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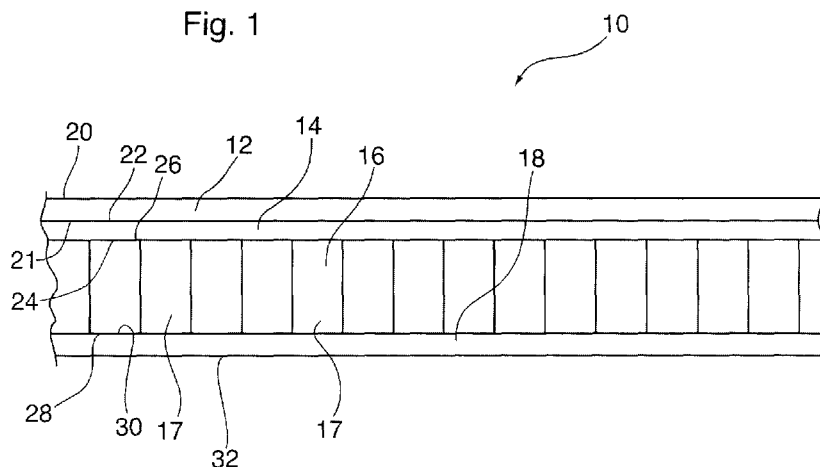
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(54) Title: METAL-SKINNED COMPOSITE VEHICLE BODY PANEL

Fig. 1



(57) Abstract: In a first aspect, the invention is directed to a vehicle body panel that includes a first layer made of a metal, a second layer contains resin that contains fiber material, a third layer made from a third layer material that defines a plurality of structural cells, and a fourth layer that contains resin that contains fiber material.

METAL-SKINNED COMPOSITE VEHICLE BODY PANEL**FIELD OF THE INVENTION**

5 [0001] The present invention relates to body panels for vehicles.

BACKGROUND OF THE INVENTION

[0002] It is known in the automotive industry to use sandwich PANELS of carbon fiber and aluminum honeycomb for vehicle body panels, particularly on very expensive, high performance sports cars. While such body panels are advantageous in that they are typically much lighter than conventional steel body panels while being able to match a steel panel in terms of strength, their use has traditionally been limited to very expensive and/or very low production volume vehicles for several cost-related reasons. One reason in particular is that a lot of labour is typically involved in providing these body panels with a class 'A' surface finish that is paintable and suitable for use as an exterior surface of the vehicle. As a result, higher production volume vehicles and vehicles at a more reasonable price point are not provided with these body panels even though there is generally a strong motivation in the automotive industry to lighten vehicles. It would be beneficial if the costs associated with these types of body panel could be reduced so that the benefits thereof can economically be applied to higher production volume vehicles and to vehicles that are at a more affordable price point for an average consumer.

SUMMARY OF THE INVENTION

[0003] In a first aspect, the invention is directed to a vehicle body panel that includes a first layer made of a metal, a second layer that contains resin that contains fiber material, a third layer made from a third layer material that defines a plurality of structural cells, and a fourth layer that contains resin that contains fiber material.

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[0004] In a preferred embodiment, the layers have specific properties. The first layer is not more than about 0.016 inch thick and that is made from a 2024-T3 Aluminum alloy. The second layer is not more than about 0.010 inch thick and that is made up of an epoxy that contains fiber material; the third layer is made up of a plurality of hexagonal honeycombs oriented generally perpendicularly to the first layer. The third layer is made from 5052 aluminum having a sheet thickness of not more than about 0.0007 inch. The third layer has a layer thickness of not more than about 0.080 inch. Each honeycomb cell is not more than about 1/8 inch wide across the hexagon (from face-to-face, as opposed to the distance from vertex to vertex). The fourth layer is made up of a second resin that contains fiber material.

[0005] In a second aspect, the invention is directed to a method of making a vehicle body panel in a die having a first die plate and a second die plate, comprising:

inserting a first layer preform in the second die plate, wherein the first layer preform is made up of a metal;

inserting a charge kit in the first die plate, wherein the charge kit is made up of a second layer, a third layer and a fourth layer all joined together, wherein the second layer contains resin that contains fiber material, wherein the third layer is made up of a plurality of honeycombs oriented generally perpendicularly to the first layer preform, and wherein the fourth layer contains resin that contains fiber material;

heating the charge kit sufficiently to cause the charge kit to permit deformation;

closing the first and second die plates together to cause the charge kit to conform to the space between the second die plate and the first layer preform and to cause the charge kit to join to the first layer preform;

hardening the charge kit to form a molded part that includes the charge kit and the first layer preform;

opening the first and second die plates; and

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removing the molded part from the die.

[0006] In a third aspect, the invention is directed to another method of making a vehicle body panel in a die having a first die plate and a second die plate wherein the first and second die plates together define a die cavity, comprising:

5 inserting a charge kit in the first die plate, wherein the charge kit is made up of a first layer, a second layer, a third layer and a fourth layer all joined together, wherein the first layer is made from metal, the second layer contains resin that contains fiber material, the third layer is made up of a plurality of honeycombs oriented generally perpendicularly to the first layer preform, and the fourth layer contains resin that contains
10 fiber material;

heating the charge kit sufficiently to cause the charge kit to permit deformation;

closing the first and second die plates together to cause the charge kit to conform to the die cavity;

15 hardening the charge kit to form a molded part;

opening the first and second die plates; and

removing the molded part from the die.

[0007] In a fourth aspect, the invention is directed to another method of making a vehicle body panel in a die having at least a first die plate wherein the first die plate
20 defines a first die cavity portion, comprising:

inserting a charge kit in the first die plate, wherein the charge kit is made up of a first layer, a second layer, a third layer and a fourth layer all joined together, wherein the first layer is made from metal, the second layer contains resin that contains fiber material, the third layer is made up of a plurality of honeycombs oriented generally
25 perpendicularly to the first layer preform, and the fourth layer contains resin that contains fiber material;

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heating the charge kit sufficiently to cause the charge kit to permit deformation;

applying pressure to the charge kit to cause the charge kit to conform to the first die cavity portion;

5 hardening the charge kit to form a molded part; and
releasing the molded part from the die.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will now be described by way of example only with
10 reference to the attached drawings, in which:

[0009] Figure 1 is an sectional view of a vehicle body panel in accordance with an embodiment of the present invention;

[0010] Figures 2a, 2b and 2c are parts of a table of test data showing the performance of several different body panels, some of which are made in accordance
15 with embodiments of the present invention;

[0011] Figures 3a-3g are sectional views of a die illustrating the process for manufacturing the body panel shown in Figure 1

[0012] Figure 3h is another sectional view of the panel shown in Figure 1 and;

[0013] Figure 4 is a flow diagram illustrating the process for manufacturing the
20 body panel shown in Figure 1.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Reference is made to Figure 1, which shows a vehicular body panel 10, in accordance with an embodiment of the present invention. The body panel may be any suitable type of body panel, such as a hood, or a roof panel for a vehicle. The body panel
25 10 is made up of a plurality of layers including: a first layer 12 made of a metal, a second layer 14 made of a resin containing fibers, a third layer 16 made of a material containing structural cells 17 and a fourth layer 18 made of a resin containing fibers. The first layer

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12 is made from a metal that has a suitable combination of low density, mechanical strength and paintability. Examples of some materials that may be suitable include Aluminum alloys, Magnesium alloys, Titanium alloys and steel. Figures 2a-2c show a table of selected metals used in test samples of body panels.

5 [0014] The first layer 12 is thinner than metal sheet material that is typically used for vehicle body panels. For example, in a typical Aluminum alloy body panel of the prior art, the thickness of the sheet metal used therein may be approximately 0.040 inch or more. By contrast, the sheet thickness of the first layer 12 may be as low as about 0.008 inch, in particular where the material is a fully hard Aluminum alloy, such as 1100-
10 H18 Aluminum alloy. The sheet thickness of the first layer 12 may be as low as about 0.012 inch, in particular where the material is a half-hard Aluminum alloy. The range of acceptable sheet thickness for the first layer is between about 0.008 inch and about 0.016 inch.

15 [0015] Some other Aluminum alloys that may be used for the first layer 12 include: 2024-T3 and 6061-T6.

[0016] Where the first layer material is a Magnesium alloy, particular an alloy that is tempered to a half hard state, the thickness of the first layer may be in the range of about 0.016 inch or greater. The thickness may be less than, for example, 0.020 inch. A particular alloy that may be used is AZ31B-H34.

20 [0017] By making the first layer from a relatively thin sheet, the costs associated with stamping and/or otherwise forming or cutting the first layer 12 are reduced compared to the costs associated with the forming of sheet metal used for conventional vehicle body panels (ie. body panels that are made from sheet metal only).

25 [0018] The first layer 12 has a first surface 20 that has a class 'A' finish that makes it suitable for painting as a visible exterior surface of the vehicle. The preparation of the first surface 20 to make it suitable for use as an exterior surface is well known. By providing the metallic first layer, the comparatively laborious treatment that is required

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for preparing some resin surfaces to be suitable as paintable exterior surfaces, is avoided. The first layer 12 has a second surface 21 that is opposed to the first surface 20.

[0019] The second layer 14 is a resin that includes fiber material, and joins the first layer to the third layer. The resin itself may be any suitable type of resin such as an epoxy. The table in Figures 2a-2c shows several examples of second layer material that can be used. The fiber may be any suitable type of fiber. The fiber may be weaved, and if so, it may have any suitable angle to the weave relative to the longitudinal axis of the vehicle on which the body panel 10 is to be used. For example, the weave may be at 0 degrees and 90 degrees relative to the vehicle's longitudinal axis. Alternatively, the weave may be at -45 degrees and +45 degrees relative to the vehicle's longitudinal axis. Alternatively, the fibers may instead be unidirectional. The fibers may be provided in some combination of the aforementioned possibilities. In an alternative embodiment, the fibers may instead be randomly oriented, and may be less than about 1 inch in length. The fibers may be glass fibers, aramid fibers, carbon or graphite fibers, polyethylene fibers or other types of fiber.

[0020] The resin may be a thermoset material, such as, for example, epoxy, urethane, vinyl ester, polyester or a polyamide. Alternatively, the resin may be a thermoplastic material, such as polyethylene, polypropylene, or nylon.

[0021] An exemplary material that can be used for the second layer 14 is MTM28/GF0100, which is an epoxy with a glass fabric made by Advanced Composites Group Inc. of Tulsa, Oklahoma, USA.

[0022] The second layer 14 may be made up of a single ply or multiple plies of material. Where multiple plies are provided, all the plies are preferably made from a resin that contains fibers. It is optionally possible for the plies to differ in terms of their composition.

[0023] The thickness of the second layer 14 may be within a range of about 0.006 inch to about 0.016 inch for some single ply configurations, and may be up to about 0.028 inch for two-ply configurations.

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[0024] The second layer 14 has a first surface 22 that mates with the second surface 21 of the first layer 12, and a second surface 24 that is opposed to the first surface 22.

[0025] The third layer 16 is made up from a third layer material that defines a plurality of structural cells 17. In the embodiment shown in Figure 1, the cells 17 are in the form of hexagonal honeycombs that are oriented generally perpendicularly to the first layer. Alternatively, the cells 17 may be in some other form such as diamond-shaped honeycombs, square honeycombs, or any other suitable type of honeycomb. For the purposes of the present disclosure and claims, a honeycomb is intended to denote a hollow, polygonal structure that is not necessarily limited to being a hexagonal structure.

[0026] The third layer material may be any suitable material, such as 5052 Aluminum alloy. The wall thickness of the third layer material may be approximately 0.0007 inch. In an exemplary embodiment where the cells 17 are hexagons, the size of each cell 17 may be less than or equal to about 1/8 inch across the hexagon (face-to-face). The density of the honeycomb formed with the aforementioned Aluminum alloy may be about 3.1 lbs/cu. ft.

[0027] The thickness of the third layer 16 may be between about 0.080 inch and about 0.100 inch, particularly when the cells 17 are hexagonal honeycombs. Other thicknesses may, however, alternatively be used.

[0028] A preferred honeycomb for use in the body panel 10 is under the material spec: 3.1 1/8 0.0007N 5052 aluminum, made by Hexcel Corporation, Stamford, Connecticut, USA.

[0029] The third layer 16 has a first surface 26 and a second opposing surface 28. The first surface 26 is connected to the second surface 24 of the second layer.

[0030] The fourth layer 18, and covers the opposite side of the third layer 16. The fourth layer 18 has a first surface 30 and a second surface 32. The first surface 30 is connected to the second surface 28 of the third layer 16. The second surface 28 may be exposed, since it does not have to have a class 'A' finish, because it is not a surface of the

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vehicle that is visible during normal use of the vehicle. This does not mean that the second surface 32 of the fourth layer 18 can never be visible to a person using the vehicle or located near the vehicle. For example, in an embodiment where the body panel 10 is a hood, the second surface 32 of the fourth layer 18 may be the underside of the hood, which is only visible when the hood is opened, and which is therefore not visible during normal use of the vehicle.

[0031] In a particularly preferred embodiment, the first layer 12 is an Aluminum alloy that is half-hard with a thickness of about 0.012 inch; the second layer 14 is a single ply of epoxy with glass fabric under the product number MTM28/GF0100 made by Advanced Composites Group, with a thickness of 0.010 inch; the third layer 16 has a layer thickness of 0.08 inches and is made up of hexagonal honeycombs with a density of 3.1 lb./cu. ft. and have a dimension of 1/8 inch across the hexagon (face-to-face), with walls that are non-perforated and made from 0.0007 inch thick 5052 Aluminum alloy; and the fourth layer 18 is the same thickness and material as the second layer 14.

[0032] A method for manufacturing the body panel 10 is described as follows, with reference to Figures 3a-3h. As shown in Figure 3g, a die 40 which defines a die cavity 41 (Figure 3g) is provided for molding the body panel 10. The die 40 includes a first die plate 42 containing a first die cavity portion 44 (Figure 3f), and a second die plate 46 containing a second die cavity portion 48. In the exemplary embodiment shown in Figures 3a-3h, the die plates 42 and 46 extend generally horizontally and are movable along a vertical axis A between the open and closed positions. It will be understood that this does not mean that both die plates 42 and 46 must be moveable. It is intended to cover embodiments wherein one die plate (eg. the second, or upper die plate 46) is movable, while the first die plate 42 is stationary. The die plates 42 and 46 are movable between an open position wherein they are separated by a selected amount, and a closed position wherein they mate together. In the open position, one or both of the die plates 42 and 46 can receive the materials to be molded, and also a molded part can be removed from one of the die cavity portions 44 and 48. In the closed position, the materials fed into the die cavity are molded and hardened (eg. cured) as necessary. The method of

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manufacture is shown at 100 in Figure 4. Figures 3a-3h illustrate steps in the method shown in Figure 4. An optional first step 102 (Figure 4) is provided in the event that an add-on element 51 (Figure 3b) will be mounted to the body panel 10. At step 102 a support 52, which is used to support the add-on element 51, is positioned at a selected position on the first mold plate 42. The support 52 may be made from any suitable material, such as, for example, one or more plies of fiberglass. In an embodiment wherein the body panel 10 is a hood, there may be several add-on elements 51, including, for example, a latch, one or more hinges, and a prop rod insert block. Accordingly, there may be several supports 52 positioned at selected positions on the first die plate 42. The first die plate 42 is heated so that the support 52 heats up thereby increasing malleability.

[0033] At step 104 (Figure 4), the add-on element 51 (Figure 3b) is positioned in the support 52. The support 52, which has been heated somewhat and is somewhat malleable as a result, is urged down into an associated depression 54 in the first die plate 42. The depression 54 is part of the first die cavity portion 44. The support 52 need not be positioned all the way down into the depression 54 at step 104.

[0034] At step 106 (Figure 4), a charge kit 56 (Figures 3c and 3d), which is a preformed sandwich of the second, third and fourth layers 14, 16 and 18, is provided and is positioned in the first die plate 42. In some embodiments, particularly wherein the charge kit 56 is positioned manually by an operator into position in the first die plate 42, the charge kit 56 is provided with one or more locating apertures 58 which mount on one or more locating dowels 60 projecting from the surface of the die plate 42. The locating apertures 58 and the locating dowels 60 ensure that the charge kit 56 is positioned in a selected position on the die plate 42. The apertures 58 may optionally be sized to fit snugly on the dowels 60. Alternatively, one or more of the apertures 58 may be in the form of slots.

[0035] The charge kit 56 may be preformed at a separate station (not shown) where a CNC machine cuts the second, third and fourth layers to desired sizes. The layers 14, 16 and 18 are then placed in their respective positions to form the sandwich.

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The second and fourth layers 14 and 18 extend beyond the edges of the third layer 16, and together form an edge portion 61. Along the edge portion 61, the second and fourth layers 14 and 18 may be stapled or otherwise joined by some suitable means thereby substantially fixing the position of the third layer 16 in between them. In embodiments
5 where the second and fourth layers 14 and 18 are stapled, the staples used therefor are positioned outside any portions of the die plates 42 where they will damage the surfaces 62 and 64 on the first and second die plates that make up the die cavity 41 (Figure 3g). The locating apertures 58 are also provided in the edge portion 61.

[0036] At step 108 (Figure 4), a first layer preform 66 (Figure 3e) is provided and
10 is positioned in the second die plate 46. The first layer preform 66 forms the first layer 12 in the body panel 10. The first layer preform 66 is already formed into substantially its final shape prior to insertion in the second die plate 46. The forming of the first layer preform 66 can be carried out in another station (not shown). As a result of its close fit with the surface 64 that defines the second die cavity portion 48, locating apertures are
15 not necessary for the first layer preform 66. A vacuum chuck system may be provided in the second die plate 46 to hold the first layer preform 66 in place in the second die cavity portion 48.

[0037] Prior to insertion into the second die plate 46, any protective covering that may be present on the first layer preform 66 is removed. Additionally, the metallic first
20 layer 12 may undergo a cleaning process to prepare it for joining to the second layer. The cleaning process may include a solvent wash. Alternatively, the cleaning process may be electro-chemical, such as anodizing (in embodiments wherein the first layer is made from an Aluminum alloy).

[0038] At step 110 (Figure 4), and as shown in Figures 3f and 3g, the second die
25 plate 46 is moved towards the first die plate 42 so as to bring the first layer preform 66 into contact with the charge kit 56 with a selected joining pressure. The locating dowels 60 are at this time received in dowel receiving apertures 67 in the second die plate 46. The joining pressure is selected to provide a close bond between them and between the elements that make up the charge kit 56. At the joining pressure, the third layer 16 is

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crushed by a selected amount. The amount of crushing of the third layer 16 depends on the region of the die cavity 41. Initially the pressure may be about 75 psi, and then may be increased to the joining pressure using any suitable method. At the joining pressure, the main portion, shown at 68, of the body panel 10, the third layer 16 may be crushed by
5 about 5% to about 10% of its uncrushed thickness. In a hem portion 70 that is outside of the main portion 68, the die cavity 41 may be sized to substantially completely crush the third layer 16. The die 40 may be kept closed for any suitable amount of time to permit the second and fourth layers 14 and 18 to harden (to cure in the case where a thermoset material is used (eg. epoxy), or to form in the case where a thermoplastic material is
10 used).

[0039] The temperature that is used to cure the second and fourth layers 14 and 18 in embodiments wherein they are thermoset materials may be about 300 degrees F to about 600 degrees F. The time required for the material to cure may be, for example, between about 2 minutes and 10 minutes. In the case where a thermoplastic material is
15 used for one or both of the second and fourth layers 14 and 18, the forming time for the thermoplastic material may be less than 2 minutes.

[0040] At step 112, once the material in the die cavity 41 has been cured (or otherwise hardened), the die 40 is opened and the molded part (shown at 68 in Figure 3g) is removed therefrom. In some embodiments the molded part 68 may be removed while
20 hot. At step 114, the edge portion 61 is trimmed from the molded part 68. The trimming may be carried out by any suitable means, such as by shears, shearing dies, saws, cutting discs, laser, abrasive waterjet, and CNC cutting tools.

[0041] At step 116, the molded part 68 is hemmed thereby forming the body panel 10. This hemming step 116 may entail applying mastic at a suitable location (ie.
25 to, or proximate to the hem portion 70), folding over the hem portion 70 so that the mastic holds it in the folded position thereby forming a hem.

[0042] It is optionally possible to form the metallic first layer 12 in the die 40 at the same time as the second, third and fourth layers 14, 16 and 18 are formed, instead of

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preforming the first layer. In such a case, the pressures in the die 40 that cause the selected amount of crushing of the third layer 16 would also have to be high enough to form the first layer 12 into the desired shape. The feasibility of this process would depend on several factors such as the geometry (both initial and final) of the first layer
5 12, the material properties of the first layer 12 and of the second, third and fourth layers 14, 16 and 18. In such an embodiment, the charge kit may be made up of all four layers 12, 14, 16 and 18 placed together into the first die cavity portion 44. In such an alternative, the first layer 12 could be joined to the second layer 14 in the charge kit in any suitable in any suitable way. A benefit of this alternative embodiment is that the step
10 of separately preforming the first layer 12 would be avoided, thereby saving cost, labour and floor space associated with that step.

[0043] In another alternative, the die 40 may be made up of a single die plate that may be similar to the lower die plate 42 (Figure 3a) that defines a die cavity portion for receiving the charge kit. An elastomeric sheet would then be pressed against the charge
15 kit to push the charge kit into the die cavity portion in the die plate. Fluid pressure or some other suitable pressure generating means is provided on the other side of the elastomeric member so as to cause the elastomeric member to press against the charge kit. The single die plate is heated so as to soften the charge kit. Alternatively any other means of generating pressure and using the pressure to urge the charge kit into a die
20 cavity portion could be used to form the molded part 68.

[0044] While the above description constitutes a plurality of embodiments of the present invention, it will be appreciated that the present invention is susceptible to further modification and change without departing from the fair meaning of the accompanying claims.

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CLAIMS:

1. A vehicular body panel, comprising:
a first layer made of a metal;
5 a second layer made from resin that contains fiber material;
a third layer made from a third layer material that defines a plurality of structural cells, wherein the second layer joins the first layer to a first side of the third layer; and
a fourth layer made from resin that contains fiber material connected to a second side of the third layer.
10
2. A vehicular body panel as claimed in claim 1, wherein the third layer material defines a plurality of honeycombs oriented generally perpendicularly to the first layer.
3. A vehicular body panel as claimed in claim 1, wherein the first layer is made from
15 an Aluminum alloy.
4. A vehicular body panel as claimed in claim 3, wherein the first layer has a thickness that is less than about 0.016 inch.
- 20 5. A vehicular body panel as claimed in claim 3, wherein the first layer has a thickness that is less than about 0.012 inch.
6. A vehicular body panel as claimed in claim 1, wherein the first layer is made from a Magnesium alloy.
25
7. A vehicular body panel as claimed in claim 6, wherein the first layer has a thickness that is less than about 0.020 inch.

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8. A vehicular body panel as claimed in claim 6, wherein the first layer has a thickness that is less than about 0.016 inch.
9. A vehicular body panel as claimed in claim 1, wherein the second layer includes
5 woven fibers.
10. A vehicular body panel as claimed in claim 1, wherein the third layer is made with an Aluminum alloy.
- 10 11. A vehicular body panel as claimed in claim 1, wherein the honeycomb comprises an arrangement of hexagonal shapes.
12. A vehicular body panel as claimed in claim 1, wherein the second and fourth layers are made of the same material.
- 15 13. A vehicular body panel as claimed in claim 1, wherein the first layer has a first surface that is exposed and that has a class 'A' surface finish.
14. A method of making a vehicle body panel in a die having a first die plate and a
20 second die plate, comprising:
inserting a first layer preform in the second die plate, wherein the first layer preform is made up of a metal;
inserting a charge kit in the first die plate, wherein the charge kit is made up of a second layer, a third layer and a fourth layer all joined together, wherein the second layer
25 is made from resin that contains fiber material, wherein the third layer is made up of a plurality of honeycombs oriented generally perpendicularly to the first layer preform, and wherein the fourth layer is made from resin that contains fiber material;
heating the charge kit sufficiently to cause the charge kit to permit deformation;

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closing the first and second die plates together to cause the charge kit to conform to the space between the second die plate and the first layer preform and to cause the charge kit to join to the first layer preform;

hardening the charge kit to form a molded part that includes the charge kit and the
5 first layer preform;

opening the first and second die plates; and

removing the molded part from the die.

15 15. A method of making a vehicle body panel as claimed in claim 14, wherein the second die plate includes at least one locating dowel, and wherein the charge kit has at least one locating aperture that receives the at least one locating projection when the charge kit is inserted in the second die plate to position the charge kit in a selected position in the second die plate.

15 16. A method of making a vehicle body panel as claimed in claim 15, wherein the method further comprises trimming the molded part to remove the at least one locating aperture therefrom.

20 17. A method of making a vehicle body panel as claimed in claim 15, wherein the step of closing the die plates together crushes the honeycombs by a selected amount.

25 18. A method of making a vehicle body panel as claimed in claim 17, wherein the honeycombs have an initial thickness prior to closing the die plates together, and wherein the step of closing the die plates together crushes a first selected region of the honeycombs by between 5% and 10% of their thickness, and crushes the rest of the honeycombs by more than the first region.

19. A method of making a vehicle body panel as claimed in claim 18, wherein, after the molded part is removed from the die, the second region is folded to form a hem.

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20. A method of making a vehicle body panel as claimed in claim 14, wherein, prior to inserting the first layer into the first die plate, the first layer is formed with a selected shape to mate substantially completely with the first die plate.

5

21. A method of making a vehicle body panel as claimed in claim 14, wherein a portion of the first layer preform is exposed in the molded part and has a class 'A' surface finish.

10 22. A method of making a vehicle body panel in a die having a first die plate and a second die plate wherein the first and second die plates together define a die cavity, comprising:

15 inserting a charge kit in the first die plate, wherein the charge kit is made up of a first layer, a second layer, a third layer and a fourth layer all joined together, wherein the first layer is made from metal, the second layer contains resin that contains fiber material, the third layer is made up of a plurality of honeycombs oriented generally perpendicularly to the first layer preform, and the fourth layer contains resin that contains fiber material;

20 heating the charge kit sufficiently to cause the charge kit to permit deformation; closing the first and second die plates together to cause the charge kit to conform to the die cavity;

hardening the charge kit to form a molded part;
opening the first and second die plates; and
removing the molded part from the die.

25

23. A method of making a vehicle body panel in a die having at least a first die plate wherein the first die plate defines a first die cavity portion, comprising:

inserting a charge kit in the first die plate, wherein the charge kit is made up of a first layer, a second layer, a third layer and a fourth layer all joined together, wherein the

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first layer is made from metal, the second layer contains resin that contains fiber material, the third layer is made up of a plurality of honeycombs oriented generally perpendicularly to the first layer preform, and the fourth layer contains resin that contains fiber material;

- 5 heating the charge kit sufficiently to cause the charge kit to permit deformation;
 applying pressure to the charge kit to cause the charge kit to conform to the first die cavity portion;
 hardening the charge kit to form a molded part; and
 removing the molded part from the die.

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24. A vehicular body panel, comprising:

 a first layer that is not more than about 0.012 inch thick and that is made from a 2024-T3 Aluminum alloy, wherein the first layer has a first side that has a class 'A' finish, and a second side;

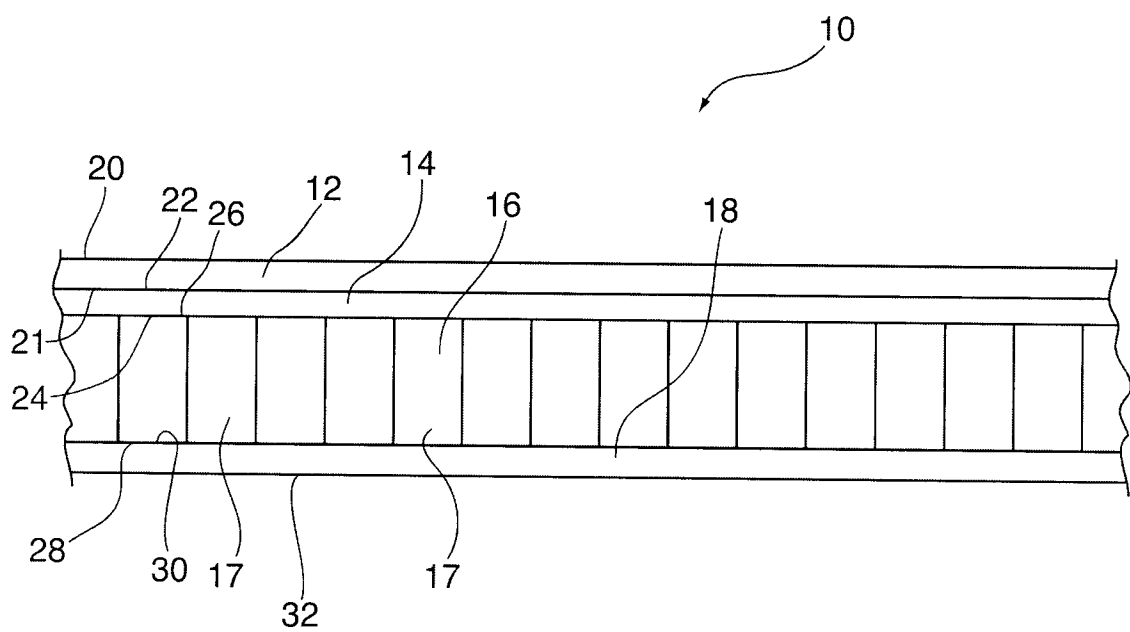
- 15 a second layer that is not more than about 0.010 inch thick and that is made from an epoxy that contains fiber material;

- a third layer made up of a plurality of hexagonal honeycombs oriented generally perpendicularly to the first layer, wherein the third layer is made from 5052 aluminum having a sheet thickness of not more than about 0.0007 inch, wherein the third layer has a layer thickness of not more than about 0.080 inch, wherein each honeycomb is not more
20 than about 1/8 inch across the hexagon face-to-face, wherein the second layer joins the second side of the first layer to a first side of the third layer; and

 a fourth layer made from resin that contains fiber material connected to a second side of the third layer.

25

Fig. 1



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Fig. 2A

	Metal Skinned Composite plaque, MSC plaque #1	Metal Skinned Composite plaque, MSC plaque #2	Metal Skinned Composite plaque, MSC plaque #3
A Surface Skin Material	2024-T3 Al	2024-T3 Al	AZ31B-H24 Mg
A Surface Skin Thickness	0.016"	0.012"	0.020"
Under Skin Ply(s) Material	1 Ply Glass/Epoxy Style #7781	2 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781
Under Skin Ply Thickness	0.010"	2x 0.010"	0.010"
Honeycomb Material	Nomax H/C	5052 Alum H/C	5052 Alum H/C
H/C Thickness / Density (lbs/ft^2)	0.25" / 3.0	0.188" / 3.1	0.188" / 3.1
Inner Ply Material	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781
Inner Ply Thickness	0.010"	0.010"	0.010"
Avg. Dent Depth		0.10mm	0.15mm

Fig. 2A'

Metal Skinned Composite plaque, MSC plaque #4	Metal Skinned Composite plaque, MSC plaque #5	Metal Skinned Composite plaque, MSC plaque #6
2024-T3 Al	2024-T3 Al	2024-T3 Al
0.016"	0.012"	0.016"
6.0 oz/yd ² Plain Weave Glass/Epoxy	6.0 oz/yd ² Plain Weave Glass/Epoxy, 2nd Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781
0.006"	0.016"	0.010"
5052 Alum H/C	5052 Alum H/C	5052 Alum H/C
0.188"/ 3.1	0.188"/ 3.1	0.188"/ 3.1
1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781
0.010"	0.010"	0.010"
0.23mm	0.09mm	0.19mm

Fig. 2B

	Metal Skinned Composite plaque, MSC plaque #7	Metal Skinned Composite plaque, MSC plaque #8	Metal Skinned Composite plaque, MSC plaque #9
A Surface Skin Material	2024-T3 Al	AZ31B-H24 Mg	2024-T3 Al
A Surface Skin Thickness	0.012"	0.020"	0.012"
Under Skin Ply(s) Material	6.0 oz/yd^2 Plain Weave Glass/Epoxy,	6.0 oz/yd^2 Plain Weave Glass/Epoxy,	1 Ply Glass/Epoxy Style #7781
Under Skin Ply Thickness	0.006"	0.006"	0.010"
Honeycomb Material	5052 Alum H/C	5052 Alum H/C	5052 Alum H/C
H/C Thickness / Density (lbs/ft^2)	0250 / 3.1	0.250 / 3.1	0.250 / 3.1
Inner Ply Material	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781
Inner Ply Thickness	0.010"	0.010"	0.010"
Avg. Dent Depth	0.33mm	0.23mm	0.20mm

Fig. 2B'

Metal Skinned Composite plaque, MSC plaque #10	Metal Skinned Composite plaque, MSC plaque #11	Metal Skinned Composite plaque, MSC plaque #12
1100-H18 Al Full Hard 0.008"	1100-0 Al Full Soft 0.012"	1100-H18 Al Full Hard 0.008"
1 Ply Glass/Epoxy Style #7781 0.010"	1 Ply Glass/Epoxy Style #7781 0.010"	6.0 oz/yd ² Plain Weave Glass/Epoxy, 0.006"
5052 Alum H/C 0.250 / 3.1	5052 Alum H/C 0.0250 / 3.1	5052 Alum H/C 0.0250 / 3.1
1 Ply Glass/Epoxy Style #7781 0.010"	1 Ply Glass/Epoxy Style #7781 0.010"	1 Ply Glass/Epoxy Style #7781 0.010"
0.47mm	0.71mm	0.63mm

Fig. 2C

	Metal Skinned Composite plaque, MSC plaque #13	Metal Skinned Composite plaque, MSC plaque #14	Metal Skinned Composite plaque, MSC plaque #15
A Surface Skin Material	1100-0 Al Full Soft	1100-H18 Al Full Hard	1100-H18 Al Full Hard
A Surface Skin Thickness	0.012"	0.008"	0.008"
	6.0 oz/yd ² Plain Weave Glass/ Epoxy	6.0 oz/yd ² Plain Weave Glass/Epoxy, 2nd Ply Glass/Epoxy Style #7781	4.4 oz/yd ² Plain Weave Glass/Epoxy, 2nd Ply Glass/Epoxy Style #7781
Under Skin Ply(s) Material			
Under Skin Ply Thickness	0.006"	0.016"	0.014"
Honeycomb Material	5052 Alum H/C	5052 Alum H/C	5052 Alum H/C
H/C Thickness / Density (lbs/ft ²)	0.250 / 3.1	0.250 / 3.1	0.250 / 3.1
Inner Ply Material	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy Style #7781	1 Ply Glass/Epoxy #7781
Inner Ply Thickness	0.010"	0.010"	0.010"
Avg. Dent Depth	0.73mm	0.25mm	0.31mm

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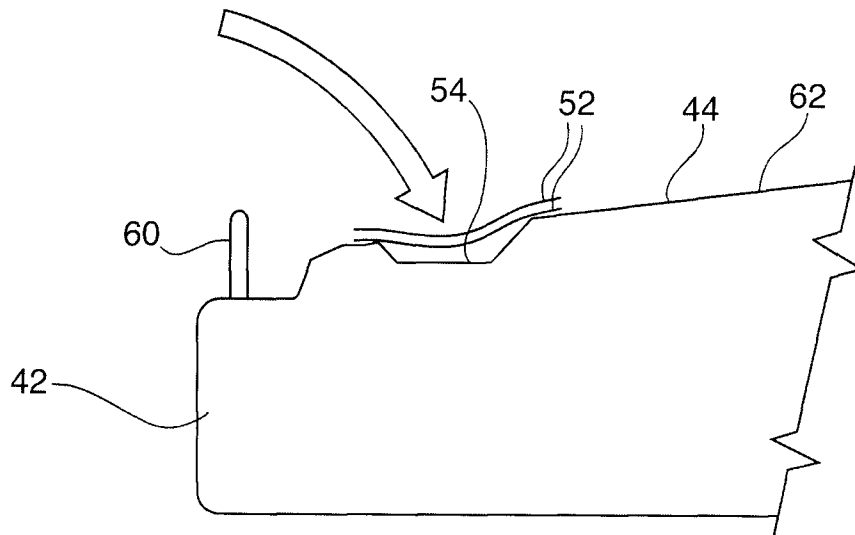


Fig. 3a

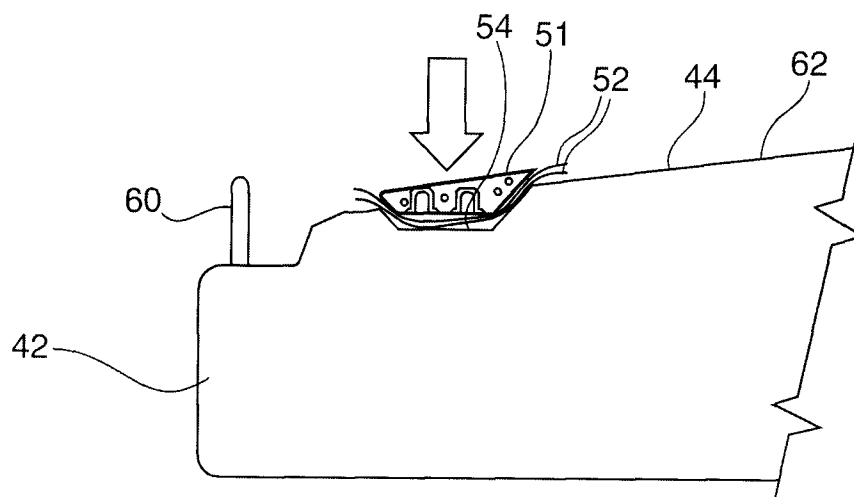


Fig. 3b

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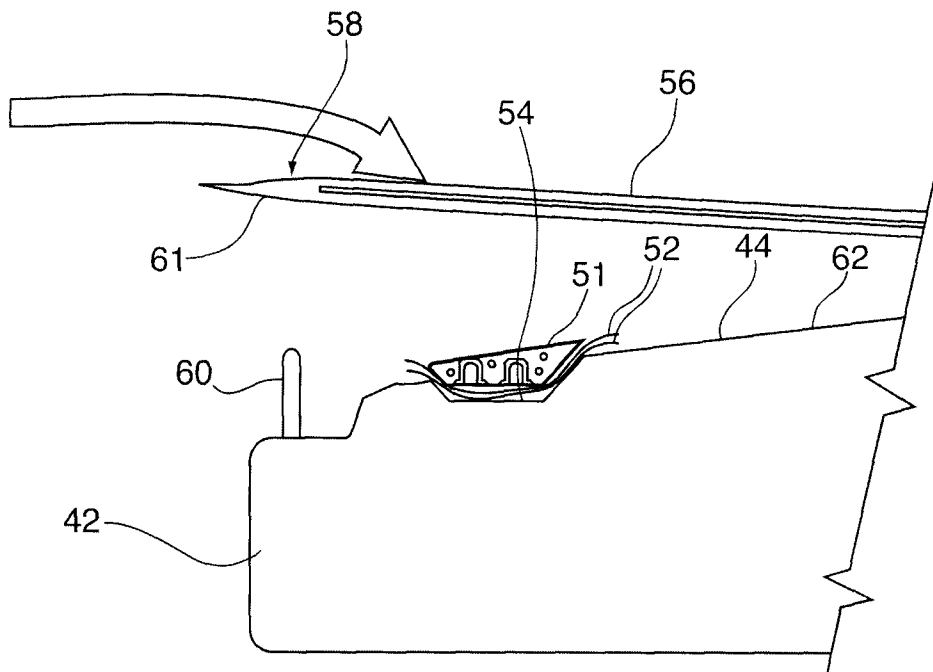


Fig. 3c

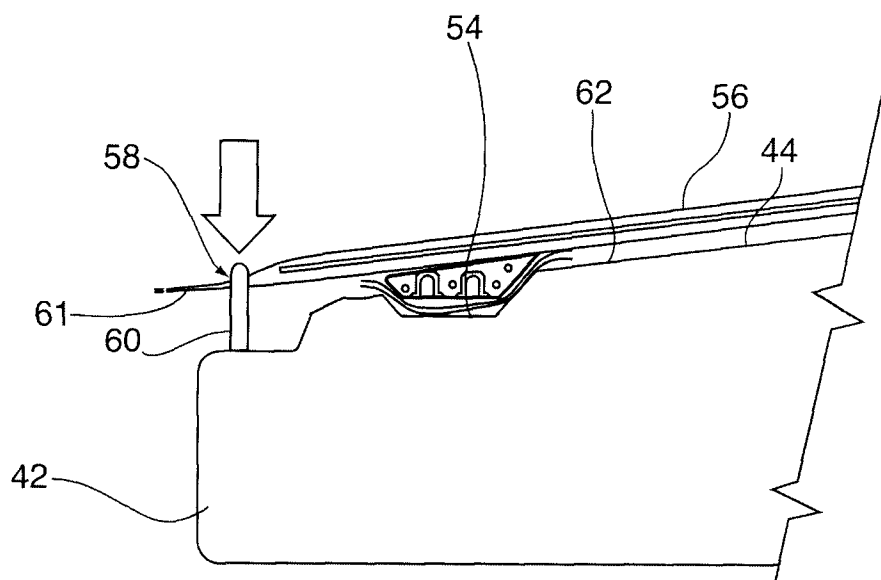


Fig. 3d

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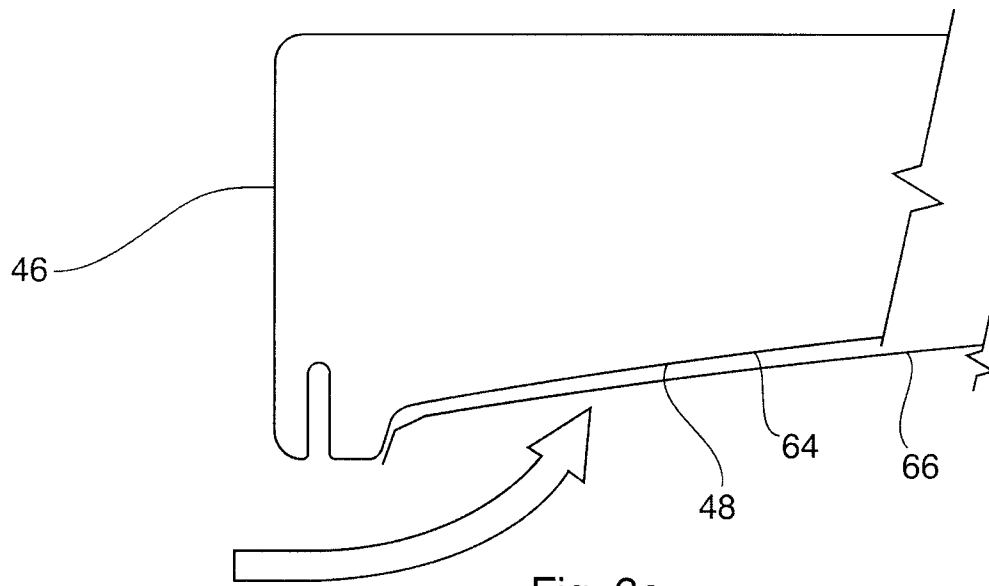


Fig. 3e

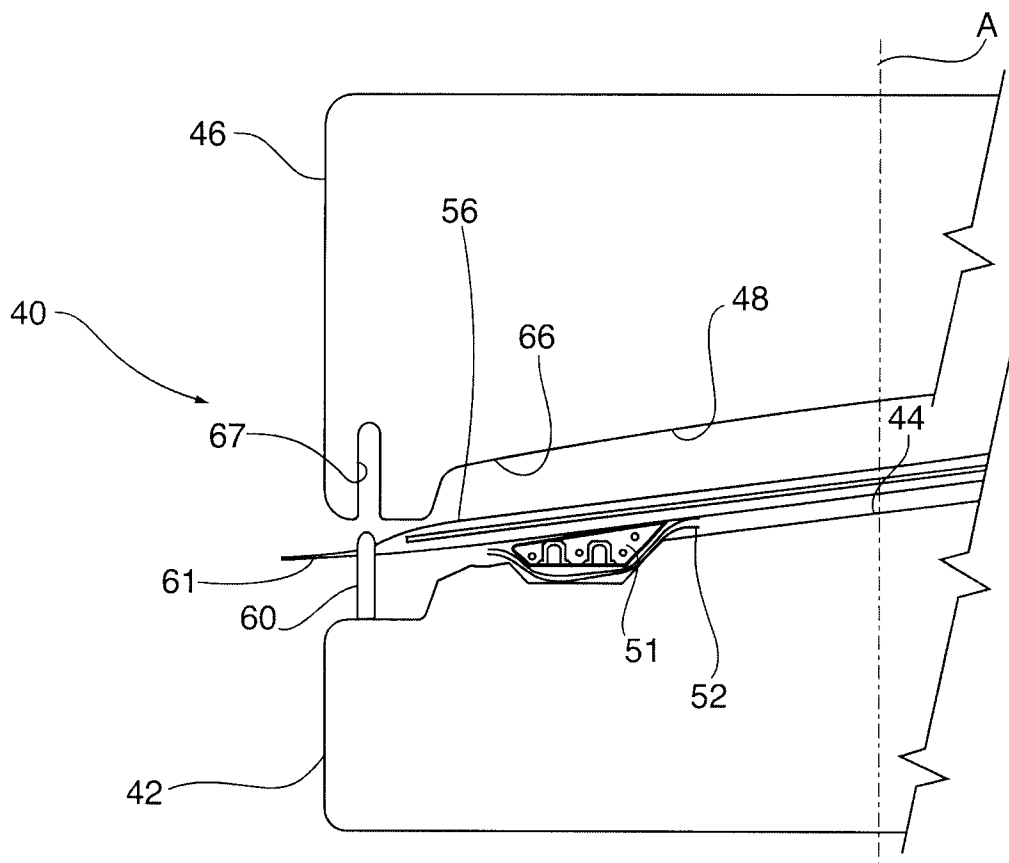


Fig. 3f

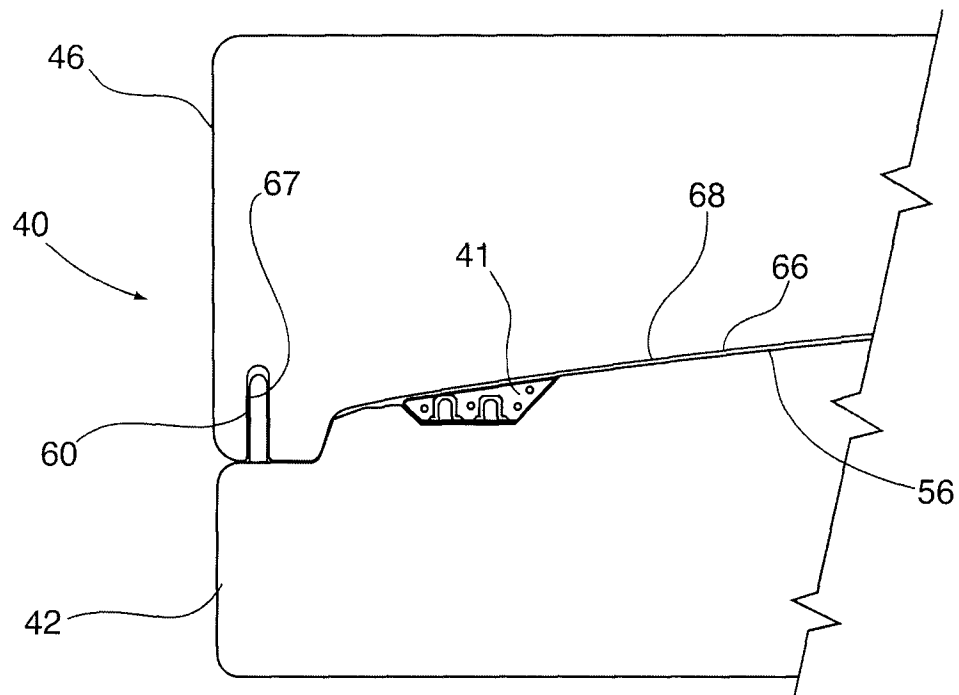


Fig. 3g

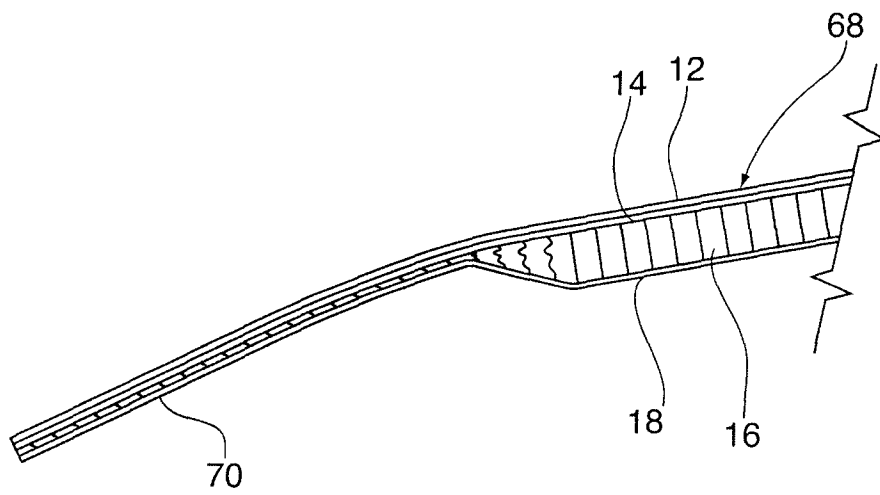
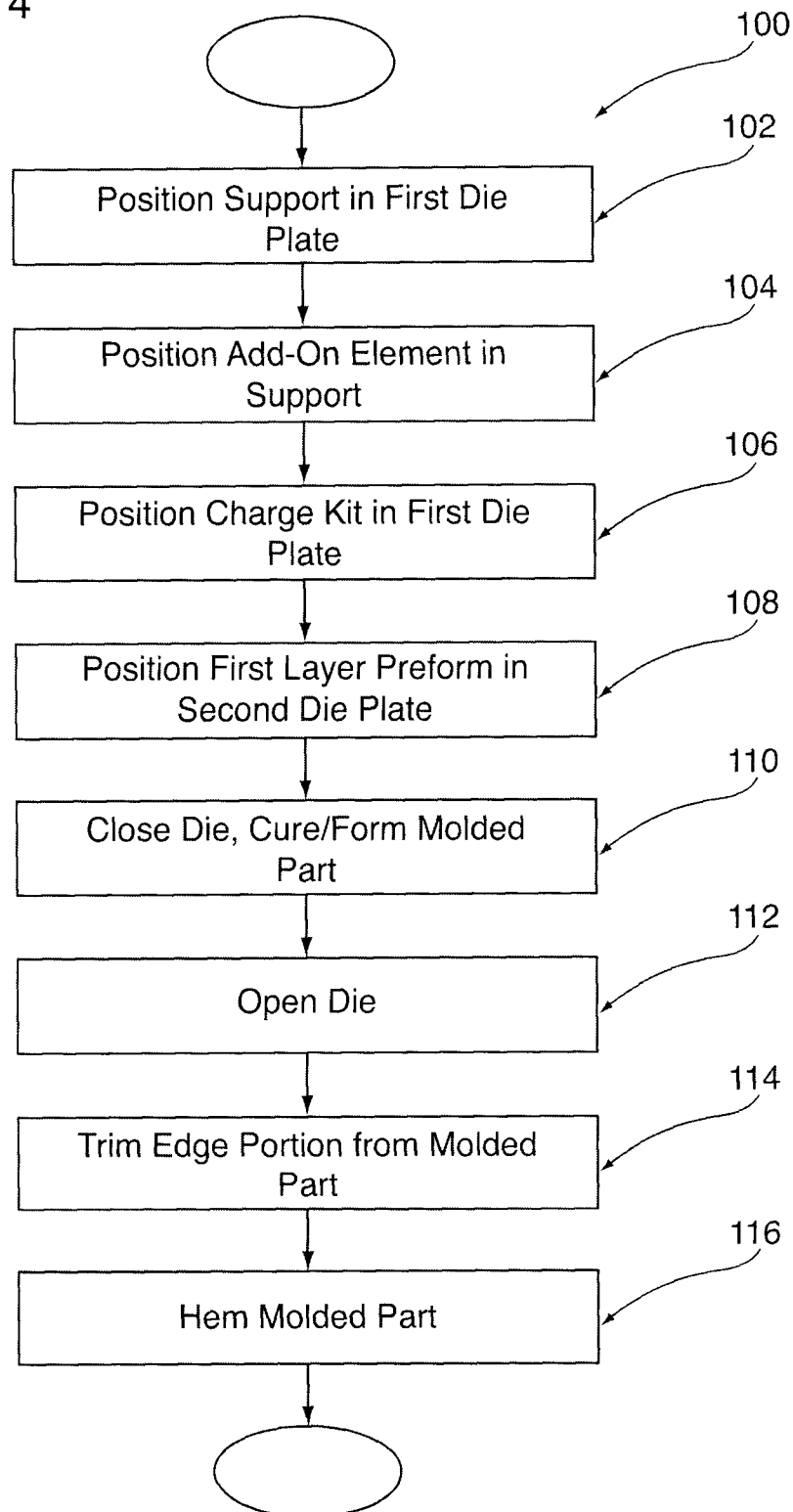


Fig. 3h

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Fig. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2010/001666

A. CLASSIFICATION OF SUBJECT MATTER IPC: B62D 25/02 (2006.01) , B32B 15/08 (2006.01) , B32B 27/08 (2006.01) , B32B 3/12 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC: B62D 25/02 (2006.01) , B32B 15/08 (2006.01) , B32B 27/08 (2006.01) , B32B 3/12 (2006.01) USPC: 428/ , 296/		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Canadian Patent Database		
Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) TotalPatent, keywords: body panel, layer, metal, resin, honeycomb, cells		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant	Relevant to claim No.
X ---- A	EP 1,844,993 A1 (STACHEL, P. ET AL.) 17 October 2007 (17-10-2007) *see entire document*	1-13 ---- 14-24
A	EP 1,476,334 B1 (CLOUGH, A.) 7 March 2007 (07-03-2007) *see entire document*	1-24
A	WO 03/047842 A1 (CATE, P. ET AL.) 12 June 2003 (12-06-2003) *see entire document*	1-24
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 31 December 2010 (31-12-2010)	Date of mailing of the international search report 26 January 2011 (26-01-2011)	
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Authorized officer Robert Gruber (819) 953-1889	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2010/001666

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
EP1844993A1	17 October 2007 (17-10-2007)	None	
EP1476334B1	07 March 2007 (07-03-2007)	EP1476334A2 AT356006T DE60312307D1 GB0201980D0 GB0202122D0 JP2005515932T WO03064221A2 WO03064221A3	17 November 2004 (17-11-2004) 15 March 2007 (15-03-2007) 19 April 2007 (19-04-2007) 13 March 2002 (13-03-2002) 20 March 2002 (20-03-2002) 02 June 2005 (02-06-2005) 07 August 2003 (07-08-2003) 16 October 2003 (16-10-2003)
WO03047842A1	12 June 2003 (12-06-2003)	AU2002349150A1 GB0128954D0	17 June 2003 (17-06-2003) 23 January 2002 (23-01-2002)