Apparatus and Method for Fabricating Composite Wood and Metal Trusses

Apparatus for attaching web members (7) to a frame to form a truss (1), the apparatus comprising: a feed system for transporting the frame to a work station; a magazine (43) for storing a plurality of web members; means (45) for picking a web member from the magazine; means for transferring the picked web member to a press head at a pressing station; means for selectively holding the web member at a predetermined position on the press head; and means for activating the press head to press the web member into the frame. A corresponding method is also provided.
APPARATUS AND METHOD FOR FABRICATING COMPOSITE WOOD AND METAL TRUSSES

Background of the Invention

The present invention relates to apparatus for fabricating composite wood and metal trusses, and particularly for fabricating trusses typically used as floor joists such as are described in US Patent No 5,833,222. A corresponding method is also described.

Such trusses typically comprise two generally parallel spaced lengths of lumber, known as chords, which are connected together at intervals along their length by means of generally V-shaped metal web members. The metal web members usually have integral teeth to engage in the wooden chords. Usually several vertical wooden web members are also incorporated along the length of the chords to provide rectangular openings in the truss, for example for the passage of ductwork through the truss. On-site flexibility is provided by incorporating a board or boards at one or both ends so that the truss can be trimmed to length without sacrificing structural stability.

A method of manually assembling such trusses is described in US Patent No 5,833,222. An apparatus and a method for the automated assembly of such trusses is shown in PCT publication WO 01/07202. The disclosures of US 5,833,222 and WO 01/07202 are incorporated herein by reference.

Summary of the Invention

Embodiments of the present invention provide improvements over aspects of the apparatus and method described in WP 01/07202.

According to one aspect of the present invention there is provided apparatus for attaching web members to a wooden frame, the apparatus comprising: a feed system for transporting the frame to a work station; a magazine for storing a plurality of web members; means for picking a web member from the magazine; means for transferring the picked web member to a press head; means for selectively holding the web member at a predetermined position on the press head; and means for activating the press head to press the web member into the frame.

The wooden frame may be assembled in a separate machine, or in an extension to the apparatus of the invention. It comprises two generally parallel spaced lengths of lumber, known as chords, which are connected together at intervals along...
their length by vertical wooden web members to provide rectangular openings in the frame along its length, and optionally boards at one or both ends.

This frame is then side fed to the apparatus of the invention via a conventional conveyor and then lifted to the vertical so that one chord is generally vertically above the other. Corresponding methods of assembling web members onto a wooden frame and of using the apparatus according to the invention are also provided.

For example, according to a second aspect of the invention there is provided a method for attaching web members to a wooden frame to assemble a truss, the method comprising firstly assembling the wooden frame from two spaced elongate wooden chords connected together at intervals along their length by vertical web members, feeding the wooden frame sideways, and in a horizontal orientation with the chords being in generally the same plane, to a web applicator station, lifting the frame into a generally vertical position, storing a plurality of web members at a web applicator station, selectively moving a web member to a press head at the applicator station and operating the press head to press the web member into the wooden frame to form the truss.

According to one embodiment of the invention the feed system comprises a rack and pinion pusher device. This has the advantage of reducing direct contact with the wooden frame. The pusher device is preferably powered by a servo motor controlled from a computer interface.

Preferably the web members have an inverted V shape in which the apex of the V is arranged to be fastened to the top chord of the frame and the arms are arranged to be fastened to the bottom chord of the frame. A magazine for the web members is disposed on each side of the frame in the web applicator station so that web members can be attached to either or both sides of the frame. The magazines comprise chains with separate spaces for each web member and the chains are driven in a manner which indexes the web members toward the frame in the middle of the work station. Upper and lower web member magazines may be provided on each side of the frame so that full and half web members can be provided for pressing into the frame.

Advantageously the means for picking a web member from a magazine is pneumatically driven and controlled by the computer interface. The web member is transferred to a press head by a web carrier driven by a servo motor via a threaded rod, all controlled by the computer interface, to position the web member correctly in
relation to the timber frame. The web members are preferably formed of metal and are held in the correct position on the press face by magnetism, preferably by pneumatically controlled tool machine magnets. This allows particularly accurate positioning without the use of mechanical stops on the press faces and assists in keeping the pressing area clean of debris and fragile stuff.

The press is synchronised via a mechanical rack and pinion arrangement which has advantages in that it can be used to more accurately define the positions of the press plates in the apparatus and relative to the frame allowing more accurate application of the web members and more accurate automation of the apparatus. At the same time as the web member is being pressed into the top and bottom chords of the timber frame, dual air rams operate against a servo controlled anvil to move into the frame to clamp the timber to hold the chords apart at the correct depth. When the web member has been pressed into the timber the dual air rams are moved out of the frame.

According to a further aspect of the invention there is provided apparatus for attaching web members to a wooden frame, the apparatus comprising: a feed system for transporting the frame to a work station; a magazine for storing a plurality of web members; means for picking a web member from the magazine; means for transferring the picked web member to a press head; means for selectively holding the web member at a predetermined position on the press head; means for proving pressure to the inside of the frame to hold the component parts at predefined positions, and means for activating the press head to press the web member into the frame.

A second pneumatic clamp is also preferably used to hold the frame in position longitudinally, particularly against any movement caused by the pusher feeder of the conveyor.

Preferably the press plates are kept as clean and free from debris as possible.

In one embodiment there is a servo controlled camber device on the out feed section of the pressing station. This comprises a camber roller, the height of which is accurately controllable so that it can be raised slightly as the ends of the frame pass over it so as to cause a slight lengthwise bowing of the frame. The displacement of the camber roller is calculated and effected by computer control. The aim of the camber device is to impart a bow of about 10mm in 10m of the finished truss but the camber roller is displaced a larger amount because the truss tends to relax and any imparted bow will decrease slightly after the truss exits the machine. This bowing of the truss
compensates for the weight of material which is put on top of the truss when it is
installed in a building to form a floor and thus prevents it from sagging in use.

The use of servo control and rack and pinion operation wherever possible has
the advantage of allowing more accurate control and positioning and particularly
allowing computer control and synchronisation as well as repeatability.

**Brief Description of the Drawings**

Fig. 1 is a perspective view of one side of a truss fabricated by apparatus
according to one aspect of this invention;

Fig. 2 is an enlarged vertical section of Fig. 1;

Fig. 3 is a perspective view of the apparatus of the invention;

Fig. 4 is a schematic perspective view of the input feed system forming a part
of the apparatus of figure 3;

Fig. 4A is a side elevation view of the input feed system of Fig. 4;

Fig. 4B is a left end elevation view of the input feed system of Fig. 4;

Fig. 4C is a top plan view of the input feed system of Fig. 4;

Fig. 5A is a side perspective view of a pusher device forming part of the
apparatus of Fig. 4;

Fig. 5B is a perspective view of the pusher device of Fig. 5A from the other
side;

Fig. 6 is an end elevation view of one embodiment of a web applicator station
forming part of the apparatus of the invention;

Fig. 6A is an end elevation view of another embodiment of a web applicator
station;

Fig. 7A is a perspective view of a magazine for holding web members being a
part of the apparatus of the invention;

Fig. 7B is a side elevation view of the magazine of Fig. 7A;

Fig. 7C is a top plan view of the magazine of Fig. 7A;

Fig. 7D is an end elevation view of the magazine of Fig. 7A holding a single
web member;

Fig. 7E is a perspective view of an alternative magazine for holding full and
half web members;

Fig. 8A is a perspective view of a web member picking and positioning device
forming part of the apparatus of the invention;
Fig. 8B is a front elevation view of the web member picking and positioning device of Fig. 8A;

Fig. 8C is a left side elevation view of the web member picking and positioning device of Fig. 8A;

Fig. 8D is a top elevation view of the web member picking and positioning device of Fig. 8A;

Fig. 8E is a perspective view of the positioning device of Fig. 8A with the web member picking device removed;

Fig. 8F is a perspective view of the web member picking device of Fig. 8A;

Fig. 9A is a perspective view of a pressing station forming part of the apparatus of the invention and mounted on a support structure;

Fig. 9B is a side elevation view of the pressing station of Fig. 9A;

Fig. 9C is a top plan view of the pressing station of Fig. 9A;

Fig. 9D is an end elevation view of the pressing station of Fig. 9A;

Fig. 10A is perspective view of a hydraulic ram forming part of the apparatus of the invention;

Fig. 10B is a side elevation view of the ram of Fig. 10A;

Fig. 10C is a top plan view of the ram of Fig. 10A;

Fig. 10D is a front elevation view of the ram of Fig. 10A;

Fig. 11 is a schematic perspective view of the framework used in the web applicator station of the apparatus according to the invention; and

Fig. 12A and Fig. 12B are perspective views showing the web applicator station of Fig. 11 in more detail.

Detailed Description of the Drawings

Referring first to Figs. 1 and 2 of the drawings, a composite wood and metal truss of the type fabricated by the apparatus of this invention, designated in its entirety by the reference numeral 1, is shown to comprise parallel top and bottom chords 3 and 5, each of said chords comprising a length of lumber (e.g. a nominal "2x4"). Each chord is of rectangular cross section, having a top surface (3T) for the top chord, (5T) for the bottom chord and side surfaces (3L and 3R) for the top chord, (5L and 5R) for the bottom chord. The top and bottom surfaces are the wider surfaces, i.e., the nominal 4-inch surface, in the case of use of 2x4s. A first series of metal web members each designated in its entirety by the reference numeral 7 is located on one
side of the truss (arbitrarily designated as the left side) and a second series of the metal web members 7 is located on the other side (the right side). The metal web members on each side are spaced at intervals along the length of the truss. The spacing on the one side may be as shown in Fig. 1 different from the spacing on the other but is preferably the same on each side because this improves production speed. Thus, four members 7 are shown on one side (the near side) spaced along the length of the truss at four positions as indicated at X1, X3, X5 and X6, and three members on the other side spaced along the length of the truss at positions X2, X4 and X5.

Other numbers and arrangements of web members (not shown) are possible. A trimmable web member 9, such as a board, is provided at one end of the truss. This board is of material which may be sawn through for trimming the truss at said one end to shorten its length. It may be a wood board or a board of orientated strand material; in the latter case it is referred to as an orientated strand board (OSB). It is secured at the top to the top chord 3 and at the bottom to the bottom chord 5 by being glued in grooves (not shown) in the chords. The truss 1 is shown as further comprising vertical web members each designated 11 and each comprising a short length of lumber (e.g., a length of "2x4") extending vertically between the upper and lower chords 3 and 5 and fastened thereto with press in nail plates 13. These vertical wooden web members 11 are spaced at intervals along the length of the truss. In the illustrated embodiment, two vertical members 11 are provided at spaced apart locations near the middle of the truss to define an opening for receiving ductwork or the like. A third member 11 is shown at the opposite end of the truss 1 from the board 9. The vertical web members 11 are spaced along the length of the truss at positions such as indicated at Y1, Y2 and Y3. While only one board 9 is shown, it will be understood that the truss may be made to have another board like the board 9 at the other end, e.g., the chords may be made longer than shown in Fig. 1 and the aforementioned third vertical member eliminated.

The metal web members 7 are conventional generally V-shaped metal (for example steel) web members having integrally formed nailing teeth or nails 7N at the apex 7V of the V and at the ends of the branches or arms 7A of the V, applied in inverted position to the sides of the chords 3 and 5. Reference may be made to the co-assigned U.S. Patent No. 4,348,850 for an example of such a metal web member. The web members may have other configurations. The nails 7N are driven into the sides 3L, 3R, 5L and 5R of the chords. The four generally V-shaped metal web members 7
on the one side of the upper and lower chords 3 and 5 are fastened thereto at the
intervals X1-X3, X3-X5 and X5-X6 which occur between the aforesaid positions and
the five V-shaped metal web members on the other side are fastened thereto at the
intervals X2-X4 and X4-X5 which occur between the aforesaid positions. The vertical
wooden web members 11 are fastened in between the chords at the intervals Y1-Y2
and Y2-Y3. The spacing of and intervals between the V-shaped members 7 is in
reference to the apices thereof (or stated another way, in reference to centre lines
bisecting the V).

This invention is particularly concerned with the application of the V-shaped
metal web members 7. The production of the wooden truss prior to applying the V-
shaped metal webs is done separately and could for example be done using apparatus
as described in WO 01/07202, or manually.

Fig. 3 shows a perspective view of the apparatus of the invention including an
input feed stage 3000, a metal web member applicator station 33 and an exit stage C6
connected by a longitudinally extending conveyor C.

The partially assembled wooden truss 1, taking the form of a wooden frame,
including for example the chords 3, 5 and vertical web members 11 is manually
placed in a horizontal orientation on laterally extending support beams 2000 (also
shown in Fig. 4) and is side fed on powered chain conveyors which are mounted on
the laterally extending beams 2000 and are driven by a motor 2030. There is a feeder
section extending about 500 mm from the longitudinal conveyor C in which there is a
feeding pusher formed by a separate chain on the same motor 2030. The truss 1 is
pushed the last 500mm to the conveyor C, by a pushing feeder formed by a tooth on
the chain, over horizontal rollers 2015 until the forward beam 3 of the truss 1 abuts
the vertical rollers 2020. This separation provides added safety for an operator.

Here the truss 1 is lifted b the vertical so that beam 3 is vertically above beam
5 separated by the vertical web members 11 and the board 9. It is lifted to the
vertical orientation by the operation of the horizontal rollers 2015 and the vertical
rollers 2020. The horizontal rollers 2015 are raised through 90 degrees to the vertical
thus rotating the truss 1 to the vertical position and supporting it between the two sets
of rollers 2015 and 2020.

The truss 1 is then moved to the web applicator station 33 via conveyor C
which may be a conventional conveyor, and is shown in perspective view in Fig. 4, in
side elevation view in Fig. 4a, in end elevation view in Fig. 4b, and in top plan view in Fig. 4c.

The truss 1 is moved along the length of the in-feed stage 3000 into the web member applicator station 33 by a pusher comprising a spring loaded triangular device. The device is held up by a spring but is retracted when it reverses back under the truss, in preparation to push the following truss along the conveyor C. The pusher is shown in Figs. 5A and 5B as item 2001 and is operated by a rack and pinion mechanism. The pusher device, and particularly the rack and pinion operation of it, is advantageous because it reduces contact with the wood and eliminates direct measuring on the wood, which occurs in the conveyor described in WO 01/07202 and is less accurate and repeatable. The pusher 2001 is powered by a servo motor controlled from a computer interface, e.g., a PC terminal, via a programmable logic circuit (PLC).

Figs 6 and 6A illustrate the web member applicator station 33 shown in Fig. 3 in one embodiment in Fig. 6 and in a slightly different embodiment in Fig. 6A.

In Fig. 6 at station 33 metal web members 7 are applied to opposite side surfaces 3L, 3R, 5L, 5R of the pair of chords 3, 5 forming the wooden frame 1, at particular intervals and the frame dwells at the station 33 for a dwell period for each application between the forward feed of the frame 1. Thus at station 33, there is a first metal web member applicator 41L on the left side of the conveyor (left as viewed in forward, i.e. downstream, direction of feed by the conveyor C) for applying a metal web member 7 to the pair of chord lengths of lumber 3, 5 on that side during a dwell period of said pair at station 33, and there is a second metal web applicator 41R on the other (right) side of the conveyor for applying a metal web member 7 on said other right side during said dwell period. The metal web member applicators 41L, 41R are shown in Fig. 6 and are essentially identical, each having a holder 43 for holding a supply of the metal web members 7 (only two are shown on each applicator), a transfer device 45 for transferring a web member 7 into position on the respective side of the frame at station 33, and a driver 47 for effecting driving of the nails 7N (the fasteners) into the lengths of lumber constituting the frame on the opposite (left and right) sides of the frame to fasten the metal web members 7 to the frame.

In Fig. 6 it can be seen that each of the metal web applicators 41L, 41R at station 33 comprises a holder 43 for holding a supply of the metal web members 7, a transfer device 45 for transferring a member 7 into position on the respective side
(right or left) of the frame at station 33 and a driver 47 for effecting driving (pressing) of the nails 7N of the members 7 into the top and bottom chords 3, 5 of the frame. The applicator components are mounted on a framework designated in its entirety by the reference numeral 781 and shown in Fig. 1OE and Fig. 9A comprising a table 783 on legs 785 each having an adjustable foot 786. Posts 787 extend up from the table adjacent the corners thereof. Beams 789 span the posts at the sides of the frame and beams 791 span the posts at the upstream and downstream regions of the frame, topping off the framework well above the table.

The drive 47 (see Fig. 6 and Fig. 9A) of each applicator 41L, 41R comprises a platen 793, which may be referred to as a press platen, on the plunger 795 of a hydraulic cylinder 797, under control of valve 797V, which may be referred to as a press cylinder. The latter is mounted at the end thereof constituting its forward end on plate 799. Each plate 799 is mounted in a vertical position on the table in an upstream-downstream vertical plane adjacent the respective side of the table by means of backing plates 801 on the outside of the plate 799. A cap plate 803 spans the backing plates 801. The platens 793 have back bracing as indicated at 805 and are movable on the table in transverse direction in relation to conveyor C toward and away from the frame extending there between. In this regard, it may be noted that the frame is adapted to be fed forward (intermittently in increments) in a vertical position in a vertical upstream-downstream plane passing centrally through the framework 781 over the table (the vertical plane of conveyor C).

Each holder 43 (one at the left, one at the right) comprises a magazine as shown in Fig. 6 and Figs. 7A to 7E and designated 807, which may be slanting downward and inward as shown in Fig. 6, from the upper end of a vertical strut 809 at the outer end of a horizontal beam 811 supported on a post 813 extending up from the cap plate 803. The rack 807, strut 809 and beam 811 are in the configuration of a right triangle, the rack constituting the hypoteneuse of the triangle. Each rack-strut-beam assembly extends transversely with respect to the conveyor line C, each rack slanting down toward but terminating short of the aforesaid upstream-downstream central plane.

Alternatively the magazines may be horizontal as shown in Fig. 6A.

Each rack 807 (i.e. the one at the left and also the one at the right) comprises a box beam supported at its ends on the upper end of strut 809 and on the inner (upper) end of the beam 811. An elongate top structure 817 extends lengthwise on the box
beam 815 having a width corresponding to the width of the apex 7V of the metal web member 7 with the widest apex.

Mounted on the top structure 817 is a ratchet feeding chain conveyor 2005 to carry the metal web members 7. This may be single conveyor as shown in Figs 7A to D to carry V shaped metal web members 7, or a double conveyor 2006A, 2006B as shown in the upper magazine 43A of Fig. 7E which carries half V shaped metal web members. The double arrangement of magazines 43, 43A shown in Fig. 7E is also shown in Fig. 6A and allows a choice of full V web members or half Y web members during a job depending upon the application. Chain conveyors are also provided for the bottom of each downhanging leg of the inverted V, so each web member 7 is fully supported and its position accurately determined within the apparatus. The magazines can be adapted for different heights and widths of web members by cranking the handles 2098 to alter the vertical distance between the upper and lower conveyors, and additional handles (not shown) are used for adjusting the width.

The web members in the magazine are incremented toward the middle of the apparatus, ie toward the transfer device 45, by the synchronised movement of the chain conveyors until they reach a stop mechanism 2070 formed by retractable arms 2071. This again accurately defines the position of the web members in the apparatus and ensures accurate picking of the web member by the transfer device 45 at the appropriate time. The arms 2071 are retracted to release the web member 7 in synchronisation with the operation of the transfer device 45.

Fig. 8A shows the transfer device 45 at station 33 which comprises a carriage designated 851 in its entirety movable vertically up and down in a framework 781 between a raised pick-off position between the inner ends of the magazine racks 807 and a lowered position between the platens 799 of the press plates 793 for effecting the pick-off from the rack 807 of a V-shaped metal web member 7 (in its inverted position) and carrying it down for application (as will be subsequently described) to a respective platen for the ensuing pressing of the member 7 to drive its teeth (nails) into the chords 3, 5, The carriage 851 comprises identical left and right side web carrier means each designated 855. Each of said carrier means comprises a member 857 fixed to the flanges 858 of the head at the respective side of the head extending down from the head. Fixed to the members 857 adjacent their lower ends for rotation on a horizontal axis extending parallel to the central vertical plane of the apparatus is a shaft 859 having a pair of web carrier arms 861 thereon. The shaft 859 is rotatable to
swing the arms 861 between a horizontal outwardly extending web member carrying position and a downwardly extending clearance position out from under the web member. The shaft 861 can also be adjusted to a non-horizontal position so that a web member 7 can be applied to the frame 1 at a predetermined angle according to the application conditions and as calculated and determined by computer control. The arms 861 are controlled vacuum devices to better hold onto the web member during movement but to allow controlled release when the web member 7 is in the correct position on the press plate. The carriage 851 is movable up and down by a screw thread 2200 which gives very accurate and repeatable positional control.

The carriage 851 may be raised to its upper limit with the arms 861 in their retracted clearance position extending downward. Then, assuming the apparatus is handling the situation where the left-hand applicator 41L is to apply a web member 7 to a frame 1 extending over table 783 (and dwelling in position for application thereto on the left side thereof of the web member 7) picks the foremost (leading) web member 7 from the magazine and effects forwarding of that member 7 onto the left-hand arms 861 on the carriage, these arms having been swung to their web member carrying position extending generally horizontally outward. The web members 7 may be formed with recesses along the arms of the V facing the transfer device so that the arms 861 engage into the recesses to pick the web members from the magazine rack and move them to the pressing station. The magazine 807 then increments to move the next web member 7, ready for the next time a left-hand member 7 is needed.

With the V-shaped metal web member (inverted) on the left-hand arms 861, cylinder 875 is operated to drive the carriage 851 down to its lowered position between the platens 793 shown in Fig. 9A wherein the web member 7 is at the requisite elevation (and longitudinal position relative to conveyor C) for being driven (i.e. for having its nails 7N pressed) into the upper and lower chords 3, 5 by the platens 793.

The web member 7 is gripped on the face of the left-hand platen 793 by pneumatically controlled tool machine magnets mounted on the platen. The left-hand arms 861 of the transfer device 43 swing down to their retracted position and the carriage 851 is raised to its retracted position between the down ends of racks 807.

This clears the way for operation of the platens 793 to press the member 7 on the left-hand platen home. Cylinders 797 are operated to drive the platens inward for this purpose, the right-hand platen backing up the frame while the left-hand platen
does the driving (pressing) of the nails (not shown) on the member 7 on the left-hand platen into the chords. The tool machine magnets are then de-energized to release their grip and the platens are retracted by cylinders 797.

The operation for the situation where the right-hand applicator 41R is to apply a web member 7 to a frame corresponds to the above-described operation of the left-hand applicator 41L, involving the right-hand components operating like the left-hand components. Operation for the situation where both left-hand and right-hand applicators 41L and 41R function at the same time to apply two web members 7 (one left, one right) to a frame involves simultaneous operation of left-hand and right-hand components.

There may be upper and lower magazines on each side of conveyor C as the web applicator station 33 to provide full and half webs for pressing into the wooden truss. Such an arrangement is shown in Fig. 7E.

The metal web members 7 are fed to the web applicator station 33 via the chain driven magazine feeders 43 which are shown in detail in Figs. 7A to 7E. These magazine feeders index the webs toward the vertical web carrier shown in Figs. 8A to 8F.

The magazine feeders 43 comprise chains 2005 with separate spaces for each metal web member 7. This is an improvement compared to the gravity feed arrangement used in the known apparatus of WO 01/07202 and allows greater control over the positioning and movement of the metal web members 7.

The vertical web carrier 45 is shown in detail in Figs. 8A to 8F and is driven by a servo-motor via a threaded rod and is controlled via the computer interface and PLC. The metal web members 7 are individually picked by pneumatic means and are positioned vertically in relation to the wooden truss by a servo motor via the computer interface and PLC. This allows extremely accurate positioning and orientation on the truss.

The metal webs 7 are applied to the wooden truss by applying pressure at station 33. The pressure is applied using a press such as is illustrated in Figs. 9A to 9D. This comprises two press plates 2010 having press surfaces 2020 facing each other. The metal web 7 to be applied is held on the press plate surface 2020 by pneumatically controlled tool machine magnets. There is no "hard stop" device on the press face. This is advantageous compared to the electromagnets used in WO 01/07202. The press plates 2010 are synchronised via a rack and pinion arrangement.
shown in Fig. 9A where the racks are referenced 2040 and the pinion 2050. This is in contrast to, and advantageous over, the hydraulic splitter valve used in WO 01/07202. This arrangement is particularly advantageous because it ensures exact positioning of the pressing plates on either side of the truss and enables positioning of the truss in the exact centre of the two pressing plates. This allows for more accurate and efficient pressing of the web members into the wooden truss and also helps to avoid any distortion of the truss which may occur if the accuracy is not so good.

The wooden truss 1 is supported in the web applicator station 33 by pneumatic air clamps which are illustrated in Figs. 10A and 10E. One set of these pneumatic air clamps, in the form of dual air rams, are positioned to hold each of the top and bottom chords 3, 5 of the wooden truss 1 so that they are held apart to the correct depth for pressing the metal web members 7 in the pressing station. The air clamps operate against a servo controlled anvil controlled for movement in and out of the truss and only operate pneumatically to clamp the chords when the metal webs are being pressed into the timber. The rams have interchangeable heads to accommodate different depths of truss. This has the advantage of allowing very accurate positioning of the web members relative to the chords and compensating for, and sometimes even correcting, imperfections in the original timber such as warps and curving and bows. It has been found in some

Appropriate sensors may be incorporated and the PLC can be pre-programmed with truss construction and configuration information such as web member locations to facilitate truss manufacture. It is preferred that all sensor sig instances that this feature can produce a more accurate and uniform resulting truss than the original starting material!

In addition there is a servo controlled camber device on the out-feed section of the pressing station 33.

The web applicator station 33 is shown in more detail in Figs 11, 12A and 12B. Fig. 11 illustrates the supporting framework for the web applicator station 33. In Figs 12A and 12B details of the pressing parts are shown including the press plates 799, the rack and pinion synchronising mechanism 2040, 2050 for the press, a driving motor 2055 and out-feed drive wheels 2056. The pneumatic clamps can also be seen particularly in Fig 12A. Clamp 2085, shown in more detail in Figs 10A to 10D, is a double headed clamp which is arranged to swing into the wooden frame 1 when a web member is to be applied to the frame, and be swung out of the frame when the
frame is to be moved along the conveyor C. The anvil clamp 2095 comprises two rollers set in an anvil frame and provides an anvil against which the air clamp operates. A second pneumatic clamp (not shown) may comprise two steel pipes mounted above the drive wheels 2056 with air cylinders each side to push the frame against longitudinal movement. The second pneumatic clamp can also be reversed to move the frame out of the pressing station when the pressing operation is concluded, to prepare for the next frame. The out-feed section also comprises a low speed buffer conveyor (not shown) which moves the finished trusses sideways away from the conveyor C and out of the way of the next truss exiting from the pressing station. This is particularly advantageous for operator safety and incorporates a pneumatic device to lift the chain into operation at the appropriate time in synchronism with the pressing station.

In addition there is a servo controlled camber device on the out-feed section of the pressing station 33 which is shown by the reference 2090. This is a height adjustable roller which is computer controlled to impart a camber to the truss by slightly bending the two ends of the truss upwards. The aim is to create a finished camber of about 10mm in 10m for normal use and this requires the camber roller 2090 to be moved upwards more than 10mm to impart a bigger initial camber because the truss relaxes after it exits the apparatus. The camber roller 2090 operates in conjunction with the anvil roller 2095 at the input side of the pressing station.

With a camber introduced into the truss it is also necessary to adjust the angle and height of the web members 7 depending upon their position along the length of the truss. This is achieved by the computer control of the height and angle of the arms 859 on the carriage 851 of the transfer device 45.

The arrangement of the invention has the advantage of causing a minimum of adaptation of the apparatus for different heights of truss. In principal the only changes required would be to adjust the position of the anvil 2095 and the height of the magazines for the metal webs. (This assumes that the metal webs are uniform in width).

The apparatus as a whole is preferably under control of a PLC (programmable logic controller), for example model 9030 by GE Fanuc Automation, Route 29 and Route 606, Charlottesville, Virginia, controlling relays for the motors and valves of the apparatus. The PLC is programmed for the synchronous operation of the
apparatus in appropriate cycles as will be evident to a skilled person and having regard to the disclosure in WO 01/07202.

In particular the PLC is programmed to operate the pusher, the web magazines and the vertical web carrier as well as the conveyors, the tool machine magnets, the air clamps and the pressing plates in synchronisation so that the operation of the apparatus is automatic, requiring little or no operator intervention, so that all parts are accurately positioned, and also to ensure the optimum safety of supervising operators.

Appropriate sensors may be incorporated and the PLC can be pre-programmed with truss construction and configuration information such as web member locations to facilitate truss manufacture. It is preferred that all signals be sent to the PLC which in turn will send signals to the various controlled elements to control their operations in a pre-programmed manner. In this way very accurate location of the metal web members can be achieved: for vertical and horizontal precision and also for the angle of the V as appropriate.

It is also contemplated that various safety devices such as interlock switches and stop switches, not shown, can be utilized on the apparatus as is known in the art to provide for further operating control. For example, when guards are used guard interlock switches would be used so the machine will not operate if a guard is open. If a malfunction occurs, stop switches can be used by an operator to stop the machine operation. Guards (not shown) may also be provided for operator safety.

The finished truss is fed to the exit conveyor C6 and is fed out of the apparatus. When the truss exits the conveyor, a sensor, such as a limit switch, sends a signal to the PLC which in turn stops the exit conveyor until another truss is ready for conveying from the web applicator station 33.
CLAIMS

1. Apparatus for attaching web members to a frame to form a truss, the apparatus comprising:
   a feed system for transporting the frame to a work station;
   a magazine for storing a plurality of web members;
   means for picking a web member from the magazine;
   means for transferring the picked web member to a press head at a pressing station;
   means for selectively holding the web member at a predetermined position on the press head; and
   means for activating the press head to press the web member into the frame.

2. Apparatus according to claim 1, wherein the frame comprises two generally parallel spaced chords, which are connected together at intervals along their length by vertical web members to provide rectangular openings in the frame along its length.

3. Apparatus according to claim 1 or 2, wherein the frame is assembled in a separate machine.

4. Apparatus according to claim 1 or 2, wherein the frame is assembled in an extension of the apparatus.

5. Apparatus according to any one of the preceding claims, further comprising a conveyor for side feeding the frame to the work station and means for lifting the frame to the vertical so that one chord is generally vertically above the other.

6. Apparatus according to any one of the preceding claims wherein the feed system comprises a rack and pinion pusher device.

7. Apparatus according to claim 6 wherein the pusher device is powered by a servo motor controlled from a computer interface.
8. Apparatus according to any one of the preceding claims wherein the web members have an inverted V shape with two arms connected at the apex of the V which is arranged to be fastened to the top chord of the frame and wherein the ends of the arms are arranged to be fastened to the bottom chord of the frame.

9. Apparatus according to any one of the preceding claims comprising a web member magazine disposed on each side of the frame in the work station so that web members can be attached to either or both sides of the frame.

10. Apparatus according to claim 9, wherein the magazines comprise chains with separate spaces for each web member and the chains are driven in a manner which indexes the web members toward the frame in the middle of the work station.

11. Apparatus according to claim 9 or 10, wherein upper and lower web member magazines are provided on each side of the frame so that full and half web members can be provided for pressing into the frame.

12. Apparatus according to any one of the preceding claims wherein the means for picking a web member from a magazine is pneumatically driven.

13. Apparatus according to any one of the preceding claims wherein the means for picking a web member from a magazine is controlled by the computer interface.

14. Apparatus according to any one of the preceding claims further comprising a web carrier for transferring the web member to a press head, the web carrier being driven by a servo motor via a threaded rod.

15. Apparatus according to claim 14, wherein the web carrier and servo motor are controlled by a computer interface.

16. Apparatus according to any one of the preceding claims wherein the web members are formed of metal and wherein the press face comprises magnetic means to hold a web member at said predetermined position.
17. Apparatus according to claim 16, wherein the magnetic means comprises a pneumatically controlled tool machine magnet.

18. Apparatus according to any one of the preceding claims further comprising a mechanical rack and pinion arrangement for synchronising the press head.

19. Apparatus according to any one of claims 2 to 18 further comprising dual air rams arranged to operate against a servo controlled anvil to move into the frame to hold the chords apart at a predetermined depth.

20. Apparatus for attaching web members to a frame, the apparatus comprising:
   a feed system for transporting the frame to a workstation;
   a magazine for storing a plurality of web members;
   means for picking a web member from the magazine;
   means for transferring the picked web member to a press head at a pressing station;
   means for selectively holding the web member at a predetermined position on the press head;
   means for providing pressure to the inside of the frame to hold the component parts at predefined positions; and
   means for activating the press head to press the web member into the frame.

21. Apparatus according to any one of the preceding claims further comprising a pneumatic clamp adapted to hold the frame in position longitudinally to resist movement caused by the pusher feeder of the conveyor.

22. Apparatus according to any one of the preceding claims further comprising a servo controlled camber device on an outfeed section of the pressing station, the camber device comprising a camber roller, the height of which is controllable so that it can be displaced slightly as the ends of the frame pass over it so as to cause a slight lengthwise bowing of the frame.

23. Apparatus according to claim 22, wherein the displacement of the camber roller is calculated and effected by computer control.
24. Apparatus according to claim 22 or 23, wherein the camber device is adapted to impart a bow of about 10mm in 10m of the finished truss.

25. Apparatus according to claim 22, 23 or 24, wherein the camber roller is displaced an amount larger than 10mm in 10m.

26. A method of assembling a truss comprising using the apparatus of any one of claims 1 to 25.

27. A method for attaching web members to a frame to assemble a truss, the method comprising using a frame assembled from two spaced elongate wooden chords connected together at intervals along their length by vertical web members, feeding the frame sideways, and in a horizontal orientation with the chords being in generally the same plane, to a web applicator work station, lifting the frame into a generally vertical position, storing a plurality of web members in a magazine at the work station, selectively moving a web member from the magazine to a press head at a pressing station and operating the press head to press the web member into the frame to form the truss.

28. A method of assembling a truss by attaching web members to a frame, the method comprising the steps of:

   transporting the frame to a work station;
   storing a plurality of web members in a magazine at the work station;
   picking a web member from the magazine;
   transferring the picked web member to a press head at a pressing station;
   selectively holding the web member at a predetermined position on the press head; and
   activating the press head to press the web member into the frame.

29. A method according to claim 28, wherein the frame comprises two generally parallel spaced chords, which are connected together at intervals along their length by vertical web members to provide rectangular openings in the frame along its length.
30. A method according to claim 29, further comprising side feeding the frame to the work station on a conveyor and lifting the frame to the vertical so that one chord is generally vertically above the other.

31. A method according to claim 28, 29 or 30 comprising attaching web members to both sides of the frame.

32. A method according to any one of claims 27 to 31, wherein the magazines comprise chains with separate spaces for each web member and the chains are driven in a manner which indexes the web members toward the frame in the middle of the work station.

33. A method according to any one of claims 27 to 32 comprising using a web carrier for transferring the web member to the press head, and driving the web carrier by a servo motor via a threaded rod.

34. A method according to any one of claims 27 to 33 comprising using metal web members and wherein the press face comprises magnetic means to hold the web members.

35. A method according to any one of claims 27 to 34 further comprising holding the chords apart at a predetermined depth.

36. A method according to any one of claims 27 to 35 further comprising holding the frame in position longitudinally.

37. A method according to any one of claims 27 to 36 further comprising introducing a camber to the truss in an out feed section of the pressing station, and controlling the angle of camber so as to cause a slight lengthwise bowing of the frame.

38. A method according to claim 37, wherein the camber comprises a bow of about 10mm in 10m of the finished truss.
39. A method according to claim 37 or 38, wherein the camber comprises a bow of larger than 10mm in 10m.
# INTERNATIONAL SEARCH REPORT

**International application No:**

PCT/EP02/054456

## A. CLASSIFICATION OF SUBJECT MATTER

**INV.** B27F7/15 E0C3/292

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## B. RELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B27F E04C B27M

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

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 4 479 600 A (ALBRIGHT BOLAND R [US]) 30 October 1984 (1984-10-30) abstract; figures</td>
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<tr>
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<tr>
<td>A</td>
<td>US 4 348 850 A (REEDER MILTON E ET AL) 14 September 1982 (1982-09-14) cited in the application figures</td>
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**Date of the actual completion of the international search:** 17 July 2008

**Date of mailing of the international search report:** 28/07/2008

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**Name and mailing address of the ISA/EPO:**

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**Authorized officer:**

Meritano, Luciano
**INTERNATIONAL SEARCH REPORT**

**International application No**
PCT/EP2008/054456

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**DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td></td>
<td></td>
<td>WO 0107202 A1</td>
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<td>DE 3070550 D1</td>
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<td></td>
<td>EP 0032951 A1</td>
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<td>JP 56501458 T</td>
<td>08-10-1981</td>
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<tr>
<td></td>
<td></td>
<td>WO 8100425 A1</td>
<td>19-02-1981</td>
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<tr>
<td></td>
<td></td>
<td>ZA 8004772 A</td>
<td>30-09-1981</td>
</tr>
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