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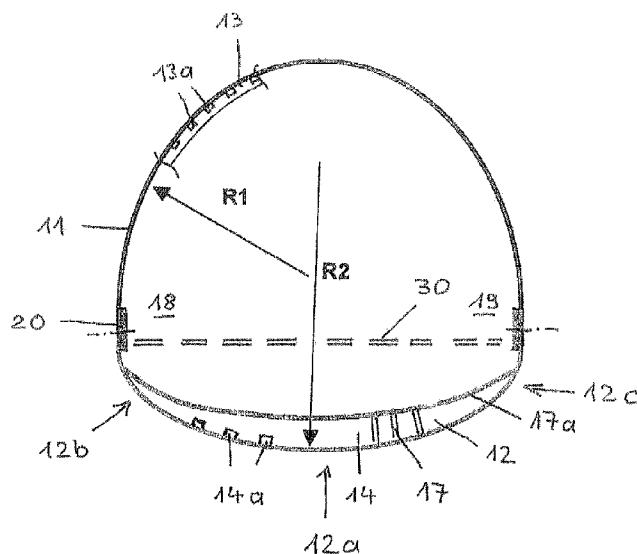
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(54) Title: AIRCRAFT FUSELAGE STRUCTURE AND METHOD FOR ITS PRODUCTION



(57) Abstract: An aircraft fuselage structure is described, which is constructed from a plurality of shells (11, 12) which are joined together, each form part of the aircraft fuselage (10) and comprise a support structure (13, 13a, 14, 14a) and a skin (15, 16) which is arranged on the latter and outwardly seals the aircraft fuselage (10) in a compression-proof manner. According to the invention, the aircraft fuselage structure comprises an upper and side shell (11) and a lower shell (12), of which the lower shell (12) has a radius (R2) which is essentially significantly larger than the radius (R1) of the upper and side shell (11), the upper and side shell (11) and the lower shell (12) being joined together at transition regions (18, 19) extending in the longitudinal direction of the aircraft, and the support structure (13, 13a) of the lower shell (12) being designed in terms of its strength in such a manner that it is capable of absorbing the internal pressure loading of the lower shell (12) without the use of a main crossmember.

AIRCRAFT FUSELAGE STRUCTURE AND METHOD FOR ITS PRODUCTION

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The invention relates to an aircraft fuselage structure according to the preamble of Claim 1, and to a method for the production of an aircraft fuselage structure of this type according to the preamble of Claim 26.

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Fuselage structures of commercial aircraft nowadays are typically produced from a plurality of shells of uniform skin materials in approximately circular cross sections and usually have a transverse stiffening means in the form of a crossmember (main crossmember) in the vicinity of the vertical centre of the fuselage. The overall number of crossmembers acts at the same time as a supporting grid system for the passenger cabin. The approximately circular or oval cross section serves to stabilize the fuselage against the internal pressure of the cabin. The most modern type of fuselage skins are produced using carbon-fibre composite materials, and therefore a uniform material is used over the circumference of the fuselage. The transverse stiffening by means of the crossmembers mentioned typically divides the fuselage, which is essentially circular in cross section, into two sections, thereby producing an upper deck and a lower deck.

It is an object of the invention to provide an aircraft fuselage structure and a method for the production of a structure of this type, with which an aircraft fuselage can be provided which manages without the spatial limitations caused by the conventional type of crossmember and at the same time has a high degree of stability.

35 This object is firstly achieved by an aircraft fuselage structure with the features of Claim 1. The object is secondly achieved by a method for the production of an aircraft fuselage structure with the features of Claim 26.

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Exemplary embodiments of the invention are explained below with reference to the drawing, in which:

Fig. 1 shows a highly schematized cross-sectional view of an aircraft fuselage structure as can be illustrated by an exemplary embodiment of the invention and as can be produced according to an exemplary embodiment of the method according to the invention;

Fig. 2 shows a sectional view through the skin of an aircraft fuselage structure according to an exemplary embodiment of the invention, said view illustrating the connection of the skin of an upper and side shell and of a lower shell of the aircraft fuselage structure according to the invention;

Fig. 3 and Figs 4a) and b) each show cross-sectional illustrations in order to explain the construction of connecting tabs which serve, according to exemplary embodiments of the invention, to connect the skin of an upper and side shell and of a lower shell according to exemplary embodiments of the invention.

Fig. 1 shows, in highly schematized form, a cross-sectional illustration of an aircraft fuselage 10 which is formed by an upper and side shell 11 and a lower shell 12. The upper and side shell 11 has a support structure which is formed by respective frames 13 and stringers 13a, of which only a few are illustrated partially and in schematized form in Fig. 1, and the lower shell 12 has a support structure which is formed by frames 14 and stringers 14a which are likewise illustrated only in schematized form. A respective skin 15 and 16 outwardly sealing the aircraft fuselage 10 in a compression-proof manner is arranged on the support structures 13, 13a and 14, 14a of upper and side shell 11 and of lower shell 12.

As shown in Fig. 1, the lower shell 12 has a radius R2 which is essentially significantly larger than the radius R1 of the upper and side shell 11. The upper and side shell 11 and the

lower shell 12 are joined together on both sides of the fuselage 10 at transition regions 18, 19 which extend in the longitudinal direction of the aircraft. The support structure 14, 14a of the lower shell 12 is designed in terms of its strength in such a manner that it is capable of absorbing the internal pressure loading of the lower shell 12 without the aircraft fuselage needing to be stiffened in the transverse direction in the manner of a conventional crossmember (main crossmember).

The radius R_2 , averaged over the circumference, of the lower shell 2 can be more than 1.2 times, more than 1.5 times or more than twice the radius R_1 , averaged over the circumference, of the upper and side shell 11 without the abovementioned values being intended to be understood as comprising a limitation.

The upper and side shell 11 can have an essentially constant radius R_1 .

The lower shell 12 can have a central region 12a which extends from the centre of the aircraft to both sides and has an essentially constant radius R_2 and have a smaller radius at the sides 12b, 12c in the vicinity of the transition regions 18, 19, at which the upper and side shell 11 merges into the lower shell 12, and therefore the lower shell 12 merges smoothly into the upper and side shell 11. In this case, the lower shell 12 can have, in the central region 12a, a radius R_2 which is more than 1.3 times, more than twice or more than 2.5 times the radius R_1 of the upper and side shell 11 without the abovementioned values being intended to be understood as comprising a limitation.

The lower shell 12 can be produced in one piece with regard to the circumferential direction. However, it may, if appropriate, also be produced in a plurality of pieces with regard to the abovementioned direction.

The upper and side shell 11 can be produced in a plurality of partial shells with regard to the circumferential direction. However, if appropriate, it could also be produced in a single shell in the abovementioned direction.

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The expression "upper and side shell" for the upper part 11 of the aircraft fuselage structure is to be understood here in such a manner that this upper part 11 also comprises lateral regions of the fuselage in addition to upper regions thereof, while the lower part 12 of the aircraft fuselage, which part is referred to as the lower shell, predominantly only comprises lower regions of the fuselage structure. Since, as Figure 1 reveals, both the upper part 11 and the lower part 12, however, each also comprise lateral regions of the aircraft fuselage, this manner of designation is not to be understood within a relatively narrow context and as being limiting, and it is meant that the part 11 primarily takes up the upper region of the fuselage and its sides, and the part 12 primarily takes up the lower region of the fuselage.

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The lower shell 12 can be produced from light metal components. In principle, both the upper and side shell 11 and the lower shell 12 can be produced either from light metal components in a conventional construction or from fibre-reinforced components in a modern construction.

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In the exemplary embodiment illustrated, the aircraft fuselage structure is produced in a hybrid construction, in which the lower shell 12 is produced from light metal components and the upper and side shell 11 is produced from fibre-reinforced components. The support structure of the lower shell 12 contains frames 14 (transverse frames), which run in the circumferential direction and, as is apparent from Fig. 1, have a substantially greater height than corresponding frames of the upper and side shell 11. In particular, the frames 14 of the lower shell 12, which run in the circumferential direction, have a height which increases from the side towards the centre, in a manner corresponding to the load profile in

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the lower shell 12. The greater height of the frames 14 of the lower shell 12 is required in order to absorb the internal pressure loading occurring because of the greater radius R2. However, the greater frame height is also advantageous insofar as it can be used at the same time as a protective measure for the lower shell 12 when it is subjected to a hard stress and as a supporting structure for the cabin. A deck 30 can be arranged on the frames 14 of the lower shell 12, the deck 30 only being indicated by dashed lines in Fig. 1 and not being the subject matter of this application.

The frames 14 of the lower shell 12 can have reinforced internal chords 17a and reinforcing ribs 17, which run radially and each serve to produce the required strength of the frames 14.

In the exemplary embodiment described here, the upper and side shell 11 comprises a support structure with frames 13 and stringers 13a produced from fibre-reinforced material and a skin 15 produced from fibre-reinforced material. The skin 15 of the upper and side shell 11 can be produced from carbon-fibre-reinforced plastic material or else from an aluminium and fibre composite material, in particular an aluminium and glass-fibre composite material.

As Fig. 2 shows, the upper and side shell 11 and the lower shell 12 are connected in the transition region 18, 19 by means of a "glass-fibre and aluminium composite tab" 20 ("GLARE") which comprises a laminate in which layers 21 of a textile fibre material, in particular glass-fibre material, and light metal layers 22, in particular layers of an aluminium alloy, are arranged in an alternating manner. A lamination 23 is provided on that side of the skin of the shells 11, 12 which is opposite the glass-fibre and aluminium composite tab 20. Composite tabs of this type serve to compensate for different thermal coefficients of expansion of light metal alloys and fibre-reinforced plastics. Their composite structure enables them to ensure adaptation of the

different coefficients of expansion of the materials involved.

The connection between upper and side shell 11, on the one hand, and lower shell 12, on the other hand, is produced by a multi-row rivet connection 24, 25, in particular a three-row rivet connection in each case. The rivet connection 24, 25 can contain titanium rivets or titanium bolts.

The construction of the connection between upper and side shell 11, on the one hand, and lower shell 12, on the other hand, is illustrated according to a further exemplary embodiment in Fig. 3. A glass-fibre and aluminium composite tab 20 is again arranged on one side of the connection and a lamination 23 on the other side.

Figs 4a) and b) show, in a schematized cross-sectional illustration and, respectively, in a schematized, perspective, partially broken open illustration, the construction of the abovementioned glass-fibre and aluminium composite tab 20 with glass-fibre layers 21 and light metal layers 22 arranged in an alternating manner.

According to an exemplary embodiment of the invention, the production of an aircraft fuselage structure according to the invention, as has been described above, takes place by production of an upper and side shell 11 from a fibre composite material, including the support structure 13, 13a of said shell, which can be formed by stringers 13a and frames 13, by means of an adhesive bonding process; production of a lower shell 12 from aluminium or light metal material, including its support structure 14, 14a, which can be formed in turn by stringers 14a and frames 14; connection of the upper and side shell 11 to a glass-fibre and aluminium composite tab 20 (this firstly, in order to be able to better compensate for fibre composite tolerances); insertion of the upper and side shell 11 onto the lower shell 12 into the glass-fibre and aluminium composite tab connected to the upper and side shell 11. The riveting of the glass-fibre composite

tab 20 to the lower shell 12 can take place by means of rivets, in particular by means of titanium bolts. All of the fuselage segments are joined in the manner described, and then the fuselage segments are joined to form the overall fuselage
5 by locking of the transverse joints in turn by means of rivets, in particular titanium rivets or titanium bolts.

The hybrid construction described is advantageous insofar as weight-saving fibre composite materials are used for the upper
10 and side shell 11 where the loading due to internal pressure is smaller on account of the fuselage shape with the smaller radius R_1 and a risk due to external effects is lower, while the use of light metal or aluminium material for the lower shell 12 is advantageous with regard to a higher capability of
15 resistance to external effects, is relatively simple to check and repair and is advantageous with regard to electroplating properties and electric shielding as a discharge measure with respect to electric charging of the upper shell 11 and as
20 shielding of lines and electronic devices from the environment.

List of reference numbers

10	Aircraft fuselage
11	Upper and side shell
12	Lower shell
12a	Central region
13	Frame
13a	Stringer
14	Frame
14a	Stringer
15	Skin
16	Skin
17	Reinforcing ribs
17a	Internal chord
18	Transition region
19	Transition region
20	Glass-fibre and aluminium composite tab
21	Glass-fibre layers
22	Light metal layers
23	Lamination
24	Rivet connection
25	Rivet connection
30	Deck

Patent Claims

1. Aircraft fuselage structure which is constructed from a plurality of shells (11, 12) which are joined together, each form part of the aircraft fuselage (10) and comprise a support structure (13, 13a, 14, 14a) and a skin (15, 16) which is arranged on the support structure and outwardly seals the aircraft fuselage (10) in a compression-proof manner, characterized in that the aircraft fuselage structure comprises an upper and side shell (11) and a lower shell (12), of which the lower shell (12) has a radius (R2) which is essentially significantly larger than the radius (R1) of the upper and side shell (11), the upper and side shell (11) and the lower shell (12) being joined together at transition regions (18, 19) extending in the longitudinal direction of the aircraft, and in that the support structure (13, 13a) of the lower shell (12) is designed in terms of its strength in such a manner that it is capable of absorbing the internal pressure loading of the lower shell (12) without the use of a main crossmember.
2. Aircraft fuselage structure according to Claim 1, characterized in that the radius (R2), averaged over the circumference, of the lower shell (12) is more than 1.2 times the radius (R1), averaged over the circumference, of the upper and side shell (11).
3. Aircraft fuselage structure according to Claim 1, characterized in that the radius (R2), averaged over the circumference, of the lower shell (12) is more than 1.5 times the radius (R1), averaged over the circumference, of the upper and side shell (11).
4. Aircraft fuselage structure according to Claim 1, characterized in that the radius (R2), averaged over the

circumference, of the lower shell (12) is more than twice the radius (R1), averaged over the circumference, of the upper and side shell (11).

- 5 5. Aircraft fuselage structure according to one of Claims 1 to 4, characterized in that the upper and side shell (11) has an essentially constant radius (R1).
- 10 6. Aircraft fuselage structure according to one of Claims 1 to 5, characterized in that the lower shell (12) has a central region (12a) which extends from the centre of the aircraft to both sides and has an essentially constant radius (R2) and has a smaller radius at the sides (12b, 12c) in the vicinity of the transition regions (18, 19),
15 so that the lower shell (12) merges smoothly into the upper and side shell (11).
- 20 7. Aircraft fuselage structure according to Claim 6, characterized in that the lower shell (12) has, in the central region (12a), a radius (R2) which is more than 1.3 times the radius (R1) of the upper and side shell (11).
- 25 8. Aircraft fuselage structure according to Claim 6, characterized in that the lower shell (12) has, in the central region (12a), a radius (R2) which is more than twice the radius (R1) of the upper and side shell (11).
- 30 9. Aircraft fuselage structure according to Claim 6, characterized in that the lower shell (12) has, in the central region (12a), a radius (R2) which is more than 2.5 times the radius (R1) of the upper and side shell (11).
- 35 10. Aircraft fuselage structure according to one of Claims 1 to 9, characterized in that the lower shell (12) is produced in one piece with regard to the circumferential direction.

11. Aircraft fuselage structure according to one of Claims 1 to 10, characterized in that the upper and side shell (11) is produced in a plurality of partial shells with regard to the circumferential direction.
12. Aircraft fuselage structure according to one of Claims 1 to 11, characterized in that the lower shell (12) is produced from light metal components.
13. Aircraft fuselage structure according to one of Claims 1 to 12, characterized in that the upper and side shell (11) is produced from fibre-reinforced components.
14. Aircraft fuselage structure according to Claims 12 and 13, characterized in that the aircraft fuselage structure is produced in a hybrid construction with a lower shell (12) of light metal components and an upper and side shell (11) of fibre-reinforced components.
15. Aircraft fuselage structure according to Claim 12 or 14, characterized in that the support structure of the lower shell (12) contains frames (14), which run in the circumferential direction and have a substantially greater height than corresponding frames of the upper and side shell (11).
16. Aircraft fuselage structure according to Claim 15, characterized in that the frames (14) of the lower shell (12), which run in the circumferential direction, have a height which increases towards the centre.
17. Aircraft fuselage structure according to Claim 15 or 16, characterized in that the frames (14) of the lower shell (12) have reinforced internal chords (17a).
18. Aircraft fuselage structure according to Claim 15, 16 or 17, characterized in that the frames (14) of the lower

shell (12) have reinforcing ribs (17), which run radially.

19. Aircraft fuselage structure according to Claim 13 or 14,
5 characterized in that the upper and side shell (11) comprises a support structure with frames (13) and stringers (13a) produced from fibre-reinforced material, and a skin (15) produced from fibre-reinforced material.
- 10 20. Aircraft fuselage structure according to Claim 19, characterized in that the skin (15) of the upper and side shell (11) is produced from carbon-fibre-reinforced plastic material.
- 15 21. Aircraft fuselage structure according to Claim 19, characterized in that the skin (15) of the upper and side shell (11) is produced from aluminium and glass-fibre composite material.
- 20 22. Aircraft fuselage structure according to one of Claims 14 to 21, characterized in that the upper and side shell (11) and the lower shell (12) are connected in the transition region (18, 19) by means of a glass-fibre and aluminium composite tab (20) with glass-fibre layers (21)
25 and light metal layers (22) arranged in an alternating manner in a laminate.
23. Aircraft fuselage structure according to Claim 22,
30 characterized in that a lamination (23) is provided on the glass-fibre and aluminium composite tab (20).
24. Aircraft fuselage structure according to Claim 22 or 23,
35 characterized in that the connection between upper and side shell (11), on the one hand, and lower shell (12), on the other hand, is produced by a multi-row rivet connection (24, 25).
25. Aircraft fuselage structure according to Claim 24,

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characterized in that the rivet connection (24, 25) contains titanium rivets.

26. Method for the production of an aircraft fuselage structure which is constructed from a plurality of shells (11, 12) which are joined together, each form part of the aircraft fuselage (10) and comprise a support structure (13, 13a, 14, 14a) and a skin (15, 16) which is arranged on the support structure and outwardly seals the aircraft fuselage (10) in a compression-proof manner, the aircraft fuselage structure comprising an upper and side shell (11) and a lower shell (12), of which the lower shell (12) has a radius (R2) which is essentially significantly larger than the radius (R1) of the upper and side shell (11), the upper and side shell (11) and the lower shell (12) being joined together at transition regions (18, 19) extending in the longitudinal direction of the aircraft, and the support structure (14, 14a) of the lower shell (12) being designed in terms of its strength in such a manner that it is capable of absorbing the internal pressure loading of the lower shell (12) without the use of a main crossmember, characterized by production of the upper and side shell (11) from a fibre composite material, including the support structure (13, 13a); production of the lower shell (12) from aluminium material, including the support structure (14, 14a); connection of the upper and side shell (11) to a glass-fibre and aluminium composite tab which contains glass-fibre layers (21) and light metal layers (22) arranged in an alternating manner in a laminate; fitting the upper and side shell (11) to the lower shell (12), including the glass-fibre and aluminium composite tab (20) which protrudes on the upper and side shell (11); connection of the glass-fibre and aluminium composite tab to the lower shell (12).

27. Method according to Claim 26, characterized in that the production of the upper and side shell (11) from the

fibre composite material includes a process of adhesively bonding stringers (13a) and frames (13) contained in the support structure and the skin (15).

- 5 28. Method according to Claim 26 or 27, characterized in that the production of the lower shell (12) from aluminium material comprises production of stringers (14a) and frames (14) and skin (16).
- 10 29. Method according to Claim 26, 27 or 28, characterized in that the connection of the glass-fibre and aluminium composite tab (20) to the upper and side shell (11) and to the lower shell (12) comprises riveting by means of titanium bolts (24, 25).
- 15 30. Method according to one of Claims 26 to 29, characterized in that the connection of the upper and side shell (11) and the lower shell (12) comprises the provision of a lamination (23) on the glass-fibre and aluminium composite tab (20).
- 20 31. Method according to one of Claims 26 to 30, characterized in that the method comprises the production of all of the essential fuselage segments and the joining and connection of the fuselage segments to form the overall fuselage.
- 25 32. Method according to one of Claims 26 to 31, characterized in that the method comprises locking of the transverse joints between the fuselage sections by means of titanium bolts.
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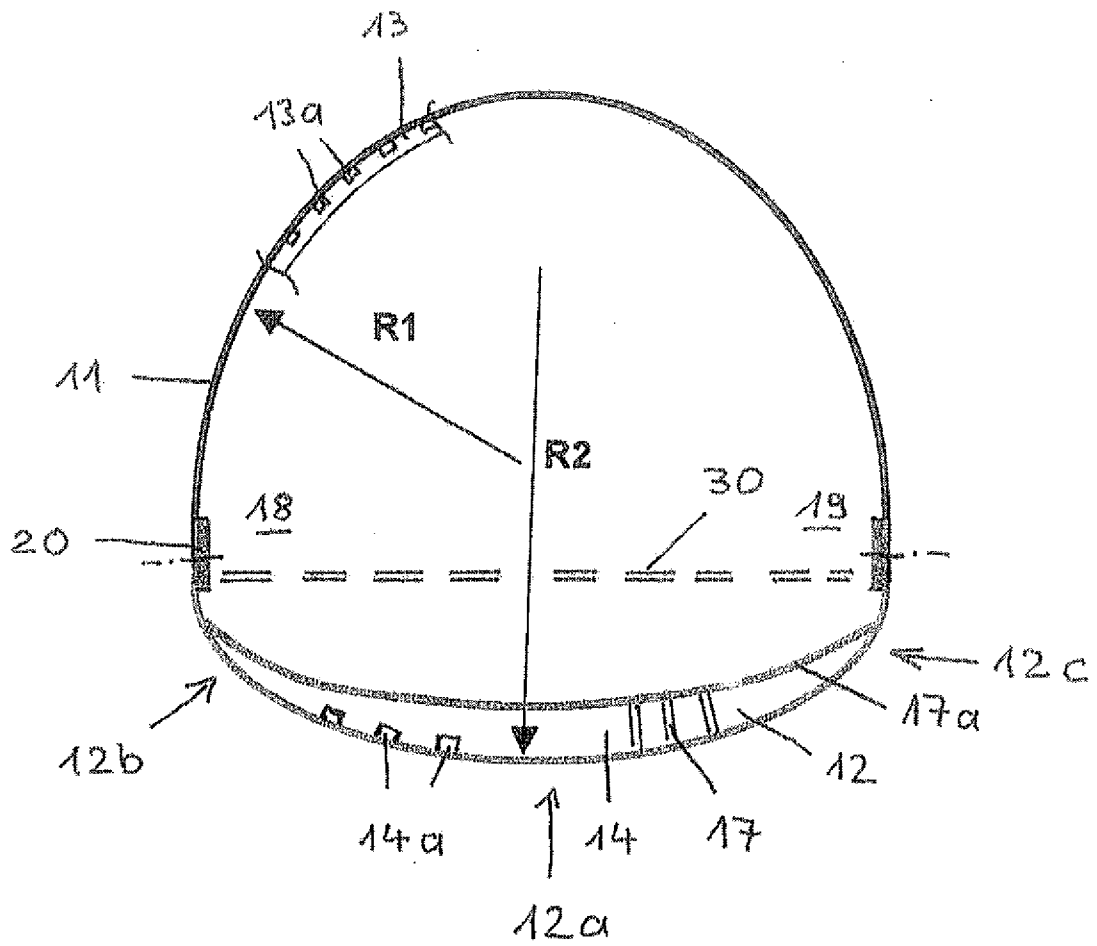


Fig. 1

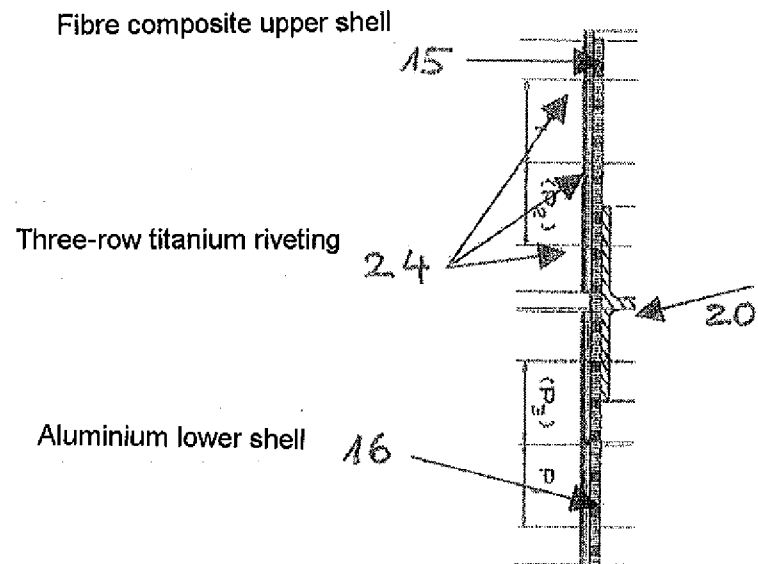


Fig. 2

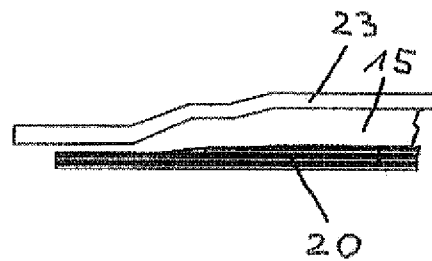


Fig. 3

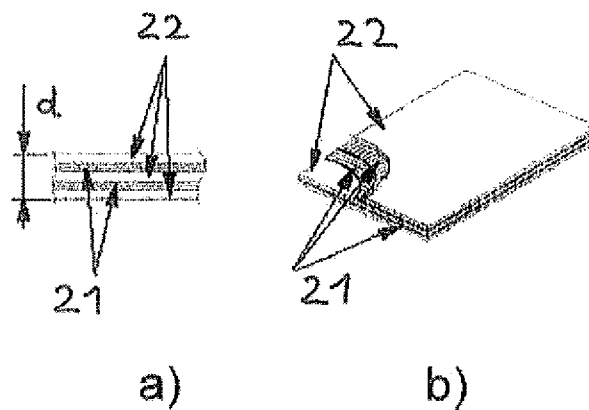


Fig. 4