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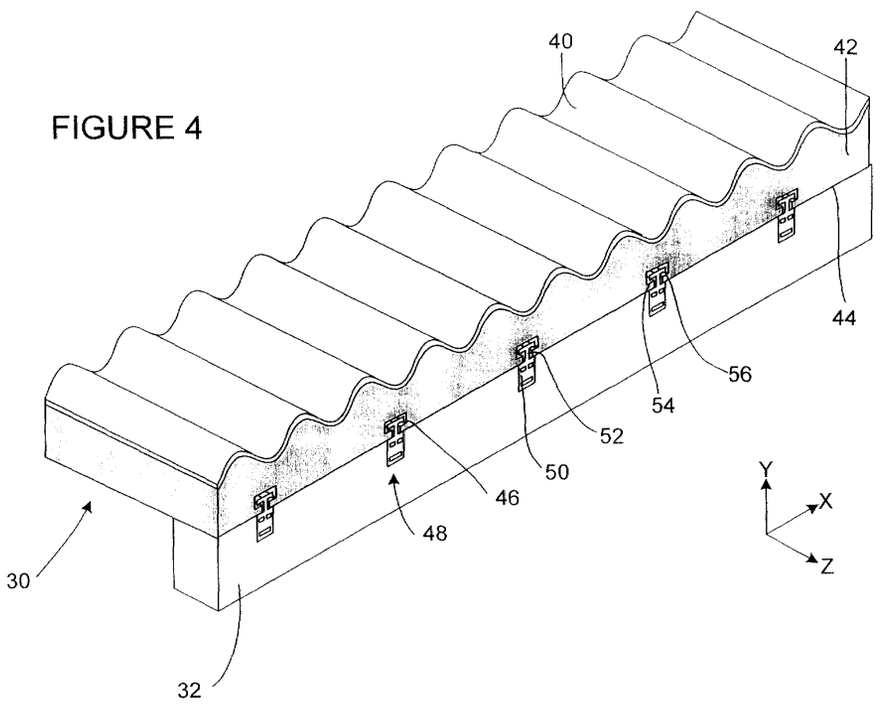
(54) Roofing system

(57) A method for attaching a steel roofing sheet to a longitudinal beam. Attachment members 48 interact with recesses 46 in the underside of the roofing sheet 30 so as to be engaged with those recesses. The attachment members 48 may then be screwed to a longitudinal beam so that the roofing sheet is attached to the beam. The recesses and the engaging part of the attachment members are substantially T-shaped. The T-shaped portion of the attachment member is inserted into the recess in a first orientation and is rotated by 90° so as to be in a second orientation so as to engage the T-shape of the recess.

FIGURE 4



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Description

[0001] The present invention relates generally to roofs, their construction and a method for erecting them. More particularly, the present invention relates to metal roofing made from individual metal sheets that are supported by beams.

[0002] Hitherto, it has been known to construct roofs from sheets of metal rather than roof tiles. The sheets themselves essentially take the form of an external sheet of steel backed by some insulating material. An internal sheet is also sometimes provided to retain the insulating material. These composite sheets are very rigid meaning that it is possible to use quite long and/or wide sheets without needing as many beams or trusses to support them. This reduces construction costs and also adds to the potential maximum loft space since there is a reduced need for support for the beams.

[0003] Figure 1 of the accompanying schematic drawings illustrates how the known roofing sheets are attached to supporting beams.

[0004] As is shown in Figure 1, a roofing sheet 10 is supported by beams 12, 14. The roofing panel comprises an outer steel layer 18 and an inner retaining layer 22. Sandwiched between these layers is a layer of insulating material 20. The layers 18, 20 and 22 form an integral unit known as a "roofing sheet" 10.

[0005] Traditionally, the roofing sheet 10 has been attached to the beams 12, 14 using a series of simple nails, screws or nuts and bolts. This involves the penetration of all three layers of the roofing sheet 10 so that a nail/screw etc. may be passed into one of the beams 12, 14. Nail heads 24 are schematically illustrated in Figure 1.

[0006] This prior art method gives rise to two problems. The first is that the nail penetrates completely through all the layers of the roofing sheet 10 and thus gives rise to a source of leakage. The second problem is that a construction worker is required to be on the outside of the structure to bang the nails in and/or to operate the nail gun/screwdriver/spanner. This is a potentially dangerous task and it is necessary to use a skilled construction worker who has taken appropriate safety precautions. This increases the cost and time of construction.

[0007] The present invention seeks to alleviate the above mentioned problems by providing a roofing system which is less prone to leakage and which can be principally constructed from inside the building, with attachment from outside only being required at the roof ridge where a ridge cap can be used to cover holes, and at the edges where other forms of edge like or other trim can be used for a similar purpose.

[0008] Accordingly, the present invention provides a method for attaching roofing sheets to a beam, said method comprising:

providing roofing sheets having an outer surface and an inner surface and having shaped attachment recesses which are at the inner surface and which do not pierce the outer surface, providing attachment members having shaped portions which are retainable within said attachment recesses, and inserting said portion of said attachment members into said recesses and retaining them therein,

wherein said attachment members are integral with the beam or are attached to the beam in another step.

[0009] Using the method of the invention, the attachment members can be inserted from the inner surface of the roofing sheets, so that no work on the outer surface of the roof is reduced and there are no holes through the major part of the roofing sheet to permit leakage. The attachment members function primarily to prevent lifting of the roofing sheets by wind.

[0010] The invention therefore makes it practical to use large roofing sheets which require substantially less timber or other structural supports as compared to conventional roof constructions. For example the roofing sheets may be mounted on beams or other supports at a spacing of 1.2m to 3m centres.

[0011] Preferably the attachment members are attached to the beam in another step, after the locking portions have been inserted into and retained in the recesses.

[0012] In one aspect, the present invention provides a method for attaching a roofing sheet to a beam, said method comprising:

providing a roofing sheet having at least one recess on one surface;

providing an attachment member retainable within said recess;

retaining said attachment member within said recess;

wherein said attachment member is integral with the beam or is attached to the beam in another step.

[0013] Preferably, the step of retaining an attachment member within a recess comprises inserting the attachment member into the recess in a first orientation, and rotating the attachment member so as to be in a second orientation. Generally this results in a portion of the attachment member being locked in the recess. It may be described as a "click-lock" arrangement. Preferably, the second orientation is 90° rotated from the first orientation. Suitably the recess is substantially T-shaped in a plane perpendicular to said one surface or inner surface of said roofing sheet. In this embodiment it is advantageous that the attachment member also has a substantially T-shaped portion. Generally the attachment recesses are at the inner surface of the roofing sheet. Recesses may be provided at edge surfaces of the roofing sheet provided that attachment members can be inserted therein from the inner surface. For example corre-

sponding recesses in edge surfaces of adjacent roofing sheets may together define an attachment recess to receive an attachment member. For example in the case of an attachment member which has a substantially T-shaped portion, two recesses in abutting edge surfaces of adjacent sheets may each define substantially one half of a T-shaped recess.

[0014] The attachment member is preferably connected to the beam using screws passed through holes in the attachment member.

[0015] Advantageously, the recess comprises one of a locating hole and a locating protrusion and the attachment member comprises one of a corresponding locating protrusion or a corresponding locating hole. The corresponding holes and protrusions may then be engaged after the step of retaining the attachment member to the recess so as to provide for correct positioning of the attachment member in the recess.

[0016] In one embodiment, said recess includes at least one locating hole in it, said attachment member includes at least one locating protrusion on it and said method comprises:

locating said locating protrusion in said locating hole after the step of retaining said attachment member in said recess.

[0017] In another embodiment, said recess includes at least one locating protrusion in it, said attachment member comprises at least one locating hole on it and said method comprises:

locating said locating protrusion in said locating hole after the step of retaining said attachment member in said recess.

[0018] In one aspect, the method further comprises supporting a fascia parallel to said one surface or inner surface of said roofing sheet.

[0019] In a preferred embodiment, the roofing sheet comprises a plurality of recesses and a different attachment member is retained in each recess. The invention therefore provides a method as described above wherein said roofing sheet has a plurality of recesses and a respective plurality of attachment members are provided, said method further comprising:

retaining each of said plurality of attachment members within a respective one of said plurality of recesses.

[0020] Preferably, the attachment members are retained at one or other end of the recesses.

[0021] The present invention also provides a roofing sheet comprising:

an outer surface;
an inner surface;
at least one attachment recess on said inner surface for retaining an attachment member.

[0022] The recess is preferably T-shaped in a plane perpendicular to said inner surface and may span the entire length of the roofing sheet or may extend by only a small amount i.e. by a distance substantially less than an entire length of said roofing sheet. Preferably the recess has a dimension in the plane of said inner surface which is substantially equal to, or greater than, the width of an attachment part which is intended to be inserted into said recess.

[0023] Preferably, the recess is larger than the width of an attachment part to be inserted and has a similar length (e.g. has a dimension in the plane of said inner surface which is substantially equal) to the thickness of a beam which the sheet is intended to be attached to.

[0024] Preferably there is a plurality of said recesses on said inner surface.

[0025] Suitably the recess(es) is (are respectively) formed from a shell surrounded by insulating material. The shell may be a separate component and may be formed from a single piece of material, or from two separate pieces of material.

[0026] Alternatively the shell may be integral with the inner surface of said roofing sheet i.e. the layer forming the said inner surface.

[0027] Preferably, the shell has at least one hole in it to engage with protrusions formed on the attachment member. This hole is preferably substantially parallel to the inner surface of the roofing sheet.

[0028] Suitably the outer layer is formed from steel and there is an insulating layer provided between said outer layer and said inner layer.

[0029] The present invention further provides an attachment member or clip for use with the method of the present invention, comprising a first portion having means for attachment to a beam and a second portion having shaped means for being retained in a shaped attachment recess in a roofing sheet.

[0030] The means for being retained preferably comprises a substantially T-shaped portion. It also preferably comprises at least one protrusion thereon to aid in the location of the attachment member in a recess having a corresponding hole.

[0031] The means for attachment to a beam preferably comprises a plurality of holes through which screws may be passed.

[0032] In other aspects the invention provides a combination of roofing sheet and attachment member for use with the method as described above, or a combination formed from the roofing sheet as described above and the attachment member as described above.

[0033] The invention further provides a roof constructed according to the method as described above, or using the roofing sheet as described above or using the attachment member as described above.

[0034] The invention also includes a method substantially as described below with reference to Figures 2-15 and/or Figures 16-24 of the accompanying drawings.

[0035] The invention also includes a roofing sheet constructed and arranged substantially as described below with reference to Figures 2-15 and/or Figures 16-24 of the accompanying drawings.

[0036] The invention additionally includes an attach-

ment member constructed and arranged substantially as described below with reference to Figures 2-15 and/or Figures 16-24 of the accompanying drawings.

[0037] The invention will now be further described by way of non-limitative example only, with reference to the accompanying schematic drawings, in which:-

Figure 1 shows a known construction of roofing sheet attached to a plurality of beams via a prior art method;
Figure 2 illustrates the construction of a pitched roof in accordance with the present invention;
Figure 3 is a cross-sectional view along the line 3-3 in Figure 2;
Figure 4 is a perspective view showing the method for attaching a roofing sheet to a beam according to the present invention;
Figure 5 is a perspective view of the underside of a roofing sheet in accordance with an embodiment of the present invention;
Figure 6 is a perspective view of the underside of a roofing sheet in accordance with another embodiment of the present invention;
Figure 7 is a perspective view of the underside of the roofing sheet of Figure 6 having attachment members in its recesses in accordance with the present invention;
Figure 8 is a perspective view of the underside of the roofing sheet of Figure 7 which is attached to a beam in accordance with the present invention;
Figure 9 is a close-up view of one of the recesses shown in Figure 3;
Figure 10 is a close-up view of a modified recess according to the present invention;
Figure 11 is a close-up view of another modified recess according to the present invention;
Figure 12 is a close-up view of the attaching member shown in Figure 3;
Figure 13 is a cut-away cross-sectional view showing an inner surface configuration in accordance the present invention.
Figure 14 is a cut-away cross-sectional view showing a modified inner surface configuration in accordance with the present invention; and
Figure 15 is a cut-away cross-sectional view showing another modified inner surface configuration in accordance with the present invention.
Figure 16 is a cross sectional view similar to Figure 3 of a further embodiment;
Figure 17A is a an elevation of a roofing panel of Figure 16 attached to a beam;
Figure 17B is an elevation similar to Figure 17A of two adjoining roofing panels;
Figure 18 is a cross sectional view similar to Figure 16, illustrating two other embodiments;
Figure 19 is a cross sectional view of an additional embodiment.
Figure 20 is a perspective view of a structural tray for forming the inner surface of a panel and also defining retaining recesses.
Figure 21 is a end view of another configuration of structural tray.
Figure 22 is a fragmentary perspective cross-sectioned view of the inner part of a panel using the structural tray of Figure 20, on the line 22-22 in Figure 20.
Figure 23 is a perspective view of an extension piece for the attachment member of Figure 12.
Figure 24 is a perspective view of an alternative form of T-shaped clip.
Figure 25 is a perspective view of an other alternative form of attachment member.
Figure 26 is a side view of a roofing panel supported on a purlin.

[0038] Figure 2 illustrates the construction of a pitched roof according to the present invention.

[0039] In this embodiment, six roofing sheets 30 are supported by six beams 32. The beams are further supported in a inverted V-shape by support structures 34. However, the support of the beams 32 by the support structures 34 is not material to the invention. The invention concerns the support of the roofing sheets 30 by the beams 32.

[0040] As can be seen in Figure 2, no nails are used to penetrate the roofing sheets 30 so as to attach them to the beams 32. In fact, the present invention does not involve the penetration of the outer metal layer of the roofing sheet 30 at all.

[0041] Figure 3 shows a cross-section along the line 3-3 in Figure 2 which clearly illustrates the system used for attaching the roofing panels 30 to the beams 32. Only one of the panels 30 from Figure 2 is shown in Figure 3 for the sake of simplicity.

[0042] The roofing panel 30, in common with the roofing panel 10 shown in Figure 1, is comprised of three layers. These are an outer metal layer 40, an insulating layer 42 and an inner retaining layer 44 (shown to have negligible thickness in Figure 3). The roofing sheet 30 is, however, distinguished from the roofing sheet 10 by virtue of a plurality of recesses 46 formed in the retaining layer 44. These recesses are generally T-shaped as viewed in Figure 3. The important point about the recesses is that they present a relatively small opening width in the X-direction at the surface of the layer 44 but enlarge in the X-direction as you move away from the surface of the layer 44. In doing this, the recesses present surfaces 54, 56 parallel to the layer 44 which are able to support a force downward in the sense of Figure 3, (i.e. in the negative Y-direction). Five recesses are shown in Figure 3. However, any number (either more or less than five) may be used so as to provide a number sufficient for attaching the roofing sheet 30 to the beam 32. Usually, a particular number of recesses will be provided per unit length of roofing sheet. It will be apparent also that recesses may be formed at the

abutment of two roofing panels 30 as seen in Figure 2. One half of a T-shaped recess may be formed at the edge of each of the two panels, so as to form the T-shaped recess when the two panels are laid edge to edge.

[0043] The beam 32 has attached to it a plurality of attachment members 48. These comprise thin plates which are attached to the beam 32 by fixing portions 50 so that a substantially T-shaped part 52 protrudes from the top surface of the beam 32. This T-shaped part 52 engages with the corresponding T-shaped recess 46 of the roofing sheet 30 in the manner shown in Figures 3 and 4. The T-shaped comprises a single upright member or stem with a pair of arms extending perpendicularly at the top thereof. The arms form over-hanging portions of the attachment member.

[0044] Figure 4 is a perspective view of a roofing sheet 30 attached to a beam 32 in the same manner as shown in Figure 3. The roofing sheet 30 is partially cut away for clarity. As can be seen in Figure 4, the attachment members 48 are thin compared to the width of the beam 32, e.g. they are of about 1.5mm thick. More importantly, they are thinner than the widths of the recesses 46 at the points where each recess emerges on the surface of the layer 44. This means that the attachment members 48 can be aligned with the Z-direction before being inserted into the recesses 46 and then twisted by 90° to achieve the position shown in Figures 3 and 4. They can then be attached to the longitudinal beam 32 using screws or nails which will pass through the holes in the portion 50 of the attachment member 48.

[0045] A preferred method in accordance with the present invention therefore involves firstly positioning the roofing sheet 30 on the plurality of longitudinal beams 32, secondly inserting an attachment member 48 into each recess 36 of the roofing sheet 30, thirdly rotating the attachment member 48 so as to be locked in the recess 36 and fourthly attaching the attachment member 48 to the longitudinal beam 32. One attachment member 48 will in general be needed for each point where a recess crosses a beam along the surface of layer 44.

[0046] Figure 5 shows a perspective view of the underside of a roofing sheet 30 showing the configuration of the recesses 36 according to one embodiment of the invention.

[0047] In this embodiment the recesses 36 extend across the entire length of the roofing sheet 30 in the Z-direction.

[0048] This configuration allows an alternative method for attaching the roofing sheet 30 to the beam 32 to be applied. According to this alternative method, the various attachment members 48 are attached to the beam 32 before the T-shaped parts 52 are interlocked with the recesses 46. Alternatively, the attachment members 48 come already attached to the beam 32 or the beam 32 is formed with such members at the time of its manufacture. Then, the roofing sheet 30 may be slid in the Z-direction to engage the parts 52 in the recesses 46. When the roofing sheet 30 is in place it can be locked against the beam 32 in a variety of ways. For example, a wedge could be driven in the space between the top of the beam 32 and the sheet bottom layer 44. This would tend to separate the roofing sheet 30 from the beam 32 so that frictional contact between the surfaces 54 and 56 of the recess and the underside of the over-hanging portions of the attachment member 48 takes place. Alternatively, the recesses 46 could be blocked with filler or any other suitable material to prevent further movement in the Z-direction. The relative shape of the recesses 46 and the attachment members 48 assures that movement of the roofing sheet 30 relative to the beam 32 in the X or Y-directions is impossible.

[0049] Another embodiment of the invention is shown in Figure 6. In this embodiment, the recesses 46 only extend a small amount in the Z-direction. Their length in this direction is greater than the width of the attachment members 48 so that these members may be rotated 90° to align with the Z-direction so as to be inserted into the slot formed at the point where the recess emerges on the layer 44.

[0050] In a preferable case, the recesses 46 have a length in the Z-direction similar to (or slightly larger than) the width of the beam 32 in this direction. In this case, the beam 32 can be securely attached to the roofing sheet 30 in a manner which conceals the recesses 46 and which prevents sliding of the roofing sheet 30 in the Z-direction. This method will be described with reference to Figures 7 and 8.

[0051] Firstly, a respective attachment member 48 is inserted into each respective recess 46 of the roofing sheet 30. This is achieved by rotating the attachment portions by 90° to align them with the Z-direction, inserting them into the mouth of each recess so that the top of the T-shaped part 52 of each attachment member passes by the surfaces 54 and 56 of the recess 46 and then rotating each attachment member again by 90° so that they are each locked in the recess 46. The attachment members may then be moved so as to be at one or other end of their recess. Preferably, they are arranged to be at the opposite end to the corresponding end which is occupied by the most closely adjacent attachment member. This is illustrated in Figure 7 which shows the underside of a roofing sheet 30 having an attachment member 48 inserted into each recess 36. The attachment members 48 are positioned at alternate ends of the respective recesses as you move along the roofing member in the X-direction.

[0052] Next, the roofing sheet 30 is presented to the beam 32 so that the beam substantially conceals each of the recesses 46 and so that the attachment members 48 are parallel to the sides of the beam. The portions 50 of the attachment members 48 are then secured to the beam 32 by means of screws or nails. This results in the structure shown in Figure 8.

[0053] As can be seen from Figure 8, the beam sub-

stantially conceals each of the recesses 46. Further, the roofing sheet 30 cannot move in either the X or Z directions due to the positioning of the attachment members at one end of their respective slot.

[0054] The above configuration can be varied in accordance with the present invention. For example, each recess 46 can have two attachment members, one at each end. Alternatively, only one or some of the recesses 46 could have two attachment members 48, with the rest having only a single attachment member at one of the ends. Substantially any configuration of attachment members which prevents movement of the roofing sheet 30 relative to the beam 32 is envisaged by the present invention.

[0055] Figure 9 shows a close-up of the recess 46 shown in Figure 3. In this embodiment, the recess 46 is created within the insulating material 42 by means of a metal plate 60 bent into the form shown in Figure 9. The bent plate 60 is retained in a hole formed in the retaining layer 44. The bent plate 60 ensures that the recess keeps its shape even in cases when an insulating material 42 is used which is soft and has very little supporting strength. The plate acts as a "shell" within the insulation material 42, and engages the T-shaped portion of the attachment member when it is locked in the recess.

[0056] The lower over-hanging portions 54, 56 of the locking shell (i.e. at the underside of the arms of the T-shape) provide surfaces parallel to the layer 44 which are able to support the downward force (in the Y-direction) when the attachment member is locked in the shell. These portions of the shell are therefore the most important for secure and firm attachment of the roofing sheet 30 to the beam 32.

[0057] Figure 10 shows an alternative arrangement for the bent plate 60 comprising two overlapping plates 62 and 64. These plates have the advantage in that they can be inserted through the hole in the layer 44 when the soft insulating material is already in place. It is more difficult to insert the plate 60 shown in Figure 9 through the hole in the surface 44. Instead, in the case of Figure 9, the plate 60 is positioned by inserting the two wings through the hole from the insulating side of the layer 44. This must be done before the outer layer 40 sandwiches the insulating material 42 along with the inner layer 44. It will be apparent that a two-part shell of this kind is also suitable for use at the abutment of two adjacent panels, with one plate 62 being installed at the edge of one panel and the other plate 64 being installed at the edge of the other panel.

[0058] In a further (unillustrated) alternative, the plate 60 could be integral with the surface 44 rather than being an extra attachment. In other words, the recess 46 would be formed by appropriate bending or moulding of the inner plate 44. In this case, the roofing sheet 30 can be manufactured by juxtaposing the outer layer 40 with the inner layer 44 and simply filling the gap between these two layers with foam or similar insulating material, e.g. by foaming in situ with the shells 60 in place to create the recesses 46 with the insulating material.

[0059] Figure 11 shows an alternative embodiment of recess being a modification of the Figure 9 embodiment. However, the modification is equally applicable to the Figure 10 embodiment, or the embodiment where the plate 60 is integral with the surface 44. The modification comprises providing two holes 66 in the surface of the plate 60 in the lower over-hanging portion 54, 56 of the T. These holes do not necessarily run the whole length of the recess in the Z-direction although they could do if required. More preferably, they are limited in the Z-direction. The holes 66 serve to provide locating holes for projections 68 on the attachment member (see Figure 12). These holes may be in any suitable shape, for example square, circular etc.

[0060] An attachment member particularly for use with the recess of Figure 11, but also useable in any of the described embodiments is shown in Figure 12. The attachment member 48 comprises a top section 52 substantially in the form of a T and a bottom section 50 having various holes for attaching the member 48 to a beam. The holes 70 and 72 are designed to allow for some adjustment of the attachment member as it is screwed in. In Figure 12, the holes are such that a substantially horizontal adjustment is possible, although the holes could be oriented 90° to those shown to provide for a vertical adjustment. Preferably, both a horizontal and vertical adjustment can be allowed by the prudent choice of size and shape for the holes 70 and 72. At the lower over-hanging portions (i.e. the underside of the arms) of the T-shaped sections 52 are provided projections 68. In Figure 12, these projections are shown as triangular but they may take any suitable shape. The projections are for engagement with the holes 66 in the recess shown in Figure 11.

[0061] A method of attaching a roof section 30 to a beam 32 using the recess shown in Figure 11 in the roof section 30 and an attachment member as shown in Figure 12 will now be described.

[0062] Firstly, the roof section 30 is positioned correctly relative to the beam 32. An attachment member 48 is then inserted into each recess of the roofing sheet 30 by turning it by 90° and pushing upwards. Once the attachment member is completely inside the recess to its limit it is once again turned by 90° so as to be in the positions schematically shown in Figures 3 and 4. The attachment member 48 is then positioned in the recess 46 so as to have a correct longitudinal positioning, i.e. a correct position in the Z-direction (perpendicular to the plane of Figures 11 and 12). This longitudinal positioning may advantageously be provided by the locating of the projections 68 within the holes 66. In other words, the attachment member 48 may be slid in a the Z-direction until the projections 68 fall into the respective holes 66, at which point it is no longer possible to slide the member. If the holes 66 run the entire longitudinal length of the roofing sheet 30 positioning in this direction should be done by conventional means (e.g. by measurement).

[0063] In Figure 12, the shape of the projection 68 is such that the tips of the projections 68 dig in to the insulating material 42. This further serves to lock the attachment member 48 into position with the projections 68 protruding into the holes 66. To ensure good location, the attachment member 48 is preferably pulled downwards as the next step of the method.

[0064] The final step of the method comprises attaching the part 50 of the attachment member 48 to the beam 32 using screws passed through the holes 70 and 72 and into the beam 32. Advantageously, the top surface of the beam 32 is in contact with the lowest surface of the roofing sheet 30 which in this example will be the bottom surface of the plate 60.

[0065] With a construction according to the above mentioned method, the roofing sheet 30 is securely and firmly attached to the beam 32 without the need to pierce the outer surface 40 of the sheet and without the need to work on the roof itself. All of the attaching steps may be performed inside the building being constructed. Further, the T-shaped recess and attachment part 52 provide that the roof is supported in substantially all directions.

[0066] Figure 13 illustrates a close-up of part of a roofing sheet 30 of the type shown in Figure 3. As well as having the modification shown in Figure 11, this embodiment allows for a fascia 74 to be provided on the inner surface of the roofing sheet 30. The fascia 74 is gripped between the member 60 and the inner layer 44 of the roofing sheet 30. The fascia 74 provides a more aesthetic appearance to the inside of the roof. For the Figure 13 embodiment, it could be made of any suitable material including moulded plastics, bent metal etc.

[0067] Figure 14 shows a modification of the embodiment shown in Figure 13. In Figure 14 the surface 44 has been dispensed with so that the insulation material 42 is retained solely by the fascia 74 and the bent plate 60.

[0068] A yet further embodiment is shown in Figure 15. In this case, the plates 60 are provided with an extra protrusion at their lower surface so as to form a pair of flanges 75a, 75b, to grip a substantially board-like sheet 76. This could be simple plasterboard or any type of wood to provide a more natural finish. Alternatively, man-made wood board such as plywood or MDF (medium density fibreboard), chipboard or metals such as steel, aluminium, copper, lead or zinc could be used. Furthermore, plastics, plastic woods, asbestos or non-asbestos cement fibre may be used in a plain moulded form or with other adjacent facings.

[0069] The embodiments of Figures 16-19 use an outer layer 40, suitably of steel, whose profile shows generally plane valley portions 40a alternating with ridges 40b. Alternatively the valley portions may be curved. The outer layer is formed with a series of small steps 43 to give the appearance of overlapping roof tiles.

[0070] There is a T-shaped recess 46 defined by a two-piece metal shell 60 (cf Figure 10) on the centre line of the panel. The shell 60 comprises two generally S-shaped plates 62, 64 with right-angled corners. One of the plates 62 has a top part which extends for substantially the full width of the T-shape. The other plate 64 has a shorter top part which underlaps the top part of plate 62. The lower parts of each S-shape are modified to form flanges 75a, 75b as described with reference to Figure 15.

[0071] At each lateral edge of the panel there is a recess 46a, 46b corresponding to a portion of the top section of a T-shape i.e. an indent into the edge face of the insulating layer. These recesses 46a, 46b are defined by respective metal plates 62, 64 of generally S-shaped configuration corresponding to the two pieces which form the shell 60. When two adjacent panels are brought together edge to edge, the recesses 46a and 46b combine to form a T-shaped recess similar to the T-shaped recess 46 at the centre of the panel. The insulating material 42 above the recesses 46a, 46b extends further (e.g. by about 5mm) beyond the faces 63, 65 of the plates 62, 64, so that when the insulating material of two adjacent panels is brought together there is a space between the faces 63 and 65 which forms the stem of the T-shaped recess. As shown in Figure 17B, the T-shaped part 52 of attachment members 48 may be inserted between the abutting edges of adjacent panels 41a and 41b which overlap at joint line 45. The attachment member can be inserted when aligned with the Z-direction (see Figure 4), and can then be rotated through 90° so that the top section of the T-shaped part 52 enters the facing recesses 46a and 46b of the two panels and engages therein. The fixing portion 50 of the attachment member can then be secured to the beam 32 by fixing devices such as screws, nails or the like through the holes in the fixing portion 50.

[0072] The metal plates 62 and 64 define the arms 46a and 46b of the recess and also the surfaces 63 and 65 at the sides of the upright members or of the stem of the T-shaped recess.

[0073] In making the roofing panel, metal plates 62 and 64 are located in the appropriate positions relative to the inner layer 44 (with overlapping plates 62, 64 forming a shell 60 on the centre line), the outer layer 40 is placed at the appropriate distance from the inner layer 44, and foam insulation is injected into, or is formed in situ in, the space between the inner and outer layers. The foam enters into the channels 41 on the underside of the ridges 40b, and also surrounds the shell 60 and the metal plates 62, 64 to hold them in position. A sealant tape or fire tape 80 may be applied to the exposed edge of the insulating layer above the recesses 46a, 46b.

[0074] Figure 18 shows a combination of two embodiments which are generally similar to that of Figure 16 except as regards the lower layer. On the left hand side of Figure 18, the lower layer 84 is shown as being substantially thicker than in the previous embodiments. It comprises plasterboard, MDF, metal, timber or a similar

finishing material which suitably will provide an aesthetic appearance to the panel. It can be routed, as shown at 85, to give the appearance of timber boards. At each edge, the layer 84 is bifurcated to form an upper flange 86 and a lower flange 88. The upper flange lies between the insulating layer 42 and the lower flange 75b of the metal plates 64 and 62, the flange 75b being received in a channel between the flanges 86 and 88. The lower flange 88 of the layer 84 extends further than the upper flange 86 so that it covers the opening of the recesses 46. It can be routed at the joint line so that the joint is not conspicuous. This flange 88 can be penetrated at appropriate locations to insert attachment members through it into the recesses.

[0075] On the right hand side of Figure 18, the lower layer 84 is the same as on the right hand side, but there is a metal liner 90 interposed between it and the insulating layer. This is to improve the fire rating if for example timber or MDF is used as the lower layer.

[0076] Figure 19 shows an embodiment similar to that of Figure 16 except that two additional S-shaped metal plates 92 (similar to those at the edges) have been installed, extending for the length of the panel parallel to the central recess 46 and locking section 60 and spaced on either side there of at approximately one quarter and three quarters of the width of the panel. These shaped metal pieces do not function as locking sections but acts as reinforcements to improve the stability of the panel if desired. The locking sections 62, 64, as well as the reinforcements 92, have a single flange at the foot thereof, the flange being located between the insulating layer 42 and lower layer 44 (as in Figure 9). Holes may be cut through the lower layer 44 at appropriate locations for inserting attachment members

[0077] Figure 20 shows a structural tray 100, suitably of metal, for use as the lower layer of a panel according to the invention. The tray 100 has a base 102 and edge walls 104 with out-turned shelves 106 at the top of the edge walls. There are slots 108 in the edge walls spaced at suitable intervals along the length thereof (Z-direction) corresponding to the spacing of beams. The metal cut to form each slot 108 has been turned down through 90° to form an over-hanging portion 109 similar to the lower over-hanging portions 54, 56 described above against which the arms of the T-shaped portion 52 of an attachment member 48 will act. Each slot 108 has a length sufficient to accommodate the top section of a T-shaped attachment member which has been inserted between the edge walls 104 of adjacent panels and then turned through 90° to engage the arms of the T-shape into the slot 108 and against the over-hanging portion 109. Alternatively each slot may have a length similar or slightly greater than the width of a beam in the Z direction, so that attachment members may be inserted at either or both end(s) of the slot in the manner described above with reference to Figures 6-8. In this embodiment the upright or stem part of the T-shaped recess may extend for the length of the roofing sheet but the perpendicular arms of the T-shaped recess (which provide the locking configuration) may be located only at positions corresponding to the spacing of beams.

[0078] Figure 21 shows an alternative form of structural tray having inwardly turned shelves 110 but otherwise similar to that of Figure 20.

[0079] A structural tray may be used, having the profile shown in Figure 20 or 21 but with one or more T-shaped recesses 46 for insertion of attachment members. It may be convenient to form the shell of the T-shaped recess(es) by shaping of the material of the structural tray.

[0080] When the roofing panels are being secured to wooden beams, simple attachment members as shown in Figure 12 will generally be sufficient. However in some circumstances, for example when the panels are being mounted on steel purlins (see figure 26), it may be necessary or desirable to extend the attachment member. Figures 23 shows an extension piece 120 comprising a rectangular strip of metal similar to the attachment member 48 with holes 122 for securing the extension piece to the substrate (e.g., beam, purlin or the like). At the top of the extension piece there are tabs 124 which hook into the slot 72 of the attachment member 48.

[0081] Figure 24 shows a form of T-shaped spring clip 130 to be used at edges of the roofing panels instead of an attachment member 48. The clip 130 is of bent metal plate with the stem of the T-shape being formed by two parallel upright portions 132 and the arms of the T-shape being formed by outwardly bent (over-hanging) portions 134 which terminate in a curved-down portion 136.

[0082] Figure 25 shows a alternative form of attachment member for use at the edge of a roofing panel and/or in locations where access to a beam is restricted. The attachment member has a fixing portion 150 comprising two plates 151, 152 at right angles to each other for fixing to front and top faces of a beam respectively. A stem portion 153 extends upwardly from the plates 151, 152 and is then bent to form one arm 154 of a T-shape (or an inverted L-shape). This arm 154 is suitable for engagement in a recess 46a such as shown in Figure 16.

[0083] Figure 26 is a side view of two overlapping roofing panels 160, 161, each comprising an outer layer 162, an insulating layer 163 and an inner layer 164. The over lapping edge of panel 161 forms a step similar in appearance to one of the pre-formed steps 43 shown in Figure 17. The joint is supported on a steel purlin 165. An attachment member 48 and extension piece 120 (not shown) may be used to attach a roof panel to the remote flange 166 of the purlin.

[0084] In the above description, the recesses 46 and the part 52 of the attachment member (which have relative or corresponding shapes) are described as T-shaped. However, any suitable shape which performs the same function is envisaged. For example, an inverted L-shape or E-shape, a F-shape, or a Y-shape would be appropriate. Virtually any shape having a single up-

right member with one or more generally perpendicular protrusions or arms from that member will function in the required fashion. At peripheral edges of a roof, where there is no adjacent roofing sheet, inverted L-shaped or F-shaped members will be particularly suitable.

[0085] The outer surface 40 of the roofing sheet 30 is typically made of metal such as steel but may be made of any natural or man-made product. These include asbestos or non-asbestos cement fibre, timber, shingles, aluminium, copper, lead, zinc, nylon, plastics such as polyvinylchloride or polypropylene, any of which are usually pre-formed in the shape traditionally used for roofing on dwellings or buildings e.g. a stimulated roofing tile formation. A substantially sinusoidal profile is depicted in Figures 3 to 8 and a ridge valley profile is depicted in Figures 16-19, although any shape is intended to be within the scope of the present invention.

[0086] The insulation layer 42 is preferably formed of a material having good heat insulating properties such as wood, paper, rockwool, glass fibre, phenolic resin polystyrene, polyurethane, hard foam, non-combustible insulating sheet, chemical foamed insulation, expanded insulation or extended insulation. The insulating layer 42 is preferably bonded to the outer layer by a bonding agent or activator. Adhesives are also suitable. The insulation may be rolled onto the outer surface 40 and adhered thereto or it could be formed on the outer surface 40, eg by spraying a foam. Most suitably it is foamed insulation, i.e. insulation which is foamed in situ between the outer layer 40 and the inner layer 44, 74 or 76.

[0087] The attachment members 48 and locking sections 60, 62, 64 may be formed of any suitable material but are preferably a metal such as galvanised steel. Alternatively, structural plastics such as high density polypropylene, polyimide resins or polyamide resins may be used for either the attachment members or locking sections. They may suitably have a thickness in the ranges of 0.5mm - 2.5mm, particularly 1.0 - 2.0mm, e.g. about 1.3 - 1.6mm.

[0088] The total thickness of the roofing sheet of the present invention is typically in the range of 10 to 250 mm and is preferably 35 to 120 mm. The thickness of the individual layers shown in the accompanying drawings are purely schematic. In fact, the top layer 40 suitably has a thickness of between 0.1 to 5 mm (more preferably 0.4 to 1.5 mm, typically 0.6 mm) and the inner layer 44 has a similar thickness range to this.

[0089] The term "beam" is used herein to cover any suitable structural support for a roofing sheet, including timber or steel, and including a purlin.

[0090] Terms such as "upper", "lower", "top", "bottom", "up" and "down" are used herein to refer to the orientation of the assembly as shown in the drawings and are not intended to have any limiting effect.

Claims

1. A method for attaching roofing sheets to a beam, said method comprising:

   providing roofing sheets having an outer surface and an inner surface, and having shaped attachment recesses which are at the inner surface and do not pierce the outer surface,
   providing attachment members having shaped portions which are retainable within said attachment recesses,
   and inserting said portion of said attachment members into said recesses and retaining them therein,
   wherein said attachment members are integral with the beam or are attached to the beam in another step.

2. The method of claim 1 wherein the step of retaining an attachment member within an attachment recess comprises inserting the attachment member into the recess in a first orientation, and rotating the attachment member so as to be in a second orientation.

3. The method of claim 2 wherein the step of retaining the attachment member with the recess effects a locking of a portion of the attachment member in the recess.

4. The method of any preceding claim wherein the attachment recesses are at the inner surface of the roofing sheet, and the attachment members are inserted therein from the inner surface.

5. The method of any preceding claim wherein the roofing sheets are assembled such that corresponding recesses in edge surfaces of adjacent roofing sheets together define an attachment recess to receive an attachment member.

6. The method of any preceding claim wherein the attachment member is connected to the beam using screws passed through holes in the attachment member.

7. The method of any preceding claim wherein the recess comprises one of a locating hole and a locating protrusion and the attachment member comprises one of a corresponding locating protrusion or a corresponding locating hole, and the corresponding holes and protrusions are engaged after the step of retaining the attachment member to the recess so as to provide for correct positioning of the attachment member in the recess.

8. The method of any preceding claim further compris-

ing the step of supporting a fascia parallel to said one surface or inner surface of said roofing sheet.

9. The method of any preceding claim wherein the roofing sheet comprises a plurality of recesses and a different attachment member is retainable in each recess, a plurality of recesses and a respective plurality of attachment members are provided, and said method further comprises the step of:

retaining each of said plurality of attachment members within a respective one of said plurality of recesses.

10. A roofing sheet comprising:

an outer surface;
an inner surface;
at least one shaped attachment recess on said inner surface for retaining an attachment member.

11. The roofing sheet as claimed in claim 10 wherein the recess is substantially T-shaped in a plane perpendicular to said one surface or inner surface of said roofing sheet.

12. The roofing sheet as claimed in claim 10 or claim 11 wherein the recess has a dimension in the plane of said inner surface which is substantially equal to, or greater than, the width of an attachment part which is intended to be inserted into said recess.

13. The roofing sheet as claimed in claim 12 wherein the recess is larger than the width of an attachment part to be inserted and has a similar length to the thickness of a beam which the sheet is intended to be attached to.

14. The roofing sheet as claimed in any of claims 10 to 13 wherein a plurality of said recesses are provided on said inner surface.

15. The roofing sheet as claimed in any one of claims 10 to 14 wherein the recess is formed from a shell surrounded by insulating material.

16. The roofing sheet as claimed in claim 15 wherein the shell is:

a separate component formed from a single piece of material, or from two separate pieces of material, or
integral with the inner surface of said roofing sheet.

17. The roofing sheet as claimed in claim 15 or 16 wherein the shell has at least one hole in it to engage with protrusions formed on the attachment member.

18. The roofing sheet as claimed in any one of claims 10 to 17 wherein the outer layer is formed from steel and there is an insulating layer provided between said outer layer and said inner layer.

19. An attachment member or clip for use with the method of any one of claims 1 to 9, comprising a first portion having means for attachment to a beam and a second portion having shaped means for being retained in a shaped attachment recess in a roofing sheet.

FIGURE 1

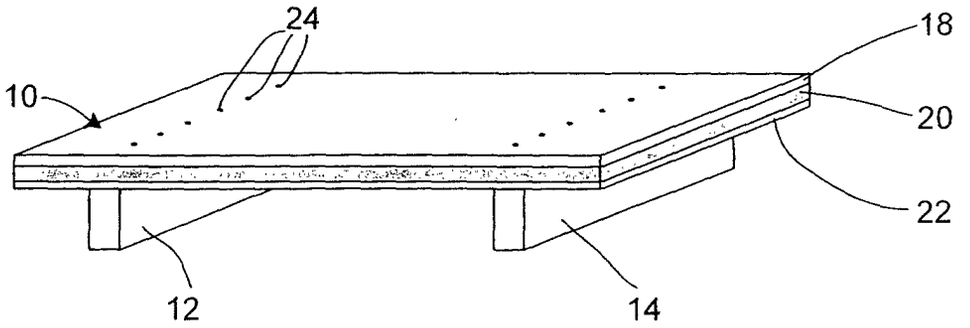


FIGURE 2

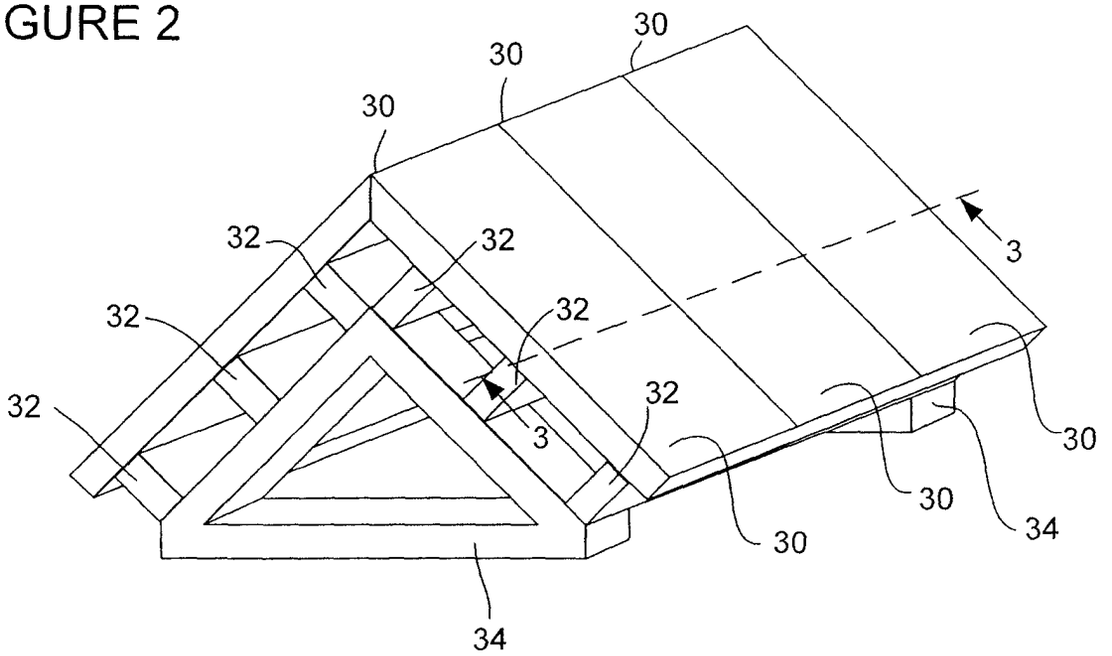


FIGURE 3

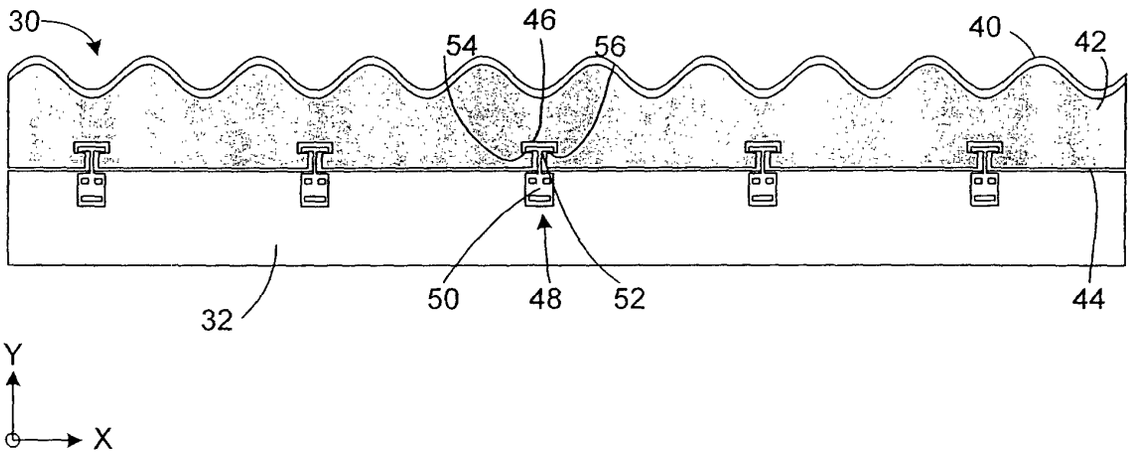


FIGURE 4

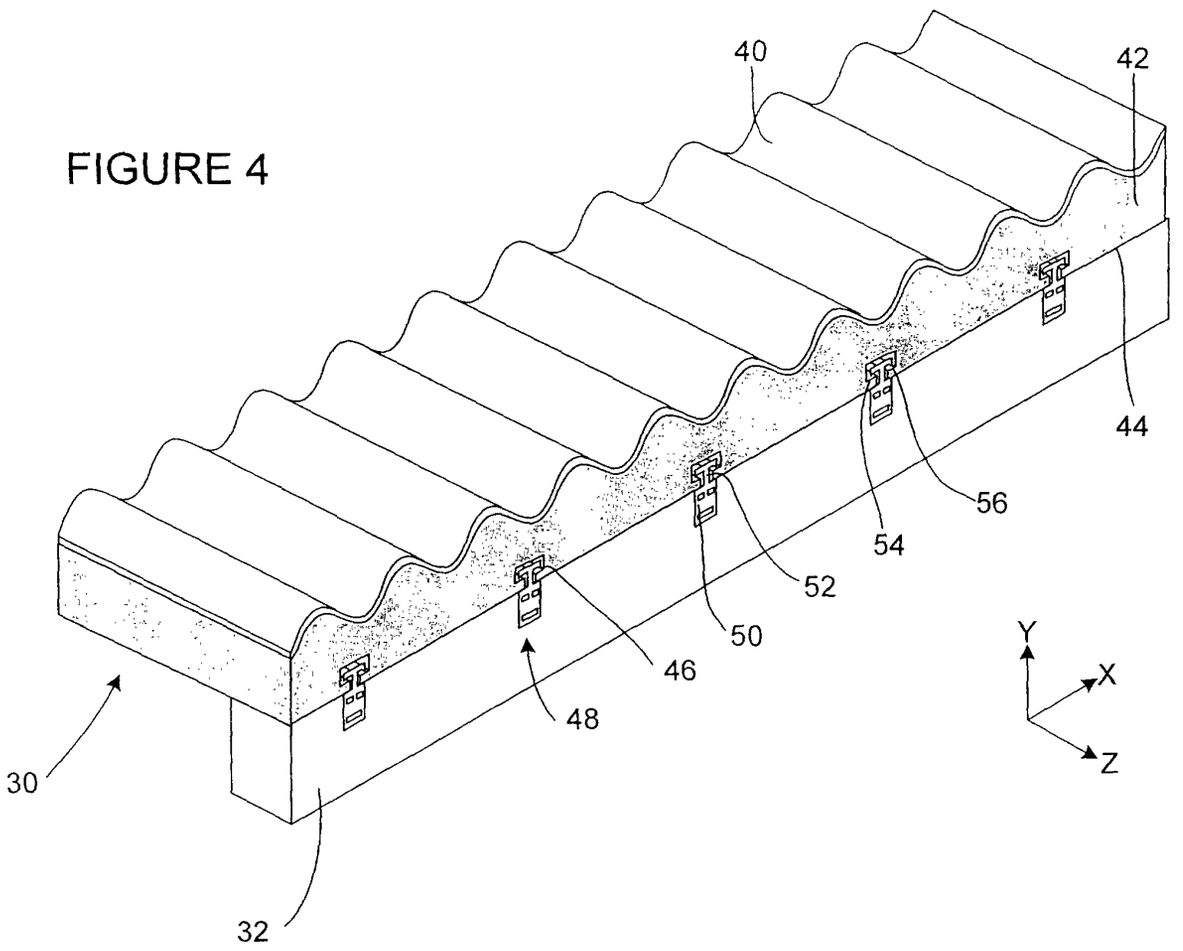


FIGURE 5

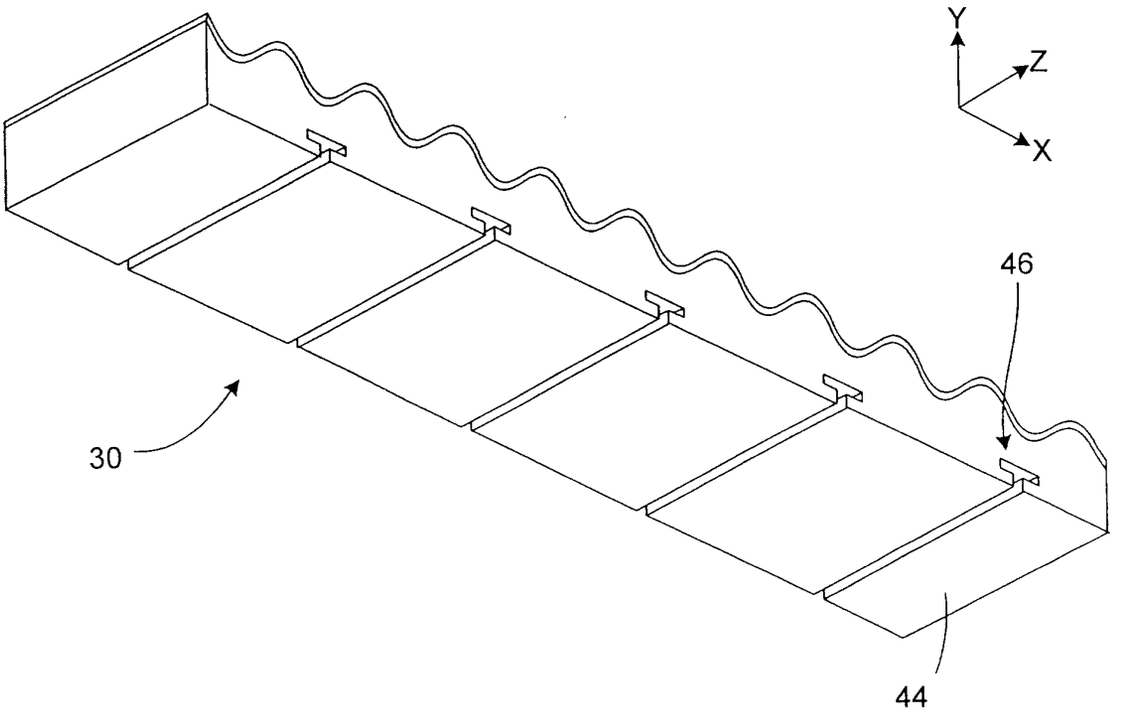


FIGURE 6

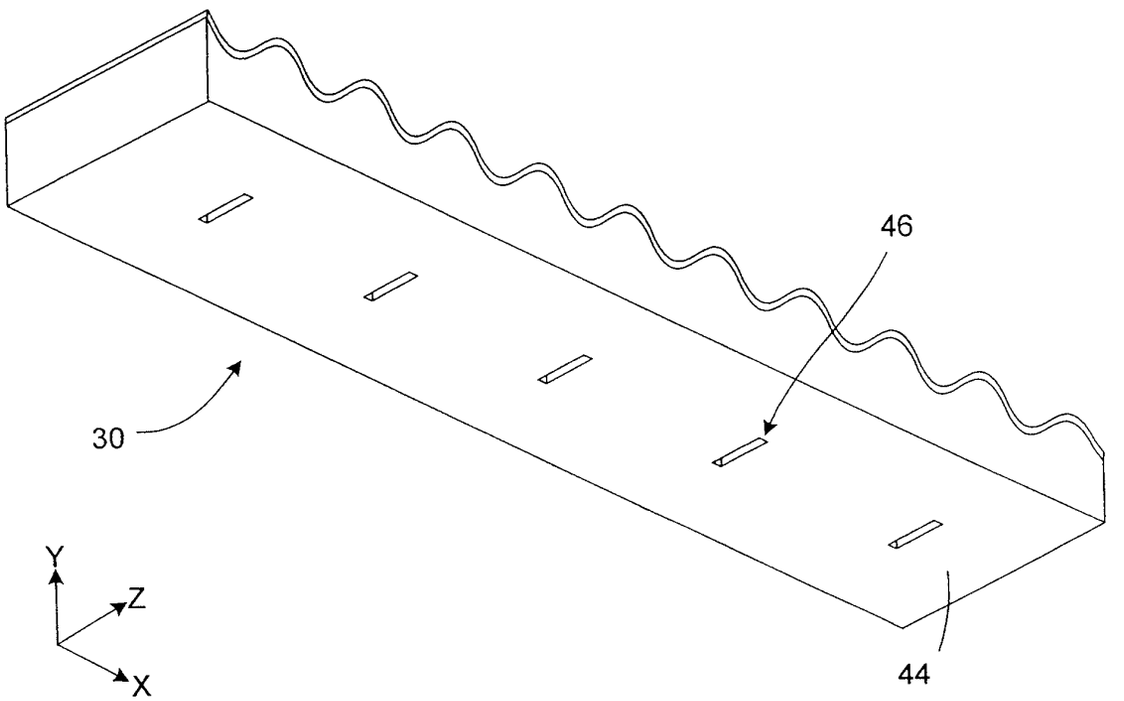


FIGURE 7

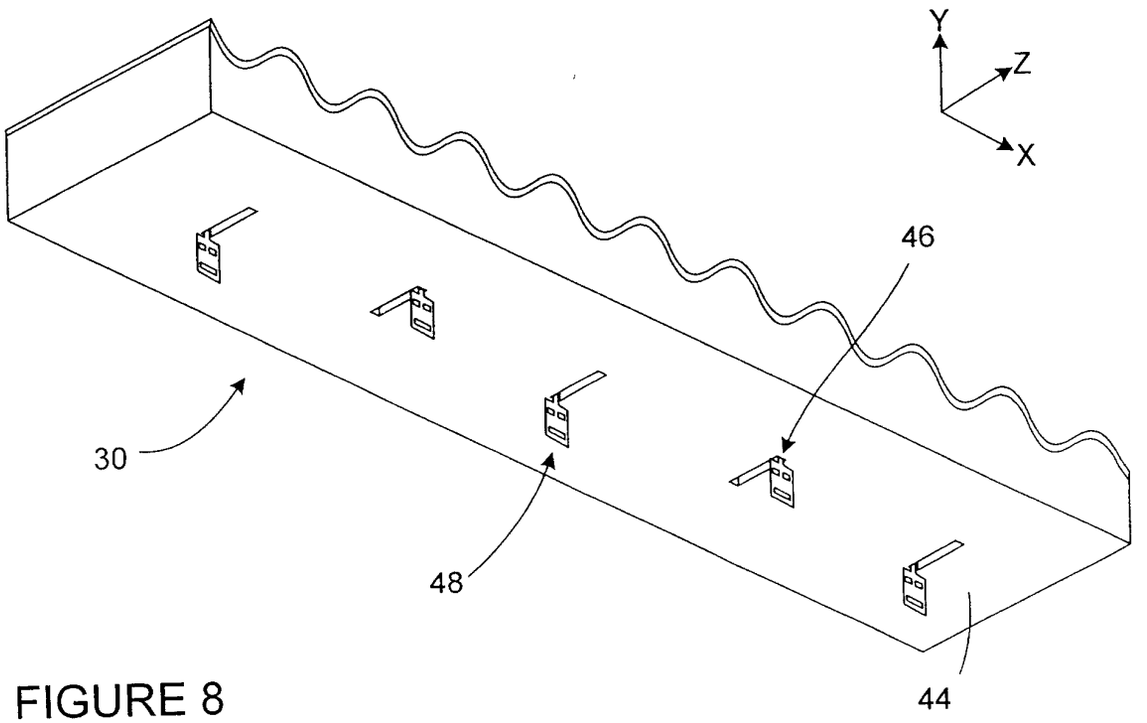


FIGURE 8

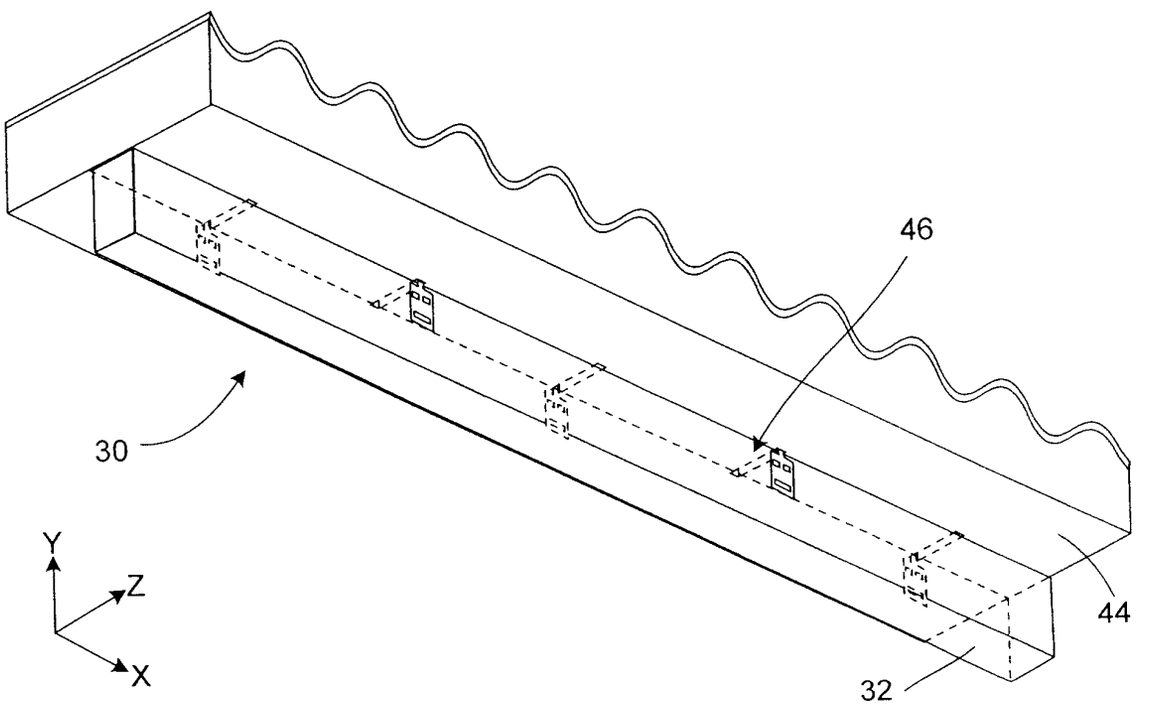


FIGURE 9

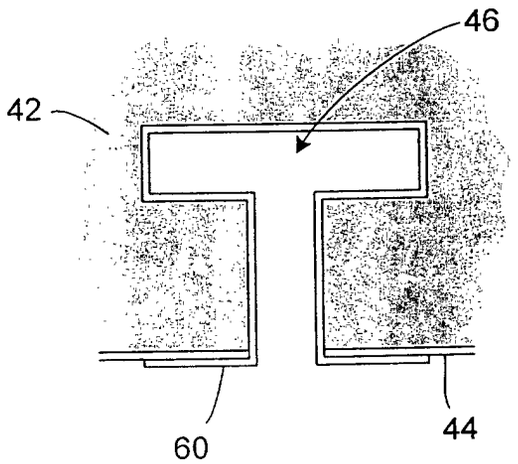


FIGURE 10

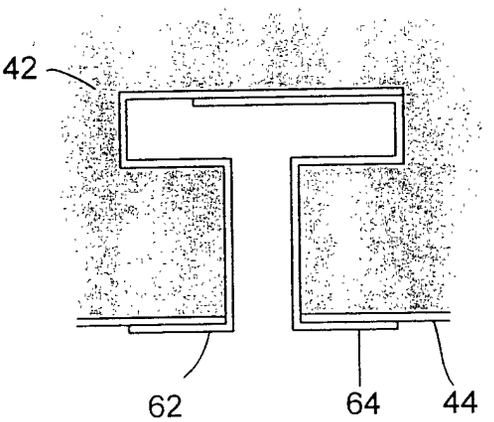


FIGURE 11

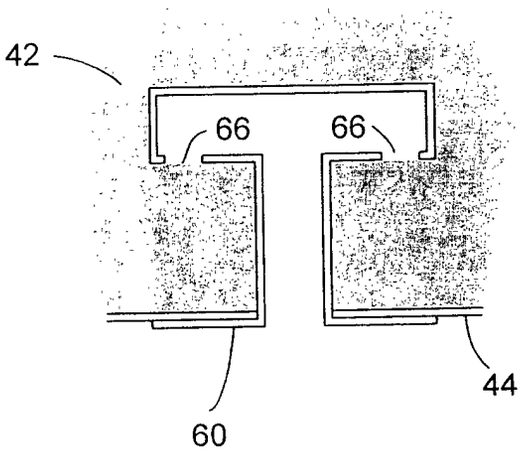


FIGURE 12

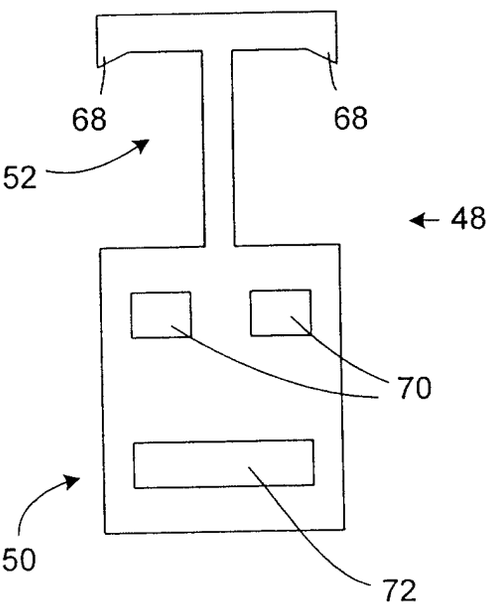


FIGURE 13

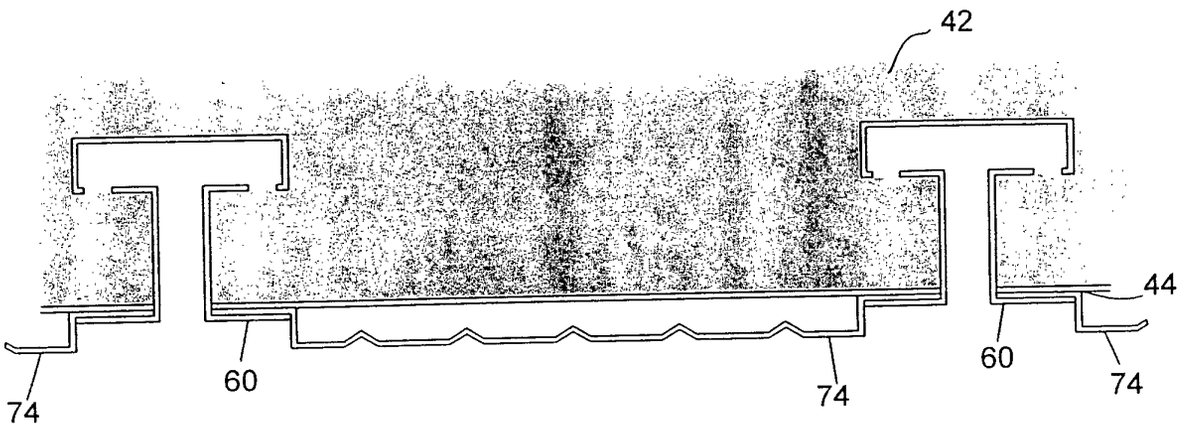


FIGURE 14

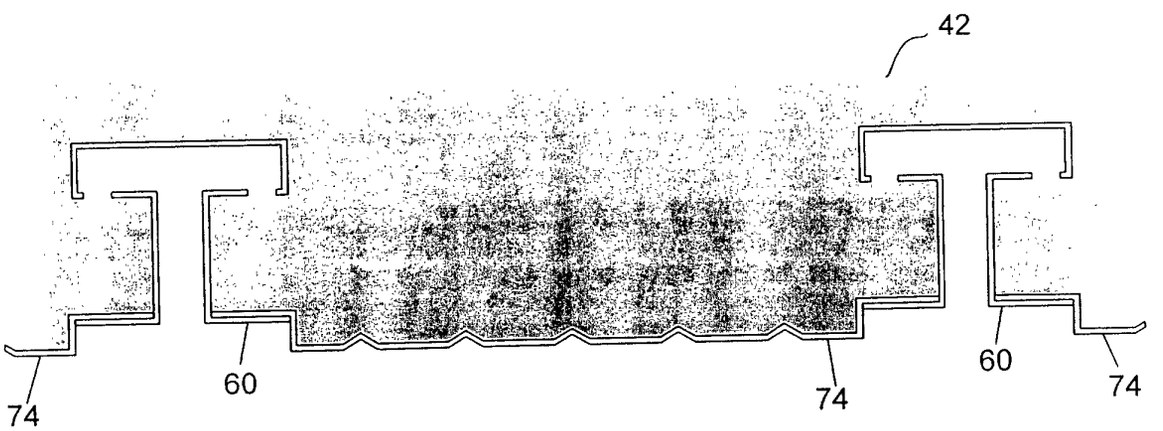
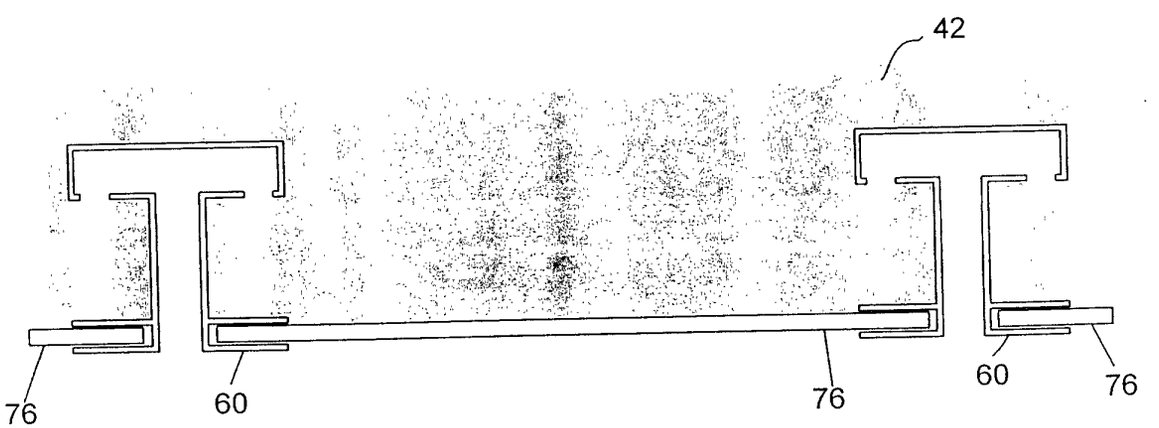


FIGURE 15



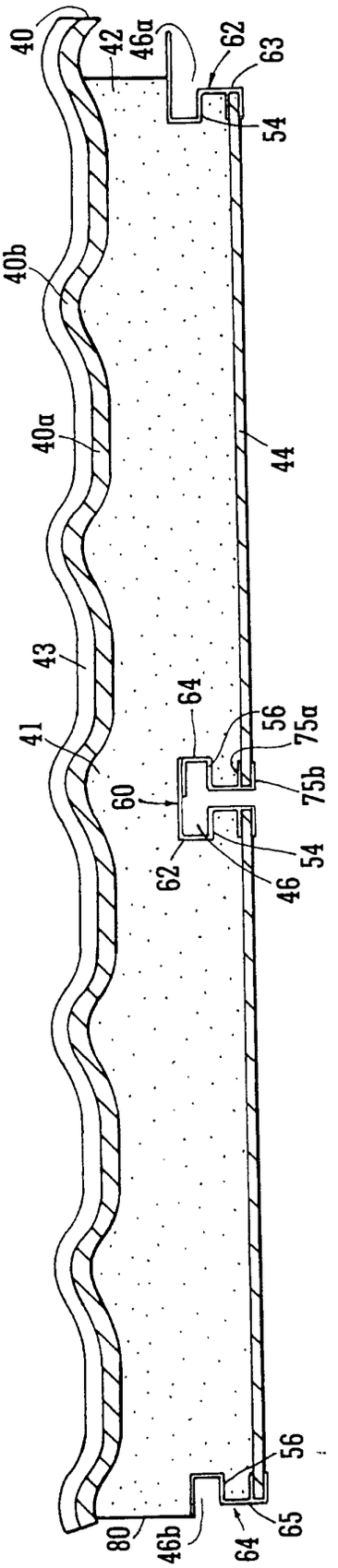

40
42
46a
62
63
54
40b
40a
44
43
64
56
75a
41
75b
60
54
62
46
56
80
46b
64
65

FIG. 16

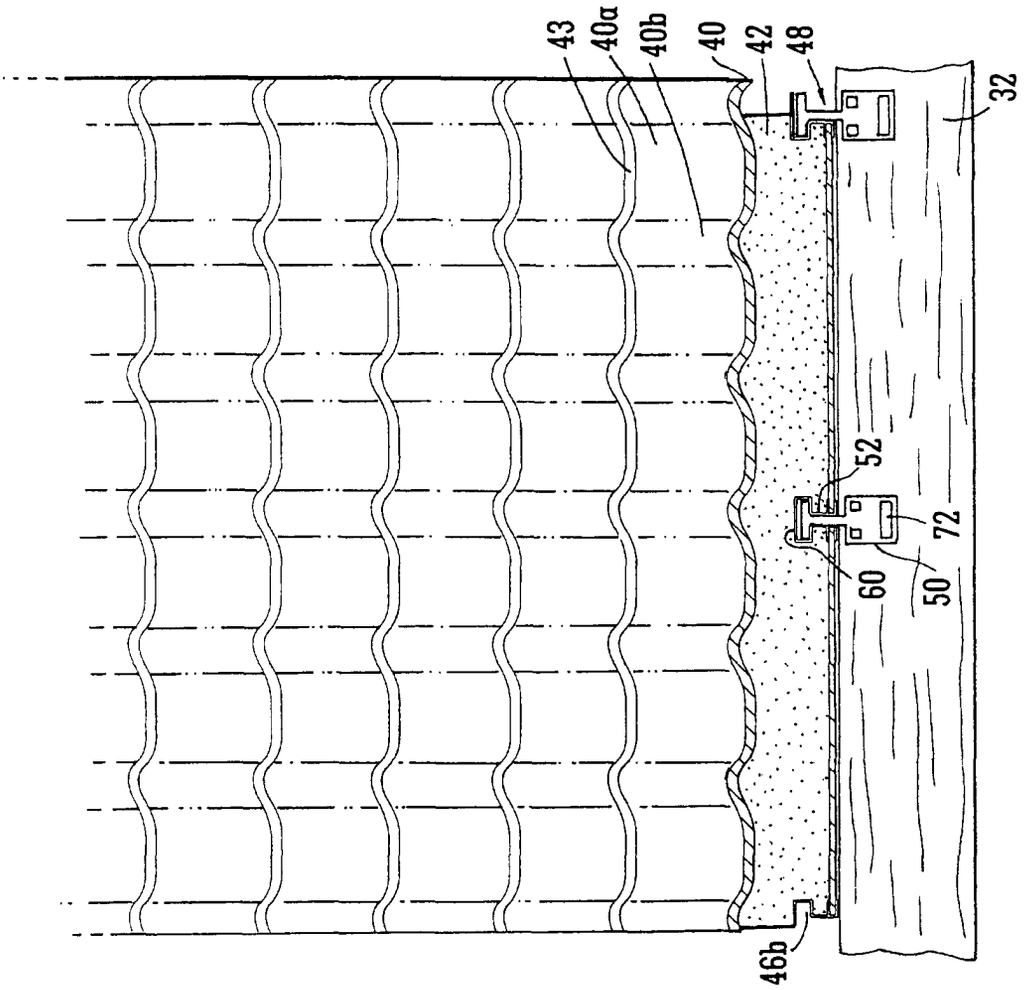
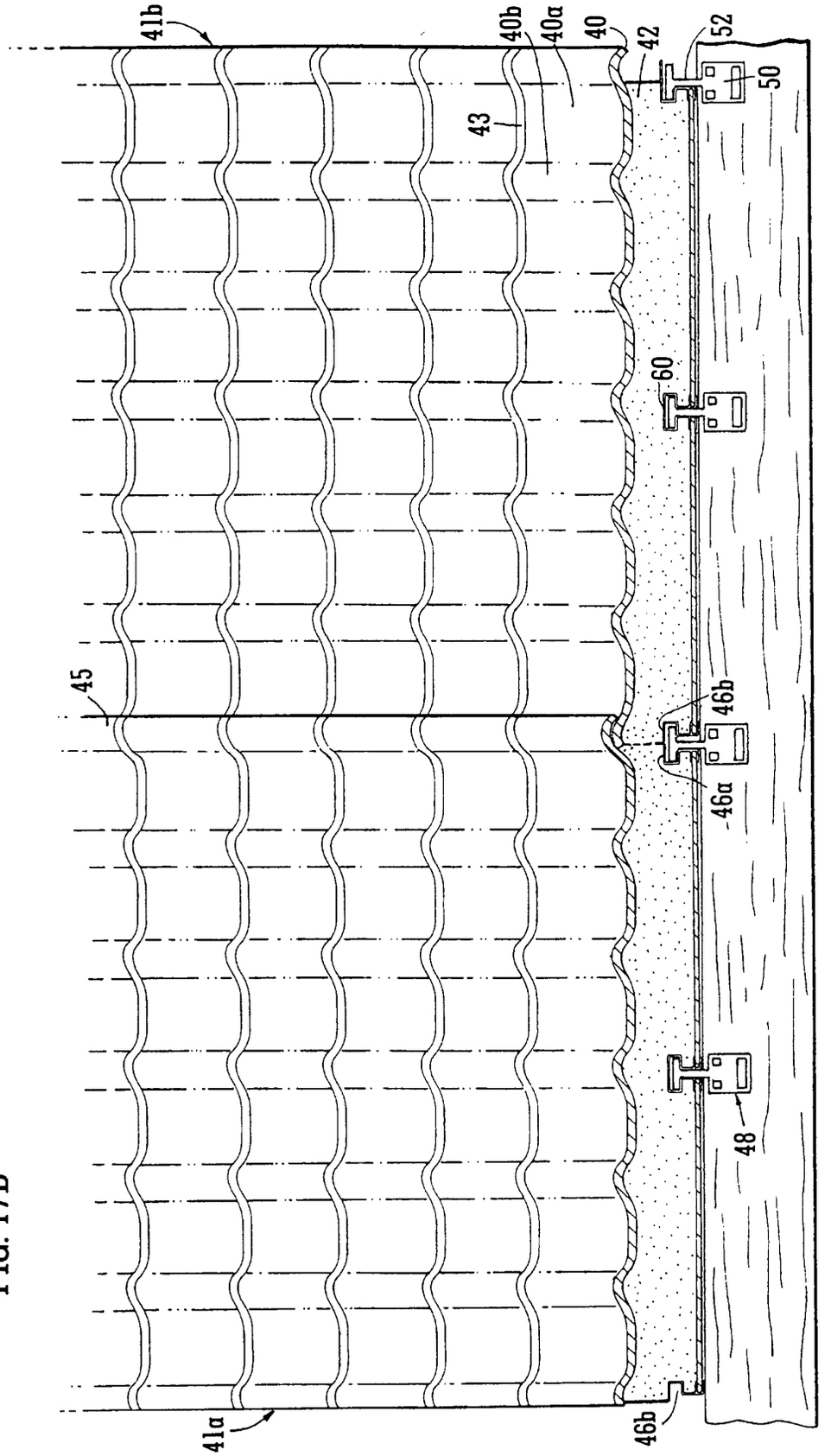


FIG. 17A

FIG. 17B



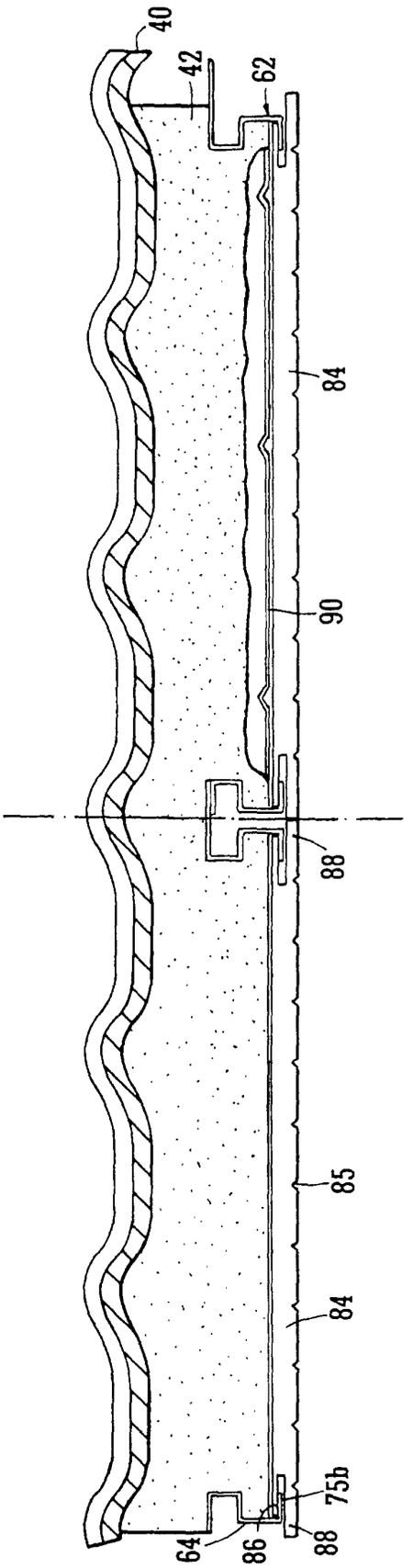


FIG. 18

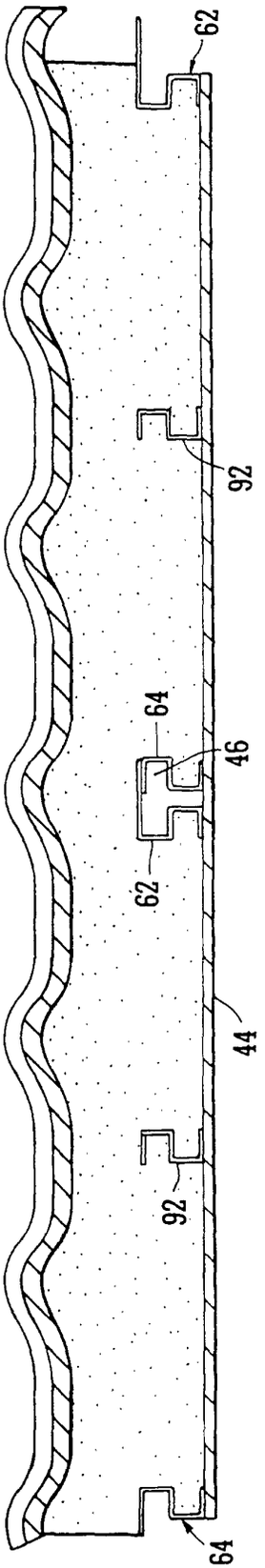


FIG. 19

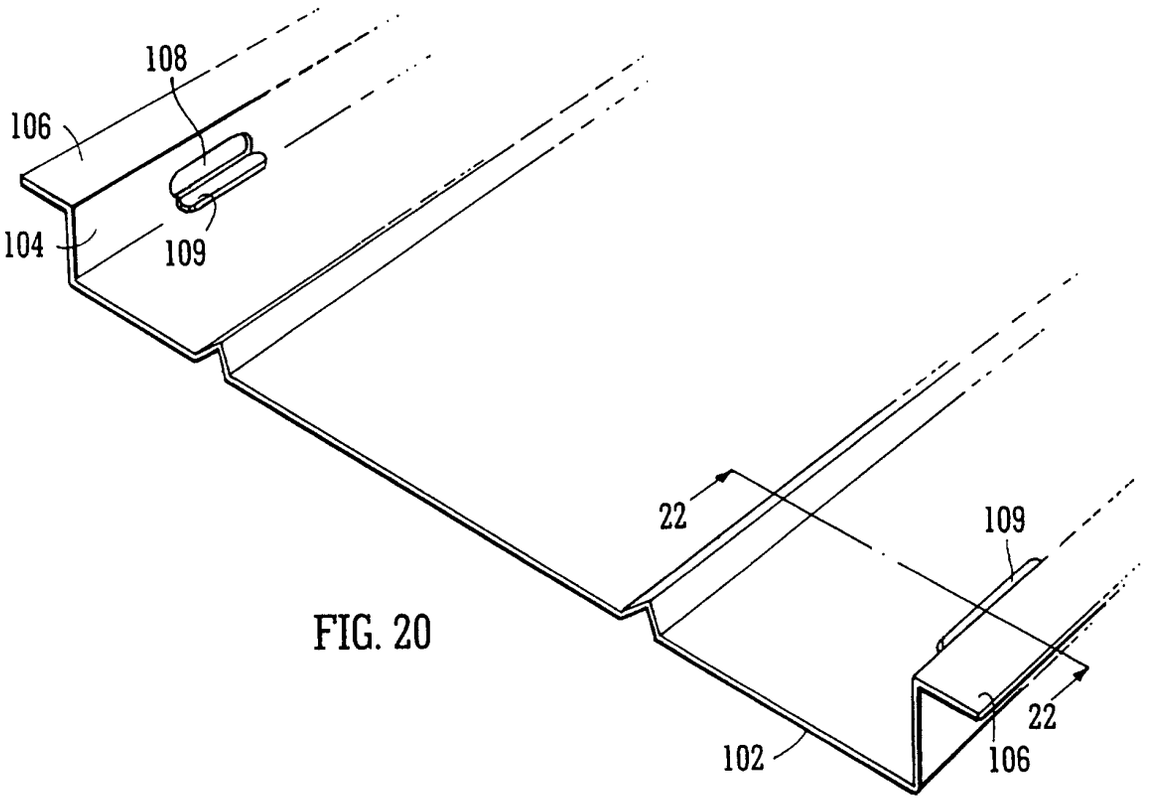


FIG. 20

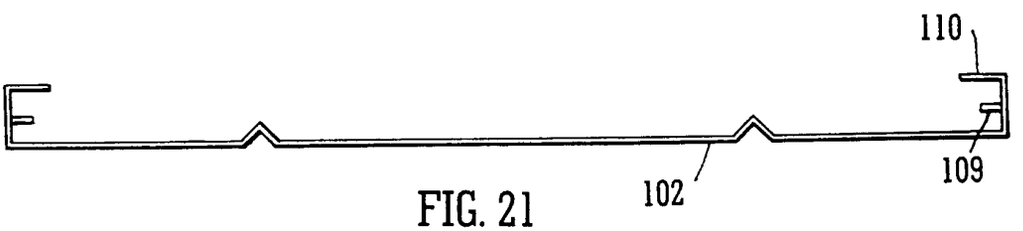


FIG. 21

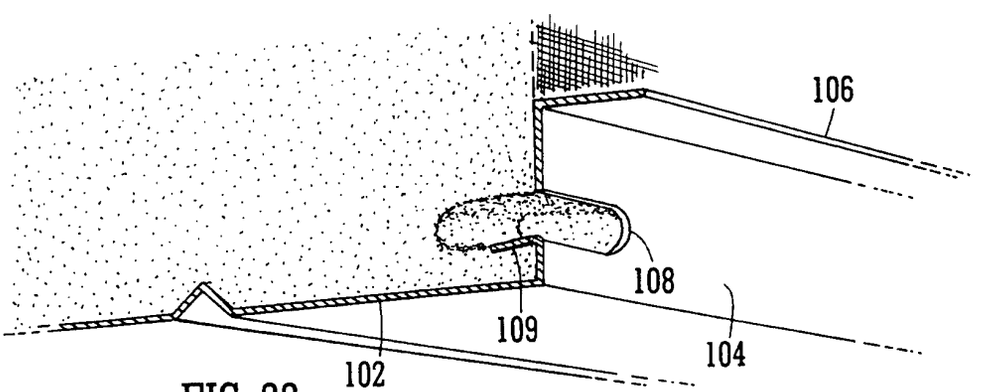


FIG. 22

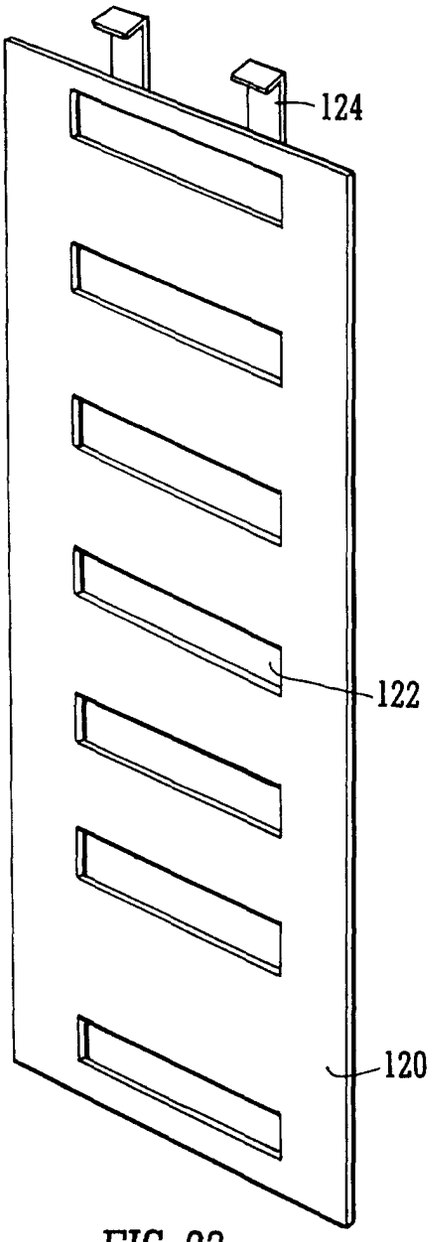


FIG. 23

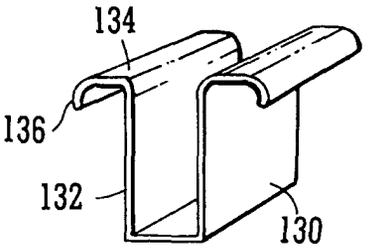


FIG. 24

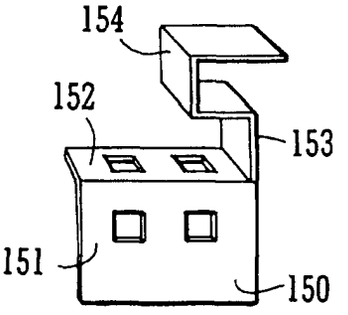


FIG. 25

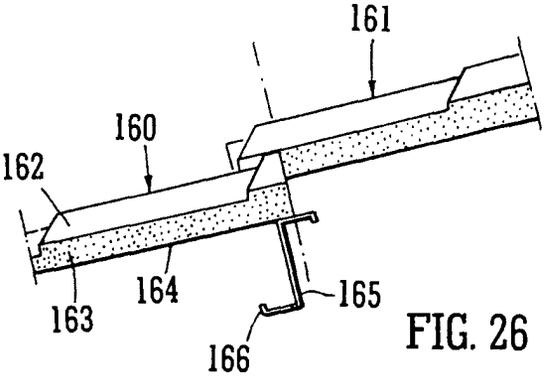


FIG. 26