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(71) Applicant: **Simmons, Robert J.**  
**Hayward, CA 94542 (US)**

(72) Inventor: **Simmons, Robert J.**  
**Hayward, CA 94542 (US)**

(74) Representative: **Gilmour, David Cedric Franklyn et al**  
**POTTS, KERR & CO.**  
**15 Hamilton Square**  
**Birkenhead**  
**Merseyside CH41 6BR (GB)**

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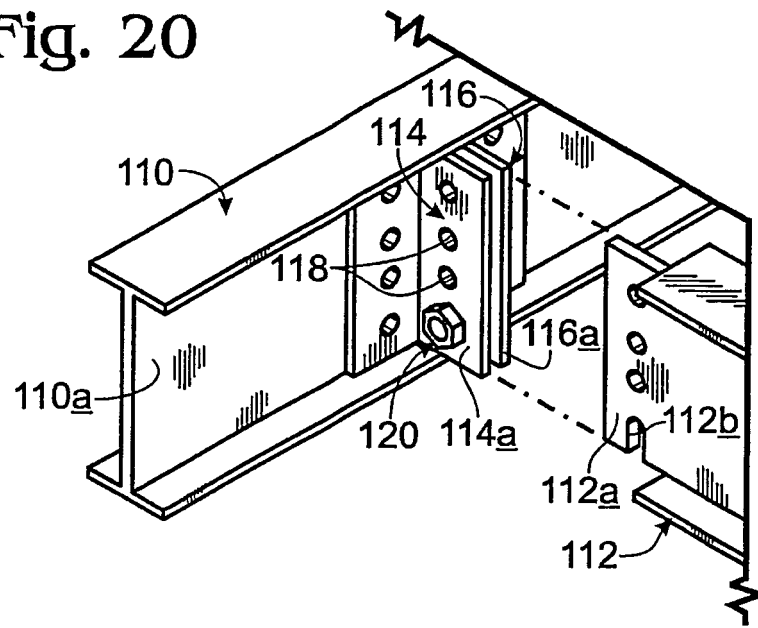
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(54) **Building frame structure**

(57) A method of installing an elongate cross-beam in a beam-to-beam cross-connection between a pair of nominally in-place, previously installed building-frame beams which, before such installing, are spaced apart by a substantially correct lateral distance in the building frame, and where the cross-beam to be installed includes a generally planar, upright central web, said method comprising establishing for each of such two spaced beams which are to be cross-connected (a) a pair of brackets having substantially parallel-planar legs, or elements, which are spaced apart in a manner creating an upright, generally planar, straight-down, vertically accessible, open-topped region, or recess, having a lateral width which is suitable for receiving freely the thickness of such a cross-beam's central web, and (b) a catch spanning the space between such elements at a location which is below the open top of the region, preparing each of the opposite ends of such a cross-beam's central web to be vertically clear so as to permit downward insertion of that end through the open top of, and into, the region, and to possess a downwardly facing hook designed to become caught by, and to seat downwardly by gravity on and against, the mentioned catch, vertically lowering a cross-beam having such prepared-

web-ends to cause these ends to be inserted into, and to be received within, the mentioned open-topped regions between the spaced parallel-planar elements that are associated with the two, spaced, building-frame beams which are to be cross-connected, thus to cause the hooks in the prepared web ends to become caught, hooked and seated by gravity on and against the catches associated with such regions, and performing said lowering without requiring any appreciable increasing of the pre-lowering lateral spacing between the two, spaced building-frame beams, and by said lowering (a) causing the lowered cross-beam to become hooked and interconnected by gravity to and between the spaced building-frame beams, and (b) creating thereby a gravity-stabilized, correctly spatially organized beam-to-beam cross-connection between the lowered cross-beam and the two, spaced building-frame beams. Also, a method of similarly installing an elongate beam to form an interconnection between a pair of nominally in-place, previously installed building-frame columns which, before such beam installing, are spaced apart by a substantially correct lateral distance in the building frame, and where the beam includes a generally planar, upright central web.

Fig. 20



## Description

### Background and Summary of the Invention

**[0001]** This invention pertains to building frame structure, and more particularly to unique column, beam, cross-bracing and interconnect structures employable in such structure. A preferred embodiment of the invention, and a manner of practicing it, as well as several illustrated modifications, are illustrated and described herein.

**[0002]** Proposed, among other things, according to the invention is a new, elongate column structure which is formed from an assembly of plural, elongate, angle-iron-like components that are united by bolting them together through interposed spacers which help to define the final configuration of the column. In a preferred column embodiment of the invention, four such angle-iron-like components are employed, with each of these taking the form, generally, of an elongate, right-angle, angle-iron section of otherwise conventional construction, and with cross-like spacers (one or more) interposed and holding these components apart. These four elongate components are arranged in such a fashion that their legs essentially radiate in a star-like manner from the long axis of the assembled column. Each leg in each angle-iron-like component confrontingly faces one other leg in one adjacent such component.

**[0003]** The angle-iron-like components and the spacer, or spacers, are nut-and-bolt connected to create a frictional interface between these elements. Depending upon the tightness employed in such connections, the level of frictional engagement can be adjusted. The assembled combination of angle-iron-like components and spacers forms a generally cross-shaped (transverse cross section) column assembly. Each column assembly is also referred to herein as a column structure, and as a column.

**[0004]** Given this type of column assembly, it will be apparent that there are spaces or recesses provided in the regions between confronting legs in an assembled column. In a building frame structure, and still referring to a preferred form of the invention, these recesses are employed to receive modified and inserted end regions (or extensions) of the central webs in elongate I-beams. These same recesses also receive the ends of cross-braces which, in a preferred embodiment, each take the form of flat metal bar stock. The modified I-beams result from removal of short portions of their upper and lower flanges to create central-web extensions. Bolt holes, or openings, that are provided appropriately in the flanges in the angle-iron-like components in a column, and as well as in the end central-web extensions in a beam, are employed with nut-and-bolt assemblies to complete an anchored assembly between a column and a beam. In such a column/beam assembly, the column and beam directly engage one another through a frictional interface wherein the level of frictional engagement is nut-and-bolt adjustable.

**[0005]** With respect to such a column/beam interconnection, the lower-most opening provided in an I-beam's web-end projection takes the form of an open-bottomed hook which, during quick, preliminary assembly of a frame structure, extends into the open, or recessed, region between flanges in a column. Under the influence of gravity, the downwardly exposed and facing hook catches and seats onto a preliminarily entered nut-and-bolt assembly, wherein the bolt's shank extends across and spans the space between a pair of flanges to act as a catch on which this hook can seat and become gravity-set. Such seating quickly introduces preliminary stabilization in a frame being assembled, and also acts to index the proper relative positions of columns and beams.

**[0006]** Modifications to this preferred form of the invention are recognized, and are possible in certain applications. For example, columns might be formed with three rather than four elongate components. With respect to a column having just three such components, the included angles between legs in these elements, progressing circularly about the column's long axis, might be 120°-120°-120°, 135°-135°-90°, or 180°-90°-90°. Illustrations of these arrangements, which are not exhaustive, are illustrated herein.

**[0007]** Another modification area involves the configuration and structure of a cross-brace. Such a configuration could, for example, take the form of a right-angle angle iron, of a tubular element, or of a welded assembly of a flat plate and an angle iron. Illustrations of these configurations while not exhaustive, are also provided herein.

**[0008]** While different lengths of component-assembled columns can be made in accordance with the invention, such lengths being principally a matter of designer choice, two different column lengths are specifically shown and discussed herein. The principal one of these lengths characterizes a column having a length which is basically the height-dimension of two typical stories in a multi-story building. The other length characterizes a column having a length of approximately of one such story height. The individual columns are stacked end-for-end to create elongate upright column stacks that define an overall building-frame height.

**[0009]** According to one interesting feature of the invention, where two stacked columns abut end-to-end, this abutment exists essentially at the location of one of the floor heights intended in the final building. At this location, and according to a special feature of the present invention, a direct structural splice is created between such end-contacting, stacked columns, such a splice being established through the nut-and-bolt connected end extension of the central web in a beam. Thus, structural connections between beams and columns act, according to the invention, as connective splices or joints between adjacent, stacked columns. The amount of tightness introduced into the splice-related nut-and-bolt assemblies controls the level of frictional engagement present there between beam and column.

**[0010]** Another interesting feature of the invention involves a unique way for introducing vertical-plane cross-bracing in various upright rectangles of space that are spanned by a pair of vertically spaced beams, and by a pair of horizontally spaced columns. While different specific components can be used to act as cross-bracing structure, one form that is particularly useful, and which is illustrated herein, is that of conventional steel flat bar stock which crosses, and thus braces, such a space. Opposite ends of such bar stock are bolted in place in the recesses between confronting flanges of the angle-iron-like components in the columns.

**[0011]** As will become apparent from the description in detail which follows below, taken along with the accompanying drawings, forces which are exerted and transmitted between columns and beams in a building structure formed in accordance with the present invention lie in upright planes which pass through the central longitudinal axes of the columns and beams. Accordingly, load management is, as is most desired, directed essentially centrally between adjacent connected components. Forces transmitted through cross-bracing elements also essentially lie in these same planes.

**[0012]** The nut-and-bolt, frictional-interface connections proposed by the invention for the regions of interconnection between elongate column components and spacers, and between beams and columns, allow for limited relative sliding motions between these elements under certain load-handling circumstances. Such motions enhance the load-management capabilities of a building frame structure, and furnish a certain helpful amount of energy dissipation in the form of non-damaging heat.

**[0013]** The detailed description of the invention now given below will clearly bring out these special offerings and advantages of the several facets of the present invention.

**[0014]** One further arrangement proposed by the present invention involves a cross-beam connection between mid-regions of laterally next-adjacent horizontal beams. Through-bore brackets bolted to and through the central webs of adjacent beams, and having some of the same features of the flange end regions in columns where splices can be made, allow for installation of elongate cross-beams which extend from beam-to-beam in locations that are intermediate a pair of columns.

#### Description of the Drawings

##### **[0015]**

Fig. 1 is a schematic, stick-figure drawing illustrating portions of a building frame structure which has been constructed in accordance with the present invention.

Fig. 2 is an upper-end, fragmentary view of one column which is constructed in accordance with the present invention, and which is employed in the building frame structure of Fig. 1.

Fig. 3 is a top axial view of the same column pictured fragmentarily in Fig. 2.

Figs. 4, 5A and 5B, inclusive, illustrate, in isolated manners, the assembled structure of a column spacer which is employed in the column of Figs. 2 and 3, and of the individual components which make up this spacer.

Fig. 6 is a fragmentary, isometric view of a specifically configured I-beam which is employed according to the invention.

Fig. 7 is a fragmentary, isometric view of a specifically configured channel beam which also may be employed according to the invention.

Fig. 8 is a fragmentary drawing illustrating interconnections which exist between stacked columns and beams in the frame structure of Fig. 1, and between columns and diagonal cross-bracing.

Fig. 9 is a fragmentary detail illustrating a preliminary step in the assembly and splice-joining of a beam and a pair of stacked columns.

Fig. 10 is a larger-scale view illustrating, isometrically, roughly the same thing which is pictured in Fig. 9.

Fig. 11 is a view illustrating a completed splicing connection between two beams and a pair of stacked columns.

Fig. 12 is a view taken generally along the line 12-12 in Fig. 11.

Fig. 13 presents a view which is very similar to that presented in Fig. 9, except that here what is shown is the interconnection between a beam and a column at a location vertically intermediate the ends of the column.

Fig. 14 is a view showing a base-plate structure which is employed at the lower ends of column stacks present in the building frame structure of Fig. 1.

Fig. 15 is a fragmentary schematic view, somewhat like the view presented in Fig. 2, illustrating a feature of the invention which involves the capability of angle-iron-like components in a column to shift independently and longitudinally relative to one another, and also relative to a spacer (not shown) in this column.

Figs. 16 and 17 are views which compare how a conventional rectangular tube-shaped column, and a cross-shaped column constructed in accordance with the present invention, differently accommodate the attachments thereto of internal wall structure in a building.

Figs. 18 and 19 are somewhat like Fig. 3, except that here what are shown are two different modified forms of an assembled, star-like cross-section column built in accordance with the present invention.

Fig. 20 illustrates fragmentarily an end of a cross-beam connection.

Figs. 21 and 22 illustrate two different cross-sectional versions of modified forms of columns constructed in accordance with the invention.

Figs. 23-25, inclusive, illustrate modified forms of

cross-braces.

# Detailed Description of, and Manner of Practicing, the Invention

**[0016]** Turning attention now to the drawings, and referring first of all to Figs. 1-5B, inclusive, indicated generally at 21 in Fig. 1 is a fragmentary portion of a multi-story building frame structure which has been constructed in accordance with the present invention. In frame structure 21, four column stacks 22, 24, 26, 28 are shown, each of which is made up of a plurality of end-to-end, splice-joined elongate columns that are constructed in accordance with the present invention. The phrase "column stack" is employed herein to refer to such plural, end-connected columns, and the word "column" is employed herein to designate a single column assembly which has been built in accordance with the invention. In order to illustrate one characteristic versatility which is furnished by the invention, two different types of columns - - double-story and single-story - - are shown in these column stacks.

**[0017]** Three columns in stack 22 are shown at 30, 32, 34. As will shortly be more fully explained, the upper end 32a of column 32 is joined to the lower end of column 30, and the lower end 32b of column 32 is joined to the upper end of column 34. Columns 30 (shown only fragmentarily) and 32 are two-story columns (see length L), and column 34 is a single-story column herein (see length 1). One more column is specifically labeled at 35 in Fig. 1. This column is essentially the same in construction as column 32.

**[0018]** Extending between and joined to the columns in the several column stacks pictured in Fig. 1 are plural, horizontal beams, such as the three beams shown at 36, 38, 40. The distances between next-adjacent ones of these three beams are the same, and have the spacing of one story-height in frame structure 21. Beam 36 has its near end in Fig. 1 splice-connected (still to be explained) to column stack 22 at the region of end-to-end joinder between columns 30, 32. Beam 38 has its near end in Fig. 1 connected vertically centrally between the opposite (upper and lower) ends of column 32. Beam 40 has its near end in Fig. 1 connected to the region of end-to-end joinder between columns 32, 34. As will soon be explained, the manners in which the just-mentioned ends of beams 36, 40 are connected to columns in column stack 22 is somewhat different from the manner in which the near end of beam 38 in Fig. 1 is connected centrally between the upper and lower ends of column 32.

**[0019]** Presented in Fig. 1, as can be seen, are plural, large, black dots. These dots represent the locations of spacers, or spacer structures, which form parts in the various columns that are employed in frame structure 21. For example, shown at 42, 44 in Fig. 1 are two black dots (spacers) which form part of column 32. These two dots indicate the presence of spacers within column 32 at locations in structure 21 which are roughly midway be-

tween floors. Thus, dot 42 represents a spacer which is present in column 32 generally vertically centrally between beams 36, 38. Dot 44, and the spacer which it represents in column 32, resides generally vertically centrally between beams 38, 40. A black dot 45 represents a spacer which is present in single-story column 34, generally vertically centrally between the upper and lower ends of column 34. Clear, or open, circular dots in Fig. 1 represent the end-to-end connections between vertically adjacent columns in the respective column stacks.

**[0020]** Figs. 2 and 3 illustrate somewhat more specifically the structure of column 32, and thus also, the structures of many other ones of the various columns employed in the column stacks pictured in Fig. 1. Column 32 herein is formed with four, elongate, angle-iron-like components substantially parallel one another, and also parallel the central long axis 32c of column 32. Each of components 46, 48, 50, 52 has a right-angular cross-section formed by angularly intersecting legs, such as legs 46a, 46b in component 46. These legs meet at an elongate, linear corner, such as corner 46c. Corner 46c lies closely adjacent, and substantially parallel to, axis 32c.

**[0021]** As can be seen, column 32 has a generally cross-shaped transverse cross-sectional configuration, formed in such a fashion that the legs in the angle-iron-like components essentially radiate laterally outwardly (star-like) from axis 32c. Each leg in each angle-iron-like component is spaced from, confrontive with, and generally parallel to one leg in a next-adjacent angle-iron-like component.

**[0022]** As seen in Fig. 2, the upper end region 32a in column 32 is furnished with aligned through-bores, such as through-bores 54 which are provided in flange 46b. As will soon be explained, these through-bores are employed for the attachment of beams, such as beam 36, and for splicing joinder to the underside of an overhead beam, such as beam 30.

**[0023]** Provided at the locations of previously mentioned black dots 42, 44 in Fig. 1 are cross-shaped, two-component spacers, such as spacer 42 which is variously shown in Figs. 3-5B, inclusive. Spacer 42 is formed from two like-configured components, one of which is shown isolated at 42a in Fig. 5A, and other of which is shown isolated at 42b in Fig. 5B. These spacer components are centrally notched so that they can be fit together as shown in Fig. 4, and the outward extensions of components 42a, 42b are provided with through-bores, such as bores 56 shown in component 42b.

**[0024]** Spacer 42 is placed generally longitudinally centrally between beams 36, 38, and between the confronting legs of column components 46, 48, 50, 52. It is bolted there in place through appropriate nut-and-bolt assemblies, such as the assembly shown at 58 in Fig. 3, and through suitable accommodating through-bores (not shown) provided in the legs in components 46, 48, 50, 52. Spacer 44 is similarly positioned in column 32 vertically centrally between beams 38, 40. When in place, the

spacers space apart the angle-iron-like components in the column with what can be thought of as the centerlines of these spacers aligned with previously mentioned column axis 32c. Preferably, the thickness of each of components 42a, 42b is about equal to the thickness of the central web portions of the beams which are employed in the building frame structure of Fig. 1.

**[0025]** In each column, the angle-iron-like components, the spacer, or spacers which hold these apart, and the nut-and-bolt assemblies (and related through-bores) which bind all together, are toleranced in such a manner, that there is present in the region associated with each spacer a friction interface. This interface can allow for a certain small amount of relative longitudinal motion (along the long axes of the columns) between these elements. The amount of tightness introduced into the nut-and-bolt assemblies dictates the level of frictional engagement, which is thus selectable and adjustable. The significance of this feature of the invention will be more fully discussed shortly.

**[0026]** An assembled column, like column 32, thus takes the form of an assembly of four, right-angle, angle-iron-like components disposed as described and illustrated relative to one another, and held together through nut-and-bolt assemblies which clamp the angle-iron-like components onto the spacers, such as spacers 42, 44. A consequence of this construction is that there are openings or recesses laterally outwardly facing along the length of column 32, defined, in part, by the spacings which exist between the confronting legs in the angle-iron-like components.

**[0027]** These recesses are employed herein to receive, as will below be described, the extending end portions of the central webs in beams, such as beams 36, 38, 40.

**[0028]** Digressing for just a moment to Fig. 15, here, angle-iron-like components 46, 48, 50, 52 are represented fragmentarily as spaced elements. In Fig. 15, dashed lines 60, and a dashed arrow 62, show angle-iron-like component 48 slightly upwardly shifted from its solid outline position relative to the other three angle-iron-like components 46, 50, 52. Similarly, dash-double-dot lines 64, and dash-double-dot arrow 66, illustrate upward shifting of angle-iron-like component 50 relative to components 46, 48, 52. These moved positions for components 48, 50 are highly exaggerated in Fig. 15. This has been done to point out clearly a feature of the invention (mentioned earlier) which is that the tolerances that are built into the fastening regions between these angle-iron-like components and the spacers is such that, under severe loading conditions which produce bending of column 32, the angle-iron-like components therein can actually shift slightly relative to one another so as to act somewhat as independent elements. Such shifting also creates frictional, energy-dissipating braking action in the regions where these elements contact one another. This capability of a column built in accordance with the present invention offers a column which can act as a heat energy

dissipater to absorb shock loads to a building frame.

**[0029]** Turning attention to now to Figs. 6, 7, 18 and 19, and beginning with Figs. 6, here there is shown fragmentarily at 36 an end region of previously mentioned beam 36. Beam 36 includes a central web 36a, and upper and lower flanges 36b, 36c, respectively. As can be seen, short portions of the end regions of flanges 36b, 36c, have been removed to create and expose what is referred herein as an extension 36d in and from central web 36a.

**[0030]** Provided in extension 36d are three vertically spaced through-bores 36e, and a downwardly facing through-bore-like hook 36f. How this modified form of an otherwise conventional I-beam functions in the setting of the present invention will be described shortly.

**[0031]** Fig. 7 illustrates at 68 an alternative beam construction contemplated for use in and with respect to the present invention. Beam 68 has been formed from an otherwise conventional channel member having a central web 68a, and upper and lower flanges 68b, 68c, respectively. End portions of the upper and lower flanges have been removed as shown to create and expose an extension 68d from central web 68a. Extension 68d, like previously mentioned beam extension 36d in Fig. 6, includes three through-bores 68e, and a through-bore-like hook 68f. It will become very apparent shortly, without further direct discussion, how channel beam 68 can be used alternately with I-beam structure 36.

**[0032]** Figs. 18 and 19 illustrate modified forms of star-like-cross-section column construction contemplated by the present invention. In Fig. 18 there is shown a column 70 which has a kind of three-sided configuration formed by angle-iron-like components 72, 74, 76. Components 72, 74, 76 include paired, angularly intersecting, elongate legs, such as legs 72a, 72b, which meet at an elongate linear corner, such as corner 72c that substantially parallels and is slightly spaced from the long axis 70a of column 70. In the particular configuration shown in Fig. 18, the included angle in each of the three angle-iron-like components between the paired legs therein is about 120-degrees.

**[0033]** Suitable spacer structures, like that shown at 78, act between components 72, 74, 76 in column 70 in much the same manner that a spacer, like spacer 42, acts between column components, such as components 46, 48, 50, 52 previously discussed. Joinder between spacer structures and angle-iron-like components is also similar to that previously described with respect to column 32.

**[0034]** In Fig. 19, there is shown generally at 80 yet another column structure which has a kind of three-way configuration somewhat like that pictured for column 70 in Fig. 18. In order to simplify matters herein, the same set of reference numerals employed for the several components pictured in Fig. 18 for column 70 are also employed in similar locations and for similar components in column 80 in Fig. 19. The principal difference between column 80 and column 70 is that, in column 80, the angularly intersecting legs in two of the angle-iron-like com-

ponents possess an included angle of about 135-degrees, and the third angle-iron-like component has legs possessing an included angle of about 90-degrees.

**[0035]** Shifting attention now to Figs 8-12, inclusive, Fig. 8 illustrates, in much greater detail, that region within building structure 21 which includes columns 30, 32 and beams 36, 38. In this figure, the columns and beams shown are fully assembled with respect to one another, with end region 36d in beam 36 generating an end-two-end splice between the adjacent ends of columns 30, 32, and with the end region in beam 38 joined through nut-and-bolt assemblies to a region in column 32 which is generally longitudinally centrally between its opposite ends. One should recall that column 32 has a length which essentially spans the dimension of two stories in frame structure 21. As can generally be seen in Fig. 8, a nut-and-bolt pattern which involves four nut-and-bolt assemblies is employed at the region of joinder between columns 30, 32 and beam 36. In the region of joinder between column 32 and beam 38, where no splice occurs between columns, the end of beam 36 is attached to legs in column components 46, 48 also utilizing a four nut-and-bolt pattern of nut-and-bolt assemblies. Thus, the attached end region in beam 36 includes three through-bores and a downwardly facing hook. Similarly the end region in beam 38 includes three through-bores and also a downwardly facing hook.

**[0036]** Also pictured in Fig. 8 is cross-bracing structure including a pair of bar-stock-configured cross-braces 82, 84. These two cross-braces span the rectangular area which is bounded by beams 36, 38, and by columns 32, 35. The ends of the cross braces extend through and between the spaces/recesses provided between the legs in the angle-iron-like components, and are suitably anchored there as by nut-and-bolt assemblies generally located at the regions in Fig. 8 shown at 86, 88. Cross-braces 82, 84 essentially lie in a common plane shared with the long axes of beam 36, 38, as well as with the long axis of column 32.

**[0037]** Fig. 9 illustrates the conditions of various components just prior to inter-connection of beam 36 with columns 30, 32. In solid lines in Fig. 9 the upper end of column 32 is prepared preliminarily with the presence of a nut-and-bolt assembly 90 wherein the shank of the bolt extends through the lower-most ones of the through-bores provided in angle-iron-like components 46, 48. Column 30 does not yet occupy its solid outline position in Fig. 9, but rather may be poised and spaced upwardly in the dash-dot outline position pictured in Fig. 9.

**[0038]** The end of beam 36 which includes central-web extension 36d is advanced toward the recess between angle-iron-like components 46, 48, and is introduced into proper position as illustrated by curved arrow 92. This involves insertion of extension 36d between components 46, 48, and hooking, employing gravity, hook 36f onto the shank of the bolt in nut-and-bolt assembly 90.

**[0039]** Beam 36 is then oriented so that its long axis is substantially orthogonal with respect to the long axis

of column 32, and column 30 is lowered toward and into its solid outline position in Fig. 9. When this has taken place, appropriate line-up occurs between the through-bores provided in beam extension 36d, in the upper end of column 32, and in the lower end of column 30, so as to permit the insertion and tightening of nut-and-bolt assemblies with respect to the other illustrated through-bores.

**[0040]** This results in a completed assembly between columns 30, 32 and beam 36 in a condition where web extension 36d in beam 36 creates a splice between the adjacent ends of columns 30, 32. This condition is clearly shown in Figs. 11 and 12. Fig. 10 is also helpful in illustrating this condition, with this figure picturing the conditions of components just before lowering of overhead column 30 downwardly onto the upper end of column 32. The various nut-and-bolt assemblies so employed to create a splicing interconnection between beam 36 and columns 30, 32 are appropriately tightened to establish the desired level of frictional interengagement which exists directly between the confronting surfaces of beam 36 and columns 30, 32.

**[0041]** Fig. 13 illustrates somewhat the same process of interconnection that takes place between beam 38 and the vertical mid-region of column 32.

**[0042]** Completing now a description of things shown in the various drawing figures, Fig. 14 pictures at 94 a base-plate structure which is employed in frame structure 21 adjacent the bases of the different column stacks, such as column stack 22. These base-plate structures effectively tie the stacks to the foundation (not specifically shown). Base-plate structure 94 includes a generally horizontal plate 96, on the upper surface of which there is welded a cross-structure 98. This cross-structure is essentially a replica of a spacer structure like that described for spacer 42. The cross-structure receives the lower end of the lower-most column in stack 22, with the confronting spaced legs of that column, at its lower end, receiving the cross-structure. Appropriate nut-and-bolt assemblies (not shown) anchor things in place at this base-plate structure.

**[0043]** Figs. 16 and 17 illustrate very schematically yet another facet of the present invention. Specifically what is shown in a comparative manner in these two figures is the difference which exists with respect to walls (having a thickness W) brought together at a corner within a building under circumstances with a conventional rectangular tube-like column (Fig. 16) employed, and with a cross-shaped column (Fig. 17) provided in accordance with the present invention.

**[0044]** In Fig. 16, a conventional, hollow, rectangular, square-cross-section column 100 is pictured along with four interior walls structures 102, 104, 106, 108. What one will here notice is that, if wall structures having generally the wall thicknesses pictured in Fig. 17 are employed, the corners of column 100 protrude and are exposed. In order not to have these corners protrude, the wall thicknesses would have to be larger, and larger wall

thicknesses translates into lesser usable floor space in a finished building.

[0045] As can be seen in Fig. 17, where the cross-sectional transverse perimeter outline of column 32 is illustrated, these same wall structures 102, 104, 106, 108 come together in a manner where the corners are not broken by the protrusion of any part of column 32.

[0046] In Fig. 20 a cross-beam connection (one end only) is illustrated fragmentarily between a pair of orthogonally related beams 110, 112 which may form a part of the frame structure pictured at 21 in Fig. 1. Very specifically, a longitudinal central region in beam 110 has attached (by bolting) to opposite sides of its central web 110a two pairs of right-angle brackets, such as the pair containing brackets 114, 116. Brackets 114, 116 include spaced, parallel confronting legs 114a, 116a, respectively, which are spaced apart (in the illustration now being described) with essentially the same spacing provided for the legs in previously discussed angle-iron-like components 46, 48, 50, 52.

[0047] A four through-bore pattern, including bores such as the two shown at 118, is provided in legs 114a, 116a. A nut-and-bolt assembly 120 is fitted into the lower-most opposing through-bores, with the shank of the bolt spanning the space between legs 114a, 116a.

[0048] The fragmentarily visible but yet unattached, end of beam 112 is prepared with a matchingly through-bore central web extension 112a, wherein the lower-most through-bore is actually a hook 112b which is like previously mentioned hook 36f. Full attachment of beams 110, 112 is accomplished in somewhat the same manner described above for column-beam attachment.

[0049] Fig. 21 illustrates the cross section of a modified column 130 which, for elongate components, includes a flat plate 132, and two right-angle angle-iron-like elements 134, 136. One spacer structure associated with these elements is shown at 138.

[0050] Fig. 22 illustrates at 140 another modified-cross-section column including a channel member 142, and two right-angle angle-iron-like components 144, 146. A spacer for these components is shown at 148.

[0051] Fig. 23 shows a modified cross-brace construction 150 which is made up of the welded combination of a flat plate 152 and an angle iron 154.

[0052] Fig. 24 shows at 156 another modified form of a cross-brace, which here takes the shape of a conventional right-angle angle iron..

[0053] Fig. 25 shows at 158 still another modified cross-brace form which has a rectilinear, tubular configuration.

[0054] The special features of the present invention are thus fully illustrated and described. The column and beam components of the present invention, which can readily be created using standard structural cross sections, allow for extremely easy, intuitive and unfailingly accurate on-site assembly and construction. Nut-and-bolt interconnectors, which are essentially all that are required fully to assemble a building frame from these com-

ponents, establish all necessary connections and joints without welding. Regions of joinder between columns and beams are promoted where end portions of beams create load-managing splices between vertically stacked, adjacent columns. Similar connections exist from beam-to-beam. Plural-element assembled columns, in various different producible configurations, present distinctly smaller gravitational footprints than do comparable gravitational load-capacity tubular columns. Interconnected columns, beams and cross-braces deliver and handle loads essentially in common upright planes containing their respective longitudinal axes. Relative motion, energy dissipating, frictional interconnections exist (a) within columns, (b) between columns, beams and cross-braces, and (c) from beam-to-beam to offer appropriate and forgiving responses to severe loads delivered to a building.

## 20 Claims

1. A method of installing an elongate cross-beam in a beam-to-beam cross-connection between a pair of nominally in-place, previously installed building-frame beams which, before such installing, are spaced apart by a substantially correct lateral distance in the building frame, and where the cross-beam to be installed includes a generally planar, upright central web, said method comprising establishing for each of such two spaced beams which are to be cross-connected

(a) a pair of brackets having substantially parallel-planar legs, or elements, which are spaced apart in a manner creating an upright, generally planar, straight-down, vertically accessible, open-topped region, or recess, having a lateral width which is suitable for receiving freely the thickness of such a cross-beam's central web, and (b) a catch spanning the space between such elements at a location which is below the open top of the region, preparing each of the opposite ends of such a cross-beam's central web to be vertically clear so as to permit downward insertion of that end through the open top of, and into, the region, and to possess a downwardly facing hook designed to become caught by, and to seat downwardly by gravity on and against, the mentioned catch, vertically lowering a cross-beam having such prepared-web-ends to cause these ends to be inserted into, and to be received within, the mentioned open-topped regions between the spaced parallel-planar elements that are associated with the two, spaced, building-frame beams which are to be cross-connected, thus to cause the hooks in the prepared web ends to



- become caught, hooked and seated by gravity on and against the catches associated with such regions, and performing said lowering without requiring any appreciable increasing of the pre-lowering lateral spacing between the two, spaced building-frame beams, and by said lowering (a) causing the lowered cross-beam to become hooked and interconnected by gravity to and between the spaced building-frame beams, and (b) creating thereby a gravity-stabilized, correctly spatially organized beam-to-beam cross-connection between the lowered cross-beam and the two, spaced building-frame beams.
2. A method of installing an elongate beam to form an interconnection between a pair of nominally in-place, previously installed building-frame columns which, before such beam installing, are spaced apart by a substantially correct lateral distance in the building frame, and where the beam includes a generally planar, upright central web, said method comprising establishing for and within each of such two spaced columns (a) a pair of spaced, substantially parallel-planar legs, or elements, which are spaced apart in a manner creating an upright, generally planar, straight-down vertically accessible, open recessed region having a lateral width which is suitable for freely receiving the thickness of such a beam's central web, and (b) a catch spanning the space between such elements at a location which is within the recessed region, preparing each of the opposite ends of such a beam's central web (a) to be vertically clear so as to permit insertion and downward movement of the web end into and in the recessed region, and (b) to possess a downwardly facing hook designed to become caught by, and to seat downwardly by gravity on and against, the mentioned catch, maneuvering and vertically lowering a beam having prepared-web-ends to cause these ends to be inserted into, and to be moved downwardly within, the mentioned recessed regions associated with the elements that are, in turn, associated with the two spaced building-frame columns, thus to cause the hooks in the prepared web ends to become caught, hooked and seated by gravity on and against the catches associated with such regions, and performing said maneuvering and lowering without requiring any appreciable increasing of the pre-lowering lateral spacing between the building-frame columns, and by said lowering, (a) causing the lowered beam to become hooked and interconnected by gravity to the spaced building-frame columns, and (b) creating thereby a gravity-stabilized, correctly spatially organized interconnection between the lowered beam and the spaced building-frame columns.
3. A construction whenever produced by the method of claim 1 or 2.
4. A construction including an elongate cross-beam in a beam-to-beam cross-connection between a pair of nominally in-place, previously installed building-frame beams which, before such installing, were spaced apart by a substantially correct lateral distance in the building frame, and where the cross-beam to be installed includes a generally planar, upright central web, further comprising
- (a) a pair of brackets having substantially parallel-planar legs, or elements, established for each of such two spaced beams which are cross-connected and which are spaced apart in a manner creating an upright, generally planar, straight-down, vertically accessible, open-topped region, or recess, having a lateral width which has received freely the thickness of said cross-beam's central web, and (b) a catch spanning the space between such elements at a location which is below the open top of the region, each of the opposite ends of such a cross-beam's central web having been previously prepared to be vertically clear so as to permit downward insertion of that end through the open top of, and into, the region, and to possess a downwardly facing hook designed to become caught by, and to seat downwardly by gravity on and against, the mentioned catch, and said cross-beam having such prepared-web-ends having been vertically lowered to have caused these ends to be inserted into, and to be received within, the mentioned open-topped regions between the spaced parallel-planar elements that are associated with the two, spaced, building-frame beams which are cross-connected, being such as to cause the hooks in the prepared web ends to have become caught, hooked and seated by gravity on and against the catches associated with such regions, and performing said lowering without requiring any appreciable increasing of the pre-lowering lateral spacing between the two, spaced building-frame beams, and by said lowering having (a) caused the lowered cross-beam to become hooked and interconnected by gravity to and between the spaced building-frame beams, and (b) created thereby a gravity-stabilized, correctly spatially organized beam-to-beam cross-connection between the lowered cross-beam and the two, spaced building-frame beams.
5. A construction including an elongate beam forming an interconnection between a pair of nominally in-

place, previously installed building-frame columns which, before such beam installing, were spaced apart by a substantially correct lateral distance in the building frame, and where the beam includes a generally planar, upright central web, further comprising

- (a) a pair of spaced, substantially parallel-planar legs, or elements established for and within each of such two spaced columns, which are spaced apart in a manner creating an upright, generally planar, straight-down vertically accessible, open recessed region having a lateral width which has freely received the thickness of said beam's central web, and (b) a catch spanning the space between such elements at a location which is within the recessed region, each of the opposite ends of such a beam's central web having been previously prepared (a) to be vertically clear so as to permit insertion and downward movement of the web end into and in the recessed region, and (b) to possess a downwardly facing hook designed to become caught by, and to seat downwardly by gravity on and against, the mentioned catch, and said beam having prepared-web-ends having been maneuvered and vertically lowered to have caused these ends to be inserted into, and to be moved downwardly within, the mentioned recessed regions associated with the elements that are, in turn, associated with the two spaced building-frame columns, being such as to have caused the hooks in the prepared web ends to have become caught, hooked and seated by gravity on and against the catches associated with such regions, and being maneuvered and lowered without requiring any appreciable increasing of the pre-lowering lateral spacing between the building-frame columns, and by said lowering having, (a) caused the lowered beam to become hooked and interconnected by gravity to the spaced building-frame columns, and (b) created thereby a gravity-stabilized, correctly spatially organized interconnection between the lowered beam and the spaced building-frame columns.
6. A building frame assembly including building-frame columns interconnectable by an elongate beam substantially as herein described with reference to Fig 13 of the accompanying drawings
7. A building frame assembly including two building-frame beams interconnectable by an elongate beam substantially as herein described with reference to Fig 20 of the accompanying drawings.
8. A load-bearing interconnection or splice between two end-to-end columns (22, 24, 26, 28) and a beam

for a structural building column assembly (21), comprising:

two like elongate, upright, vertically stacked and aligned next-adjacent columns (22, 24, 26, 28) including a lower column and an upper column (30, 32, 34), with each column possessing an end (32a) which confronts a like end in the other column (30), and with each column (30, 32, 34, 35) being formed by plural, adjacent, elongate, angle-iron-like components (46, 48, 50, 52) each having a pair of angutany-joined elongate legs (46a, 46b), and within each column (30, 32, 34, 35) a spacer structure (42) is interposed and secured to said angle-iron-like components intermediate, and longitudinally spaced from, the opposite ends of said components (46, 48, 50, 52), and along the length of the column, in a manner positioning said angle-iron-like components, with each of the component's respective legs spaced from, confronting, and generally paralleling a leg in/of an adjacent component, to define a space between confronting legs adapted to receive the central web (36d, 68d) of a beam (36, 68, 40), **characterized by** the feature that said central web (36d, 68d) of the beam (36, 38, 40) is employed in said interconnection or splice, wherein the central web of each elongate, generally horizontal beam (36, 38, 40) is a generally upright, planar central web (36a, 68a) with an end (36d, 68d) which, with respect to each of said aligned columns (30, 32, 34, 35), extends into said defined space which exists in each of said columns between two confronting legs in a selected two or pair of angle-iron-like components in a column, with said web end bridging vertically in a splicing or interconnecting condition across the location where said column ends confront one another, and securing means (58, 120) or a structure anchoring an end of said central web to each of said two confronting legs in the selected pair of adjacent angle-iron-like components in said stacked columns.

9. An elongate, interconnected structural column/beam assembly comprising an elongate column with a laterally facing recess, a catch element positioned in said recess, and an elongate beam having an elongate central web including an end extension that includes a hook, which extension, with the column and beam interconnected, is received in said recess in a circumstance with said hook engaging said catch element.
10. The assembly of claim 9, wherein said column takes the form of an assemblage of elongate angle-iron-like components, adjacent ones of said angle-iron-like components include elongate, facially confront-

ing, spaced legs, and said recess is defined by a spaced, confronting pair of said legs.

11. The assembly of claim 9 which further includes a cross-beam interconnection between a pair of orthogonally related, elongate beams, with said interconnection including a catch element joined to one beam, and an associated hook provided for the other beam.
12. The assembly of claim 10 which forms part of a building frame structure that includes upright planar regions each bounded by a pair of laterally spaced columns, and by a pair of vertically spaced beams which are interconnected with said columns, and wherein there is further included in that building structure an elongate, cross-bracing element which extends at an angle across at least one of such planar regions, with opposite ends of said cross-bracing element received and secured within the laterally facing recesses in said columns in said laterally spaced pair of columns.
13. A structural building column assembly employable, in plurality, as spaced, upright structures in a building frame which also includes elongate, generally horizontal beams having ends connected to and spanning the spaces between adjacent columns, said column assembly comprising plural, elongate, side-by-side adjacent, angle-iron-like column components, each possessing angularly intersecting, elongate legs, spacer structure connectively interposed said column components, and positioning said components in mutual, spaced-apart relationships, with each leg in each column component spaced from, confronting, and generally paralleling a leg in a next-adjacent column component, and with the spaces between confronting legs being adjustable, and nominally generally sized to received between them an end portion of a beam, and securing-accommodating structure formed in a pair of said confronting legs at a location spaced along the length of the column from said spacer structure, enabling binding-force-adjustable, connective securing, at that location, of a beam end disposed between such confronting legs, adjustment of such connective securing enabling changing of the level of frictional engagement between the connected beam and column.
14. The column assembly of claim 13 which further comprises spacer-binding adjustment mechanism operatively interconnecting said column components and said spacer structure, adjustable to establish the level of frictional engagement between the column components and the spacer structure.

15. The column of Claim 1 which, as viewed along its long axis, has a generally star-like radial appearance defined by said flanges.

16. An elongate structural column comprising a long axis, and plural, elongate components effectively joined to one another generally side-by-side, and in such a fashion that they are permitted, in a limited manner, to shift reversibly generally longitudinally relative to one another.
17. The column of claim 7, wherein next-adjacent ones of said elongate components include facially confronting, generally parallel, elongate legs which are spaced apart by spacers, and between said legs and said spacers there is a frictional-contact interface which performs with sliding-friction behavior under a circumstance with one of said components shifting generally longitudinally relative to an adjacent such component.

Fig. 1

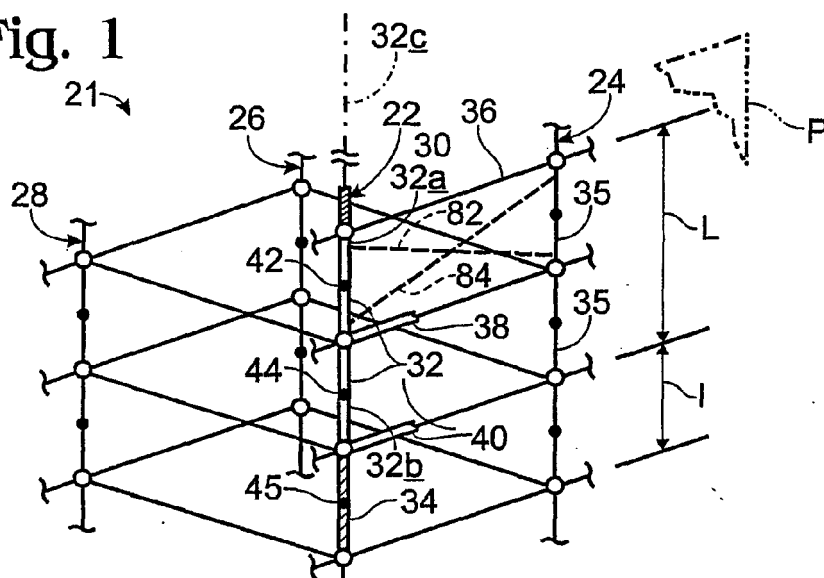


Fig. 2

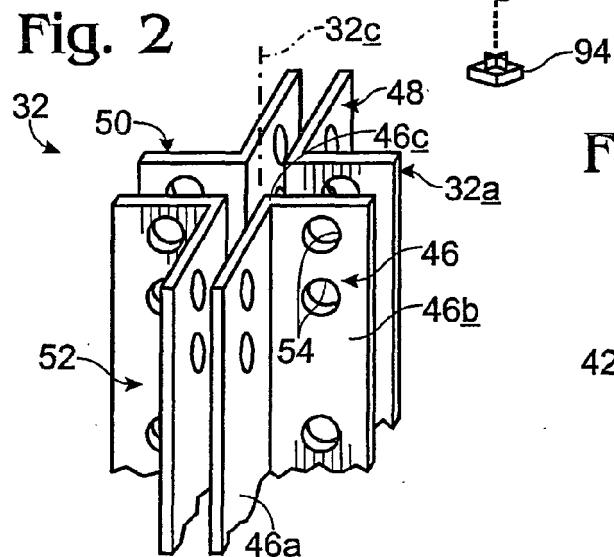


Fig. 3

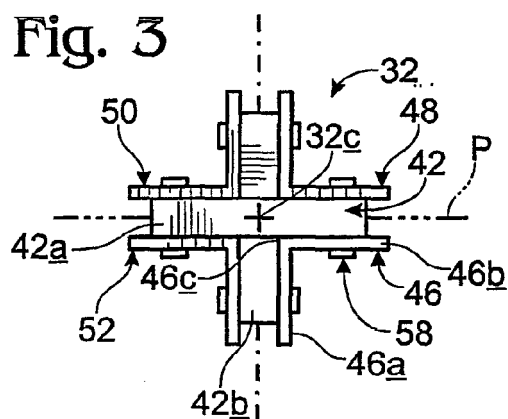


Fig. 4

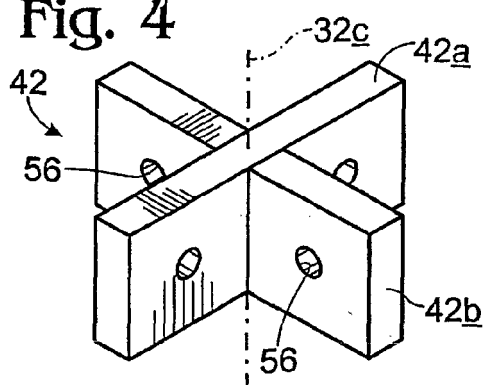


Fig. 5A



Fig. 5B

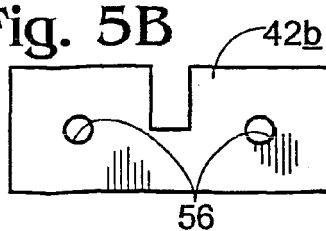


Fig. 6

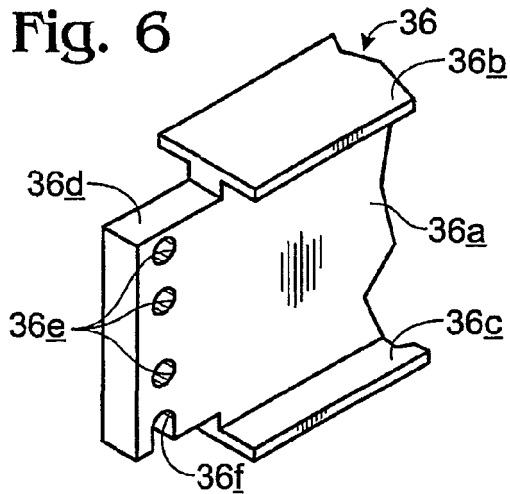


Fig. 7

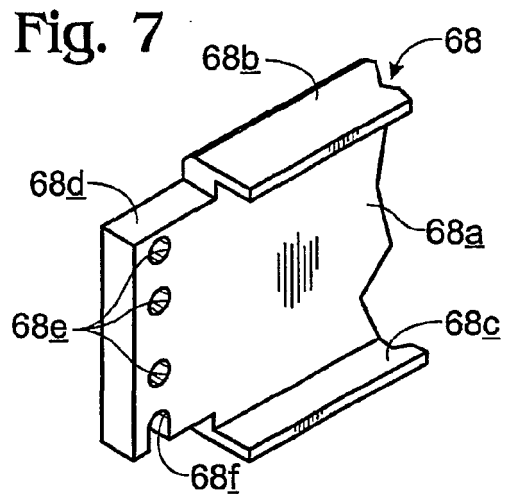


Fig. 8

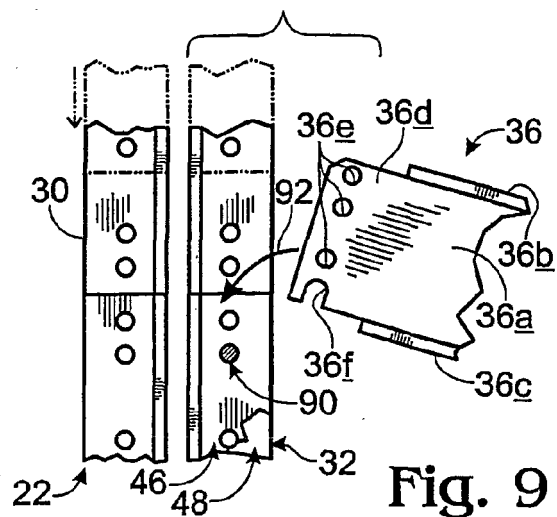
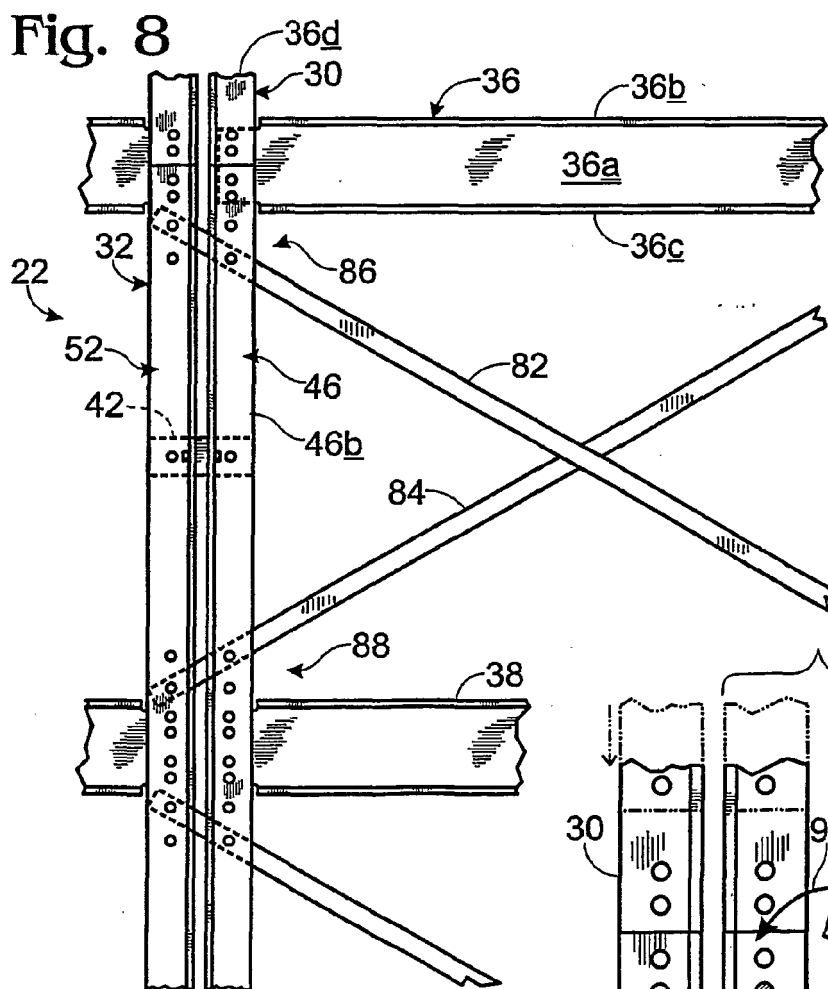


Fig. 9

Fig. 10

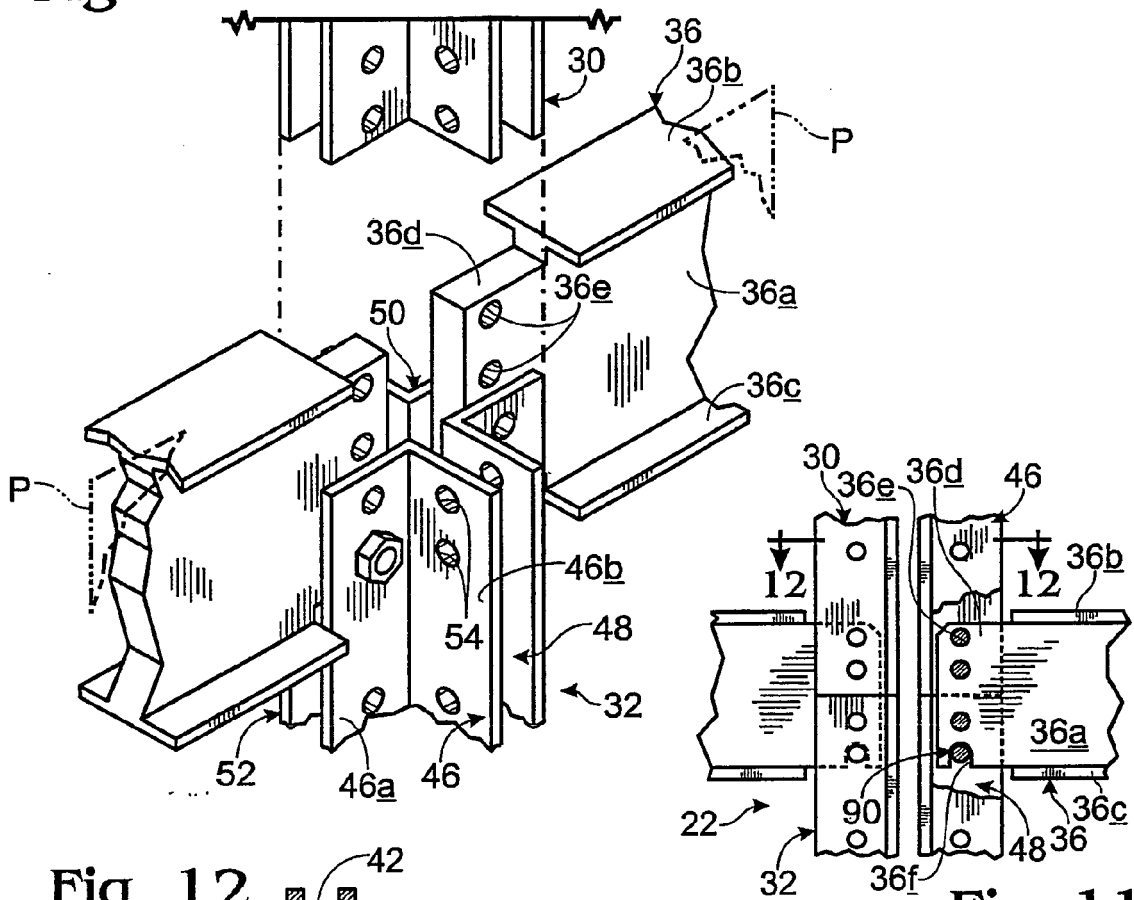


Fig. 11

**Fig. 12**

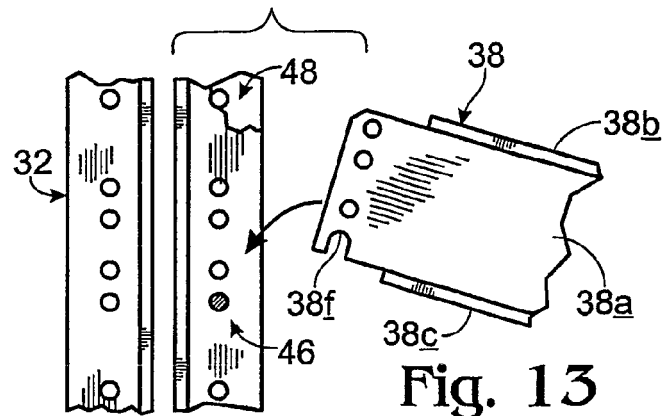
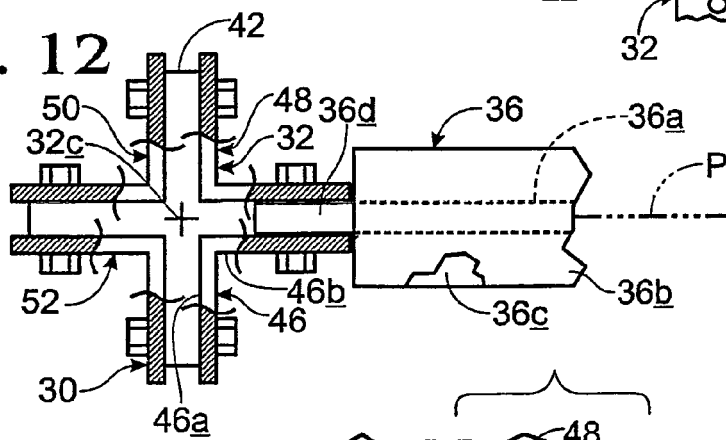


Fig. 13

Fig. 14

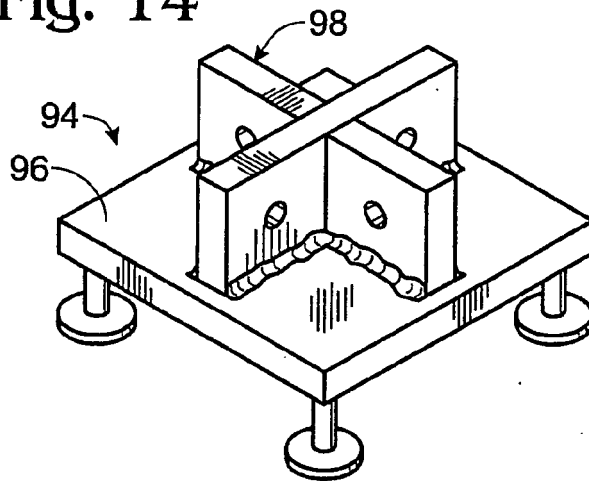


Fig. 15

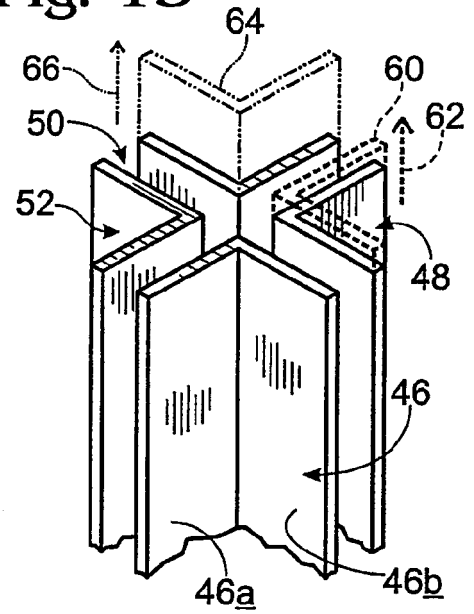


Fig. 16

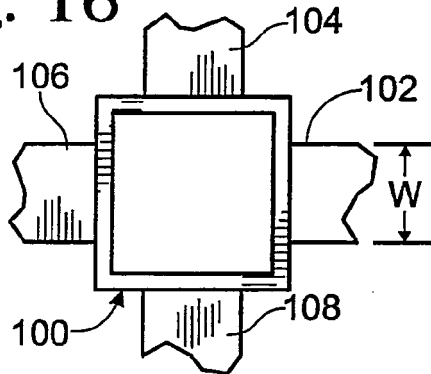


Fig. 17

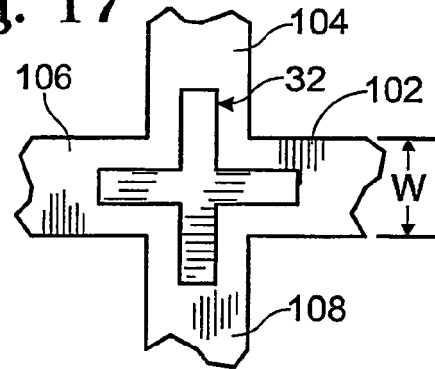


Fig. 18

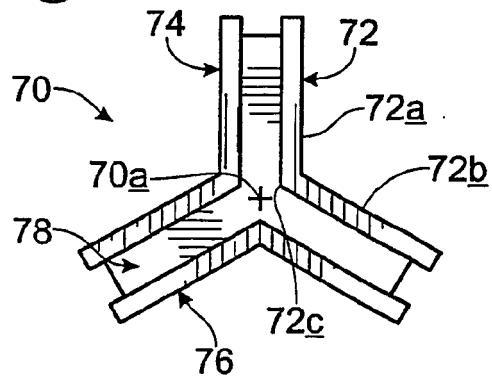


Fig. 19

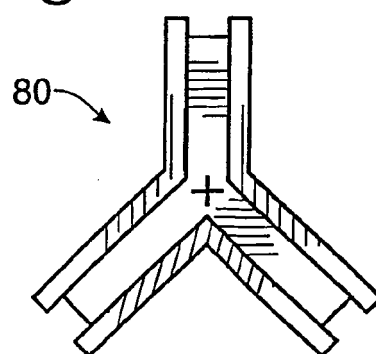


Fig. 20

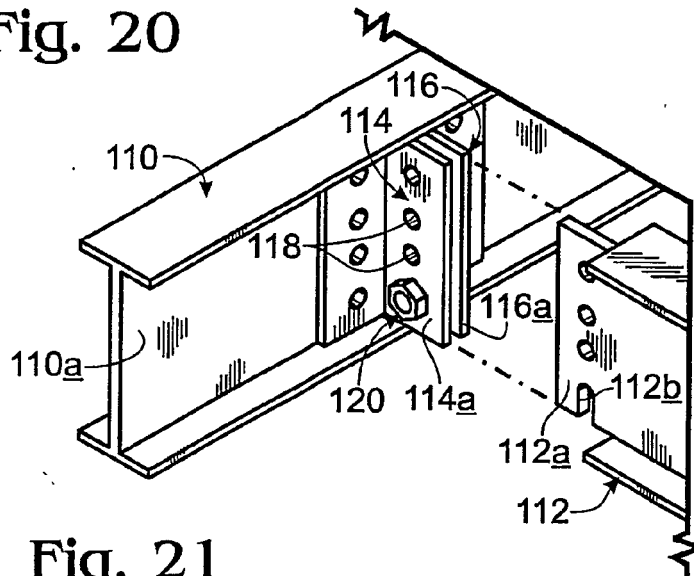


Fig. 21

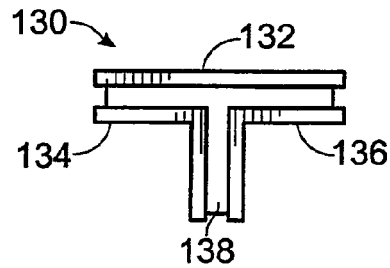


Fig. 22

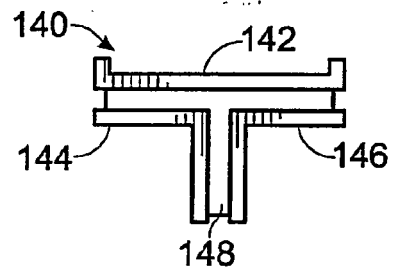


Fig. 23

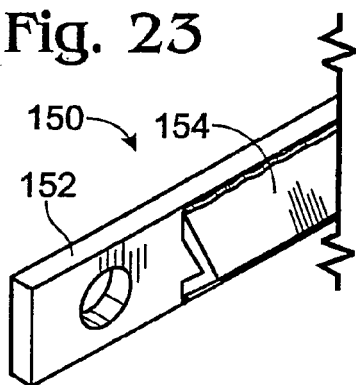


Fig. 24

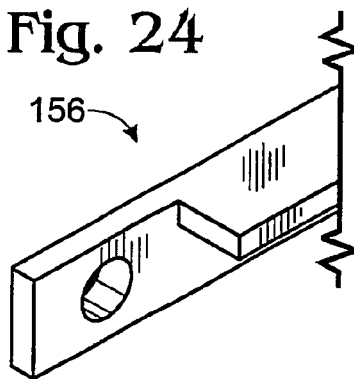
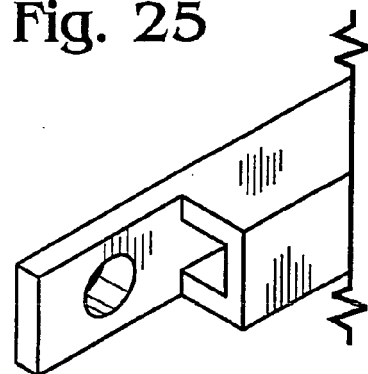


Fig. 25







European Patent  
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# PARTIAL EUROPEAN SEARCH REPORT

Application Number

which under Rule 45 of the European Patent Convention EP 07 00 6256  
shall be considered, for the purposes of subsequent  
proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT			
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<div> <div>TECHNICAL FIELDS SEARCHED (IPC)</div> <div>E04B E04C</div> </div>			
<b>INCOMPLETE SEARCH</b>			
<p>The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.</p> <p>Claims searched completely :</p> <p>Claims searched incompletely :</p> <p>Claims not searched :</p> <p>Reason for the limitation of the search:</p> <p>see sheet C</p>			
Place of search		Date of completion of the search	Examiner
The Hague		15 June 2007	Zuurveld, Gerben
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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EPO FORM 1503 03/82 (P04C07)



European Patent  
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**INCOMPLETE SEARCH  
SHEET C**

Application Number  
EP 07 00 6256

Claim(s) not searched:  
6,7

Reason for the limitation of the search:

Rule 29(6) EPC

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 00 6256

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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15-06-2007

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