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(54) Wall panel structure for portable building unit

(57) A wall panel of the kind specified wherein the panel is provided with a frame member extending along or adjacent one edge of the panel and the frame member comprising a frame element comprising a channel shape formation comprising two spaced limbs defining an open mouth therebetween at their one ends and interconnected by a transversely extending web and having a plurality of bracing elements extending transversely between the limbs and disposed between the one ends of the limbs and said web and arranged at spaced positions longitudinally of the frame element.

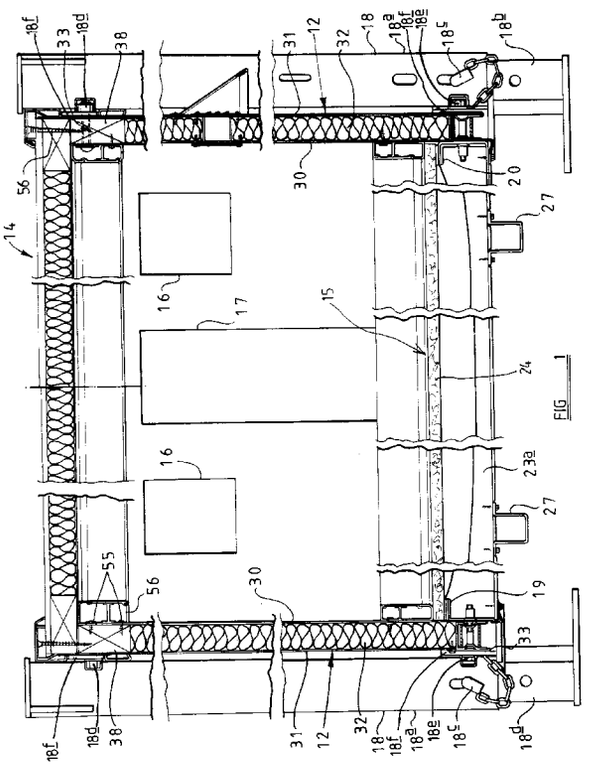

FIG 1

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Description

This invention relates to a wall panel, hereinafter referred to as being of the kind specified, in or for a building unit, hereinafter referred to as being of the kind specified.

In this specification a wall panel of the kind specified comprises a structural sandwich having inner and outer skins sandwiching therebetween and being bonded to an infilling. Preferably the infilling is a rigid foam or expanded plastics material.

By a portable building unit of the kind specified we mean a portable building unit which is factory assembled for delivery to a prepared site in an assembled condition complete with at least a floor structure and a side wall comprising a wall panel. The building unit may have four side walls, or where the unit is to be assembled with other similar units it may have one or more side walls omitted. Where the unit is for a single storey building or is for the top storey of a multi-storey building it may have a roof structure.

The invention has been particularly devised in connection with a building unit of the kind specified having a wall panel connected to a floor structure and to a leg means whereby floor loads are transmitted through the wall panel to the leg means. In addition, the wall panel may support a roof structure and so also transmit roof loads to the leg means.

Hitherto a wall panel of the kind specified has comprised a timber peripheral frame, a bottom member of which is fastened to the floor structure. However, in use of such a wall panel in a building unit as described above, the connection of the wall panel to the floor structure must transmit the above mentioned floor loads between the floor structure and the wall panel. The presence of a timber bottom peripheral frame member can lead to inadequacy in the connection, particularly because the timber is susceptible to rot, especially as it is relatively close to the ground.

Accordingly, an object of the invention is to overcome or to reduce the above mentioned disadvantages hitherto encountered with a wall panel of the kind specified.

According to a first aspect of the present invention we provide a wall panel of the kind specified wherein the panel is provided with a frame member extending along or adjacent one edge of the panel and the frame member comprising a frame element comprising a channel shape formation comprising two spaced limbs defining an open mouth therebetween at their one ends and interconnected by a transversely extending web and having a plurality of bracing elements extending transversely between the limbs and disposed between the one ends of the limbs and said web and arranged at spaced positions longitudinally of the frame element.

Preferably the frame element is of channel shape and the web interconnects the limbs at their other ends.

The provision of the bracing elements in combination with a frame element having said channel form permits the use of a relatively thin wall member for the frame element and made of suitable material such as steel or other metal or a plastics material with or without suitable reinforcement, whilst providing adequate strength to resist forces imposed during use of the structure as well as being rugged enough for transport and manufacture of the panel.

A plurality of pairs of opposed apertures may be provided in the limbs to receive, in the apertures of each pair, a fastener to connect the wall panel to a floor structure.

Preferably a recess is provided around an aperture of each pair in at least one limb to receive a part of the fastener.

Preferably a recess is provided around each aperture of each pair.

The or each recess may be of generally frusto-conical configuration.

The or each recess may be provided by a deformed region of the limb in which the apertures are provided.

Each bracing element may be retained between the limbs by engagement of an inwardly deformed region of the limb with the bracing element.

Each bracing element may comprise a tube.

Each bracing element may comprise a generally cylindrical tube.

The inwardly deformed regions of the limbs may be engaged within the ends of the tube to retain the tubular bracing element between the limbs.

The inwardly deformed region on the opposite side thereof to that which engages the bracing element may provide a said recess.

The panel may have at least one other frame member extending along or adjacent at least one other edge of the panel and preferably the panel has a peripheral frame comprised of said frame element and other frame members.

The or each other frame member may be made of timber.

The frame members may be connected to each other.

The outer skin of the wall panel may comprise a plurality of sheets, the longer edges of the sheets being disposed to extend vertically and having at their adjacent longer edges inturned flanges which are secured together.

Openings may be provided in the channel shaped element to receive the flanges.

The frame element may be disposed with the one ends of the limbs facing outwardly of the panel and the transversely extending web disposed transversely of the thickness of the panel.

In this case the openings for the flanges may be provided in the transversely extending part and in the limbs adjacent to the transversely extending part.

The limbs may be generally planar, as may be the transversely extending part which may extend perpendicular to each limb.

Alternatively, the outer skin of the wall panel may comprise a plurality of sheets, the longer edges of the sheets being disposed to extend horizontally and the shorter edges of the sheets extending vertically and the sheets having at their adjacent longer edges inturned flanges which are secured together.

In this case, since the flanges extend parallel to and spaced from the frame element it need not be provided with openings.

In this case the frame element may have a rebate provided in the limb adjacent the outer skin, the rebate providing a shoulder which faces towards the free end of the associated limb and the outer skin may conform to the shape of the rebated limb.

In either case the frame element may be fastened to an element of the floor structure by means of a threaded fastener comprising a shank and first and second abutments provided on the shank, at least one of the abutments being threadedly engaged with the shank for axial movement relative thereto, with one abutment in clamping relationship with an outer limb of the channel section element and the other abutment in clamping engagement with the element of the floor structure with the shank of the fastener extending through a bracing element.

Preferably said one abutment is fixed to the shank and comprises, for example, a head of a bolt and the other abutment comprises a nut threadedly engaged with the shank.

The nut may be fixed relative to the frame element.

According to a second aspect of the present invention we provide a method of making a wall panel of the kind specified comprising the step of taking a frame element comprising a channel shape formation comprising two spaced limbs defining an open mouth therebetween at their one ends and interconnected by a transversely extending part, positioning a plurality of bracing elements to extend transversely between the limbs and disposed between the one end of the limbs and said web at spaced positions longitudinally of the frame element, and acting on the outwardly facing surface of at least one of the limbs with a tool adjacent said bracing elements to provide an inwardly deformed formation to engage a bracing element to retain it between the limbs.

Preferably the tool punches an aperture in the limb within the inwardly deformed formation.

Preferably the method comprises acting on the outwardly facing surface of both limbs with pairs of opposed tools adjacent said bracing elements to provide inwardly deformed formations to engage opposite ends of the bracing elements to retain them between the limbs.

Preferably said pairs of opposed tools punch apertures in the limbs within the respective inwardly deformed formations.

The inwardly deformed formation may be of generally frusto-conical configuration and may provide a recess in the outwardly facing surface of the limb.

The or each tool may comprise a leading, piercing, portion and a trailing, deforming, portion of greater cross-sectional dimension than the piercing portion, the piercing portion being adapted to pierce the aperture in a limb and the trailing portion being adapted to bend or swage the material of the limb in co-operation with the bracing element to form the inwardly deformed formation.

Preferably the bracing element is generally cylindrical, at least at the ends thereof, and the deforming portion is frusto-conical having a larger diameter which is at least equal to the internal diameter of the bracing element.

The piercing portion may be generally cylindrical and of a diameter corresponding to the diameter of the smaller end of the deforming portion.

The or each tool may be caused to act on the channel shaped element by a fluid operated piston and cylinder means.

Preferably an individual fluid operated piston cylinder means provided for each tool.

The method may comprise the step of disposing a plurality of bracing elements on locating means at predetermined positions in a piercing and forming apparatus, the locating means being disposed in a predetermined relationship with pairs of opposed tools, disposing the channel section element with the one ends of the limbs facing downwardly over the bracing elements and then carrying out said step of acting on the outwardly facing surface of the limbs with the pairs of opposed tools.

According to a third aspect of the invention we provide a portable building unit of the kind specified comprising a wall panel according to the first aspect of the invention or a wall panel made by a method according to the second aspect of the invention.

Embodiments of the invention will now be described with reference to the accompanying drawings, wherein:

FIGURE 1 is a transverse cross-section through a building unit embodying the invention;

FIGURE 2 is a longitudinal cross-section through the building unit of Figure 1;

FIGURE 3 is an enlarged fragmentary view showing the connection between a wall panel and a floor structure of the building unit of Figure 1;

FIGURE 4 is a fragmentary perspective view showing the relationship between a frame member of a wall panel of the building of Figure 1 and a seam between external skin sheets;

FIGURE 5 is a fragmentary side elevation showing a connection between channel shaped elements of a flat member or a wall panel of the building of Figure 1;

FIGURE 6 is a section on the line 6-6 of Figure 5;

FIGURE 7 is a fragmentary section showing the connection of a leg to the building unit of Figure 1;

FIGURE 8 is a portion of Figure 7 drawn to an enlarged scale;

FIGURE 9 is an elevation of a wall panel for the building unit with an outer skin omitted but with the position occupied by its periphery shown in dashed line;

FIGURE 10 is a section on the line 10-10 of Figure 9;

FIGURE 11 is a section on the line 11-11 of Figure 9;

FIGURE 12 is an elevation similar to that of Figure 9, but of an alternative wall panel;

FIGURE 13 is a section on the line 13-13 of Figure 12;

FIGURE 14 is a side elevation of a channel shape element used in a wall panel of the building of Figure 1;

FIGURE 15 is a view similar to that of Figure 1 but through an alternative embodiment of the invention;

FIGURE 16 is a view similar to that of Figure 2 but through the embodiment of Figure 15;

FIGURE 17 is a fragmentary view of part of Figure 15 to an enlarged scale;

FIGURE 18 is a view similar to that of Figure 9 but in respect of a wall panel of the embodiment of Figure 15;

FIGURE 19 is a side elevation, partly broken away, of a channel shape element for use in the embodiment of Figure 15;

FIGURE 20 is a section to an enlarged scale on the line 20-20 of Figure 19;

FIGURE 21 is a plan view, with parts omitted, of part of a piercing and forming apparatus for use in the manufacture of a bottom frame member for use in the wall panels of the building unit of the preceding Figures;

FIGURE 22 is a side view of the part of the apparatus shown in Figure 21;

FIGURE 23 is a perspective view, with parts omitted, shown by an apparatus for making wall panels embodying the invention;

FIGURE 24 is a fragmentary cross-section through part of the apparatus of Figure 23 showing the clipping of a channel shape element to a platen.

FIGURE 25 is a side elevation of an air release tube used in the apparatus of Figure 23;

FIGURE 26 is an end view of the air release tube of Figure 25, and

FIGURE 27 is an underneath plan view of the air release tube of Figure 25.

Referring now to the Figures, there is shown a portable building of generally right parallelepiped configuration having two longer side walls 12 and two shorter end walls 13, a roof structure 14 and a floor structure 15. Door and window openings are provided in the walls as shown at 16 and 17 respectively. Of course, if desired, the doors and windows may be located at other positions than those shown.

The building unit is provided with four legs 18, two on each side of the building arranged symmetrically. The floor structure 15 comprises two parallel longitudinally extending floor side beams 19, 20 disposed to extend along the longitudinal sides of the floor structure. The floor side beams 19, 20 are identical and are made as rolled sections in steel and are of essentially channel configuration with the web of the channel disposed vertically and the limbs extending inwardly of the floor structure.

Fastened by welding to the side beams 19, 20 are a plurality of cross-beams which extend transversely of the floor structure and are located at spaced positions longitudinally of the side beams. The outer cross-beams 23 are of channel configuration with the web disposed horizontally and the limbs extending vertically downwardly and are provided with out-turned lateral flanges. The intermediate cross-beams 23a are of channel configuration but with the webs disposed vertically and the limbs disposed so as to extend towards one side of the building unit and each upper limb has a downwardly depending flange 23b. The cross-beams are provided with cut-outs at each end to accommodate the limbs of the side beams.

Supported on the cross-beams 23, 23a and the upper limbs of the floor side beams 19, 20 is a floor deck 24 made of moisture resistant structural board, such as wood particle board with a fully bonded veneer covering. However, if desired, other material may be used.

The cross-beams 23, 23a are connected to top hat section skids 27 made of galvanised rolled steel section and provided to sit on a lorry bed during transportation.

Each wall of the building unit is formed as a panel having a stressed skin structural sandwich of inner and outer skins 30, 31 which are sandwiched between and bonded together by means of a polyurethane foam 32. In addition a peripheral frame 33 is provided between the

inner and outer skins. In the present example the outer skin 31 comprises a coloured steel cladding, for example, galvanised steel sheet having a coloured PVC coating on the external surface to give a long and maintenance free life. The outer skin 31 is made up of a plurality of such galvanised steel sheets 37 which, as best shown in Figures 4 and 10, are seamed vertically with one sheet being formed with a wider flange 34 at one edge and a narrower flange 35 at the other edge. The joint is formed by folding the free marginal portion 36 of the wider flange 34 around the free edge of the narrower flange 35 to lie in face-to-face relation with the adjacent portion of the latter on the side thereof remote from the remainder of the wider flange. The folded over portion of the two flanges may then, if desired, be further folded over as a whole through 180° to form a joint having five thicknesses of metal with the marginal edged portion 36 of the wider flange sandwiched between portions of the narrower flange and with such three layer portion itself sandwiched between portions of the wider flange. Such a joint can be formed by rolling in two successive operations, if desired. However, the panels 38 may be interconnected by other configurations of interconnected flanges such as by clipping together equal length upstanding flanges or otherwise securing flanges together, or indeed the sheets may be secured together in any other desired convenient manner.

The internal skin 30 is made of galvanised steel sheet with a polyester powder coating, or of gypsum wallboard, but may be made of any other desired material.

The polyurethane foam is 47mm thick which gives good thermal insulation and securely bonds the sheets together.

As best shown in Figure 9, the peripheral frame 33 comprises an upper member 38 and end vertical members 39. In addition, intermediate vertical members are provided as shown at 40. As best shown in Figures 10 and 11, the intermediate members are provided adjacent the seams between the sheets 37, the number and positioning of the intermediate members 40 and the sizes of the sheets 37 being chosen in accordance with the overall size of the particular panel desired and the available maximum width of the sheets 37. The inner skin 30 is also provided with inwardly directed flanges shown at 30a in Figures 10 and 11 and these are received in a slot 30b provided in the intermediate frame member 40 and also in a peripheral frame member 39. It will be seen that the sheets 37 of the inner and outer skins overlie the majority of the extent of the peripheral frame member but leave a small portion 30c, 31a of the peripheral frame members exposed respectively.

Figures 12 and 13 show an example of an alternative configuration of panel and hence the same reference numerals have been used to refer to corresponding parts.

The frame 33 also has a bottom member 41 which comprises a channel shaped element made, in the present example, of galvanised cold rolled steel, as best shown in Figures 3 and 8, and comprises spaced generally parallel inner and outer limbs 42a, 42b which define an open mouth between their one ends 44 and which are interconnected at their other ends by a transversely extending web 43. The channel is disposed so that the web 43 is disposed inwardly of the panel whilst the one ends 44 of the limbs are disposed facing downwardly. The panels 37 of the outer skin overlie an upper part of the outer limb 42b, to leave a lower part exposed, as shown at 31a, whilst the panels of the inner skin overlie the inner limb 42a to leave a lower part exposed, as shown at 30a.

The inner and outer limbs 42a, 42b have an inwardly deformed formation 45 which is of frusto-conical configuration providing an aperture 46 and a recess or countersink 47.

A countersink head 48 of a fastener 49 having a shank 49a which extends through the apertures 46 and through an aperture 50 in the vertical web of the floor side members 19, 20 or end transverse floor members 23 and is threadedly engaged with a nut 51 which, in the present example, is a rivet nut captive with the web of the floor frame member 20, 23. A cylindrical bracing element 53 is disposed between the limbs 42a, 42b and, as hereinafter to be described, during assembly is retained theredisposed by the formations 45.

At their upper ends the wall panels are connected to the roof structure 14 by means of being screwed to the upper frame member 38 by wood screws 56.

Each leg 18 comprises an upper part 18a of hollow rectangular tubular configuration to provide a socket which receives telescopically a lower part 18b with suitable means such as peg 18c to permit the two parts of the leg to be interconnected at a desired extension.

The legs are attached to the building unit, as shown in Figure 1, by means of bolts 18d, 18e passing through brackets 18f disposed on opposite sides of the legs 18 at the top and bottom of the unit respectively. The bolts 18d pass through the upper frame member 38 with their heads disposed inside a roof duct and with a nut engaged with their threaded end adjacent the bracket 18f. The bolts 18e pass through the bottom member 41 with their heads disposed adjacent the brackets 18f and are surrounded by a bracing element 53 and threadedly engaged with a rivet nut captive with the web of the floor frame members 19, 20.

The unit described above has structural integrity which is afforded by the floor side beams 19, 20 and cross-beams 23, 23a, the stressed structural sandwich panels and in particular the channel shaped element 41 comprising the bottom frame member thereof in combination with the bracing elements 53 and the bolted connection to the side and cross-members 19, 20 and 23a of the floor structure, together with the connection of the wall panels to the roof structure 14 and the connection of the wall panels to the legs 18.

The manufacture of wall panels 12, 13 will now be described, referring first to Figures 21 and 22. These illustrate one station of an apparatus for acting on a chan-

nel section steel element to form apertures and inwardly deformed formations in the limbs thereof at predetermined positions along the length thereof to provide the channel shape element 41. At each station the apparatus comprises a V or U-section block 60 mounted in a recess 61 of a support 62 in which opposed tools 63 are slidably mounted under the control of hydraulic piston and cylinder unit 64. The support 62 is mounted on a base 65 for movement longitudinally of the apparatus and is guided by means of a co-operating key and keyway assembly 66. A gauging arm 67 together with a locating screw 68 is provided so that each mounting block 62 at each station can be positioned accurately at a desired longitudinal relative position.

A cylindrical spacer element 53 is rested on each V-shaped block 60 and then a channel shaped element 41 is disposed over the spacer elements 53 and moved downwardly until it engages supports 69. The piston and cylinder units 64 are actuated to move the tools 62 inwardly towards each other so that they act upon the limbs 42, 43 of the channel shaped element 41 to pierce an aperture 46 therein and form the above described frusto-conical inwardly deformed formation 45.

Each tool 63 has a leading portion 70 of cylindrical shape having a flat circular end surface, and a trailing frusto-conical forming portion 71, the smaller diameter end of which merges with the cylindrical portion 70 and the larger diameter end of which has a diameter equal to the internal diameter of the spacer 53.

At its outer end the frusto-conical part 71 merges with a cylindrical part 72 of the respective tool 63.

If desired, a recess may be provided in only one of the limbs where the element is always to be used in a handed configuration. In such case the opposed punch would be appropriately formed without a frusto-conical part so that only an aperture would be provided.

Further, if desired, an aperture may be formed in one or both of the limbs by other means than that described hereinbefore and the above described apparatus may be used to provide a recess and aperture or only a recess in only one limb by providing a single tool opposed to a fixed anvil arrangement.

In addition, at a suitable stage appropriate circular apertures are provided in the web 42 to receive wood screws for connection to the vertical frame members 39, 40 whilst slots 75 are formed in the base 42 and limbs 43a, 43b at desired positions along the length of the element 41 to receive the flanged seams 34 - 36 between adjacent panels 37. Suitable sealing tape 76 is applied over such slots which are to be used so as to provide a seal with the flanged formation (Fig.4) and silicone sealant is also applied.

It should be appreciated that the formations 45 and slots 75 are provided symmetrically in the elements so that they do not require to be handled during manufacture. If desired, a symmetrical disposition could be provided since, for example, there is no requirement to provide a recessed formation on the inner limb 43a, nor is there need to provide slots 75 on this limb.

The thus apertured element 41 is then connected by wood screws to the other frame members 38, 39 and 40 and the inner and outer skins 30, 31 are assembled on opposite sides of the resultant frame and a plurality of such frames and sheets are assembled in a stack, as illustrated in Figure 23. It will be seen from Figure 23 that the upper and lower frame members 38, 41 are disposed alternately at opposite ends of the stack. As best shown in Figure 24, each channel shape element 41 is clipped to a platen 77 by clips 78 which engage with slots 79 formed in the limbs 42a, 42b of the element 41 as well as in a groove 79a of the platen 77 which contains a spring clip 79b so that the element 41 is accurately positioned relative to the platen 77.

The upper frame members are provided with grooves 80 to permit egress of foam, as hereinafter to be described, whilst the web part 42 of the channel section elements 41 is provided with feed openings 87 and with circular apertures 81 in which foam ejection tubes 82 are mounted. As best shown in Figures 25-26, each foam ejection tube is of frusto-conical internal and external shape and comprises a hollow tubular spout part 83 having at one end a mounting part 83a having a radially outwardly extending generally annular flange 84 and with a reduced thickness weakened portion 85 between the mounting and spout parts. At its other end the spout part 83 has a nozzle portion 86 which extends generally perpendicularly to the spout part 83. The foam ejection tubes 82 are introduced into the apertures 81 from the interior of the frame prior to assembly with the skins 30, 31 until the flange 84 abuts the surface of the web 42. The frusto-conical external configuration of the mounting part 83a ensures that the tube is a good sealing fit with the web 42.

In use, the above described assembly is introduced into a press, not shown, and pressure is applied to the stack of components. Polyurethane foam material in fluid state is then injected into the interior of each compartment 88 between frame members of each panel by means of a lance 89 supplied with the foam material via a hose 90. As the foam material is introduced air escapes through the grooves 80 and tubes 82 and excess foam begins to escape through the grooves 80 and through the tubes 82. Because the spout part 83 of the tubes is of sufficient length to ensure that the nozzle parts 86 project outwardly beyond the open mouth of the element 41 and hence of the edge of the stack, any foam falling therefrom is guided away from the stack to avoid contamination of the components and thus avoid build-up of foam which would prevent fitting of bottom wall trims. In addition the tubes are dimensioned to limit the amount of foam which is ejected. The dimensions, and in particular the tapered configuration, impedes the flow of foam. Accordingly, whilst air is freely released as the space within the chambers 88 is filled with foam, the rate of foam movement along the tube 82 is restricted because of the relative viscosity of the foam and dimensions of

the tube so that a relatively high pressure can be built up in the chambers 88, thereby enabling a high density of foam to be achieved within the chambers 88 of the panel.

The length of the channel shaped element 41 is limited, in practice, by press brake capacity and practical handling requirements. Where the wall of a building unit has a length greater than such capacity more than one element is required. The elements 41 must be connected together to provide a rectilinear frame member and foam must also be prevented from escaping at the joints. This connection is achieved by means of a sleeved connection, as shown in Figures 5 and 6. The sleeve is indicated at 90 and comprises a channel shape section that is a mating fit into the channel shaped element 41.

In order to maintain the accuracy of the spacing between the holes 46 in adjacent elements, the elements and the sleeve have an accurately positioned tab and slot location arrangement. Each element 41 has a vertical slot 91 in one flange 43. The slots are accurately positioned from one end of the element within tight tolerances. The connection sleeve 90 has two vertical tabs 92 which are partly punched through one flange, and the centres of the tabs are also accurately positioned.

When the elements 41 are laid end to end, the sleeves are inserted into the channel of the sleeves 41 and the elements are manipulated until the tabs 92 are located in the slots 91 and the resultant assembly of elements 41 have a datum end to hole accuracy of ± 1mm over an overall length of up to 18 metres. A desired number of thus assembled elements is provided for a given desired wall length and are connected to the end vertical frame members 39 adjacent their ends of the assembly and to appropriate intermediate vertical frame members 40 at desired positions along the length thereof.

Referring now to Figures 15 - 20, there is shown an alternative embodiment of building unit.

In this embodiment there is another form of portable building of right parallelepiped configuration having two longer side walls 112, 113. In the embodiment illustrated one of the side walls is omitted since the building unit is connected to an adjacent side by side building unit which would be provided with an opposite side wall to side wall 112 illustrated. The building has two shorter end walls 113, a roof structure 114 and a floor structure 115. Door and window openings are provided as desired.

The floor structure 115 comprises two parallel longitudinally extending floor side beams 19, 20 disposed to extend along longitudinal sides of the floor structure. The floor side beams 19, 20 are identical and are made as rolled sections in steel and are essentially of channel configuration with the web of the channel disposed vertically and the limbs extending inwardly of the floor structure. The limbs are provided with inturned lips 19a, 20a.

Fastened by welding to the side beams 119, 120 are a plurality of cross-beams which extend transversely of the floor structure and are located at spaced positions longitudinally of the side beams. The cross-beams are of channel configuration with the web disposed vertically and the limbs extending horizontally and the upper limb of each cross-beam has a downturned lip 123a whilst the edge cross-beams 123 have their lower lip provided with an upturned flange 123b. Supported on the cross-beams and the upper limbs of the floor side beams is a floor deck 24 made of moisture resistant structural board, such as wood particle board with a fully bonded veneer covering.

The floor side beams 119, 120 comprise bottom members of two upstanding sub-frames which lie in a vertical plane, each comprising respective horizontal roof beams 122a, 122b interconnected at their ends to the floor side beams by uprights 124a 124b. Each sub-frame affords a rectangular aperture defined by the beams and uprights which may be closed by end and side wall panels 112, 113 as hereinafter to be described.

Each unit has a "roof' structure which extends between and is secured to the roof beams 122a, 122b therebelow by attachment to the lower flanges thereof. The roof structure of each unit intended to provide the top storey of a building has a roof panel 150. The roof panel 150 comprises an inner skin 151 of plastic coated steel, an outer skin 152 also of plastic coated steel, and a perimeter framework, part of which is shown at T with the space between them being filled by an insulated infilling comprising a foam plastics material 53 which, in the present example is polyurethane foam and which is bonded to the inner and outer skins.

The roof panel 50 may be provided with reinforcing members made of steel or other suitable material disposed between the inner and outer skins 151, 152.

The wall panels 112, 113 are of similar construction to the wall panels described hereinbefore with the first embodiment except that the outer sheets are provided with horizontally extending seams which are disposed adjacent transversely extending intermediate members 140 of a framework. The framework, as with the first embodiment, comprises a peripheral frame 133 having an upper frame member 138 and vertical frame members 139 all made of timber and a steel generally channel shape element 141 providing the bottom frame member. The frame members are fastened together by suitable fastenings as shown in Figure 18 with connecting blocks being provided which are screwed to the channel shape element 141. As best shown in Figures 19 and 20 the element 141 has inner and outer limbs 142a, 142b having an open mouth at their one ends 144 and interconnected at their other ends by a transversely extending web 143. The outer limb 142b is formed with a rebate 142c which provides a downwardly facing shoulder 142d. In all other respects the channel shape element 141 and the construction of the wall panel is as described hereinbefore in connection with the first embodiment, except that the inner skin is made of gypsum board. As best shown in Figure 17 the provision of the rebate 142c permits the outer skin 131 to be bent into the rebate and thus provide a styling feature consistent with the horizon-

tal seams described hereinbefore. Reference is directed to EP-A-0546540 for a fuller description of the basic construction of the building unit of this embodiment and the disclosure of that specification is incorporated herein by reference.

Although in the hereinbefore described and illustrated examples of the invention the peripheral frame elements have been disposed at an adjacent edge of a wall part if desired one or more of the elements may extend along the edge by virtue of being spaced from and adjacent to the associated edge.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, or a class or group of substances or compositions, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Claims

1. A wall panel of the kind specified wherein the panel is provided with a frame member extending along or adjacent one edge of the panel and the frame member comprising a frame element comprising a channel shape formation comprising two spaced limbs defining an open mouth therebetween at their one ends and interconnected by a transversely extending web and having a plurality of bracing elements extending transversely between the limbs and disposed between the one ends of the limbs and said web and arranged at spaced positions longitudinally of the frame element.

2. A wall panel according to claim 1 wherein the frame element is of channel shape and the web interconnects the limbs at their other ends.

3. A wall panel according to claim 1 or claim 2 wherein the frame element comprises a cold rolled steel element.

4. A wall panel according to any one of the preceding claims wherein a plurality of pairs of opposed apertures are provided in the limbs to receive, in the apertures of each pair, a fastener to connect the wall panel to a floor structure.

5. A wall panel according to claim 4 wherein a recess is provided around an aperture of each pair in at least one limb to receive a part of the fastener.

6. A wall panel according to claim 5 wherein a recess is provided around each aperture of each pair.

7. A wall panel according to claim 5 or claim 6 wherein the or each recess is of generally frusto-conical configuration.

8. A wall panel according to any one of claims 5 to 7 wherein the or each recess is provided by a deformed region of the limb in which the apertures are provided.

9. A wall panel according to any one of the preceding claims wherein each bracing element is retained between the limbs by engagement of an inwardly deformed region of the limb with the bracing element.

10. A wall panel according to any one of the preceding claims wherein each bracing element comprises a tube.

11. A wall panel according to claim 10 wherein each bracing element comprises a generally cylindrical tube.

12. A wall panel according to claim 10 or claim 11 when dependent on claim 9 wherein the inwardly deformed regions of the limbs are engaged within the ends of the tube to retain the tubular bracing element between the limbs.

13. A wall panel according to claim 9 or any one of claims 10 to 12 when dependent on claim 9 wherein the inwardly deformed region on the opposite side thereof to that which engages the bracing element provides a said recess.

14. A wall panel according to any one of the preceding claims wherein the panel has at least one other frame member extending along or adjacent at least one other edge of the panel.

15. A wall panel according to claim 13 wherein the panel has a peripheral frame comprised of said frame element and other frame members.

16. A wall panel according to claim 14 or claim 15 wherein the or each other frame member is made of wood.

17. A wall panel according to any one of claims 14 to 16 wherein the frame members are connected to each other.

18. A wall panel according to any one of the preceding claims wherein the outer skin of the wall panel comprises a plurality of sheets, the longer edges of the sheets being disposed to extend vertically and having at their adjacent longer edges inturned flanges which are secured together.

19. A wall panel according to claim 18 wherein openings are provided in the channel shaped element to receive the flanges.

20. A wall panel according to any one of the preceding claims wherein the frame element is disposed with the one ends of the limbs facing outwardly of the panel and the transversely extending web disposed transversely of the thickness of the panel.

21. A wall panel according to claim 20 when dependent on claim 19 wherein the openings for the flanges are provided in the transversely extending part and in the limbs adjacent to the transversely extending part.

22. A wall panel according to any one of the preceding claims wherein the limbs are generally planar, as may be the transversely extending part which may extend perpendicular to each limb.

23. A wall panel according to any one of claims 1 to 17 wherein the outer skin of the wall panel comprises a plurality of sheets, the longer edges of the sheets being disposed to extend horizontally and the shorter edges of the sheets extending vertically and the sheets having at their adjacent longer edges inturned flanges which are secured together.

24. A wall panel according to claim 23 wherein the frame element is not provided with openings.

25. A wall panel according to claim 23 wherein the frame element has a rebate provided in the limb adjacent the outer skin, the rebate providing a shoulder which faces towards the free end of the associated limb and the outer skin may conform to the shape of the rebated limb.

26. A wall panel according to any one of the preceding claims wherein the frame element is fastened to an element of the floor structure by means of a threaded fastener comprising a shank and first and second abutments provided on the shank, at least one of the abutments being threadedly engaged with the shank for axial movement relative thereto, with one abutment in clamping relationship with an outer limb of the channel section element and the other abutment in clamping engagement with the element of the floor structure with the shank of the fastener extending through a bracing element.

27. A wall panel according to claim 26 wherein said one abutment is fixed to the shank. and the other abutment comprises a nut threadedly engaged with the shank.

28. A wall panel according to claim 27 wherein the nut is fixed relative to the frame element.

29. A method of making a wall panel of the kind specified comprising the step of taking a frame element comprising a channel shape formation comprising two spaced limbs defining an open mouth therebetween at their one ends and interconnected by a transversely extending part, positioning a plurality of bracing elements to extend transversely between the limbs and disposed between the one end of the limbs and said web at spaced positions longitudinally of the frame element, and acting on the outwardly facing surface of at least one of the limbs with a tool adjacent said bracing elements to provide an inwardly deformed formation to engage a bracing element to retain it between the limbs.

30. A method according to claim 29 wherein the tool punches an aperture in the limb within the inwardly deformed formation.

31. A method according to claim 30 wherein the method comprises acting on the outwardly facing surface of both limbs with pairs of opposed tools adjacent said bracing elements to provide inwardly deformed formations to engage opposite ends of the bracing elements to retain them between the limbs.

32. A method according to claim 31 wherein said pairs of opposed tools punch apertures in the limbs within the respective inwardly deformed formations.

33. A method according to any one of claims 29 to 32 wherein the or each inwardly deformed formation is of generally frusto-conical configuration.

34. A method according to any one of claims 29 to 33 wherein the or each inwardly deformed formation provides a recess in the outwardly facing surface of the limb.

35. A mthod according to any one of claims 29 to 34 wherein the or each tool comprises a leading, piercing, portion and a trailing, deforming, portion of greater cross-sectional dimension than the piercing portion, the piercing portion being adapted to pierce the aperture in a limb and the trailing portion being adapted to bend or swage the material of the limb in co-operation with the bracing element to form the inwardly deformed formation.

36. A method according to claim 35 wherein the bracing element is generally cylindrical, at least at the ends thereof, and the deforming portion is frusto-conical having a larger diameter which is at least equal to the internal diameter of the bracing element.

37. A method according to claim 36 wherein the piercing

portion is generally cylindrical and of a diameter corresponding to the diameter of the smaller end of the deforming portion.

38. A method according to any one of claims 29 to 37 wherein the or each tool is caused to act on the channel shaped element by a fluid operated piston and cylinder means.

39. A method according to claim 38 wherein an individual fluid operated piston cylinder means is provided for each tool.

40. A method according to any one of claims 29 to 39 wherein the method comprises the step of disposing a plurality of bracing elements on locating means at predetermined positions in a piercing and forming apparatus, the locating means being disposed in a predetermined relationship with pairs of opposed tools, disposing the channel section element with the one ends of the limbs facing downwardly over the bracing elements and then carrying out said step of acting on the outwardly facing surface of the limbs with the pairs of opposed tools.

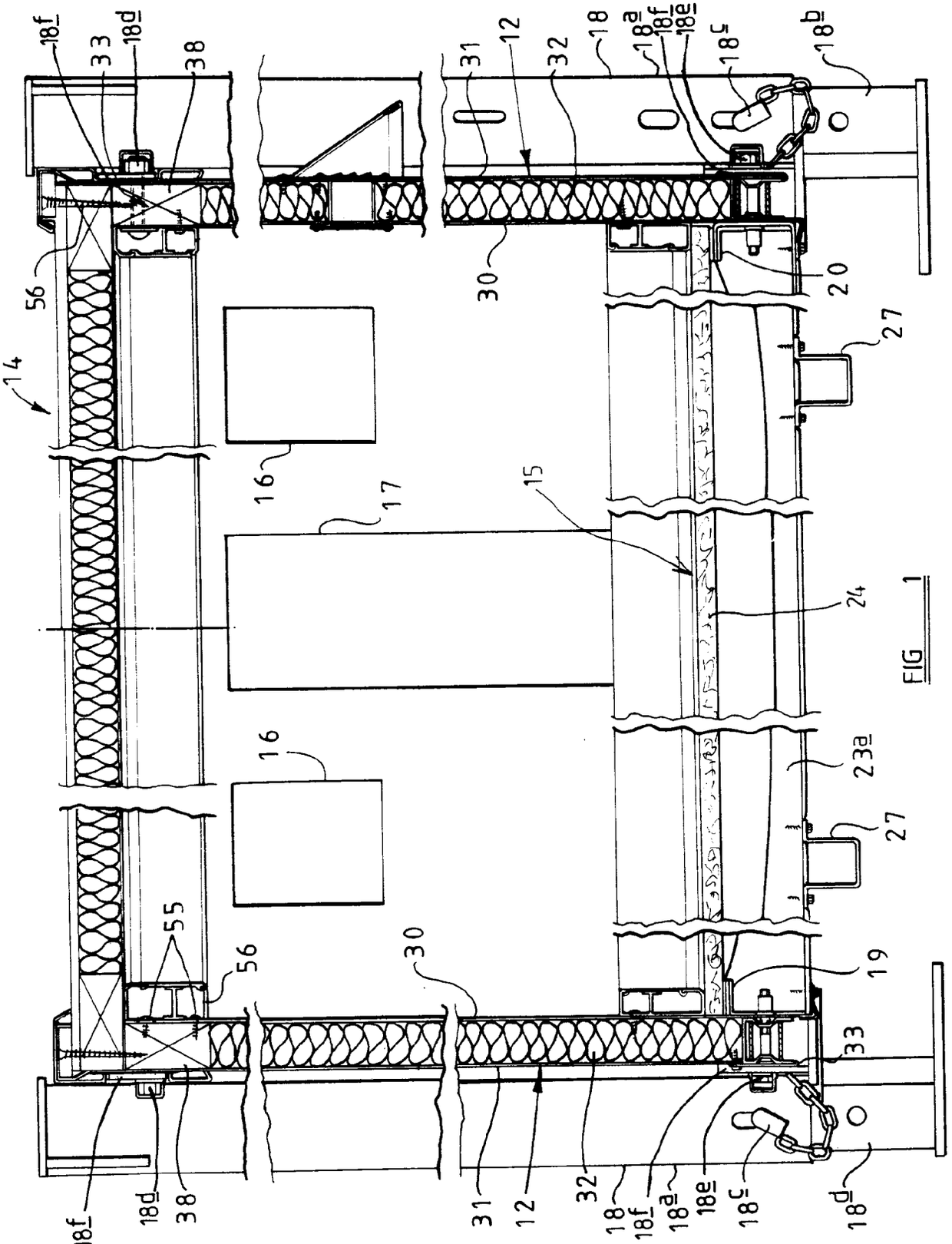
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FIG 1

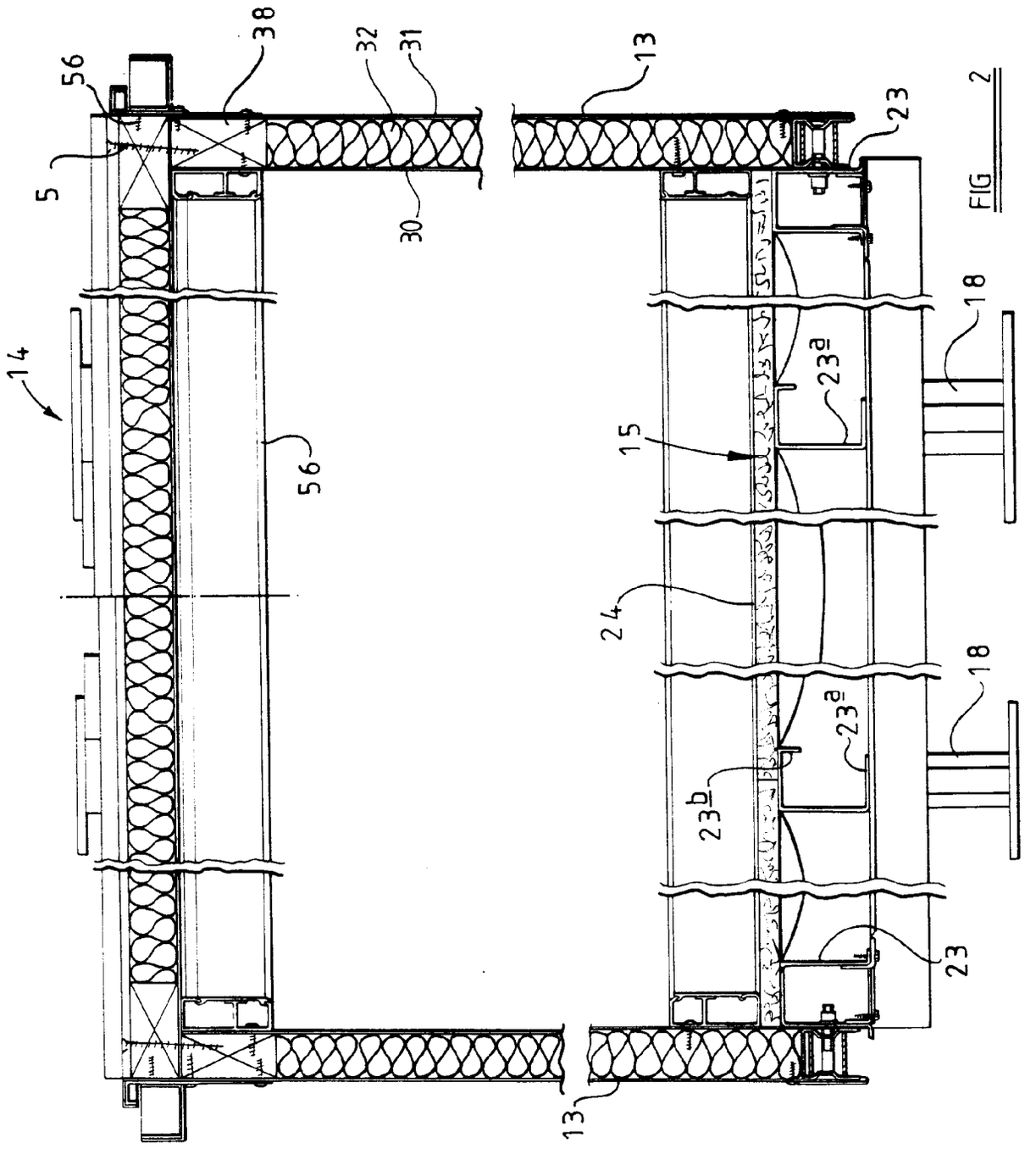


FIG 2

FIG 3

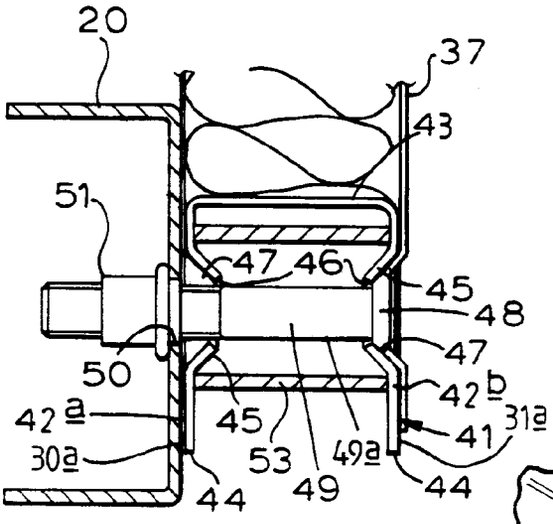


FIG 4

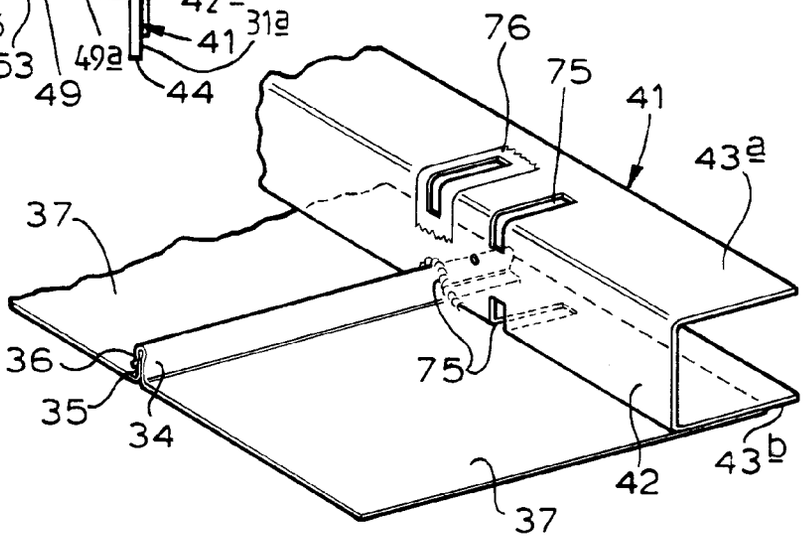
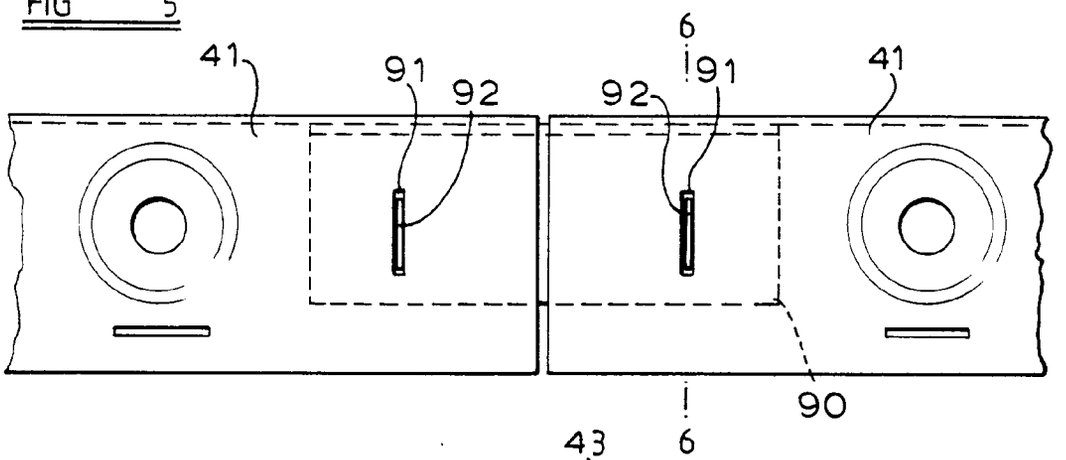


FIG 5



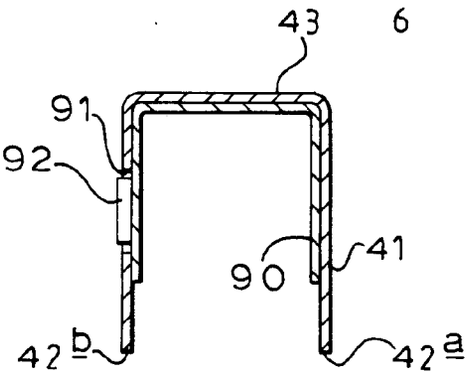


FIG 6

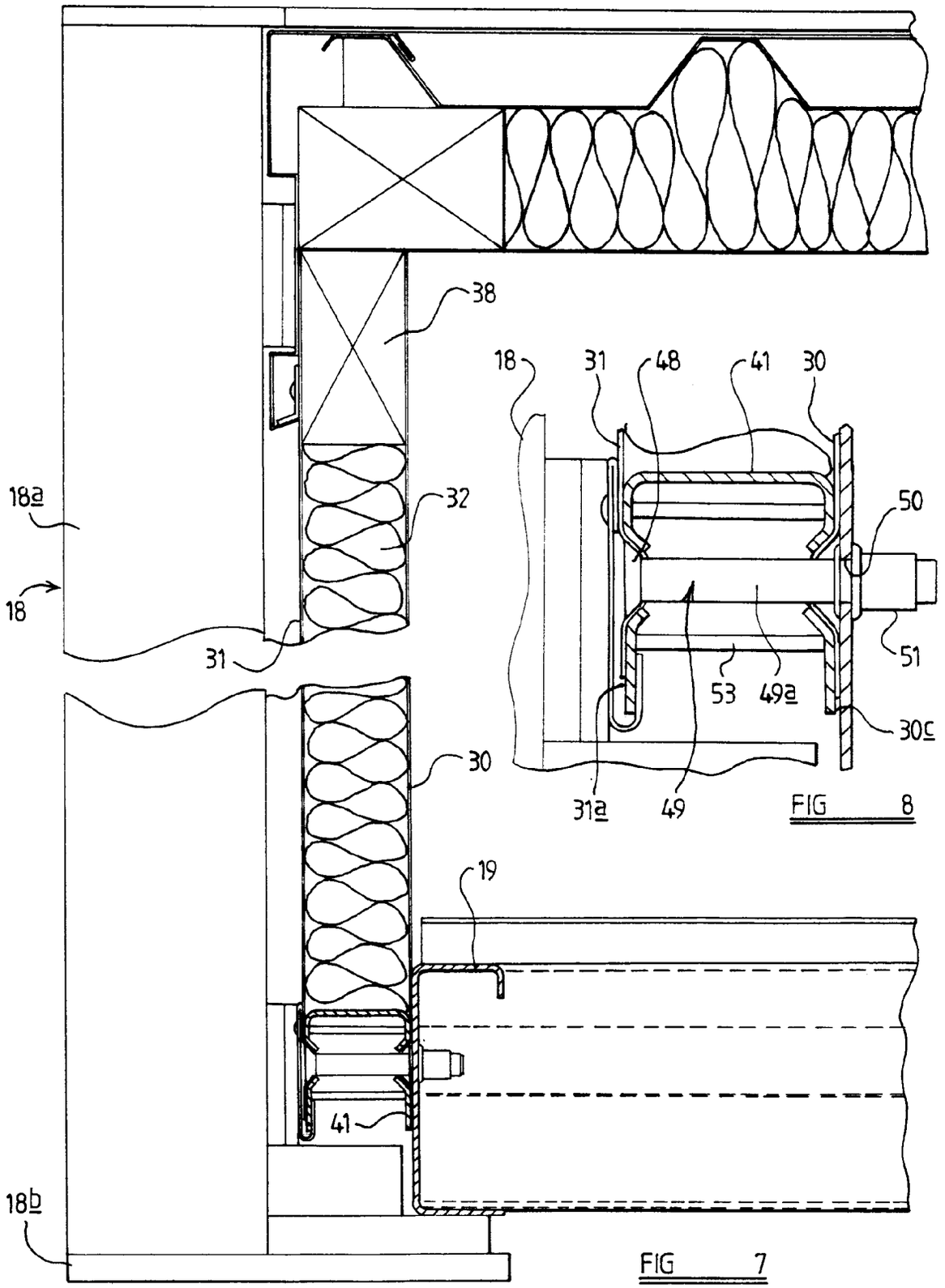


FIG 7

FIG 8

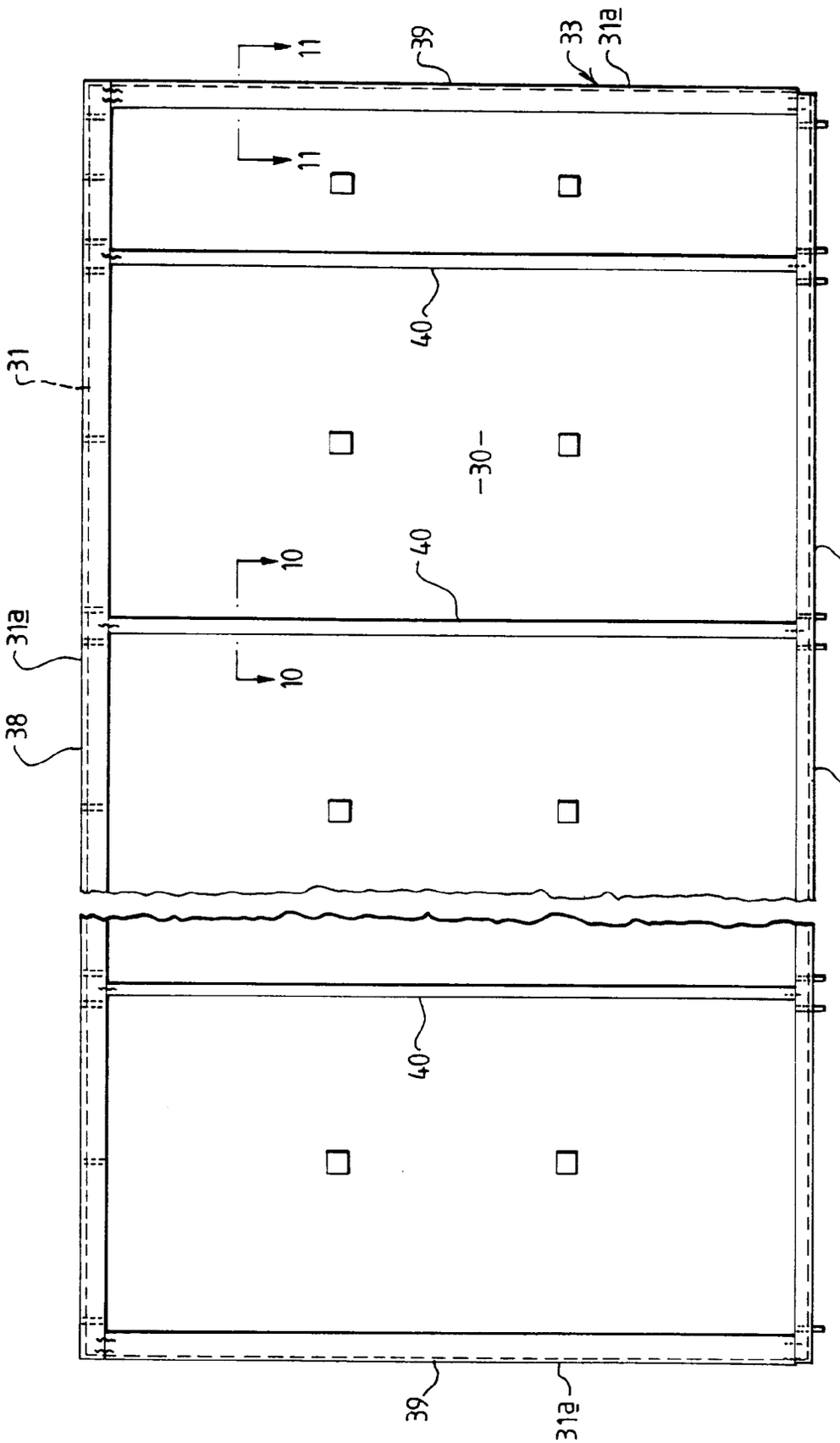
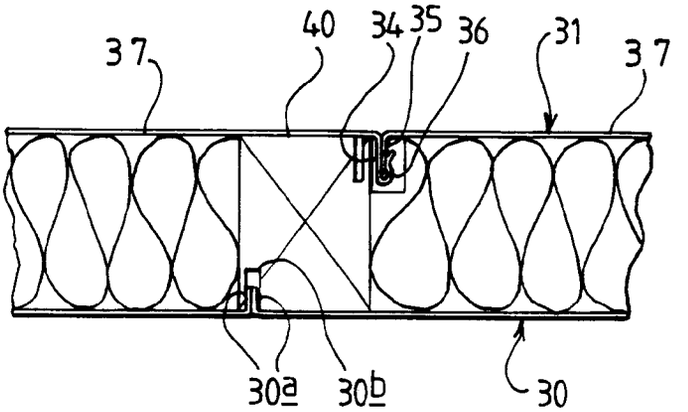


FIG 9

FIG 10



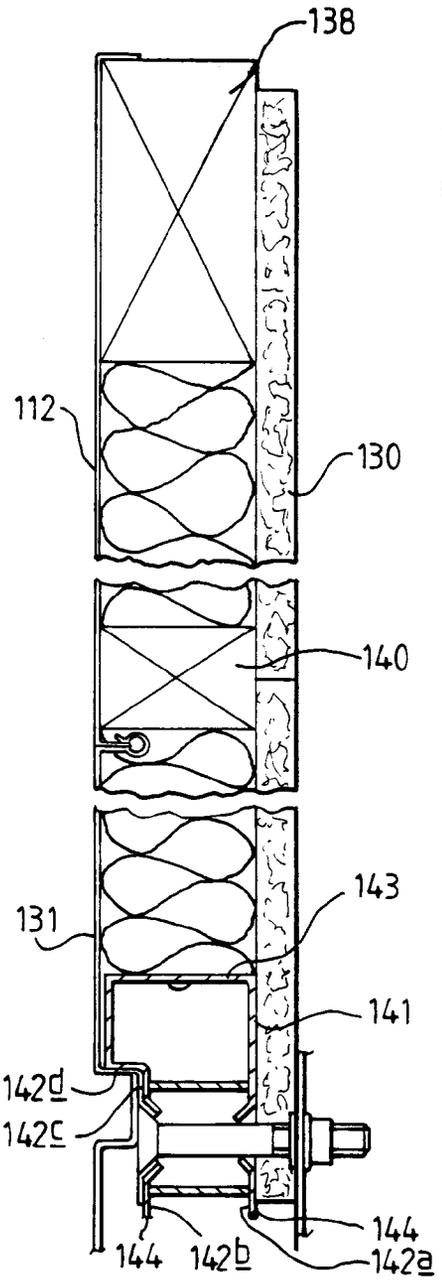


FIG 17

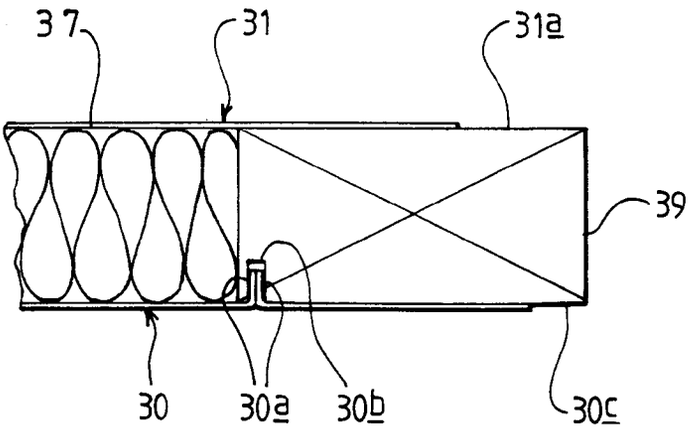


FIG 11

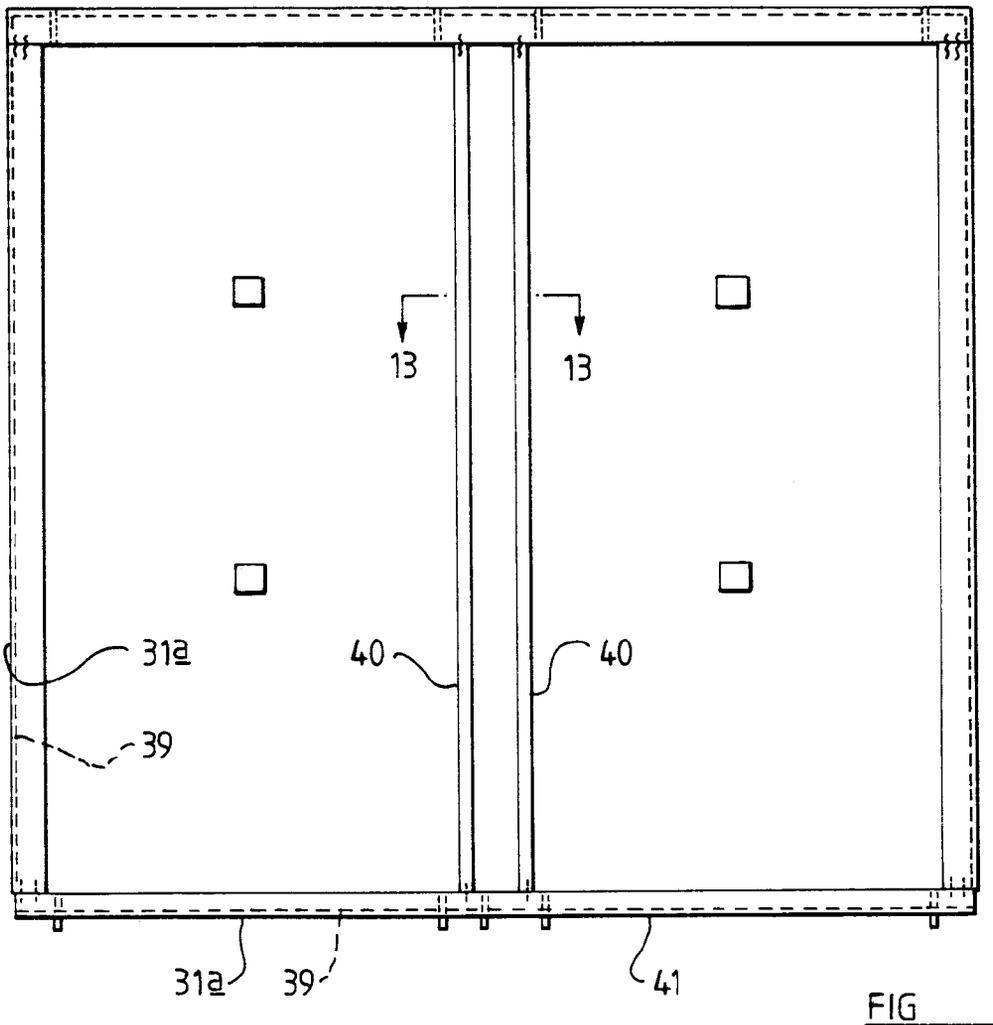

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FIG 12

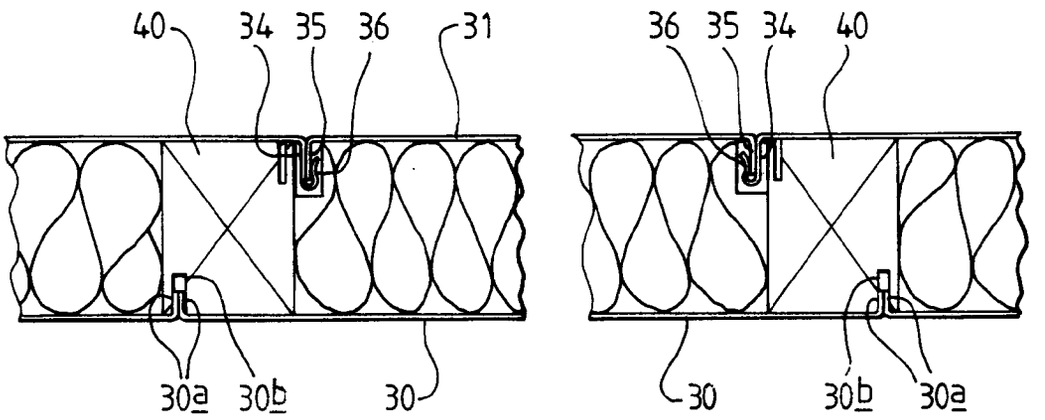
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FIG 13

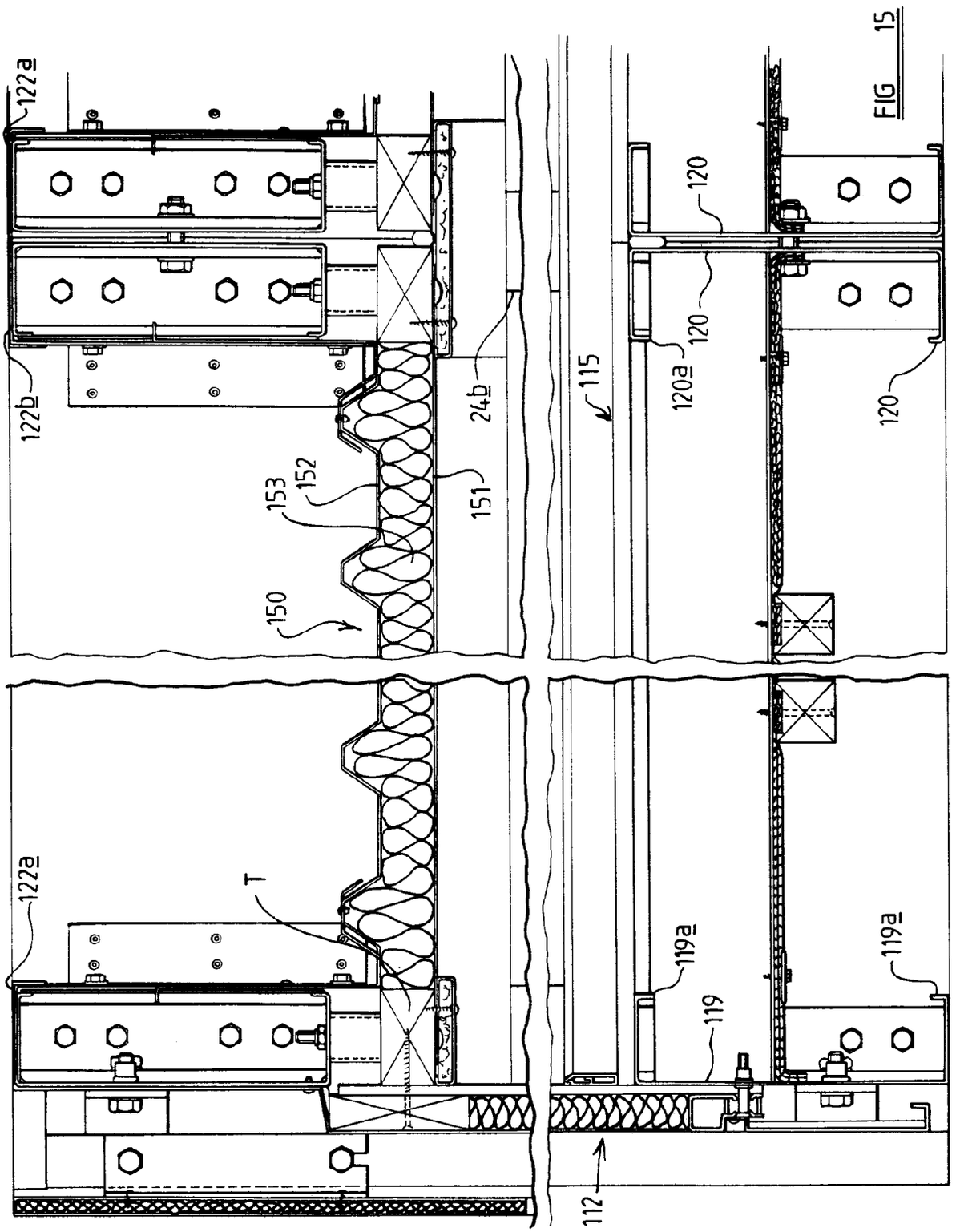
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FIG 15

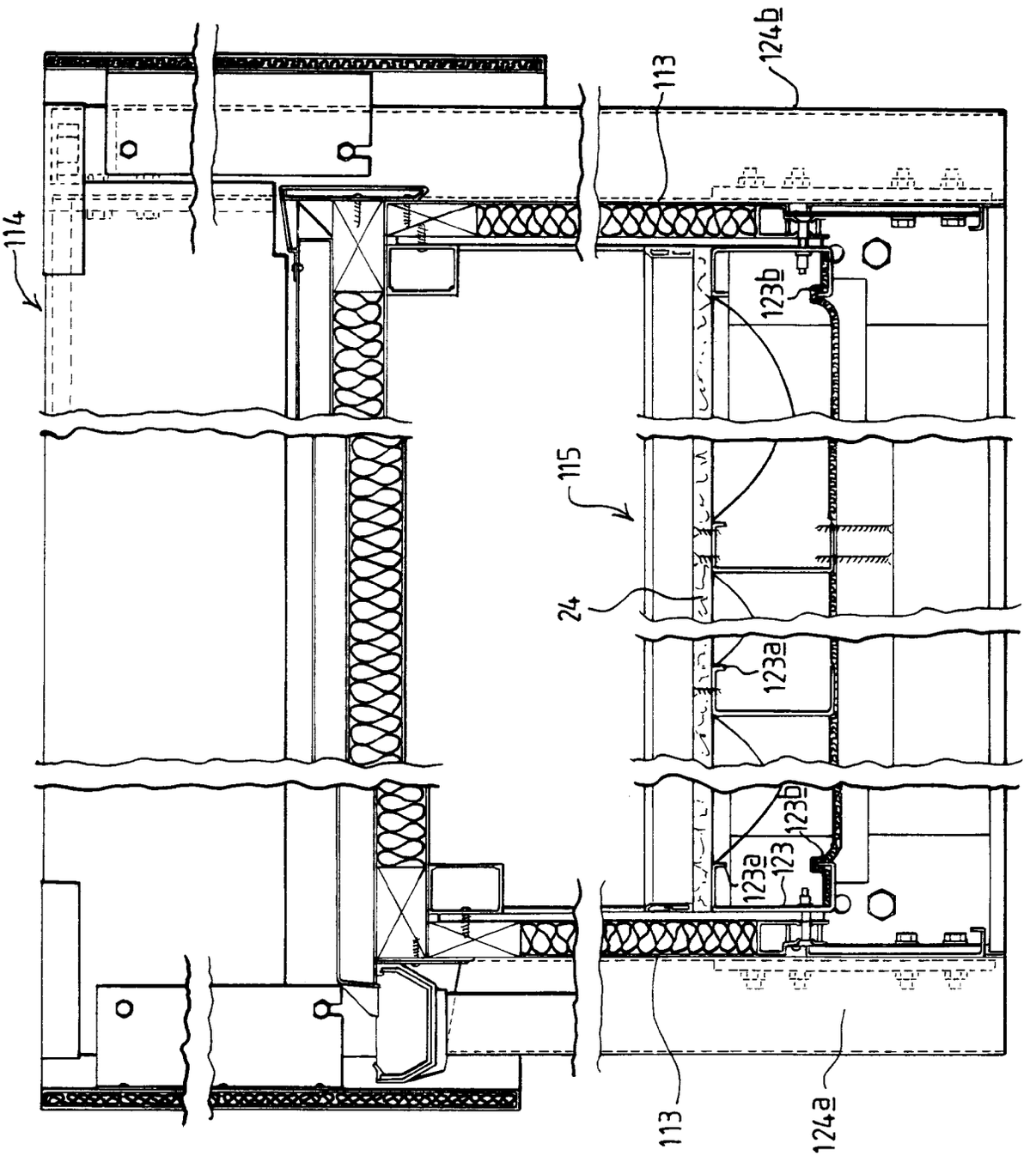

FIG 16

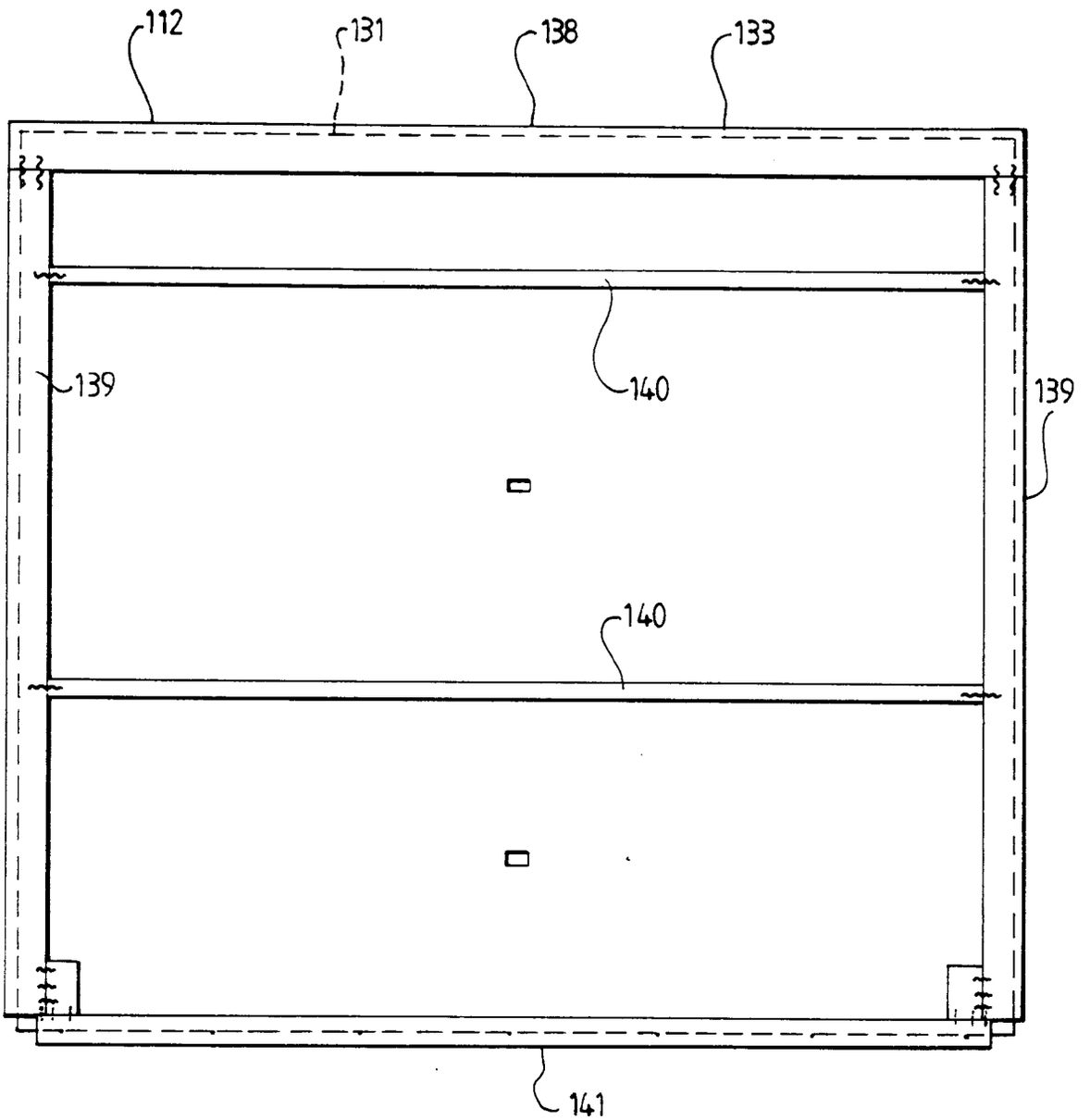

FIG 18

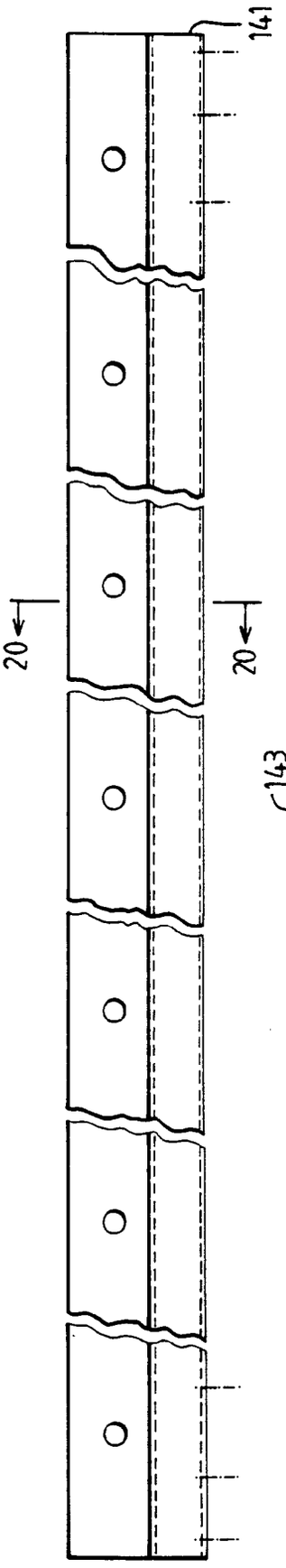

FIG 19

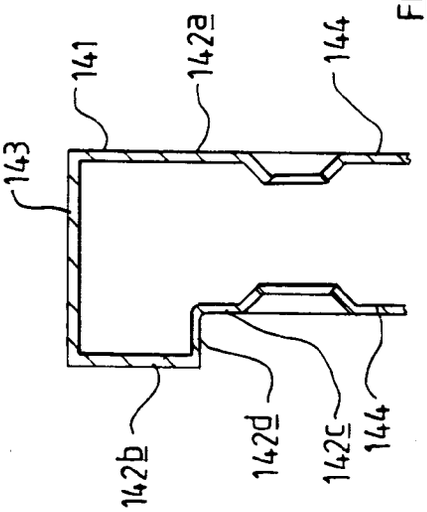

FIG 20

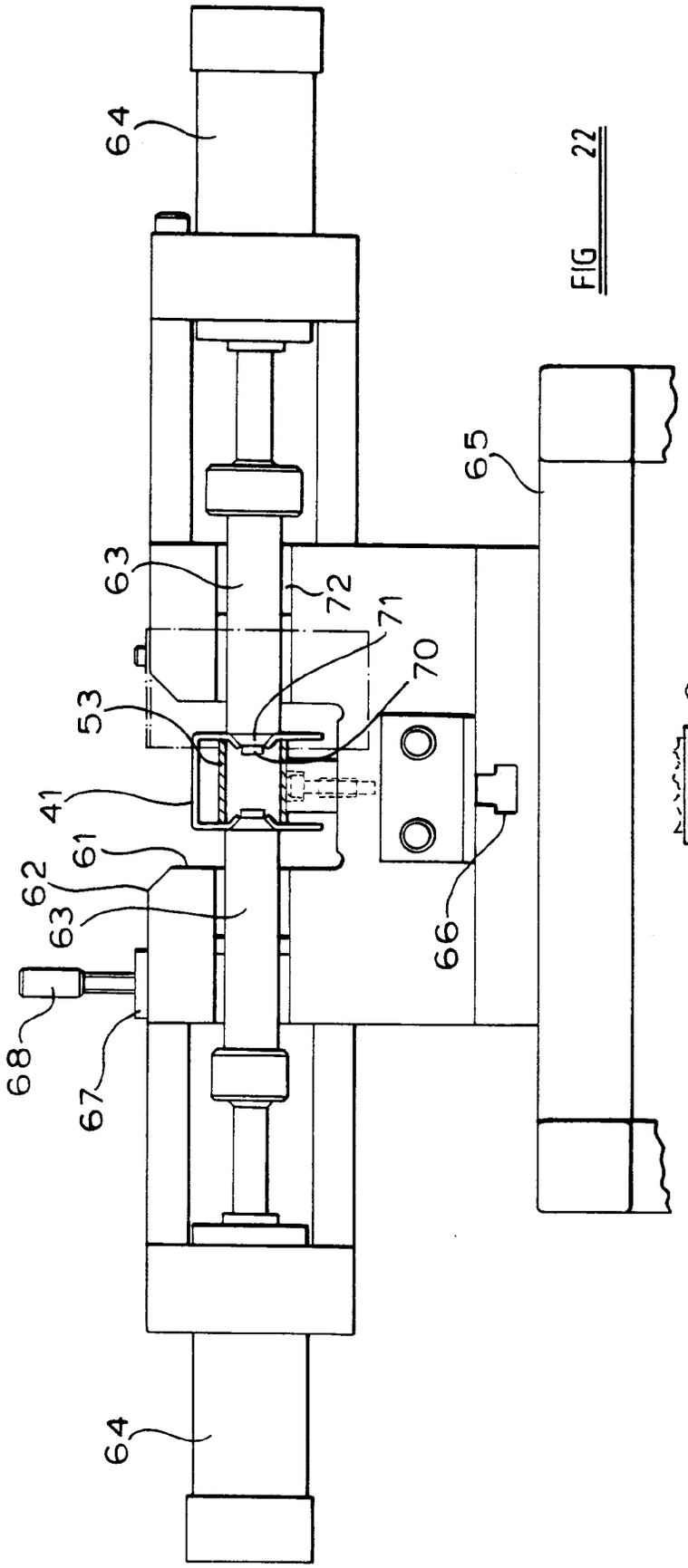

FIG 22

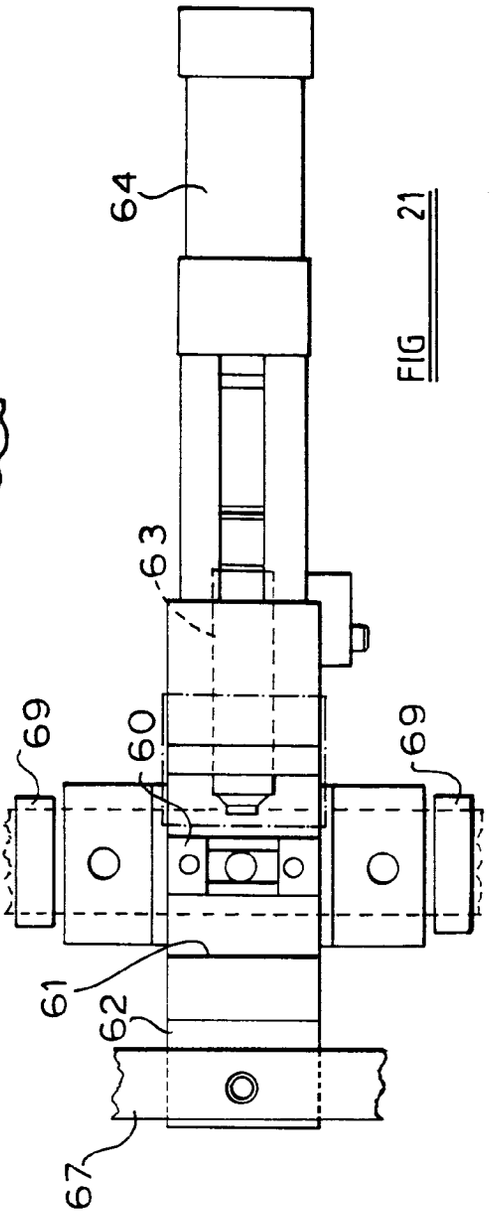

FIG 21

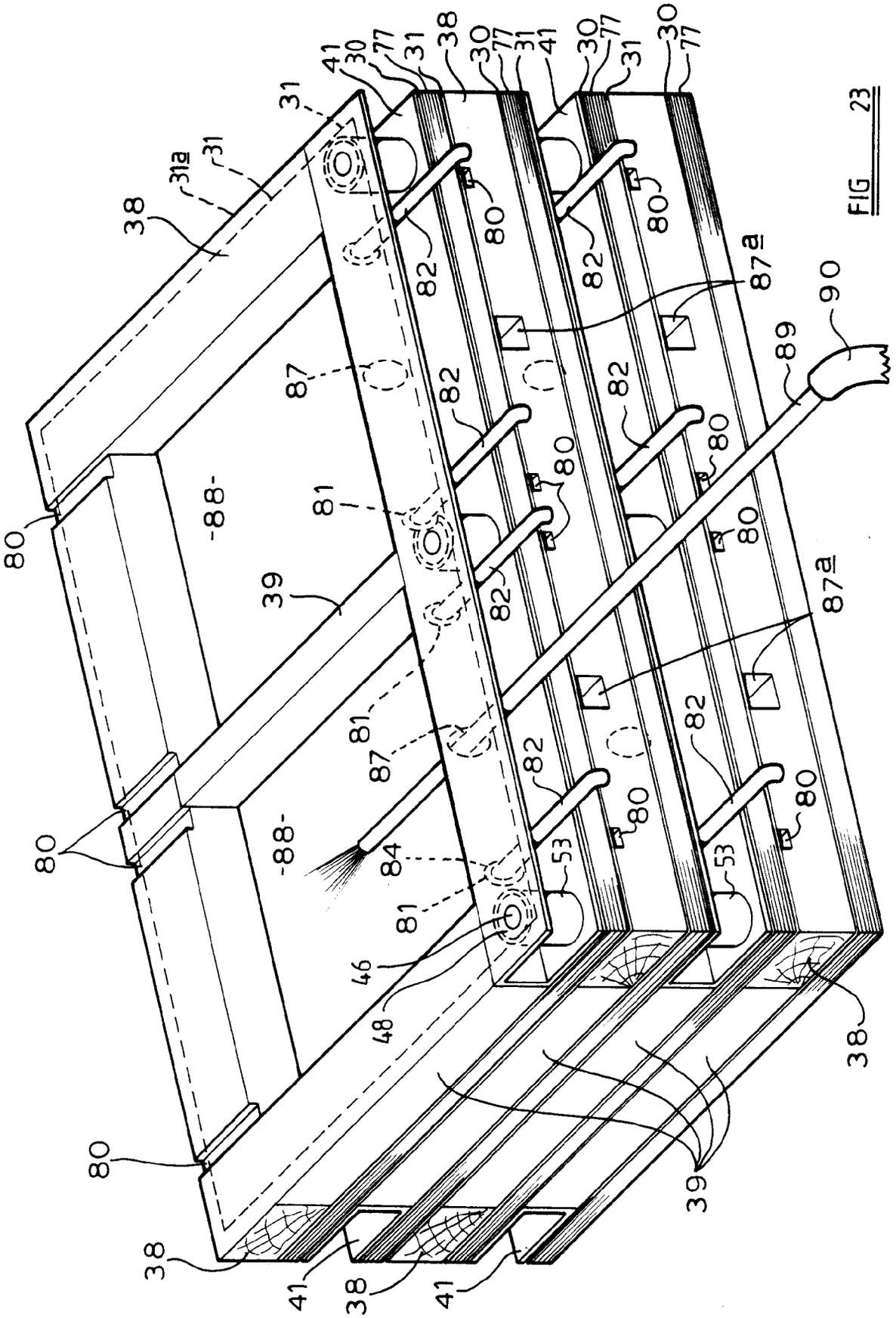
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FIG 23

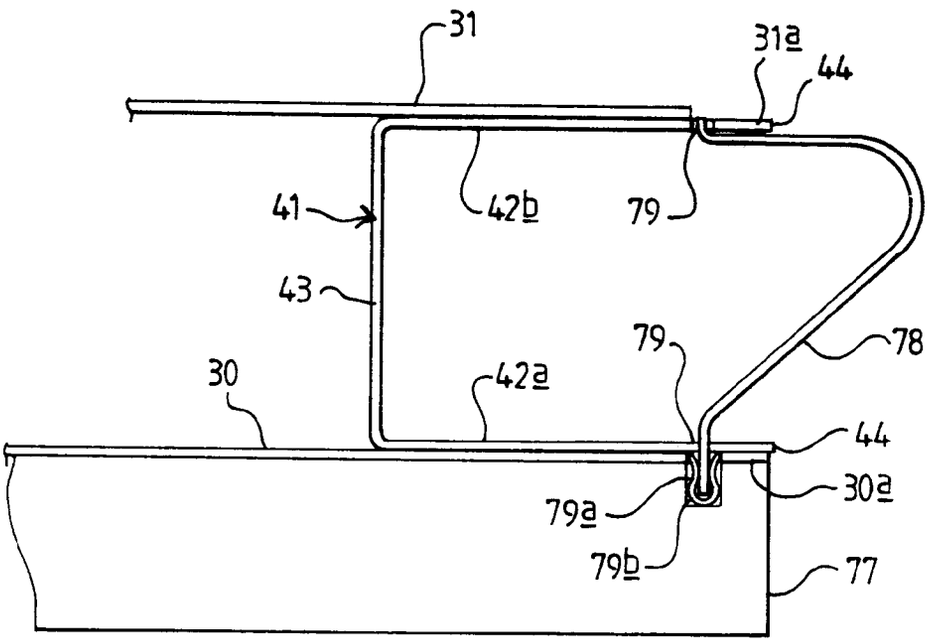

FIG 24

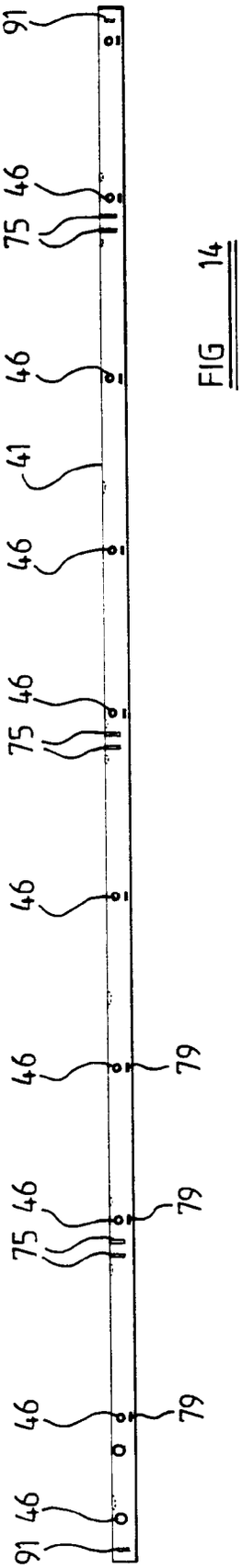

FIG 14

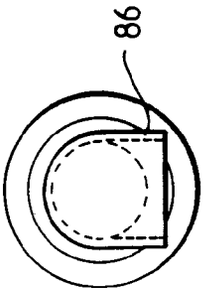

FIG 26

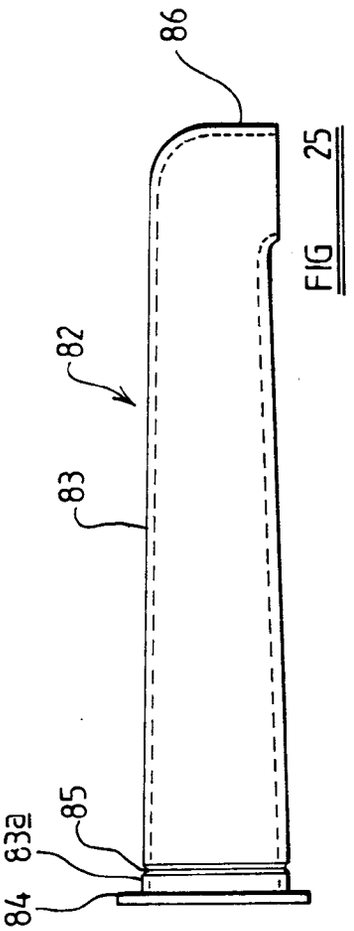

FIG 25

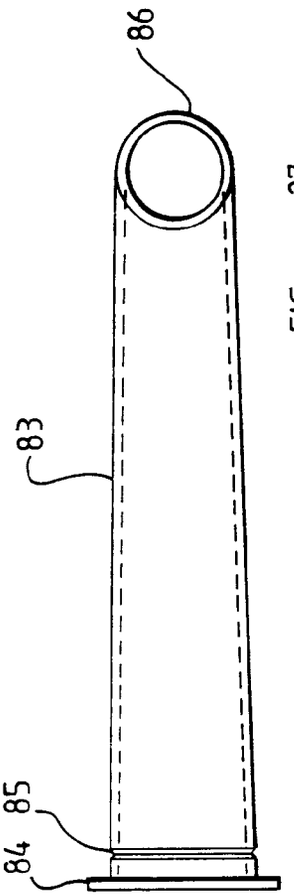

FIG 27