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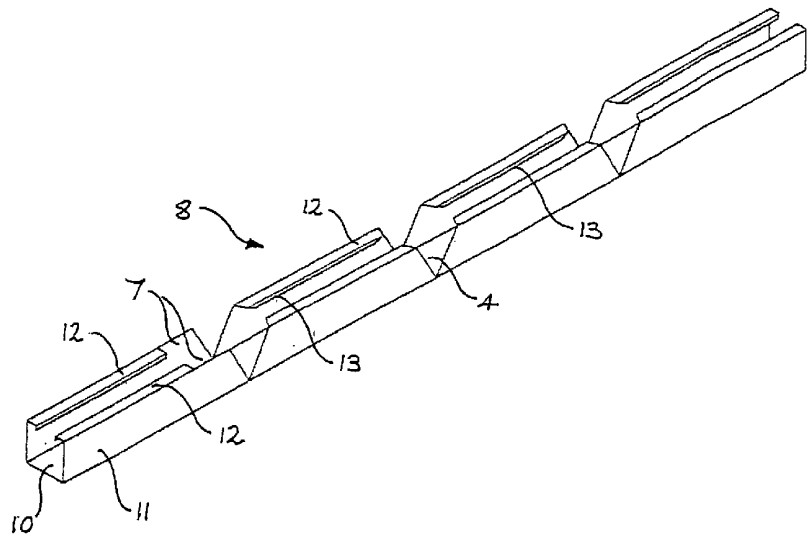

(57) Abstract: In a first aspect, the invention provides a method of forming a web (1) for use in a structural member (2), said method comprising the steps of forming a strip of sheet material (3), forming a series of notches (4) along longitudinal edges (5) of the strip and thereby defining generally transverse fold lines adjacent the respective notches (4), and folding the strip to predetermine degrees along the respective fold lines (6), thereby to form a web (1) adapted for use in the structural member (2). In a second aspect, the invention provides a flange section including a generally U-shaped channel section, and at least one substantially enclosed box section disposed on one side of the channel section, the flange section being adapted for use as, or as part of, a structural member. In a third aspect, the invention provides a composite structural beam, including a top or bottom flange or chord formed from a flange section as described, and a web formed in accordance with the method as described.

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A METHOD OF FORMING A WEB FOR A STRUCTURAL MEMBER

FIELD OF THE INVENTION

The present invention relates generally to structural members, and more particularly to web and flange sections for use in structural members.

The invention has been developed primarily for use in structural beams, joists and purlins as well as other girder type products such as trusses, posts and girts. The invention will therefore be described primarily in the context of structural members of this type, particularly for use in the building and construction industry. It will be appreciated, however, that the invention is not limited to this particular field of use, and is potentially applicable to any situation where a structural member is required, including componentry for general machinery.

Statements in relation to prior art in this document should not be construed as express or implied admissions that the technology referred to necessarily forms part of common general knowledge in the art.

BACKGROUND OF THE INVENTION

Structural beams, joists, purlins and the like are well known. They have been manufactured over the years using a wide range of materials, and a variety of manufacturing techniques. All of these offer some advantages in particular applications, but are also subject to significant inherent limitations. Some of the more common forms of prior art are discussed below.

One popular known method of manufacture involves milling beams, joists and purlins from native old growth and regrowth forest logs, as well as from plantation grown logs. This is the traditional source of structural framing, roofing and flooring componentry. It would also currently be the predominant source of beams and joists,

and to a lesser extent purlins, on a worldwide basis. Milling timber has the advantage of being comparatively inexpensive for smaller section product. However, it inherently possesses a number of problems and limitations. For example, the timber can shrink, twist, warp, bow, cup, bend and rot. Moreover, it cannot be exposed to the elements for any length of time or these problems will be exacerbated. It is therefore generally not sufficiently durable for external use. In any case, it tends to deteriorate with time, subject to the prevailing climatic conditions. It can be destroyed by pests and is particularly susceptible to termite infestation. It can also burn. Furthermore, timber of this type generally does not have long span characteristics. It therefore typically requires dimensionally larger sections to carry spans that are comparable with competing products. For the same reason, it is also heavy, making it expensive to transport and difficult to handle on site. Timber is also not typically supplied with service holes or ducts, and cutting cavities for this purpose can substantially compromise its structural integrity, and thereby reduce its span and load capacities even further. It cannot easily be supplied in long or exact lengths and, to do so, increases the cost. Furthermore, overlogging, environmental constraints and the comparatively high cost of agro-forestry is increasing the market cost of timber disproportionately with respect to that of other materials.

It is also known to manufacture I-beams, joists and purlins from a combination of clear grain, kiln dried structural soft wood flanges or chords, in conjunction with webs formed from particle board, oriented strand board, or plywood. Such composite timber beams are dimensionally stronger and will span greater distances than milled sections for a given profile. They are also more stable than milled timber beams. For these reasons, these products have captured a significant section of the joist and beam market in western economies. Despite these advantages, however, they possess a number of

associated problems. These include the fact that they are more expensive than milled timbers. They can rot. They cannot be exposed to the weather for prolonged periods because of their propensity for rapid deterioration. They can still be destroyed by pest infestation and will burn. For these reasons, they are not generally suitable for external use. Composite timber beams are also not typically supplied with service holes and ducts, while the locations in which such cavities can be incorporated are limited and their formation again compromises structural integrity.

It is also known to form girder beams, joists and purlins using clear grain, kiln dried timber for the web as well as for the top and bottom flanges or chords, which although produced from the same material, are manufactured separately. Larger dimensioned parallel trusses in this configuration are more cost effective, due to the relatively lower number of mitred webs and nail plate joints required. Nevertheless, they are expensive to manufacture for smaller dimensioned structural beams, joists and purlins because of the high labour cost of mitre cutting, the number of components which must be fabricated, and the additional nail plates involved. Timber webbed girder beams, joists and purlins can provide services access between the webs. However, these products still have inherent limitations including the fact that they are relatively expensive for a given span or load. They can also rot and cannot be exposed to the weather for any significant length of time. They can again be destroyed by pest infestation or fire. They still deteriorate over time and are therefore not generally suitable for external use. Furthermore, because they make use of high grade timber, the cost is adversely affected by the disproportionate rise in the base cost of milled timber.

It is also known to form girder beams, joists and purlins using galvanised steel webs incorporating integral nail plates, to facilitate attachment to clear grain, kiln dried top and bottom flanges. These products have some advantages over timber I-beams,

including a span capacity which is generally greater than that of milled timber, the possibility for services access through the web pattern, and they are relatively light weight. There are, however, nevertheless inherent problems. In particular, the difficulty of manufacturing webs of varying length in custom sizes and in different patterns, limits the versatility of the product. Beams of this type are also comparatively expensive, relative to both milled timber and other timber I-beams. Moreover, because of the timber component, these products can still rot and can therefore not be exposed to the elements for any significant length of time. They remain vulnerable to pest infestation and fire, will deteriorate over time, subject to the general climatic conditions, and are therefore still not ideally suitable for external use. Moreover, because they make use of high grade timber, the cost is again susceptible to the disproportionate growth in the cost of milled timber.

It is also known to manufacture laminated timber beams, joists and purlins using high grade, clear grain, kiln dried timber milled into narrow sections which are then glue laminated and dressed into solid structural members. These products do have relatively long span and high load carrying capacities and for this reason, they tend to be used in certain applications as major structural beams. They do, however, possess a number of disadvantages including the fact that they are particularly expensive. They can also rot and can therefore not be left exposed to the elements for any significant length of time. Being fundamentally composed of timber, they remain vulnerable to pest infestation, will deteriorate with time, and can be destroyed by fire. They are also not supplied with service holes or cavities and the cutting of service holes can substantially reduce structural strength. They are extremely heavy, making them expensive to transport and difficult to handle on site. They are not generally suitable for external use and because

they rely upon high grade timber, the cost is again affected by the disproportionate rise in the cost of milled timber.

Steel section beams, joists and purlins are also known. In one fabrication technique, these are cold rolled from bright or galvanised mild or high tensile steel coil, and typically formed into either "C" or "Z" section profiles. These products are comparatively low cost and easy to manufacture in the case of small profiles and they can provide relatively high span characteristics. However, they are also subject to a number of limitations. Firstly, the process is uneconomic as a means of producing larger structural members. Also, the sections even in smaller sizes cannot be easily cut. Yet, because they are high volume, low margin products, it is usually uneconomic to supply them in custom lengths. They are generally also not supplied with service holes or cavities, which are difficult to cut on site and can substantially compromise structural strength. These products are also not "user friendly" in cottage industry construction. A particular problem in this regard arises due to the fact that timber flooring, battens, plywood, OSB, particle board, weatherboard or plasterboard must be fixed to the steel sections with screws, as the material cannot be effectively nailed. This adds to the material as well as the labour costs. The characteristics of the profiles also typically cause distortion under load, potentially creating problems when interfacing with attached sheeting. Furthermore, only the more expensive "zincalume" or galvanised products can be used externally.

Another known variation involves the manufacture of steel I-beams, joists and purlins by cold roll forming mild or high tensile bright steel coil, into welded I-beam profiles. These products tend to have relatively high span characteristics, but again include a number of limitations. Firstly, they are comparatively expensive to manufacture because of the welding process, and are particularly costly for small profiles

because of the relative amount of welding involved. They are also costly in the case of very large profiles, because of the amount of steel used. They cannot easily be cut to length, and are not generally supplied with service cavities or holes which are difficult to cut on site and can reduce structural strength. In some circumstances, sheeting and cladding can be nail fixed. However, the products are still not as "user friendly" as timber. Furthermore, when welded from bright steel, a post manufacturing coating is required for external use, which adds significantly to the overall cost.

It is further known to form steel I-beams and C sections from extruded molten mild steel. Extruded steel beams can carry high loads, but also have a number of inherent drawbacks. Firstly, they are extremely expensive for general use and are also extremely heavy. They are therefore really only suitable for major portal frames and structural beams. They are generally only supplied in standard lengths and it is even more expensive to cut them, or have them supplied in custom lengths. They are again not supplied with service holes and cutting such holes adds significantly to the cost, while reducing strength. The material is particularly "unfriendly" to work with, especially where other materials are required to be fixed to it. These products also need to be coated post-production for external use and in any event, they are prone to rusting over time. This not only reduces strength, but results in unsightly surface rust stains.

An additional limitation of known structural beams and framing members is that the size, shape and composition are generally required to be specified or selected for the particular intended application. There is minimal flexibility for interchangeability between structural components for different applications. In a production context, this implies more extensive plant and equipment, greater stock volumes, more complex inventory control, and ultimately higher costs.

It is an object of the present invention to overcome or substantially ameliorate one or more of the disadvantages of the prior art, or at least to provide a useful alternative.

DISCLOSURE OF THE INVENTION

Accordingly, in a first aspect, the invention provides a method of forming a web for use in a structural member, said method comprising the steps of forming a strip of sheet material, forming a series of notches along longitudinal edges of the strip and thereby defining generally transverse fold lines adjacent the respective notches, and folding the strip to predetermine degrees along the respective fold lines, thereby to form a web adapted for use in the structural member.

Preferably, the web is alternately folded in opposite directions to form a "zigzag" configuration, when viewed in plan.

Preferably, the sheet material is drawn progressively from a coil or roll, and the method includes the further step of cutting the sheet material to preselected lengths. Preferably, the sheet material is steel, and most preferably galvanised or zincalume coated steel. The steel is preferably of a high tensile composition, so as to be nailable with greater strength and rigidity.

In some preferred embodiments, each fold line is defined by a pair of opposing notches extending inwardly from corresponding positions on opposite sides of the strip. In other embodiments, however, the notches may be offset to produce non-orthogonal angled folds, or other desired shapes or configurations of webbing. It will also be appreciated that a fold line may be formed by a single notch.

In one preferred embodiment of the method, the notches are "sheer notches", formed by removal of a narrow strip of material, to create a square ended fold, with overlapping side walls. In an alternative embodiment, the notches are "wedge notches",

formed by removal of a generally V-shaped section of material to form a mitre ended fold, with abutting side walls. It will be appreciated, however, that other shaped notches, and combinations of notches of different shapes, may also be used to achieve the desired bending and folding characteristics, and the desired final shape.

Preferably, the method includes the further step of folding or roll forming the strip longitudinally to form a channel section. In one preferred embodiment, the channel section is generally U-shaped.

In a particularly preferred form of the invention, the sheet material is folded longitudinally to form a channel section which is generally C-shaped in profile, having a base, parallel side walls extending upwardly from the base, and top flanges returning inwardly from the upper edges of the respective side walls, in mutually opposing coplanar relationship. In this embodiment, the notches are preferably V-shaped, and preferably extend downwardly through the respective side walls, terminating at the point of intersection with the base.

In a second aspect, the invention provides a flange section including a generally U-shaped channel section, and at least one substantially enclosed box section disposed on one side or both sides of the channel section.

Preferably, the flange section is adapted for use as a top or bottom flange or chord, in conjunction with a web, optionally formed in accordance with the method as previously defined, to form a composite structural member.

Preferably, the flange section is press or roll formed from light gauge sheet metal, and is optionally galvanised or zincalume coated. The section is preferably formed so as to be nailable. Most preferably, the flange section is formed from a relatively high tensile steel.

Preferably, the channel is generally square in cross-sectional profile. The box section is preferably also generally square in cross-sectional profile.

Preferably, the box section is fully enclosed by joining overlapping portions of the sheet material. Preferably, the overlapping portions of sheet material are joined by stitching. That is to say, the material is preferably joined by intermittent fastening along a length of the section. The stitching is preferably achieved by crimping, clinching, punching, swaging, folding, stapling, welding, gluing, riveting, screw fastening or bolting, or by some combination of these methods. It will be appreciated, however, that subject to overall strength requirements and other design parameters, such overlapping and fastening techniques need not be used, and the box section need not be fully closed.

In one preferred embodiment, the flange section includes a pair of box sections, disposed on either side of the U-shaped channel. Preferably, the channel is configured nestingly to receive the top or bottom of a web manufactured in accordance with the method previously described, such that the flange section forms a top or bottom flange or chord of a composite structural member.

In one particularly preferred form, the invention provides a composite I-beam, with top and bottom flanges or chords formed from flange sections as described above, and a web formed in accordance with the method previously described. Preferably, the flanges are secured to the web using nails, pins, screws, bolts or rivets, positioned such that the points are enclosed within the respective box sections. Nails are most preferably used.

In the preferred embodiment, the flange sections and the web are each formed from sheet metal fed continuously from rolls or coils. One particularly preferred production technique involves simultaneous feeding from three coils, two for the respective top and bottom flanges, and one for the web. These coils preferably feed simultaneously into a single roll forming machine for high speed continuous delivery of complementary top

flange, web and bottom flange components for a composite structural beam, joist or purlin, in an optimum configuration for rapid assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Figure 1 is a plan view showing a strip of sheet metal, incorporating preformed notches for use in the formation of a web, in accordance with the invention;

Figure 2 is a perspective view showing the strip of Figure 1, folded or roll formed longitudinally into a straight C-shaped web section in accordance with the invention;

Figure 3 is a perspective view showing the section of Figure 2, folded along lines defined by the preformed notches, to form a web according to a first embodiment of the invention;

Figures 4 to 6 show a sequence of views corresponding to Figures 1 to 3 respectively, for a web according to a second embodiment of the invention;

Figures 7 to 9 show a corresponding sequence, for a web according to a third embodiment of the invention;

Figure 10A is a cross-sectional view showing a first form of flange section folded from sheet material according to a further aspect of the invention;

Figure 10B shows a flange section with the same overall profile as the section of Figure 10A, but formed by a different sequence and orientation of folds;

Figures 11A and 11B show a second form of flange, similar to that shown in Figures 10A and 10B, but with the box sections stitched closed;

Figures 12A and 12B correspond to Figures 10A and 10B, but show a third form of flange;

Figures 13A and 13B correspond to Figures 11A and 11B, but show a fourth form of flange section;

Figures 14A to 14H show a further series of flange profiles, with differently shaped box sections;

Figure 15 is a front elevation showing a web joined to top and bottom flanges by nail fastening to form a composite structural beam, joist or purlin according to the invention;

Figure 16 is an enlarged cutaway section from Figure 15 showing the joint between the web and the bottom flange in more detail;

Figure 17 is a cross-sectional view taken along line 17-17 of Figure 16, showing the location and configuration of the nail fasteners in more detail;

Figure 18 is similar to Figure 17, but shows an alternative single sided box section profile for the bottom flange;

Figure 19 is similar to Figure 16, but shows the configuration of the joint between the web and the top flange with the web hinged in the opposite direction;

Figure 20 is a cross-sectional view taken along line 20-20 of Figure 19;

Figure 21 is similar to Figure 20, but shows an alternative single sided box section profile for the top flange which is similar to that of Figure 18;

Figure 22 is a cross-sectional view showing an alternative application for a flange section according to the invention, for use independently as a framing member to which sheet material can be fastened by nailing; and

Figure 23 shows a variation on Figure 22, using a double sided box section profile.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring to the drawings, the invention provides a method of forming a web 1 (Figure 3) for use in a structural member 2, such as a beam, joist, purlin or truss (see Figure 15). The method includes the initial steps of forming a strip 3 of sheet material, preferably galvanised high tensile steel. In a production environment this would typically be drawn progressively from a coil or roll and cut to length, for example by guillotining. Referring initially to Figures 1 to 3, the method then involves forming a series of notches 4 along the longitudinal edges 5 of the strip to define generally transverse fold lines 6 (shown in ghost) adjacent the respective notches. In this first embodiment of the invention as illustrated, each fold line is defined by a pair of opposing V-shaped notches extending inwardly from corresponding positions on opposite sides of the strip. It will be apparent, however, that in other embodiments the notches may be shaped differently, and may be offset to produce angled folds. It will also be appreciated that the fold lines may be formed by single notches. Additional checkouts 7 and other cutouts may also be formed in the strip by punching, cutting or other suitable means, to facilitate subsequent folding and assembly as described more fully below.

The next step in the process involves folding or roll forming the notched strip 3 longitudinally into a channel section 8, as shown in Figure 2. The channel section has a generally C-shaped cross-sectional profile, comprising a base 10, parallel side walls 11 extending upwardly from the base, and top flanges 12 returning inwardly from the upper edges of the respective side walls, in mutually opposing generally coplanar relationship. The inner edges 13 of the channel flanges 12 are turned downwardly so that potentially sharp edges or burrs are not exposed and the flanges 12 are also strengthened. Once the

strip is folded into a channel section in this way, the V-notches 4 extend downwardly through the respective side walls 11 to terminate at the intersection with the base.

From there, the channel section 8 is successively bent in alternate directions, along the fold lines 6 to form the web 1 which is generally of a "zigzag" configuration, as best seen in Figure 3. In this particular embodiment, the V-notches 4 are configured such that in the inward folds 15, the side walls on either side of each notch abut to form a mitre ended joint. In the case of the alternate outward folds 16, the side walls adjacent each V-notch are splayed apart by 180° to form an open joint. In the case of the end fold 17, the side walls adjacent the V-notches are permitted to overlap as shown in ghost, by virtue of the checkouts 7 in the channel flanges 12 (see Figures 1 and 2).

Figures 4 to 6 show a second embodiment of the invention wherein like features are denoted by corresponding reference numerals. This sequence proceeds from a notched strip 3 (Figure 4) to a corresponding channel section 8 (Figure 5) and finally a folded web 1 (Figure 6). In this case, the notches are not V or wedged shaped, but are rather "sheer" notches, formed by removal of a narrow strip of material. Notches of this type can be used to form square ended joins, with overlapping side walls in the case of the inward folds 15. In this case, the absence of inwardly turned top flanges on the section obviates the need for additional checkouts to permit the side walls to overlap.

Figures 7 to 9 show a third embodiment of the invention, where again like features are denoted by corresponding reference numerals. In this case, it will be appreciated that sheer notches similar to those of the previously described embodiment are used. However, these notches 4 are offset and the channel section 8 is asymmetrical, which results in the web section 1 shown in Figure 9.

It will thus be appreciated that a variety of shapes and configurations of notches, in conjunction with differently shaped strips and channel profiles, may be used to achieve

particular bending and folding characteristics, and specific final shapes, according to various design parameters and the intended structural application for the web.

A web manufactured in this way can be used in conjunction with a top flange and a bottom flange to form a composite structural member such as a beam, joist, purlin, rafter, truss, or the like. The top and bottom flanges may be typically but not exclusively manufactured from any roll formed sheet or coil metal. The most suitable materials, sizes, thicknesses and configurations can be selected according to the applicable design parameters, cost constraints, intended applications, and the like.

It will be appreciated that within the scope of these variations, combinations and permutations, a number of significant advantages flow from the present invention. These include relatively low manufacturing costs, price stable input material costs, high strength to weight ratios, greater span and load carrying capacities for given section profiles and material inputs, ease of handling, and reduced transport costs. In addition, structural members incorporating web sections according to the invention are more user friendly because they are relatively light weight, dimensionally accurate, nailable, easy to manufacture in custom lengths, easy to cut to length on site, and easy to assemble. Significant advantages in terms of both dimensional accuracy and ease of assembly arise by virtue of the fact that each straight section of the web channel remains integrally connected to the adjacent sections through the intermediate fold lines. Advantageously, the web sections also inherently provide convenient access for building services including pipe work, electrical cabling, data cabling, air conditioning ducting and the like, without the time and expense involved in cutting dedicated access holes on site and without compromising structural integrity.

In a further aspect, the invention provides a particular type of flange section 20 for use as a top or bottom flange or chord, in conjunction with a web manufactured in

accordance with the method previously described. This allows the formation of composite structural members with especially advantageous performance characteristics.

Referring to Figure 10A, the flange section 20 according to a first embodiment of this further aspect of the invention includes an open generally square U-shaped channel section 22, and a substantially closed generally square box section 24 disposed on one side of the open channel. The flange section 20 is conveniently press or roll formed from light gauge sheet metal and again is preferably galvanised or zincalume coated. The sheet metal is preferably a relatively high tensile steel so as to provide a stronger joint when nail fastened, as described more fully below. Figure 10B shows a flange section 20 with the same overall profile as the section of Figure 10A, but formed by a different sequence and configuration of longitudinal folds.

Figures 11A and 11B show further forms of flange, similar to those shown in Figures 10A and 10B respectively, but with the box sections fully enclosed by the joining of overlapping portions of the sheet material along a join line or seam 25. The overlapping portions of sheet material are ideally joined by stitching, in the sense that the material is joined by a mechanism of involving intermediate fastening along the length of the seam. Such stitching may be achieved by crimping, clinching, punching, swaging, folding, stapling, welding, gluing, riveting, nailing, screwing, bolting, by some combination of these methods, or by other suitable means. This has the advantage of fully enclosing the box section 24 and increasing the strength of the section. In particular, torsional rigidity and buckling strength are substantially enhanced.

Figures 12A and 12B show further forms of flange section 20. These are similar to the sections shown in Figures 10A and 10B respectively, but are symmetrical, incorporating a pair of the box sections 24, disposed on either side of the open square channel section 22. Figures 13A and 13B are similar to Figures 11A and 11B

respectively, in the sense that overlapping portions of sheet metal are stitched along seam lines 25 such that the respective box sections are fully enclosed.

Further variations are shown in Figures 14A to 14H, wherein the box sections are configured slightly differently, using an increased number of longitudinal fold lines, to provide particular bending strength, torsional stiffness, and deflection characteristics. Countless other variations are also contemplated.

Figures 15 and 16 show, by way of example, the web 1 of Figure 3, joined to top and bottom flanges 26 and 27, formed from the flange section 20 shown in Figure 13A to form the composite I-beam 2. Figure 17 shows a cross-sectional view taken along line 17-17 of Figure 16. With reference to Figure 17, it will be seen that each bottom apex 28 of the web is nestingly received and located within the complementary square channel section 22, formed in the bottom flange 27. These components are conveniently fastened together using nails 29, from one side only if necessary, which permits rapid assembly with minimal skill and effort. The formation of the web and flange from steel sheet or coil or other suitable material ensures adequate pull out strength and advantageously, the point 30 of each nail 29 is conveniently and safely concealed within a respective one of the box sections 24. Figure 18 shows an alternative arrangement, using a single sided box section profile for the bottom flange 27, and correspondingly shorter nails. Otherwise, the assembly process and the principles of operation are substantially the same. Figures 19 to 21 show a similar sequence of views in relation to the method of fastening the top flange 26 to the upper apices of the web, again using nails. It will be appreciated that this assembly process is far quicker, easier and less expensive than other fastening methods, including screw fastening, and obviates the need for any final finishing step because the nail points are inherently concealed.

Advantageously, the flange sections and the web may be formed by a production technique involving the simultaneous feeding of sheet metal from three coils or rolls, two for the respective top and bottom flanges, and one for the web. This technique may be embodied such that the three coils feed simultaneously into a single roll forming machine, for high speed continuous delivery of complementary top flange, web and bottom flange components for a composite structural beam, joist or purlin. Furthermore, these components can readily be cut to preselected lengths as part of an automated production process and delivered in an optimum configuration to permit rapid assembly whether as a subsequent integrated process step, in an intermediate location, or on site. This result can be achieved efficiently and cost effectively because the web and flange profiles are essentially manufactured in the same way, from the same material, at the same time, from the same machine. They can therefore be delivered for rapid assembly, as the three components of a finished product of predetermined size and configuration.

In a further aspect of the invention, the flange sections 20 may be used independently as framing members 35 such as studs, plates, sills, heads, noggins, rafters and the like, as shown in Figures 22 and 23. When used in this way, the flange sections are not combined with a web to form composite structural beams. Rather, the flanges are used as self contained framing members to which sheet material such as plasterboard 36 can be fastened by nailing, with the nail points again being conveniently concealed within the channels 22 or box sections 24. Importantly, the strength of the profile allows light gauge steel to be used in such applications. This lowers material and manufacturing costs, and at the same time makes plaster fixing relatively easy with standard "needle point" gypsum screws. The flange sections can also be used as webs, and more generally as componentry for structural framing and partitioning.

The invention in its various aspects thus provides an integrated, flexible system of componentry which can be designed and used in a variety of ways to form a multiplicity of structural framing members including beams, joists, purlins, trusses, frame studs, plates, sills, heads, noggins, rafters, trimmers and other componentry. The flexibility, adaptability, and interchangeability of the components of the system maximises design options, while streamlining manufacturing as well as inventory and stock control. The components can be nail fixed from one side only, with the nail points safely concealed, making the system particularly convenient, efficient and user friendly in a variety of domestic, commercial and industrial applications. The system is not susceptible to pest infestation, and will not burn, rot, twist, warp, cut, bow or bend either as supplied or with exposure to the elements. In addition, the product has a long service life and when appropriately treated by galvanising or zincalume coating, will not rust. Accordingly, it is eminently suitable for external use. It thus compares favourably with the prior art in terms of strength, useability, durability, flexibility and cost. The system can be manufactured from roll or coil stock smelted from recycled steel, thereby reducing the depletion of natural mineral resources. Moreover, as a replacement product for timber, it can reduce the depletion of old growth forests as well as minimise the need for establishment of stagnant, monocultural environments created by agroforestry plantations. In all these respects, the invention represents a practical, commercial, and environmentally significant improvement over the prior art.

Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:-

1. A method of forming a web for use in a structural member, said method comprising the steps of forming a strip of sheet material, forming a series of notches along longitudinal edges of the strip and thereby defining generally transverse fold lines adjacent the respective notches, and folding the strip to predetermine degrees along the respective fold lines, thereby to form a web adapted for use in the structural member.

2. A method according to claim 1 wherein the web is alternately folded in opposite directions to form a "zigzag" configuration.

3. A method according to claim 1 or claim 2 wherein each fold line is defined by a pair of opposing notches extending inwardly from corresponding positions on opposite sides of the strip.

4. A method according to any one of the preceding claims wherein selected pairs of notches are offset to produce non-orthogonal folds.

5. A method according to any one of the preceding claims wherein one or more fold lines are defined by a single notch on one side of the strip.

6. A method according to any one of the preceding claims wherein one or more of said notches take the form of sheer notches, formed by removal of a narrow strip of material, to create a square ended fold with overlapping side walls.

7. A method according to any one of the preceding claims, wherein one or more of said notches take the form of wedge notches, formed by removal of a generally V-shaped section of material to form a mitre ended fold, with abutting side walls.

8. A method according to any one of the preceding claims, including the further step of folding or roll forming the strip longitudinally to form a channel section.

9. A method according to claim 8, wherein the channel section is generally U-shaped in profile.

10. A method according to claim 8 or claim 9, wherein the sheet material is folded longitudinally to form a channel section which is generally C-shaped in profile, having a base, generally parallel side walls extending outwardly from the base, and top flanges returning inwardly from upper edges of the respective side walls in mutually opposing generally co-planar relationship.

11. A method according to claim 10, wherein the notches are generally V-shaped, extending downwardly through the respective side walls, terminating at or near an intersection with the base.

12. A method according to any one of the preceding claims, including the further step of drawing the sheet material progressively from a coil or roll, and cutting the sheet material into preselected lengths.

13. A method according to any one of the preceding claims, wherein the sheet material is steel or an alloy of steel.

14. A method according to claim13, wherein the steel is provided with a protective coating.

15. A method according to claim 14, wherein the protective coating is formed by galvanising or zincalume coating.

16. A method according to any one of claims 13 to 15, wherein the steel is formed from a relatively high tensile composition, so as to be effectively nailable.

17. A flange section including a generally U-shaped channel section, and at least one substantially enclosed box section disposed on one side of the channel section, the flange section being adapted for use as, or as part of, a structural member.

18. A flange section according to claim 17, wherein the channel is generally square in cross-sectional profile.

19. A flange section according to claim 17 or claim 18, wherein the box section is generally square in cross-sectional profile.

20. A flange section according to any one of claims 17 to 19, being formed from sheet material and wherein the box section is fully enclosed by joining overlapping portions of the sheet material.

21. A flange section according to claim 20, wherein the overlapping portions of sheet material are joined by stitching, in the form of intermittent fastening along a length of the section.

22. A method according to claim 21, wherein the stitching is effected by a fastening technique selected from a group comprising crimping, clinching, punching, swaging, folding, stapling, welding, gluing, riveting, screw fastening, and bolting, or from some combination of these techniques.

23. A flange section according to any one of claims 17 to 19, wherein the box section is not fully enclosed.

24. A flange section according to any one of claims 17 to 23, including a pair of said box sections, disposed on either side of the channel.

25. A flange section according to any one of claims 17 to 24, wherein the channel is configured nestingly to receive a top or bottom section of a web, such that the flange section forms a top or bottom flange or chord of a composite structural member.

26. A flange section according to claim 25, wherein the channel is configured nestingly to receive the top or bottom section of a web formed in accordance with the method as defined in any one of claims 1 to 16.

27. A flange section according to any one of claims 17 to 26, being press or roll formed from sheet metal.

28. A flange section according to claim 27 wherein the sheet metal is composed substantially or steel or an alloy of steel.

29. A flange section according to claim 28, wherein the sheet steel includes a protective coating.

30. A flange section according to claim 29, wherein the protective coating is formed by galvanising or zincalume coating.

31. A flange section according to any one of claims 28 to 30, being formed from a relatively high tensile steel, to facilitate effective nail fastening.

32. A composite structural beam, including a top or bottom flange or chord formed from a flange section as defined in any one of claims 17 to 31, and a web formed in accordance with the method defined in any one of claims 1 to 16.

33. A composite beam according to claim 32, including top and bottom flanges as defined, to form a composite I-beam.

34. A composite beam according to claim 32 or claim 33, wherein the flanges are secured to the web by fastening means selected from a group comprising nails, pins, screws, bolts or rivets, positioned such that protruding points are enclosed within the respective box sections.

35. A composite beam according to any one of claims 32 to 34, wherein the flange sections and the web are each formed from sheet metal fed substantially continuously from bulk rolls.

36. A method of forming a composite beam as defined in claim 35, including the step of simultaneously feeding sheet metal from multiple rolls, respectively for the top and bottom flanges, and the intermediate web.

37. A method according to claim 36, including the further step of feeding sheet metal from the respective coils into a single roll forming apparatus for substantially continuous

delivery of complementary top flange, web and bottom flange components for a composite structural beam.

38. A method according to claim 37, including the further step of cutting the respective components to corresponding preselected lengths as part of an automated production process, to facilitate delivery in an optimum size configuration for subsequent on site assembly.

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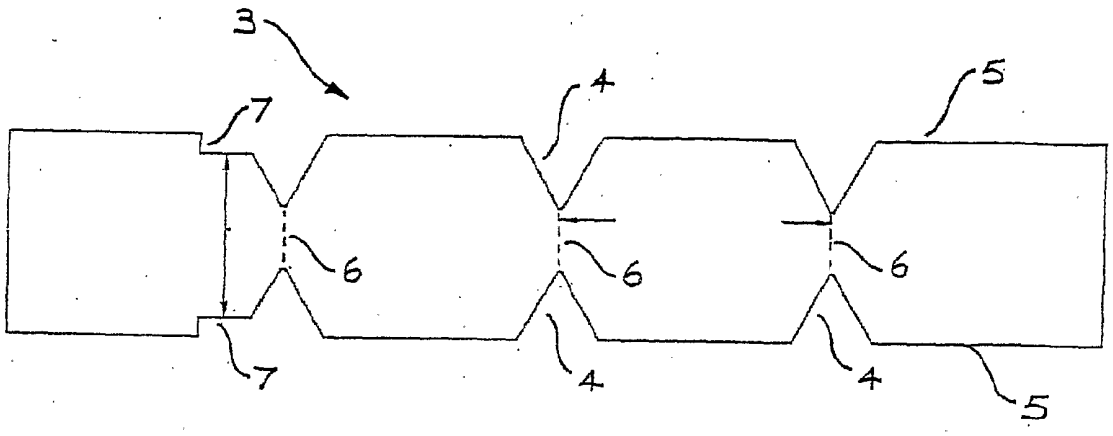

FIGURE 1

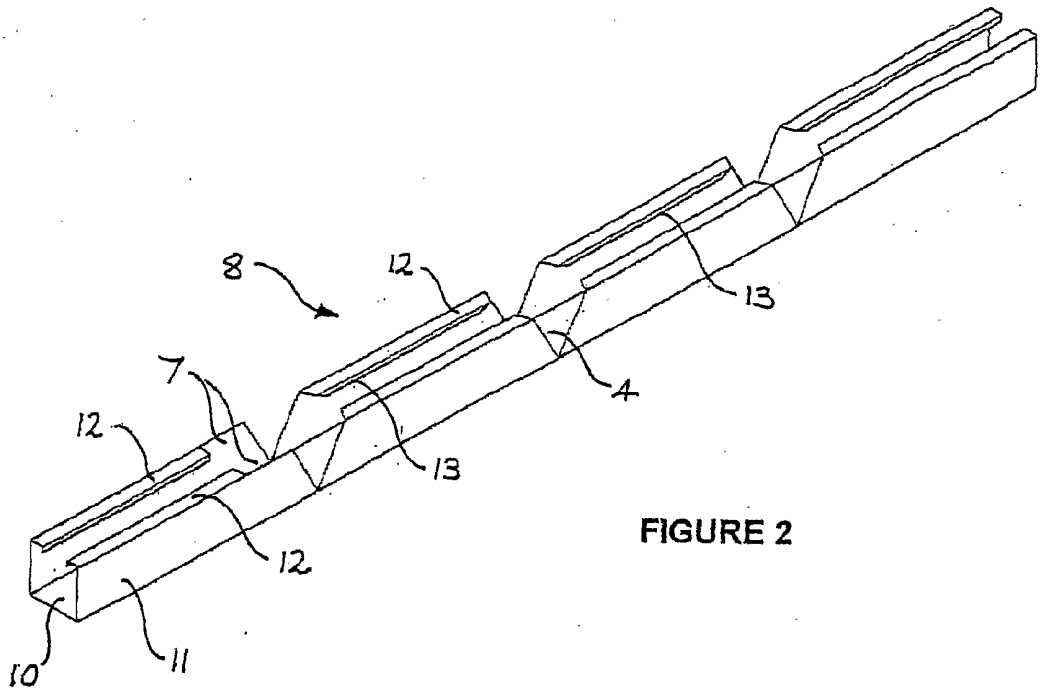

FIGURE 2

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Received 26 June 2001

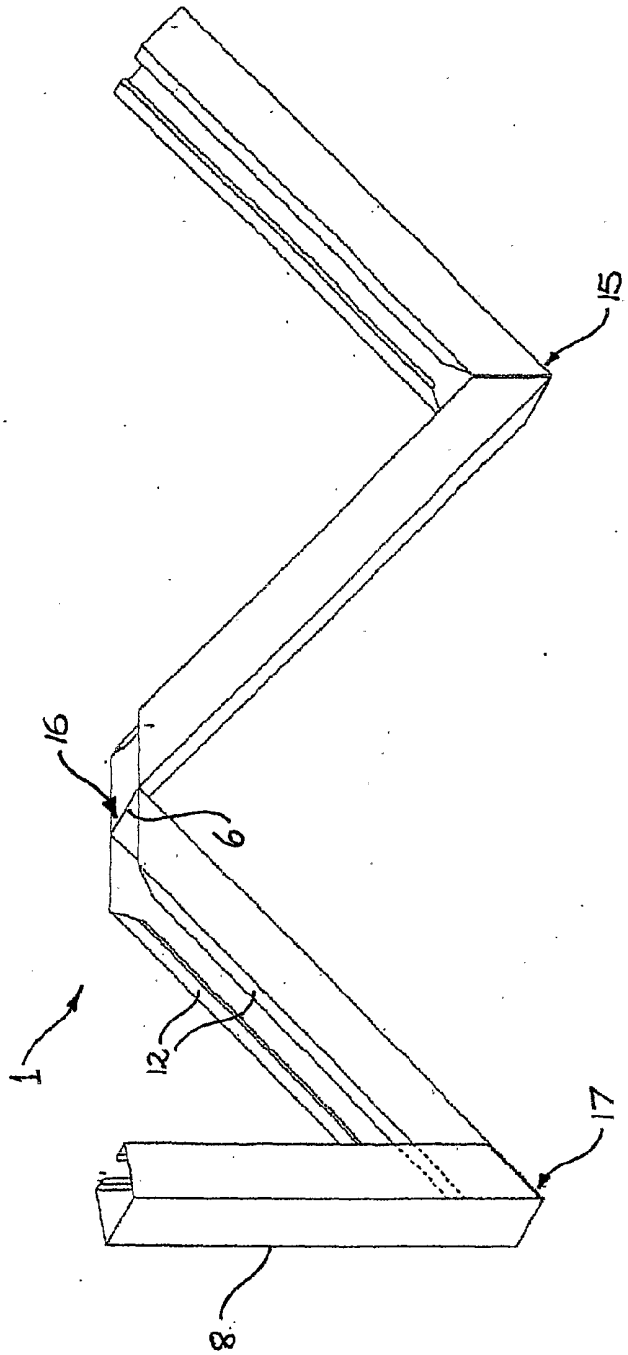

FIGURE 3

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Received 26 June 2001

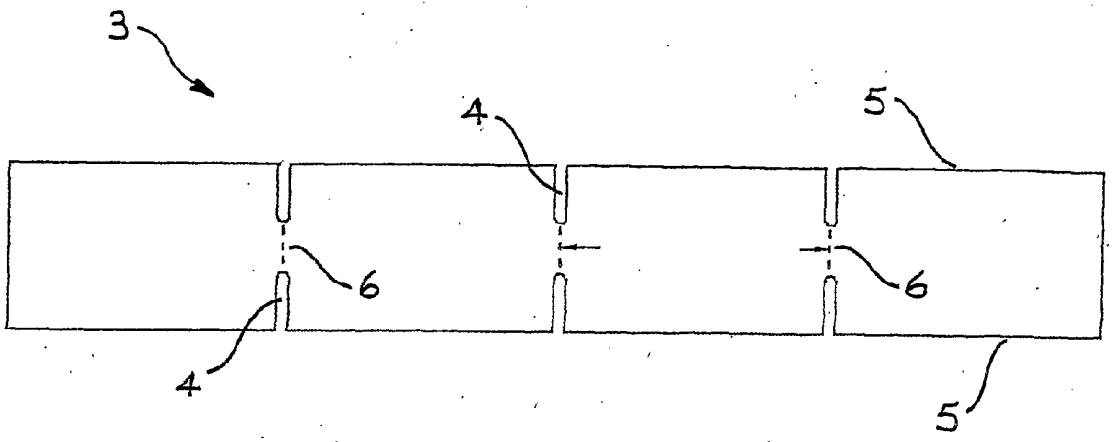

FIGURE 4

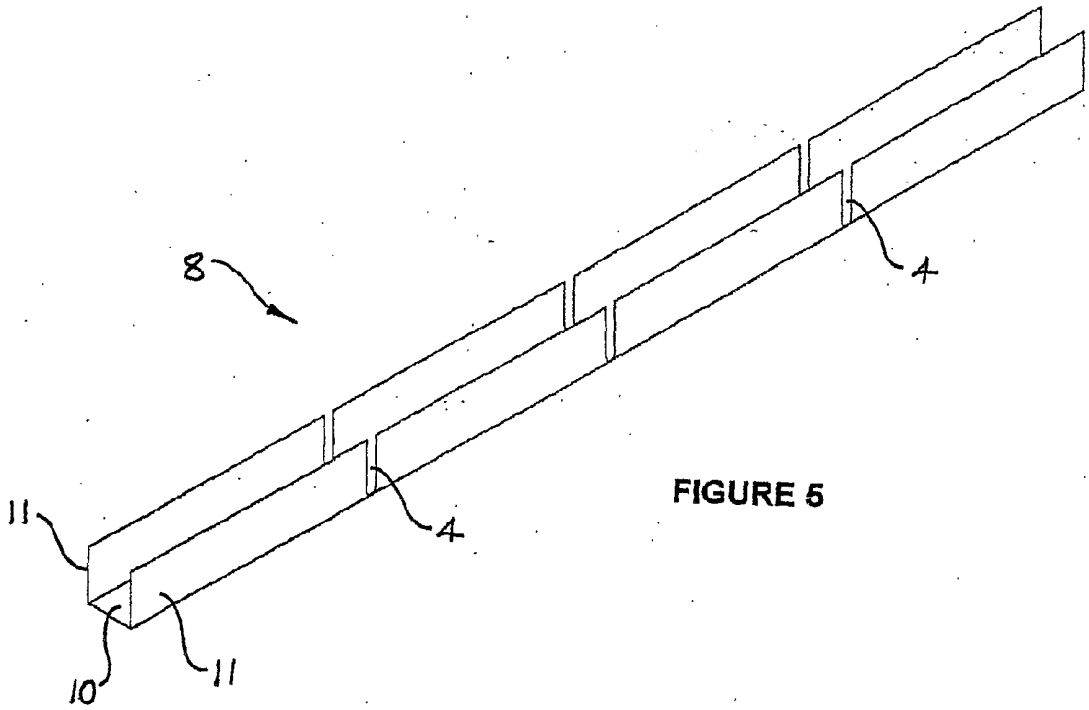

FIGURE 5

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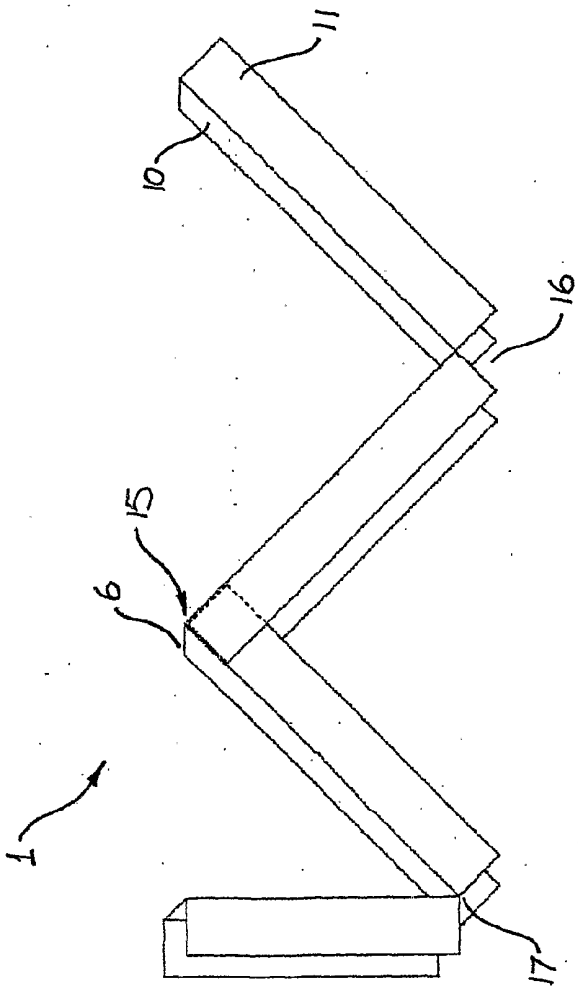

FIGURE 6

PCT/AU01/00529
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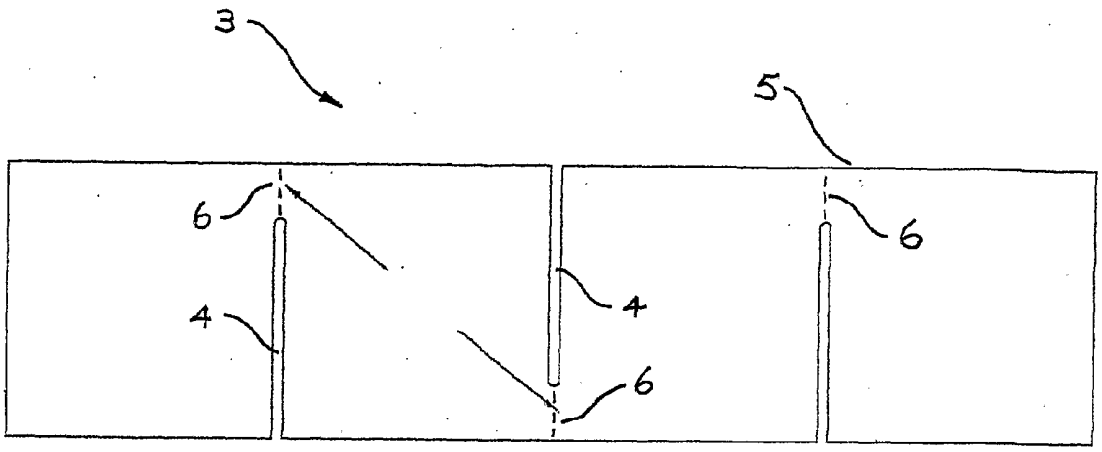

FIGURE 7

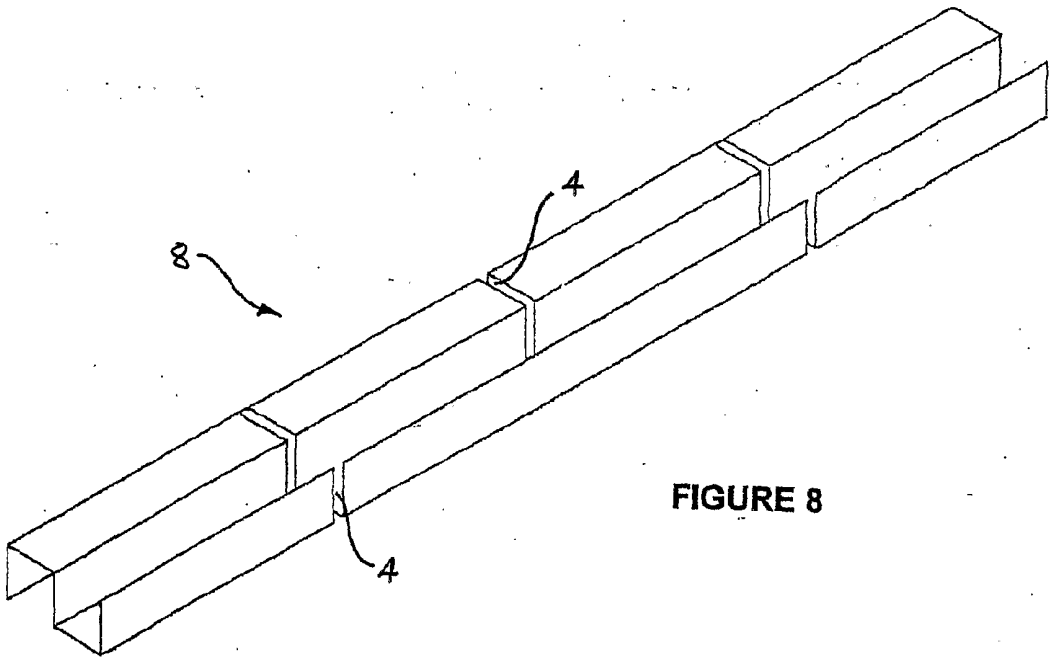

FIGURE 8

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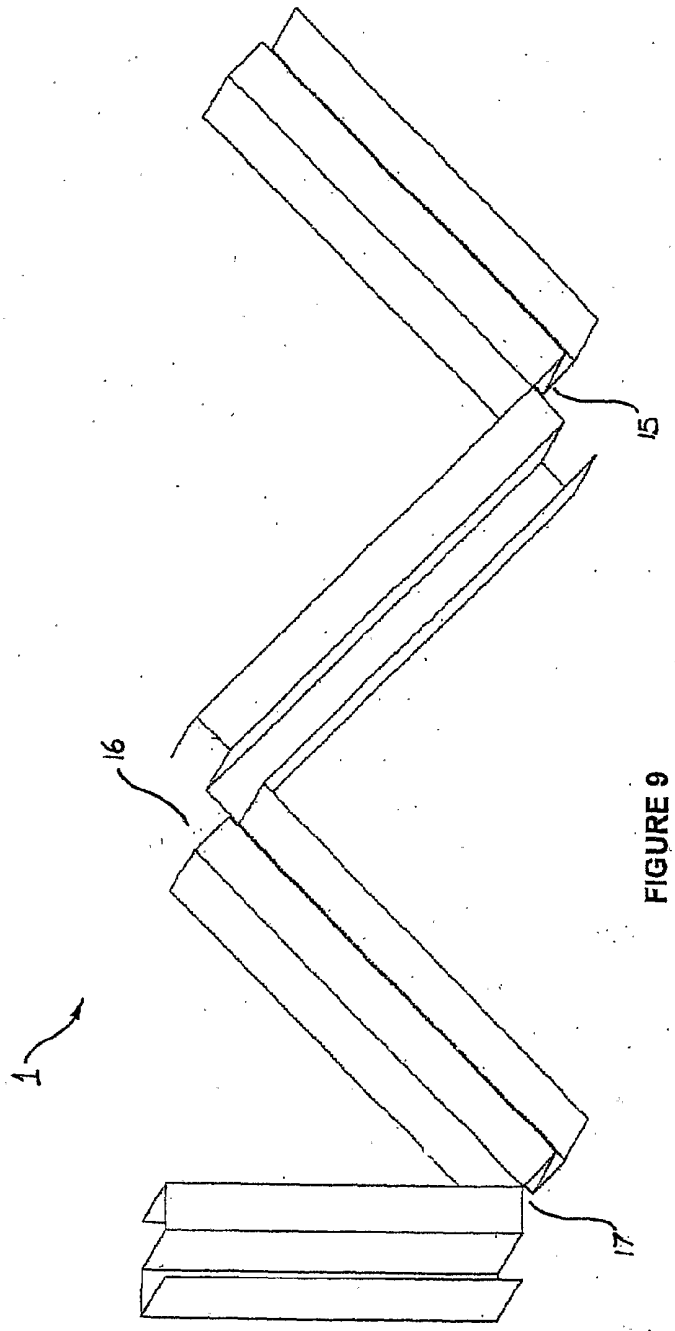

FIGURE 9

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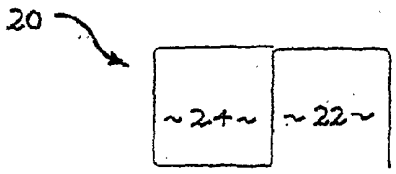

FIGURE 10A

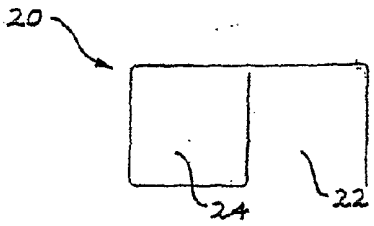

FIGURE 10B

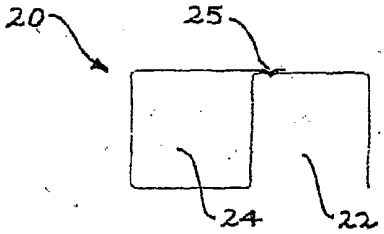

FIGURE 11A

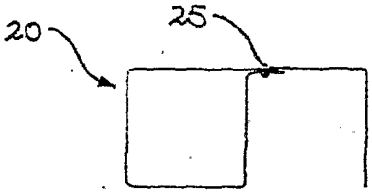

FIGURE 11B

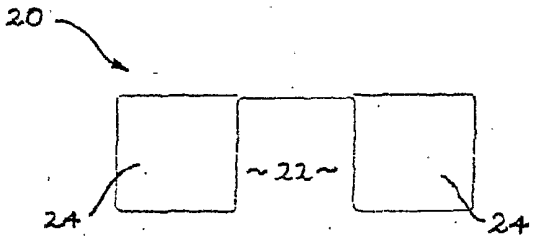

FIGURE 12A

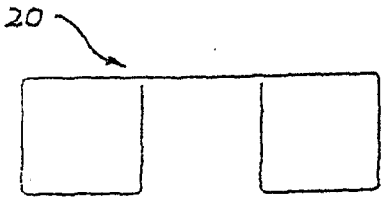

FIGURE 12B

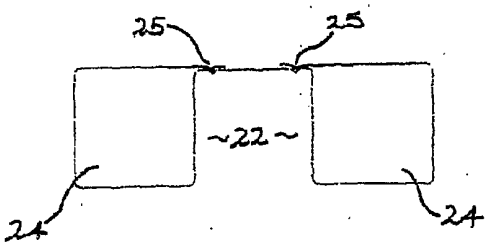

FIGURE 13A

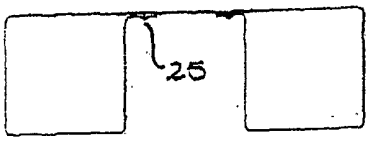

FIGURE 13B

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Received 26 June 2001

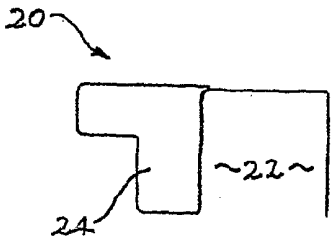

FIGURE 14A

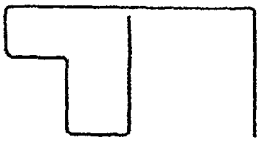

FIGURE 14B

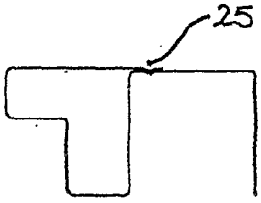

FIGURE 14C

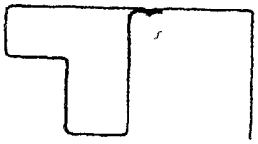

FIGURE 14D

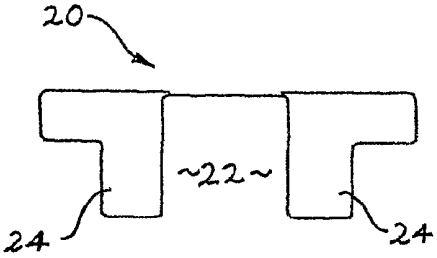

FIGURE 14E

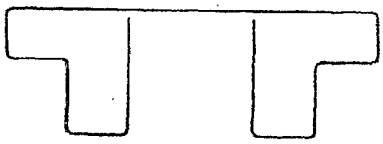

FIGURE 14F

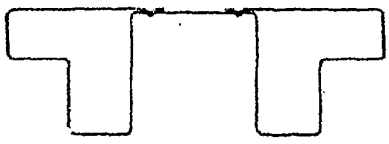

FIGURE 14G

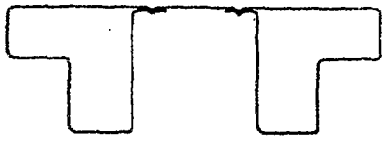

FIGURE 14H

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Received 26 June 2001

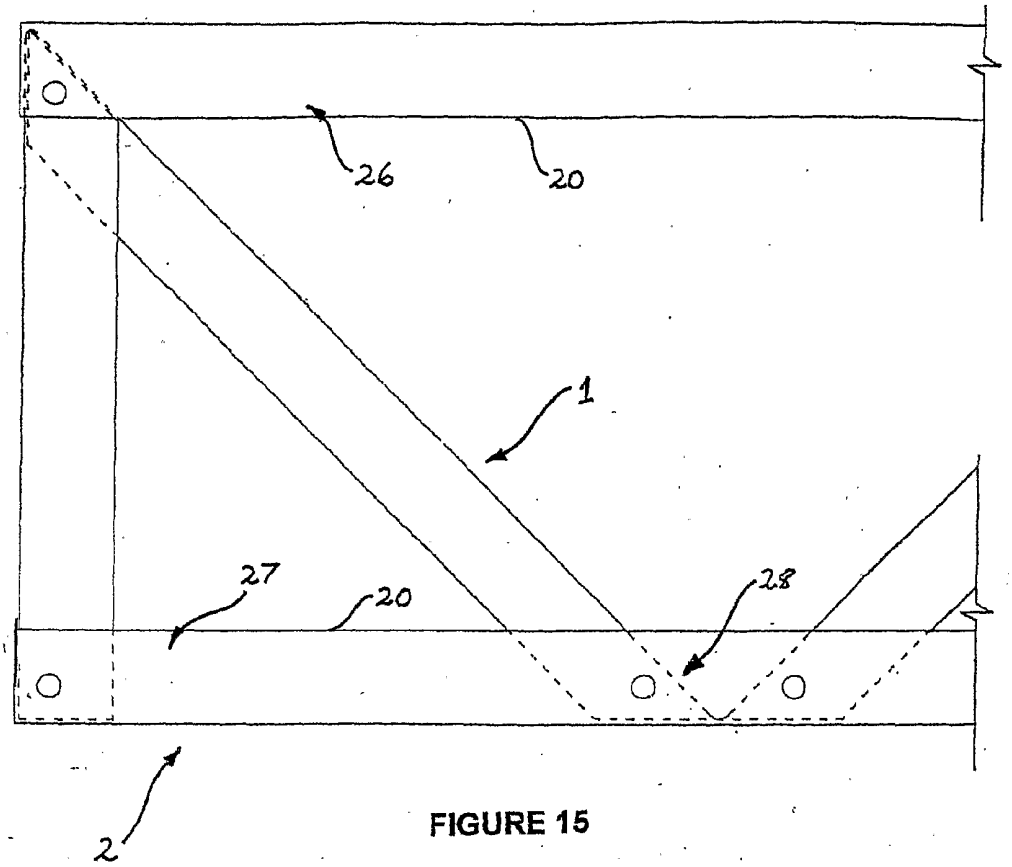

FIGURE 15

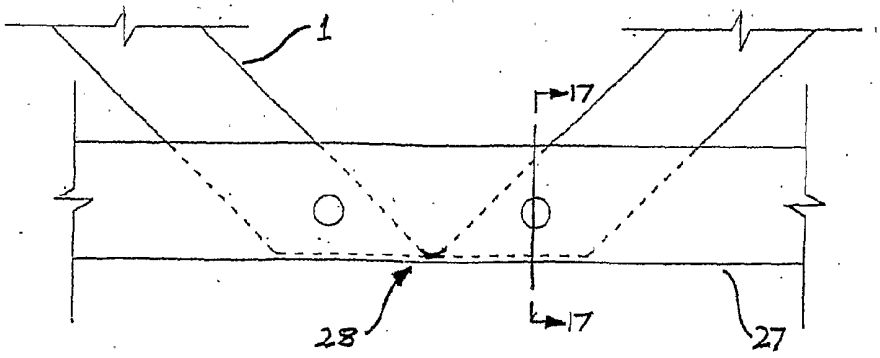

FIGURE 16

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Received 26 June 2001

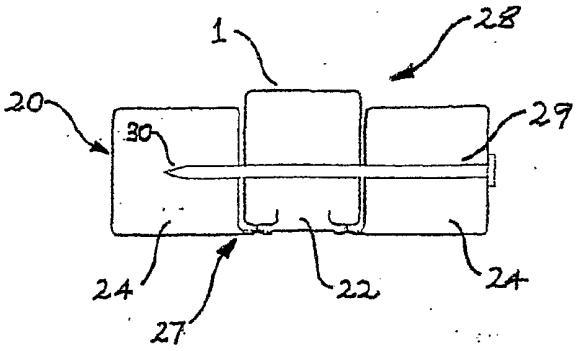

FIGURE 17

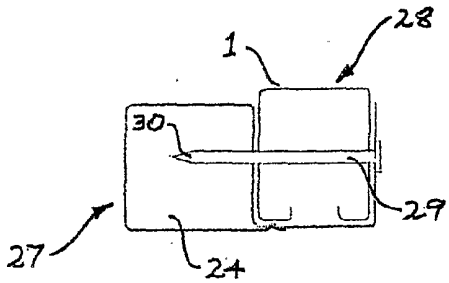

FIGURE 18

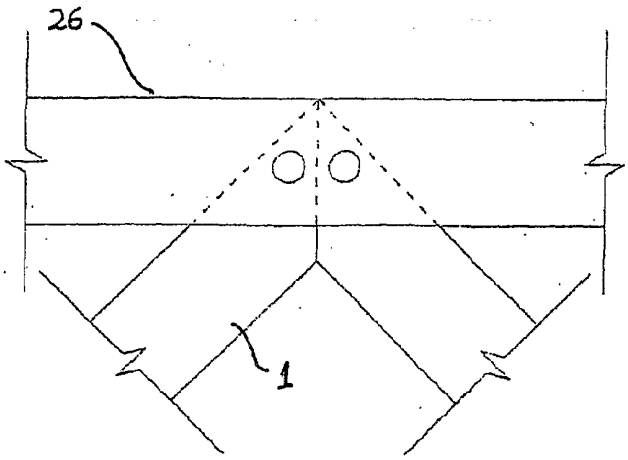

FIGURE 19

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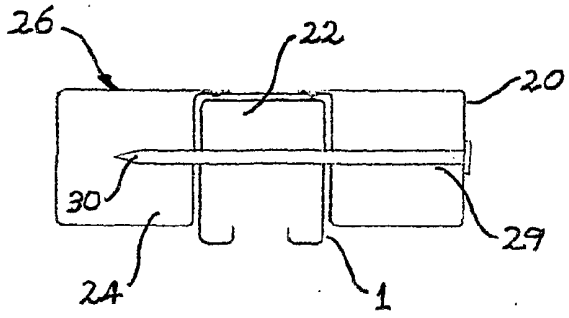

FIGURE 20

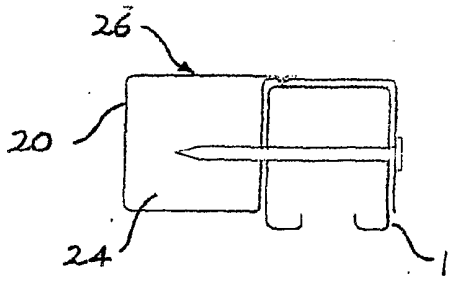

FIGURE 21

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Received 26 June 2001

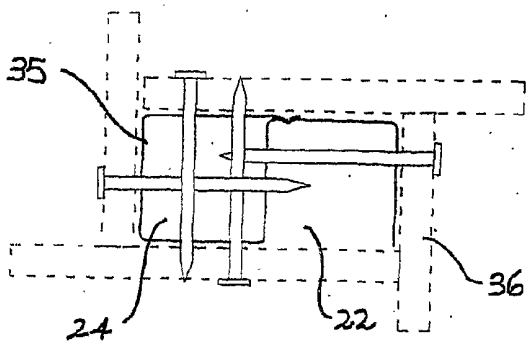

FIGURE 22

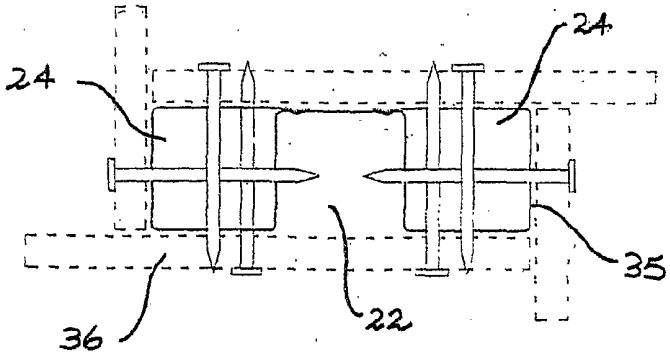

FIGURE 23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU01/00529

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: E04C 3/07

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)

REFER ELECTRONIC DATABASE CONSULTED BELOW.

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

AU IPC: E04C 3/07

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

DWPI & Keywords: truss, web, chord, strut, notch, cut, punch, stamp, box, enclosed, hollow, rhs, channel, u, c, and similar terms (Note: DWPI includes WPAT, WPI, WPIL)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 12025/76 A (HEBBLETHWAITE) 22 September 1977 whole document	1-3, 8, 9, 12-16
X	EP 318450 A1 (SKANSKA AB) 31 May 1989 whole document	1-4, 8, 9, 12-16
A	US 3961738 A (OLLMAN) 8 June 1976 figures 1 & 3	

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 August 2001	8 August 2001
Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**GEOFF SADLIER** Telephone No : (02) 6283 2114

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU01/00529

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98/59128 A1 (ECO-BEAM TECHNOLOGIES PTY LTD) 30 December 1998 figures 3, 4 & 6	1-3, 8, 12-16
A	CA 2134367 A1 (STONEHOUSE) 27 April 1996 figures 8-10	
X	AU 14733/97 A (BELL) 4 September 1997 figure 1	17, 19-22, 24, 27-31
X	GB 1468266 A (PRATT) 23 March 1977 figures 1 & 3	17, 19, 23-25, 27-30
X	FR 2289694 A1 (PROFILES & TUBES DE L'EST) 28 May 1976 figures 1 & 2	17, 24
X	WO 98/09035 A1 (BHP STEEL (JLA) PTY LTD) 5 March 1998 figures 1 & 2	17, 20-22, 24, 27-30
X	WO 99/14451 A1 (TUBE TECHNOLOGY PTY LTD) 25 March 1999 figures 1-3, 8	17-20, 24, 25, 27-31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU01/00529

Box I Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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

1. ☐ Claims Nos :

because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos :

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

3. ☐ Claims Nos :

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II 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:

Claims 1-16: - a method of forming a web for use in a structural member.

Claims 17-38: - a flange section including a generally U shaped channel section.

See additional comments in supplemental box.

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 an additional fee, this Authority did not invite payment of any additional fee.
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.

☒ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: II

The 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. In coming to this conclusion the International Searching Authority has found that there are different inventions as follows:

1. Claims 1-16 are directed to a method of forming a web for use in a structural member and comprise the step of forming a strip of sheet material. It is considered that forming a series of notches along the longitudinal edges of the strip and thereby defining generally transverse fold lines adjacent the respective notches, and folding the strip to predetermined degrees along the respective fold lines comprises a first "special technical feature".

2. Claims 17-38 are directed to a flange section including a generally U-shaped channel section. It is considered that having at least one substantially enclosed box section disposed on one side of the channel section, the flange section being adapted for use as a structural member comprises a second "special technical feature".

Since the abovementioned groups of claims do not share any of the technical features identified, a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept, a priori.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU01/00529

This Annex lists the known "A" publication level 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 Cited in Search Report		Patent Family Member			
AU	12025/76	NONE			
EP	318450	SE	8704679		
US	3961738	NONE			
WO	9859128	AU	36432/97	BR	9714746
CA	2134367	NONE			
AU	14733/97	NONE			
GB	1468266	NONE			
FR	2289694	NONE			
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END OF ANNEX