

Title: Variable gap cover for an aircraft, mould assembly for forming such a cover and a method for manufacturing a variable gap cover

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The present invention relates to a variable gap cover for an aircraft, a mould assembly for forming such a cover and a method for manufacturing a variable gap cover. Such a variable gap cover is used to cover gaps at the outer surface of high-speed vehicles such as aircraft and high-speed trains, which gaps have an effect on the aerodynamic properties of the high-
10 speed vehicle. Such gaps are in particular located between a first vehicle part and a second vehicle part which are moveable with respect to each other.

Aircraft such as aeroplanes are high-speed vehicles having vehicle parts that are movable with respect to each other between a first position and a second position and that have a
15 gap between them. For example, on aircraft, elevators, rudders, flaps and ailerons are articulated to fixed vehicle parts, between which there are gaps. Such gaps, which may have large dimensions, may generate unanticipated behaviour in the flow of air circulating around the vehicle, and thus affect the aerodynamic contour. This problem is especially important for aircraft. The sealing of these gaps, which may be complex, is necessary for the purpose
20 of reducing the drag of the vehicle and for enhancing the aerodynamic efficiency of the surface. Additionally, the aesthetic appearance of the vehicle improves upon covering such gaps.

Commonly known variable gap covers comprise so-called P-seals, comprising a flexible seal
25 component having a P-bulb cross-section which is attached to a first vehicle part, and which is adapted to slide on the second vehicle part and sealingly engage the second vehicle part upon movement between the first and second position. Such a P-seal is described in US5,388,788.

30 In US2008/0121758 a variable gap cover is disclosed, adapted to be attached to the first vehicle part, comprising a tongue-shaped section of a single piece laminated composite structure which covers the gap between the first position and a second position of the first and second vehicle parts. At the end of the tongue-shaped section there is a free end which ends on the outer surface of the second vehicle part.

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Further known variable gap covers comprise so-called curtain-seals, comprising a flexible wall seal attached to both vehicle parts. Such a curtain-seal is e.g. described in US582,206, US7,694,915 and in US2009/0095841.

The known variable gap covers have disadvantages, amongst others in view of weight,
5 costs, deformations, aesthetical deterioration, wear and parasitic leakage degrading the aerodynamic efficiency.

It is an object of the present invention to provide an improved variable gap cover for an aircraft, the gap being present between a first vehicle part and a second vehicle part which
10 are movable with respect to each other between a first position and a second position and have a gap between them.

The present invention further relates to an improved mould assembly for forming such a cover and a method for manufacturing such a variable gap cover.
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This object is achieved according to the invention in that the improved variable gap cover is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix and comprises:

- a first rigid attachment plate section adapted to be attached to the first vehicle part,
20 comprising at least one fibre layer,
- a second rigid attachment plate section adapted to be attached to the second vehicle part, comprising at least one fibre layer,
 - o the first and second rigid attachment plate sections jointly form an aerodynamic contour over the gap, at least in the first position of the vehicle parts,
- 25 - a flexible sheet section, provided between and formed integral with the first and second attachment plate section, comprising at least one fibre layer.

Advantageously, such a variable gap cover does not suffer from interfering contact between the flexible sheet section and the moving vehicle parts, and hence wear and contact loads
30 are reduced/ avoided.

Advantageously, the flexible sheet section of such an improved variable gap cover provides the flexibility required for movement of the first and second vehicle part with respect to each other, e.g. rotation. In embodiments, the flexible sheet section is able to withstand
35 aerodynamic pressure differences and provides aerodynamic sealing. The combination of geometry and composite material of the flexible sheet section provides improved durability under the enforced displacements. Simultaneously, the attachment plate sections are rigid

to enable proper attachment to the vehicle parts. The single piece laminated composite structure facilitates the method for manufacturing such a variable gap cover.

In embodiments, the flexible sheet section has the shape of a fold, in particular a fold that is omega-shaped in cross-section, in the first position of the vehicle parts, and in the second

5 position the flexible sheet section is stretched. Alternatively, it is also conceivable that the flexible sheet section is stretched in the first position of the vehicle parts, and in the second position the flexible sheet section has the shape of a fold, in particular a fold that is omega-shaped in cross-section. Instead of the sheet section having an omega-shape, which is in fact a single pleat/ fold, also a box pleat or even further folded flexible sheet section is
10 envisaged.

Advantageously, the flexible sheet section is provided between the vehicle parts, thereby not influencing aerodynamics.

15 The variable gap cover is advantageously applied in an aircraft, although the application in other high-speed vehicles such as trains, watercraft and spacecraft is also conceivable. The gap to be covered is present between a first and second vehicle part which are movable with respect to each other between a first position and a second position and have a gap between them. Typically, the first and second vehicle parts are pivotable or rotatable with
20 respect to each other. Alternatively, the first and second vehicle part are slidable (translatable) with respect to each other between a first position and a second position and have a gap between them. Alternatively, e.g. flaps are curvilinearly translatable with respect to the wing. The first and second vehicle part are for example selected from:

- wing and aileron and/or trimtab and/ or lift dumpers,
- 25 - wing and flaps, flaperons, spoilers and/ or slats,
- horizontal tail plane or stabilizer and flaperon, spoiler, elevator or airbrake, trimtabs,
- vertical tail plane (fin) and rudder, elevator and/ or trimtabs,
- hull and airbrakes or control surfaces,
- hull and door, e.g. entrance door, personnel door, cargo door or hatch door, e.g. for
30 landing gear.

The dimensions of the variable gap cover will depend on the application, but in embodiments the variable gap cover may have a length of 1-12m to cover a gap of such length.

35 The variable gap cover comprises two rigid attachment plate sections, adapted to be attached to the vehicle parts. At least in the first position of the vehicle parts, these rigid attachment plate sections adjoin or overlap to jointly form an aerodynamic contour over the

gap. It is noted that adjoining plate sections may be in contact with each other, or lie next to each other, leaving a small slit therebetween. Advantageously, the overlap does not involve contact between the rigid attachment plate sections. A small gap is preferably allowed, to prevent wear and improve durability. The flexible sheet section of the invention will provide a
5 seal for this small slit to prevent aerodynamic leakage due to parasitic airflow through the slit which would undesirably impair aerodynamic airflow.

In embodiments, the first attachment plate section comprises an attachment portion and a cantilevered portion, adapted to overlap the second attachment plate section, and the
10 flexible sheet section is formed integral with the first attachment plate section between the attachment portion and the cantilevered portion. According to the invention, the cantilevered portion of the first attachment plate section adjoins or overlaps the second attachment plate section at least in the first position of the vehicle parts. Optionally, the cantilevered portion has a design similar to known tongue-shaped designs, e.g. known from US2008/0121758.

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In embodiments, one end of the flexible sheet section is formed integral with the above-described embodiment of the first attachment plate section between the attachment portion and the cantilevered portion, and the opposite end of the flexible sheet section is formed integral with and as a continuation of an end of the second attachment plate section.

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Also embodiments are conceivable where the flexible sheet section is formed integral with the two ends of the rigid attachment plate sections. Possibly, the ends adjoin each other in the first position of the vehicle parts. It is also conceivable that the flexible sheet section is formed integral with the two intermediate portions of the rigid attachment plate sections.

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In embodiments, an outer surface of at least one of the attachment plate sections is adapted to form part of an outer skin of the vehicle. Advantageously, such outer surface is coated with paint corresponding to the outer skin of the vehicle. In embodiments, it is conceivable that a substantial part of the outer skin of the vehicle is formed by the variable gap cover of
30 the invention. Hence, where conventionally additional panels were applied and a gap cover, is it possible with the variable gap cover of the invention to integrate such panel into the gap cover.

In advantageous embodiments, an outer surface of at least one of the attachment plate
35 sections is adapted to be provided flush with an outer skin (panel) of the vehicle part to which it is to be attached. This may be in particular advantageous during the assembly of the variable gap cover with the first and second vehicle parts.

In embodiments, a portion, e.g. an end portion of at least one of the attachment plate sections that is to be attached to a vehicle part is provided with transversal holes for receiving connectors. Such connectors are advantageously selected from rivets, nut-bolt assemblies and bolt-rivetable nut assemblies.

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According to the invention, the variable gap cover is of a single piece laminated composite structure, wherein multiple fibre layers are embedded in a continuous polymer matrix. In embodiments, the continuous polymer matrix is formed by a thermoplast, in particular a high-performance thermoplastic such as polyphenylene sulfide (PPS), polyether imide

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(PEI), polyether ketone (PEK), polyether ketone ketone (PEKK) or polyether ether ketone (PEEK). An advantage of a thermoplastic material is that they are flexible and durable

under bending actions. Alternatively, the continuous polymer matrix is formed by a thermosetting matrix material. Advantageously, the continuous polymer matrix has advantageous properties such as resistance to heat, aging, sunlight and abrasion. A

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particular advantage of a variable gap cover having fibres in a thermoplastic matrix is that it electrically isolates contacting metal parts, thus protect against galvanic corrosion. Another advantage is that thermoplastics are not prone to fatigue, as compared to metal.

The rigid attachment plate sections, adapted to be attached to the vehicle parts, comprise at least one fibre layer, possibly fibre fabric. Advantageously, the fibre comprises carbon fibers as these have excellent strength and stiffness properties. It is conceivable that other fibre layers are applied instead of, or in addition to the carbon fibre, such as aramid or glass fibers. Advantageously, both the first and the second attachment plate section comprise the same type of fibre. It is possible to obtain rigidity of the attachment plate sections by increasing the number of fibre layers, and/ or by selecting the fibre orientation and a type of fibre. This selection can be based on the type and/or thickness of the fibre, and/ or the type of fibre fabric. The fibres may be non-woven, e.g. long fibres may be positioned unidirectional. The fibres may also be in the form of a fabric, e.g. a layer of woven fibres.

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The flexible sheet section also comprises at least one fibre layer. Advantageously, this fibre comprises fibreglass or woven aramid, e.g. Kevlar, Twaron, Ultra-high-molecular-weight polyethylene (UHMWPE). It is possible to obtain flexibility of the flexible sheet section by reducing the number of fibre layers, and/ or by selecting a type of fibre and fibre orientation. This selection can be based on the type and/or thickness of the fibre, and/ or the type of fabric.

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The composite structure of the variable gap cover of the invention allows the number of fibre layers within an attachment plate section or the flexible sheet section to be variable, e.g. between 1-15 layers. For example, more layers are provided in areas which are exposed to greater stresses.

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The present invention also relates to a mould assembly for wet layup forming of a variable gap cover for an aircraft, which mould assembly is adapted to be placed in an autoclave in which the variable gap cover is allowed to cure or consolidate,

the gap being present between a first vehicle part and a second vehicle part which are

10 movable with respect to each other between a first position and a second position and have a gap between them, wherein the variable gap cover is adapted to be attached to the first vehicle part, and is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix, the variable gap cover comprising:

- a first rigid attachment plate section adapted to be attached to the first vehicle part,
- 15 comprising at least one fibre layer,

- a second rigid attachment plate section adapted to be attached to the second vehicle part, comprising at least one fibre layer,

- o the first and second rigid attachment plate sections jointly form an aerodynamic contour over the gap, at least in the first position of the vehicle parts,

- 20 - a flexible sheet section, provided between and formed integral with the first and second attachment plate section, comprising at least one fibre layer,

the mould assembly comprising:

- a forming tool onto which fibre layers of the first attachment plate section are laid-up, possibly pre-impregnated fibre layers,

- 25 - a bulb-shaped tooling block, bulb-shaped in cross-section, adapted to be positioned on top of at least one layer of fibre layers of the first attachment plate section, onto which bulb-shaped tooling block fibre layers of the flexible sheet section and the second attachment plate section are laid-up.

30 A mould assembly is required to establish the shape of a variable gap cover. During wet layup forming, layers of fiber fabric layers are placed in an open mould. Either pre-impregnated fibre layers are applied, or the fibre layers are in a consequent step being saturated with a wet polymer matrix material by pouring it over the fabric and working it into the fabric. The mould is then left so that the polymer matrix will cure/ consolidate.

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The layers of fiber fabric of the first attachment plate sections are laid up on a forming tool, e.g. a flat or curved surface. As indicated above, the mould assembly of the invention further

comprises a bulb-shaped tooling block, adapted to be positioned on top of at least one layer of saturated fibre layers of the first attachment plate section, onto which bulb-shaped tooling block fibre layers of the flexible sheet section and part of the second attachment plate section are laid-up. In embodiments, the bulb-shaped tooling block comprises a curved
5 mould surface to provide a curvature to the second attachment plate section that allows the first rigid attachment plate section to overlap the second attachment plate section to form an aerodynamic contour over the gap,
at least in the first position of the vehicle parts.

- 10 In embodiments, the mould is placed into an autoclave (heated pressure vessel) to allow the polymer matrix to cure. For example, depending on the material, the mould is allowed to cure at 330-340°C at an elevated pressure of 5-7 bar.

Even more advantageously, the mould assembly further comprises a vacuum bag which is
15 adapted to be positioned on top of the layers on the forming tool and bulb-shaped tooling block, to pull a vacuum on the variable gap cover prior to placing the mould assembly in the autoclave. The vacuum bag allows the single piece laminated composite structure to be cured with a continuous vacuum to extract entrapped gasses from laminate. This is a very common process in the aerospace industry because it affords precise control over moulding
20 during cure or consolidation. This precise control creates the exact laminate geometric forms needed to ensure strength and safety, as is desired in the aerospace industry.

The invention further relates to a method for manufacturing a variable gap cover for an aircraft, the gap being present between a first vehicle part and a second vehicle part which
25 are movable with respect to each other between a first position and a second position and have a gap between them, wherein the variable gap cover is adapted to be attached to the first vehicle part and to the second vehicle part, and is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix,

30 wherein the variable gap cover comprises:

- a first rigid attachment plate section adapted to be attached to the first vehicle part, comprising at least one fibre layer,
- a second rigid attachment plate section adapted to be attached to the second vehicle part, comprising at least one fibre layer,
- 35 o the first and second rigid attachment plate sections jointly form an aerodynamic contour over the gap, at least in the first position of the vehicle parts,

- a flexible sheet section, provided between and formed integral with the first and second attachment plate section, comprising at least one fibre layer,

the method comprising the steps of:

- providing fibre layers for the first and second attachment plate sections and the flexible sheet section,
- providing a forming tool onto which the fibre layers of the first attachment plate sections are laid-up,
- positioning a bulb-shaped tooling block on top of at least one layer of fibre layers of the first attachment plate section,
- laying up fibre layers of the flexible sheet section and the second attachment plate section onto the bulb-shaped tooling block,
- consolidating the composite gap cover in an autoclave at an elevated pressure, and possibly at an elevated temperature,
- removing the bulb-shaped tooling block.

In embodiments, prior to consolidating the composite gap cover a vacuum bag is positioned over the fibre layers on the forming tool and bulb-shaped tooling block, and a vacuum is pulled on the variable gap cover.

The invention will be elucidated further in relation to the attached drawings, in which:

Fig. 1a schematically represents an aeroplane in side view;

Fig. 1b schematically represents the aeroplane of fig. 1a in top view;

Fig. 2 shows a the cross-section along the line A-A of fig. 1b, comprising a variable gap cover according to the prior art;

Fig. 3 shows in a cross-sectional view, similar to that of fig. 2, a variable gap cover according to the present invention assembled to a first and second vehicle part, in a first position;

Fig. 4a shows the variable gap cover of fig. 3 in a second position;

Fig. 4b shows the variable gap cover of fig. 3 in a third position;

Fig. 5 shows the variable gap cover of fig. 3 in the first position in an isometric view;

Fig. 6a is a cross-sectional representation of a mould assembly for forming such a variable gap cover in an exploded view, not drawn to scale;

Fig. 6b shows the mould assembly of fig. 6a with the layers of fibre fabric on top thereof, not drawn to scale;

Fig. 7 is a schematical and non-proportional representation of an alternative mould assembly with the layers of fibre fabric on top thereof, not drawn to scale.

In figs. 1a and 1b an aeroplane 100 is schematically shown, comprising a fuselage 1, wings 2 and a vertical tail plane 3, also referred to as vertical stabiliser. To the vertical tail

plane 3 a horizontal tail plane 4 is attached, also referred to as horizontal stabiliser. In the shown embodiment, elevators 5 are provided which are movable (rotatable) with respect to the horizontal tail plane 4. This is shown in cross-section along line A-A in fig. 2. A rudder 6 is provided and is movable with respect to vertical tail plane 3, and ailerons 7 and flaps 8 are provided and are movable with respect to wings 2. Furthermore, spoilers 9 are movably attached to the wings 2.

In fig. 2 the cross-section along the line A-A of fig. 1b is represented, comprising a fixed horizontal tail plane 4 and an elevator 5 that is movable with respect to the horizontal tail plane 4, and a gap G between them. In particular, elevator 5 is rotatable about a rotation axis 17 with respect to the horizontal tail plane 4. A conventional variable gap cover comprising in particular two P-seals 13, are attached to the horizontal tail plane 4.

In the shown embodiment, the horizontal tail plane 4 comprises skin panels 10 and in line therewith overhang/ access panels 12, both connected via fasteners 16 to a rear spar 11. Here, the P-seals 13 are connected via fasteners 16 to the overhang/ access panels 12. In the shown embodiment, the elevator 5 comprises skin panels 10' and in line therewith leading edge skin panels 14, both connected via fasteners 16 to a front spar 15. These fasteners, not shown per se, are advantageously chosen from the group of bolts, nuts and blind bolts.

As explained above, the P-seal 13 is a flexible seal component having a P-bulb cross-section which is here attached to the overhang/access panel, and which is adapted to slide on the elevator 5, in particular the leading edge skin panels 14 of the elevator 5, and sealingly engage these leading edge skin panels 14 upon movement of the elevator 5.

In figs. 3, 4a and 4b a cross-sectional view through horizontal tail plane 104 and elevator 105 similar to that of fig. 2 is shown. Similar parts have been given similar reference numbers, to which '100' has been added. Elevator 105 is movable with respect to the horizontal tail plane 104, and a variable gap is present between them. In particular, elevator 105 is rotatable about a rotation axis 117 with respect to the horizontal tail plane 104. Elevator 105 and horizontal tail plane 104 are shown in a first position in fig. 3, and a second and third position in figs. 4a and 4b. In the second position of fig. 4a, the elevator 105 has pivoted about pivot axis 117 in an upward direction, and in the third position in fig. 4b in a downward direction. By comparing figs. 3, 4a and 4b, it is evident that the gap between horizontal tail plane 104 and elevator 105 is a variable gap, in particular the upper

gap G' and lower gap G'' between the skin panels 110, 110' of the vehicle parts 104 and 105.

In the shown embodiment, the horizontal tail plane 104 comprises skin panels 110

5 connected via fasteners 116 to a rear spar 111. In the shown embodiment, the elevator 105 comprises skin panels 110', connected via fasteners 116 to a front spar 115. These fasteners, not shown per se, are advantageously chosen from the group of bolts, nuts and blind bolts.

10 In the shown embodiment, at the bottom part of the drawing, a variable gap cover 120 according to the present invention is shown, covering lower gap G''. No seal is provided over the gap G' between the skin panels 110 of the horizontal tail plane 104 and the skin panels 110' of the elevator 105 indicated at the upper part of the drawing. This single seal 120 may sufficiently close the gap between the fixed and movable parts 104, 105. Alternatively, the
15 single seal may be provided in the upper gap G' instead of the lower gap G''. An improved seal is conceivable comprising two variable gap cover covers according to the invention, covering both upper gap G' and lower gap G''.

The variable gap cover 120 according to the present invention is shown in an isometric view

20 in fig. 5. The variable gap cover 120 is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix and comprises:

- a first rigid attachment plate section 120a, here attached via fasteners 116 to the front spar 111 of the horizontal tail plane 104,
- a second rigid attachment plate section 120b, here attached via fasteners 116 to the
25 rear spar 115 of the elevator 105,
 - o wherein the first and second rigid attachment plate sections 120a, 120b adjoin one another in the shown position of the vehicle parts 104, 105 to form an aerodynamic contour over the gap G,
- a flexible sheet section 120c, provided between and formed integral with the first and
30 second attachment plate sections 120a, 120b.

All plate sections comprise at least one fibre layer. Inherently, the ends of the attachment plate sections 120a, 120b that are attached to the vehicle parts 104, 105 are provided with transversal holes for receiving such fasteners 116.

35 As visible in fig. 3, in the first position of the adjoining plate sections 120a, 120b a small slit S is present therebetween. Despite the slit S, the plate sections 120a, 120b still form an

aerodynamic contour over the gap G. The flexible sheet section 120c of the invention serves to seal the slit between these plate sections.

Upon comparing the seals of fig. 2 and 3, it is evident that the overhang/ access panels 12 and leading edge skin panels 14 are now redundant, and formed integral in the variable gap cover 120. In line herewith, one may refer to the first rigid attachment plate section 120a as a rigid overhang panel section 120a, and to the second rigid attachment plate section 120b as the rigid leading edge skin panel section 120b.

10 In the shown embodiment, the first attachment plate section 120a comprises an attachment portion 120ab and a cantilevered portion 120ac, here adjoining the second attachment plate section 120b in the first, second and third position of the vehicle parts as visible in figs. 3, 4a and 4b. The flexible sheet section 120c is formed integral with the first attachment plate section 120a between the attachment portion 120ab and the cantilevered portion 120ac, here at area 120ad of the first attachment plate section. At the opposite end, the flexible sheet section 120c is formed integral with and as a continuation of an end portion 120be of the second attachment plate section 120b.

In the embodiment of figs. 3, 4a and 4b, the outer surfaces of both the first and second rigid attachment plate sections 120a, 120b form a continuation of the skin panels 110 of the horizontal tail plane 104 and the skin panels 110' of the elevator 105. In particular, the outer surface of the attachment plate sections is flush with the outer skin panels of the vehicle part to which it is to be attached. It is thus well conceivable that this outer surface is treated similar to the outer skin portions: e.g. same paint, coating, treatment or the like.

25 In the embodiments of figs. 3, 4a and 4b the flexible sheet section 120c has the shape of a fold, in particular a fold that is omega-shaped in cross-section, also referred to as a 'bulb-shape'. The flexible sheet is stretched in the second position of fig. 4a, and compressed in the third position fig. 4b, slightly altering the general omega-shape.

30 In figs. 6a and 6b a mould assembly 50 for wet layup forming a variable gap cover 20 for an aircraft according to the invention is schematically shown in cross section, not drawn to scale. The mould assembly 50 is adapted to form a variable gap cover 20, similar to the variable gap cover 120 as shown in figs. 3-5. This mould assembly 50 is adapted to be placed in an autoclave in which the variable gap cover is allowed to cure. The variable gap cover to be formed in the mould assembly 50 is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix.

The mould assembly 50 is advantageously made of metal, e.g. steel. The mould assembly 50 comprises a forming tool 56 onto which (optionally pre-impregnated) fibre layers of the first attachment plate section 20a, adapted to be attached to the first vehicle part, and possibly, although not shown, also of the second attachment plate section 20b, adapted to be attached to the second vehicle part, are laid-up. The fibre layers may be pre-impregnated with a resin, e.g. a thermoplastic resin. It is also conceivable that saturation with a polymer takes place after laying up the fibre layers. The first attachment plate section 20a comprises layers forming an attachment portion 20ab, a cantilevered portion 20ac, and an area 20ad of the first attachment plate section 20a with which flexible sheet section 20c is formed integral with, between the attachment portion 20ab and the cantilevered portion 20ac. Advantageously, the forming tool 56 has an outer surface 56a having a curvature corresponding to that of the outer contour of an overhang/ access panel 12 as shown in fig. 2, as this panel is redundant in view of the design of the variable gap cover of the present invention.

The mould assembly further comprises a bulb-shaped tooling block 55, which is in fig. 6b positioned on top of the saturated fibre layers of the first attachment plate section 20a, in particular on top of the cantilevered portion 20ac of the first attachment plate section 20a. Onto the bulb-shaped tooling block 55 pre-impregnated fibre layers of the flexible sheet section 20c, part of the attachment portion 20ab of the first attachment plate section 20a and of the second attachment plate section 20b are laid-up.

In the shown embodiment, the bulb-shaped tooling block 55 comprises a curved mould surface 55a to provide a curvature to the second attachment plate section 20b that allows the cantilevered portion 20ac of the first rigid attachment plate section 20a to overlap the second attachment plate section 20b to form an aerodynamic contour over the gap in the first position of the vehicle parts. Furthermore, the curvature of the second attachment plate section advantageously corresponds to the curvature of a leading edge skin panel as shown in fig. 2, as this panel is redundant in view of the design of the variable gap cover of the present invention.

In embodiments, not shown, the shown mould assembly 50 further comprises a vacuum bag, which can be positioned on top of one or more fibre layers on the forming tool 56 and bulb-shaped tooling block 55, to pull a vacuum on the variable gap cover prior to placing the mould assembly 50 in the autoclave.

According to the invention, the variable gap cover is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix, e.g. polyphenylene sulphide (PPS). Advantageously, all fibre layers are embedded in the same polymer matrix. In figs. 6a and 6b, the polymer matrix is not shown, and the fibre layers are
5 intentionally shown in an enlarged view.

The variable gap cover 20 of figs. 6a and 6b comprises a first rigid attachment plate section 20a adapted to be attached to the first vehicle part, comprising an attachment portion 20ab and a cantilevered portion 20ac. The cantilevered portion 20ac here comprises 4 layers 30-
10 33 of carbon fibre fabric, e.g. woven carbon fibres. Generally, 4-8 layers are conceivable. The attachment portion 20ab comprises 2-4 extra layers 34, 35, 36, 37 of carbon fibre fabric. Layers 36, 37 are locally provided in order to make the attachment portion 20ab sufficiently strong for receiving fasteners and attaching it to a vehicle part such as horizontal tail plane 104. An edge part 34a of layer 34 has been bent vertically upwards for improving the
15 transition of the rigid attachment plate section 20a to the flexible sheet section 20c. Edge part 35a has been bent upwards for the same purpose. The edge parts 34a, 35a together form an integral blade stiffener, stiffening the cantilevered portion 20ac. Layer 30 of the first rigid attachment plate section 20a will form an outer surface 30a of the variable gap cover, and will be positioned flush with the outer skin panels of the vehicle part to which it is to be
20 attached. It is thus well conceivable that this outer surface is treated similar to the outer skin portions: e.g. same paint, coating, treatment or the like. Analogously, layer 41 of the second rigid attachment plate section 20b will form an outer surface 41a of the variable gap cover, and will be positioned flush with the outer skin panels of the vehicle part to which it is to be attached.

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The variable gap cover 20 of figs. 6a and 6b further comprises a second rigid attachment plate section 20b adapted to be attached to the second vehicle part, comprising 8-16 layers of carbon fibre fabric, here 8 layers 41-48. Edge 20bf of the attachment plate section 20b that is to be fastened to the vehicle part is sufficiently thick and strong for receiving
30 fasteners and attaching it to the vehicle part.

The variable gap cover 20 of figs. 6a and 6b further comprises a flexible sheet section 20c, provided between and formed integral with the first and second attachment plate sections 20a and 20b. Flexible sheet section 20c here comprises two layers 51, 52, e.g. of glass fibre
35 fabric, e.g. woven glass fibres, or of aramid fibres. In the shown embodiment, the flexible sheet section further comprises, between the two layers 51, 52, an electrically conducting layer 53, e.g. a layer of a mesh of conducting metal wires, e.g. a copper wire mesh, which is

also to be embedded in the polymer matrix material. The conducting layer 53 electrically connects the first vehicle part and the second vehicle part, resulting in a reliable electrical connection, integrated into the variable gap cover. Hence, separate movable and flexing electrically connecting straps are redundant.

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To ensure a single piece laminated structure, edge portions 51a, 52a and 53a of the layers of the flexible sheet section 20c are consolidated with the other layers of the first rigid attachment plate section 20a, for fastening the first rigid attachment plate section 20a to a first vehicle part. Analogously, edge portions 52b and 53b of the layers of the flexible sheet
10 section 20c are consolidated with the other layers of the second rigid attachment plate section 20b, for fastening the second rigid attachment plate section 20a to a second vehicle part.

In fig. 7 part of an alternative mould assembly 60 is shown, comprising a similar bulb-shaped tooling block 65 with layers of fibre on top thereof, not drawn to scale, as shown and described in figs. 6a and 6b. This mould assembly 60 differs from the assembly of figs. 6a and 6b in that a prismatic tooling block 66 is provided. Furthermore, it is visible that an end portion 71a of layer 71 of the flexible sheet section 70c extends around tooling block 65, onto cantilevered portion 70ac of the first attachment plate section 70a, and is
20 consolidated with that cantilevered portion 70ac, whereas in the embodiment of figs. 6a and 6b, this layer 51 extends onto attachment portion 20ab of the first attachment plate section 20a. This prismatic tooling block, having a substantially delta-shaped, triangular cross-section provides a stiffening rib to the variable gap cover 70. The stiffening rib has a triangular cross-section at the transition 70ad of flexible sheet 70c and attachment portion
25 70ab of first attachment plate section 70a, so that the cantilevered portion 70ac of the first attachment plate section 70a is advantageously stiffened, and so that the producibility of the layers at the transition is improved. In embodiments, the prismatic tooling block 66 is made of metal, and is advantageously removable after consolidating or curing. It is also conceivable that a prismatic foam core 66 is applied, which is light and can be left in the
30 product.

CLAIMS

1. Variable gap cover (120) for an aircraft, the gap (G) being present between a first vehicle part (104) and a second vehicle part (105) which are movable with respect to each other between a first position and a second position and have a gap (G) between them, wherein the variable gap cover (120) is of a single piece laminated composite structure
- 5 wherein multiple fibre layers are embedded in a continuous polymer matrix and comprises:
- a first rigid attachment plate section (120a) adapted to be attached to the first vehicle part (104), comprising at least one fibre layer,
 - a second rigid attachment plate section (120b) adapted to be attached to the second vehicle part (105), comprising at least one fibre layer,
 - 10 o the first and second rigid attachment plate sections jointly form an aerodynamic contour over the gap, at least in the first position of the vehicle parts,
 - a flexible sheet section (120c), provided between and formed integral with the first and second attachment plate sections, comprising at least one fibre layer.
- 15 2. Variable gap cover according to claim 1, wherein the first attachment plate section (120a) comprises an attachment portion (120ab) and a cantilevered portion (120ac) adapted to overlap the second attachment plate section (120b), and wherein the flexible sheet section (120c) is formed integral with the first attachment plate section (120a) between the attachment portion and the cantilevered portion.
- 20 3. Variable gap cover according to one or more of the preceding claims, wherein the flexible sheet section (120c) is formed integral with and as a continuation of an end (120be) of the second attachment plate section (120b).
- 25 4. Variable gap cover according to one or more of the preceding claims, wherein the flexible sheet section (120c) has the shape of a fold, in particular a fold that is omega-shaped in cross-section, in the first position of the vehicle parts, and in the second position the flexible sheet section is stretched.
- 30 5. Variable gap cover according to one or more of the preceding claims, wherein an outer surface (30a; 41a) of at least one of the attachment plate sections (20a; 20b) is coated with paint.

6. Variable gap cover according to one or more of the preceding claims, wherein an outer surface of at least one of the attachment plate sections is adapted to be provided flush with an outer skin (110; 110') of the vehicle part to which it is to be attached.

5 7. Variable gap cover according to one or more of the preceding claims, wherein a portion of at least one of the attachment plate sections (120a, 120b) that is to be attached to a vehicle part (104, 105) is provided with transversal holes for receiving connectors (116).

8. Variable gap cover according to one or more of the preceding claims, wherein the
10 continuous polymer matrix is formed by a thermoplast such as polyphenylene sulfide (PPS).

9. Variable gap cover according to one or more of the preceding claims, wherein the fibre layer for the flexible sheet section is a fibre fabric, e.g. made of glass fibre or aramid.

15 10. Mould assembly (50) for wet layup forming of a variable gap cover for an aircraft, which mould assembly is adapted to be placed in an autoclave in which the variable gap cover is allowed to cure,

the gap being present between a first vehicle part and a second vehicle part which are movable with respect to each other between a first position and a second position and have

20 a gap between them, wherein the variable gap cover is adapted to be attached to the first vehicle part, and is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix, the variable gap cover comprising:

- a first rigid attachment plate section (20a) adapted to be attached to the first vehicle part, comprising at least one fibre layer,

25 - a second rigid attachment plate section (20b) adapted be attached to the second vehicle part, comprising at least one fibre layer,

- o the first and second rigid attachment plate sections jointly form an aerodynamic contour over the gap, at least in the first position of the vehicle parts,

- a flexible sheet section (20c), provided between and formed integral with the first and
30 second attachment plate section, comprising at least one fibre layer,

the mould assembly comprising:

- a forming tool (56) onto which the fibre layers of the first attachment plate section are laid-up,

35 - a bulb-shaped tooling block (55), adapted to be positioned on top of at least one layer of fibre layers of the first attachment plate section, onto which bulb-shaped tooling block fibre layers of the flexible sheet section and the second attachment plate section are laid-up.

11. Mould assembly according to claim 10, wherein the bulb-shaped tooling block (55) comprises a curved mould surface to provide a curvature to the second attachment plate section that allows the first rigid attachment plate section to overlap the second attachment plate section to form an aerodynamic contour over the gap, at least in the first position of the vehicle parts.

12. Mould assembly according to claim 10 or 11, further comprising a vacuum bag adapted to be positioned on top of the layers on the forming tool and bulb-shaped tooling block, to pull a vacuum on the variable gap cover prior to placing the mould assembly in the autoclave.

13. Method for manufacturing a variable gap cover for an aircraft, the gap being present between a first vehicle part and a second vehicle part which are movable with respect to each other between a first position and a second position and have a gap between them, wherein the variable gap cover is adapted to be attached to the first vehicle part and the second vehicle part, and is of a single piece laminated composite structure wherein multiple fibre layers are embedded in a continuous polymer matrix, wherein the variable gap cover comprises:

- a first rigid attachment plate section adapted to be attached to the first vehicle part, comprising at least one fibre layer,
- a second rigid attachment plate section adapted to be attached to the second vehicle part, comprising at least one fibre layer,
 - o the first and second rigid attachment plate sections jointly form an aerodynamic contour over the gap, at least in the first position of the vehicle parts,
- a flexible sheet section, provided between and formed integral with the first and second attachment plate section, comprising at least one fibre layer,

the method comprising the steps of:

- providing fibre layers for the first and second attachment plate sections and the flexible sheet section,
- providing a forming tool onto which the fibre layers of the first attachment plate sections are laid-up,
- positioning a bulb-shaped tooling block on top of at least one layer of fibre layers of the first attachment plate section,
- laying up fibre layers of the flexible sheet section and the second attachment plate section onto the bulb-shaped tooling block,
- consolidating the composite gap cover in an autoclave at an elevated pressure,
- removing the bulb-shaped tooling block.

14. Method according to claim 13, wherein prior to consolidating the composite gap cover a vacuum bag is positioned over the fibre layers on the forming tool and bulb-shaped tooling block, and a vacuum is pulled on the variable gap cover.

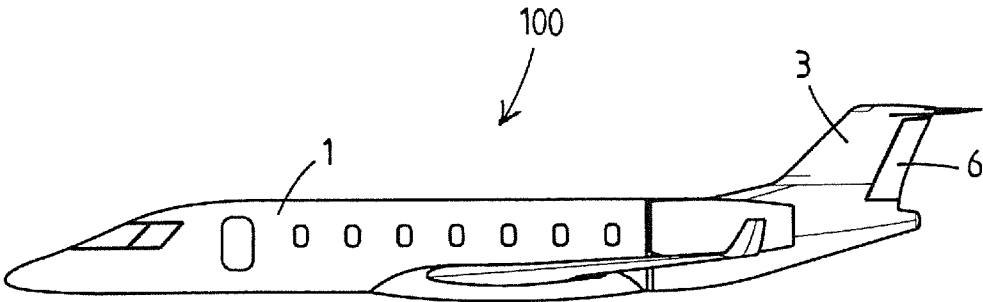


Fig.1a

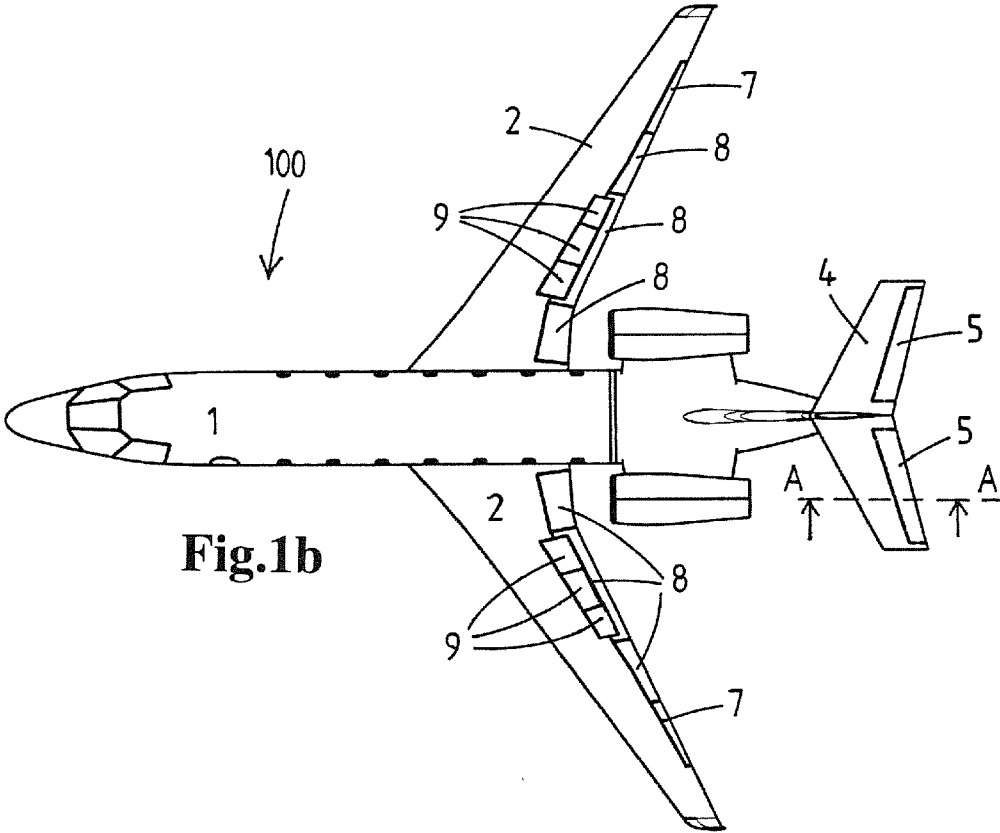
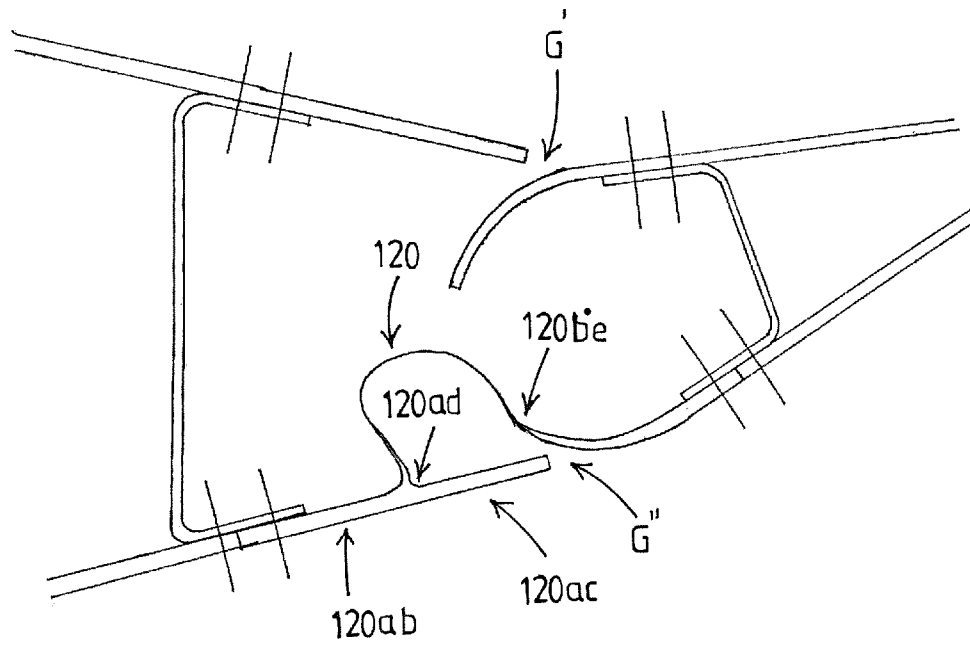
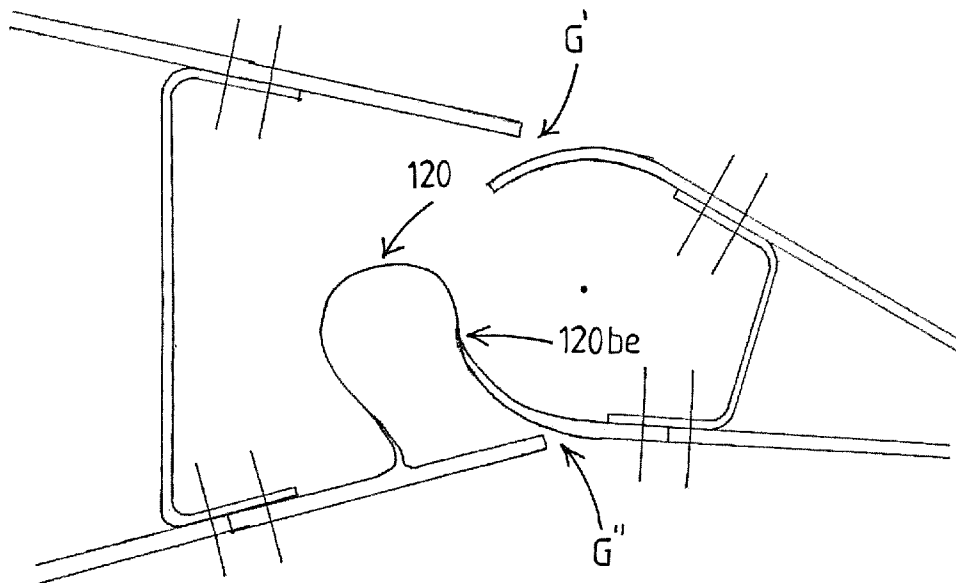
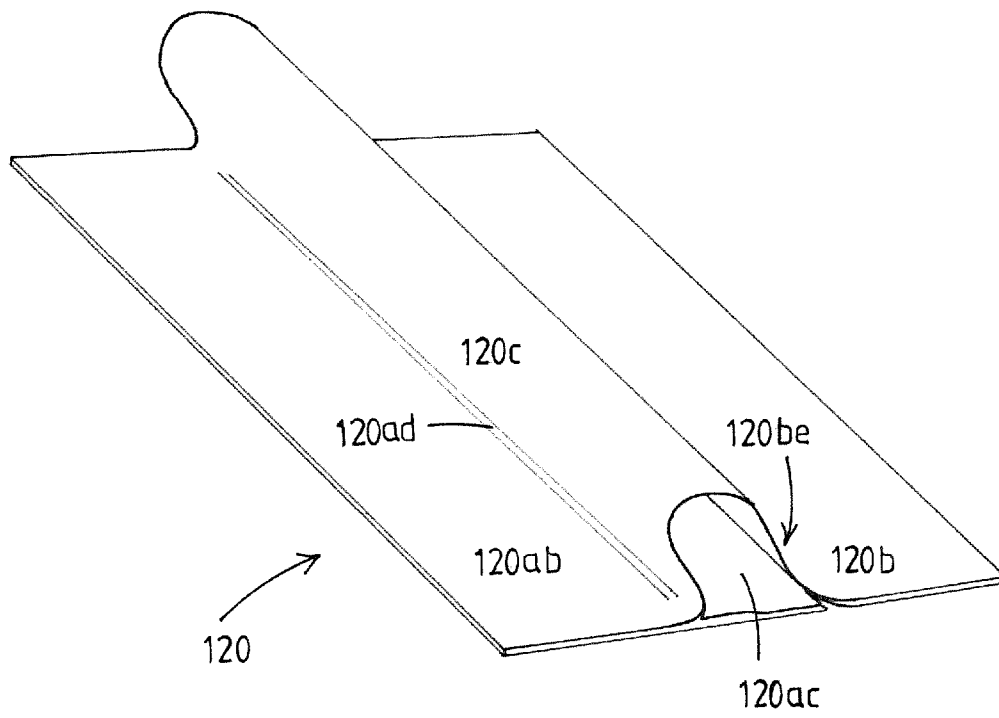
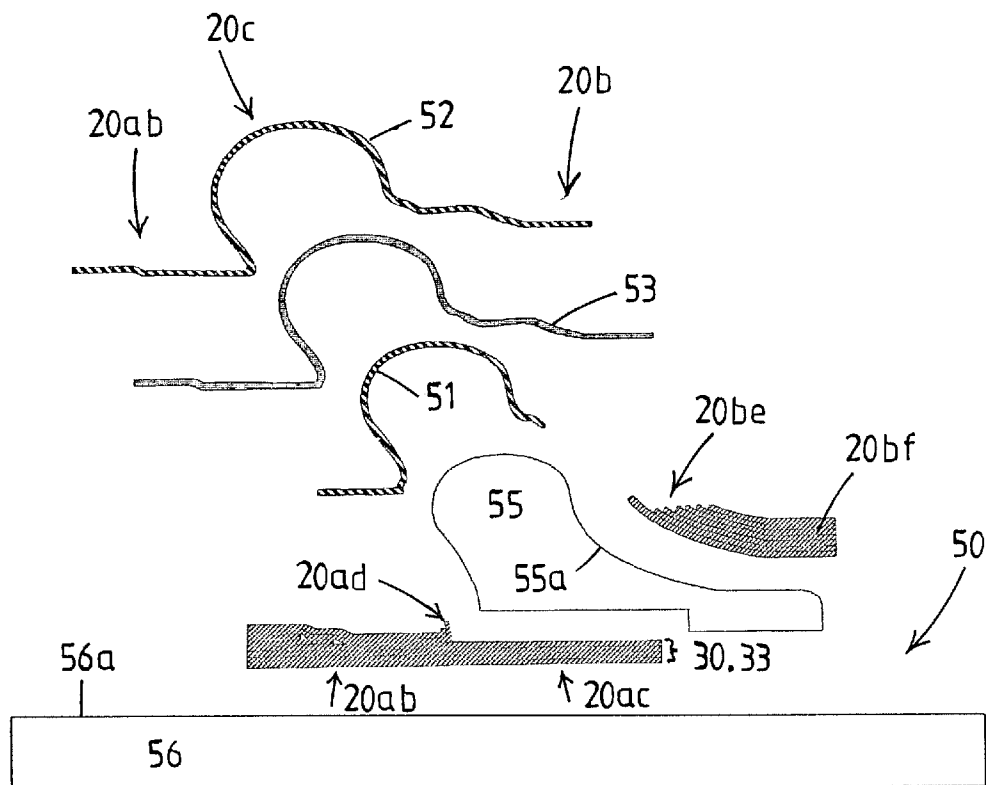
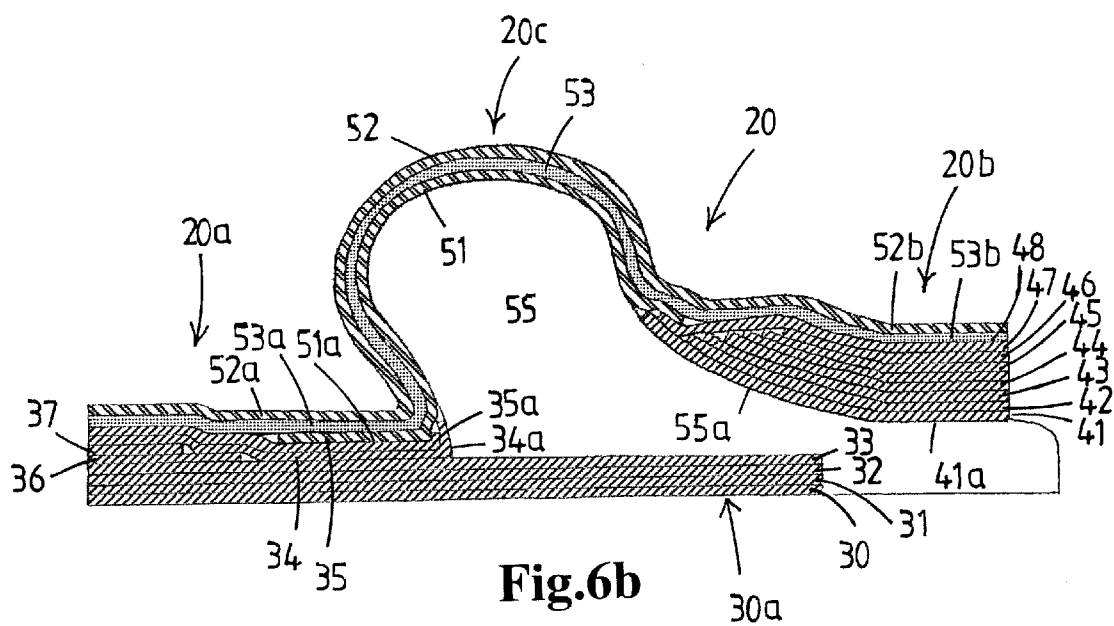


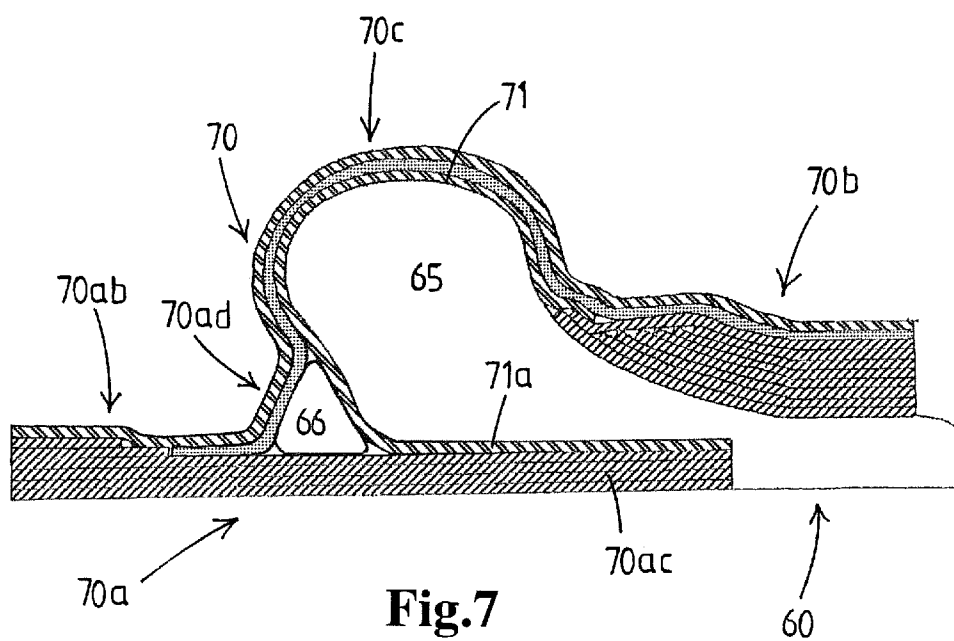
Fig.1b



**Fig.4a****Fig.4b**

**Fig.5**

**Fig.6a****Fig.6b**



INTERNATIONAL SEARCH REPORT

International application No

PCT/NL2016/050456

A. CLASSIFICATION OF SUBJECT MATTER

INV. B64C7/00 B29C70/46
ADD.

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)

B64C F16J B29D B29C B29L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

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Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

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27/09/2016

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Dorpema, Huijb

INTERNATIONAL SEARCH REPORT

International application No
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