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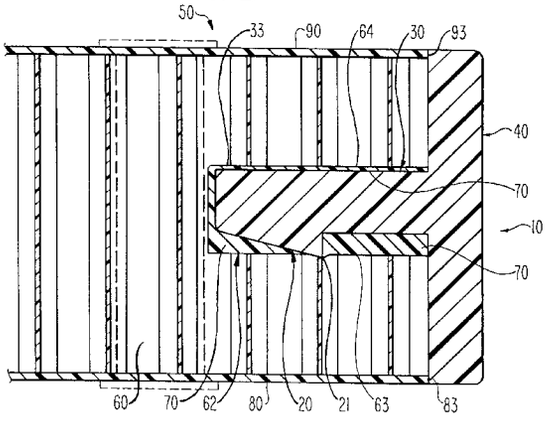
(54) A panel edge closeout.

(57) A panel edge closeout (10) arrangement comprises first (80) and second panel skins (90) with a honeycomb core (60) therebetween. The peripheral edges (83,93) of the panel skins are aligned, and the peripheral edge of the honeycomb core has a core slot (62) cut therein. An extruded panel edge closeout has a web portion (40) extending between and covering the peripheral edges (83,93) of the first (80) and second panel (90) skins and a flange portion (30) extending from the web portion (40) into the peripheral core slot (62) of the honeycomb core (60). An engaging arrangement is provided for engaging the panel edge closeout with the honeycomb core (62) to maintain the panel edge closeout (10) in place on the peripheral edges of the honeycomb panel. Preferably, projections (21) from the panel edge closeout (10) engage the walls of the core slot (62) in an interference fit and may be finally held in place with a syntactic adhesive (70).

FIG. 2



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BACKGROUND OF THE INVENTION

1) Field of the Invention

The present invention relates to an arrangement for closing out the edge of a honeycomb panel, in particular honeycomb panels employing graphite skins.

2) State of the Prior Art

Panels, such as floor panels used in aircraft, have been made from panel skins which have a honeycomb core material therebetween. Both graphite and glass panel skins have been used for these types of honeycomb panels.

In the above-types of panels, the panel skins have peripheral edges with the periphery of the honeycomb core located between the peripheral edges of the panel skins. n using honeycomb panels, especially for aircraft flooring, one potential disadvantage has been that the edges of the various layers may not be flush with each other. In addition, the edges need to be protected, because it is likelier that the edges will be damaged by an impact than other parts of the panels. Such damage can occur during installation, handling and fitting. Panels can also be damaged when they are removed during aircraft maintenance. After panels have been installed, the edges thereof can also have slight gaps therebetween. This thus leaves a vulnerable area which is generally more subject to impact.

To solve the above problems, it has been known to close-out the edge of a panel, protecting the edges, raking the edges of the panel become flush with each other and decreasing the vulnerability by reinforcing and supporting the edges.

Present methods of closing out the edges of a panel involve mechanically removing the honeycomb core 1/2 to 1 cells deep about the entire periphery of the panel and then hand fill the resulting open core area with a syntactic resin. After the syntactic resin cures, the edge is either machined or hand sanded smooth and flush with the edges of the panel. However, this type of closing out of panel edges is expensive and time consuming, but yet is performed on almost all aircraft honeycomb core panels, unless they are fitted with a channel or other edge covering.

In addition, when honeycomb panels employ graphite panel skins, their edges tend to experience galvanic corrosion when in contact with metals. This can cause problems, for example when the graphite skin edge of a honeycomb panel is employed as a floor panel for a vehicle such as an airplane and is installed against aluminum seat tracks.

SUMMARY OF THE INVENTION

The object of the present invention are to provide an improved method of closing out the edge of a honeycomb panel. More particularly, the object of the present invention is to provide an arrangement and method of closing out the edge of a honeycomb panel so as to provide a significant measure of mechanical impact protection against damage, to reinforce the panel edge and to place a physical separation between the panel components and any adjacent or joining component. More particularly, a specific object of the present invention is to provide an arrangement and method of separating the edges of graphite panel skins in a honeycomb panel from any adjacent metallic components so as to avoid the generation of galvanic corrosion.

The above objects of the present invention are accomplished by the provision of a panel edge closeout arrangement which comprises first and second panel skins having respective peripheral edges, a honeycomb core between the first and second skins, with a honeycomb core having a peripheral core slot, and a closeout having a web portion extending between and covering the peripheral edges of the first and second panels and a flange portion extending from the web portion into the peripheral core shot of the honeycomb core. The flange portion has an engaging arrangement thereon engaging the honeycomb core.

Furthermore, in particular when the panel skins are made of graphite, the closeout is preferably made of an electrically non-conducting material. It is preferred that the electrically non-conducting material is an extrudable resin. Furthermore, the resin is preferably a material selected from the group consisting of acrylic, ABS, polystyrene, polyethylene, PVC, polycarbonate, acetate, butyrate, propionate, polyurethane and thermoset materials. Of the above materials, polyurethane is preferred.

According to a further preferred feature of the present invention, an adhesive may be provided in the peripheral core slots so as to bond the closeout in the peripheral core slot. The adhesive is preferably a syntactic resin, the syntactic resin comprising glass or phenolic microballoons, epoxy resin and a hardener. This syntatic resin could also comprise a polyester resin with glass or phenolic microballoons.

The first and second panel skins may also be resin imprenated fabric skins. In this case the purpose of the closeout, as discussed above, is primarily for protecting the edges and corners of the laminate skins from damage.

The peripheral core slot in the honeycomb core has opposite walls defining the peripheral core slot therebetween. The opposite walls are spaced apart by a predetermined amount, and the engaging arrangement engages at least one of the opposite walls with an interference fit. That is, the flange, at the engaging arrangement, is provided so as to be wider than the predetermined amount by which the oppo-

site walls are spaced apart. The engaging member is preferably a projection which protrudes from both sides of the flange equally. Also, the flange preferably has a tapered front end which tapers outwardly and rearwardly toward the web to a point on the flange defining the projection. Also, the flange may have a projection from one side only with the opposite side flat and without projection.

The flange can have at least one projection on each opposite side thereof engaging respective opposite walls with an interference fit. Further, the flange can also have two such projections on each opposite side thereof engaging the opposite walls of the core slot with an interference fit.

The web can also be provided with two separate flanges for two separate core slots for use in a sandwich panel employing two separate honeycomb cores to be adhered together as a double honeycomb core sandwich panel.

The above objects according to the present invention are further accomplished by providing a method of closing out the edge of a panel which has two panel skins with peripheral edges and a honeycomb core therebetween. This method comprises the steps of first providing a closeout which has a web portion and a flange portion extending from the web portion. The flange portion has an engaging arrangement thereon. A peripheral core slot is then cut in the honeycomb core, and the flange portion is inserted into the peripheral core slot, engaging the honeycomb core with the engaging member with an interference fit and covering the peripheral edges of the panel skins with the web portion. The method according to the present invention may further comprise the step of providing an adhesive in the peripheral core slot prior to inserting the flange portion so as to bond the flange position in the peripheral core slot.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of the present invention will become apparent to those of ordinary skill in the art from the following detailed description of the preferred embodiments of the invention when taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a cross-sectional side view of a panel edge closeout according to a first embodiment of the present invention;

Fig. 2 is a cross-sectional side view of a honeycomb panel employing a panel edge closeout according to Fig. 1;

Fig. 3 is a cross-sectional side view of a panel edge closeout according to a second embodiment of the present invention;

Fig. 4 is a cross-sectional side view of a honeycomb panel employing the panel edge closeout of Fig. 4;

Fig. 5 is a cross-sectional side view of a third embodiment of the panel edge closeout according to the present invention;

Fig. 6 is a cross-sectional side view of a honeycomb panel employing the panel edge closeout according to Fig. 5;

Fig. 7 is a perspective view of a honeycomb panel with a peripheral core slot having adhesive applied to a peripheral core slot;

Fig. 8 is a partial plan view of a panel edge closeout according to the present invention, with the panel edge closeout making a 90° turn with closeout slot geometry to accomplish the 90° turn with low residual stresses;

Fig. 9 is a partial cross-sectional top view of a honeycomb panel employing a panel edge closeout according to the present invention for closing out the circular edges of a hole in the panel;

Fig. 10 is a cross-sectional side view of a panel edge closeout according to a fourth embodiment of the present invention; and

Fig. 11 is a cross-sectional side view of a double honeycomb panel employing the panel edge closeout according to Fig. 10.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment according to the present invention is illustrated in Fig. 1 and 2. Figure 1 illustrates a panel edge closeout 10, and Figure 2 illustrates the panel edge closeout 10 engaged with a honeycomb panel structure 50.

The panel edge closeout 10 includes a web 40 which acts as an edge shield for shielding the edges of the panel skins of the honeycomb panel. A flange 30 is integral with the web 40 and extends from one side thereof. The flange 30 has a distal end 33 which is inserted into the honeycomb panel. The flange 30 also has an engaging arrangement 20 on one side thereof, the engaging arrangement comprising a projection 21 projecting from one side of the flange 30.

The panel edge closeout 10 can be made of acrylic, ABS, polystyrene, polyethylene, PVC, polycarbonate, acetate, butyrate, propionate, polyurethane or thermoset materials, such as phenolics, melamines, epoxy and glass reinforced materials. However, polyurethane is generally preferred, because polyurethane has good resistance to most fluids and solvents and is formulated to be self-extinguishing. Furthermore, polyurethane passes FAA requirements for deflammability of aircraft interiors.

However, a thermoset material, for example pultruded out of glass and phenolics, may be particularly preferred in applications requiring materials that are not flammable. Further possible extrusion materials include polyethermide, polysulfone, polyether sulfone, polyphenyl sulfone and poly-carbonate.

Noting Fig. 2, a honeycomb panel 50 comprises a first panel skin 80, a second panel skin 90 and a honeycomb core 60 sandwiched between the first and second panel skins 80 and 90. The first and second panel skins have first and second edges 83 and 93, the edges being aligned with each other. The honeycomb core 60 may be Nomex or glass. The first and second panel skins 80 and 90 may be a reinforced laminate such as glass or graphite/phenolic or epoxy panel skins. The honeycomb panel 50 is generally similar to the honeycomb panel described in commonly assigned U.S. Patent No. 4,956,217, which patent is incorporated herein by reference.

According to the present invention, the periphery of the honeycomb core 60 is provided with a core slot 62 extending along the periphery parallel to the panel skins 80 and 90 and opening on the peripheral edge of the honeycomb panel 50. The core slot 62 has lower and upper walls 63 and 64. The flange 30 of the panel edge closeout 10 is inserted into the core slot 62, with the projection 21 engaging one of the upper and lower walls 63 and 64 with an interference fit to hold the panel edge closeout 10 on the peripheral edge of the honeycomb panel 50.

The panel edge closeout 10 is dimensioned such that the web 40 covers and protects the edges 83 and 93 of the panel skins 80 and 90 as illustrated in Fig. 2. Further, the engaging arrangement 20 with the projection 21 on the flange 30 of the panel edge closeout 10 is dimensioned, relative to the core slot 62, such that the interference fit will be produced when the flange 30 is inserted into the core 62. That is, the core slot 62 has a predetermined spacing between the lower and upper walls 63 and 64, and the width of the flange 30 at the projection 21 is chosen so as to be wider than the predetermined spacing between the walls of the core slot 62.

According to an optional feature of the present invention, a syntactic foam adhesive 70 is provided in the core slot 62 prior to the insertion of the flange 30. When the flange 30 is inserted into the core slot 62, the syntactic adhesive 70 is displaced around the flange 30 and into adjacent core cells of the honeycomb core 60. After the adhesive has cured, there is formed an interlocking mechanical bond with the projection 21 to help retain the projection 21 in the core slot 62. The syntactic adhesive 70 can also help to increase the mechanical strength of the first and second panel edges 83 and 93 during flexure and impact. A syntactic adhesive, it is noted, is thick and non-draining, and thus has less of a tendency to drain and settle on the lower panel skin 80 due to gravity than would a liquid adhesive. A preferred syntactic adhesive comprises a syntactic resin comprising glass microballoons, epoxy resin and a hardener. In the absence of non-flammability requirements, a polyester or epoxy resin with phenolic microballoons may be used.

It should be stressed that syntactic adhesive 70 is optional. An interference fit of the projection 21 may be sufficient to secure the panel edge closeout 10 in position.

The panel edge closeout arrangement according to the present invention is formed as follows. First, the honeycomb panel 50 is formed with the Nomex or glass honeycomb core 60 between the panel skins 80 and 90 of glass-graphite/epoxy or glass-graphite/phenolic panel skins, an epoxy adhesive film for assembling the honeycomb panel 50 being employed. The panel assembly is cured at 50 psi and 260°F for one hour. The peripheral edge of the cured panel is then slotted with a tool having a centering guide and a saw blade to the depth and width of the desired slot 62. After slotting to the correct depth, and noting Fig. 7, a pneumatic sealing gun 91 is loaded with a syntactic foam 70. The sealing gun 91 is fitted with a tip 92 that can fit into the core slot 62. The syntactic foam 70 is then injected into the core slot 62 so that the foam will fill the slot 62. The panel edge closeout 10, formed as an extrusion, for example, is then snapped into place in the slot 62, with the web 40 being pushed to be flush with the edges 83 and 93. The engaging arrangement with the projection 21 is fully inserted into the core slot 62 and the syntactic foam 70. By forcing the flange 30 into the core slot 62, the syntactic foam 70 is displaced into the adjacent core cells above and below the core slot 62. The flange 30 is then encapsulated by the syntactic foam 70 to integrate the syntactic foam, the honeycomb core 60 and the panel edge closeout 10. The assembly is left to cure for 8 - 10 hours at ambient temperature, after which is formed an interlocking mechanical bond which retains the engaging arrangement 20.

Noting Fig. 8, the corner of a honeycomb panel 50 can be turned by the panel edge closeout 10 simply by cutting a notch, for example a notch with two 47-50° cuts, through the flange 30, but not the web 40. The web 40 can then be bent around the corner as illustrated in Fig. 8. The corner, after being bent, may be momentarily heated to stress relieve the web.

Also, noting Fig. 9, other edges shapes can be conformed to by the panel edge closeout 10. In the example illustrated in Fig. 9, a circular hole is formed in the honeycomb panel 50, and the panel edge closeout closes out the inner peripheral edges of the honeycomb panel 50 by having the flange 30 cut at a number of locations to allow the web 40 to be bent into a circle as illustrated.

As discussed above, adhesive 70 is employed to bond the panel edge closeout 10 to the peripheral edge of the honeycomb panel 50 and the core slot 62. However, it is not absolutely necessary to use an adhesive. The core slot 62 may be machined sufficiently undersized so that the interference press fit of the projection 21 of the engaging arrangement 20 will

stay in place in the core slot 62 without an adhesive. For example, the width of the flange 30 at the projection 21 might be 0.104", and the core slot might then be approximately 0.060" wide. Generally, however, the core slot 62 is machined to 0.010 to 0.030" narrower than the minimum width of the flange 30 at the engaging arrangement 20. In one example, the core slot is machined to 0.090" wide +/- 0.005", with the extrusion being 0.104" +/- 0.002" wide. This provides a minimum of 0.007" and a maximum of 0.021" of interference fit. Generally, the core slot 62 should be a minimum of 0.04" deeper than the length of the flange 30.

The critical dimension of the panel edge closeout 10 of the present invention is thus the width of the flange 30 at the projection 21 relative to the width of the core slot 62. There must be an interference fit sufficient to hold the panel edge closeout 10 in position while the syntactic adhesive 70 cures. It is also preferred that there be a minimum of 0.02" from the projection 21 to the adjacent wall of the flange 30. Also, preferably the flange 30 has a minimum thickness of 0.050". These preferred dimensions are primarily necessary only for the requirements for extruding the panel edge closeout 10 and for adequate flow of the material during the manufacture of the closeout, and do not relate to the performance of the panel edge closeout 10.

Figs. 3-6 illustrate further embodiments according to the present invention. Except as otherwise indicated, these embodiments operate on the same principles as discussed above. In addition, features similar to those illustrated in Figs. 1 and 2 have been referenced with the same reference numerals in Figs. 3-6.

Figs. 3 and 4 illustrate a second embodiment according to the present invention. The major difference with this embodiment is that a panel edge closeout 110 has the engaging arrangement 20 with two projections 21 and 22 extending from opposite sides thereof for engaging both the lower and upper walls 63 and 64 of the core slot 62. The distal end 33 of the flange 30 is tapered outwardly and rearwardly therefrom to the projections 21 and 22. Fig 4 illustrates the panel edge closeout 110 in place in a honeycomb panel 50.

Figs. 5 and 6 illustrate a panel edge closeout 210 which employs four projections 21, 22, 23 and 24 in the engaging arrangement 20 for further engaging the lower and upper walls 63 and 64 of the honeycomb panel 50.

It should be noted that, instead of a projection such as projection 21 for holding the panel edge closeout in the core slot o2, a groove could be provided instead, the groove engaging with the hardened syntactic adhesive 70 to hold the panel edge closeout in the core slot 62.

Figs. 10 and 11 illustrate a panel edge closeout 310 that employs two flanges 30 extending from the single web 40 for use in a double honeycomb sandwich panel 50. Each flange 30 has an engaging arrangement 20 thereon, the engaging arrangement comprising a projection 21 that tapers toward distal end 33 as illustrated.

The primary difference between this fourth embodiment of the present invention and the other above-described embodiments lies in the fact that this embodiment is used for a double honeycomb sandwich panel 50 as illustrated in Fig. 11. In this honeycomb panel 50, two separate honeycomb cores 60a and 60b are used in a layered formation, being adhered together with a septum 61 therebetween. The edge closeout 310 is used similarly to the edge closeouts in the above embodiments, but is used for two core slots 62 in the respective honeycomb cores 60a and 60b. In addition to providing the advantages as discussed above, the edge closeout 310 can also help to secure the two honeycomb cores 60a and 60b together.

In one example of this fourth embodiment, the web 40 is 1" top to bottom as illustrated in the figures, and is 0.060" thick. The flanges are similarly 0.60" thick and are spaced 0.170" from the ends of the web 40. Engaging arrangements 20 project approximately 0.60" from the respective flanges 30, to a separation of approximately 0.420". Engaging arrangements 20, further, can extend about 0.25" along the ends of the flanges 30, from the projections 21 to the distal ends 33. The material may be ULTEM 9065 with an opaque brown or natural color.

From the above, it can be seen that a panel edge closeout arrangement and method of forming this arrangement can be provided which provides a simple and inexpensive closeout system and can be easily and securely formed for a honeycomb panel in order to both strengthen the edges of the panel, protect the edges of the panel and prevent galvanic corrosion. Various modifications of the above panel edge closeout arrangement and method will occur to those of ordinary skill in the art without departing from the scope of the invention as defined by the appended claims, and as such, should be considered a part of this invention.

Claims

Claim 1. A panel edge closeout arrangement, comprising:

first and second panel skins having respective peripheral edges;

a honeycomb core between said first and second skins, said honeycomb core having a peripheral core slot; and

a closeout having a web portion extending between and covering said peripheral edges of said first

and second panel skins, a flange portion extending from said web portion into said peripheral core slot of said honeycomb core, and an engaging means for engaging said closeout with said honeycomb core.

Claim 2. The panel edge closeout arrangement of claim 1, wherein said panel skins are graphite and said closeout is made of an electrically non-conducting material.

Claim 3. The panel edge closeout arrangement of claim 2, wherein said electrically non-conducting material is an extrudable resin.

Claim 4. The panel edge closeout arrangement of claim 3, wherein said extrudable resin is a material selected form the group consisting of acrylic, ABS, polystyrene, polyethylene, PVC, polycarbonate, acetate, butyrate, propionate, polyurethane and thermoset materials.

Claim 5. The panel edge closeout arrangement of claim 3, wherein said extrudable resin is polyurethane.

Claim 6. The panel edge closeout arrangement of claim1, wherein said engaging means further comprises an adhesive in said peripheral core slot bonding said closeout in said peripheral core slot.

Claim 7. The panel edge closeout arrangement of claim 6, wherein said adhesive comprises a syntactic resin.

Claim 8. The panel edge closeout arrangement of claim 7, wherein said syntactic resin comprises glass microballoons, epoxy resin and hardener.

Claim 9. The panel edge closeout arrangement of claim 7, wherein said syntactic resin comprises an epoxy or polyester resin with phenolic microballoons.

Claim 10. The panel edge closeout arrangement of claim 1, wherein said first and second panel skins are glass skins.

Claim 11. The panel edge closeout arrangement of claim 1, wherein:

said peripheral core slot in said honeycomb core has opposite walls defining said peripheral core slot therebetween;

said opposite walls are spaced apart a predetermined amount; and

said engaging means engages said flange with at least one of said opposite walls with an interference fit.

Claim 12. The panel edge closeout arrangement fo claim 11, wherein said flange, at said engaging means, is wider than said predetermined amount by which said opposite walls are spaced apart.

Claim 13. The panel edge closeout arrangement of claim 11, wherein said engaging means comprises a projection protruding form one side of said flange.

Claim 14. The panel edge closeout arrangement of claim 13, wherein said flange has a tapered front end tapering outwardly and rearwardly toward said web to a point on said flange defining said projection.

Claim 15. The panel edge closeout arrangement of claim 13, wherein said flange has at least one said projection on each opposite side thereof engaging respective said opposite walls with an interference fit.

Claim 16. The panel edge closeout arrangement of claim 15, wherein said flange has two said projections on each opposite side thereof engaging said opposite walls with an interference fit.

Claim 17. A method of closing out the edge of a panel having two panel skins with peripheral edges and a honeycomb core therebetween, said method comprising the steps of:

providing a closeout having a web portion and a flange portion extending from said web portion, said flange portion having a projection thereon;

cutting a peripheral core slot in said honeycomb core; and

inserting said flange portion into said peripheral core slot, engaging said honeycomb core with said projection with an interference fit and covering said peripheral edges of said panel skins with said web portion.

Claim 18. The method of claim 17, and further comprising the step of providing an adhesive in said peripheral core slot prior to inserting said flange portion.

Claim 19. The panel edge closeout arrangement of claim 1, and further comprising:

a second honeycomb core between said first and second skins having a second peripheral core slot;

a septum between the first said honeycomb core and said second honeycomb core; and

a second flange portion, extending from said web portion of said closeout into said second peripheral core slot, having a second engaging means for engaging said closeout with said second honeycomb core.

Claim 20. The panel edge closeout arrangement of claim 2, wherein said electrically non-conducting material is a thermoset material selected from the group consisting of phenolics, melamines, epoxy and glass reinforced materials.

Claim 21. The panel edge closeout arrangement of claim 20, wherein said thermoset material is pultruded out of glass and phenolics.

FIG. 1

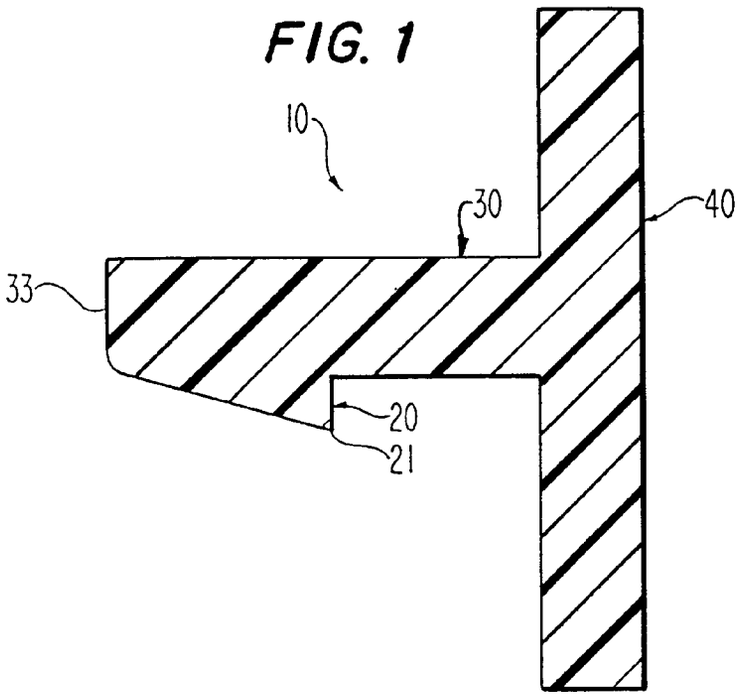

FIG. 2

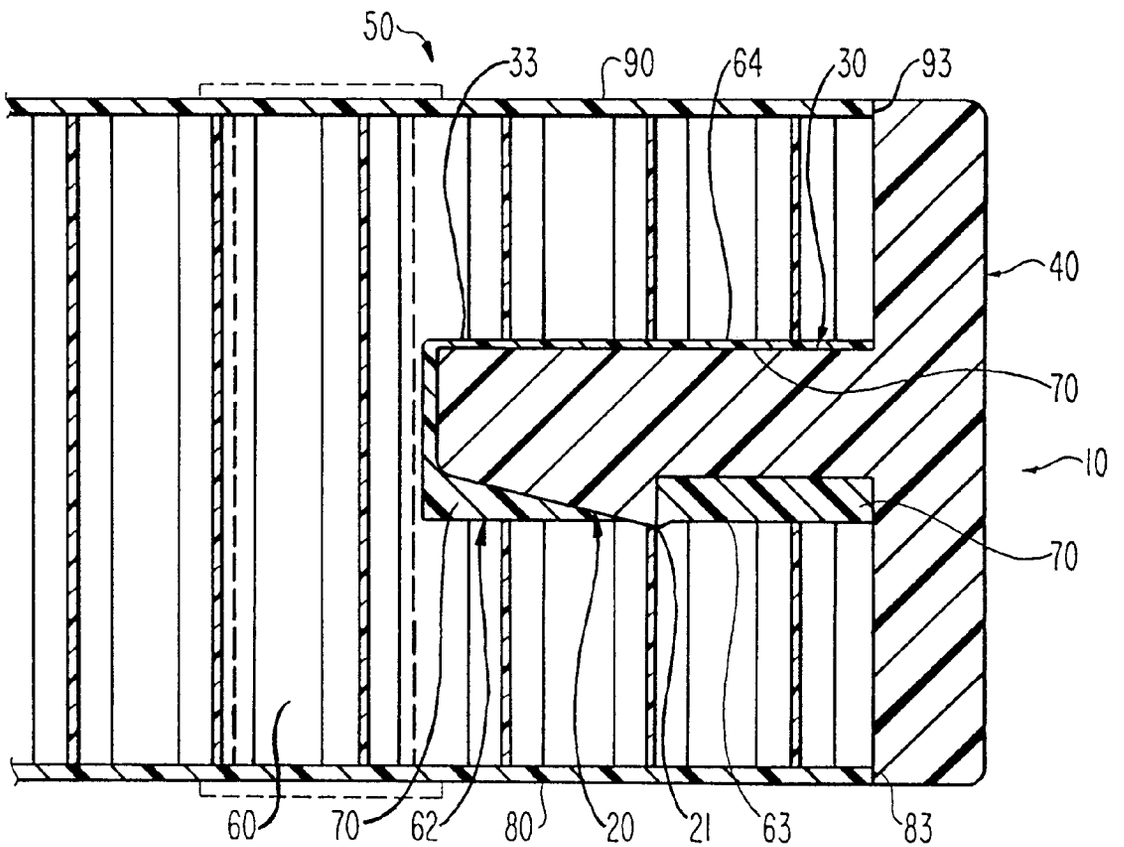

FIG. 3

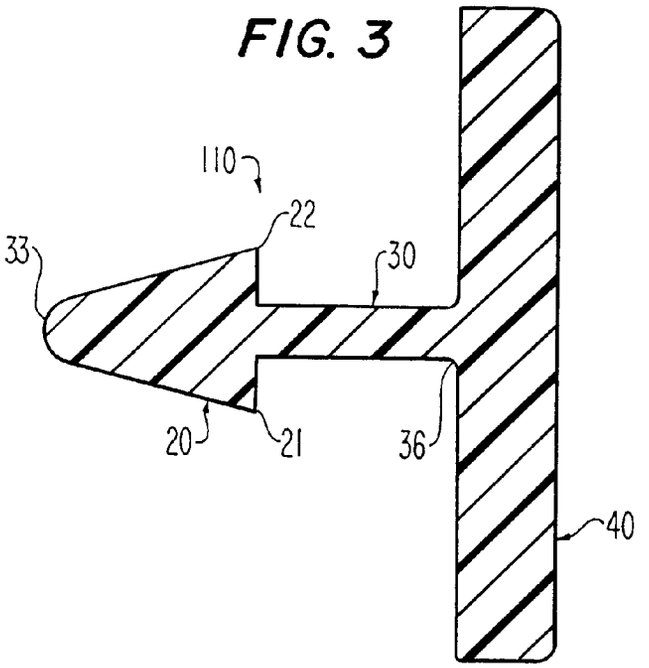

FIG. 4

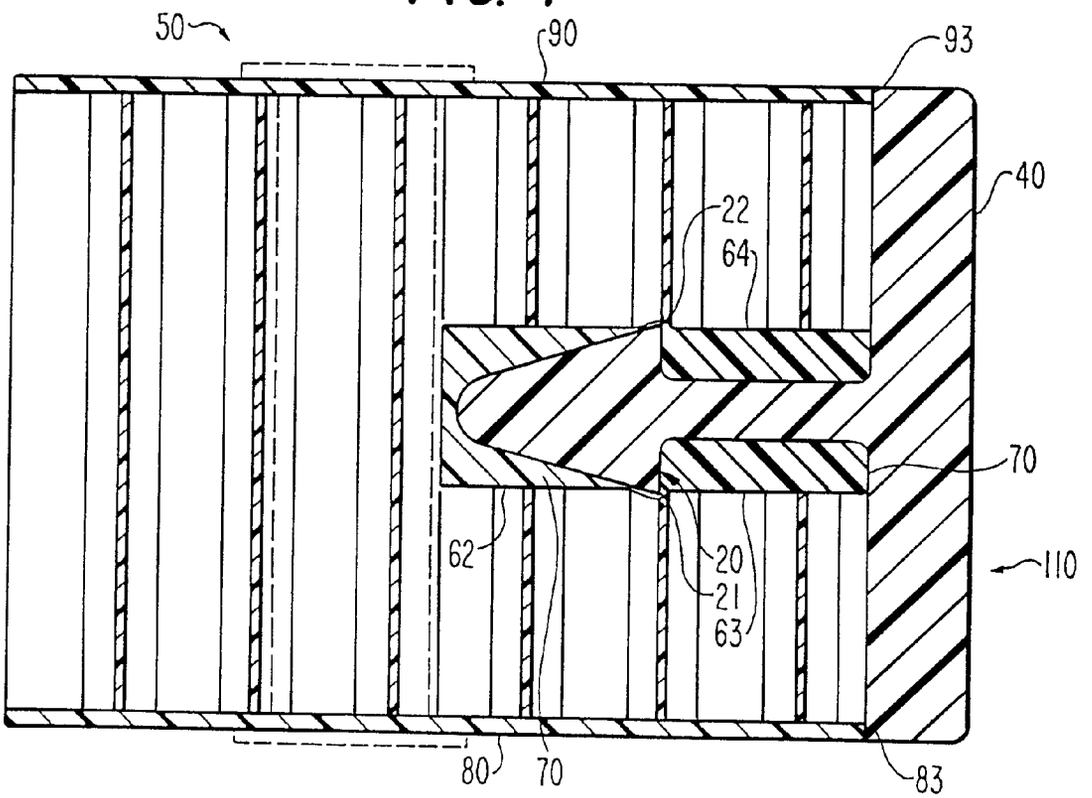

FIG. 5

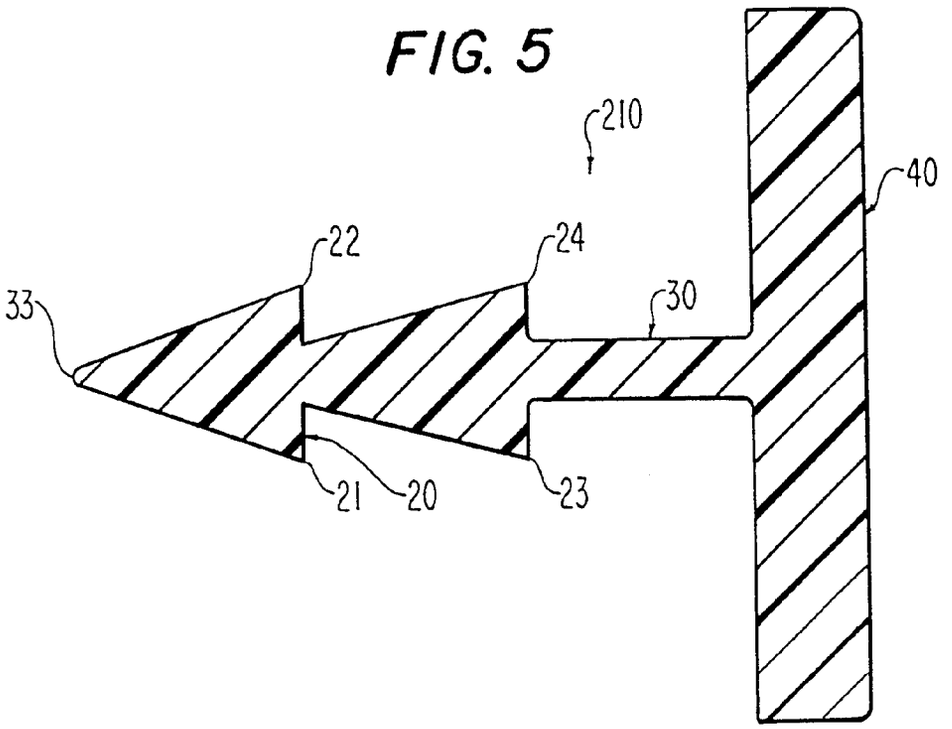
210
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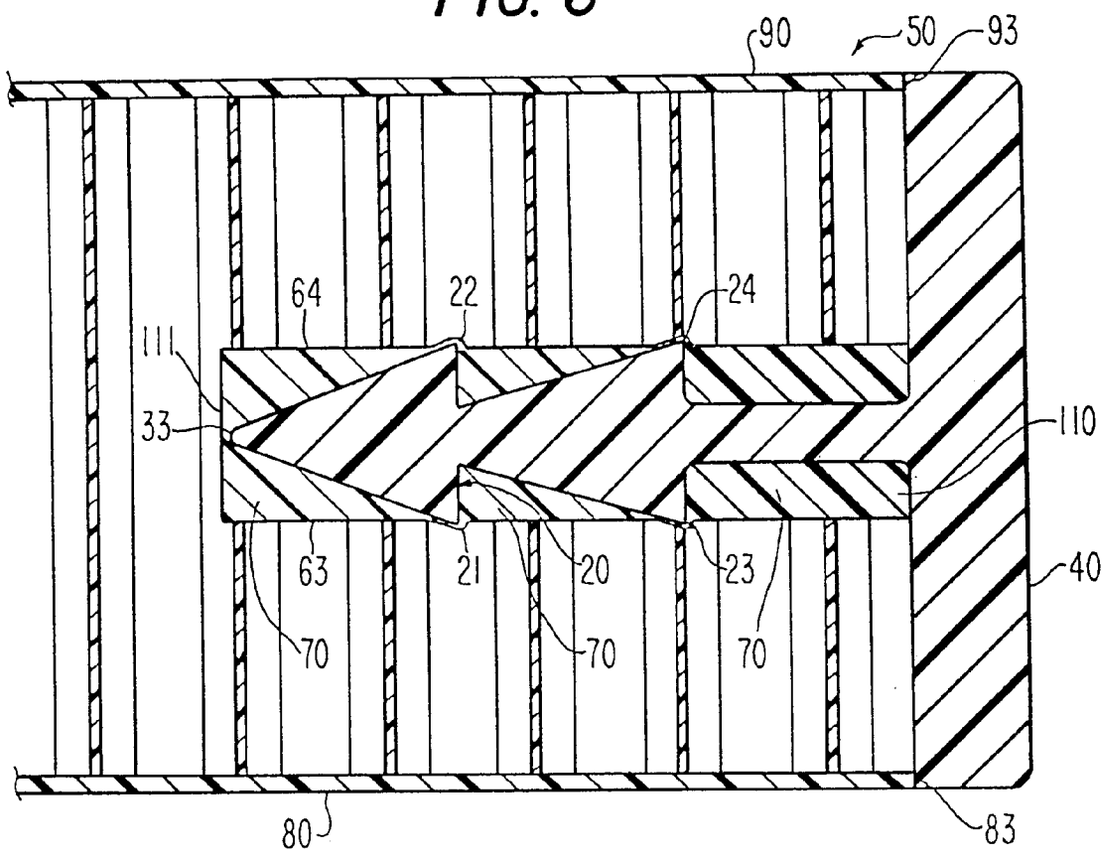
FIG. 6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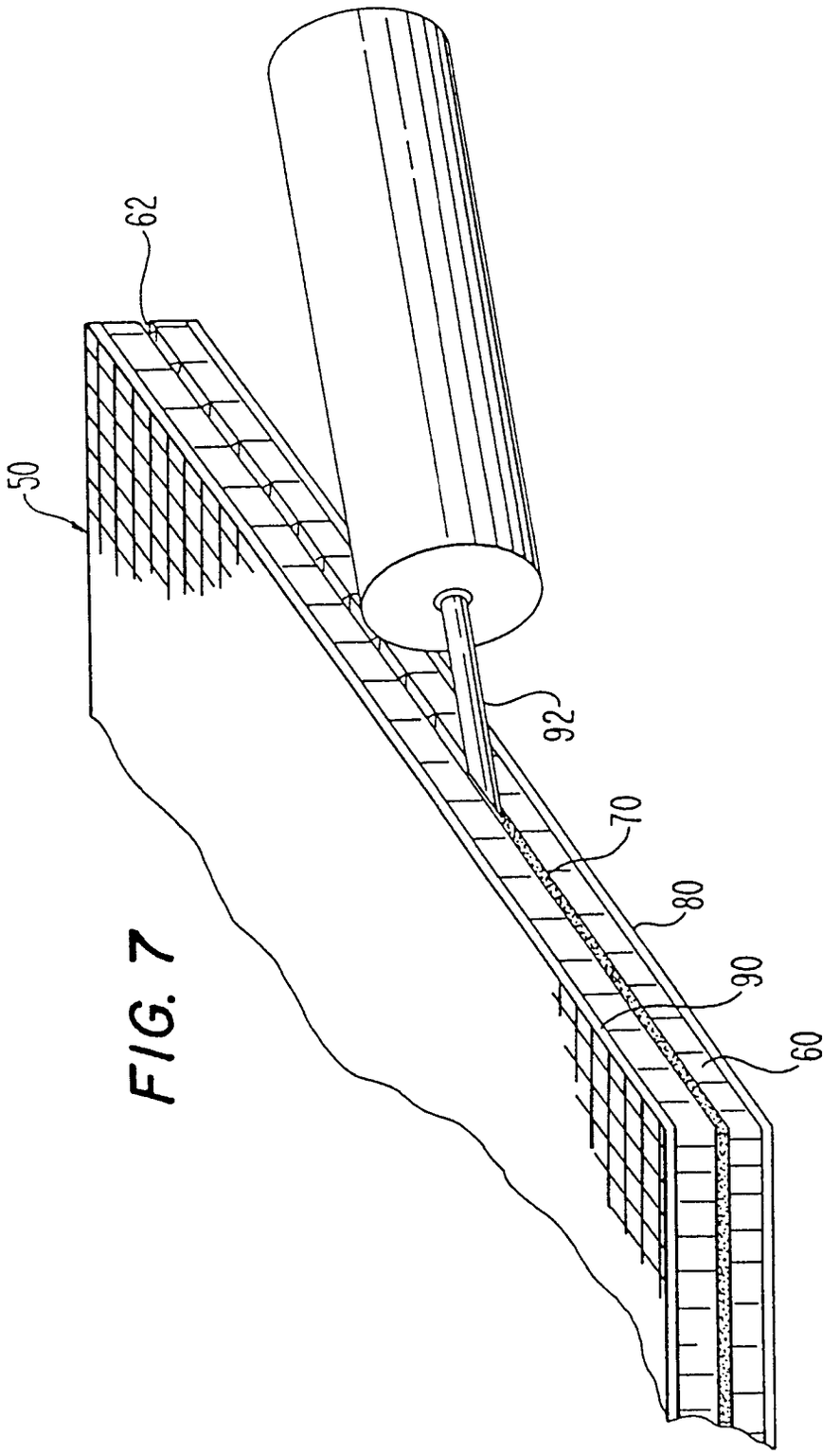


FIG. 7

FIG. 9

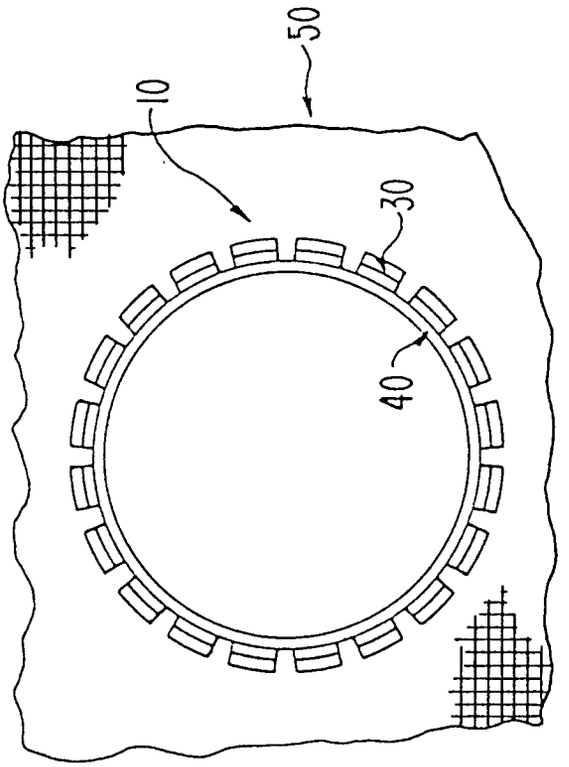


FIG. 8

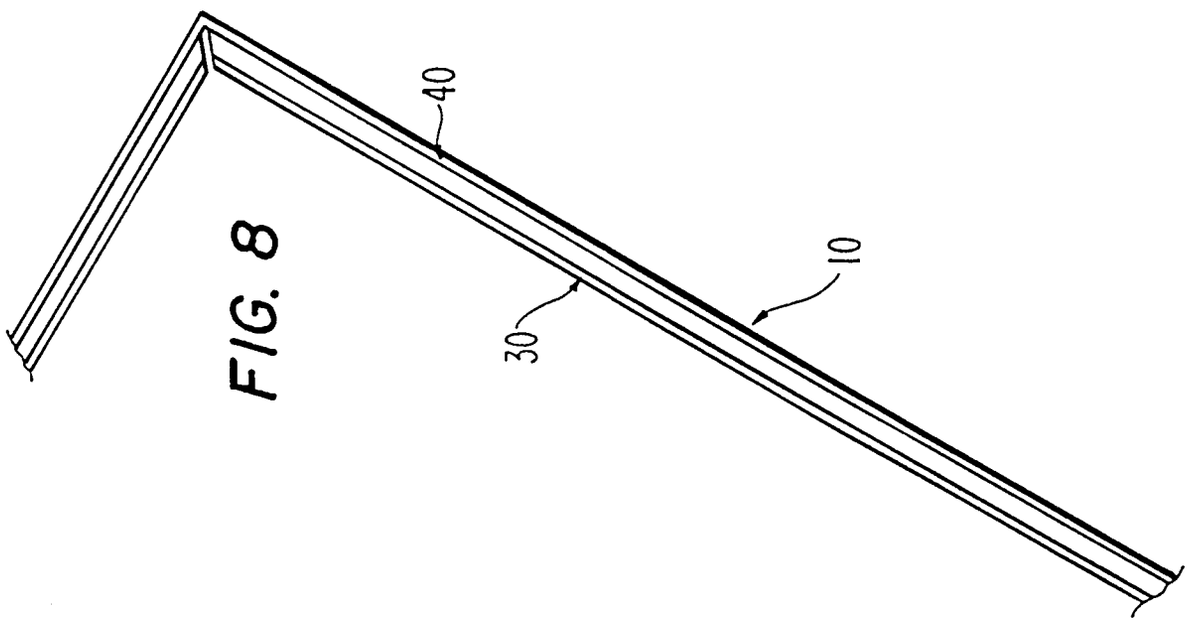


FIG. 10

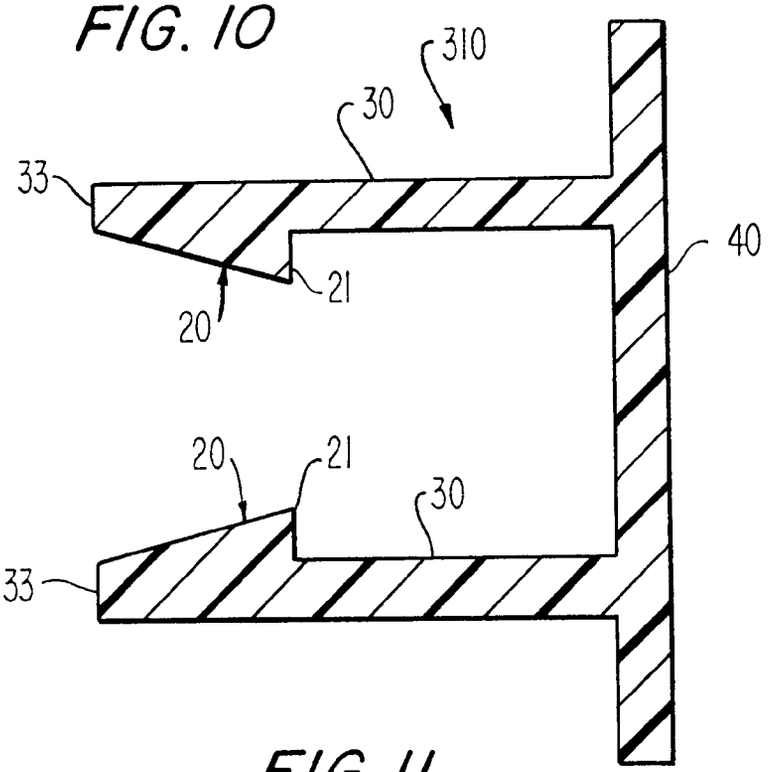
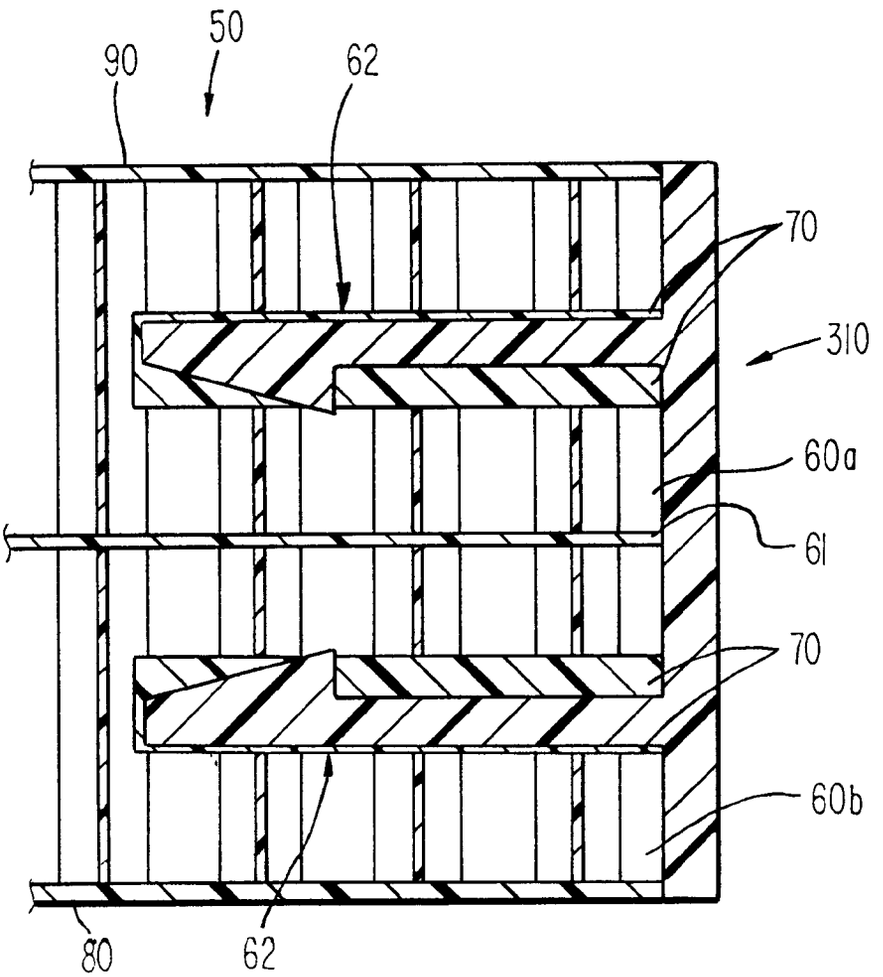


FIG. 11



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 81 0541

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	US-A-5 034 256 (SANTISO III ET AL.) * column 2, line 28 - column 3, line 57; figure 1 *	1,2,6, 10,17	E04C2/36 A47B13/08 E06B3/88
Y	US-A-2 797 447 (WINER) * column 2, line 16 - column 3, line 53; claim 1; figures 1-3 *	1,2,6, 10,17	
A	US-A-3 644 160 (VALENTINE JR. ET AL.) * column 4, line 39 - column 5, line 55; claim 9; figure 3 *	3,4,11, 12,15-17	
A	US-A-4 971 849 (AZZAR) * column 3, line 52 - line 56 *	3	
A	DE-A-30 15 267 (IMPLAST PLADESKRADDERI A/S) * page 6, line 12 - line 26; figures 2,3,5 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5) E04C A47B E06B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 November 1993	MYSLIWETZ, W

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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