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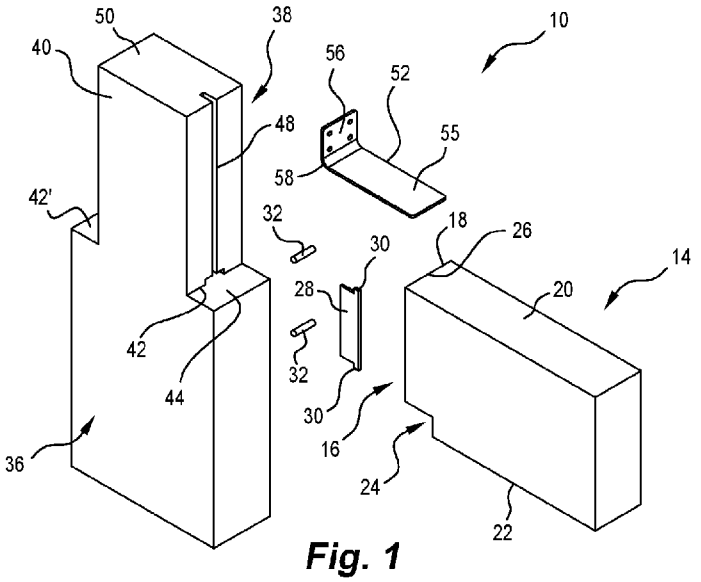


Fig. 1

(57) Abstract: A building system is disclosed comprising a beam and column connection particularly suited for mass timber buildings. A first connection arrangement comprises a projection and slot arrangement with the beam being supported on an upwardly facing bearing surface. A second connection arrangement may be provided to tie the column to the beam. The system also discloses arrangements to accommodate greater tolerance at the connection and to provide an ability to accommodate limited rotation under dynamic loading.

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BUILDING SYSTEM AND METHOD OF CONSTRUCTION

TECHNICAL FIELD

This disclosure relates to building systems and more specifically to systems and methods for connecting structural components such as beams and columns. The disclosure has particular application to mass timber building systems and is herein described in that context. However, the systems and methods disclosed may have broader application, such as in precast concrete construction or hybrid building construction involving mass timber and for example steel, concrete or material composites, and accordingly the disclosure is not limited to building systems solely using mass timber.

BACKGROUND ART

Mass timber are engineered wood products that are used in building construction as major structural elements. These products include cross-laminated timber (CLT), glue laminated timber (glulam), and laminated veneer lumber (LVL). These products have significant advantages over more traditional building elements such as steel or concrete as they exhibit similar strength properties, but are lighter, more environmentally sustainable and can be precision cut which enables them to be prefabricated and allows for improved construction timelines.

Whilst mass timber construction provided significant benefits, its widespread use has been limited due to the cost of mass timber products as compared to steel or concrete, difficulties in scaling mass timber building techniques to allow for multistorey or larger scale construction and in accommodating the behaviour of the mass timber under certain conditions (for example, under fire testing, environments with large humidity and temperature variations, and under dynamic loading such as in seismic conditions). Accordingly, whilst mass timber construction has significant benefits, there is an ongoing need for improvements to mass timber building systems that can address any one or more of these issues.

It is to be understood that, if any prior art is referred to herein, such reference does not constitute an admission that the prior art forms a part of the common general knowledge in the art in Australia or any other country.

SUMMARY

In its broadest terms, the disclosure is directed to improved connections and methods of assembly in building systems utilising mass timber products. In some forms, the connections are designed to reduce total cost of construction using mass timber building

systems through increasing the speed of installation, reducing the amount of time for labour and ancillary equipment (such as cranes), and/or the cost of fabrication including component cost. In some forms, the connections are designed to allow the building system to be easily scaled, and to enhance the performance of the building system for example under fire testing or dynamic loading.

In some embodiments, there is disclosed a building system comprising a beam having a region having at an edge face, and a column having a connection region incorporating an upwardly facing bearing surface, one of the edge face and the connection region having a coupling projecting therefrom, the other one of the edge face and the connection region having a slot. In the formed beam to column connection, the beam extends from the column at the connection region with the beam edge face in opposing relation with the connection region, the beam being supported on the upwardly facing bearing surface and the first coupling being received within the slot to form a first connection arrangement. The building system may also include a second connection arrangement to tie the beam to the column.

In some forms, the first coupling is provided as a separate component which is affixed to, or disposed in, the beam or column.

In some forms, the beam is directly supported on the upwardly bearing surface of the column. In some forms, an intermediate member may be provided. In other forms, the beam may be supported on the upwardly facing bearing surface of the column via the first coupling (for example in a hanger bracket style arrangement).

In some forms, at least part of the connection region is integrally formed as part of the column. In some forms, at least part of the connection region is formed from an intermediate member affixed to, or disposed in, the column.

In some form, the intermediate member provides the upwardly facing bearing surface of the connection region. In some forms, the intermediate member provides the slot or first coupling of the first connection arrangement. In some forms, the intermediate member is in the form of a reaction block.

The building systems according to some forms may improve the speed of installation whilst accommodating the dimensional variations that may occur in the timber due to, for example, temperature and humidity variations. The incorporation of an upper bearing surface on which to support the beam in conjunction with a projection / slot connection provides a high degree of freedom on installation. It also allows tolerance in the

connection in an at least one direction (typically in the direction of the axis of the beam) and may provide a guiding arrangement to ensure the beam is correctly positioned relative to the column in the installed position. Such an arrangement also minimises the crane time required as final fixing of the beam and column can be done after the structural components are in the installed position.

According to some embodiments, a beam to column connection system is disclosed that includes a first connection arrangement comprising at least one interfitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column, the first connection arrangement operative to mount the beam to the column whilst allowing at least three degrees of freedom of the beam during installing; and a second connection arrangement operative to tie the beam to the column subsequent to the mounting of the beam to the column.

In some forms, the first and second connection arrangements are operative to accommodate tolerance variations at the connection between the beam and column in at least one direction. In some forms the at least one direction is in the direction of the beam axis.

In some embodiments, the first and second connection arrangements are able to accommodate at least limited relative rotation and displacement between the beam and column under dynamic loading such as may occur under seismic conditions. In some embodiments, such rotation is in the plane defined by the axis of the column and the axis of the beam.

In some aspects of the technology, a beam to column connection system is disclosed that is able to accommodate at least limited relative rotation and /or displacement between the beam and column.

In some embodiments of this aspect, the beam to column connection includes a first connection arrangement comprising at least one interfitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column.

In some embodiments, the beam column connection further comprises a second connection arrangement operative to fix the beam to the column.

In some embodiments, the first and second connection arrangements are able to accommodate at least limited relative rotation and /or displacement between the beam and column.

In some embodiments, such rotation and/or displacement is at least substantially in the plane defined by the axis of the column and the axis of the beam

In some embodiments, the rotation and/or displacement is accommodated at the first connection arrangement by relative movement of the inter-fitting projection and recess.

In some embodiments, the rotation and/or displacement is accommodated at the second connection arrangement by deformation of a connector forming the second connection arrangement. In some forms, the connector has first and second portions that are mutually inclined and hinge at the join between those portions.

The amount of rotation that can be accommodated may be dependent on the ductility of the material. In other forms the profile of the connector (e.g. width and/or thickness of the material, presences of cut outs, etc) may be designed to specifically control amount of deformation at a given loading condition.

In some embodiments, the rotation and/or displacement is accommodated at the second connection arrangement through movement and/or deformation at the fixing of at least one of the first or second portions to its respective beam or column.

In some forms, the fixing arrangement for securing a respective portion of the connector to the beam or column includes mechanical fasteners each having a shank that extends along an axis of that fastener. In some forms, the fixing arrangement is arranged to accommodate at least limited relative rotation between the members through deformation of the shanks of the mechanical fasteners. In some forms, the fixing arrangement includes a shank guide arrangement to constrain the deformation of the respective fastener shanks to be generally in a first plane containing the shank axis. Typically, this first plane is aligned generally with the beam column plane.

In some forms, the shank guide arrangement is in the form of one or more channels that are disposed below the connector and through which the shanks extend into the beam/column. In some form, these channels are formed directly in the beam/column. In other arrangements, these channels may be formed as extensions of the connector or as separate inserts.

In some forms, the fasteners are aligned such that multiple fasteners share a common channel.

In some embodiments, the fasteners further comprise a head and the heads are arranged to be spaced from the connector. Such an arrangement further assists in controlled deformation of the fastener shanks by allowing for rotation of the head without

engagement with the connectors surface. In some forms, one or more spacer is provided between the fastener heads and the connector to provide the required space.

In some forms, the second connection arrangement comprises a least one latch member that interconnects components forming the first connection arrangement. In some forms, the at least one latch member interconnects the first coupling to the intermediate member. In such an arrangement, the intermediate member and first coupling may include preformed holes which are arranged to align on forming the first connection to form a passage in which the at least one latch member is arranged to locate to interconnect the first coupling to the intermediate member.

In some forms, the preformed holes in one of the intermediate member and first coupling is slotted to accommodate tolerance variations at the connection between the beam and column in at least one direction.

In yet a further aspect , there is provided a connection system for securing first and second members comprising: a bracket having opposite upper and lower surfaces and a first portion for attachment to the first member, and a second portion for attachment to the second member: and a fixing arrangement for securing the first portion to the first member, the fixing arrangement including mechanical fasteners having a shank that extends along an axis of the fastener and arranged to accommodate at least limited relative rotation and/or displacement between the members through deformation of the shanks of the mechanical fasteners, the fixing arrangement including a shank guide arrangement to constrain the deformation of the respective fastener shanks to be generally in a first plane containing the shank axis.

The connection system is suited for the beam column connections as described above, where limited rotation and/or displacement between the beam and column is to be accommodated. However, it is to be appreciated that the connection system has broader application and is not limited to that use.

In some form, the shank guide arrangement of the connection system of this aspect comprises the one or more channels described above. In some forms, the connection system further comprises the fastener head spacers described above.

In a further aspect of the technology, disclosed is a building system comprising a beam having a region having an edge face, and a column having a connection region and further includes a guide arrangement that facilitates correct location of the beam on the

connection region of the column. A connector having a first region fixed to the column and a second region fixed to the beam may also be provided.

In some embodiments, the connection region incorporates an upwardly facing bearing surface. In the formed beam to column connection, the beam extends from the column at the connection region with the beam edge face in opposing relation with the connection region and the beam being supported on the upwardly facing bearing surface.

In a further aspect of the technology, a method of installing a beam to a column in a building system is disclosed, the method includes positioning the beam relative to the column in an installed position whereby a guide arrangement locates the beam in position on the column, and subsequently fixing the beam to the column when in the installed position.

In some forms of any of the embodiments disclosed above, at least one of the beam or the column is formed of mass timber. In some forms, both the beam and the column is formed of mass timber.

Also disclosed is a mass timber beam to column connection system comprises a first connection arrangement configured to locate the beam relative to the column and to inhibit bearing pressure on the beam and column in a direction perpendicular to the grain of the mass timber beam or column.

An advantage of such an arrangement is that it can reduce the bearing area required compared to other connections where the bearing pressure is applied perpendicular to the grain.

Also disclosed is a beam, beam assembly and/or a column, column assembly for use in a beam to column connection system or building system as disclosed in any form above.

Also disclosed is a kit for connecting a beam and column together in a building system according to any form described above, the kit comprising a first coupling provided as a separate component which is affixed to, or disposed in, the beam or column to form part of the first connection arrangement and a second connection arrangement for fixing the column to the beam and comprising a first region fixable to the column and a second region fixable to the beam.

Also disclosed is a kit for connecting a beam and column together in a building system comprising a first coupling provided as a separate component which is affixed to, or disposed in, the beam or column, and an intermediate member disposed on the other of the beam or column to receive the first coupling and a second connection arrangement for tying

the column to the beam and comprises a latch arrangement that is operable to interconnect the first coupling to the intermediate member.

Also disclosed is a bracket for securing first and second members comprising: a bracket having opposite upper and lower surfaces and a first portion for attachment to the first member, and a second portion for attachment to the second member; the first portion having attachment apertures along side regions thereof, and cut-outs formed inboard of the attachment apertures to influence flexing of the bracket under relative rotation of the first and second members.

Also disclosed is a coupling for a beam column connection comprising a body having a first portion for affixing to one of the beam or column, the first portion having opposite upper and lower ends and an attachment region that is disposed in the lower half of the first portion, wherein the attachment region has an inner surface that abuts the beam or column, the inner surface being profiled to distribute shear force across the attachment region.

Also disclosed is a coupling for a beam column connection comprising a body having a first portion for affixing to one of the beam or column, the first portion having opposite upper and lower ends, a second portion that projects from the first portion and has a bearing surface; and at least one web extending between the first and second body portions and arranged to form part of an interfitting projection and recess arrangement interconnecting the beam and column.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is an exploded view of a building system in the form of a beam column connection according to a first embodiment;

Fig. 2 is a side view of the assembled beam column connection of Fig. 1;

Fig. 3. is a sectional view of the assembled beam column connection of Fig. 1;

Fig. 4 is an exploded view of a building system in the form of a beam column connection according to a second embodiment;

Fig. 5 is a side view of the assembled beam column connection of Fig. 4;

Fig. 6 is a sectional plan view of the assembled beam column connection of Fig. 4;

Fig. 7 is a sectional side view of the assembled beam column connection of Fig. 4;

Fig. 8 is an exploded view of a building system in the form of a beam column connection according to a third embodiment;

Fig. 9 is a side view of the assembled beam column connection of Fig. 8;

Fig. 10. is a side sectional plan view of the assembled beam column connection of Fig. 8;

Fig. 11 is a second side sectional plan view of the assembled beam column connection of Fig. 8;

Fig. 12 is an end sectional view of the assembled beam column connection of Fig.8;

Fig. 13 is an exploded view of a building system in the form of a beam column connection incorporating floor plates and a subsequent column;

Fig 14 is a sectional side view of the assembled building system of Fig. 13;

Fig. 15 is an exploded view of a building system in the form of two beam column connections, each beam column connection being provided according to a fourth embodiment;

Fig. 16 is a top plan view of the assembled building system of Fig. 15;

Fig. 17 is a sectional side view of the assembled building system, taken through line A-A in Fig. 16;

Fig. 18 is an exploded view of a building system in the form of two beam column connections, each beam column connection being provided according to a fifth embodiment;

Fig. 19 is a sectional side view of the assembled building system of Fig. 18, the section being taken a line which passes through the slots of the columns for receiving couplings attached to the beam;

Fig. 20 is a sectional side view of the assembled building system of Fig. 18, the section being taken along a position adjacent the slots of the columns for receiving couplings attached to the beam;

Fig. 21 is an exploded view of a building system in the form of two beam column connections, each beam column connection being provided according to a sixth embodiment;

Fig. 22 is a top plan view of the assembled building system of Fig. 21;

Fig. 23 is a sectional side view of the assembled building system taken through line A-A in Fig. 22;

Fig. 24 is a partial perspective view showing a variant of the building system of Figs. 21 to 23;

Fig. 25 is an exploded view of a building system in the form of two beam column connections, each connection being provided in accordance with a seventh embodiment and incorporating a tie bracket;

Fig. 26 is an enlarged exploded view of one of the connections in the building system of Fig. 25;

Fig. 27 is a sectional partial side view of the connection of Fig. 26 with tie bracket installed;

Fig. 28 is a sectional partial side view of the other connection of the building system of Fig. 25 with the tie bracket installed;

Fig. 29 is a schematic perspective view of the connection of Fig. 26 showing details of the mechanical fasteners used in installing the tie bracket;

Fig. 30a is a rear perspective view of a variant of the coupling used in the building system of Fig. 24;

Fig. 30b is a front perspective view of the coupling of Fig.30a;

Fig. 31 is a sectional partial view of a beam column connection system according to an eighth embodiment using the coupling shown in Fig. 30;

Fig. 32 is a perspective view of the tie bracket used in the beam column connection of Fig. 31;

Fig. 33 is an exploded perspective view of a building system in the form of two beam column connections of Fig. 31;

Fig. 34 is a perspective view of a further alternative of tie bracket for use in building systems of embodiments disclosed;

Fig. 35 is a perspective view of a further variant of coupling of Figs 30a and 30b;

Fig. 36 is a perspective view of a beam end region comprising in-lay reinforcement features for use in building systems of embodiments disclosed;

Figs. 37 is a transparent perspective view of a building system in the form of two beam column connections according to a ninth embodiment;

Fig. 38 is a perspective view of a column for use in the building system of Fig. 37;

Fig 39 is a perspective view of a reaction block for use in the column of the building system of Fig. 37;

Fig. 40 is a perspective view of a beam end incorporating couplings for use in the building system of Fig. 37;

Fig 41. Is a perspective rear view of a coupling for mounting to the beam end for use in the building system of Fig. 37;

Fig. 42 is a transparent perspective view of a building system having beam column connection according to a tenth embodiment;

Fig. 43 is a perspective view of a column for use in the building system of Fig. 42; and

Fig. 44 is a perspective view of a beam end incorporating couplings for use in the building system of Fig. 42.

DETAILED DESCRIPTION

In the following detailed description, reference is made to accompanying drawings which form a part of the detailed description. The illustrative embodiments described in the detailed description, depicted in the drawings and defined in the claims, are not intended to be limiting. Other embodiments may be utilised and other changes may be made without departing from the spirit or scope of the subject matter presented. It will be readily understood that the aspects of the present disclosure, as generally described herein and illustrated in the drawings can be arranged, substituted, combined, separated and designed in a wide variety of different configurations, all of which are contemplated in this disclosure.

The disclosure is directed to improved connections and methods of assembly in building systems, and in some forms, utilising mass timber products. In some forms, the connections reduce the total cost of construction using mass timber building systems through increasing the speed of installation thereby reducing the amount of time for labour and ancillary equipment (such as cranes). In some forms, the connections use simplified components that are simple to install offsite thereby reducing the cost of fabrication of the mass timber products including component cost. In some forms, the connections allow the building system to be easily scaled so that they are able to be more readily used in

multistorey building construction. In some forms, connections are provided to meet specific performance criteria of the building system such as fire rating or dynamic loading such as under seismic conditions.

In some embodiments, there is disclosed a building system comprising a beam having a region that has an edge face. A first coupling projects from the beam edge face, and the system also includes a column having a connection region incorporating an upwardly facing bearing surface, and at least one slot. In some forms, at least one, and optionally both, of the beam and the column are made from mass timber such as for example glue laminated timber. In the formed beam to column connection, the beam extends from the column at the connection region with the beam edge face in opposing relation with the connection region and the beam is supported on the upwardly facing bearing surface and the first coupling is received within the slot to form a first connection arrangement. The building system may also include a second connection arrangement in the form of a connector having a first region fixed to the column and a second region fixed to the beam.

In some forms, the elements are made from mass timber (for example the column including the connection region having the upper bearing surface and the at least one slot) and are prefabricated and precision cut using for example a CNC machine based on a computer model. Moreover, the first coupling may be pre-installed in a factory environment to reduce the time for onsite installation.

In some embodiments, disclosed is a building system comprising a beam having a region having an edge face, and a column having a connection region. The building system also includes a guide arrangement that facilitates correct location of the beam on the column.

In some embodiments, the connection region incorporates an upwardly facing bearing surface. In the formed beam to column connection, the beam extends from the column at the connection region with the beam edge face in opposing relation with the connection region and the beam being supported on the upwardly facing bearing surface. In some embodiments the guide arrangement forms a first connection arrangement of the building system.

The use of a guide arrangement to facilitate correct location of the beam on the column may allow for faster installation of the beam on the column and ensure that it is correctly positioned to ensure an adequate load path between the beam and the column. In

some forms the guide arrangement may also enhance the performance of the connection by, for example, providing a structural coupling of the connection to for example resist lateral movement of the installed beam on the column. In some forms, the guide arrangement is in the form of an interfitting projection and recess.

In some embodiments of the above form, the building system further comprises a second connection arrangement in the form of connector having a first region fixed to the column and a second region fixed to the beam.

In some embodiments, a beam to column connection system includes a first connection arrangement comprising at least one interfitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column, the first connection arrangement operative to locate the beam on the column whilst allowing at least three degrees of freedom of the beam during installing.

Providing a connection arrangement that allows for a high degree of freedom in installing can significantly reduce the installation time, including reducing onsite labour and equipment (such as crane hook) time. In some forms, the coupling methodology is arranged to provide a multistep process where the beam can be correctly positioned and supported on the column (using the first connection arrangement) and then the structural elements are fixed relative to each other with a second connection arrangement. This is contrast to existing couplers which provide the mounting and fixing as a single process or component. A single coupling arrangement may require more precise positioning which is more time consuming for both labour and crane time. Also, where the structural elements are mass timber, they are prone to swelling in humid conditions which is problematic unless there are sufficient tolerance accommodated at the connection.

In some embodiments, a method of installing a beam to a column in a building system is disclosed where at least one of the beam or the column is a mass timber product, the method includes positioning the beam relative to the column in an installed position whereby a guide arrangement locates the beam in position on the column and the beam is supported on an upwardly extending bearing surface of the column, and subsequently fixing the beam to the column when in the installed position.

In some embodiments when installing the beam on the column, the building system accommodates tolerance variations at the connection between the beam and column in at least one direction.

In some embodiments, the beam column connection is able to accommodate at least limited relative rotation and/or displacement between the beam and column under dynamic loading such as may occur under seismic conditions. In some embodiments, such rotation is in the plane defined by the axis of the column and the axis of the beam.

In some embodiments, a beam to column connection system is disclosed that includes a first connection arrangement comprising at least one interfitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column, and a second connection arrangement operative to fix the beam to the column; wherein the first and second connection arrangements are able to accommodate at least limited relative rotation between the beam and column.

In some embodiments, such rotation and/or displacement is at least substantially in the plane defined by the axis of the column and the axis of the beam

In some embodiments, the first connection arrangement and/or guide arrangement includes a plate and the at least one recess is in the form of a complementary shaped slot. In some forms, the plate and slot extend in, or are parallel to, the plane defined by the axis of the column and the axis of the beam.

In some embodiments, the first connection arrangement and/or guide arrangement component is in the form of a plate fixed to one of the beam or column and having a distal edge region projecting therefrom to form the projection.

In some embodiments, the first connection arrangement and/or guide arrangement further comprises at least one web extending between first and second body portions of a coupling. In some forms, one of the body portions of the coupling is fixed to the beam.

In some embodiments, the column extends generally along a first reference axis and the at least one plate and slot are generally aligned in the direction of the reference axis when in interfitting relation. In some embodiments the slot is open at its upper end to allow the plate to be installed from that end.

In some forms, the tolerance variation is accommodated in a direction transverse to the first reference axis. In some forms, the tolerance variation is in the direction of the beam axis.

In some embodiments, the bearing surfaces that enable the beam to be supported on the column are arranged on respective surfaces of the beam and the column. In some

embodiments one of the bearing surfaces is formed as a downwardly facing surface in a recessed end region of the beam.

In some embodiments, the bearing arrangement further comprises an intermediate member disposed between the opposing bearing surfaces.

In some embodiments, the first coupling incorporates one of the bearing surfaces.

In some embodiments, the first coupling comprises a body portion comprising first and second mutually inclined portions, the one bearing surface is formed on the first portion and the second portion is adapted to be fixed to one of the beam or column.

In some embodiments, the first coupling is not fixed to the column through the one bearing surface.

In some embodiments, the second connection arrangement has a body comprising mutually inclined first and second portions, first portion being arranged to be fixed to the beam, the second portion being arranged to be fixed to the column. In some forms, the join between the first and second portions acts as a hinge to allow limited in plane rotation of between the beam and the column.

Referring now to Fig. 1, an exploded view of a building system 10 in the form of a beam column connection 12 according to a first embodiment is disclosed. In the illustrated form, the beam 14 and column 36 are formed from mass timber such as glue laminated timber. Moreover, the beam column connection is arranged such that an end of the beam engages the column thereby allowing for the possibility of direct end to end connection of the columns in a multistorey building. However, it is to be appreciated that in other forms the beam may be arranged to straddle the column such that an appropriately shaped intermediate region of the beam is arranged to engage the column.

The building system 10 as illustrated includes the beam 14 having an end region 16 terminating in an edge face 18 and upper and lower surfaces (20, 22). The beam 14 is prefabricated, typically using precision cutting under a CNC machine process. Under this process, the lower surface 22 in the vicinity of the end region includes a rebate 24 and a slot 26 is formed along the end face 18.

The slot 26 is arranged to receive a coupling 28 in the form of a plate, which is typically formed of metal, in a loose fit arrangement. The plate includes tabs 30 at its opposite ends that are arranged to be disposed within the slot 26. In the illustrated form, the rebate 34 in the beam 14 is significantly deeper than the plate 28 depth. Fixing elements 32 are installed distal of the tabs 30 to secure the plate 28 to the beam end. The combination

of the beam and installed plate forms a beam assembly 34 (best shown in Fig. 3) that is preassembled and may be arranged to be supplied to site in this assembly form.

The column 36 includes a connection region 38 that is arranged to receive and support the beam assembly 34. Similar to the beam 14, the column 36 may be formed of mass timber (such as glue laminated timber) and is prefabricated through precision cutting. In the illustrated form, an upper region 40 of the column is reduced to form a shoulder 42 having an upwardly facing bearing surface 44. The upper region 40 of the column further includes a slot 48 that is dimensioned to receive the projecting portion of the plate 28 to form a first connection arrangement of the beam column connection. The slot 48 opens to the shoulder 42 and also extends to the upper end 50 of the column. In the illustrated form, the narrowed region of the column is central to the axis of the column such that two shoulder regions (42, 42') are formed. Whilst only one slot 48 is shown, it is to be appreciated that a second slot could be provided that opens to the opposite shoulder 42' so that the building system could form a further beam column connection from the column 36.

A feature of the column 36 of the illustrated form is that the column connection region 38 is entirely made from cutting in the column without the need for additional componentry. This has the advantage of reducing cost, not only with the cost of additional componentry but also by obviating the need for assembly (with a cost saving being typically realised through reduced labour costs).

The building system 10 further comprises a second connection arrangement in the form of a connector 52 in the form of a tie bracket. The tie bracket (being in the form disclosed, an angled tie bracket) has a first portion 54 that is arranged to be fixed to the column, typically by mechanical fasteners such as screws (not shown) and a second portion 56 that is affixed to the upper surface 22 of the beam.

The tie bracket which is used with the building system, either in the embodiment depicted in Fig. 1, or in further embodiments of the building system provided by this disclosure, may be different from that shown in Fig. 1. Examples of further embodiments of the tie bracket are explained later in this document, with reference to Figs. 24 to 29 or 31 to 34.

Fig. 2 is a side view of the assembled beam column connection 34 of Fig. 1. To form the beam column connection, the lower surface 20 of the beam in the rebate 24 bears on the upwardly facing bearing surface 44 of the column. To assume this position, the beam assembly 34 is typically connected to a crane hook and is manoeuvred in position so that the plate 24 is able to locate in the column slot 48. In this way the plate 24 and slot 48

provide a guide arrangement to ensure correct positioning of the beam on the column. Further, the positioning of the beam is assisted by the degrees of freedom that is afforded by the connection. In particular, the plate and slot connection provides minimal constraint and allows the beam to be dropped vertically (in the direction of the column axis c-c) or horizontally (in the direction of the beam axis b-b), as well as being able to be angularly displaced in the plane of the column and beam axes. In addition, there may be some dimensional variation in the structural elements which could result in elongation of the beam. The beam column connection accommodates this variation by plate slot arrangement is able to accommodate variation in positioning of the elements in the direction of the beam axis b-b. A further function of the plate and slot arrangement is that these inter-fitting components form part of the overall connection and resist lateral (sideways) movement of the beam relative to the column.

Once the beam and the column are correctly positioned, the primary load path is taken from the direct bearing surfaces between the beam rebate 24 and the column shoulder 44. To fix the elements together to prevent relative movement, the tie bracket 52 is installed and fixed to both the column and beam. In the configuration disclosed, the tie bracket is mounted to the top surface 20 of the beam and to a projecting region 54 of the column. If the top beam and column were at other relative positions, different arrangement of tie brackets could be used. For example, if the heights were the same, the tie bracket could be flat. Alternatively, if a subsequent column was installed on the column 36, the tie bracket could be mounted to that subsequently installed column. In the illustrated form, the bracket is aligned (or parallel) to the beam axis b-b with a join 58 formed between the portions (55,56) of the bracket 52 running transverse to the axis b-b. An advantage of using a separate coupling, is that it also is able to better allow for large tolerance (particularly in direction of beam axis b-b) as it can be fixed once the beam is installed and in position.

A further feature of the connection 12 is that whilst the tie bracket 52 is able to tie the components together, it also provides the rotational stiffness to the connection. In some forms the tie bracket 52 may also allow for some flexing (in the form as shown in the region of the join 58). This in conjunction with the plate and slot arrangement allows for some rotation of the beam relative to the column in the plane of the column and beam axes (c-c, b-b) once the stiffness inherent in the bracket 52 is overcome. This limited rotation allows the connection to accommodate dynamic loading which may be experienced in seismic conditions. Such rotation may also require displacement between the beam and the column to be accommodated.

Fig. 3 is a sectional view of the assembled beam column connection of Fig. 1. As can be seen, the plate 28 is fully encapsulated within the timber components, whilst the tie bracket 52 remains exposed. In the illustrated form, an end region 54 of the column projects beyond the top of the beam. To assist in fire protection, a fire rated sealant such as an intumescent caulking may be subsequently applied to the join areas. Alternatively, an intumescent strip or sheet product may be pre-applied to the beam end prior to assembly.

Accordingly, the beam column connection 12 is ideally designed for mass timber construction. It is simple to install with guided vertical positioning and is self-propping (having the primary load path through the bearing surfaces between the beam and column). The connection has the necessary tolerance for site erection and flexibility for seismic rotation. The connection has minimal parts and limited on-site fastening. The components used in the connection are simple designs allowing for low cost production, and the connection has good fire rating. A further benefit is that the connection detail can be easily scaled to accommodate larger loads because of the simple component designs and the fact that the capacity of the connection is largely defined by the bearing area between the beam and the column.

Figs. 15 to 17 depict a further embodiment which is a variant of the embodiment shown in Figs. 1 to 3. The building system 410 depicted includes many of the features as those shown in Figs. 1 to 3. and like features in the beam column connection shown in Figs. 15 to 17 are designated by like reference numerals used in Figs. 1 to 3, with the addition of the prefix "4". For illustrative purposes, two beam column connections are shown (at opposite ends of beam 414) and are distinguished by use of an apostrophe on the reference numerals. For ease of description, reference is only made to one of those beam column connections 412 and it is to be understood that, unless stated otherwise, the description also applies to the connection 412'. Further, it is to be understood that the beam column connection shown in Fig. 15 may also be used in building systems with different element configurations (e.g., one column with one beam, one column with two beams, etc).

Fig. 15 is an exploded view of the building system 410. The beam 414 includes beam end face 418 provided at an end of the beam 414. The beam end face 418 is arranged to be supported by the column 436, specifically, bearing on a shoulder region 442 of the column 436. In the depicted embodiment, the column 436 includes a single shoulder region 442 formed by the upper region 440 of the column 436 being narrower than the column's lower region. Thus, the surfaces forming the shoulder 442 includes a recessed (relative to the column's lower region) vertical face 445 of the upper region 440, and an upwardly facing bearing surface 444 on the column 136. Although the columns 436 are

illustrated with one shoulder region, one or both columns 436, 436' may have two shoulder regions as in the case of the variant shown in Figs 1 to 3.

The beam 414 has a rebate 424, as in the embodiment disclosed with reference to Figs 1 to 3. However, in a further alternative arrangement, no rebate is provided.

The connection region 438 is provided by vertical face 445 of the shoulder 442. The difference between this variant and that shown in Figs 1-3 is that the beam column connection 412 is provided by a first connection arrangement having a first coupling 428 projecting from the column 436, and a cooperating second coupling feature in the form of a slot 426 provided in the end face 418 of the beam 414.

The coupling 428 includes a plate 427 which extends from a backing portion 429. Fixing elements 432 are installed, adjacent the plate 427 to fix the backing portion 429 onto the recessed face 445 of the shoulder 442. The coupling 428 may be provided by a typically metal T-section, with fixing apertures included therein. In the coupling 428, an upper edge 431 of the plate 427 is slanted in a downward direction from the backing portion 429 toward the free or leading edge of the plate 427. The downward slant may assist in guiding the beam 114 as it is manoeuvred vertically and downwardly into position.

The beam 414 includes the second coupling feature of the first connection arrangement, which comprises a slot 426 dimensioned to receive the plate 427. The slot 426 is provided along the beam end face 418 and extends through to the top surface 420 of the beam 414. The slot 426 may be provided within a vertical guide groove 433 to help guide the insertion of the plate 427 into the slot 426, with the slot 426 being positioned at the longitudinal midline of the vertical guide groove 433.

The slot 426 is also dimensioned to be wider than the thickness of the plate 427, so that there is some clearance around the plate 427 when it is inserted. The clearance provides or improves the lateral tie in the beam 414, to prevent or reduce the amount of buckling in the beam 414 in the lateral direction, i.e., transverse to the longitudinal axis of the beam 414, under seismic conditions.

In the embodiment as shown, the slot 426 is recessed into the beam 414. In another form, not illustrated, the slot could be provided by a further member (such as a block) secured to the beam 414 which thereby provides an extension of the beam. In such an arrangement, the outer surface of the further member that incorporates the slot, becomes the end face of the beam.

When the beam 414 is assembled onto the columns 436, the upper surface 422 of the beam 414 may be positioned lower than the upper surfaces 450 of the beams as in the previous embodiment. Although this is not shown, tie brackets in a similar construction as the angle plates of the earlier brackets 52 may be attached to the building system 410. Tie brackets of a different construction, such as the modified tie bracket shown in Fig. 25, may instead be used.

Both the variants shown in Figs 1 to 3 and in Figs 15 to 17, and also the further embodiments which will be described hereinafter, utilises the plate and slot connection between the beam and the column, with the plate carried by the column and the slot formed into the beam, or vice versa. Also, as with the earlier embodiment, in the embodiment shown in Figs. 15 to 17, the joins in the building system may be sealed with a fire-rated sealant such as intumescent caulking. It will also be appreciated where features which are shown and discussed in relation to Figs. 15 to 17, are not shown in Figs. 1 to 3, they may be applicable to the embodiment of Figs. 1 to 3 or other embodiments discussed later in this document. Like the previous embodiment, the embodiment shown in Figs. 15 to 17 can be scaled to different dimensions to accommodate different loads.

Fig. 4 is an exploded view of a building system in the form of a beam column connection according to a second embodiment. The building system 210 has many of the features of the earlier embodiment and like features are designated by like reference numerals with the addition of the prefix "2".

Similar to the earlier embodiment of the building system 10, the building system 210 includes a beam and column connection 212, where a beam end face 218 is arranged to be supported and extend from a connection region 238 of the column 236.

A primary difference with the building system 210 is that the beam coupling is in the form of a channel bracket 260 having a web portion 262 incorporating a mounting region in the form of apertures 264 to receive mechanical fasteners 266 (Fig. 7) and a pair of projecting flanges 268. Further, rather than having a single column slot 48 as in the earlier embodiment, a pair of slots 248 are provided to receive the flanges 268 on installing the beam 214 on the column 236.

In addition, an intermediate member 270, which in the form shown is a metal plate, is arranged to be fixed to an upwardly facing bearing surface 244 of the column. In this way, the upper surface of the plate 270 becomes the upwardly facing bearing surface of the connection region 238. The intermediate bearing member 270 is arranged to receive the lower surface 222 of the beam 212. In the building system 210, the beam 212 does not

include the rebated edge region of the earlier embodiment such that there is no interruption to the lower surface 222. However, a rebated edge could be provided if so desired.

Similar to the earlier embodiment, the coupling 228 is typically arranged to be installed on the beam 212 prior to transporting to site so as limit onsite assembly. As such, the beam and coupling are provided in the form of a beam assembly 234. Similarly, the column can be provided to site in the form of a column assembly 272 with the intermediate bearing assembly pre-installed on the bearing surface 244. It is to be appreciated, that whilst pre-installation of components is beneficial to reduce onsite handling, in any of the embodiments, the components could be provided separately to the beam and column and installed on site if required.

The tie bracket 252 is a similar construction of angle plate as the earlier bracket and is arranged in the same orientation as the earlier embodiment to allow it to have limited flex at its join 258 to enable some in plane rotation to accommodate seismic conditions. Other types of tie brackets as disclosed herein may be used depending on the relative heights between the column and beam. For example, if those elements were at the same height, a flat tie bracket could be used.

Consistent with the earlier embodiment, the beam column connection 212 is ideally designed for mass timber construction. It is simple to install with guided vertical positioning (provided by the flanges 268 of the channel bracket 260 locating in the corresponding slots 248) and is self-propping (having the primary load path through the bearing surfaces between the beam and column via the intermediate member 270). The connection has the necessary tolerance for site erection and flexibility for seismic rotation (through the orientation of the flanges 268 and slots 248 and the ability of the tie bracket 252 to flex). The connection has minimal parts and limited on-site fastening. The components used (particularly channel bracket 260) is still a relative simple design allowing for low cost production, and the connection has good fire rating. The intermediate bearing plate 270 provides a prescriptive fire rating solution which thereby allows the connection to be more readily accepted. A further benefit is that the connection detail can be scaled to accommodate larger loads because of the simple component designs. In the building system 210, the capacity of the connection is largely defined by the fixing of the channel bracket 260 to the beam. As such the system 210 is more suited to lower load conditions (say shorter span, single storey and/or residential) than the earlier embodiment. Even so, the system 210 is scalable by increasing the bracket size and fixing capacity and therefore may also be used in larger commercial buildings.

Figs. 18 to 20 depict an embodiment which is variant of the embodiment shown in Figs 4 to 7. The primary difference between the variants is in the design of the coupling 528 forming the first connection arrangement. Like features of the beam and column will be referenced with like numerals as those used in Figs. 4 to 7, except the prefix "2" will be replaced with the prefix "5". In the below, the differences between the variants are discussed. Description of the other features of the building system 210 also applies to like features of the building system 510, except for differences where mentioned.

For illustrative purposes, two beam column connections are shown (at opposite ends of beam 514) and are distinguished by use of an apostrophe on the reference numerals. For ease of description, reference is only made to one of those beam column connections 512 and it is to be understood that, unless stated otherwise, the description also applies to the other connection 512'. Further, it should be understood that the beam column connection shown in Figs. 18 to 20 may also be used in building systems with different element configurations (e.g., one column with one beam, etc). As another example, although the columns 536, 536' are illustrated with one shoulder region, one or both columns 536 may have two shoulder regions as in the case of the variant shown in Figs 4 to 7.

In Figs. 18 to 20, the beam 514 is connected to column 536. A beam column connection includes a first connection arrangement formed between a coupling 528 which is adapted to be attached to the beam 514, and a cooperating slot 548 provided on the column 536. Unlike the channel arrangement of coupling 228, the beam coupling 528 is a longitudinal coupling with a substantially T-shaped cross section, preferably made of metal. It could be provided, for example, by a steel T-section with apertures to accommodate fixing screws.

The coupling 528 includes a single plate 568 (formed as the stem of the "T") which extends perpendicularly from a backing portion 562, typically from a longitudinal midline of the backing portion 562. The plate 568 is positioned and dimensioned to be received by the cooperating slot, and the backing portion 562 is configured to be attached to the end face 518 of the beam 514. As best seen in Fig. 19, the plate 568 preferably has a lower edge which is slanted downwardly from the vertical free edge of the plate 562, toward the backing portion. This may help in guiding the insertion of the plate 568 into the slot 548 as the beam 514 is dropped toward the column 536.

On either side of the plate 568, there is provided in the backing portion 562 an arrangement of apertures 564 which form a mounting. The apertures 564 are provided to accept fixing elements such as timber screws. In the depicted example, the arrangement of

apertures 564 includes two adjacent vertical arrays of apertures. However, in other embodiments, only one or three or more vertical arrays may be provided, on either side of the plate 568. The array(s) of apertures 564 each provide a vertical shear load path. The end face 518 of the beam 514 is provided with a vertical recess 519 having a substantially planar floor dimensioned to accept the backing portion 562 such that the backing portion aligns substantially flush with the beam end face 518. Fixing elements are fixed through the backing portion 562 and through the floor of the vertical recess 519. The attachment of the coupling 528 may be done prior to transportation onsite, so that the beam 514 and the beam coupling 528 are provided as a beam assembly.

The column 536 has a narrower upper region 540 compared with the wider lower region 541, providing a shoulder in the column 536 (the shoulder being formed between a beam facing surface 545 in the upper region 540, and an upwardly facing surface 544 provided by the lower region 541). The cooperating slot 548 for receiving the plate 568 is formed in the beam facing surface 545 on the column 536. The slot 548 extends to an upper end 550 of the column 536. The cooperating slot 548 is dimensioned to be wider than the thickness of the plate 568, providing clearance within the slot 548 for the plate 568 to increase tolerance of assembly, and to accommodate for movements induced by dynamic loading such as may be experienced in seismic conditions.

Similar to the embodiment shown in Figs. 4 to 7, the embodiment shown in Figs. 18 to 20 may further include an intermediate member 570 which is typically formed of metal, and which is arranged to be attached to the upwardly facing load bearing surface 544 of the column 540, to receive the lower surface 522 of the beam 514. The intermediate member 570 forms part of the connection region 538 of the column and is attached to the upwardly facing load bearing surface 544, such that when the beam column connection is made, the intermediate member 570 will be generally aligned with the vertical recess 519.

As can be seen from Fig. 20, when the beam column connection is made, the intermediate member 570 will be positioned under the lower edge backing portion 562 of the beam coupling 528. Similar to the previous embodiment, the intermediate member 570 may be attached to the column 536 prior to being transported, and provided to the installation site together as a column assembly. The intermediate member 570 helps to eliminate compression perpendicular to the grain of the column as the reactive force is carried through the plate and translates back in the coupling 528.

As illustrated, when the beam 514 is assembled onto the columns 536, the upper surface 522 of the beam 514 is positioned higher than the upper surfaces 550 of the beams.

In other arrangement, the beam may be lower than the column, or level. Appropriately shaped tie brackets 552, may be attached to the building system 510. The tie brackets 552 may take a "dog leg" shape as disclosed. Tie brackets of different constructions, such as the modified tie brackets shown in Figs. 25 to 29, 32, 34 may instead be used.

It will be appreciated that although the building system 510 shown in Figs. 18 to 20 includes one beam connected to two columns, the beam column connection described above may be provided in a system where the beam is only connected to one column. Also, although the columns 536 shown in Figs. 18 to 20 are asymmetrical, providing only one shoulder, one or both columns may instead take a symmetrical shape, similar to the column 236 shown in Figs. 4 to 7. Like the previous embodiment, the embodiment shown in Figs. 18 to 20 can be scaled to different dimensions to accommodate different loads.

Figs. 37 to 41 depict a further embodiment which is a variant of the embodiment shown in Figs 18 to 20, which in turn is a variant on the embodiment of Figs. 4 to 7. The primary difference between the variants is in the design and function of the intermediate member 1570 and the mechanism by which the beam and column are tied together. Like features of the beam and column will be referenced with like numerals as those used in Figs. 4 to 7, except the prefix "2" will be replaced with the prefix "15". The differences between the variants are discussed below. Description of the other features of the building systems 210, 510 also apply to like features of the building system 1510, except for differences where mentioned.

For illustrative purposes, two beam column connections are shown (at opposite ends of beam 1514) and are distinguished by use of an apostrophe on the reference numerals. For ease of description, reference is only made to one of those beam column connections 1512 and it is to be understood that, unless stated otherwise, the description also applies to the other connection 1512'. Further, it should be understood that the beam column connection shown in Figs. 37 to 41 may also be used in building systems with different element configurations (e.g., one column with one beam, etc). As another example, although the columns 1536, 1536' are illustrated with one connection region 1538, one or both columns 1536 may have two connection regions 1538 as in the case of the variant shown in Figs 4 to 7.

In Figs. 37 to 41, the beam 1514 is connected to column 1536. A beam column connection includes a first connection arrangement formed between couplings 1528 which is adapted to be attached to the beam 1514, and a connection region 1538 incorporating cooperating slots 1548, 1486 and an upwardly facing bearing surface provided on the

column 1536 and on the intermediate member 1570. Similar to the variant of Figs. 18 to 20, each beam coupling 1528 is a longitudinal coupling with a substantially T-shaped cross section, preferably made of metal. It could be provided, for example, by a steel T-section with apertures to accommodate fixing screws. In the embodiment shown, two couplings 1528 are mounted side by side to accommodate larger commercial loads (for example in the vicinity of 400kN). However, it is to be appreciated that different configurations could be provided depending on requirements. This may include a single coupling or three or more couplings. Also, rather than have multiple couplings fixed separately for a larger load condition, these could be formed as a single coupling with similar characteristics.

In the form as shown, each coupling 1528 includes a single plate 1568 (formed as the stem of the "T") which extends perpendicularly from a backing portion 1562, typically from a longitudinal midline of the backing portion 1562. The plate 1568 is positioned and dimensioned to be received by a corresponding cooperating slot in the connection region 1538 on the column, and the backing portion 1562 is configured to be attached to the end face 1518 of the beam 1514.

On either side of the plate 1568, there is provided in the backing portion 1562 an arrangement of apertures 1564 which form a mounting. The apertures 1564 are provided to accept fixing elements such as timber screws 1608. In the depicted example, the arrangement of apertures 1564 includes two adjacent vertical arrays of apertures. However, in other embodiments, only one or three or more vertical arrays may be provided, on either side of the plate 568. The array(s) of apertures 1564 each provide a vertical shear load path.

In addition, in one form as illustrated in Fig 41, the rear surface 1580 of backing portion 1562, which contacts with the beam end face 1518, may include a profiled surface (in the form of small cylindrical projections (micro-dowels), teeth, hooks, serrations or the like) to engage with the beam end face to thereby key the coupling to the beam end face to improve shear transfer and stiffness between the coupling 1528 and the beam 1514. A feature of this arrangement is that the shear force is distributed across the extent of the profiled regions. An advantage is that the arrangement may reduce the number of horizontal screws needed, thereby allowing cost savings in materials and assembly. In the form as illustrated, the profiled surface is located across the full extent of the rear surface 1580 of the backing portion. Depending on loading requirements, the profiled surface may be confined to only part of the rear surface, of in some other applications (for example where lower loads are required), the rear surface may be smooth without profiling.

As the beam column connection of Figs. 37 to 41, is designed for heavier loading (as an example in the vicinity of 400kN), the beam has a large depth to accommodate those loads. Furthermore, the couplings 1528 are fixed relative low on the beam end face 1518. This positioning assists in the performance of the beam as lower positioning changes the failure mode to improve the load shear profile (to allow more ductile failure mode) than would occur if the couplings 1528 were located higher on the beam end face.

Providing a profiled region to distribute the shear force across the majority of the bracket may induce larger internal tensile forces in the beam end and may promote cracking. By confining these forces to a lower portion of the beam and to a smaller region can both reduce the internal tensile forces (the forces act more in compression) and allow slip of the bracket as a failure more (thereby creating a more ductile failure response).

The end face 1518 of the beam 1514 is provided with a shallow vertical recess 1519 having a substantially planar floor dimensioned to accept the backing portions 1562 of the couplings 1528 such that the backing portion aligns substantially flush with the beam end face 1518. Fixing elements 1608 are fixed through the backing portion 1562 and through the floor of the vertical recess 1519. The attachment of the coupling 1528 may be done prior to transportation onsite, so that the beam 1514 and the beam coupling 1528 are provided as a beam assembly.

In one form, the recessing in the beam end face 1518, is through the application of a glued timber panel 1582 which locates at least partially around the couplings 1528. The grain of the timber panel runs perpendicular to the grain in the beam and reinforces the beam end (particularly along the bottom edge of the beam end) to resist edge cracking of the beam 1514. The incorporation of the panel reinforcement can obviate the need for additional vertical screws installed in the beam as disclosed in other embodiments of the technology. In other forms, the panel reinforcement may be incorporated in conjunction with vertical screws.

Unlike the previous variants, the column 1536 does not include a narrower upper region, rather the external dimensions of the column 1536 remain the same along its length. However, the column is machined, or otherwise formed, to include the slots 1548 extending from the upper end 1550 and a pocket 1584 which is arranged to receive the intermediate member 1570. The base of the pocket forms the upper bearing surface 1544. In this embodiment, the intermediate member is shaped to fit snuggly within the pocket and is generally block shaped. The intermediate member 1570 forms a reaction block and includes slots 1586 which extend from an upper end 1587 of the member 1570 and which align and

form an extension of the slots 1548 machined into the column. Each of these slots 1586 terminate at a lower bearing surface 1588 on which the lower edge of the plates 1568 bear to transfer load through to the column via the upper bearing surface 1544 on which the reaction block 1570 locates.

In the form as illustrated, the intermediate member 1570 (or reaction block) includes two slots 1586, which are spaced apart and thus divide the upper portion of the body 1589 of the member into three portions 1589', 1589" and 1589"' which are interconnected by a basal portion 1590 of the body. In use, when the beam is installed on the column, the projecting plates 1568 locate within the slots 1586 of the intermediate member 1570 with their lower edges in engagement with the lower bearing surfaces 1586 and the side faces of the plates in opposing relation with respective internal walls of the body portions which in turn define the slots. In this way the first connection arrangement of the system is formed.

In one form, the reaction block 1570 is made from metal (for example is made as a lightweight aluminium casting). Typically, the reaction block 1570 is fitted within the pocket 1584 in the factory before being transported to site and secured in place by fixing screws 1600 which extend through preformed holes in the reaction block body 1589 into the column. A feature of the design is that through the snug fit, the reaction block is integrated within the column such that compressive loading applied to the column can be accommodated through the block. As such the load carry capacity of the column of the resulting column assembly is not diminished by the incorporation of the reaction block 1570.

Each of the column, reaction block, and coupling plate include transverse holes (being 1591, 1592, and 1594 respectively). These holes are designed to align when the beam is installed on the column and form part of a second connection arrangement of the building system to tie the beam to the column. Once aligned, latch members, which in the illustrated form may comprise dowel pins 1596 are inserted from the exterior of the column (through each of holes 1591) to tie the beam 1514 to the column 1536. To allow some tolerance in the direction of the axis of the beam, the holes 1594 in the plate 1568 of the coupling 1528 are slotted so as to provide some play in the direction of the beam axis to facilitate installation on site, to accommodate some elongation or contraction of the beam and to accommodate for movements induced by dynamic loading such as may be experienced in seismic conditions.

A feature of the design, is that with the direct tie connection between the couplings 1528 and reaction block 1570 through the dowels 1596, a high horizontal tie force can be achieved. This tie force can meet building standards (such as Eurocode horizontal tie force

requirements) where the horizontal tie force is required to be greater than 75% of the design gravity load.

In addition, to provide initial joint rotational stiffness to the beam column connection 1510, fixing screws 1598 may be installed on site are locating the beam in place. These are typically inserted at an angle through the top of the beam 1520 and into the column. Pre-drilled holes may be included in the beam to assist in this locating the screw 1598 for fixing on site. In a similar manner to the design and performance of the tie bracket 252, the fixing screws will not prevent limited rotation of the beam column connection required to allow the building system to perform under seismic conditions

Consistent with the earlier embodiment, the beam column connection 1512 is ideally designed for mass timber construction. It is simple to install with guided vertical positioning and is self-propping (having the primary load path through the bearing surfaces between the beam and column via the reaction block 1570). The connection has the necessary tolerance for site erection and flexibility for seismic rotation (through the orientation of the coupling plates 1568 and slots 1548, 1586 and the ability of the fixing screws 1598 to flex). The connection has minimal parts and limited on-site fastening. The connection has good fire rating. The intermediate member 1570 provides a prescriptive fire rating solution which thereby allows the connection to be more readily accepted. In a fire situation where the column surface is charred, a secondary gravity load path is provided utilising the vertical shear capacity of the reaction block fasteners. The coupling 1528, and intermediate member 1570 are fully encased by timber when the beam is installed on the column. A further benefit is that the connection detail can be scaled (as illustrated) to accommodate larger loads because of the simple component designs and the enhanced tie force provided by the direct connection between the reaction block 1570 and coupling 1528 through dowels 1596.

Figs. 42 to 44 depict a further embodiment which is a variant of the embodiment shown in Figs 37 to 41. The primary difference between the variants is that the connection is formed between a concrete (or other cementitious material) column and timber beam as part of a hybrid construction. Like features of the beam and column will be referenced with like numerals as those used in Figs. 37 to 41, except the prefix “15” will be replaced with the prefix “17”. The differences between the variants are discussed below. Description of the other features of the building systems 1510 also apply to like features of the building system 1710, except for differences where mentioned.

In the embodiment shown in Figs. 42 to 44, the intermediate member (or reaction block) 1770 is mounted externally to a concrete column 1736. The fixing bars 1800 of the reaction block have enlarged distal ends 1810 and are pre-cast into the column (which in turn is typically cast on site). With the external mounting of the reaction block, the column can form part of a continuous column structure as no slots, or pockets are required as per the embodiment of Figs. 37 to 41.

The beam assembly comprising beam 1720 and coupling(s) 1728 can be of the same design as the earlier embodiment disclosed in Figs. 37 to 41, with the exception that the beam end includes a deeper recess 1719 so that the outer edge of the coupling plates 1768 align with the outer face 1718 of the beam. Moreover, the recess extends from a mid-region of the end face to the bottom surface of the beam 1714. Furthermore, the transverse holes 1791 to allow insertion of the dowels 1796 extend through the beam, and not the column as in the earlier embodiment.

Installation of the beam 1714 onto the precast column 1736 is similar to that of the earlier embodiment. The beam is vertically dropped into position, with the coupling plates 1768 sliding into the corresponding slots 1786 on the preinstalled reaction block 1770. The lower edges of the plates 1768 locate on the upwardly facing bearing surface of 1786 of the reaction block 1770. In this way, the beam is supported by the column through the reaction block. In this position, the slots are arranged to align to allow insertion of the dowels to tie the beam to the column. To protect the metal components from fire, a timber element 1804 is inserted under the reaction block and fills the bottom part of the beam recess 1719 that receives the couplings 1728.

Whilst the embodiment shown in Figs. 42 to 44 is designed for hybrid construction between a concreate /mass timber connection, it is to be appreciated that such an arrangement could be used in a timber to timber connection or to secure precast concrete (or other cementitious materials) elements together.

Fig. 8 is an exploded view of a building system in the form of a beam column connection according to a third embodiment. The building system 310 has many of the features of the earlier embodiment and like features are designated by like reference numerals with the addition of the prefix "3".

The beam column connection 312 is well suited for shallower beam designs than the earlier embodiments. Whilst providing an aesthetic solution, it is also scalable by increasing the sizes of the components used. Further, the building system 310 includes the design principles and many of the advantages of the earlier embodiments.

The primary difference in the building system 310 over the earlier embodiments is that rather than providing the primary load path directly through opposing bearing surfaces between the beam and the column, in this embodiment, that bearing path is via the coupling 328, which is in the style of a hanger bracket. The bracket 328 includes a projecting ledge 370 that extends from a body portion 372. The ledge and body are interconnected by a web 374 that increases the strength of the bracket 328 (acting as a gusset) and also provides the guiding function and lateral stability which is present in the earlier embodiments. As such, the load path in supporting the beam on the column passes through the gusset 374.

To accommodate the hanger bracket 328, the connection region 338 of the column 336 is shaped to include a slot 376 that includes an enlarged region 378 to accommodate the ledge 370 and a narrower portion 380 to receive the web 374. The base of the enlarged portion 378 forms an upwardly facing bearing surface 382 to receive a lower surface 384 of the ledge 370.

On installing the beam onto the column, the web is received in the slot 376 and the ledge 370 locates on the upwardly facing bearing surface 382. No direct fixing is required between the ledge and the bearing surface. This ensures that the tolerance is provided in the beam column connection and also the rigidity of the first coupling does not dictate the amount of rotation the resulting beam column connection will allow.

Similar to the earlier embodiment, the coupling 328 is typically arranged to be installed on the beam 312 prior to transporting to site so as limit onsite assembly. As such, the beam and coupling are provided in the form of a beam assembly 334.

A secondary coupling, in the illustrated form, being tie bracket 352 of similar construction of angle plate as the earlier embodiments and is arranged in the same orientation to allow it to have limited flex at its corner 358 to enable some in plane rotation (in the plane of the beam and column axes b-b and c-c) to accommodate seismic conditions. Other configurations of tie bracket (including as disclosed below) may be used.

Consistent with the earlier embodiments, the beam column connection 312 is ideally designed for mass timber construction. It is simple to install with guided vertical positioning (provided by the web 374 locating in the corresponding slot 380). The beam is supported on an upwardly facing surface of the column. The connection has the necessary tolerance for site erection and flexibility for seismic rotation (through the orientation of the web and slot and the ability of the tie bracket 352 to flex). The connection has minimal parts and limited on-site fastening. In the building system 310, the capacity of the connection is largely defined by the bending stiffness of the bracket. Even so, the system 310 is scalable

by increasing the bracket size, increasing the gusset strength (including providing multiple gussets) and is therefore suited to lower load conditions (say shorter shallower spans, single storey and/or residential) as well as larger commercial building sizes.

Figs. 21 to 23 depict an embodiment which is a variant of the embodiment shown in Figs. 8 to 14. Primarily, the differences between the two embodiments is that the beam is set above the height of the column in this latter arrangement. Like features of the beam and column will be referenced with like numerals as those used in Figs. 8 to 14, except the prefix "3" will be replaced with the prefix "6". In the below, the differences between the variants are discussed. Description of the other features of the building system 310 also applies to like features of the building system 610, except for differences where mentioned.

As shown in Figs. 21 to 23, for illustrative purposes, two beam column connections are shown (at opposite ends of beam 614) and are distinguished by use of an apostrophe on the reference numerals. For ease of description, reference is only made to one of those beam column connections 612 and it is to be understood that, unless stated otherwise, the description also applies to the other connection 612'. Further, beam column connection shown in Figs. 21 to 23 may also be used in building systems with different element configurations (e.g., one column with one beam, etc).

As best shown in Fig. 21, the exploded view of the building system 610, the coupling 628 comprises a projecting ledge 670 that extends from a body portion 672. The ledge 670 and body 672 are interconnected by a gusset or web 674 that increases the strength of the bracket 328 and also provides the guiding function and lateral stability which is present in the earlier embodiments. On either side of the web 674, attachment apertures are provided on the body portion 672, so that the body portion 672 can be fixed onto the end face 618 of the beam 614. The body portion 672 is adapted to be fixed within a rebated portion 619 on the end face 618, which extends from the lower surface 622 of the beam 614 to the upper surface 620 of the beam 614. In the coupling 628, the body portion 672, in a region adjacent the projecting ledge 670, narrows to form a neck 673. The coupling 628 has one or more gusset welds 627 (see also Fig. 24) located in each join between the web portion 674 and the body portion 672 to enhance the strength of the coupling 628.

As with the previously embodiment, the couplings 628 may be fixed to the beam 614 prior to transportation. The couplings 628 and the beam 614 are thus provided as a beam assembly and transported onsite for assembly with the columns.

The column 636, in an upper portion 640 thereof, has a connection region 638. The connection region 634 is shaped to provide a slot 676 positioned and dimensioned to

receive the web 674 of the coupling 628. As can be seen in Fig. 23, the slot 676 may be formed to have a curved or rounded lower profile to provide for better stress distribution through the column and to simplify manufacture. The slot 676 extends to the upper surface 650 of the column 636 and differs from the slot 372 in the previous embodiment in that it does not have an enlarged region to accommodate the projecting ledge 670. The slot 676 is preferably wider than the thickness of the web 674, to increase the assembly tolerance in the beam column connection, and to allow for rotation under dynamic loading conditions such as may occur in seismic conditions.

When the beam 614 is assembled with the column 636, the projecting ledge 670 is supported by the upper surface 650 of the column 636. This can be best seen in Fig. 23, which shows a cross-section of the building system 610, sectioned along a vertical plane which includes the longitudinal mid-line A-A (see Fig. 22) of the building system 610.

Fig. 24 depicts an embodiment of a building system which is similar to the embodiment of the building system 610 shown in Fig.21. The building system shown in Fig. 24 utilises the same coupling as that shown in Fig. 21. Here, two of the same couplings 628.1, 628.2 are each used to form a connection between a beam 614.1, 614.2 and a column 656 positioned between the beams.

Another variation shown in Fig. 24 is the inclusion of tie brackets 652.1, 652.2, one in each beam-column connection. Each tie bracket 652.1, 652.2 includes two portions which are angled with respect to each other. One portion is secured to the top surface 620.1, 620.2 of the respective beam 614.1, 614.2, and another portion is secured to the column 636. In the depicted embodiment the attachment is made to the surface of a recessed portion 651.1, 651.2 in respective top surface 620.1, 620.2.

The tie brackets 652.1, 652.2 differ from those shown in Figs. 8 to 11, and are designed to facilitate deformation, which may be ductile deformation, in the fasteners when the building system is subject to external (e.g. seismic) forces that cause the building components to shift. By allowing deformation in the fasteners, this reduces the likelihood of the bracket lifting from the building components. It can also be seen that the mounting surfaces 651.1, 651.2 on the beam each includes additional features 653.1, 653.2, which are configured to allow movement of the fasteners, as will be discussed below.

Figs.30a to 33 depict an embodiment which is a further variant of the beam column connection shown in Figs. 8 to 14.. Like features of the embodiment will be referenced using the same numbers, except the prefix “1” is added. In the below, the differences between the variants are discussed. Description of the other features of the building system 310 also

applies to like features of the building system 1310, except for differences where mentioned. Moreover, in relation to Fig. 33, for illustrative purposes, two beam column connections are shown (at opposite ends of beam 1314) and are distinguished by use of an apostrophe on the reference numerals. For ease of description, reference is only made to one of those beam column connections 1312 and it is to be understood that, unless stated otherwise, the description also applies to the other connection 1312'. Further, the beam column connection shown in Figs. 30a to 33 may also be used in building systems with different element configurations (e.g., one column with one beam, etc).

Turning firstly to Figs 30a and 30b, one difference with this variant is the form of attachment of the coupling 1328 to the beam end face 1318. The coupling 1328 only includes attachment apertures 1332 along a partial extent of its body portion 1372, rather than along most of the extent of the body portion as is the case in coupling 328. In the depicted embodiment, the coupling 1328 has attachment apertures along a lower part of the body portion 1372. In one form, the apertures extend only in a lower half of the body portion 1372. In one form, the apertures extend only in a lower third of the body portion 1372.

In addition, in one form as illustrated, the rear surface of body portion 1372, which contacts with the beam end face 1318, includes a profiled area 1380. In the illustrated form, this profiled region 1380 is in the lower part of the body portion and in one form corresponds to the region where the attachment apertures 1332 are provided. In some forms, the profiled area is in a lower half of the body portion. In some forms, it is in the lower third of the body portion. The profiled region may be in the form of small cylindrical projections (micro-dowels), teeth, hooks, serrations or the like to engage with the beam end face to thereby key the coupling to the beam end face to improve shear transfer and stiffness between the coupling 1328 and the beam 1314. A feature of this arrangement is that the shear force is distributed across the extent of the profiled regions (and not localised as in the case where the rear surface of the body portion 372 is smooth with shear being transferred by fixing screws).

A feature of containing the fixing apertures and/or the profiled surface to a lower region of the coupling body portion 1372 is that it affects the failure mode profile of the coupling. This design changes the failure mode to improve the load shear profile (to allow more ductile failure mode) than would occur if the fixing apertures and the profiled surface, were more evenly distributed across the rear surface of the body portion 1372. Providing a profiled region to distribute the shear force across the majority of the bracket may induce larger internal tensile forces in the beam end that may promote cracking. By confining these forces to a lower portion and to a smaller region can both reduce the internal tensile forces

(the forces act more in compression) and allow slip of the bracket as a failure more (thereby creating a more ductile failure response). A further advantage is that the arrangement may reduce the number of horizontal screws needed, thereby allowing cost savings in materials and assembly.

Whilst, the confined attachment region is described with reference the coupling of Figs. 30a and 30b, it is to be appreciated that it may also be used in relation to other coupling arrangements. For example, in respect of different styles of couplings where shear needs to be accommodated.

A further difference in the coupling 1328 over the earlier embodiment is the web 1374 is deeper along its length. This improves lateral stability in the resulting connection and also assists in guiding installation of the beam into position on the column.

Similar to the earlier embodiments of Figs. 8 to 11, the system also includes a second coupling 1390 to fix the beam 1314 to the column 1336. The tie bracket 1390 is, in turn, a variation of the embodiment shown in Fig. 24 and is discussed in more detail below. Again, the tie bracket is designed to facilitate deformation, which may be ductile deformation, in the fasteners when the building system is subject to external (e.g. seismic) forces that cause the building components to shift. By allowing deformation in the fasteners, this reduces the likelihood of the bracket lifting from the building components.

The resulting beam column connection is described with reference to Figs. 31 and 33.

Fig.31 depicts a cross section through a beam column connection made using the coupling 1328. In the depicted connection, the column 1336 is located such that its upper surface 1350 is positioned higher than the upper surface 1320 of the beam 1314. The projecting ledge 1370 of the coupling 1328 is supported by the column 1336. When assembled the ledge 1370 locates in a rebate 1355 (see also Fig. 33) from the upper surface 1350 of the column 1336, so that it is positioned at a level which is lower than the upper surface 1350. The body portion 1372 of the coupling 1328 is attached to a cooperating end face 1318 on the beam 1314, while the web 1374 of the coupling 1328 is received in a cooperating slot or groove formed in the column 1336. Fixing screws 1357 which fasten the body portion 1372 to the beam's end face 1318 can be seen through the cross section in Fig.31.

Consistent with earlier embodiments, once installed in place, the beam and column can be fixed in place using a secondary coupling, which in one form may be through use of a separate coupling bracket (such as tie bracket 1390).

In addition, the beam column connection (in any form described above but illustrated in Figs. 31 and 33) may be further reinforced to assist in accommodating tension in the beam end region

In one form, the additional reinforcing may be in the form of one or more reinforcing members that are disposed in, or on the beam. In one form, the members are in the form of at least one reinforcing screw 782. The reinforcing screws 782 can be fitted through the beam 714 as shown in Fig.31, where they are inserted through the end face 718. The screws 782 are fitted through an upper portion of the end face 718. Particularly they can optionally be fitted through the upper 1/3 of the end face 718 as shown in Fig. 31. Insertion locations for the screws 782 will be chosen so as to avoid the fasteners which will be fitted through the top surface 1320 of the beam 1314 to secure the bracket 1390 onto the beam 1314. Fig. 36 shows that four horizontal reinforcing screws 782 are included. However, a different number of reinforcing screws can be included depending on the design loading.

Additionally, or alternatively, further reinforcing members 782 may be fitted through the bottom surface of the beam 1314. These further reinforcing members 782 may be provided in the form of reinforcing screws. The purpose of providing the screws 782 is to reinforce the beam 1314 against tensile failure, to ensure low damage to the building system under seismic conditions. The screws 782 are preferably full thread screws.

Additionally, or alternatively, further reinforcing members may be disposed in, or on the column 1336. In one form, the reinforcing members are in the form of at least one reinforcing screw 783. The screws 783 are fitted through an end surface 1338 of the column 1336 as shown in Fig. 31. Fig. 33 shows two screws 783 fitted through the end surface 738 of each column 1336, disposed on either side of the slot 1376. However, a different number of reinforcing members can be provided. The reinforcing members 783 are preferably evenly arranged about the slot 1376. The screws 783 will be located to avoid interference with the fasteners (not shown) which may be provided to secure the tie bracket 790 to the column 736.

The variants of the second coupling (e.g. tie bracket 1390) of the third embodiment shown with reference to Figs. 24, and 30a to 33, incorporate features that allow more controlled rotation of the beam column connection under dynamic loading. These features

are discussed in more detail with reference to tie brackets 800 and 900 shown in Figs. 25 to 29.

Fig. 25 depicts a building system including a beam 714, and a column 736.1, 736.2 each attached to one longitudinal end surface 718.1, 718.2 of the beam 720. There are therefore two beam-column connections in this building system.

The connection between the beam 714 and the column 736.2 includes a tie bracket 800. The tie bracket 800 (see also Fig. 26) includes a first portion 804 in the form of a plate, and a second portion 802 also in the form of a plate which extends at an angle from the first portion 804. In the depiction the two portions 802, 804 are perpendicular to each other, but they may be at an obtuse or acute angle from each other, in other embodiments. The join 803 between the two portions 802, 804 is configured to allow some flex between the portions. As the bracket 800 is mounted onto the topmost surface of the beam 714 and the outermost surface of the column 736.2, it is said to be surface mounted.

The second portion 802 includes a plurality of mounting holes (second mounting holes) 806 for accepting fasteners (813, see Figs. 27 and 29) therethrough to attach to a building element surface, which in this case is the column's side surface 734.2. The first portion 804 also includes a plurality of mounting holes (first mounting holes) 810 for accepting mechanical fasteners therethrough to mount the first portion 804 to the mounting surface, which in this case happens to be the top surface 720 of the beam 714.

The first portion 804 further includes a slot 808 which is intended to accept one or more fastener (816, see Fig. 29). The slot 808 will be dimensioned to receive the shank of the fasteners 816, whilst preventing the head passing through.

The fasteners 816 received in the slot 808 are arranged as secondary fasteners designed to maintain the bracket in contact with the beam 714, rather than resist the loading on the column beam connection. The primary fasteners 814, that accommodate the loading in the bracket connection through the beam are arranged to extend through mounting holes 804.

In the depicted embodiment, the slot 808 is provided along a central longitudinal axis of the first portion 804. The first mounting holes 810 are provide evenly about the central mounting slot 808. The first mounting holes 808 may be arranged in a plurality of linear arrays as shown. Each linear array may be provided in an orientation which is parallel to the central mounting slot 808.

To accommodate dynamic loading in the beam column connection, in one form the primary fasteners 814 are arranged to deform through their respective shanks 815. To control this deformation, preferably the first portion 804 is provided on a mounting surface which is also configured to provide a shank guiding arrangement, which allows deformation of the fasteners 814 whilst guiding this deformation substantially in a particular direction, by constraining deformation in other directions, especially one that is transverse to that particular direction. The may be achieved by providing in the mounting surface (being the beam's top surface 720) underlying the bracket, one or more grooves 812. The grooves may be channels recessed from the top surface 720. These are each intended to align with a first mounting hole 810 or two or more first mounting holes 810 which are provided in a linear array.

The grooves 812 are each dimensioned so as to allow one or more of the fastener 814 to undergo bending or deformation therein. The bending or deformation will be guided by the groove to be in the direction substantially defined by the groove 812, and the sides or sidewalls of the groove will constrain deformation particularly in a direction which is transverse to the direction defined by the groove. This arrangement may help to ensure the fasteners 814 will have ductile response when undergoing dynamic loading (such as in seismic conditions) that may result in interstorey drift (being the lateral displacement that make occur in a building between floors). This interstorey drift may induce displacement between the column and beam that is accommodated in the bracket by the ductile response of the fasteners 814. This displacement causes deformation of the primary fastener shanks 815 whilst maintaining their connection with the beam. The secondary fasteners 816 are able to slide within the slot 801 In some embodiments, the grooves 812 have a depth which limits the maximum angular deflection of the fastener 814 to a range of between about plus and minus 22.5 degrees. Also, to allow the fasteners 814 to deform, the fastener heads 820 are preferably spaced from the upper surface of the bracket so that they can accommodate some angular displacement.

Fig. 29 shows a photograph of the bracket 800 secured to a beam and a column. As illustrated, two secondary fasteners 816 are shown to be inserted through the central slot 808 and fastened into the underlying surface.

The primary fasteners 814 are preferably of a type with some ductility (e.g. class S3 ductility) to allow deformation. Preferably, each fastener 814 further includes a spacer 818, which in use will be located between the first portion 804 and the fastener's head 820. The spacer 818 may act as a compression limiter. If may have a deformable structure, which in the depicted embodiment is achieved by a webbed or mesh construction, but other types of

configuration may be used. The structure may be elastically or inelastically deformable, depending on the material used. Due to the spacer 818, the fastener head 820 will be allowed to have some degree of angular movement, such as a rocking movement, in relation to the plate 804 and also the underlying surface to which the plate 804 is mounted. This further helps to allow the fastener 814 to absorb shifting or rotational forces which may otherwise lead to the building elements becoming misaligned (out of position) or buckling. The compressibility also helps to provide tie force to absorb interstorey drift.

Fig. 25 and Fig 28 also show a bracket 900 which is a variant of bracket 800. The bracket 900, similar to the bracket 800, includes a second portion 902 in the form of a plate and having second mounting holes 906, and a first portion 904 in the form of a plate having first mounting holes 910. However, the second and first portions 902, 904 of the bracket 900 are co-planar with each other. The bracket 900 thus has opposite upper and lower surfaces. This may be useful for inclusion in the connection between aligned flush mounting surfaces from two adjacent building elements. The first portion 904 is also provided with same features as the first portion 804 of the other bracket 800. It also includes a central mounting slot 908 for accepting further fasteners, with the first mounting holes 910 provided in linear arrays, evenly arranged about the central mounting slot 908. Although not shown, the same arrangement which facilitates or guides the deformation in respect of the first portion 904 may also be provided for the second portion 902.

The second and first portions 902, 904 are respectively secured to a recessed surface 914 provided on the column 736.1 and a recessed surface 916 provided on the beam. Depending on the depth of the recesses, the upper surface of the bracket 900 may protrude above, or be concealed within, the depths of the recesses. By being concealed, the upper surface of the bracket may lie substantially flush with, or lie below, the top surfaces of the beam 714 and column 736.1, to provide respectively a flush mount or recess mount configuration.

Figs. 32 and 33 show further variants of the tie brackets which may be used across the top surfaces of the column and beam in a beam column connection (such as those described in any of the beam column connections disclosed). These brackets have different geometries to suit different arrangements of beam column configurations and to allow more control over their deformation to better control the amount of rotation provided at the beam column connection.

The bracket 1390 shown in Fig. 32 has a “dog-legged” shape and is suited for use in beam column connections where there is a stepped difference in height between the top

surfaces of the beam and the column. It may be used for example in the beam column connection shown in Fig.31 and Fig.33.

The bracket 1390 is formed as a unitary sheet material and includes an upper plate portion 1391, a lower plate portion 1395, both of which generally will be horizontally oriented in use (relative to a vertically extending column arrangement), and a connecting plate portion 1393 which will be vertically oriented in use. The corners between the connecting plate portion 1393 and the upper and lower plate portions 1391, 1395 incorporate radiused transitions to resist localised stress concentrations. Gussets 1394 are provided to reinforce the corner between the connecting plate portion 1393 and the lower plate portion 1395. In the depicted embodiment, a pair of gussets 1394 are shown. However, one or three or more gussets may be provided instead. As such, the corner at the lower plate portion is rigid (by virtue of the gussets), whereas corner between the connecting plate portion 1393 and the upper plate portion 1391 allows more flex, aided by the radiused geometry at the corner and the absence of gussets.

The upper plate portion 1391 is shaped somewhat like a "T", having a narrower first section 1391.1 providing the "stem" of the T-shape, and a wider second section 1392.2 providing the "head" of the T-shape. The "stem" or narrower section 1391.1 is the part which connects to the connecting plate portion 1393. The narrower and wider sections 1391.1, 1391.2 are partially joined, being disjointed by cut-outs or separation lines 1391.3 at either side of the narrower section 1391.1. The separation lines 1391.3 are angled inwardly from the narrower section 1391.1 toward the wider section 1391.2. The provision of the separation lines 1391.3 allows more controlled bending in the bracket to allow limited rotation within the beam column connection. Apertures 1391.4 are provided along the side edges of the wider section 1391.2, outwards of the separation lines 1391.3. The apertures 1391.4 are provided for cooperating with attachment means such as screws, bolts, etc. to attach the top plate 1391 to an underlying surface, which in Fig.31 is the upper surface 1350 of the column 1336.

In the lower plate 1395, there are formed a central slot 1395.1 which is generally located on a central axial location of the plate 1395, and side apertures for receiving attachment means such as screws, bolts, etc., to attach the lower plate 1395 to an underlying surface. In Fig.31, the underlying surface is provided by the upper surface 1351 of the beam 1314. The functions of the central slot 1395.1 and the side apertures are the same as those provided in other embodiments (particularly those described above with reference to bracket 800).

In the depicted embodiment of Figs 31 and 33, the upper plate 1391 is located over the projecting ledge 1370 of the bracket 1328 so that the attachment apertures 1391.4 will be located outwards of the projecting ledge 1370, and attachment screws (not shown) can be provided through the apertures 1391.4 to fasten the upper plate 1391 to the upper surface 1350 of the column 1336.

To cooperate with the arrangement of the projecting ledge 1370 of the coupling 1328 and the upper plate 1391 of the tie bracket 1390, the upper surface 1350 of the column 1336 is rebated at an end adjacent the beam 1314. This can be best seen in Fig. 33. The aforementioned rebate 1355 is tiered in that it has two levels, including a wider first level 1355.1 which extends downwards from the upper surface 1350 to a floor of the first level 1355.1. The first level 1355.1 is dimensioned to receive the upper plate 1391 of the tie bracket 1390. The rebate 1355 has narrower second level which extends downwards from the floor of the first level 1355.2. The depth of the first level 1355.1 is preferably chosen so that the upper surface of the tie bracket 1390 will lie flush with the upper surface 1350 of the beam 1336. The second level of the rebate provides the receiving space 1355.2 dimensioned to receive the projecting ledge 1370 of the coupling 1328. The depth of the second level 1355.2 is preferably chosen to be greater than the depth required to accommodate the thickness of the projecting ledge 1370. This is so that, in the assembled state, there will be a clearance between the tie bracket 1390 and the projecting ledge 1370. The clearance allows room for relative movement of the stem section 1391.1 in the tie bracket's upper plate 1391 with respect to the rest of the upper plate 1391, along the separation lines 1391.3. This enables limited rotation within the beam column connection, to accommodate dynamic loading which may be experienced in seismic conditions.

A slot 1376 (see Fig. 36) extends from the floor of the second level (i.e., receiving space) 1355 downwards, to receive the web 1374 of the coupling 1328.

When assembled, the upper plate 1391 of the bracket 1390 will be secured by fasteners provided through the apertures 1391.4 and into the beam 1336 through the floor of the rebate's first level 1355.1. The stem portion 1391.1 of the upper plate 1391 will generally be positioned above the projecting ledge 1370 of the coupling 1328. The lower plate 1395 of the bracket 1390 will be attached to a recessed surface 1351 on the beam 1314 dimensioned to receive the lower plate 1395 and configured to cooperate with the attachment features provided in the lower plate 1395. This recessed surface 1351 will be similar to the recessed surfaces 1351.1, 1351.2 shown in Fig. 24.

Fig. 34 depicts a further embodiment of the tie bracket 950. The bracket 950 has a wider part 952 on one end, a narrower part 954 on the opposite end, connected by a bridge 956 which is narrower still. The wider part 952 and the bridge 956 therefore form a T-shape. The narrower part 954 has the same features as the lower plate portion 695 for bracket 690. The wider part 952 is similar to the upper plate portion 691 for bracket 690, in that it has attachment apertures located on the side (short side) edges of the wider part 952. The tie bracket 950 is suitable for use across surfaces where are at the same level. The bridge portion 956 is provided to allow the controlled bending of the bracket 950 required to allow the limited rotation between the beam and the column under seismic conditions.

Fig. 35 depicts a further variant of the coupling shown in Fig 30. It is denoted with like numbers as those used for coupling 1328 in Fig.30, but with prefix "2" instead of "1". The difference being that the couplings 1328, 2328 is that the coupling 2328 includes two webs (or gussets) 2374 connecting the projecting ledge 2370 and the body portion 2372 of the coupling 2328. In further variants, three or more webs may be provided. This embodiment is suited for larger scale connections where larger loads are accommodated such as those found in commercial building, but it is not confined to that use and can be used in residential applications or other applications where the load conditions may be less.

The surfaces (typically beam end faces) to which the couplings (such as 628, 1328, or 2328) are attached may further be reinforced by having inlay reinforcing features. Fig.36 depicts a beam 1014 having an attachment surface 1020 provided on an end surface 1018 of the beam. The attachment surface 1020 is reinforced by inlay reinforcing elements 1022, 1024. The inlay reinforcing elements 1022, 1024 may be made of timber.

The inlay reinforcing elements 1022, 1024 are inserted into cooperating receiving spaces 1026, 1028, which in the depicted embodiments are elongated slots. They are secured in the slots 1026, 1028 by attachment means such as screws or bolts. With the inlay reinforcing elements positioned in the receiving spaces 1026, 1028, the outermost surfaces 1030, 1032 of the inlay reinforcing elements 1022, 1024 are flush with the rest of the attachment surface 1020 to present a level or flat surface for attachment. The inlay reinforcing elements 1022, 1024 are provided for an attachment surface 1020 that is rebated with respect to the rest of the beam's end surface 1018 as shown in Fig.35. However, they can also be provided for attachment surfaces which are not rebated.

The attachment surface shown in Fig. 35 is suited for accepting the body portion 672, 1372, 2372 of a coupling 628, 1328, or 1328 of the type shown in Figs. 21 to 24, 30, and 35. However, it will be understood that the feature of having the inlay reinforcement may

be included in any other surface on the beam or column, whether rebated or not, to which body or backing portions of the couplings are attached.

The beam column connections disclosed above may form part of an integrated solution with floor plates for multistory buildings. Figs. 13 and 14 illustrate this integrated solution using the beam column arrangement disclosed in Figs. 30a to 33. In general, the first column assembly1336 (with milled slots formed therein) is installed in place. The beam 1328, 1328' incorporating couplings 1328, 1328' preassembled onto the beams are then lifted and installed on the column 1336. The beams can then be fixed in place by the tie brackets 1390,1390'. The floor plates 150, 150' are then able to be installed and supported on the beams 1314, 1314'. In the illustrated form, the floor plates include cut outs 151,151' that locate over the tail portion 1395 of the tie brackets 1390,1390'. These provide clearance for, and access to, the raised fasteners mounting the bracket to the beams. Blocks (not shown) are provided to locate in the respective cut outs 151,151' to close them off as required. A bearer plate 152 is then installed top of the column 1336 and overlays the upper portion of the brackets 1390, 1390'. The next column section 1336' is then able to be installed.

In installing the floor plate, the bracket 1390,1390' becomes fully covered and therefore it to becomes encapsulated in the beam column connection. This cover enables the beam column connection 12 to have a high fire rating (as the timber itself provides fire protection for the steel components). To supplement the fire protection, a fire rated sealant such as an intumescent caulking may be subsequently applied to the join areas.

Improved connections and methods of assembly in building systems utilising mass timber product are disclosed that reduce the total cost of construction through increasing the speed of installation thereby reducing the amount of time for labour and ancillary equipment (such as cranes). Further, the connections use simplified components that are simple to install offsite thereby reducing the cost of fabrication of the mass timber products including component cost. Some of the building systems disclosed allow the building system to be easily scaled so that they are able to be more readily used in multistorey building construction, with the ability to scale being provided at least in part by the connections being predominantly bearing based so that for larger loads, larger bearing surfaces are provided. The disclosed connections are provided to meet specific performance criteria of the building system such as fire rating or dynamic loading such as under seismic conditions

Variations and modifications may be made to the parts previously described without departing from the spirit or ambit of the disclosure.

As examples, in some forms, the first connections arrangements (for example first couplings 328, 628,1328, 2328) may be used independently of the second connection arrangements. Similarly, the second connection arrangements (i.e. tie brackets 390, 690, 950,1390) may be used independently of the first connection arrangements. Further, different fixing arrangements may be provided. For example, in some arrangements the beam and column connection may be fixed by fasteners, or other mechanical connections, extending directly through the first couplings, thereby obviating the need for a separate coupling as the second connection arrangement.

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

CLAIMS

1. A building system comprising a beam having a region having an edge face, and a column having a connection region incorporating an upwardly facing bearing surface, one of said edge face and said connection region having a first coupling projecting therefrom, the other one of said edge face and said connection region having a slot, wherein the beam extends from the column at the connection region with the beam edge face in opposing relation with the connection region, the beam being supported on the upwardly facing bearing surface and the first coupling being received within the slot to form a first connection arrangement, wherein the building system further comprises a second connection arrangement to tie the beam to the column.

2. A building system according to claim 1, wherein the first coupling is provided as a separate component which is affixed to, or disposed in, the beam.

3. A building system according to claim 1 or 2, wherein at least part of the connection region is integrally formed as part of the column.

4. A building system according to any one of claims 1 to 3, wherein at least part of the connection region is formed from an intermediate member affixed to, or disposed in, the column.

5. A building system according to claim 4, wherein the intermediate member provides the upwardly facing bearing surface of the connection region.

6. A building system according to claim 4 or 5, wherein the intermediate member provides the slot or first coupling of the first connection arrangement.

7. A building system according to any one of claims 4 to 6, wherein the intermediate member is in the form of a reaction block.

8. A building system according to any preceding claim, wherein the first and second connection arrangements are operative to accommodate tolerance variations at the connection between the beam and column in at least one direction.

9. A building system according to claim 8, wherein the at least one direction is in the direction of an axis of the beam.

10. A building system according to any preceding claim, wherein the first and second connection arrangements are able to accommodate at least limited relative rotation and/or displacement between the beam and column.

11. A building system comprising a beam column connection comprising at least one connection arrangement arranged to accommodate at least limited relative rotation and/or displacement between the beam and column

12. A building system according to claim 11, wherein a first connection arrangement is arranged to locate the beam relative to the column and comprises at least one inter-fitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column.

13. A building system according to claim 12, wherein a first coupling projects from an edge face of the beam and forms the projection, and a column having a slot forming the recess of the first connection arrangement.

14. A building system according to claim 12 or 13, wherein the first connection arrangement is able to accommodate rotation and/or displacement by relative movement of the first coupling within the slot.

15. A building system according to any one of claims 11 to 14, wherein a second connection arrangement comprises a connector having a first region fixed to the column and a second region fixed to the beam wherein the connection arrangement is able to accommodate rotation and/or displacement by deformation of the connector.

16. A building system according to claim 15, wherein the connector includes first and second portions and the connector is arranged to deform at a region between the first and second portions.

17. A building system according to any one of claims 10 to 16, wherein the rotation and displacement is in, or parallel to, the plane defined by an axis of the column and an axis of the beam.

18. A building system according to any one of clams 10 to 17, wherein a second connection arrangement comprises a connector having a first region fixed to the column and a second region fixed to the beam and the second connection arrangement incorporates a fixing arrangement for securing the connector to one of the beam or the column, the fixing arrangement including mechanical fasteners having a shank that extends along an axis of the fastener and arranged to accommodate at least limited relative rotation and/or displacement between the members through deformation of the shanks of the mechanical fasteners, the fixing arrangement including a shank guide arrangement to constrain the deformation of

the respective fastener shanks to be generally in a first plane containing the shank axis.

19. A building system according claim 18, wherein the shank guide arrangement is in the form of one or more channels that are disposed below the connector and through which the shanks extend into the beam/column.

20. A building system according claim 19, wherein the channels are formed directly in the beam/column.

21. A building system according claim 19 or 20, wherein the fasteners are aligned such that multiple fasteners share a common channel.

22. A building system according to any one of claim 18 to 21, wherein the mechanical fasteners comprise a head and a shank and the fixing arrangement further comprises one or more spacers adapted to locate the head of the mechanical fasteners in spaced relation to the upper surface of the bracket.

23. A building system according to any one of claims 1 to 10, wherein the second connection arrangement comprises a connector having a first region fixed to the column and a second region fixed to the beam.

24. A building system according to claim 23, wherein the connector includes first and second portions and the connector is arranged to deform at a region between the first and second portions.

25. A building system according to any one of claims 1 to 10, wherein the second connection arrangement comprises a least one latch member that interconnects components forming the first connection arrangement.

26. A building system according to claim 25, when dependent on claim 4, wherein the at least one latch member interconnects the first coupling to the intermediate member.

27. A building system according to claim 26, wherein the intermediate member and first coupling include preformed holes which are arranged to align on forming the first connection to form a passage in which the at least one latch member is arranged to locate to interconnect the first coupling to the intermediate member.

28. A building system according to claim 27, wherein the preformed holes in one of the intermediate member and first coupling is slotted to accommodate tolerance variations at the connection between the beam and column in at least one direction.

29. A building system according to any one of claims 25 to 28, wherein the at least one latch member is in the form of a dowel pin.

30. A building system according to any preceding claim, comprising a guide arrangement that facilitates correct location of the beam on the column.

31. A building system according to claim 30, wherein the guide arrangement is provided by the first connection arrangement.

32. A building system according to any one of claims 11 to 31, when dependent on claim 11, wherein the column comprises a connection region incorporating an upwardly facing bearing surface, the beam extends from the column at the connection region with an edge face of the beam in opposing relation with the connection region and the beam being supported on the upwardly facing bearing surface.

33. A building system comprising a beam having a region having an edge face, and a column having a connection region, the beam edge face being installed in opposing relation with the connection region of the column and the building system further comprises a guide arrangement that facilitates correct location of the beam on the column.

34. A building system according to claim 33, wherein the guide arrangement comprises a first connection arrangement comprising at least one inter-fitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column.

35. A building system according to claim 34, wherein a first coupling projects from an edge face of the beam and forms the projection, and a column connection region incorporating a slot forming the recess of the first connection arrangement.

36. A building system according to any one of claims 1 to 10, 12, or 35, wherein the at least one projection is in the form of a plate.

37. A building system according to claim 36, wherein the column extends generally along an axis and the at least one plate and slot of the first connection arrangement are generally aligned in the direction of the column axis when in interfitting relation.

38. A building system according to any one of claims 1 to 10, 23 to 28, wherein the first coupling comprises a body portion.

39. A building system according to claim 38, wherein the body portion includes a first portion that is fixed to the beam.

40. A building system according to claim 39, wherein the first portion has opposite upper and lower ends and is fixed to the beam at an attachment region that is disposed in the lower half of the first portion.

41. A building system according to claim 40, wherein the attachment region has an inner surface that abuts the beam, the inner surface being profiled to distribute shear force across the attachment region.

42. A building system according to any one of claims 40 to 41, wherein the first portion is fixed to the beam by mechanical fasteners that extend through the attachment region.

43. A building system according to any one of claims 39 to 42, wherein the body portion further comprises a second portion having a downwardly facing bearing surface that supports the beam on an upwardly bearing face of the column.

44. A building system according to claim 43, wherein at least one web extends between the first and second body portions and comprising the at least one projection of the first connection arrangement.

45. A building system according to any preceding claim, wherein at least one of the beam or the column is formed of mass timber.

46. A building system according to any preceding claim wherein at least one of the beam or column is formed from cementitious material.

47. A beam to column connection system comprises a first connection arrangement comprising at least one interfitting recess and projection, the recess being disposed in one of the beam or column, and the projection being disposed on the other of the beam or column, the first connection arrangement operative to locate the beam relative to the column whilst allowing at least three degrees of freedom of the beam during installing; and a second connection arrangement operative to fix the beam to the column subsequent to the mounting of the beam to the column.

48. A beam to column connection according to claim 47, wherein the first and second connection arrangements are operative to accommodate tolerance variations at the connection between the beam and column in at least one direction.

49. A beam to column connection according to claim 48, wherein the at least one direction is in the direction of an axis of the beam.

50. A mass timber beam to column connection system comprises a first connection arrangement configured to locate the beam relative to the column and to inhibit bearing pressure on the beam and column in a direction perpendicular to the grain of the mass timber beam or column.

51. A mass timber beam column connection according to claim 50, wherein the column comprises a connection region incorporating an upwardly facing bearing surface, the beam extends from the column at the connection region with an edge face of the beam in opposing relation with the connection region and the beam being supported on the upwardly facing bearing surface.

52. A mass timber beam column connection according to claim 51, wherein the compressive loading is applied on the upwardly facing bearing surface of the column and is transferred to the first connection arrangement through to the end face of the beam.

53. A method of installing a beam to a column in a building system, the method comprises positioning the beam relative to the column in an installed position whereby a guide arrangement locates the beam in position on the column and the beam is supported on an upwardly extending bearing surface of the column, and subsequently tying the beam to the column when in the installed position.

54. A beam when used in a building system according to any one of claims 1 to 46.

55. A beam when used in a beam to column connection according to any one of claims 47 to 52.

56. A column when used in a building system according to any one of claims 1 to 46.

57. A column when used in a beam to column connection according to any one of claims 47 to 52.

58. A kit for connecting a beam and column together in a building system according to any one of claims 1 to 46, the kit comprising a first coupling provided as a separate component which is affixed to, or disposed in, the beam or column to form part of the first connection arrangement and a second connection arrangement for fixing the column to the beam and comprises a first region fixable to the column and a second region fixable to the beam.

59. A kit for connecting a beam and column together in a building system according to any one of claims 1 to 46, the kit comprising a first coupling provided as a separate component which is affixed to, or disposed in, the beam or column, and an

intermediate member disposed on the other of the beam or column to receive the first coupling and a second connection arrangement for tying the column to the beam and comprises a latch arrangement that is operable to interconnect the first coupling to the intermediate member.

60. A connection system for securing first and second members comprising:

a bracket having opposite upper and lower surfaces and a first portion for attachment to the first member, and a second portion for attachment to the second member: and

a fixing arrangement for securing the first portion to the first member, the fixing arrangement including mechanical fasteners having a shank that extends along an axis of the fastener and arranged to accommodate at least limited relative rotation and/or displacement between the members through deformation of the shanks of the mechanical fasteners, the fixing arrangement including a shank guide arrangement to constrain the deformation of the respective fastener shanks to be generally in a first plane containing the shank axis.

61. A connection system according to claim 60, wherein the shank guide arrangement is in the form of one or more channels that are disposed below the connector and through which the shanks extend into the respective member.

62. A connection system according to claim 61, wherein the channels are formed directly in the respective member.

63. A connection system according any one of claims 60 to 62, wherein the fasteners are aligned such that multiple fasteners share a common channel

64. A connection system according to any one of claims claim 60 to 63, wherein the mechanical fasteners comprise a head and a shank and the fixing arrangement further comprises one or more spacers adapted to locate the head of the mechanical fasteners in spaced relation to the upper surface of the bracket.

65. A bracket for securing first and second members comprising:

a bracket having opposite upper and lower surfaces and a first portion for attachment to the first member, and a second portion for attachment to the second member; the first portion having an enlarged, wider part, having formed therein attachment apertures along side regions thereof, and cut-outs formed inboard of the

attachment apertures to influence flexing of the bracket under relative rotation of the first and second members.

66. A coupling for a beam column connection comprising a body having a first portion for affixing to one of the beam or column, the first portion having opposite upper and lower ends and an attachment region that is disposed in the lower half of the first portion, wherein the attachment region has an inner surface that abuts the beam, the inner surface being profiled to distribute shear force across the attachment region.

67. A coupling according to claim 66, wherein the first portion is arranged in use to be fixed to the beam by mechanical fasteners that extend through the attachment region.

68. A coupling according to either claim 66 or 67, wherein the coupling further comprises a second portion that projects from the first portion and has a bearing surface that supports the beam on the column.

69. A coupling according to claim 68, wherein at least one web extends between the first and second body portions and arranged to form part of an interfitting projection and recess arrangement interconnecting the beam and column

70. A coupling according to claim 69, wherein the second portion extends from an upper end of the first portion.

71. A coupling for a beam column connection comprising a body having a first portion for affixing to one of the beam or column, the first portion having opposite upper and lower ends, a second portion that projects from the first portion and has a bearing surface that supports the beam on the column; and at least one web extending between the first and second body portions and arranged to form part of an interfitting projection and recess arrangement interconnecting the beam and column.

72. A coupling according to any one of claims 66 to 71, wherein the beam and column is formed of mass timber.

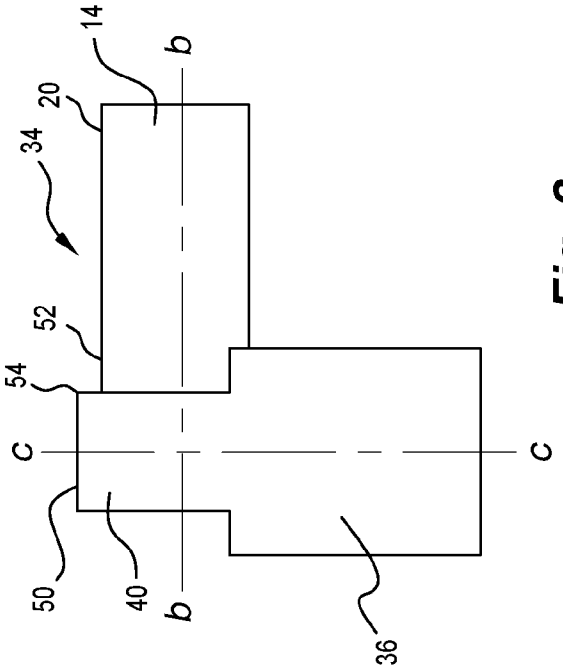


Fig. 2

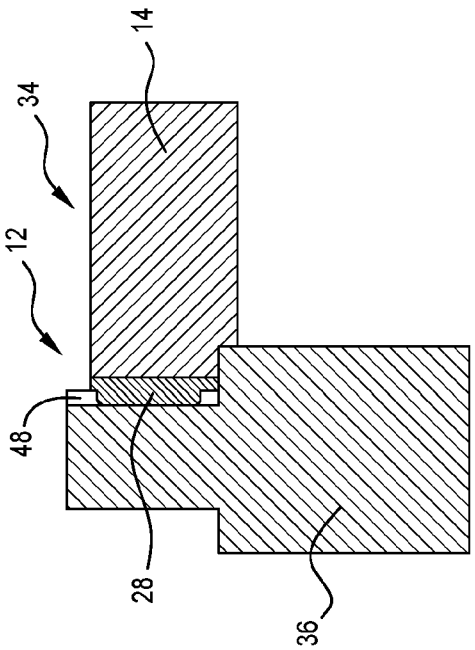


Fig. 3

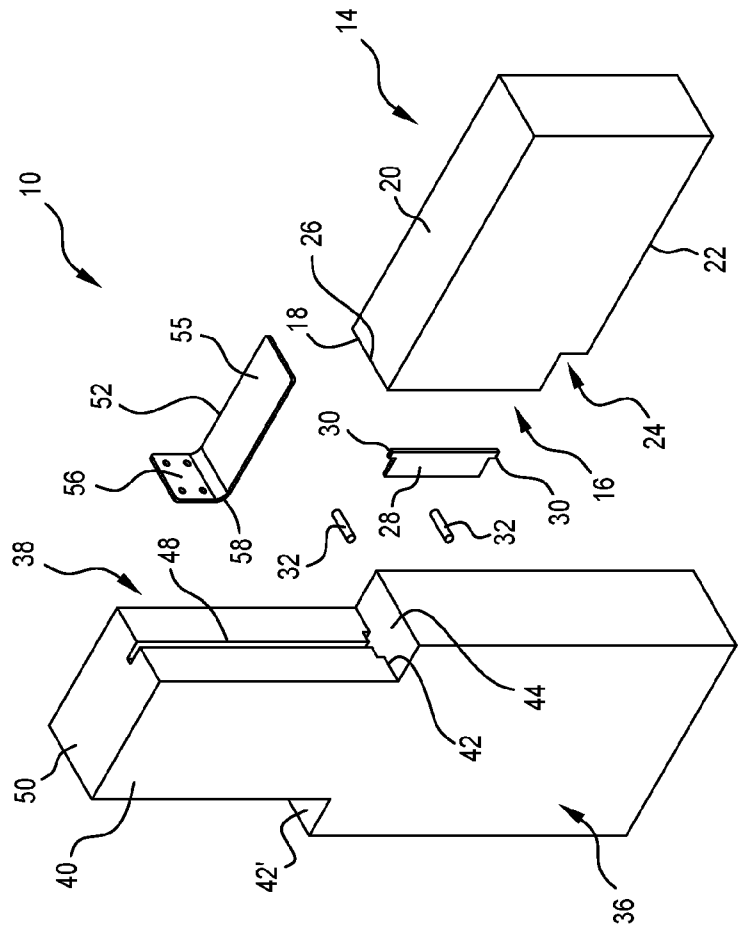


Fig. 1

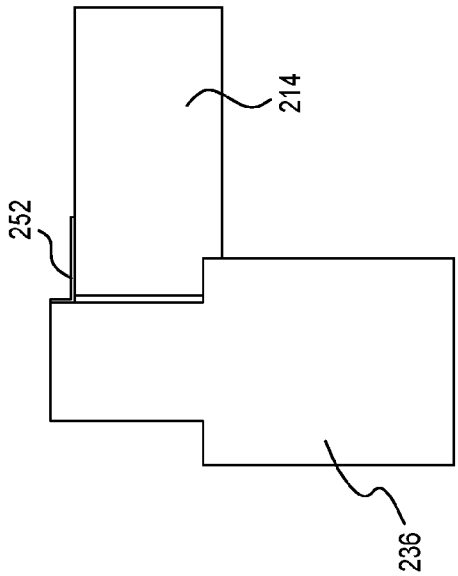


Fig. 5

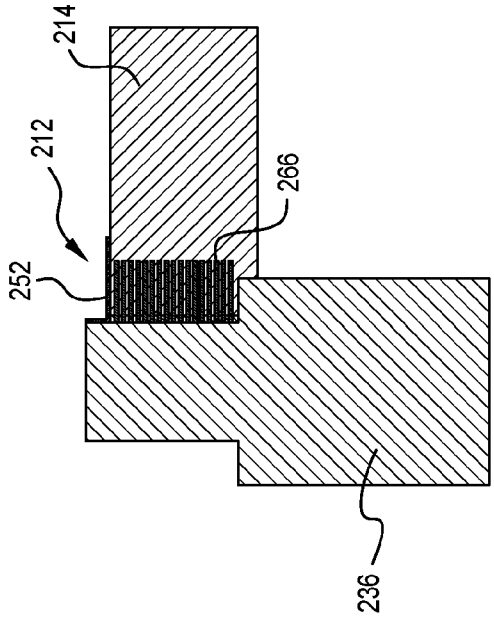


Fig. 7

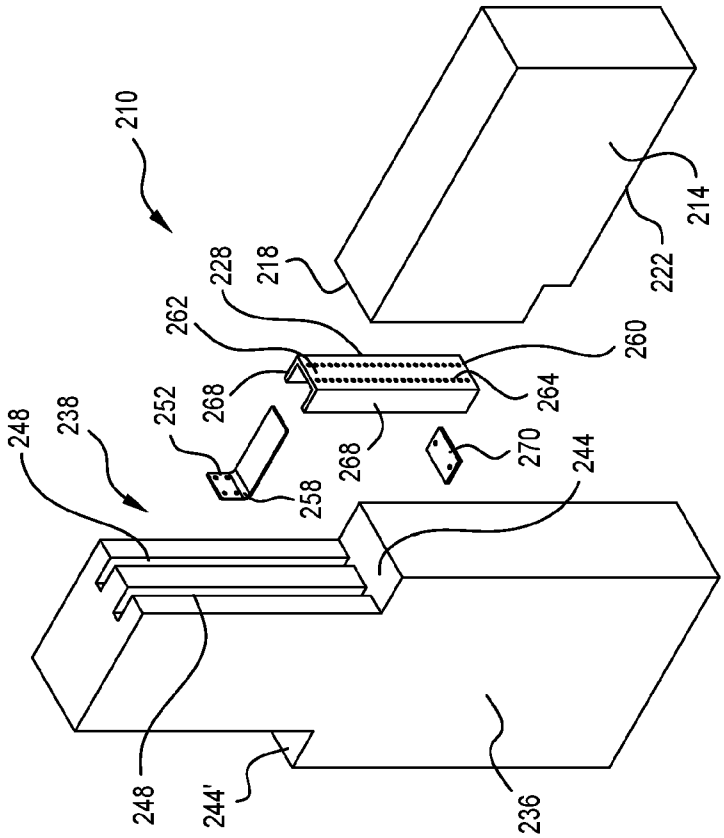


Fig. 4

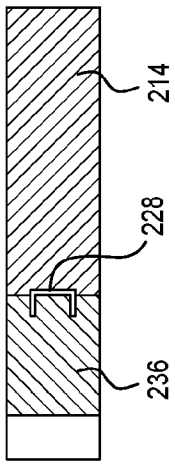


Fig. 6

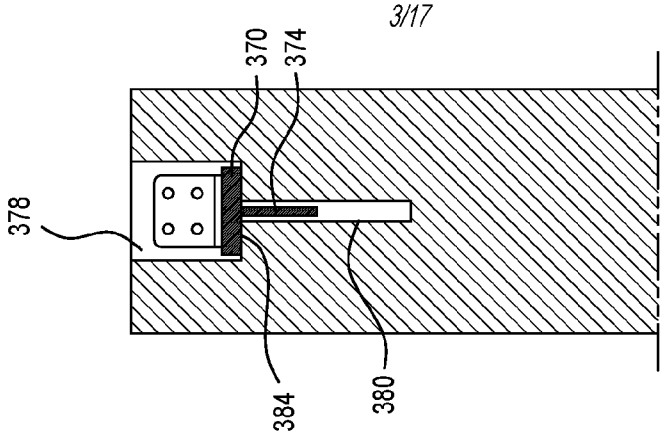


Fig. 12

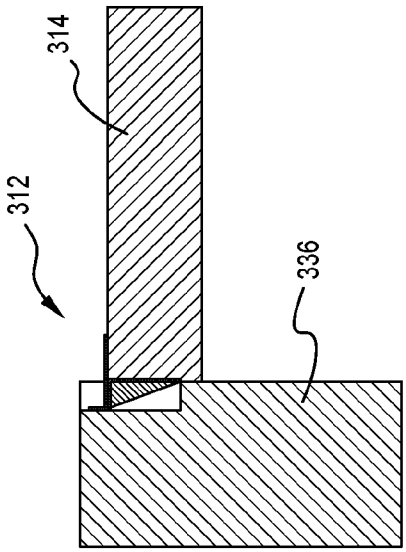


Fig. 10

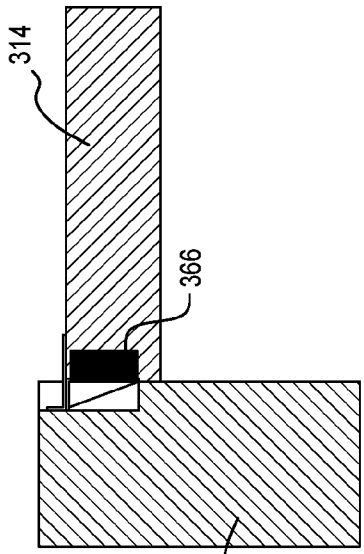


Fig. 11

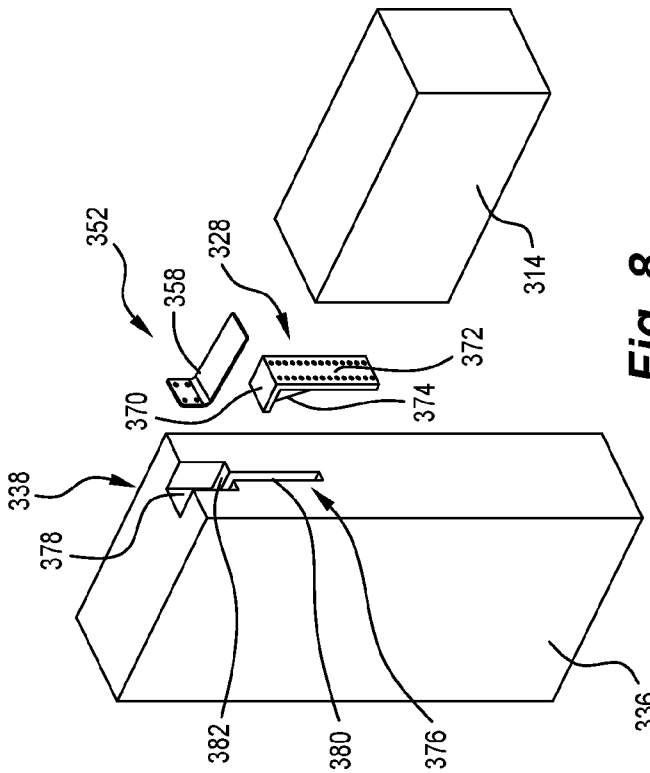


Fig. 8

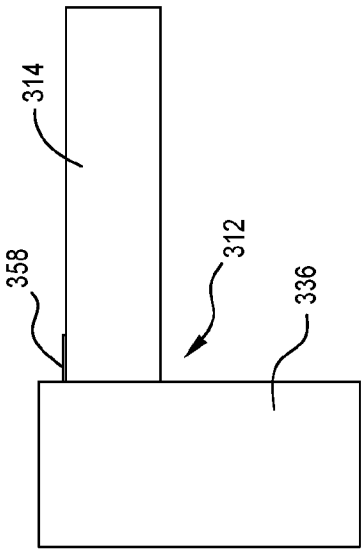


Fig. 9

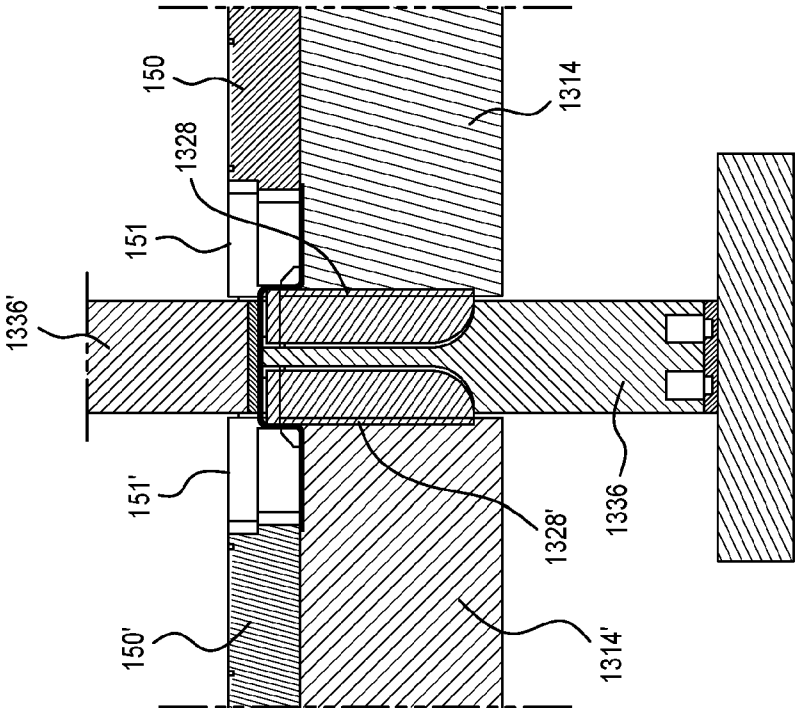

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1336'
151'
150'
1328'
1336
1314
1314'

Fig. 14

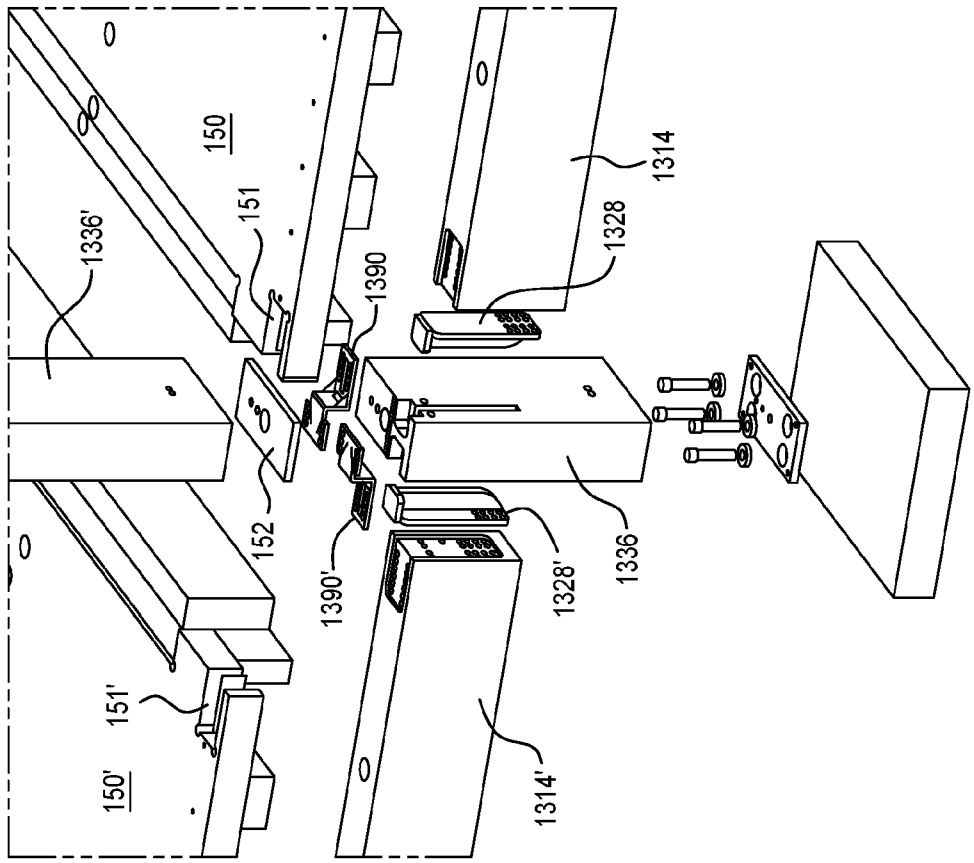

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150'
1314'

Fig. 13

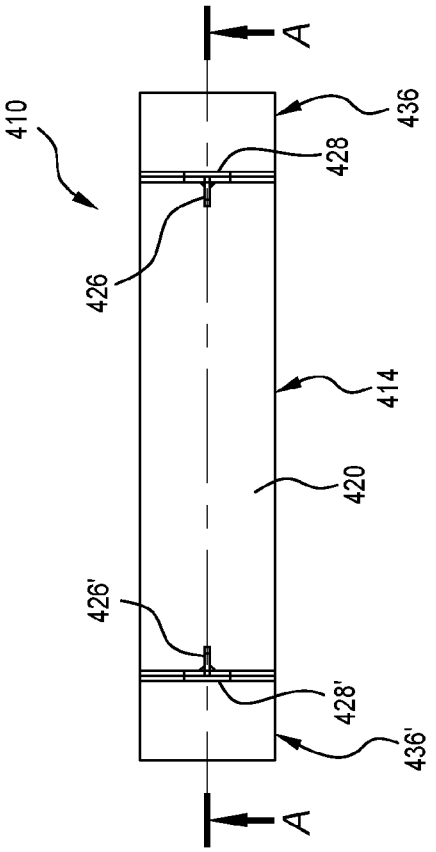


Fig. 16

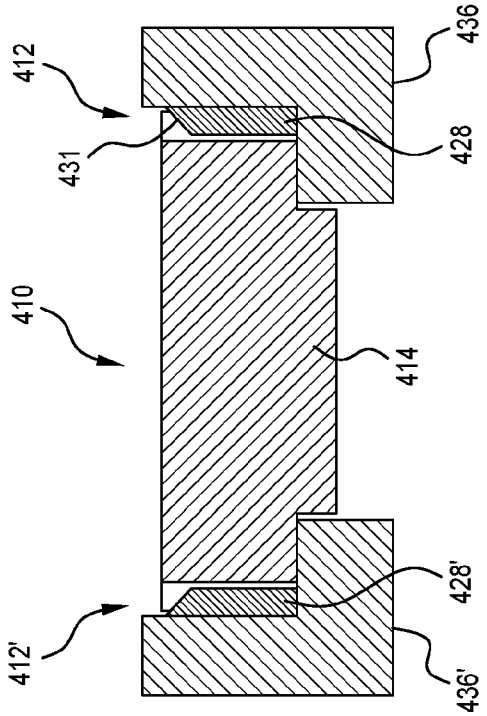


Fig. 17

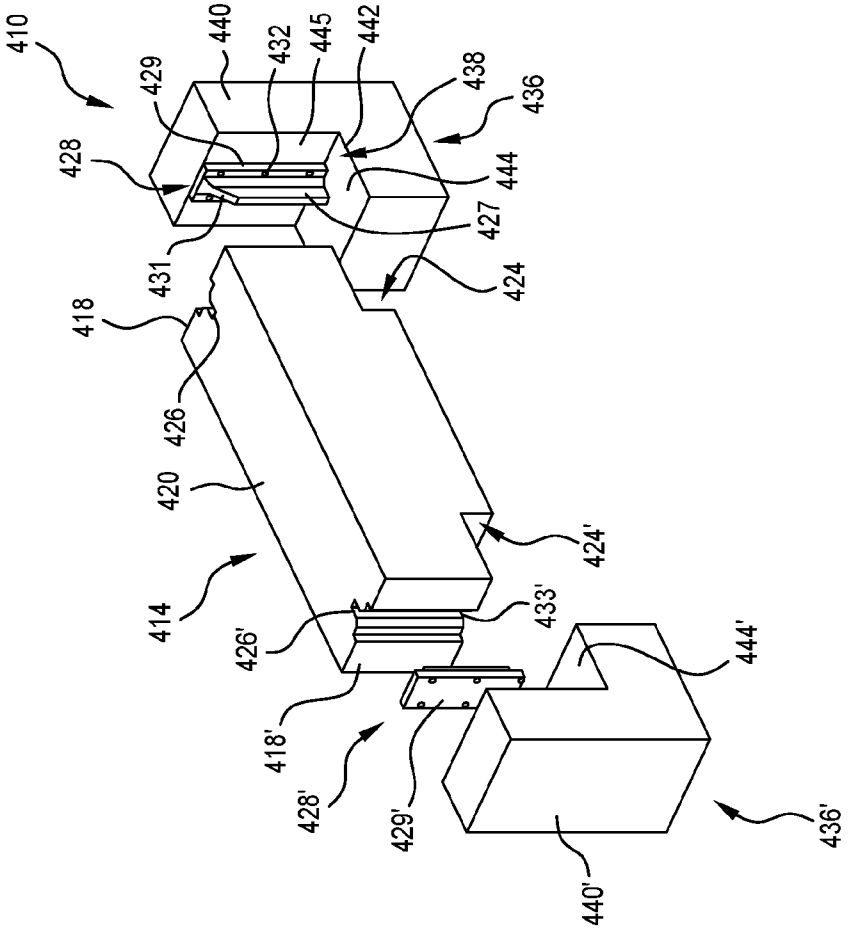


Fig. 15

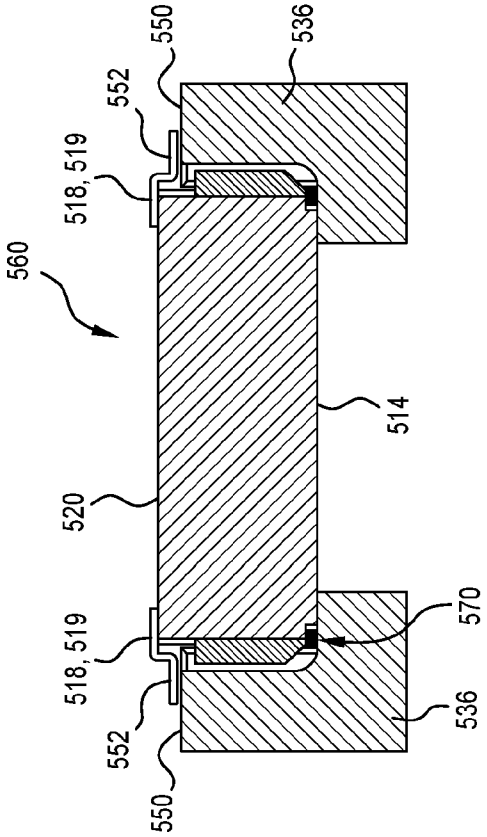


Fig. 19

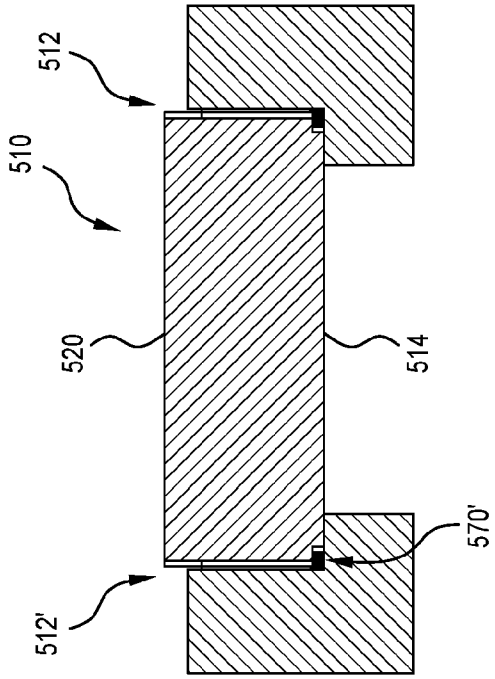


Fig. 20

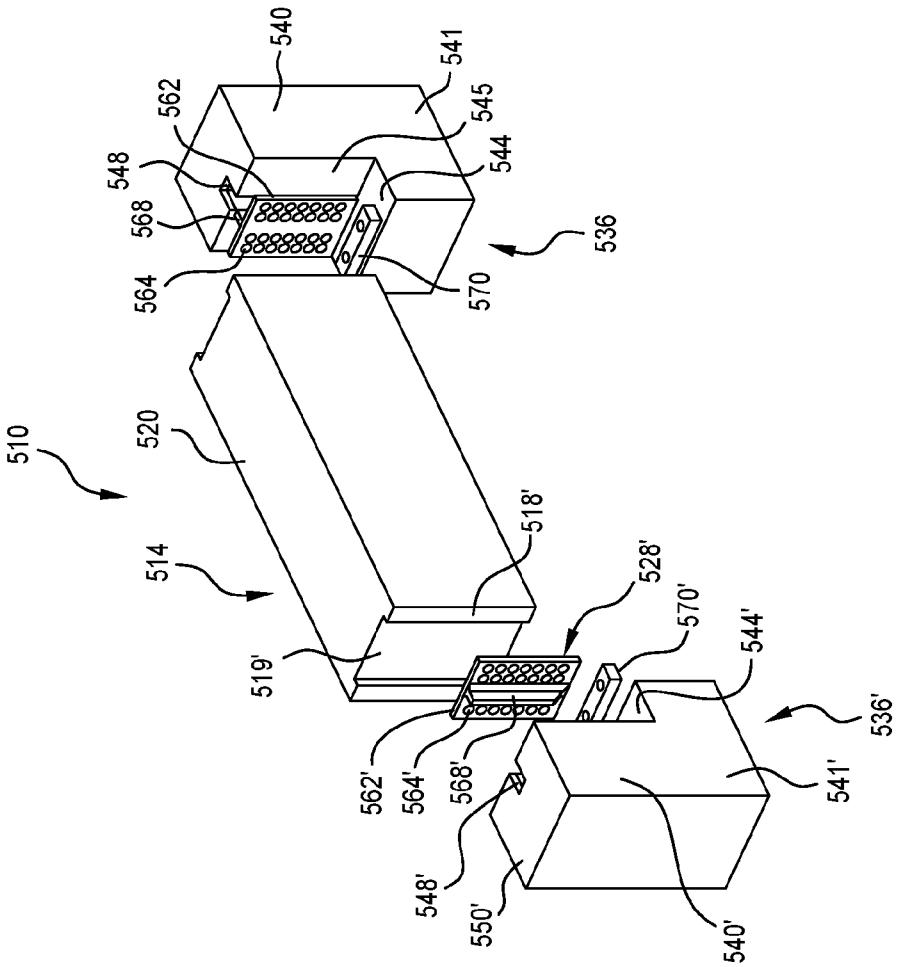


Fig. 18

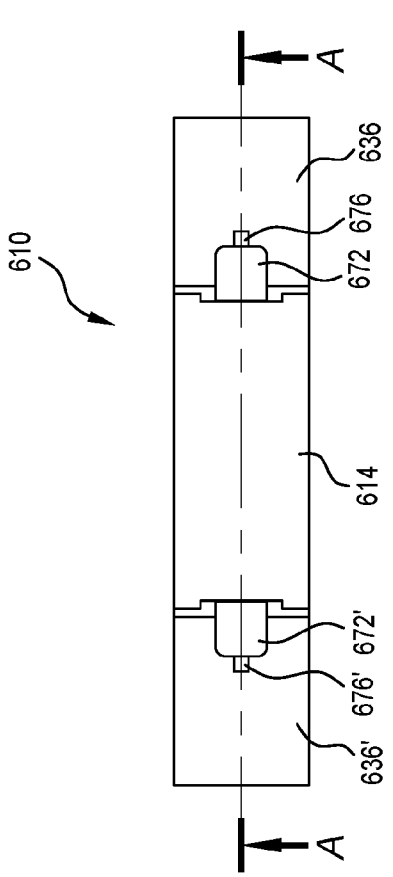


Fig. 22

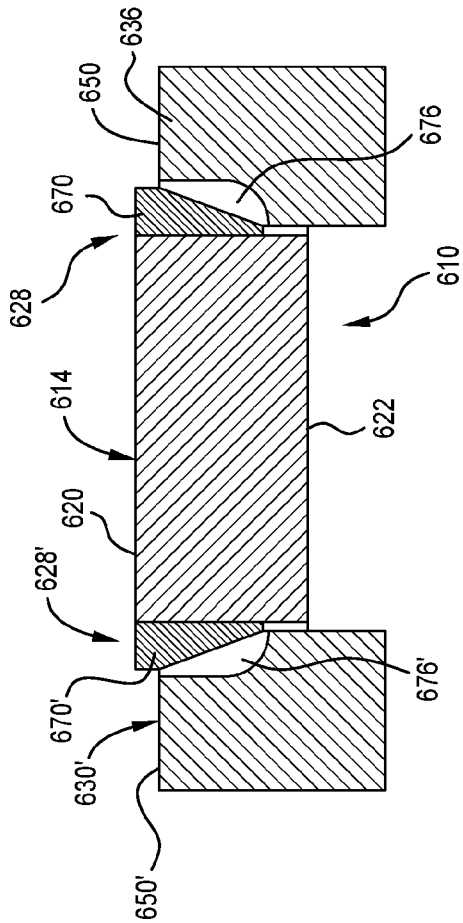


Fig. 23

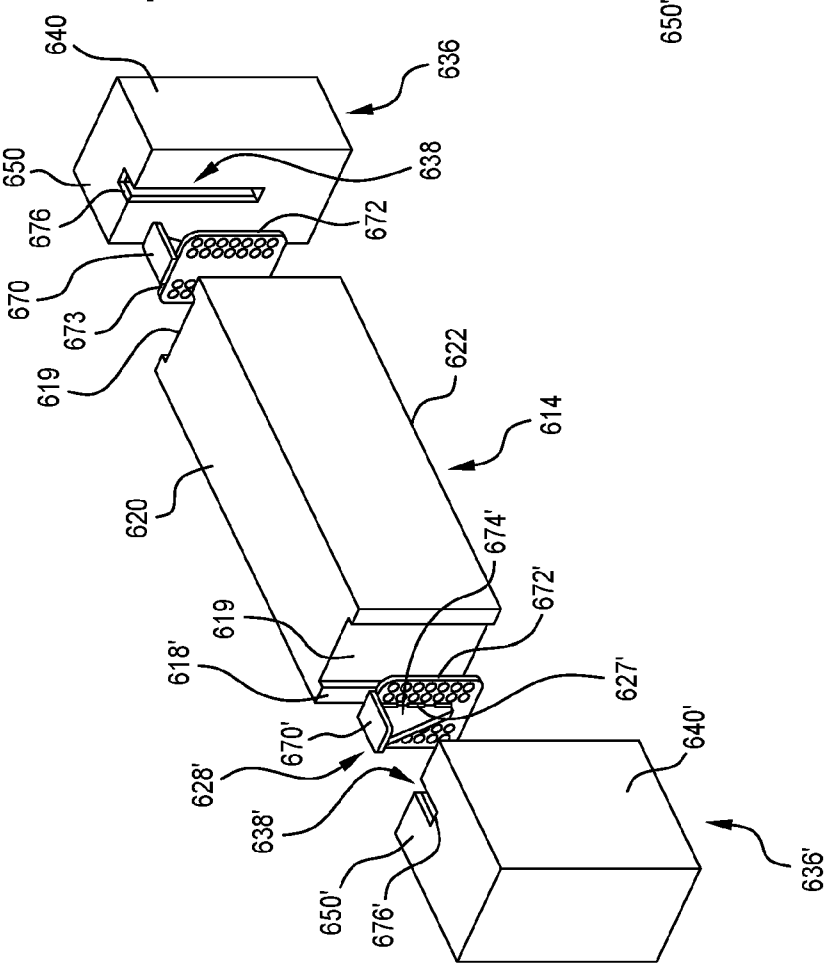


Fig. 21

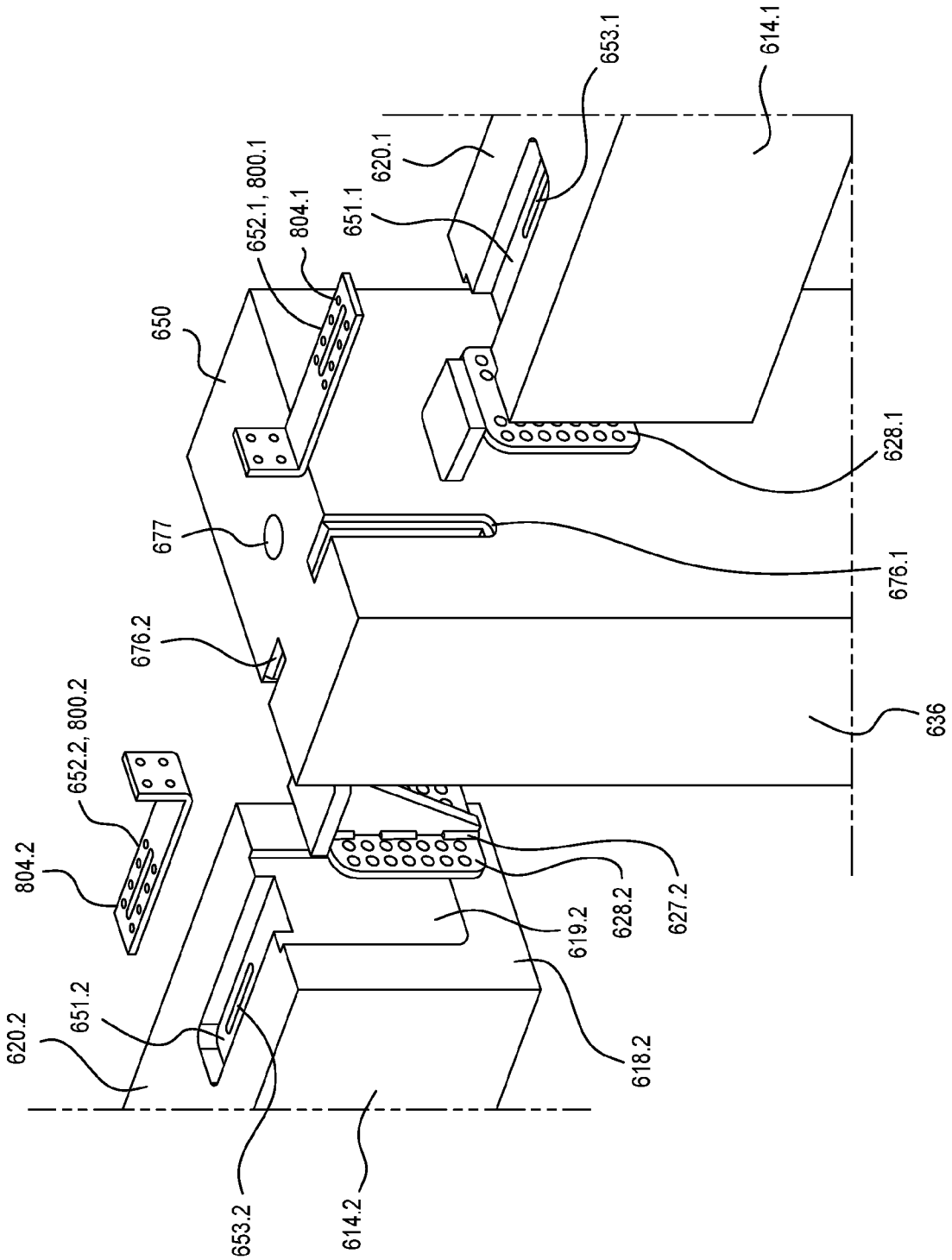

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676.1
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614.2

Fig. 24

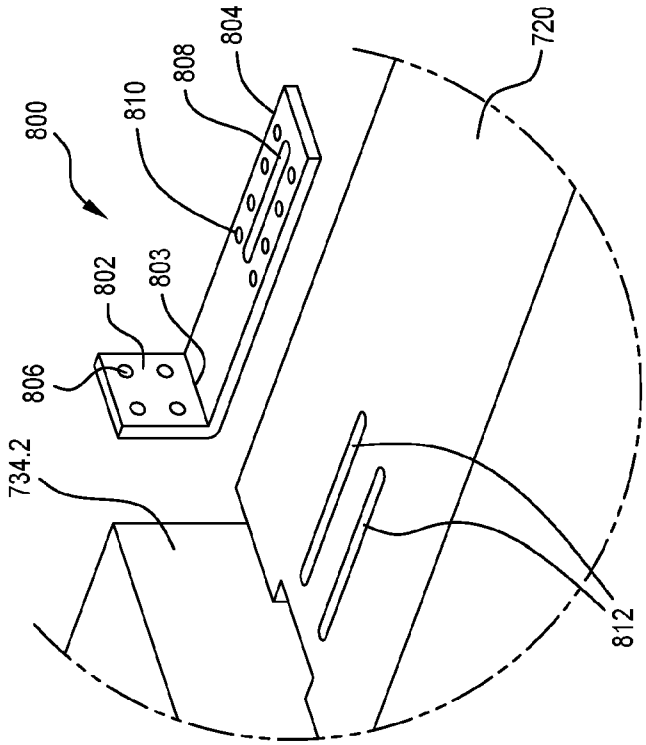

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Fig. 26

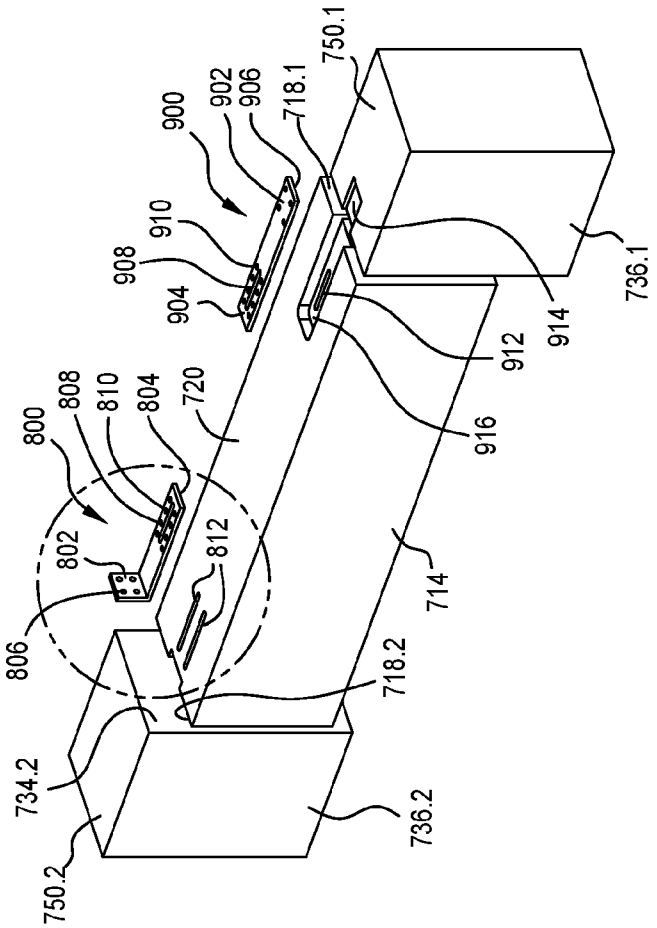

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736.2
750.2

Fig. 25

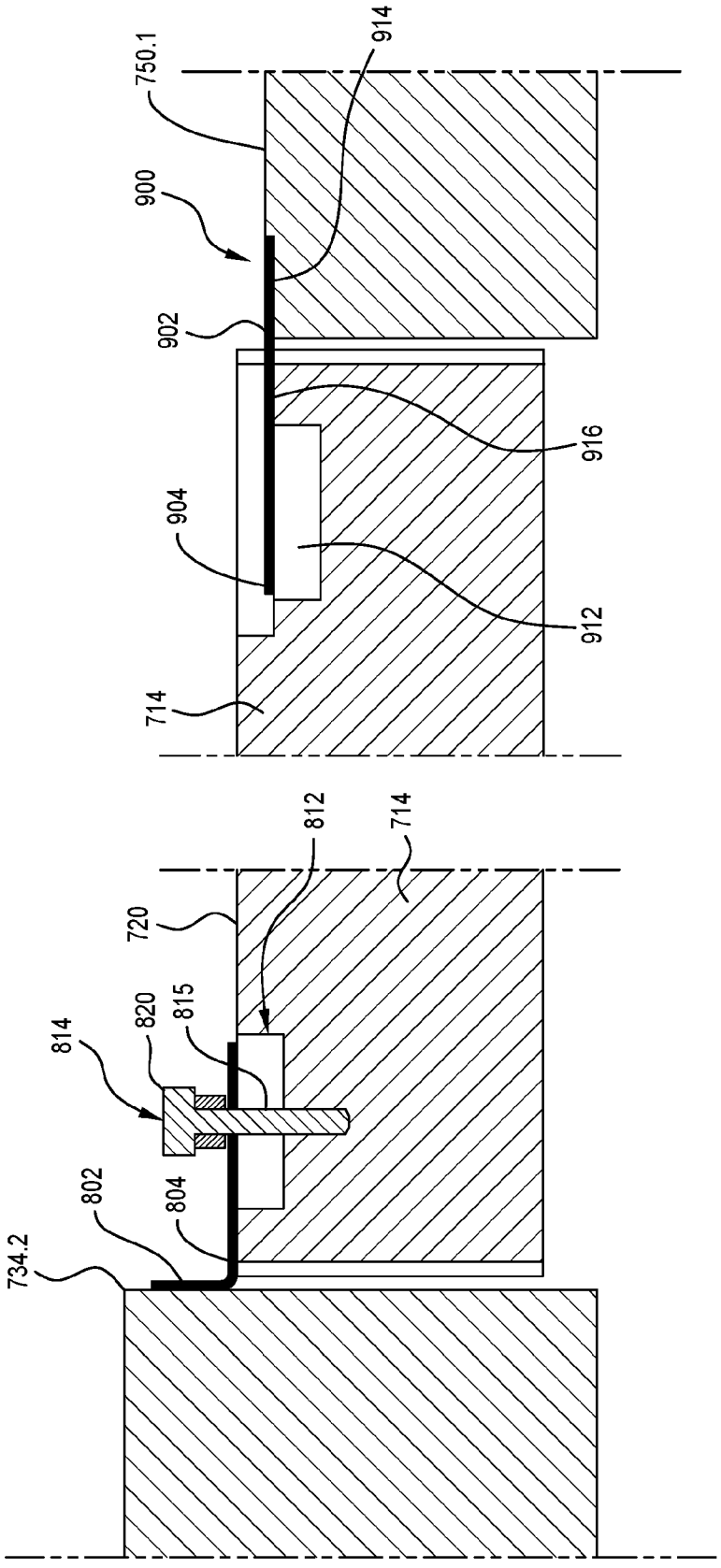

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734.2

Fig. 28

Fig. 27

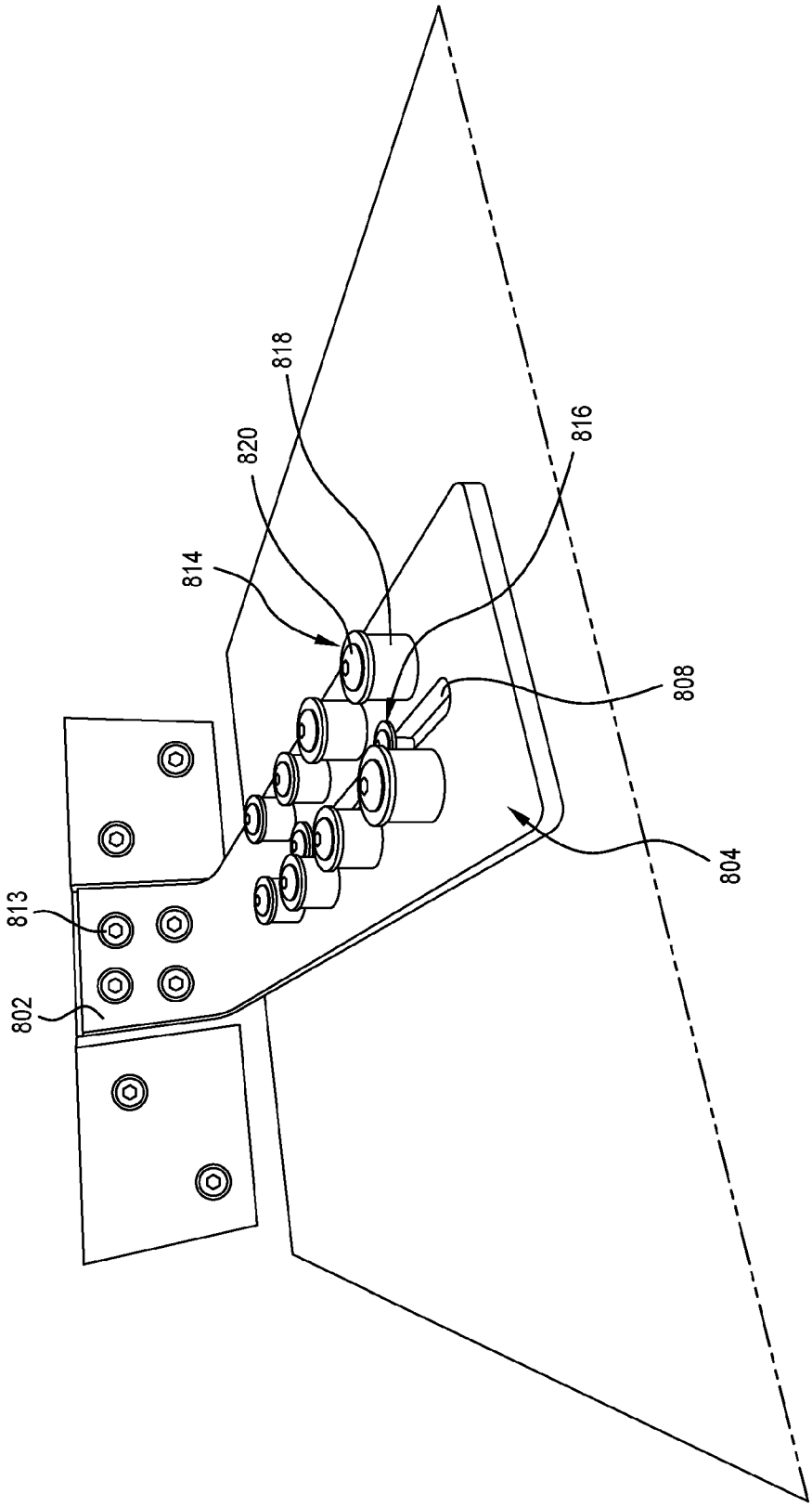


Fig. 29

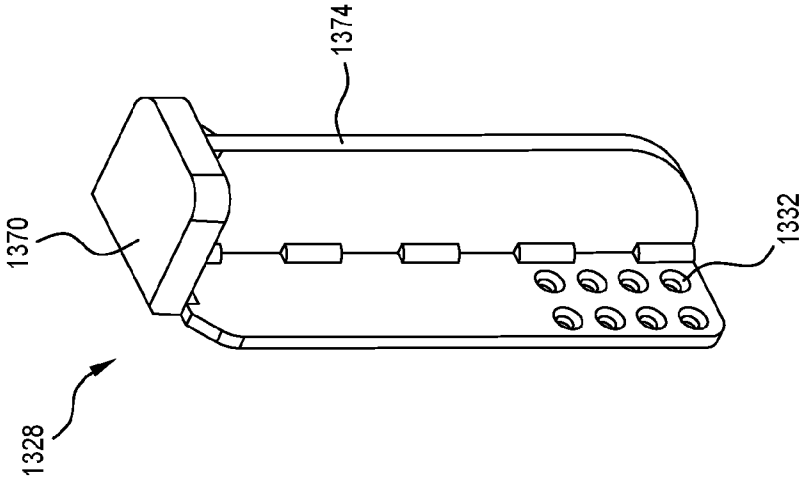


Fig. 30b

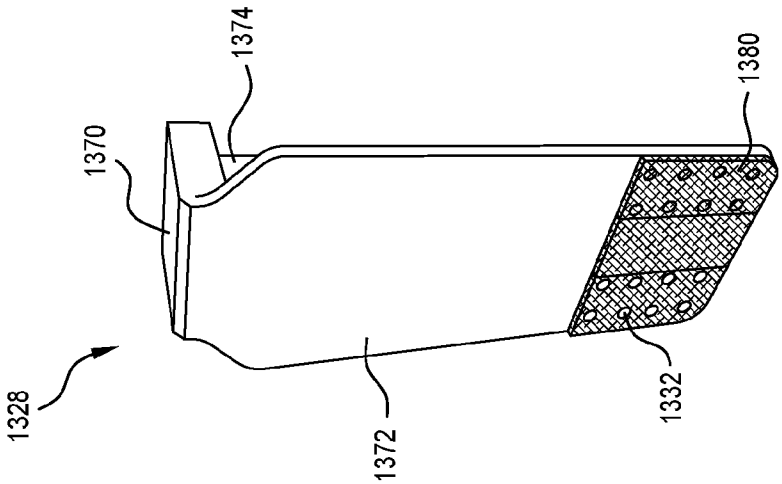


Fig. 30a

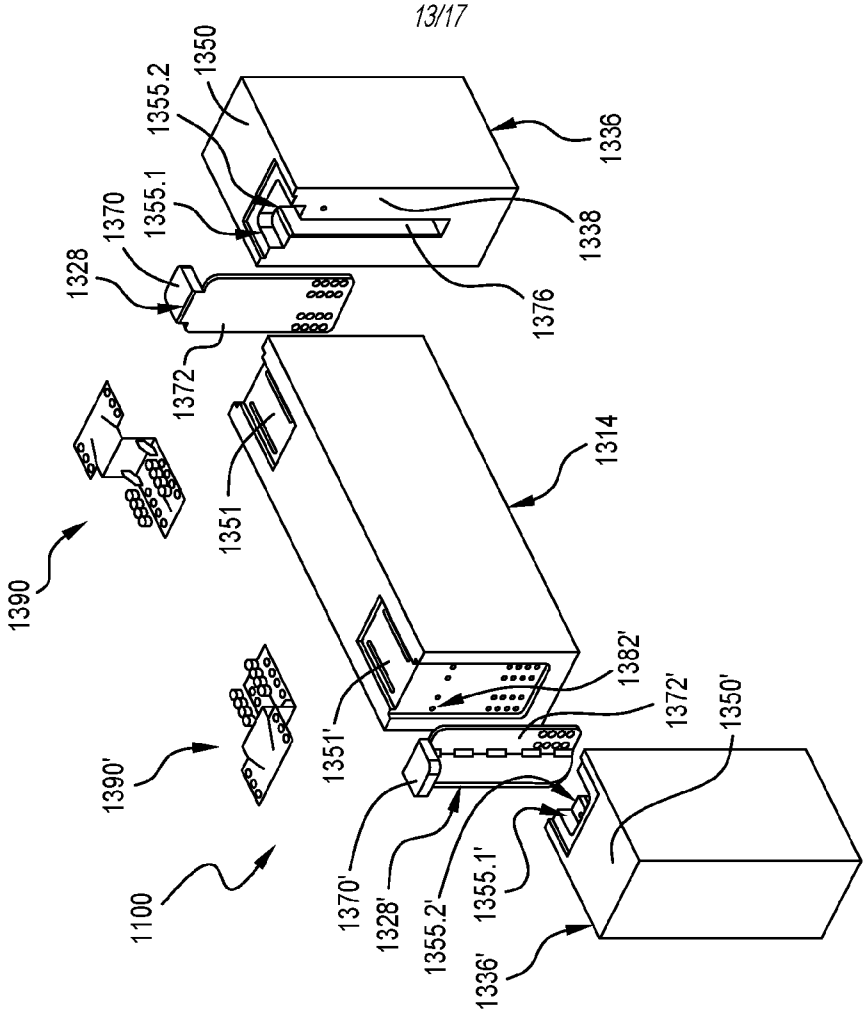


Fig. 33

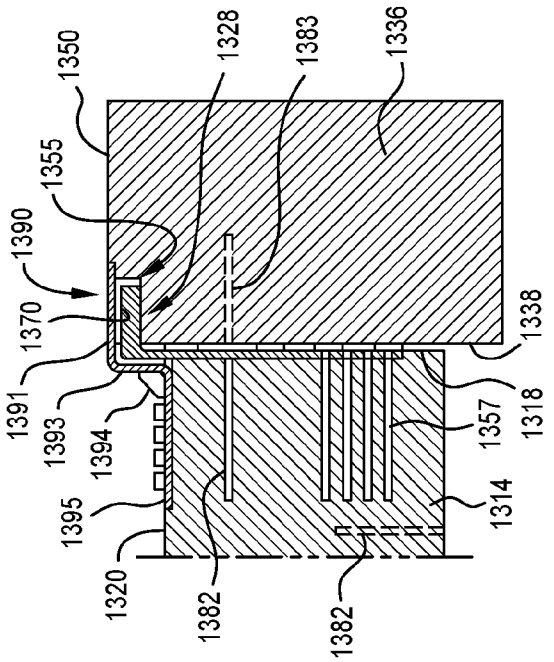


Fig. 31

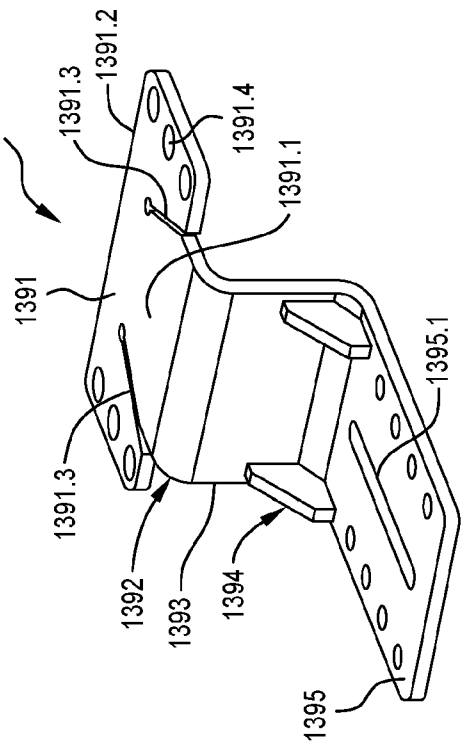


Fig. 32

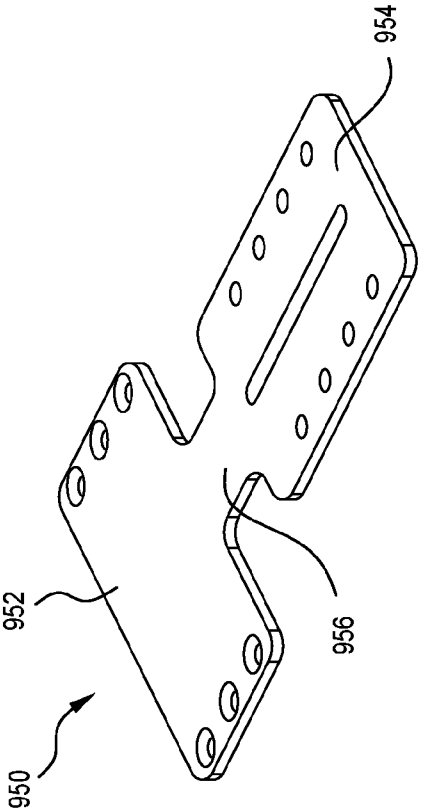


Fig. 34

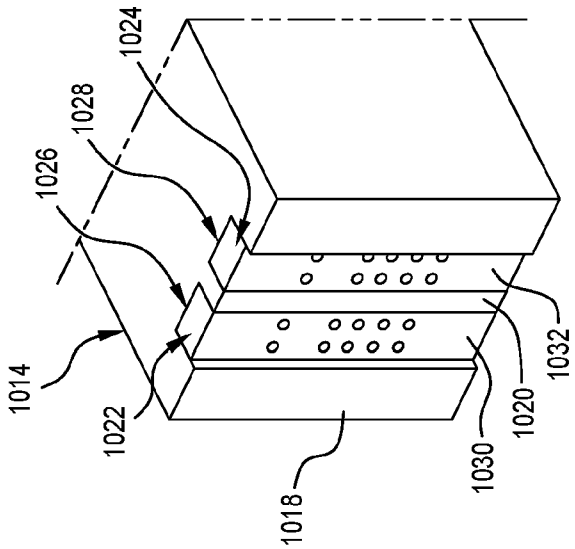


Fig. 36

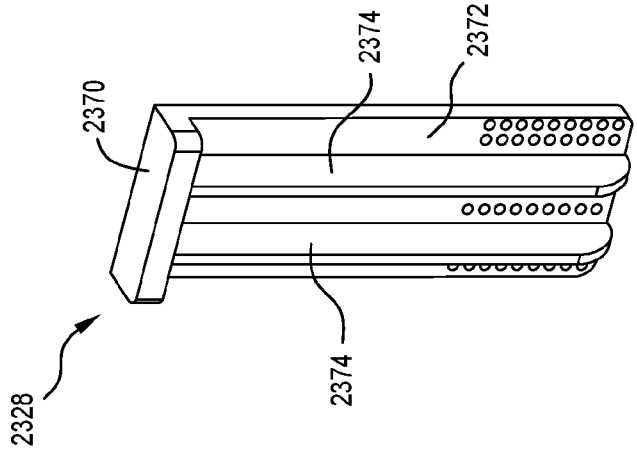


Fig. 35

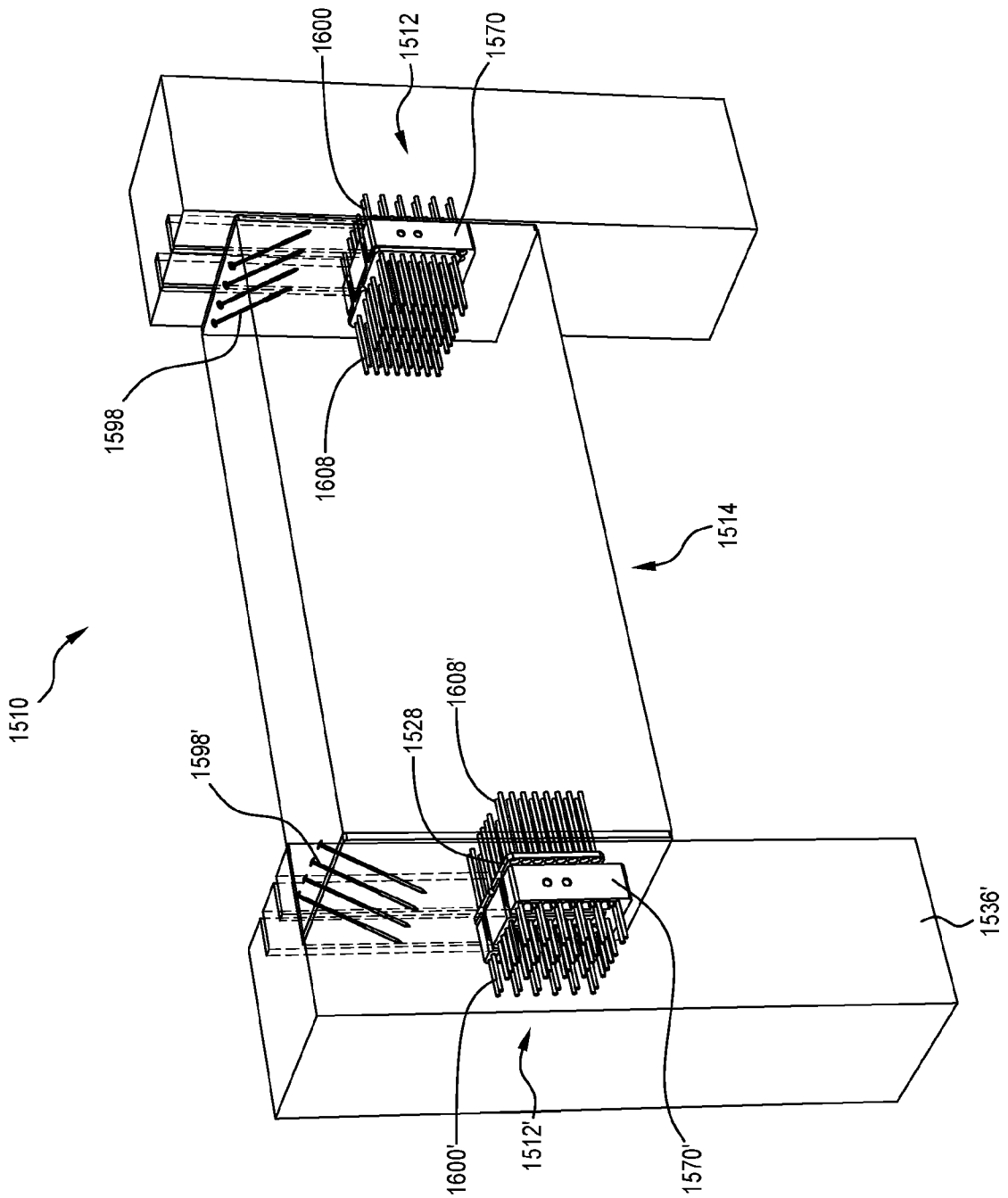

1600
1512
1570
1598
1608
1514
1510
1608'
1528
1598'
1536'
1600'
1512'
1570'

Fig. 37

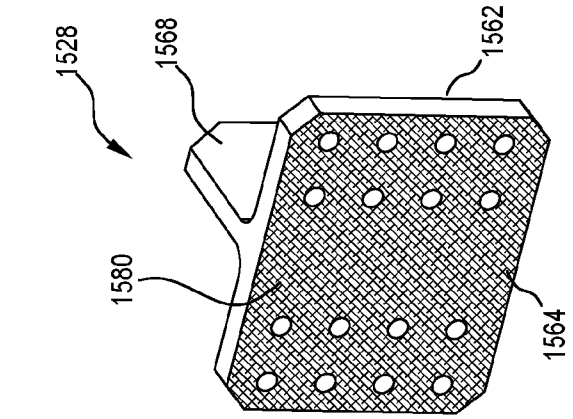


Fig. 41

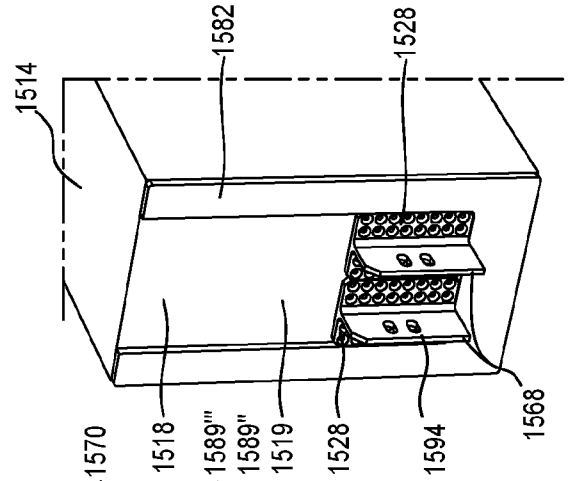


Fig. 40

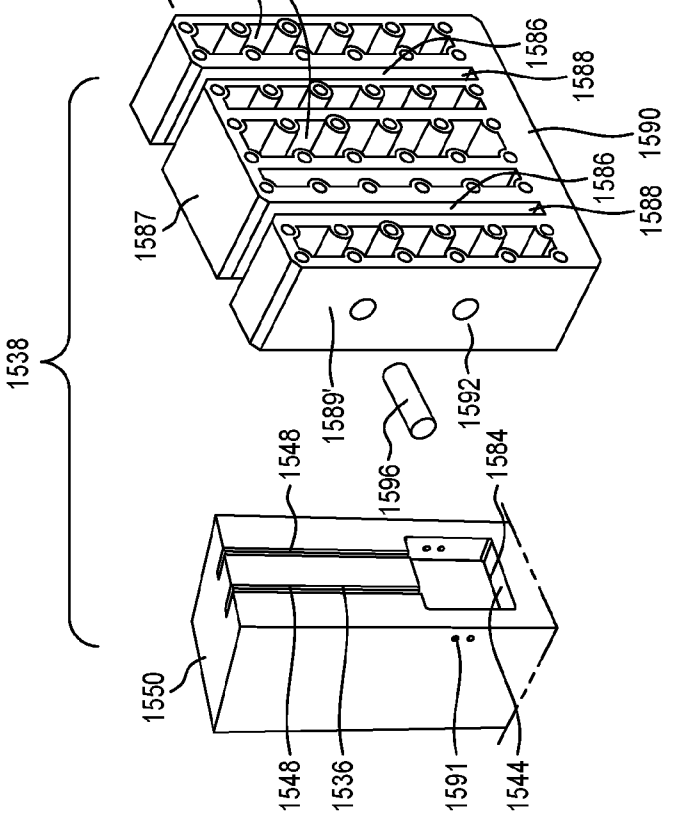


Fig. 39

Fig. 38

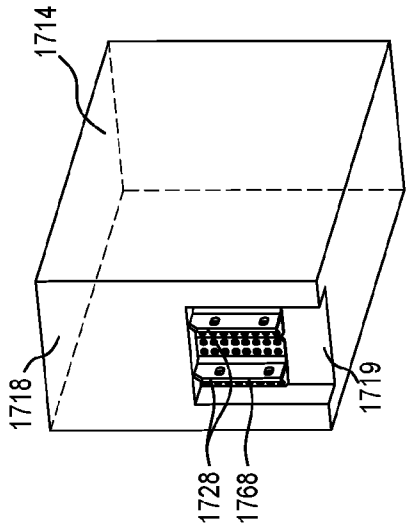


Fig. 44

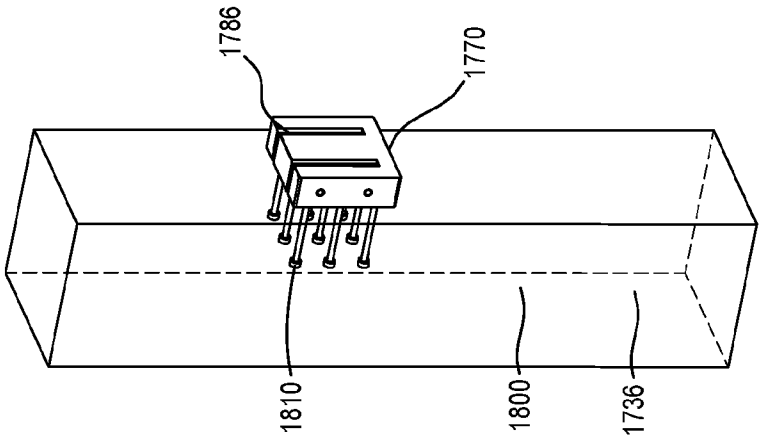


Fig. 43

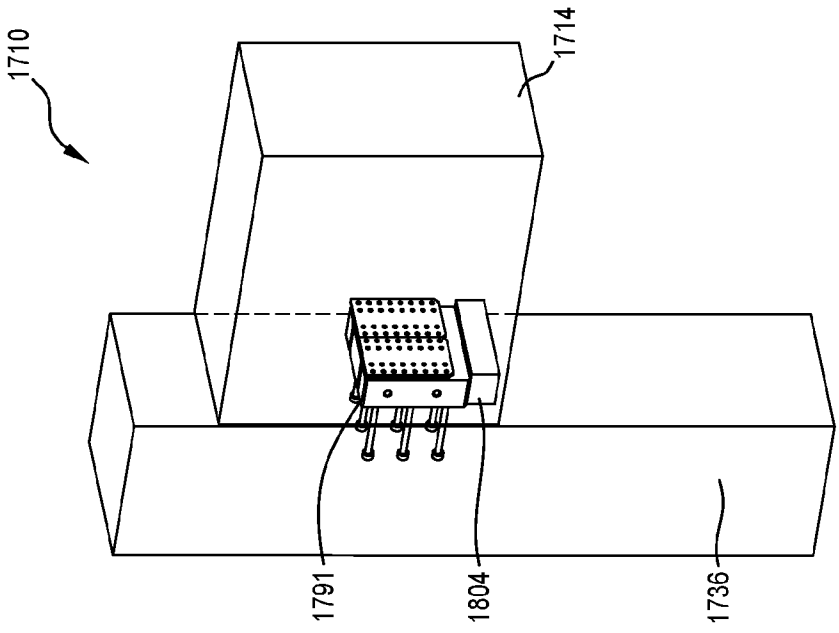


Fig. 42

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2021/051323

A. CLASSIFICATION OF SUBJECT MATTER

E04B 1/26 (2006.01) E04B 1/38 (2006.01) E04B 1/48 (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

EPODOC, WPIAP, PATENW: CPC, IPC: E04B/LOW/, E04C/LOW, F16B/LOW, and keywords: BEAM, COLUMN, UPWARD, FACE, SLOT, SLIT, GROOVE, CHANNEL, BRACKET, PLATE, TONGUE, SHANK, SCREW, INSERT, RECESS, DOWEL, LATCH, PIN, PEG, FLEX, BEND, WIDE, T_SHAPE, CONCRETE, REACTION_BLOCK, SECOND, INTERMEDIATE, and other like terms.

Applicant/Inventor name searched on Espacenet and AusPat.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

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

* Special categories of cited documents:

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

"D" document cited by the applicant in the international application

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 February 2022	03 February 2022

Name and mailing address of the ISA/AU

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INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2021/051323**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5727358 A (HAYASHI et al.) 17 March 1998 Figures	1 – 35, 38 – 64
X	US 5253945 A (HOSOKAWA) 19 October 1993 Figures	1 – 64, 71 – 72
X	JP 2000319992 A (OKURA) 21 November 2000 Figures	1 – 64
X	US 5342138 A (SAITO et al.) 30 August 1994 Figures	1 – 20, 23 – 49, 54 – 59
X	CN 210827831 U (SHANGHAI LONGZHE CONCRETE PRODUCTS CO LTD) 23 June 2020 Figures and Abstract.	1 – 17, 25 – 29, 46, 54 – 59
X	US 2018/0127969 A1 (ACQUISTAPACE et al.) 10 May 2018 Figures	65
X	KR 20190059475 A (KOREA INST OF STRUCTURAL ENGINEERING & CONSULTING) 31 May 2019 Figures	65
X	US 5896721 A (SUGIYAMA) 27 April 1999 Figures, Column 4	66 - 70, 72
X	KR 101906499 B1 (HND CONSTRUCTIONS CO LTD) 10 October 2018 Figures, PAR 0034	66 – 72
X	JP H08312007 A (SEKISUI HOUSE LTD) 26 November 1996 Figure, Abstract.	66 – 72

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2021/051323

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

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

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

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

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

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

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

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

☒ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of: **Box III**

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

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

Invention 1: Claims 1 to 17, 23, 24, 30 to 32, 33 to 59 are directed to inter alia a building system comprising connection of a beam and a column. The feature of a certain combination of "column comprising an upwardly facing bearing surface, a projecting first coupling, slot in the edge of the beam, a second connection arrangement" is specific to this group of claims. (Figs 1 – 7)

Invention 2: Claims 18 to 22 (appended to claims 10 to 17), claims 60 to 64, are directed to are directed to inter alia a building system comprising connection of a beam and a column. The feature of "a certain combination of a second connector being secured by mechanical fasteners having a shank that extends along an axis of the fastener and arranged to accommodate relative rotation and/or displacement between the members, constraining deformation" is specific to this group of claims. (Fig 29)

Invention 3: Claims 25 to 29 (appended to claims 1 to 10) are directed to inter alia a building system comprising connection of a beam and a column. The feature of a certain combination of "latch member that interconnects components forming the first connection arrangement" is specific to this group of claims. (Figs 38 – 39).

Invention 4: Claim 65 is directed to a bracket for securing first/second members. The feature of a certain combination of "the first portion having an enlarged, wider part, having formed therein attachment apertures alongside regions thereof, and cut-outs formed inboard to influence flexing of the bracket" is specific to this group of claims. (Figs 31– 34).

Invention 5: Claims 66 to 70 are directed to a coupling. The feature of a certain combination of" inner surface being profiled to distribute shear force across the attachment region" is specific to this group of claims. (see shear plates 568 in figs 18 to 20 and 1528 fig 41)

Invention 6: Claims 71 to 72 are directed to a coupling. The feature of a certain combination of "one web extending between the first and second body portions and arranged to form part of an interfitting projection and recess arrangement interconnecting the beam and column" is specific to this group of claims. (see channel bracket 260 fig 4).

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

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

In inventions 1 – 2, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to the claimed inventions 1 - 2 and which provides a technical relationship among them is a certain combination of "beam edge face with slot with a projection, column with an upwardly facing bearing surface (on which the beam in supported), first/second connection arragement. However this feature does not make a contribution over the prior art because it is disclosed in Fig 9 of JPH08296280 A, 12 November 1996. Also see Fig 1 of US5727358 A, 17 March 1998. Also see Fig 2 of US5061111, Oct 29 1991.

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to claimed inventions 1 – 2 and the requirements for unity of invention are consequently not satisfied a *posteriori*.

In inventions 1, 3 – 6 , the identified features may have the potential to make a contribution over the prior art but are not common to the claimed inventions 1, 3 – 6 and therefore cannot provide the required technical relationship. Therefore there is

no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied a *priori*.

Fees have been paid to search all claims.

INTERNATIONAL SEARCH REPORT	International application No. **PCT/AU2021/051323**

Supplemental Box

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2021/051323**

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

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 5727358 A	17 March 1998	US 5727358 A	17 Mar 1998
		CA 2147851 A1	02 Mar 1995
		JP H0762876 A	07 Mar 1995
		JP 3301568 B2	15 Jul 2002
		KR 950704581 A	20 Nov 1995
		KR 100381536 B1	12 Jul 2003
		WO 9506172 A1	02 Mar 1995
US 5253945 A	19 October 1993	US 5253945 A	19 Oct 1993
JP 2000319992 A	21 November 2000	JP 2000319992 A	21 Nov 2000
US 5342138 A	30 August 1994	US 5342138 A	30 Aug 1994
		JP H05195580 A	03 Aug 1993
		JP 2509036 B2	19 Jun 1996
		JP H05187071 A	27 Jul 1993
		JP H0823180 B2	06 Mar 1996
		JP H05179716 A	20 Jul 1993
		JP H0823181 B2	06 Mar 1996
CN 210827831 U	23 June 2020		
US 2018/0127969 A1	10 May 2018	US 2018127969 A1	10 May 2018
		US 10081938 B2	25 Sep 2018
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		KR 102034116 B1	18 Oct 2019
US 5896721 A	27 April 1999	US 5896721 A	27 Apr 1999
		JP H10147983 A	02 Jun 1998
		JP 3066735 B2	17 Jul 2000
KR 101906499 B1	10 October 2018	KR 101906499 B1	10 Oct 2018
JP H08312007 A	26 November 1996	JP H08312007 A	26 Nov 1996

End of Annex

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