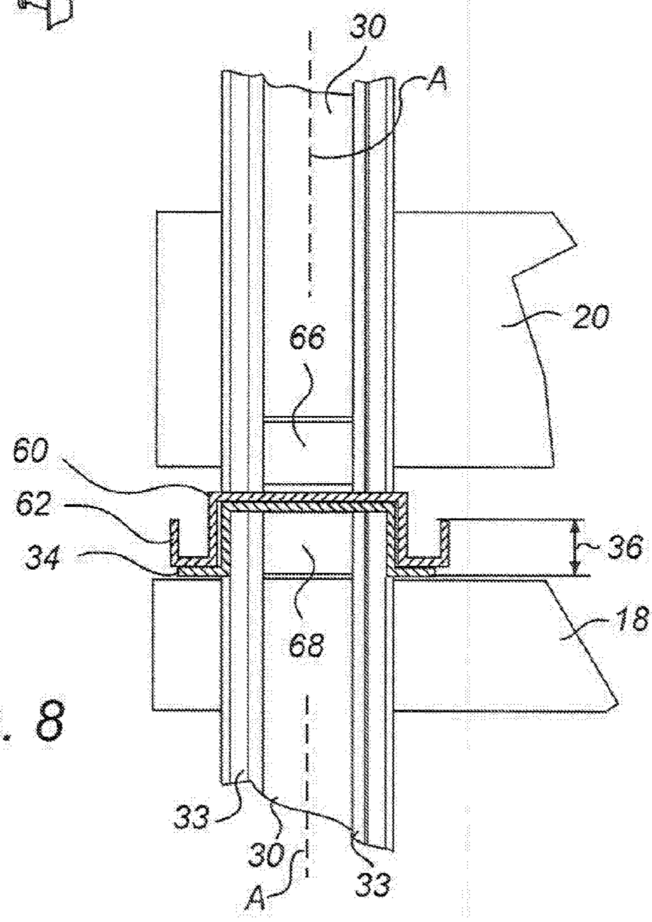
22
16
10A
30
34
30
10B

Fig. 7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66
60
62
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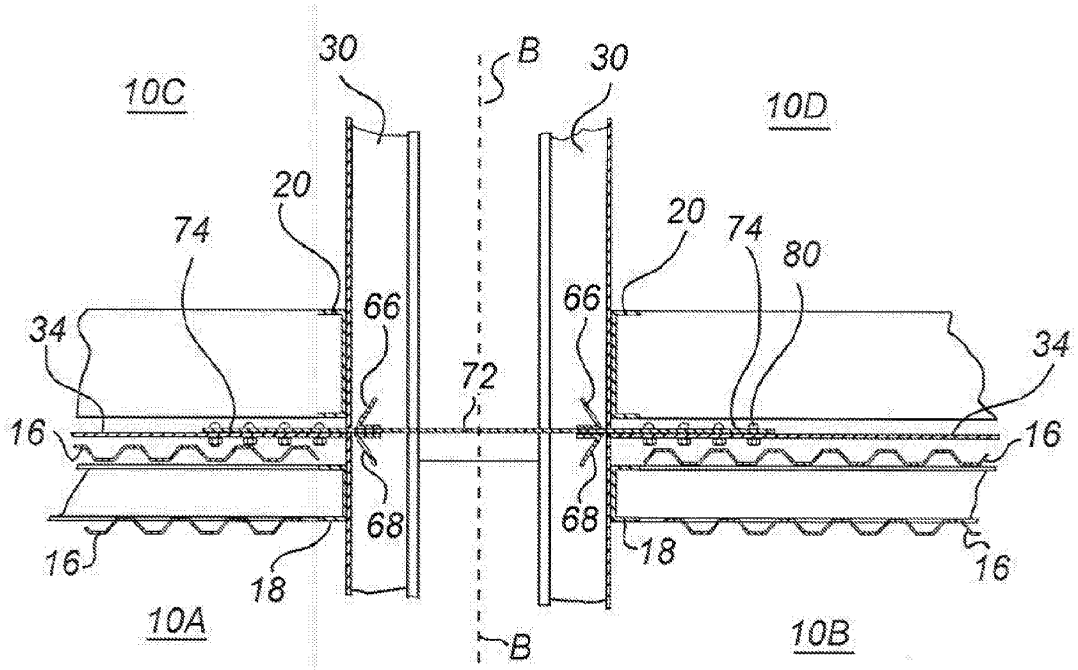
36
68
18
33
30
A
33

Fig. 8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10C
10D
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20
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80
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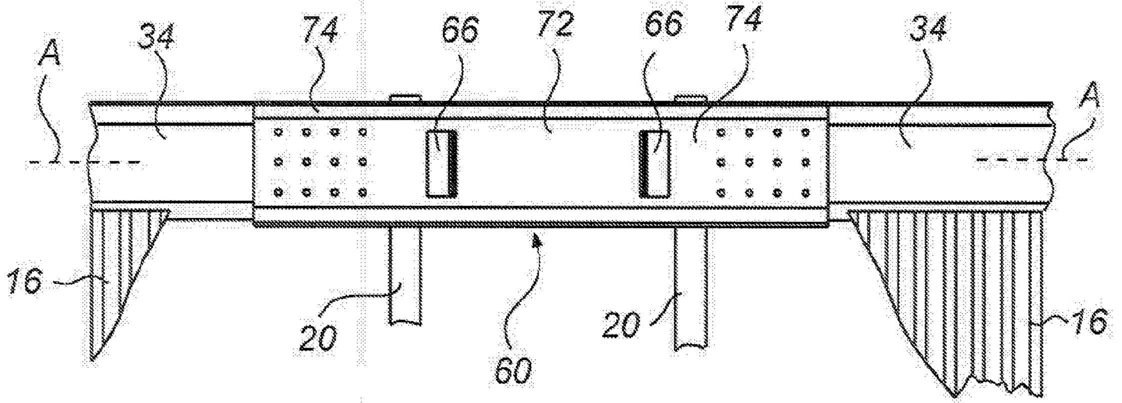
10A
10B
B

Fig. 9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72
66
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34
A
16
20
20
16
60

Fig. 10

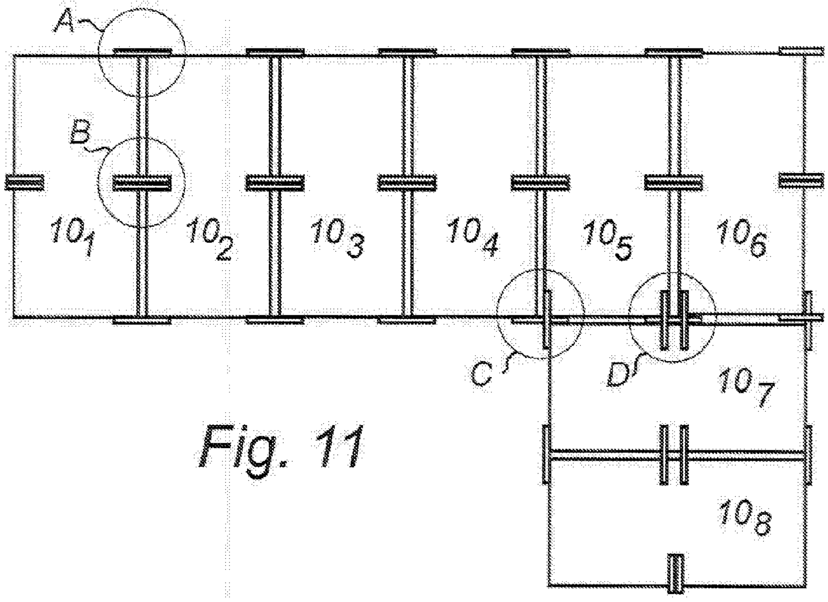
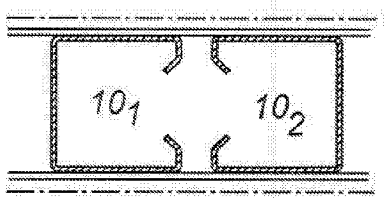


Fig. 11

Fig. 12A



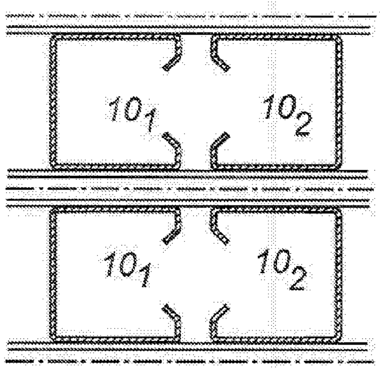


Fig. 12B

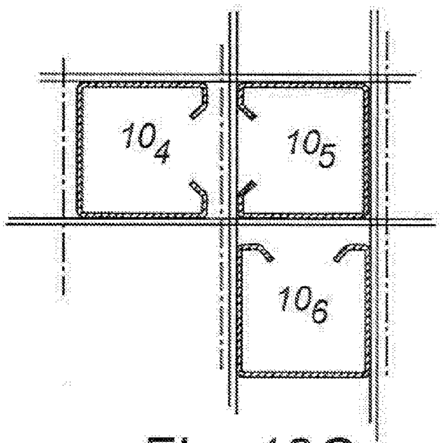


Fig. 12C

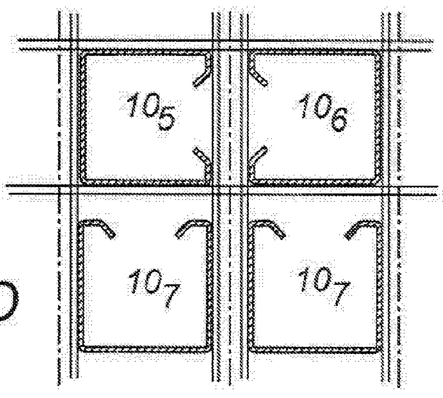


Fig. 12D

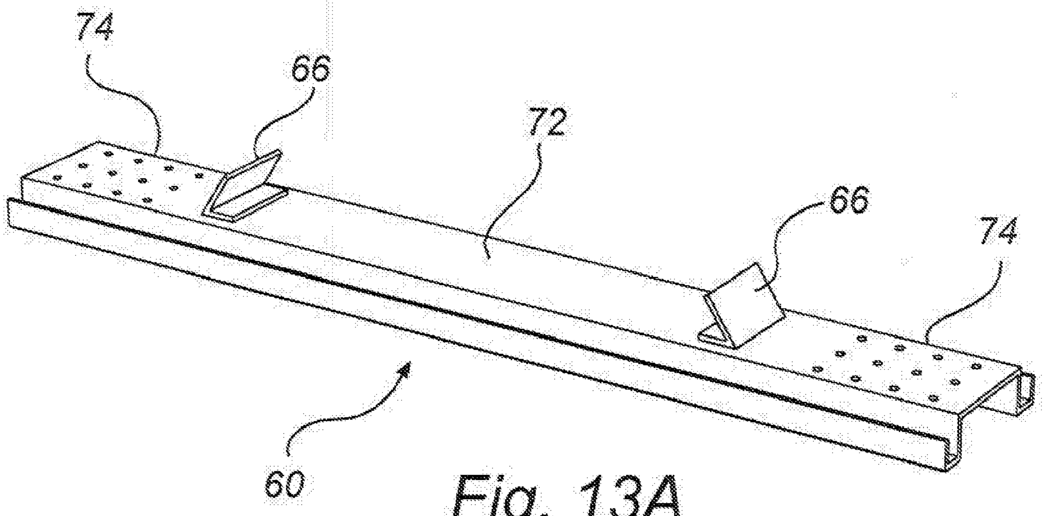


Fig. 13A

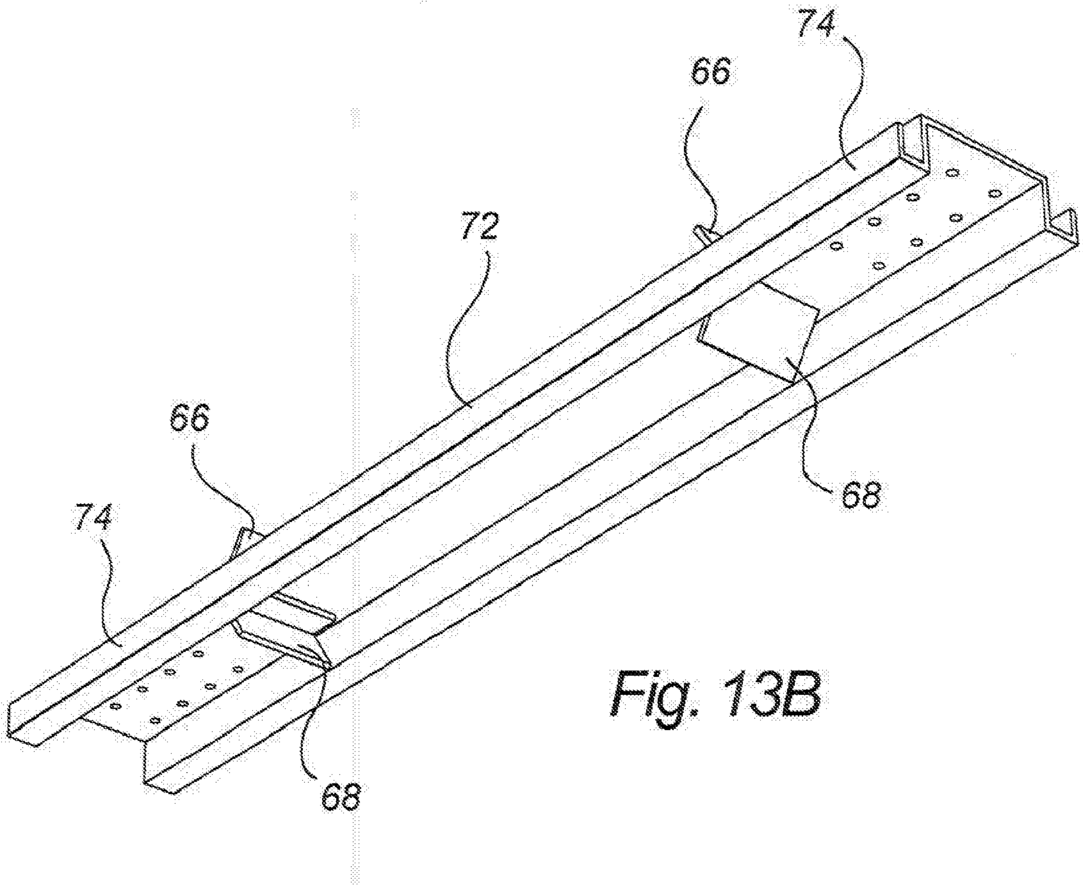


Fig. 13B

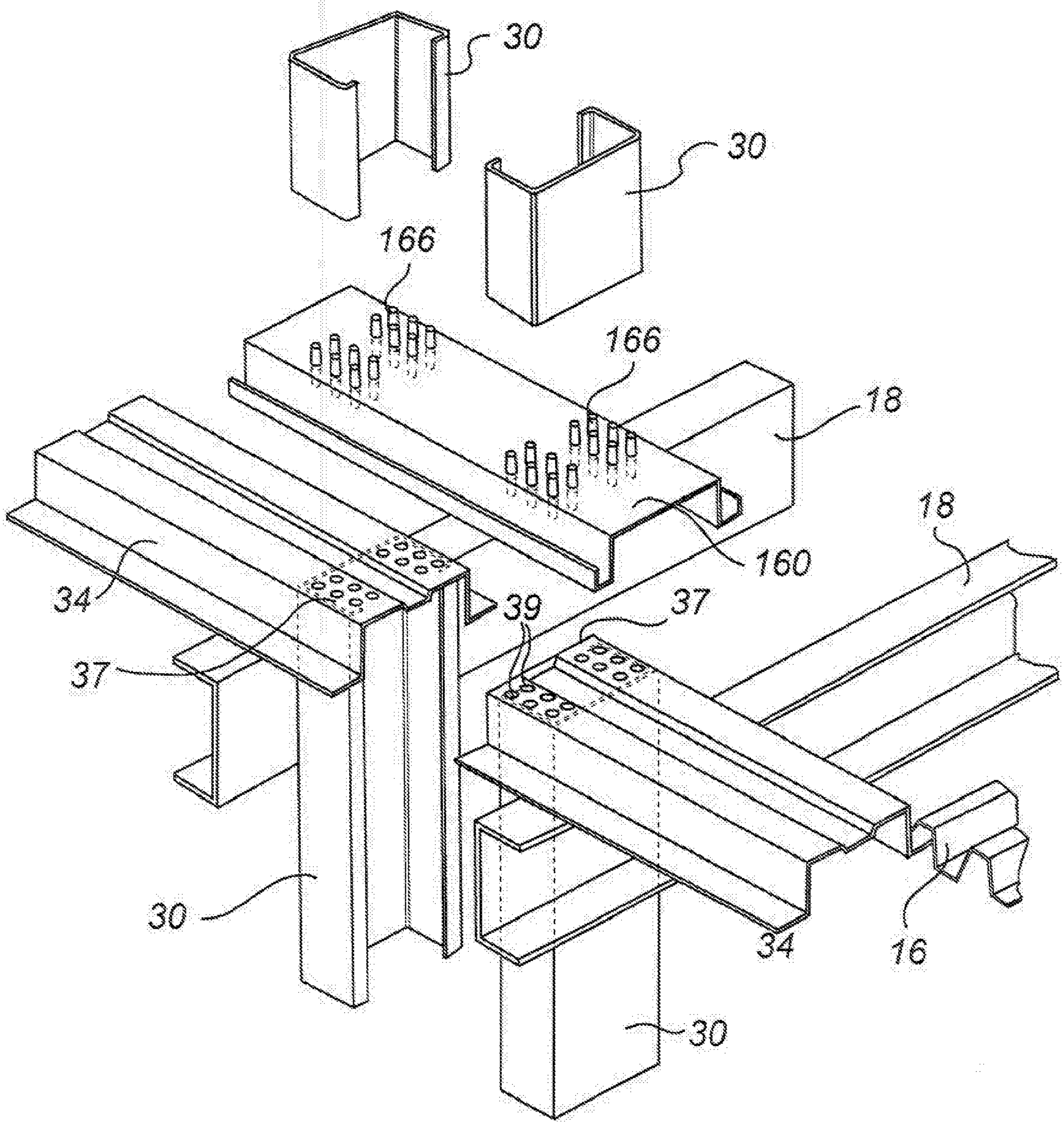


Fig. 14

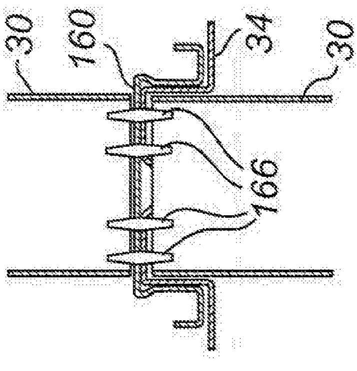


Fig. 15A

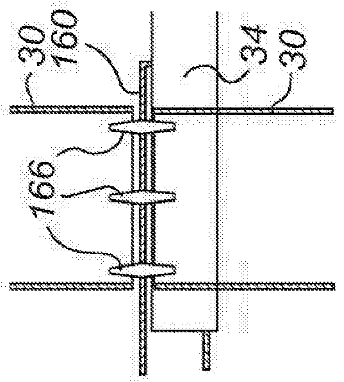


Fig. 15B

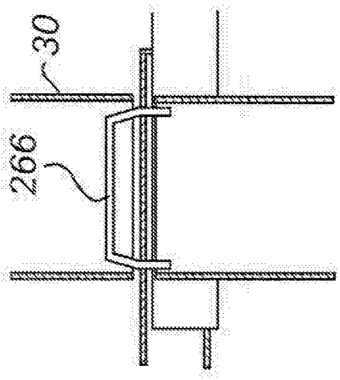


Fig. 16A

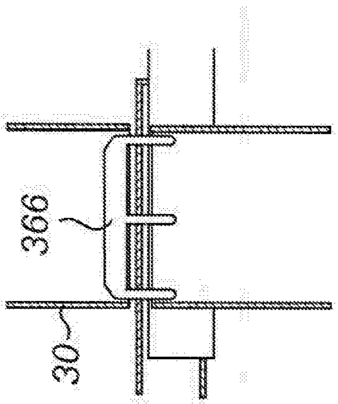


Fig. 17A

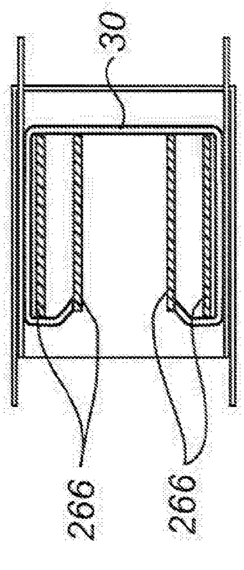


Fig. 16B

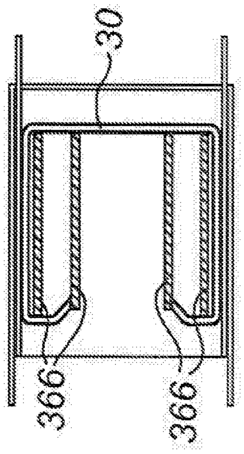


Fig. 17B