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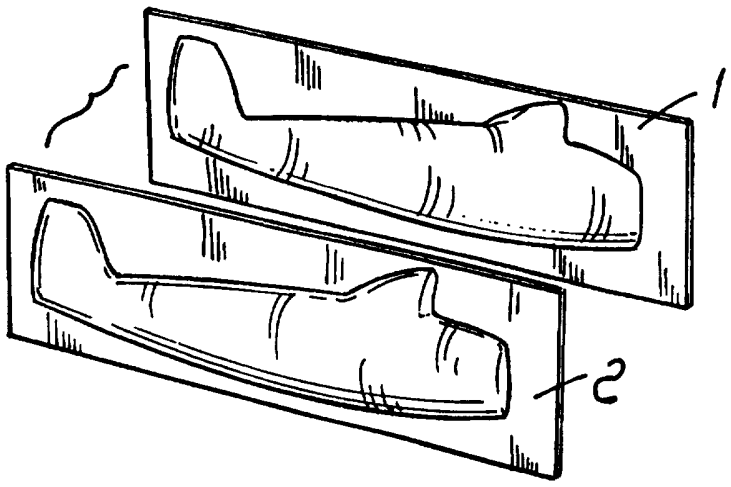
(54) Title: ULTRALIGHT AIRCRAFT AND METHOD FOR MANUFACTURING IT

(57) Abstract

An ultralight aircraft comprising a monolithic outer shell (1, 2) that constitutes the fuselage of the aircraft and a monolithic inner shell (210-280, fig.8) that consitutes the interiors of the fuselage, the inner shell (210-280) being assembled to the outer shell (1, 2) to form a single monolithic structure and monolithic wings and tail planes being assembled to the outer shell.



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ULTRALIGHT AIRCRAFT AND METHOD FOR MANUFACTURING IT

Technical Field

The present invention relates to an ultralight aircraft having a low weight, commonly termed "ultralight", made of composite material, and to a method for manufacturing said aircraft.

Background Art

Low-weight aircraft, particularly those having a gross weight of less than 450 kg, can be conventionally used outside the scope of current statutory provisions which regulate the use of ordinary aircrafts.

They can be piloted with a simplified pilot's license and can take off and land outside airport areas; the only restriction is that they cannot enter the airspaces above military facilities and inhabited areas.

These ultralights are structurally derived from motorized hang-gliders and are therefore usually formed by a frame-like structure of tubes connected to each other for example by welding, with aerodynamic surfaces made of thermoplastic fabric, for example dacron.

Ultralight aircrafts of this type are generally used by enthusiasts in their spare time; their performance is very limited both in terms of payload and of speed and their safety conditions are unstable.

There are other kinds of ultralight aircrafts, manufactured by using conventional aircraft construction methods, for example by assembly performed by riveting or welding metal plates made of light alloy.

In this last case, construction operations are complicated, owing to the need to assemble hundreds of

different parts, and therefore production costs are high.

Moreover, maintenance for this last type of "ultralight" is troublesome, due both to corrosion problems and to the difficulties objectively encountered in welding or riveting light alloy sheets for any repairs.

Disclosure of the Invention

A principal aim of the present invention is therefore to provide a monocoque ultralight aircraft made of advanced composite material.

Within the scope of this aim, an object of the present invention is to provide a monocoque ultralight aircraft that is unusually strong and safe.

Another object of the present invention is to provide a monocoque ultralight aircraft that is simple to assemble and ensures high performance.

Another object of the present invention is to provide a monocoque ultralight aircraft the construction whereof does not require welding and/or riveting operations.

Another object of the present invention is to provide a monocoque ultralight aircraft having simplified maintenance.

Another object of the present invention is to provide a method for manufacturing the monocoque ultralight aircraft according to the invention.

Another object of the present invention is to provide a device that is highly reliable and relatively easy to manufacture at competitive costs.

This aim, these objects, and others which will become apparent hereinafter are achieved by an ultralight aircraft, characterized in that it comprises a monolithic

outer shell that constitutes the fuselage of said aircraft and a monolithic inner shell that constitutes the interiors of said fuselage, said inner shell being assembled to said outer shell to form a single monolithic structure, monolithic wings and tail planes being assembled to said outer shell.

Brief Description of the Drawings

Further characteristics and advantages of the invention will become apparent from a preferred but not exclusive embodiment of the monocoque ultralight aircraft according to the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figure 1 is a perspective view of a multipart mold for producing the fuselage of the monocoque ultralight aircraft according to the invention;

figure 2 is a front transverse sectional view of the fuselage executed by closing the multipart mold shown in figure 1;

figure 3 is a sectional view of a detail of figure 2, illustrating in detail the various layers that compose the fuselage of the monocoque ultralight aircraft according to the invention;

figure 4 is a sectional view of a detail of the fuselage, in which a metal insert embedded in the various layers that constitute said fuselage is provided;

figure 5 is a perspective view of a multipart mold for producing the ultralight aircraft according to the invention;

figure 6 is a longitudinal sectional view of the wings, which are formed by closing the multipart mold;

figure 6a is a detail view of the sectional view of figure 6;

figure 7 is a sectional view of a detail of figure 6, illustrating the detail of the interconnection of the two wings;

figure 8 is an exploded view of the various elements that constitute the interiors of the aircraft according to the invention;

figure 9 is a sectional view of a wing of the ultralight aircraft according to the invention;

figure 10 is a plan view of the ultralight aircraft according to the invention; and

figure 11 is a side view of the ultralight aircraft according to the invention.

Ways of carrying out the Invention

Figure 1 illustrates a multipart mold for forming an outer shell that constitutes the self-supporting monolithic fuselage 100 of the aircraft. The mold comprises a left half-mold 1 and a right half-mold 2. The left half-mold 1 is used to form the left half of the fuselage 100 of the ultralight aircraft according to the invention, whereas the right half-mold is used to form the right half of the fuselage 100.

The two half-molds 1 and 2 are closed together and kept in position by means of adapted clamps 3, thus forming a cavity that corresponds to the fuselage of the ultralight aircraft.

Figure 2 is a sectional view of the two half-molds 1 and 2, closed together and kept in position by the two clamps 3. The further details of figure 2 and of figures 3

and 4 will be described later.

Figure 5 is a view of a multipart mold for forming the wings of the aircraft; the mold is formed by an upper half-mold 21 and by a lower half-mold 20 that are closed to each other and kept together, as shown in the sectional view of figure 6, by appropriate clamps 3, like the two half-molds 1 and 2 used to form the fuselage 100.

Figures 6 and 7 are, respectively, a sectional view of the mold for forming the wings and a sectional view of a constructive detail of a wing; they will be described hereinafter together with the explanation of the method for manufacturing the ultralight aircraft according to the invention.

Figure 10 is a view of the components constituting the interiors of the aircraft according to the invention. More particularly, the components are executed with a single mold, in successive steps, forming an inner shell, and are then assembled to the fuselage 100 formed by means of the two half-molds 1 and 2.

In figure 10, the reference numeral 210 designates the component that constitutes the bottom, to be arranged in a downward region inside the fuselage 100; 220 and 230 designate respectively the right and left lateral internal frames; 240 designates the support for the seats 250; 260 designates the instrument panel; 270 designates the control tunnel; and the reference numeral 280 designates the component that constitutes the upper portion of the interiors of the ultralight aircraft according to the invention.

With reference to the above figures, the method for

manufacturing the aircraft according to the invention is as follows.

With reference in particular to figures 1 to 4, portions of structural fiber 4, such as for example glass, carbon, kevlar, boron or others impregnated with polymerizable resin and appropriately shaped, are placed inside the two half-molds 1 and 2; sheets of cellular material of the honeycomb type 5, and another layer of structural fiber 6, also impregnated with polymerizable resin, are arranged on these portions of fiber 4; a layer of structural adhesive film 10, advantageously formed by resins, usually epoxy resins, is interposed between the layer 4 and the sheets 5 and between the sheets 5 and the layer 6 respectively.

Finally, a plastic layer 7 is applied on the plurality of layers described above and acts as a vacuum bag; said layer is sealed and subjected to suction in order to compact the layer 4, the sheets 5, and the layer 6 together.

The polymerizable resin with which the structural fiber fabric 4 is impregnated is preferably constituted by a thermosetting resin chosen in the group comprising phenolic resins, urea-formaldehyde, melamine-formaldehyde, and amine resins in general, alkyl resins, and polyester, epoxy resins, and polyurethanes.

It is also possible to use thermoplastic resins, provided that they have a softening point that is higher than the operating temperature of the composite component to be produced.

After the arrangement of the various layers described

above, compacted by the suction formed in the vacuum bag 7, the assembled mold constituted by the two half-molds 1 and 2 is subjected to pressure, for example in an appropriate autoclave, and raised to the polymerization temperature of the resins that impregnate the layers 4 and 6 and of the adhesive films 10 that are interposed between said layers and the sheets of cellular material 5.

More particularly, the sheets 5 may be omitted and the layers 4 and 6 thus coincide, forming a monolithic structure made only of resin reinforced with structural fibers.

The layers 5 can be constituted by a hexagonal cellular structure of the honeycomb type or by a resin, for example a polyester or polyurethane resin, optionally treated to make it fireproof or self-extinguishing.

After complete polymerization of the resins and of the adhesives used has occurred, the mold is opened and the monolithic fuselage 100 is removed from the shell, finished, and sent to the assembly operations.

During the step for the deposition of the various layers of fabric and sheets of cellular material, inserts 8 made of metal, plastics or other material are also embedded in the various layers in the desired positions, so as to rigidly couple them to the structure formed in the mold.

These inserts 8 allow to obtain a fuselage 100 that is provided with all the devices for the passage of the cables for actuating the ailerons, the rudders, and all the other devices required to steer the ultralight aircraft, without requiring assembly by riveting or any other conventionally used method.

This leads to a considerable saving in time and therefore to a containment of production costs.

By using the same system of embedding inserts 8 within the various layers of fabric, the inserts are placed at the points for coupling to the other parts of the aircraft (wings, rudders, undercarriage, seat couplings, engine support).

Inserts 8, made of metal, plastics, or other adapted material, or reinforcements obtained with additional layers of material impregnated with polymerizable resin, are arranged in the section of the fuselage 100 at the cabin compartment, so as to obtain a non-deformable rigid structure that surrounds the housing of the seats 250 and is capable of cushioning any impacts that might occur in case of emergency conditions.

The rigidity of the region corresponding to the cabin compartment is provided by the assembly of the components that constitute the monolithically formed interiors of the aircraft to the fuselage 100. The assembly is advantageously provided for example by gluing or mechanical fixing.

The structure obtained from the assembly of the fuselage and of the monolithically-executed interiors gives the structure of the aircraft a particular rigidity, forming a so-called "safety cage" at the cabin.

The monolithic structure that constitutes the interiors of the aircraft is shown in an exploded view in figure 8.

The wings 101 and 102 and the rudders can be formed monolithically by using the same production method used for

the fuselage 100 and for the interiors of the aircraft.

In particular, for example in the case of the wings, layers of fabric made of structural fiber 22, impregnated with polymerizable resin and shaped appropriately, are arranged in an upper half-mold 20 and in a lower half-mold 21 that are shaped appropriately. A sheet of cellular material 23 is applied on said layers 22, and a further layer of impregnated fabric 24 is placed on the sheet.

The plurality of layers described above is enclosed in a vacuum bag 25.

The half-molds 20 and 21 are kept closed together by appropriate retention devices 3 and are held at an appropriate temperature and under pressure, for example in an autoclave, for the time required for polymerization.

More particularly, the sheet of cellular material 23 may be omitted and therefore the layers 23 and 24 may coincide.

When polymerization has ended, the parts are removed from the mold and sent to assembly.

In a manner similar to the one described above, structural inserts made of metal, plastics, or any other adapted material may be embedded inside the various layers forming the structure in the case of the wings as well.

For example, figure 7 illustrates the embedding of an insert 30, for assembling the wings to the fuselage, inside the cavity formed by the two half-molds 20 and 21 in contact with the layer of cellular material 23. The inserts are appropriately coated with polymerizable structural adhesives to ensure perfect airworthiness.

Two reinforcement elements, for example two spars 50

and 60 having a double-T cross-section, are then inserted in each wing 101 and 102 to provide rigidity to the entire structure.

The execution of the rudder 103, of the ailerons 108-109 and of the tail planes 104-105 follows the same production method as the wings 101-102.

The operations for assembling the entire ultralight aircraft are thus reduced to connecting a fuselage 100 to the two wings 101 and 102, the tail planes 104 and 105, the rudder 103, the trim tabs 106 and 107, the ailerons 108, 109, and an undercarriage 110.

The wings can be designed so as to rotate along the fuselage to allow easier transport of the aircraft, for example by means of a trailer.

In practice it has been observed that the ultralight aircraft according to the invention fully achieves the intended aim and objects, since it is constructed monolithically without riveting operations. Said structure is particularly strong and easily assembled.

The assembly of two shells, an outer shell constituting the fuselage 100 and an inner shell constituting the interiors of the fuselage, allows to obtain a rigid structure that ensures a high safety standard particularly at the crew compartment.

Moreover, the ultralight aircraft according to the invention is made of advanced composite materials capable of giving the structure high rigidity and nondeformability as well as a high rigidity/weight ratio.

The monocoque ultralight aircraft thus conceived is susceptible of numerous modifications and variations, all

of which are within the scope of the inventive concept.

Thus, for example, the wings 101 and 102 of the ultralight aircraft according to the invention can be built so that the spar 50 having a double-T transverse cross-section, shown in figure 9 and provided in each wing at the portion having the greatest camber, has such a length as to protrude from the end of each wing that is directed towards the fuselage 100, so as to allow the connection, for example by bolting, of the ends of the two spars inside said fuselage, thus allowing the connection of the wings 101 and 102 to each other as well as to the fuselage 100.

This type of connection ensures high rigidity of the wing assembly, so that it is possible to eliminate the external tie rods 200 that are provided on the left and right sides of the aircraft and connect the lower portion of the fuselage 100 to the wings 101 and 102 respectively.

Moreover, the polymerization of the layers impregnated with resin can be performed not only when the molds are assembled but also when they are disassembled. More particularly, polymerization can be performed in subsequent steps, and different parts of the fuselage 100 can be made to polymerize at different times and with different methods.

Finally, all the details may be replaced with other technically equivalent elements.

In practice, the materials employed, so long as they are compatible with the specific use, as well as the dimensions, may be any according to the requirements and the state of the art.

CLAIMS

1. An ultralight aircraft, characterized in that it comprises a monolithic outer shell that constitutes the fuselage of said aircraft and a monolithic inner shell that constitutes the interiors of said fuselage, said inner shell being assembled to said outer shell to form a single monolithic structure, monolithic wings and tail planes being assembled to said outer shell.

2. An ultralight aircraft according to claim 1, characterized in that said inner shell is glued inside said outer shell.

3. An ultralight aircraft according to claim 1, characterized in that said inner shell is assembled inside said outer shell by mechanical fixing.

4. An ultralight aircraft according to claim 1, characterized in that said outer shell, said inner shell, said wings, and said tail planes are made of advanced composite material constituted by at least two layers of structural material.

5. An ultralight aircraft according to claim 4, characterized in that a core of cellular material is interposed between said at least two layers of structural material.

6. An ultralight aircraft according to claim 5, characterized in that two layers of structural adhesive film are interposed between said at least two layers of structural material and said core of cellular material.

7. An ultralight aircraft according to claim 5, characterized in that said core of cellular material and

said layers of structural material are covered by a layer of plastic material.

8. An ultralight aircraft according to claim 4, characterized in that said layers of structural material are impregnated with polymerizable resin.

9. An ultralight aircraft according to claim 8, characterized in that said polymerizable resin is a thermosetting resin.

10. An ultralight aircraft according to claim 8, characterized in that said polymerizable resin is a thermoplastic resin.

11. An ultralight aircraft according to claim 1, characterized in that the outer shell, the inner shell, the wings, and the tail planes are formed by multipart molds, said multiparts molds being kept closed by means of clamps.

12. An ultralight aircraft according to claim 1, characterized in that structural inserts are inserted in said outer shell, said inner shell, said wings, and said tail planes for the assembly of said aircraft.

13. An ultralight aircraft according to claim 12, characterized in that said inserts are embedded in said advanced composite material.

14. An ultralight aircraft according to claim 1, characterized in that two reinforcement elements are inserted longitudinally in each one of said wings.

15. An ultralight aircraft according to claim 14, characterized in that said reinforcement elements comprise spars that are shaped like a double T.

16. An ultralight aircraft according to claim 14, characterized in that said reinforcement elements protrude

from the end of each wing that is directed towards the fuselage to allow the interconnection of said reinforcement elements.

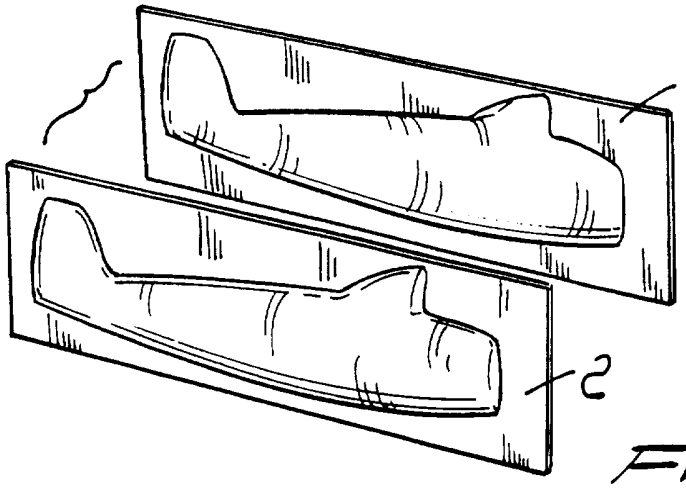

Fig.1

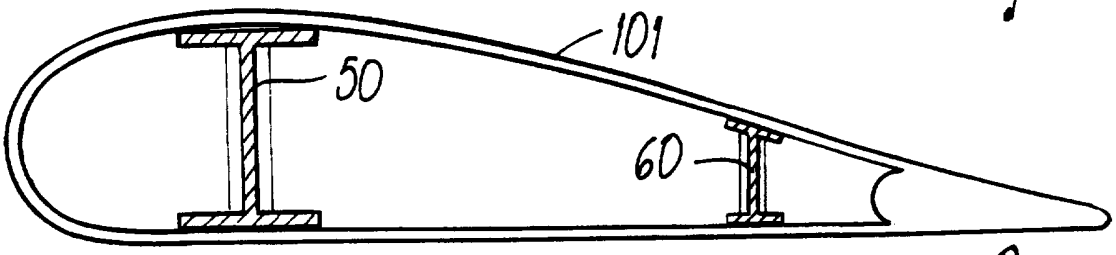

Fig.9

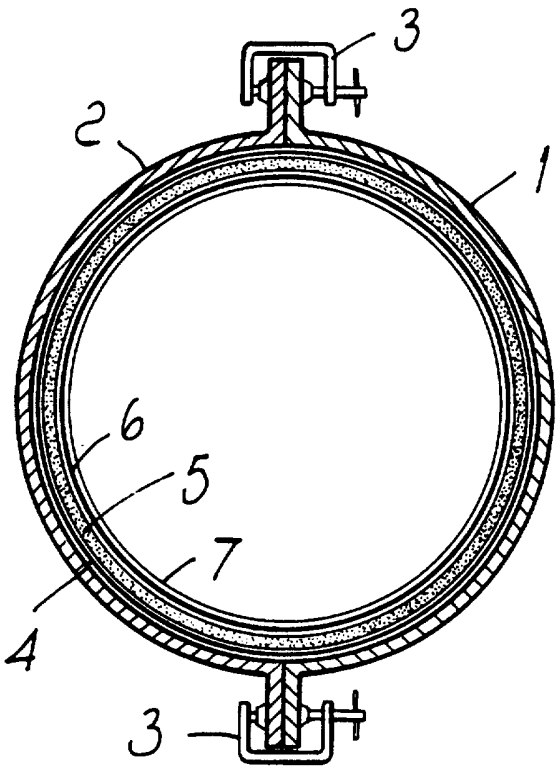

Fig.2

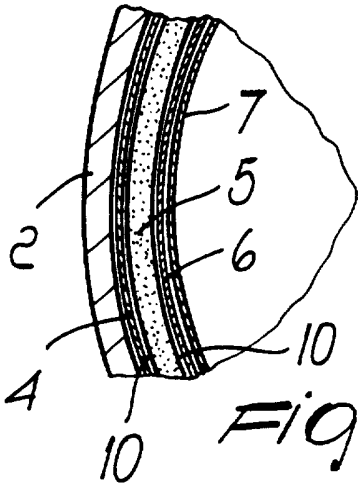

Fig.3

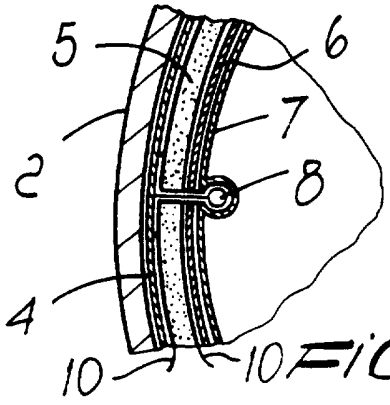

Fig.4

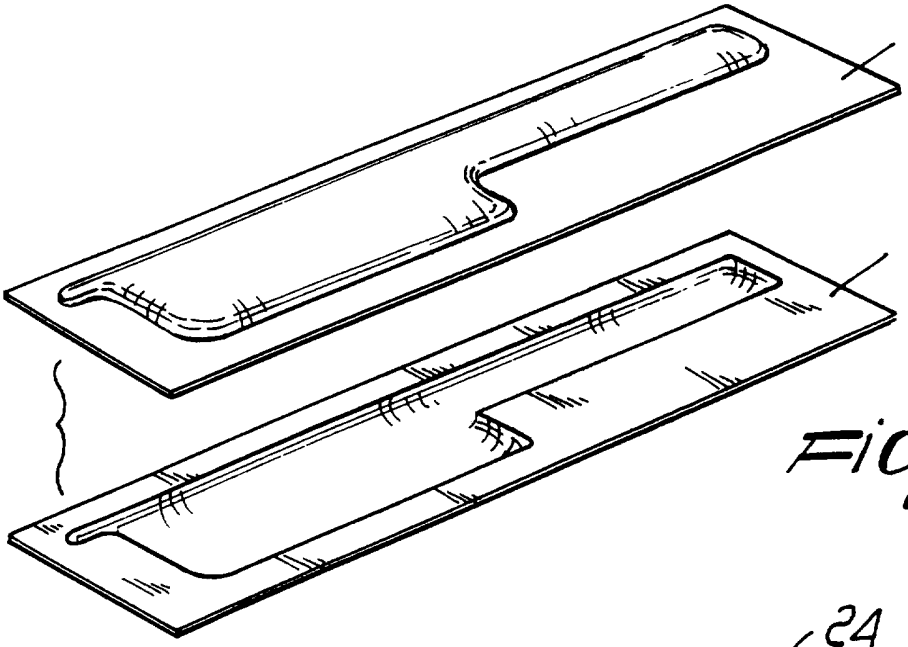

Fig. 5

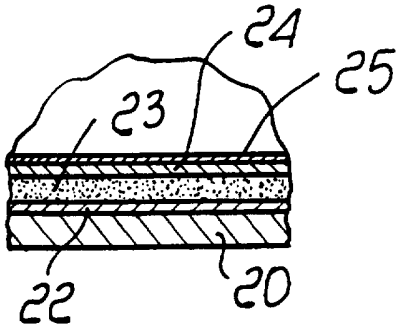

Fig. 6a

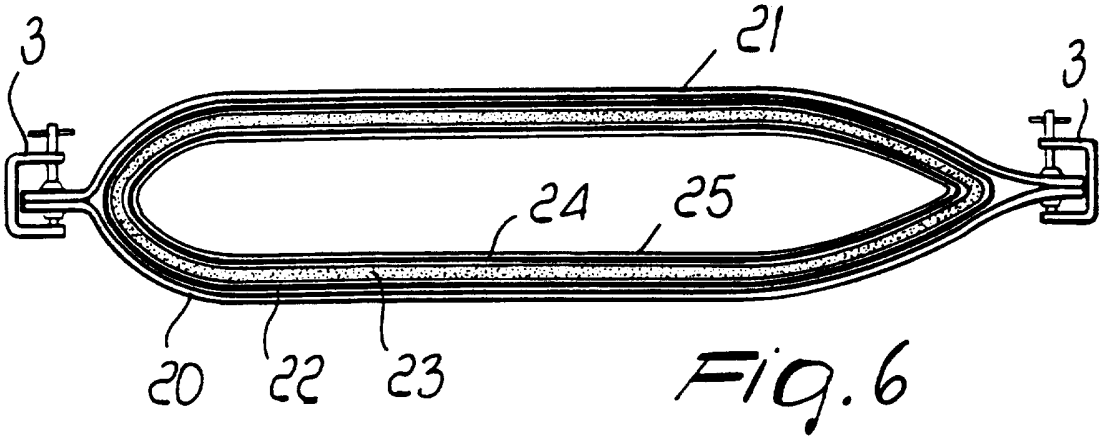

Fig. 6

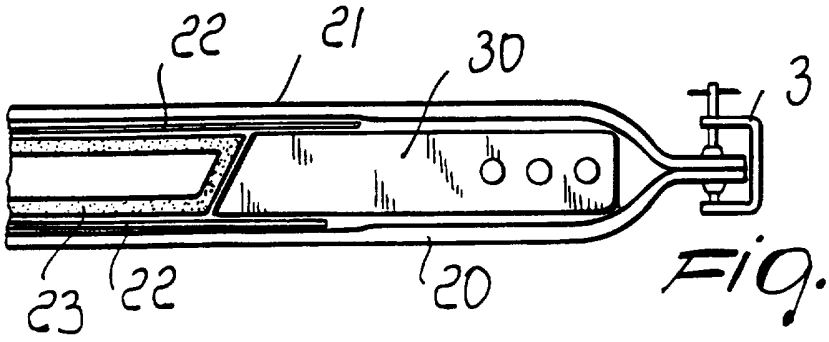

Fig. 7

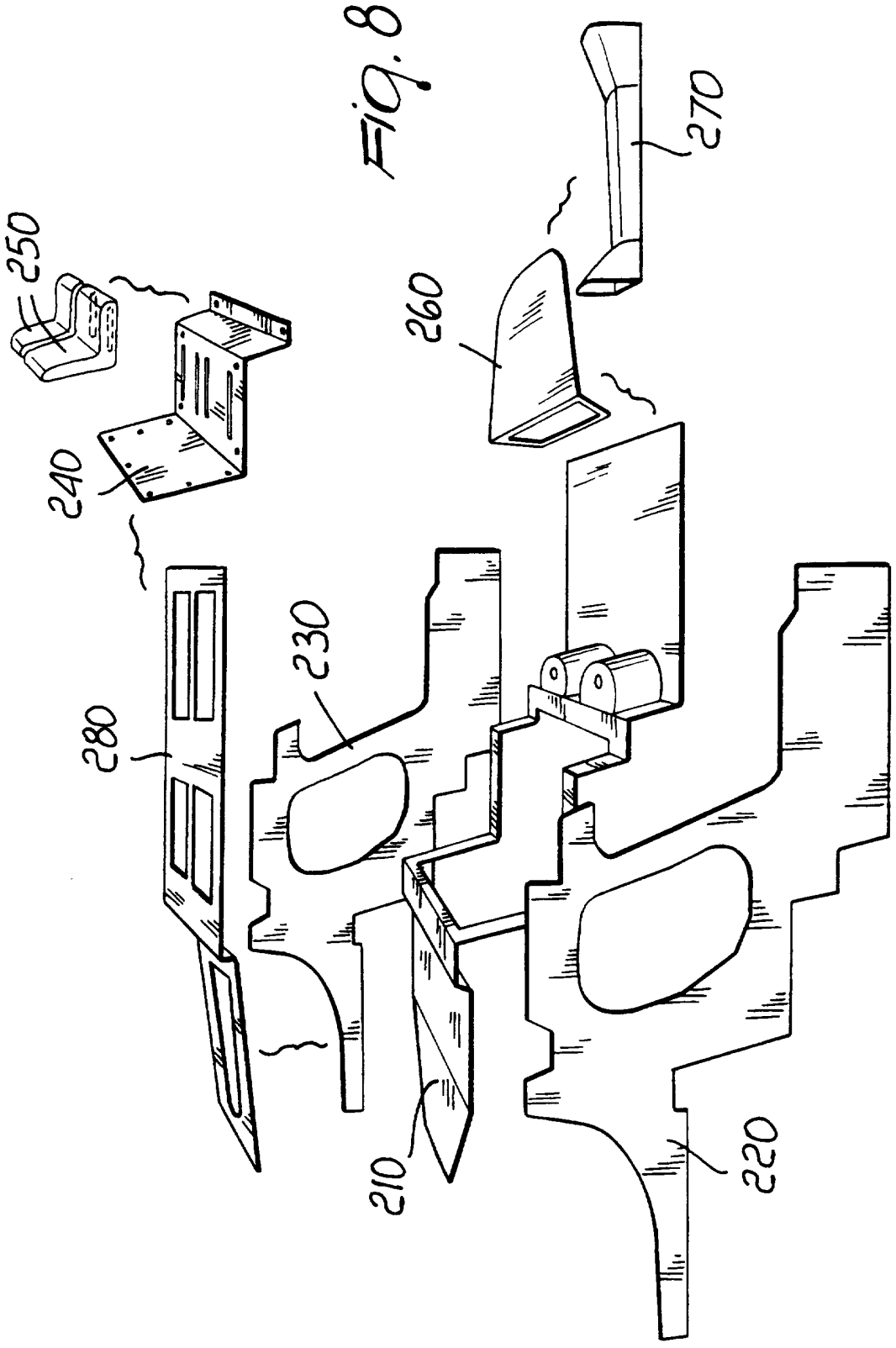

Fig. 8

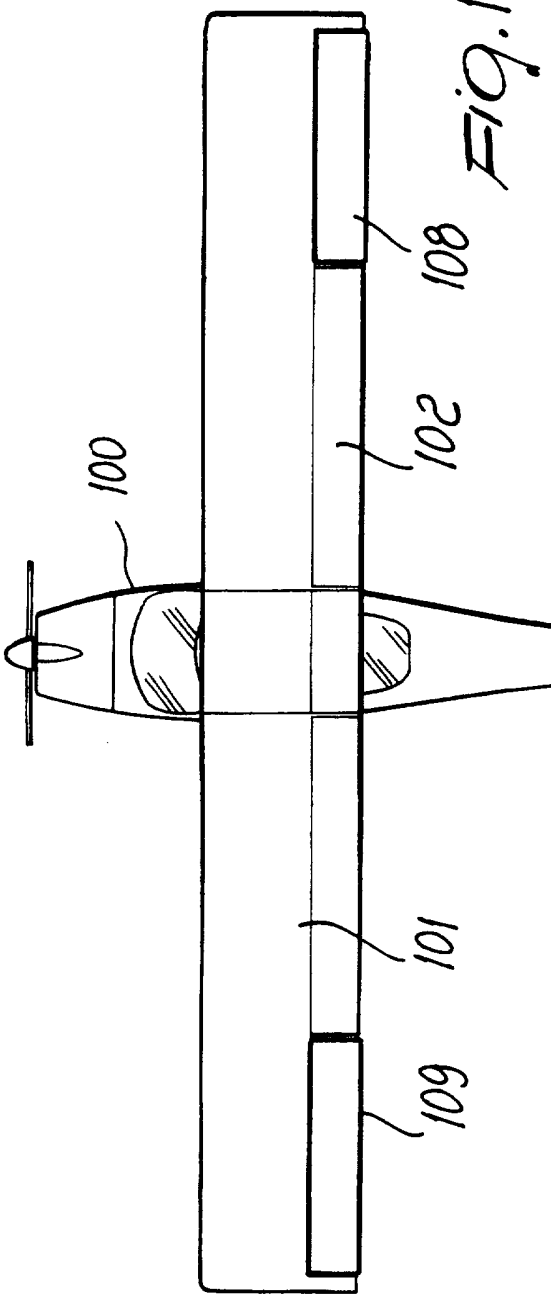

Fig. 10

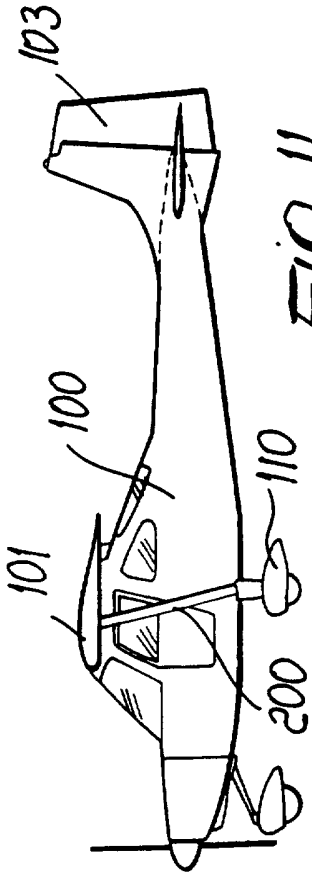

Fig. 11

INTERNATIONAL SEARCH REPORT

In tional Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B64C1/00 B64C31/028 B64C3/24

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)
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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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 202 809 A (AEROSPATIALE) 10 May 1974	1-6,8,9, 11-14,16
A	see page 3, line 10 - line 35 see page 4, line 22 - line 36 see page 5, line 25 - page 6, line 26 see claim 9 see figures	15

Y	US 4 579 301 A (BRAND ROLF) 1 April 1986	1-6,8,9, 11-14,16
	see abstract see column 2, line 52 - line 66 see column 3, line 16 - line 39 see claims 1,9-12 see figures	

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 May 1997	26.05.97

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 576 279 A (METZ JEAN FRANCOIS) 25 July 1986	11,16
A	see page 7, line 31 - page 8, line 34 see page 9, line 10 - line 29 see figures	8
A	DE 35 38 483 A (WOLF HOFFMANN FLUGZEUGBAU KG) 30 April 1987 see the whole document	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

In .tional Application No
PCT/EP 97/00425

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