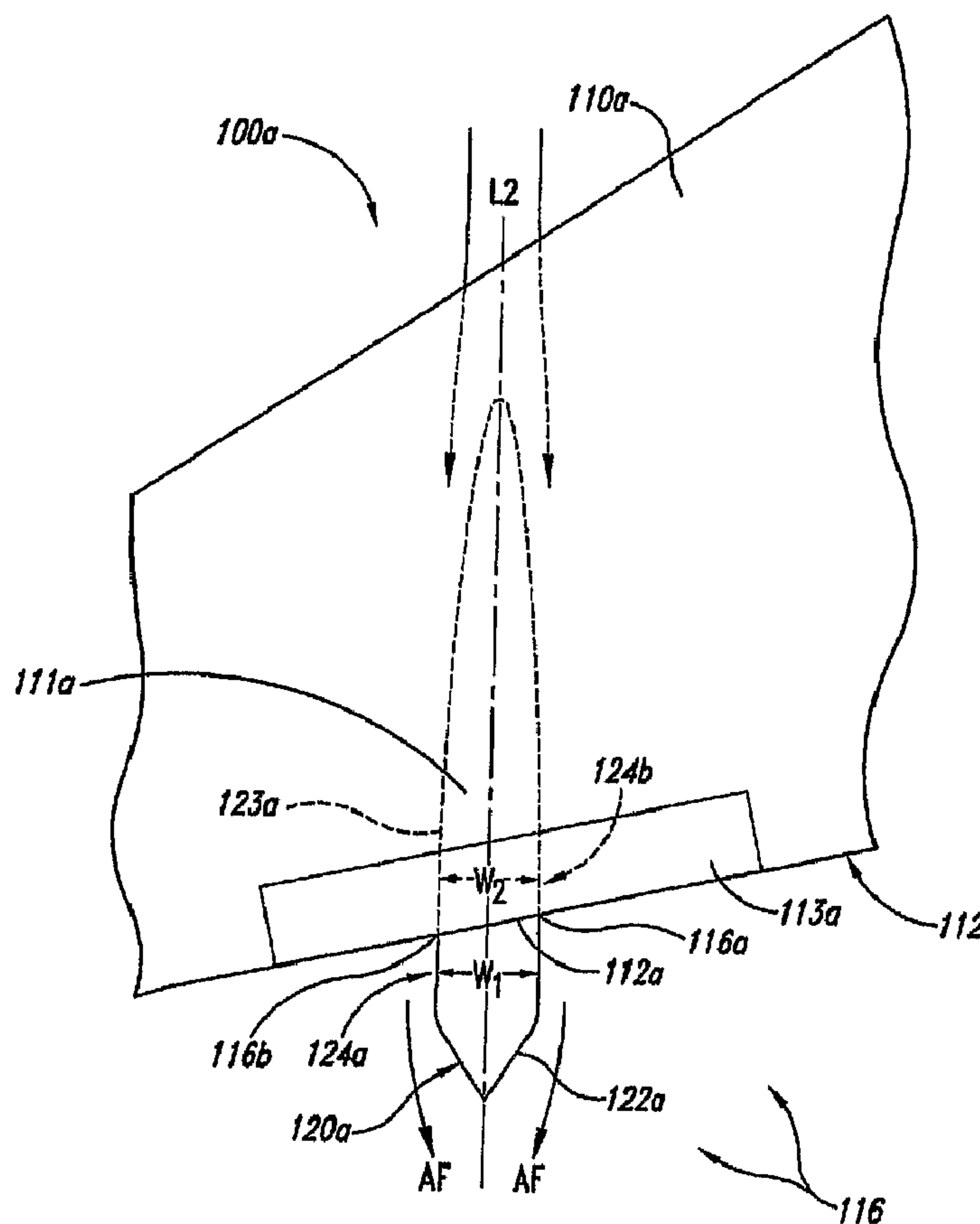




(86) Date de dépôt PCT/PCT Filing Date: 2006/04/26
(87) Date publication PCT/PCT Publication Date: 2006/11/30
(45) Date de délivrance/Issue Date: 2010/08/03
(85) Entrée phase nationale/National Entry: 2007/09/20
(86) N° demande PCT/PCT Application No.: US 2006/016002
(87) N° publication PCT/PCT Publication No.: 2006/127204
(30) Priorité/Priority: 2005/05/20 (US11/134,019)

(51) Cl.Int./Int.Cl. *B64C 9/16* (2006.01),
B64C 7/00 (2006.01)
(72) Inventeur/Inventor:
VOOGT, NICOLAAS, US
(73) Propriétaire/Owner:
THE BOEING COMPANY, US
(74) Agent: SMART & BIGGAR

(54) Titre : SYSTEMES DE CARENAGE DE VEHICULES AEROSPATIAUX ET PROCEDES ASSOCIES
(54) Title: AEROSPACE VEHICLE FAIRING SYSTEMS AND ASSOCIATED METHODS



(57) Abrégé/Abstract:

Aerospace vehicle fairing systems (100a, 100b) and associated methods, including fairings that house flap surface drive mechanisms on aircraft (150), are disclosed herein. One aspect of the invention is directed toward a fairing system (100) that



(57) **Abrégé(suite)/Abstract(continued):**

includes a fairing (120) mounted to an airfoil (110). The fairing (120) can have a longitudinal axis (L2) and a fairing section (122) extending along the longitudinal axis forward and aft of a trailing edge portion (112) of an airfoil section (111). In one embodiment of the invention, the fairing section (122) can have a wide portion (124) located aft of the airfoil section (111) with a single spanwise width (W1) that is greater than or equal to a spanwise width of any other portion of the fairing section (122). In another embodiment of the invention the fairing section (122) can have a first side (51) and a second side (52), each with a point of maximum curvature. At least one point of maximum curvature can be located aft of the airfoil section (111).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
30 November 2006 (30.11.2006)

PCT

(10) International Publication Number
WO 2006/127204 A1

(51) International Patent Classification:
B64C 9/16 (2006.01) **B64C 7/00** (2006.01)

[NL/US]; 1402 241st ST. SE, Bothell, Washington 98021 (US).

(21) International Application Number:
PCT/US2006/016002

(74) Agent: **WOO, Euclid à**; The Boeing Company, 15460 Laguna Canyon Road, MC 1650-7006, Irvine, California 92618 (US).

(22) International Filing Date: 26 April 2006 (26.04.2006)

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/134,019 20 May 2005 (20.05.2005) US

(71) Applicant (*for all designated States except US*): **THE BOEING COMPANY** [US/US]; 100 N. Riverside Plaza, Chicago, Illinois 60606 (US).

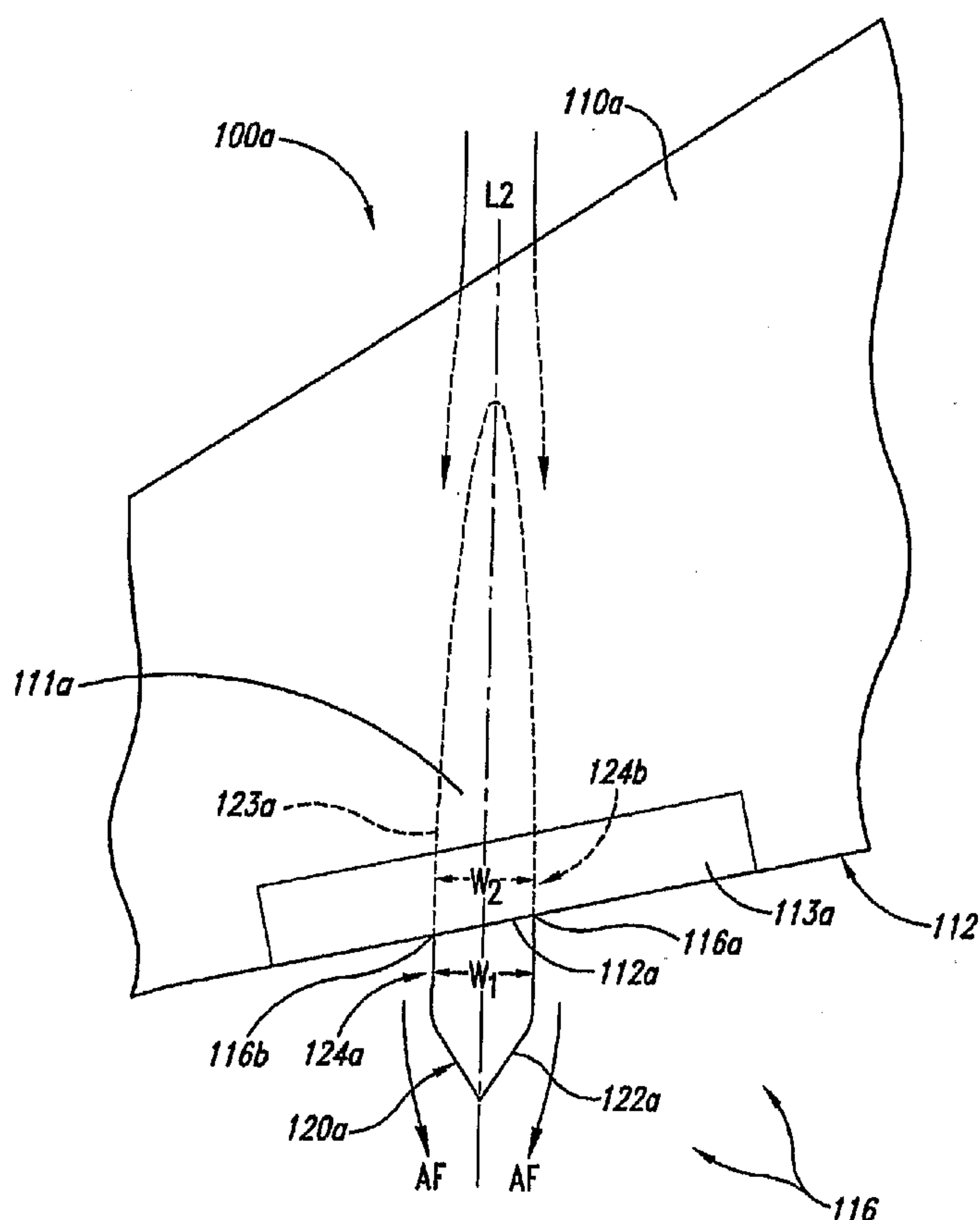
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,

(72) Inventor; and

(75) Inventor/Applicant (*for US only*): **VOOGT, Nicolaas**

[Continued on next page]

(54) Title: AEROSPACE VEHICLE FAIRING SYSTEMS AND ASSOCIATED METHODS



(57) Abstract: Aerospace vehicle fairing systems (100a, 100b) and associated methods, including fairings that house flap surface drive mechanisms on aircraft (150), are disclosed herein. One aspect of the invention is directed toward a fairing system (100) that includes a fairing (120) mounted to an airfoil (110). The fairing (120) can have a longitudinal axis (L2) and a fairing section (122) extending along the longitudinal axis forward and aft of a trailing edge portion (112) of an airfoil section (111). In one embodiment of the invention, the fairing section (122) can have a wide portion (124) located aft of the airfoil section (111) with a single spanwise width (W1) that is greater than or equal to a spanwise width of any other portion of the fairing section (122). In another embodiment of the invention the fairing section (122) can have a first side (51) and a second side (52), each with a point of maximum curvature. At least one point of maximum curvature can be located aft of the airfoil section (111).

WO 2006/127204 A1

WO 2006/127204 A1



FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

AEROSPACE VEHICLE FAIRING SYSTEMS AND ASSOCIATED METHODS

TECHNICAL FIELD

5 Embodiments of the present invention relate to aerospace vehicle fairing systems and associated methods, including fairings that house flap surface drive mechanisms on aircraft.

BACKGROUND

10 Modern high-speed aircraft generally have thin wings that provide a low drag profile during high-speed or cruise flight. The wings of these aircraft often include various movable surfaces to provide aircraft control and/or to configure the aircraft for low-speed operations (e.g., takeoff and landing). For example, in addition to carrying fuel, the wings of a high-speed transport aircraft typically included aileron surfaces, spoiler surfaces, leading edge device surfaces, and trailing edge flap surfaces. These movable surfaces are often located at or near the leading and trailing edges of the wing where the wing is too thin to fully enclose the support structure and/or drive mechanisms required to operate these surfaces. Accordingly, fairings are often mounted on the wing to house portions of the drive mechanisms and/or support structure that cannot be enclosed in the wing. These fairings are generally streamlined to have a low drag profile during high-speed or cruise flight.

20 Figure 1 is a partially schematic illustration of a transport aircraft 50 having a fuselage 51 with a longitudinal axis L1, a first wing 10a, and a second wing 10b in accordance with the prior art. The first wing includes a movable flap surface 13a and a movable aileron surface 13b. A fairing 20 is mounted on the underside of the first wing 10a to house portions of a support structure and a drive mechanism that are required to operate the flap 13a. The fairing has a longitudinal axis L2 that is at least approximately parallel to the longitudinal axis L1 of the fuselage 51. The fairing 20 has a streamlined planform (e.g., when viewed from the top of the wing) where the widest part relative to the longitudinal axis L2 of the fairing is entirely forward of the

trailing edge of the airfoil (e.g., entirely forward of the trailing edge of the flap 13a). However, even these fairings create drag on the aircraft.

SUMMARY

5 Aspects of the present invention are directed generally toward aerospace vehicle fairing systems and associated methods, including fairings that house flap surface drive mechanisms on aircraft.

10 In accordance with one aspect of the invention, there is provided a fairing system. The system includes an airfoil having a trailing edge and an airfoil section with a trailing edge portion. The system also includes a fairing mounted to the airfoil section, the fairing having a longitudinal axis and a fairing section extending along the longitudinal axis forward and aft of the trailing edge portion of the airfoil section. The airfoil section corresponds to a planform projection of a segment of the fairing on the airfoil, the fairing section having a wide portion, located aft of the airfoil section. The wide portion of the
15 fairing section has a single spanwise width measured perpendicular to the longitudinal axis of the fairing that is greater than a spanwise width of any other portion of the fairing section. The airfoil includes a moveable surface and the fairing houses at least one of at least a portion of a drive mechanism configured to move the movable surface, and at least a portion of one or more
20 supports associated with the moveable surface.

The airfoil may include a wing and the moveable surface may include a flap surface. The wing is coupled to a fuselage of an aircraft, and the fairing may include a flap fairing and the flap surface may be movable from a retracted position to at least one extended position.

25 The airfoil may include an airfoil couplable to an aerospace vehicle.

The airfoil may include one or more adjacent trailing edge points, the one or more adjacent trailing edge points being located on the trailing edge of the airfoil and immediately adjacent to the fairing. At least part of the wide portion of the fairing section may be located aft of at least one of the one or
30 more adjacent trailing edge points.

At least a part of the trailing edge portion of the airfoil section may be movable between at least two positions and the wide portion of the fairing section may be located aft of the airfoil section when the at least a part of the trailing edge portion is in a selected position.

5 The fairing section may include a first side and a second side, each side being laterally displaced from the longitudinal axis, and each side having a point of maximum curvature. The point of maximum curvature for both of the first and second sides may be located aft of the airfoil section.

10 The fairing section may include at least one of multiple pieces and the entire fairing.

At least a portion of the fairing may be positioned to move when the drive mechanism moves the movable surface.

15 In accordance with another aspect of the invention, there is provided a fairing system. The fairing system includes an airfoil having a trailing edge and an airfoil section with a trailing edge portion. The fairing system also includes a fairing mounted to the airfoil section. The fairing has a longitudinal axis and a fairing section extending along the longitudinal axis forward and aft of the trailing edge portion of the airfoil section. The airfoil section corresponds to a planform projection of a segment of the fairing on the airfoil, the fairing section having a first side and a second side. Each side of the fairing section is laterally displaced from the longitudinal axis, and each side has a point of maximum curvature. The point of maximum curvature for both of the first and second sides is located aft of the airfoil section. The airfoil includes a moveable surface and the fairing houses at least one of at least a portion of a drive mechanism configured to move the movable surface, and at least a portion of one or more supports associated with the moveable surface.

20

25

30 The airfoil may include a wing and the moveable surface may include a flap surface. The wing may be coupled to a fuselage of an aircraft, and the fairing may include a flap fairing. The flap surface may be moveable from a retracted position to at least one extended position.

The airfoil may include an airfoil couplable to an aerospace vehicle.

At least a part of the trailing edge portion of the airfoil section may be movable between at least two positions. The point of maximum curvature for both of the first and second sides may be located aft of the airfoil section when the at least a part of the trailing edge portion is in a selected position.

The airfoil may include one or more adjacent trailing edge points. The one or more adjacent trailing edge points may be located on the trailing edge of the airfoil and immediately adjacent to the fairing. The point of maximum curvature for both of the first and second sides may be located aft of at least one of the one or more adjacent trailing edge points.

In accordance with another aspect of the invention, there is provided a method for making a fairing system. The method involves locating a fairing proximate to an airfoil. The airfoil has a trailing edge and an airfoil section with a trailing edge portion, a section of the fairing extending along a longitudinal axis of the fairing forward and aft of the trailing edge portion of the airfoil section. The airfoil section corresponds to a planform projection of a segment of the fairing on the airfoil. The method also involves mounting the fairing to the airfoil including mounting a flap fairing to a wing having a movable flap surface, the flap fairing housing at least a portion of a drive mechanism for the flap surface, and the wing being coupled to a fuselage of an aircraft. The method further involves mounting the fairing to the airfoil such that at least one of a wide portion of the fairing section is located aft of the airfoil section, the wide portion of the fairing section having a single spanwise width measured perpendicular to the longitudinal axis of the fairing that is greater than a spanwise width of any other portion of the fairing section, and a point of maximum curvature for a first side and a point of maximum curvature for a second side are located aft of the airfoil section, the first side and the second side each being laterally displaced from the longitudinal axis.

Mounting the fairing to the airfoil may involve mounting a fairing to an airfoil that is couplable to an aerospace vehicle.

Mounting the fairing to the airfoil may involve mounting a fairing to an airfoil, wherein at least part of the trailing edge portion is movable between at least two positions, the movable part of the trailing edge portion being positioned in a selected position.

- 5 Mounting the fairing to the airfoil may involve mounting a second fairing to the airfoil, and may further involve removing a first fairing from the airfoil.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partially schematic illustration of an aircraft with a flap fairing in accordance with the prior art.

- 10 Figure 2 is a partially schematic illustration of an aerospace vehicle with a first fairing system and a second fairing system, where each fairing system is in accordance with embodiments of the invention.

Figure 3 is a partially schematic enlarged view of the first fairing system shown in Figure 2.

- 15 Figure 4 is a partially schematic cross-sectional view of the first fairing system shown in Figure 2 taken along line 4-4 with a first movable surface in a first position.

Figure 5 is a partially schematic cross-sectional view of the first fairing system shown in Figure 4 with the first movable surface in a second position.

- 20 Figure 6 is a partially schematic cross-sectional view of the first fairing system shown in Figure 4 with the first movable surface in a third position.

Figure 7 is a partially schematic enlarged view of the second fairing system shown in Figure 2.

DETAILED DESCRIPTION

- 25 The present disclosure describes aerospace vehicle fairing systems and associated methods, including fairings that house flap surface drive mechanisms on

aircraft. Several specific details of the invention are set forth in the following description and in Figures 2-7 to provide a thorough understanding of certain embodiments of the invention. One skilled in the art, however, will understand that the present invention may have additional embodiments, and that other embodiments of the invention may be practiced without several of the specific features described below.

Figure 2 illustrates an aerospace vehicle 150 having a first fairing system 100a and a second fairing system 100b, where each fairing system 100 is in accordance with embodiments of the invention. In some embodiments these fairing systems can reduce interference drag and/or increase lift over that of current fairings used on various aircraft. Features of the first fairing system are discussed in further detail with reference to Figures 3-6. Features of the second fairing system are discussed in further detail with reference to Figure 7.

In the embodiment shown in Figure 2, the aerospace vehicle 150 has a longitudinal axis L1 that runs through a fuselage 151 (e.g., through the forward tip and aft tip of the fuselage). The aerospace vehicle 150 also has multiple airfoils 110 coupled to the fuselage 151, including a first airfoil 110a (e.g., a left wing), a second airfoil 110b (e.g., a right wing), a third airfoil 110c (e.g., a left horizontal tail), a fourth airfoil 110d (e.g., a right horizontal tail), and a fifth airfoil 110e (e.g., a vertical stabilizer). In other embodiments, the aerospace vehicle 150 can have other arrangements including more or fewer fuselages 151, more or fewer airfoils 110, and/or other arrangements of airfoils 110 coupled to the aerospace vehicle and/or fuselage(s) 151.

In the illustrated embodiment, the first airfoil 110a includes a trailing edge 112 and two movable surfaces 113, shown as a first movable surface 113a configured as a flap surface and a second movable surface 113b configured as an aileron surface. In other embodiments, the first airfoil 110a can include more, fewer, or other types of movable surfaces 113. The first fairing system 100a can include a first fairing 120a having a longitudinal axis L2 that is at least approximately parallel to the longitudinal axis L1 of the aerospace vehicle 150. The first fairing 120a can be mounted to the first airfoil 110a so that a first section 111a of the first airfoil 110a corresponds to a planform projection of the first segment 123a of the first fairing 120a

on the airfoil. The second fairing system 100b can include a second fairing 120b having a longitudinal axis L3 that is at least approximately parallel to the longitudinal axis of the aerospace vehicle 150. The second fairing can also be mounted to the first airfoil 110a so that a second section 111b of the first airfoil 110a corresponds to a planform projection of the second segment 123b of the second fairing sections 120a on the airfoil. The first airfoil section 111a can include a first trailing edge portion 112a and the second airfoil section 111b can include a second trailing edge portion 112b.

In Figure 2, the first airfoil section 111a includes a portion of the first movable surface 113a. The first movable surface 113a is located such that a portion of the trailing edge of the first movable surface 113a makes up at least a part of the first trailing edge portion 112a. Accordingly, at least a part of the first trailing edge portion 112a is movable between at least two positions (e.g., a retracted position and an extended position). In the illustrated embodiment, the first airfoil section 111a includes a first trailing edge portion 112a that moves as a single unit. In other embodiments, the first trailing edge portion can have other arrangements, including a first trailing edge portion 112a that has movable and fixed parts and/or multiple parts that move independently of one another.

Figure 3 is a partially schematic enlarged view of the first fairing system 100a shown in Figure 2. In the illustrated embodiment, the first fairing 120a is mounted to the underside of the first airfoil 110a. For example, the first fairing section 120a can be attached to the first airfoil 110a after the first airfoil has been produced and/or fabricated onto/into the first airfoil 110a during the production process (e.g., to form a protrusion from the airfoil shape). In other embodiments, the first fairing 120a can be mounted to other portions of the first airfoil 110a. For example, the first fairing can be mounted to the top of the airfoil 110a or can be mounted to opposing surfaces of an airfoil (e.g., mounted to the left and right surfaces of a vertically oriented airfoil or to the top and bottom surfaces of a horizontally oriented airfoil). The trailing edge 112 of the first airfoil 110a can include adjacent trailing edge points 116, where the adjacent trailing edge points 116 are points on the trailing edge 112 of the first airfoil 110a immediately adjacent to the first fairing 120a. In the illustrated embodiment, two adjacent trailing edge points 116 are

shown as a first adjacent trailing edge point 116a and a second adjacent trailing edge point 116b.

5 In the illustrated embodiment, the first fairing 120a has a first fairing section 122a that extends along the longitudinal axis L2 forward and aft of the first trailing edge portion 112a of the first airfoil section 111a. In Figure 3, the first fairing section 122a includes the entire first fairing 120a. In other embodiments, the first fairing section 122a does not include the entire first fairing 120a.

10 In Figure 3, the first fairing section 122a has a wide portion 124a that has a single spanwise planform width W1 measured perpendicular to the longitudinal axis of the first fairing 120a that is greater than or equal to a spanwise width of any other portion of the first fairing section 122a. At least part of the wide portion 124a of the first fairing section 120a can be located aft of the first airfoil section 111a and/or aft of at least one of the first and second adjacent trailing edge points 116a, 116b. For example, in the illustrated embodiment a second spanwise portion 124b of the first
15 fairing section 122a, located forward of the first trailing edge portion 112a of the of the first airfoil section 111a and forward of the first and second adjacent trailing edge points 116a, 116b, has a width W2 that is equal to the width W1 of the wide portion 124a, but the first fairing section 122a does not have any portion with a width that is greater than the width W1 of the wide portion 124a.

20 It has been discovered that in certain embodiments, locating at least part of the wide portion 124a of the first fairing section 122a aft of the first airfoil section 111a and/or aft of at least one of the first and second adjacent trailing edge points 116a, 116b can affect the airflow proximate to the first fairing section 122a, resulting in a drag reduction and/or a lift increase over that of airfoils having current fairings. It
25 is thought that one factor contributing to this phenomenon is the placement of a low pressure area proximate to the trailing edge of an airfoil. For example, when the aerospace vehicle 150 is operated in a selected configuration (e.g., with the first movable surface 113a retracted) and at certain operating conditions (e.g., at low-drag, high-speed, and/or cruise conditions), the variation in width along the
30 longitudinal axis of the first fairing 120a can cause fluid or air flowing proximate to the first fairing 120a to be accelerated as the fairing increases in width (e.g. as shown schematically by the airflow arrows AF in Figure 3). As the airflow accelerates, the

local or static pressure can decrease. By placing at least part of the wide portion 124a of the first fairing section 122a aft of the first airfoil section 111a and/or aft of at least one of the first and second adjacent trailing edge points 116a, 116b, an area of lower pressure proximate to the first fairing section 122a and the trailing edge of the first airfoil 110a can be positioned to provide a favorable pressure gradient with respect to drag and/or lift as compared to current fairings. An advantage of decreasing drag and/or increasing lift is that aircraft performance can be improved, for example, by reducing fuel burn and thereby increasing range and/or decreasing operating costs over aircraft having current fairings.

In certain embodiments, where at least part of the first trailing edge portion 112a of the airfoil section 111a is movable, the wide portion 124a of the fairing section 122a is located aft of the airfoil section 111b and/or aft of at least one of the first and second adjacent trailing edge points 116a, 116b only when the part of the first trailing edge portion 112a is in a selected position, as shown in Figures 4-6. Figure 4 is a partially schematic cross-sectional view of the first fairing system 100a shown in Figure 2 taken along line 4-4 with the first movable surface 113a in a first position. For example, the first movable surface 113a in a first position can include a flap surface in a retracted position typically used for cruise, low-drag operations, and/or high-speed operations. In the illustrated embodiment, the first position is a selected position where at least part of the wide portion 124a of the fairing section 122a is positioned aft of the airfoil section 111a and/or aft of at least one of the first and second adjacent trailing edge points 116a, 116b, as described above. In Figure 4, the first fairing houses a drive mechanism 115 and the associated supports required to support and move the first movable surface 113a. Additionally, the first fairing 120a includes multiple pieces, shown as a first piece 125a and a second piece 125b. The first and second pieces 125a, 125b are configured to move relative to one another as the first movable surface 113a is moved.

In other embodiments, the first fairing system 100a can have other arrangements, including more or fewer pieces and/or the fairing can house other components (e.g., other aerospace vehicle system components) or no components. Additionally, although in the illustrated embodiment the first fairing system 100a includes a portion of a single movable surface, in other embodiments the first fairing

system 100a can include portions of multiple movable surfaces (e.g., the first fairing system 100a can be positioned to include a portion of two flap surfaces). In still other embodiments, multiple fairing systems 100 can include portions of the same movable surface, for example, multiple fairing systems 100 can house multiple drive mechanisms for a single movable surface (e.g., drive mechanisms to drive a single flap surface).

Figure 5 is a partially schematic cross-sectional view of the first fairing system 100a shown in Figure 4 where the first movable surface 113a has been placed in a second position (e.g., a flap in a first extended position). In Figure 6, the first movable surface 113a has been placed in a third position (e.g., a second extended position). In the illustrated embodiment, when the first movable surface 113a is in the second position (Figure 5) or a third position (Figure 6), the wide portion 124a of the fairing section 122a can be forward of the first trailing edge portion 112a of the first airfoil section 111a and/or forward of the first and second adjacent trailing edge points, discussed above with reference to Figure 3. For example, the first movable surface 113a can include a flap surface that can be placed in a first extended position (Figure 5) or a second extended position (Figure 6) during low-speed operations where a low-drag profile can be less important than when the first movable surface 113a is in the selected position (e.g., the retracted position).

Figure 7 is a partially schematic enlarged view of the second fairing system 100b shown in Figure 2. In the illustrated embodiment the second fairing 120b is mounted to the underside of the first airfoil 110a. The second fairing 120b has a second fairing section 122b that extends along the longitudinal axis L3 forward and aft of the second trailing edge portion 112b of the second airfoil section 111b. In Figure 7, the second fairing section 122b is asymmetrical with respect to the longitudinal axis L3 of the second fairing 120b. In other embodiments, the second fairing section 122b can be symmetrical about the longitudinal axis L3 of the second fairing 120b. Additionally, in the illustrated embodiment the second fairing section 122b includes only a portion of the entire second fairing 120b (e.g., the second fairing section 122b does not include the shaded area SA of the second fairing 120b shown in Figure 7). Additionally, in the illustrated embodiment the trailing edge 112 of the

first airfoil 110a includes a third adjacent trailing edge point 116c and a fourth adjacent trailing edge point 116d that are immediately adjacent to the second fairing 120b.

5 In the illustrated embodiment, the second fairing section 122b includes a first side S1 and a second side S2 facing in generally lateral directions. The first and second sides S1, S2 can include the farthest points laterally from the longitudinal axis L3 of the second fairing 120b. The width of the second fairing section 122b increases in an aft direction along the longitudinal axis L3 until reaching a widest portion and then decreases. Accordingly, the second fairing section 122b includes
10 multiple portions 124, with each portion having a single width. For example, four of the multiple portions 124 are identified in Figure 7 as a first portion 124a having a first width W1, a second portion 124b having a second width W2, a third portion 124c having a third width W3, and a fourth portion 124d having a fourth width W4.

15 In Figure 7, the fourth portion 124d is located forward of the second trailing edge portion 112b of the second airfoil section 111b and forward of the third and fourth adjacent trailing edge points 116c, 116d. The fourth portion 124d has a fourth width W4 that is smaller than the first, second, and third widths W1, W2, W3. At least part of the third portion 124c is located aft of the second airfoil section 111b (e.g., aft of the second trailing edge portion 112b) and aft of the third adjacent trailing edge
20 point 116c. The third portion 124c has a third width W3 that is greater than the fourth width W4, but smaller than the first and second widths W1, W2. Additionally, the third portion 124c has a width that is larger than or equal to the width of any portion 124 that is forward of the third portion 124c.

25 The entire second portion 124b is located aft of the second airfoil section 111b and aft of the third and fourth adjacent points 116c, 116d. The second portion has a second width W2 that is greater than or equal to the width of any portion 124 that is forward of the second portion 124b. The first portion 124a is located aft of the second portion 124b and has a first width W1 that is greater than or equal to the second width W2. Accordingly, the first portion 124a is the wide portion of the
30 second fairing section 122b. As discussed above with reference to Figure 3, it has been discovered that in certain embodiments locating at least part of the wide portion (e.g., the first portion 124a) of the second fairing section 122b aft of the second airfoil

section 111b can result in an airflow AF that produces a drag reduction and/or a lift increase over that of airfoils having current fairings.

In the illustrated embodiment, the second portion 124b also includes a first point P1 on the first side S1 and a second point P2 on the second side S2. The first and second points P1, P2 are points of maximum curvature of their respective sides S1, S2 in a streamwise direction (e.g., with respect to the airflow AF and/or with respect to the longitudinal axis L3 of the second fairing 120b). In Figure 7, the wide portion (e.g., the first portion 124a) includes the first and second points P1, P2, and the first and second points P1, P2 are opposite one another relative to the longitudinal axis L3 of the second fairing 120b. In other embodiments, the points of maximum curvature on the first and second sides S1, S2 are not coincidental with the wide portion (e.g., the first portion 124a) of the second fairing 120b. In still other embodiments, the points of maximum curvature on the first and second sides are not directly opposite one another relative to the longitudinal axis L3 of the second fairing 120b (e.g., the points of maximum curvature are on their respective sides, but are not directly opposite one another). In yet other embodiments, only the point of maximum curvature for one of the sides of the second fairing section 122b is located aft of the second airfoil section 111b and/or aft of at least one of the third and fourth adjacent trailing edge points 116a, 116b. As discussed above with reference to Figures 3-6, in certain embodiments at least a part of the second trailing edge portion 112b of the second airfoil section 111b is movable to at least two positions and at least one point of maximum curvature is located aft of the second airfoil section 111b and/or aft of at least one of the third and fourth adjacent trailing edge points 116a, 116b when the movable part of the second trailing edge portion 112b is in a selected position (e.g., one of the two positions). In still other embodiments, a side of the second fairing section 122b can have multiple points with the maximum curvature (e.g., the second fairing section 122b can have two points on a side that have the same curvature where that curvature is the maximum curvature on the respective side).

It has been discovered that in certain embodiments locating a point of maximum curvature of at least one of the first or second sides S1, S2 of the second fairing section 122b aft of the second airfoil section 111b can affect the airflow proximate to the second fairing section 122b. This can result in a drag reduction

and/or a lift increase over that of airfoils having current fairings. It is thought that one factor contributing to this phenomenon is the placement of a low-pressure area proximate to the trailing edge of the airfoil and the fairing. For example, the airflow tends to accelerate proximate to the point(s) of maximum curvature, thereby reducing the local or static pressure. This reduction in pressure can decrease drag and/or increase lift over that of aircraft with current fairings. An advantage of decreasing drag and/or increasing lift is that aircraft performance can be improved, reducing fuel burn, and thereby increasing range and/or decreasing operating costs over aircraft having current fairings.

In certain embodiments, fairing systems 100 in accordance with aspects of the present invention can be retrofitted on existing aircraft. For example, in selected embodiments the fairing 20 (shown in Figure 1) mounted on the first airfoil 10a of the aircraft 50 can be removed and a fairing similar to the first or second fairing system 100a, 100b discussed above with reference to Figures 2-7 can be mounted to the first airfoil 10a of the aircraft 50 shown in Figure 1. As discussed above, in certain embodiments the drag of the aircraft 50 can be reduced and/or the lift of the aircraft 50 can be increased by replacing the fairing 20 (shown in Figure 1) with a fairing system 100 in accordance with aspects of the invention.

From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the invention. Additionally, aspects of the invention described in the context of particular embodiments may be combined or eliminated in other embodiments. For example, although aspects of the present invention have been described above with reference to a wing of an aerospace vehicle, in other embodiments fairing systems in accordance with aspects of the invention can include other airfoil surfaces (e.g., a vertical stabilizer or a canard). Although advantages associated with certain embodiments of the invention have been described in the context of those embodiments, other embodiments may also exhibit such advantages. Additionally, not all embodiments need necessarily exhibit such advantages to fall within the scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A fairing system, comprising:

5 an airfoil having a trailing edge and an airfoil section with a trailing edge portion; and

a fairing mounted to the airfoil section, the fairing having a longitudinal axis and a fairing section extending along the longitudinal axis forward and aft of the trailing edge portion of the airfoil section, with the airfoil section corresponding to a planform projection of a segment of the fairing on the airfoil, the fairing section having a wide portion, located aft of the airfoil section, the wide portion of the fairing section having a single spanwise width measured perpendicular to the longitudinal axis of the fairing that is greater than a spanwise width of any other portion of the fairing section, wherein the airfoil includes a moveable surface and the fairing houses at least one of:

10

15

at least a portion of a drive mechanism configured to move the moveable surface; and

20 at least a portion of one or more supports associated with the moveable surface.

2. The system of claim 1 wherein:

the airfoil includes a wing and the moveable surface includes a flap surface, the wing being coupled to a fuselage of an aircraft; and

25

the fairing includes a flap fairing, the flap surface being movable from a retracted position to at least one extended position.

3. The system of claim 1 wherein the airfoil includes an airfoil couplable to an aerospace vehicle.

4. The system of claim 1 wherein:

the airfoil includes one or more adjacent trailing edge points, the one or more adjacent trailing edge points being located on the trailing edge of the airfoil and immediately adjacent to the fairing; and

at least part of the wide portion of the fairing section is located aft of at least one of the one or more adjacent trailing edge points.

5. The system of claim 1 wherein at least a part of the trailing edge portion of the airfoil section is movable between at least two positions and wherein the wide portion of the fairing section is located aft of the airfoil section when the at least a part of the trailing edge portion is in a selected position.

6. The system of claim 1 wherein the fairing section includes a first side and a second side, each side being laterally displaced from the longitudinal axis, each side having a point of maximum curvature, the point of maximum curvature for both of the first and second sides being located aft of the airfoil section.

7. The system of claim 1 wherein the fairing section includes at least one of multiple pieces and the entire fairing.

8. The system of claim 1 wherein at least a portion of the fairing is positioned to move when the drive mechanism moves the movable surface.

9. A fairing system, comprising:

an airfoil having a trailing edge and an airfoil section with a trailing edge portion; and

a fairing mounted to the airfoil section, the fairing having a longitudinal axis and a fairing section extending along the longitudinal axis forward and aft of the trailing edge portion of

the airfoil section, with the airfoil section corresponding to a planform projection of a segment of the fairing on the airfoil, the fairing section having a first side and a second side, each side being laterally displaced from the longitudinal axis, each side having a point of maximum curvature, the point of maximum curvature for both of the first and second sides being located aft of the airfoil section, wherein the airfoil includes a moveable surface and the fairing houses at least one of:

at least a portion of a drive mechanism configured to move the movable surface; and

at least a portion of one or more supports associated with the moveable surface.

10. The system of claim 9 wherein:

the airfoil includes a wing and the moveable surface includes a flap surface, the wing being coupled to a fuselage of an aircraft; and

the fairing includes a flap fairing, the flap surface being moveable from a retracted position to at least one extended position.

11. The system of claim 9 wherein the airfoil includes an airfoil couplable to an aerospace vehicle.

12. The system of claim 9 wherein at least a part of the trailing edge portion of the airfoil section is movable between at least two positions and wherein the point of maximum curvature for the at least one of the first and second sides is located aft of the airfoil section when the at least a part of the trailing edge portion is in a selected position.

13. The system of claim 9 wherein:

the airfoil includes one or more adjacent trailing edge points, the one or more adjacent trailing edge points being located on the

trailing edge of the airfoil and immediately adjacent to the fairing;
and

the point of maximum curvature for both of the first and second
sides being located aft of at least one of the one or more
adjacent trailing edge points.

5

14. A method for making a fairing system, comprising:

locating a fairing proximate to an airfoil, the airfoil having a
trailing edge and an airfoil section with a trailing edge portion, a
section of the fairing extending along a longitudinal axis of the
fairing forward and aft of the trailing edge portion of the airfoil
section, the airfoil section corresponding to a planform projection
of a segment of the fairing on the airfoil;

10

mounting the fairing to the airfoil including mounting a flap fairing
to a wing having a movable flap surface, the flap fairing housing
at least a portion of a drive mechanism for the flap surface, and
the wing being coupled to a fuselage of an aircraft; and

15

mounting the fairing to the airfoil such that at least one of;

a wide portion of the fairing section is located aft of the
airfoil section, the wide portion of the fairing section
having a single spanwise width measured perpendicular
to the longitudinal axis of the fairing that is greater than a
spanwise width of any other portion of the fairing section;
and

20

a point of maximum curvature for a first side and a point
of maximum curvature for a second side are located aft of
the airfoil section, the first side and the second side each
being laterally displaced from the longitudinal axis.

25

15. The method of claim 14 wherein mounting the fairing to the airfoil includes mounting a fairing to an airfoil that is couplable to an aerospace vehicle.
- 5 16. The method of claim 14 wherein mounting the fairing to the airfoil includes mounting a fairing to an airfoil, wherein at least part of the trailing edge portion is movable between at least two positions, the movable part of the trailing edge portion being positioned in a selected position.
- 10 17. The method of claim 14 wherein mounting the fairing to the airfoil includes mounting a second fairing to the airfoil, and wherein the method further comprises removing a first fairing from the airfoil.

1/5

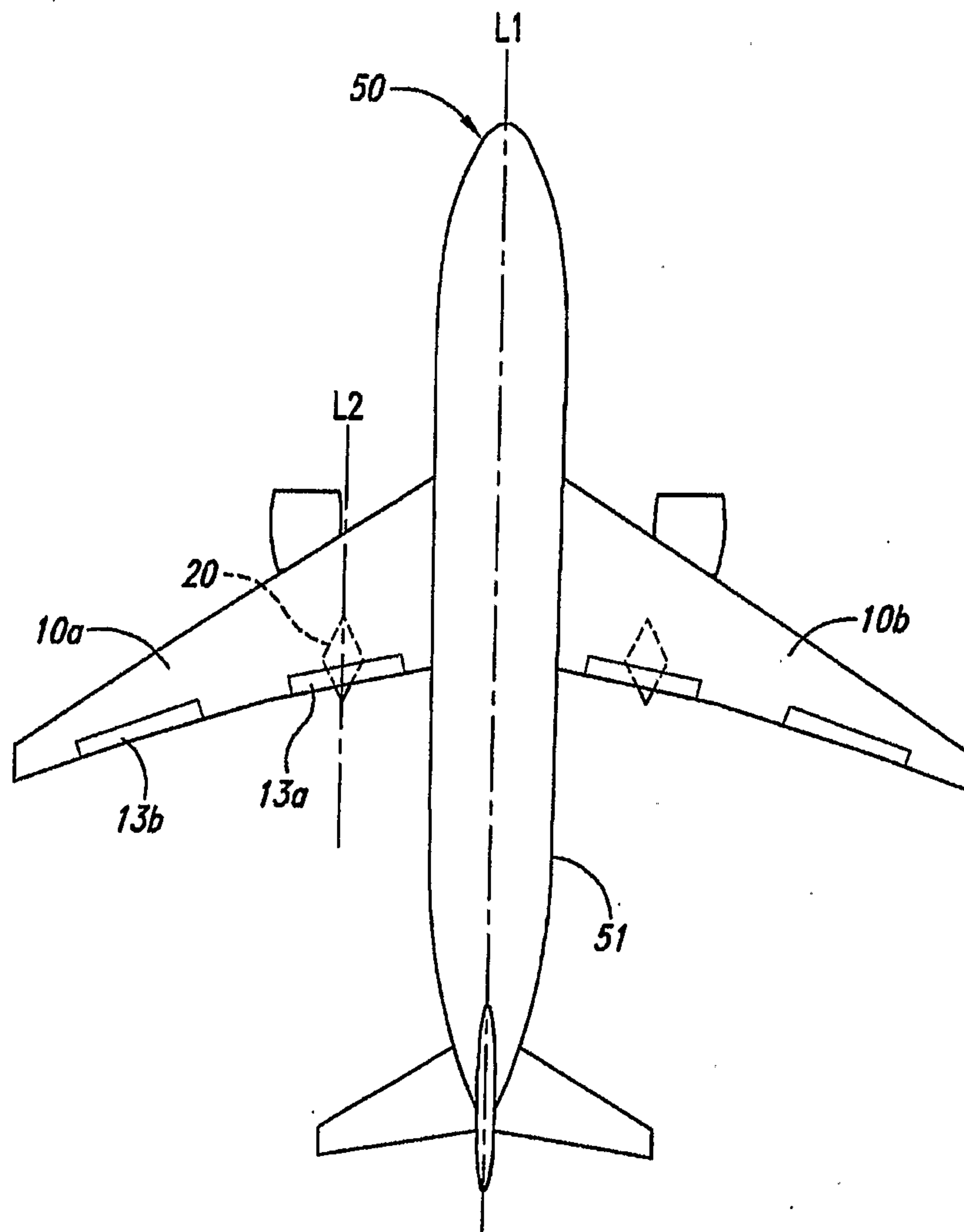
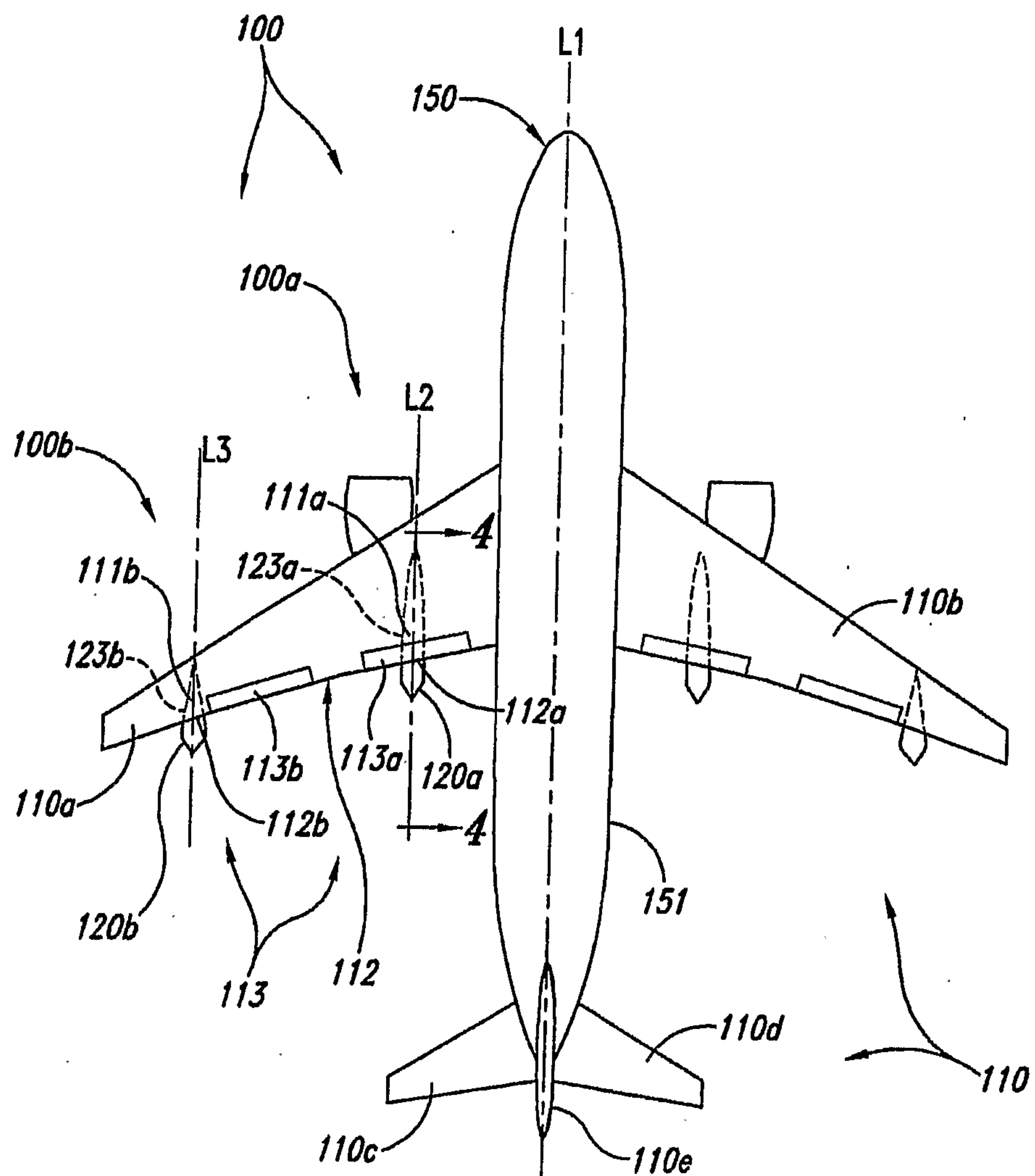


Fig. 1
(Prior Art)

2/5

*Fig. 2*

3/5

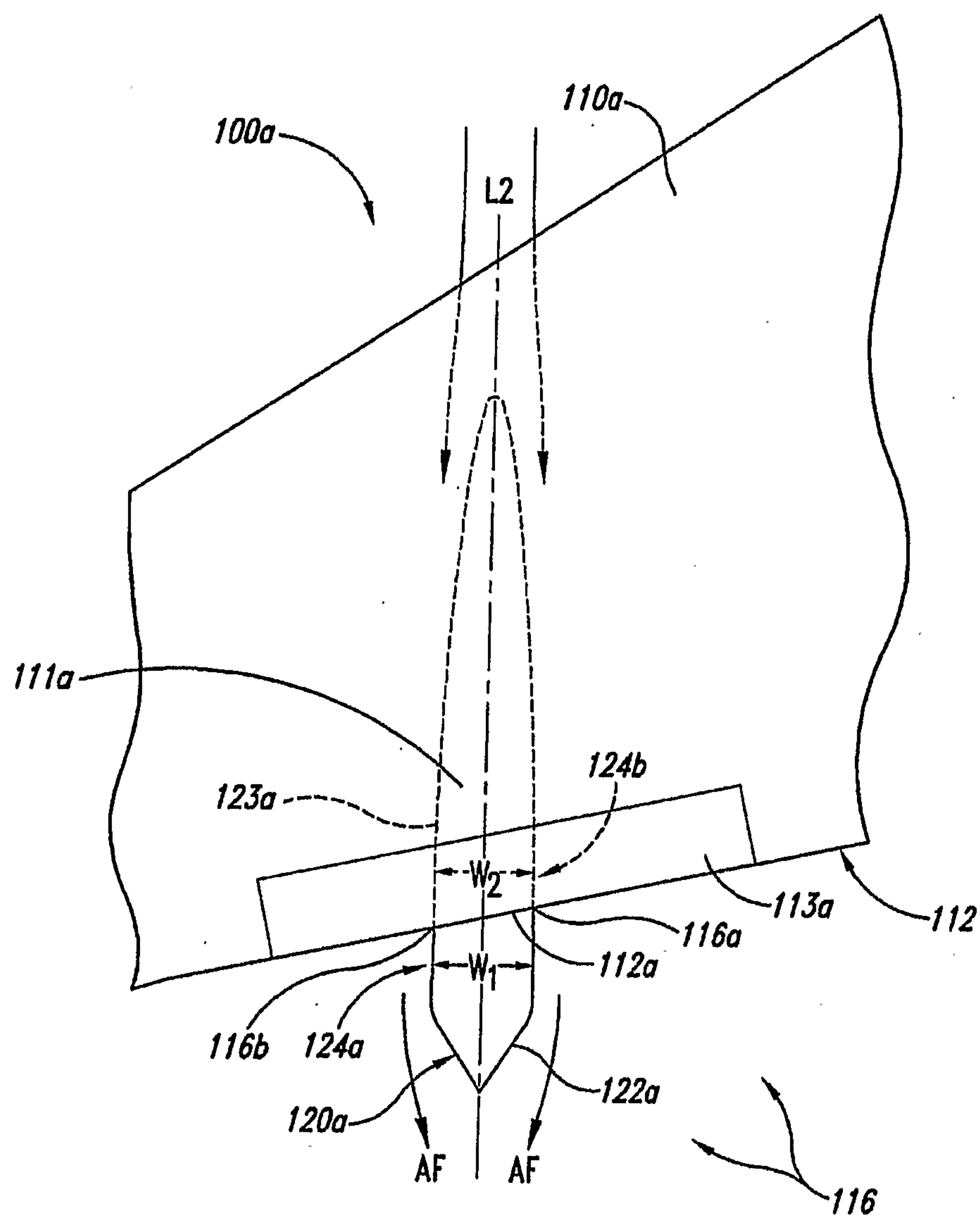
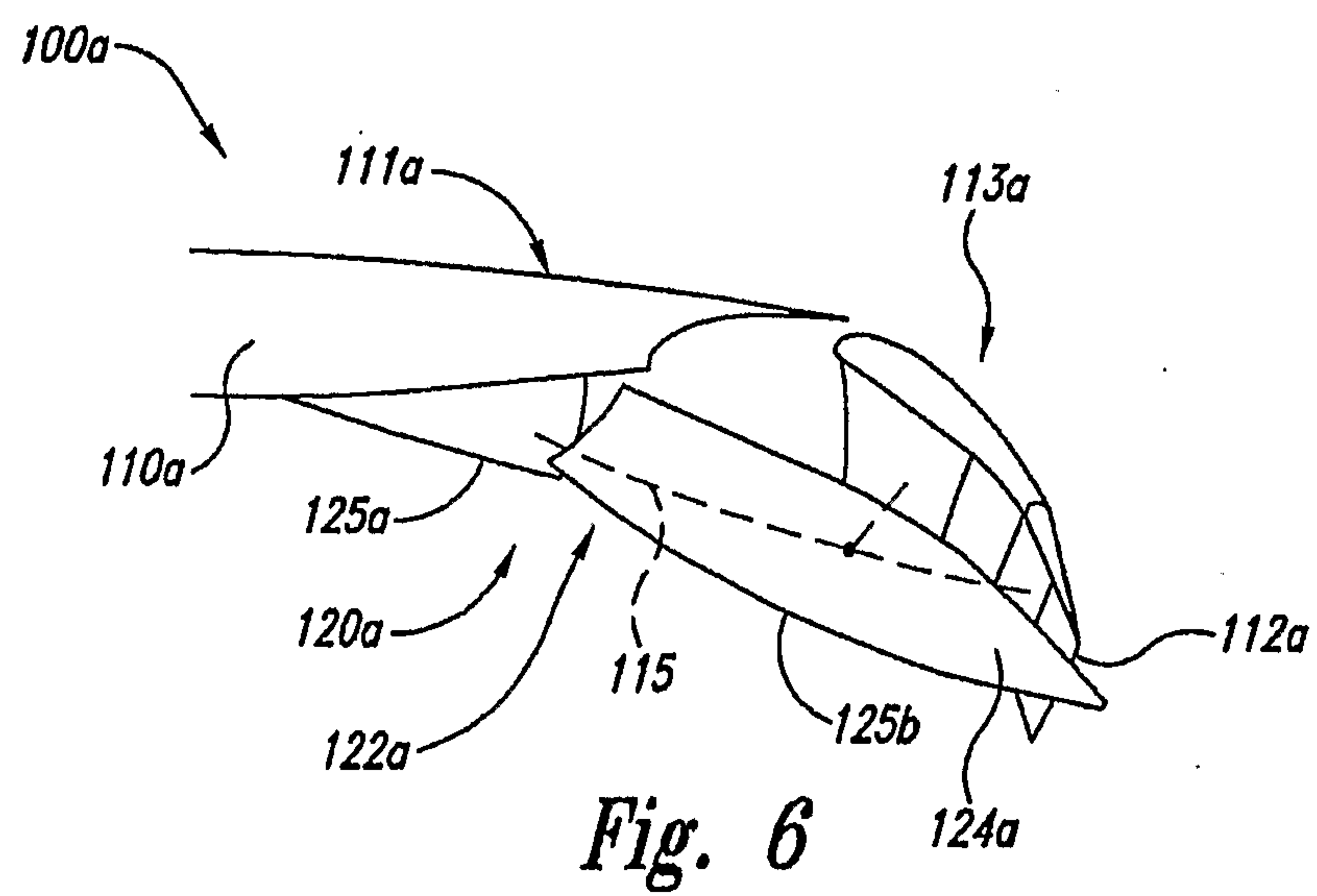
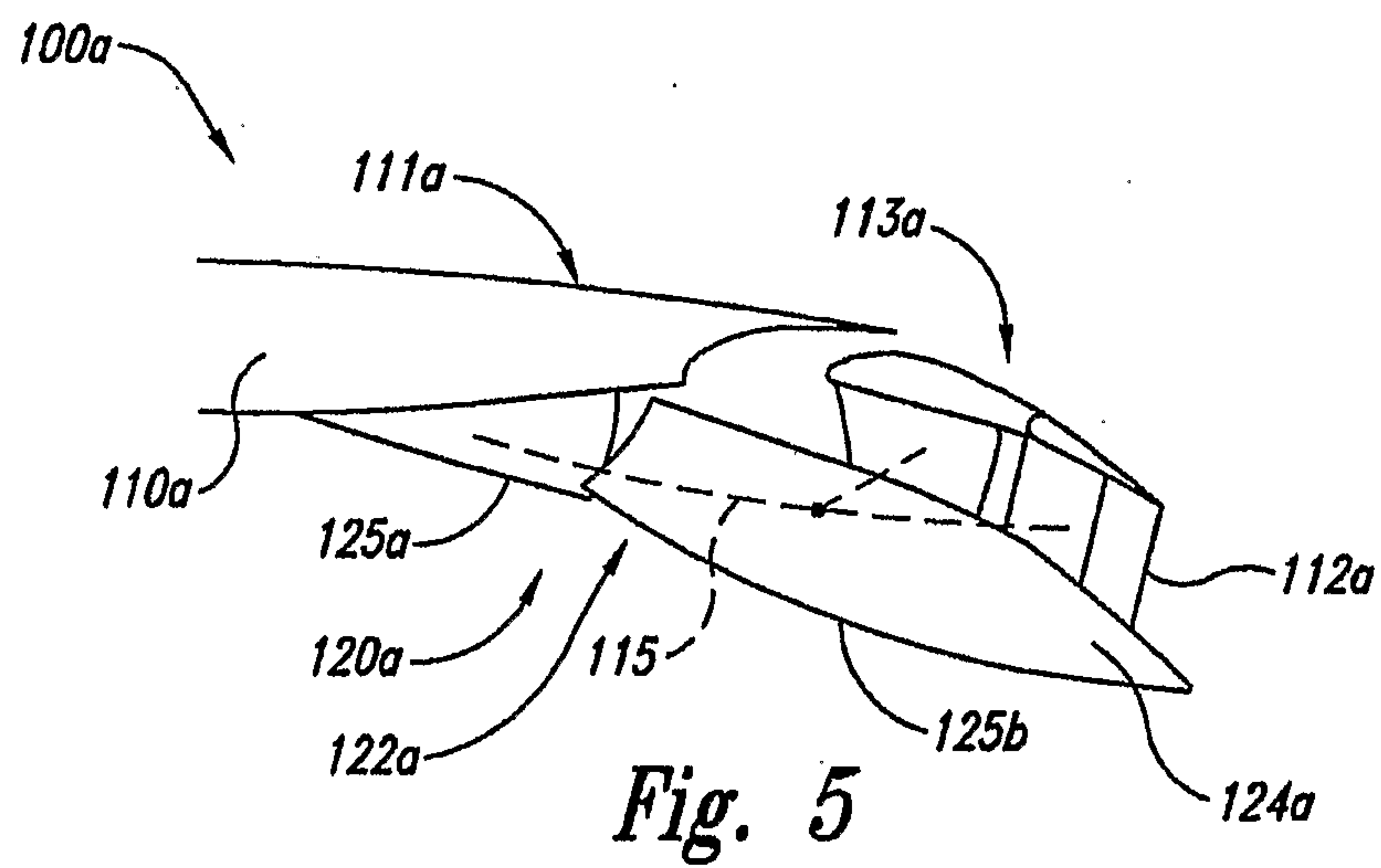
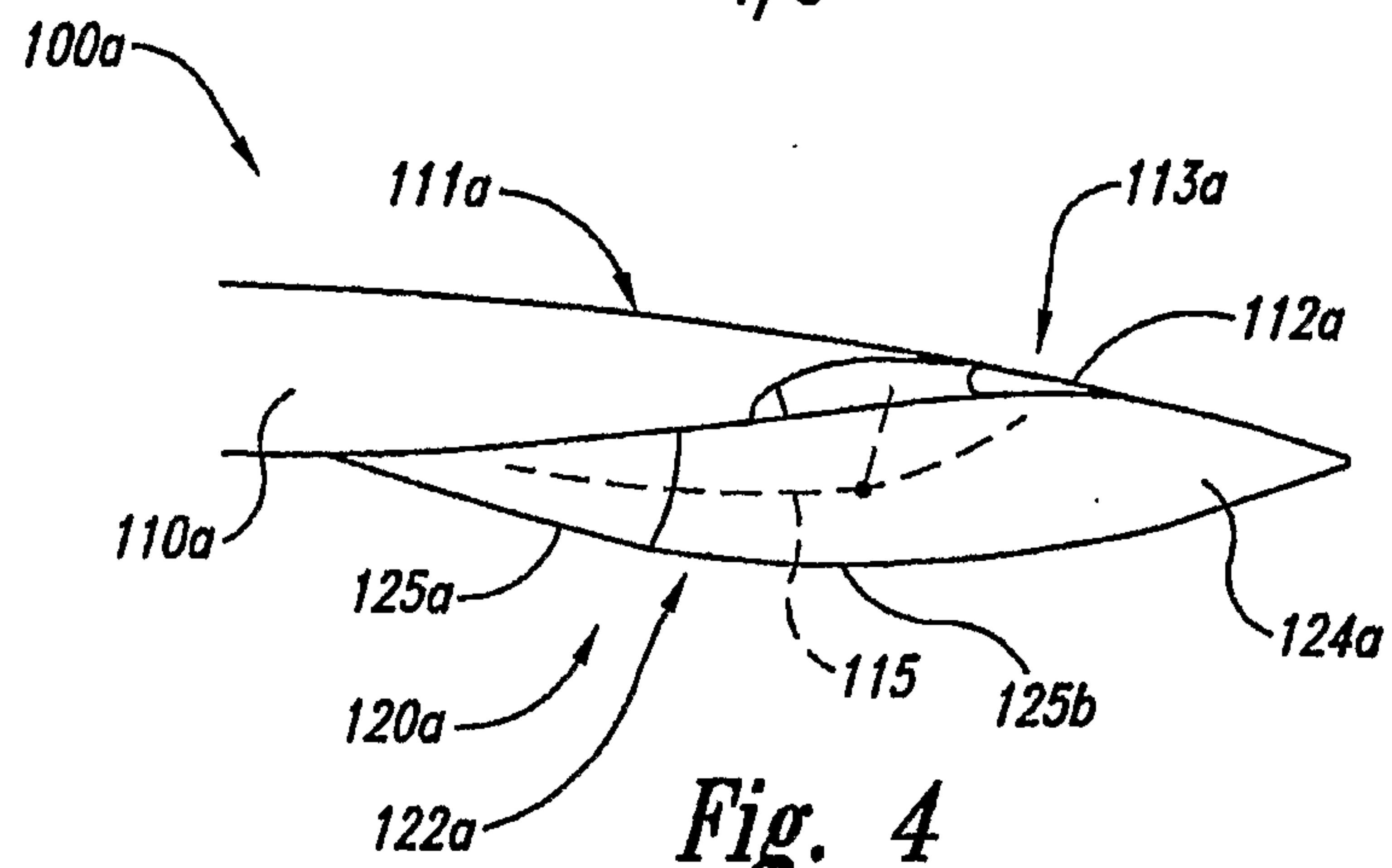
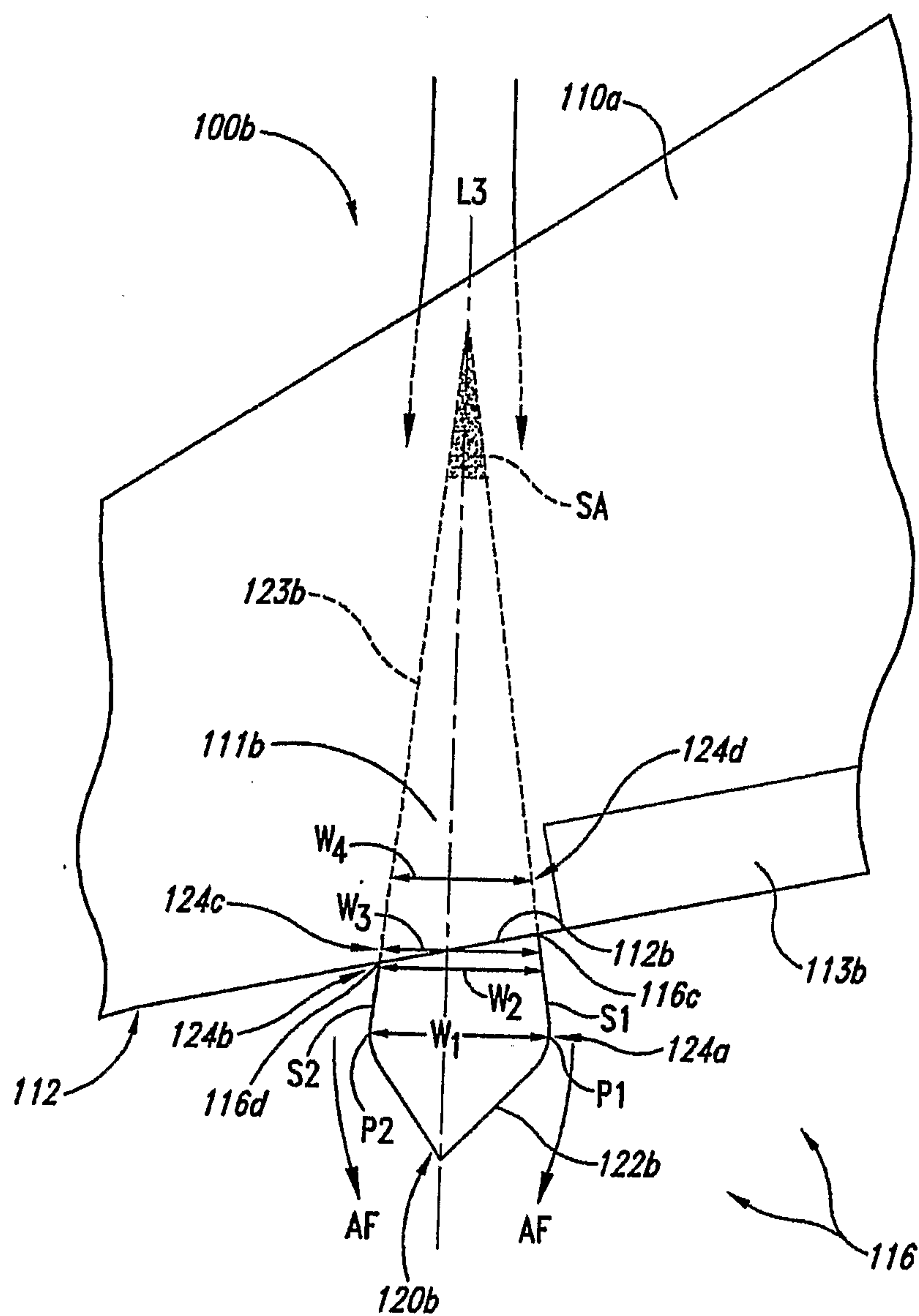


Fig. 3

4/5



5/5

*Fig. 7*

