



(51) International Patent Classification:
F01D 5/14 (2006.01)

(21) International Application Number:
PCT/US2016/013526

(22) International Filing Date:
15 January 2016 (15.01.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/105,488 20 January 2015 (20.01.2015) US

(71) Applicant: **SIKORSKY AIRCRAFT CORPORATION**
[US/US]; 6900 Main Street, P.O. Box 9729, Stratford,
Connecticut 06615 (US).

(72) Inventors: **KINLAN, Jeffrey**; 104 Richard Blvd., Shelton,
Connecticut 06484 (US). **MEYER, Leon M.**; 162 Scoville
Hill Road, Harwinton, Connecticut 06791 (US).

(74) Agent: **HAYTER, Alicia**; Cantor Colburn, LLP, 20
Church Street, 22nd Floor, Hartford, Connecticut 06103
(US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

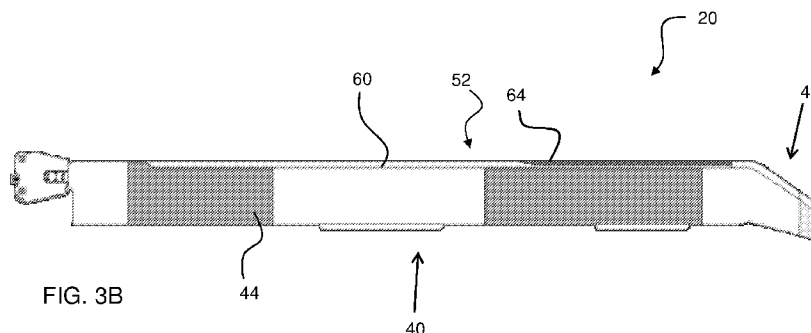
Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

(54) Title: ENHANCED DURABILITY NICKEL ABRASION STRIP



(57) Abstract: An erosion strip to protect a leading edge surface is provided including an outer layer comprising a wear-resistant material. An elastomer is affixed to an interior surface of the outer layer. An adhesive layer is shaped to adhere the leading edge surface to the elastomer such that the elastomer and adhesive layers are between the outer layer and the leading edge surface. The elastomer is configured to at least partially isolate strain at the outer layer from strain at the adhesive layer and the leading edge surface.

ENHANCED DURABILITY NICKEL ABRASION STRIP

BACKGROUND OF THE INVENTION

[0001] Exemplary embodiments of the invention relate to a rotary-wing aircraft and, more particularly, to a main rotor blade of a rotary-wing aircraft.

[0002] Rotary wing aircrafts include a plurality of main rotor blades coupled to a central hub. The rotor blades include aerodynamic surfaces that, when rotated, create lift. The configuration of the main rotor blades, particularly the tip section thereof, is selected to enhance rotor blade performance, for example to increase the hover and lift capabilities of the rotary-wing aircraft. Rotor blades are subjected to high stresses and strains resulting from aerodynamic forces developed during operation.

[0003] The leading edges of helicopter rotor blades are subject to wear, such as fatigue wear for example, due to vibratory loads. In particular there is a recurring problem of erosion of the metal leading edge abrasion strips of the main rotor blades. When such erosion occurs, the affected rotor blades must be removed from the helicopter and sent for repair, resulting in several weeks of downtime for the aircraft.

BRIEF DESCRIPTION OF THE INVENTION

[0004] According to one embodiment of the invention, an erosion strip to protect a leading edge surface is provided including an outer layer comprising a wear-resistant material. An elastomer is affixed to an interior surface of the outer layer. An adhesive layer is shaped to adhere the leading edge surface to the elastomer such that the elastomer and adhesive layers are between the outer layer and the leading edge surface. The elastomer is configured to at least partially isolate strain at the outer layer from strain between the adhesive layer and the leading edge surface.

[0005] In addition to one or more of the features described above, or as an alternative, in further embodiments the outer layer is formed from a nickel material.

[0006] In addition to one or more of the features described above, or as an alternative, in further embodiments the elastomer is bonded to the interior surface of the outer layer with an epoxy.

[0007] In addition to one or more of the features described above, or as an alternative, in further embodiments the elastomer is vulcanized to the interior surface of the outer layer.

[0008] In addition to one or more of the features described above, or as an alternative, in further embodiments the elastomer extends over all of the interior surface of the outer layer.

[0009] In addition to one or more of the features described above, or as an alternative, in further embodiments the outer layer is formed from a ceramic material.

[0010] According to another embodiment of the invention, a main rotor blade assembly is provided including a spar having a leading edge assembly. The leading edge assembly includes a main sheath laminate and a first erosion strip. The first erosion strip includes a wear-resistant outer layer, a layer of elastomer attached to and extending over at least a portion of an interior surface of the outer layer, and an adhesive which adheres the elastomer to the main sheath laminate. The elastomer is configured to at least partially isolate the strain at the outer layer from strain generated between the adhesive and the main sheath laminate.

[0011] In addition to one or more of the features described above, or as an alternative, in further embodiments the elastomer is vulcanized to the interior surface of the outer layer.

[0012] In addition to one or more of the features described above, or as an alternative, in further embodiments the elastomer is bonded to the interior surface of the outer layer with an epoxy.

[0013] In addition to one or more of the features described above, or as an alternative, in further embodiments an adhesive is arranged over an exposed surface of the elastomer. The adhesive is configured to couple the erosion strip to an adjacent component of the leading edge assembly.

[0014] In addition to one or more of the features described above, or as an alternative, in further embodiments the adhesive bonds the first erosion strip directly to a portion of the main sheath laminate.

[0015] In addition to one or more of the features described above, or as an alternative, in further embodiments the leading edge assembly includes a second erosion strip mounted upon the main sheath laminate. The second erosion strip is formed from a wear-resistant material, wherein the adhesive is configured to bond the first erosion strip to the second erosion strip.

[0016] A method of installing an erosion strip of a main rotor blade is provided including preparing a surface of an adjacent component configured to receive the erosion strip. The erosion strip includes an outer layer of a wear resistant material an elastomer affixed to a portion of the outer layer. The elastomer is configured to at least partially isolate the outer layer from strain generated in the erosion strip. An adhesive configured to couple the erosion strip to the adjacent component is prepared and the erosion strip is affixed to the adjacent component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0018] FIG. 1 is a perspective view of an exemplary rotary wing aircraft;

[0019] Fig. 2A is a perspective view of a main rotor blade according to an embodiment of the invention;

[0020] FIG. 2B is an expanded perspective view of a tip section of the rotor blade of FIG. 2A;

[0021] FIG 2C is an expanded rear oblique perspective view of a tip section of the rotor blade of FIG. 2A;

[0022] FIG. 2D is an expanded front oblique perspective view of a tip section of the rotor blade of FIG. 2A;

[0023] FIG. 2E is an expanded top view of a top section of the rotor blade of FIG. 2A;

[0024] FIG. 2F is an expanded front view of a tip section of the rotor blade of FIG. 2A;

[0025] FIG. 3A is a perspective, exploded view of a main rotor blade according to an embodiment of the invention;

[0026] FIG. 3B is a top view of a main rotor blade according to an embodiment of the invention;

[0027] FIG. 4 is a perspective view of an erosion strip according to an embodiment of the invention; and

[0028] FIG. 5 is a flow chart of a method of attaching an the erosion strip to a main rotor blade assembly according to an embodiment of the invention.

[0029] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0030] FIG. 1 schematically illustrates a rotary-wing aircraft 10 having a main rotor system 12. The aircraft 10 includes an airframe 14 having an extending tail 16 which mounts a tail rotor system 18, such as an anti-torque system for example. The main rotor assembly 12 is driven about an axis of rotation A through a main gearbox (illustrated schematically at T) by one or more engines E. The main rotor system 12 includes a plurality of rotor blade assemblies 20 mounted to a rotor hub assembly H. Although a particular helicopter

configuration is illustrated and described in the disclosed non-limiting embodiment, other configurations and/or machines, such as high speed compound rotary-wing aircrafts with supplemental translational thrust systems, dual contra-rotating, coaxial rotor system aircraft, turbo-props, tilt-rotors, and tilt-wing aircrafts are also within the scope of the invention.

[0031] Referring to FIG. 2A, each rotor blade assembly 20 of the rotor assembly 12 generally includes a root section 22, an intermediate section 24, a tip section 26, and a tip cap 28. Each rotor blade section 22, 24, 26, 28 may define particular airfoil geometries to tailor the rotor blade aerodynamics to the velocity increase along the rotor blade span. As, illustrated, the rotor blade tip section 26 may include an anhedral form 27 (FIGS. 2B-2F); however, any angled or non-angles forms such as cathedral, gull, bent, and other non-straight forms are within the scope of the present invention. The anhedral form 27 as defined herein may include a rotor blade tip section 26 which extends at least partially out of a plane defined by the intermediate section 24

[0032] The rotor blade sections 22 – 28 define a span R of the main rotor blade assembly 20 between the axis of rotation A and a distal end 30 of the tip cap 28 such that any radial station may be expressed as a percentage in terms of a blade radius x/R . The rotor blade assembly 20 defines a longitudinal feathering axis P between a leading edge 32 and a trailing edge 34. The distance between the leading edge 32 and the trailing edge 34 defines a main element chord length C_m .

[0033] Referring now to FIG. 3A, the rotor blade assembly 20 generally includes a main blade assembly 40 and a tip assembly 42. The main blade assembly 40 includes an upper skin 44, a main core 46, a spar 48, a lower skin 50, and a leading edge assembly 52. The main spar 48, main core 46, and skins 44, 50 are generally referred to as a pocket assembly, the forward portion of which is closed out by the leading edge assembly 52. The spar 48 has a generally constant thickness over most of its length. In one embodiment, the root end of the spar 48 has a substantially increased size, thickness, and/or strength to allow for the attachment of the blade 20 to a rotor hub, such as rotor hub H for example, without the need for a separate composite or metallic cuff and other associated attachment hardware. The main core 46 may be formed from a plurality of separate core pieces, each of which may be fabricated from a distinct core material to provide particular lift and strength properties.

[0034] The leading edge assembly 52 generally includes a main sheath laminate 60 upon which is mounted a wear-resistant material as an abrasion resistant system. As shown in FIG. 3A, the abrasion resistant system can be multiple strips, such as the shown first erosion strip 62 and second erosion strip 64 to provide abrasion protection. Alternatively, as shown in

FIG. 3B, the sheath laminate 60 may include a single erosion strip 64 as the abrasion resistant system to provide the abrasion protection. Additional structures, such as weight cups 61, leading edge counter weights 63, and trim tab systems 65 for example, may also be provided, in a manner known to a person having ordinary skill in the art. The tip assembly 42 generally includes a main tip core 66, a tip end pocket core 68, a tip leading edge assembly 70, and a tip cap 28. The main tip core 66 is substantially aligned with a longitudinal axis of the main core 46 and is positioned directly adjacent the third piece 58 of the main core 46.

[0035] Referring now to FIG. 4, an example of the erosion strip 64 is illustrated in more detail. The erosion strip 64 includes an outer layer 80 having a contour generally complementary to the outer mold line of the blade. The outer layer 80 may be formed from an abrasion and wear resistant material, including, but not limited to nickel, ceramic, titanium, or stainless steel for example. In one embodiment, the thickness of the outer layer 80 is between about .005 and .035 inches. While not required in all aspects, the outer layer 80 can be manufactured from AM355. It should be understood that a variety of wear-resistant materials may alternatively or additionally be provided for the leading edge assembly 52.

[0036] Extending over at least a portion of an interior surface 82 of the outer layer 80 is an elastomer 84, such as rubber for example. The selected elastomer 84 is sufficient to endure the vibratory strain thereon. By way of example, the elastomer 84 may be of a thickness at or between about .020 and .080 inches. However, other thicknesses are within the scope of the invention. A ratio of the thickness of the elastomer 84 to the outer layer 80 may be between about 1:1.75 to about 16:1. In addition, inclusion of the elastomer 84 is compatible with a portion of an adjacent ice removal system (not shown), such as a heater thereof for example. In one embodiment, the elastomer 84 extends over the entire interior surface 82 of the outer layer 80. A first surface 86 of the elastomer 84 may be bonded to the adjacent interior surface 82 of the outer layer 80 with an epoxy or other adhesive for example. In another embodiment, the elastomer 84 is vulcanized to the interior surface 82 of the outer layer 80. An adhesive 88 adheres the elastomer 84 to the leading edge of the blade, such as at the main sheath laminate 60 of FIG. 3A or the leading edge main sheath laminate 60 of FIG. 3B. In this way, the elastomer 84 reduces the effect of a strain mismatch between the leading edge of the blade and the outer layer 80 which, without the elastomer 84, could lead to a disbonding at the adhesive layer 88.

[0037] A method 100 for installing the erosion strip 64 of the main blade assembly 40 is illustrated in FIG. 5. As shown in block 102, an outer surface of a component configured to

receive the erosion strip 64, such as the first erosion strip 62 or the main sheath laminate 60 for example, is generally prepared such as by cleaning the surface 69 (FIG. 3A) for example. In embodiments where the erosion strip 64 is being replaced, preparation of the outer surface 69 includes removing any material from a previous erosion strip or any material used to attach the erosion strip thereto. In block 104, an adhesive 88 configured to chemically couple the erosion strip 64 to the outer surface of the component is then prepared. In one embodiment, the adhesive 88 is a paste or film that is applied either to the exterior surface of either the first erosion strip 62 or the main sheath laminate 60 or to an interior surface of the elastomer 84 of the erosion strip 64. Alternatively, the adhesive 88 may be prepared by removing a protective lining or other material to expose the adhesive material. Once the adhesive 88 is prepared, the erosion strip 64 is aligned with and connected to either the main sheath laminate 60 or the first erosion strip 62, as shown in block 106, by arranging the adhesive 88 in contact with the prepared outer surface 69.

[0038] The layer of elastomer 84 positioned between the outer surface 69 and the outer layer 80 of the erosion strip 64 is able to withstand a high strain generated by the vibratory forces of the main rotor blade 20. As a result, inclusion of the elastomer 84 prevents cracking or disbonding of the hard outer layer 80 from the composite leading edge material, thereby improving the durability and life of the erosion strip 64.

[0039] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. By way of example, while shown with an integrated cuff as the root section 22, it is understood that aspects of the invention can be used with other types of root sections, such as root end cuff that is attached to the main rotor spar through a multiple fastener configuration, each fastener of which must be torqued to a required standard. Further, while shown in the context of a rotary wing aircraft, it is understood that aspects could be used with blades used on fixed wing aircraft, wind turbines, maritime propellers or other blades where edges need abrasive protection. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

CLAIMS:

What is claimed is:

1. An erosion strip to protect a leading edge surface, comprising:
an outer layer comprising a wear-resistant material;
an elastomer affixed to an interior surface of the outer layer; and
an adhesive layer shaped to adhere the leading edge surface to the elastomer such that the elastomer and adhesive layers are between the outer layer and the leading edge surface;
wherein the elastomer is configured to at least partially isolate strain at the outer layer from strain between the adhesive layer and the leading edge surface.
2. The erosion strip according to claim 1, wherein the outer layer is formed from a nickel material.
3. The erosion strip according to claim according to either claim 1 or claim 2, wherein the elastomer is bonded to the interior surface of the outer layer with an epoxy.
4. The erosion strip according to either claim 1 or claim 2, wherein the elastomer is vulcanized to the interior surface of the outer layer.
5. The erosion strip according to any of the preceding claims, wherein the elastomer extends over all of the interior surface of the outer layer.
6. The erosion strip according to any of the preceding claims, wherein the outer layer is formed from a ceramic material.
7. A main rotor blade assembly comprising:
a spar;
a leading edge assembly including:
a main sheath laminate; and
a first erosion strip including a wear-resistant outer layer, a layer of elastomer attached to and extending over at least a portion of an interior surface of the outer layer, and an adhesive which adheres the elastomer to the main sheath laminate, the elastomer being configured to at least partially isolate the strain at the outer layer from strain generated between the adhesive and the main sheath laminate.
8. The main rotor blade assembly according to claim 7, wherein the elastomer is vulcanized to the interior surface of the outer layer.
9. The main rotor blade assembly according to claim 7, wherein the elastomer is bonded to the interior surface of the outer layer with an epoxy.

10. The main rotor blade assembly according to any of the preceding claims, wherein an adhesive is arranged over an exposed surface of the elastomer, the adhesive being configured to couple the erosion strip to an adjacent component of the leading edge assembly.
11. The main rotor blade assembly according to claim 10, wherein the adhesive bonds the first erosion strip directly to a portion of the main sheath laminate.
12. The main rotor blade assembly according to claim 10, further comprising a second erosion strip mounted upon the main sheath laminate, the second erosion strip being formed from a wear-resistant material, wherein the adhesive is configured to bond the first erosion strip to the second erosion strip.
13. A method of installing an erosion strip of a main rotor blade comprising:
 - preparing a surface of an adjacent component configured to receive the erosion strip, the erosion strip including an outer layer of a wear-resistant material and an elastomer affixed to a portion of outer layer, the elastomer being configured to at least partially isolate the outer layer from strain generated in the erosion strip;
 - preparing an adhesive configured to couple to the erosion strip to the adjacent component; and
 - affixing the erosion strip to the adjacent component.
14. The method according to claim 13, wherein the adjacent component is another erosion strip of a leading edge assembly of the main rotor blade.
15. The method according to claim 13, wherein the adjacent component is a main sheath laminate of a leading edge assembly of the main rotor blade.

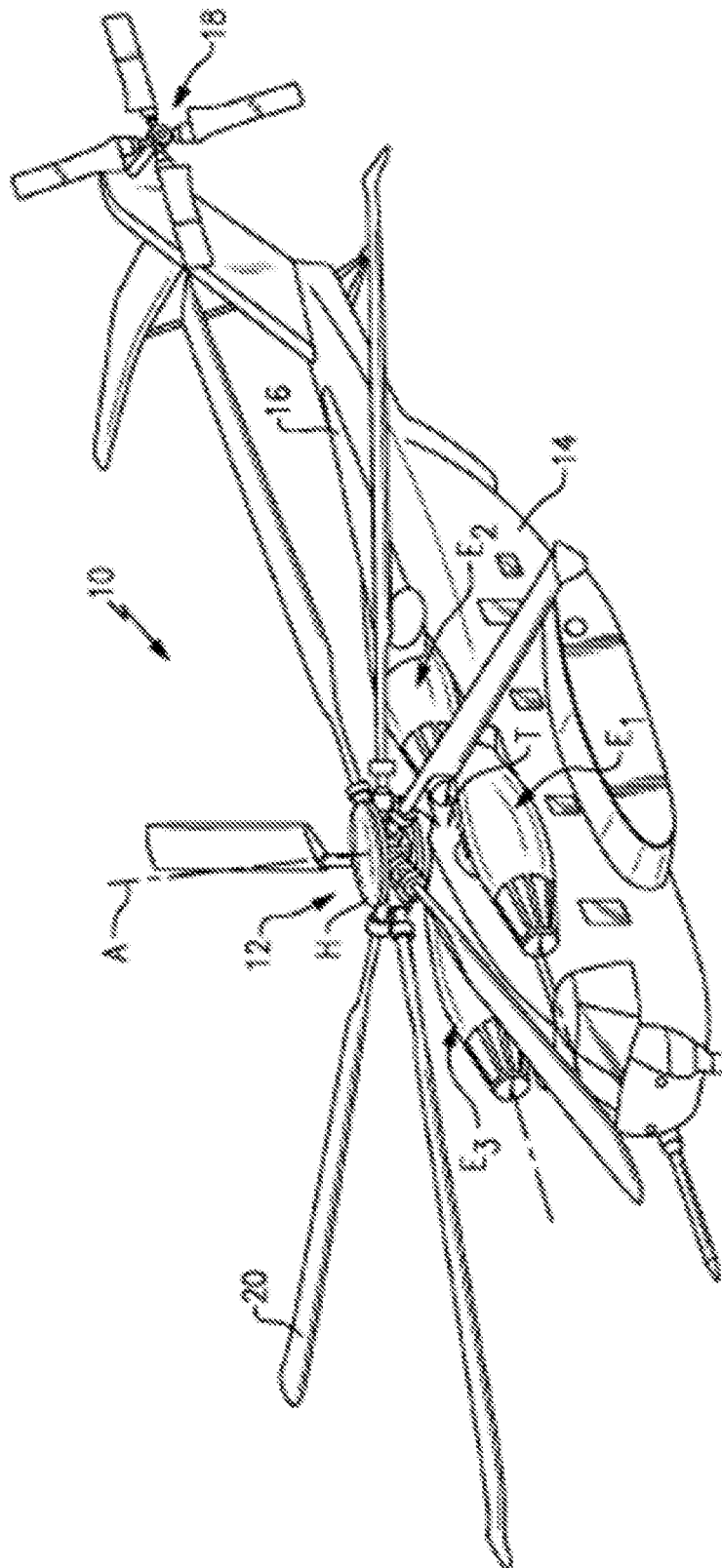
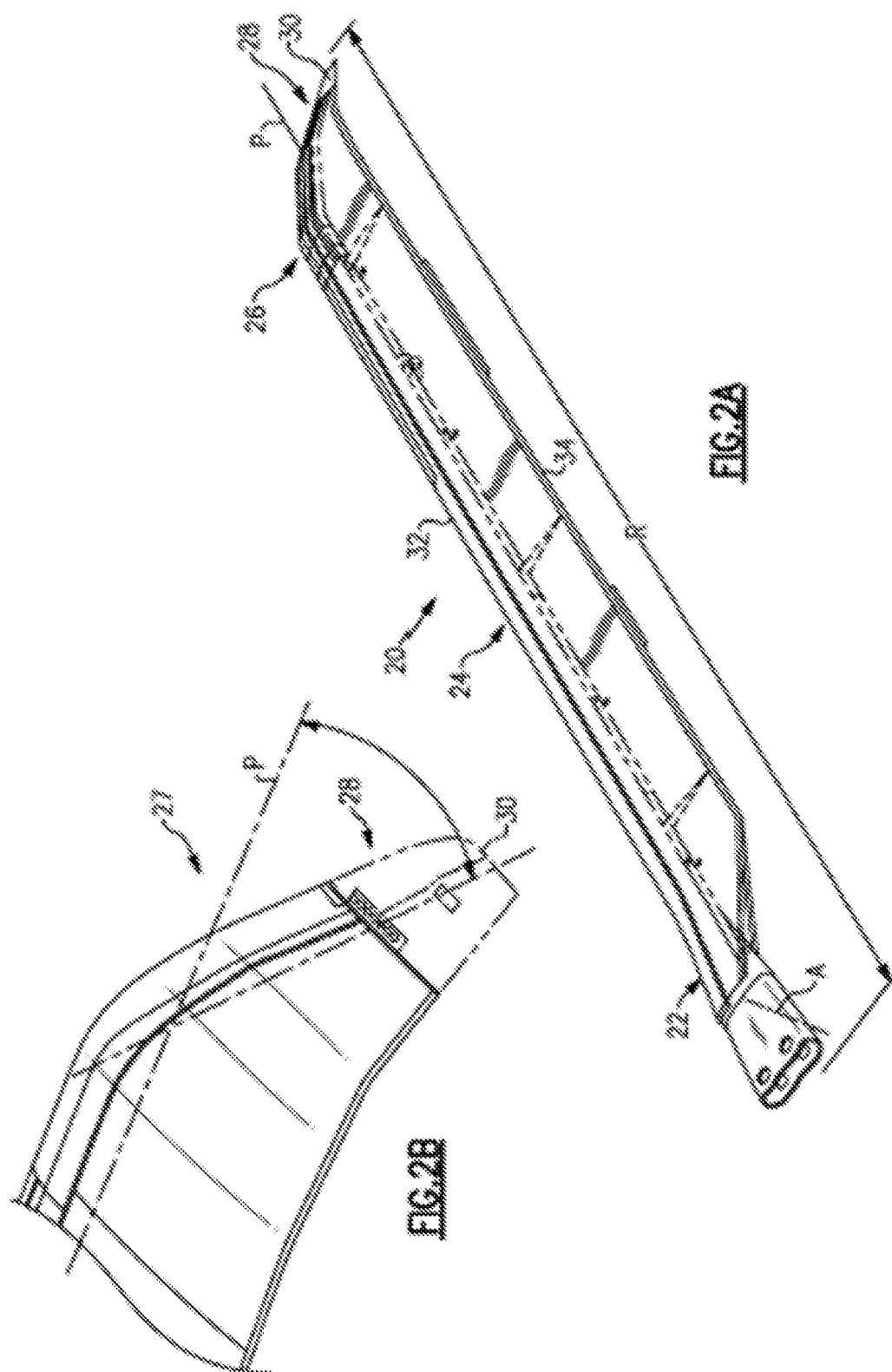


FIG. 1



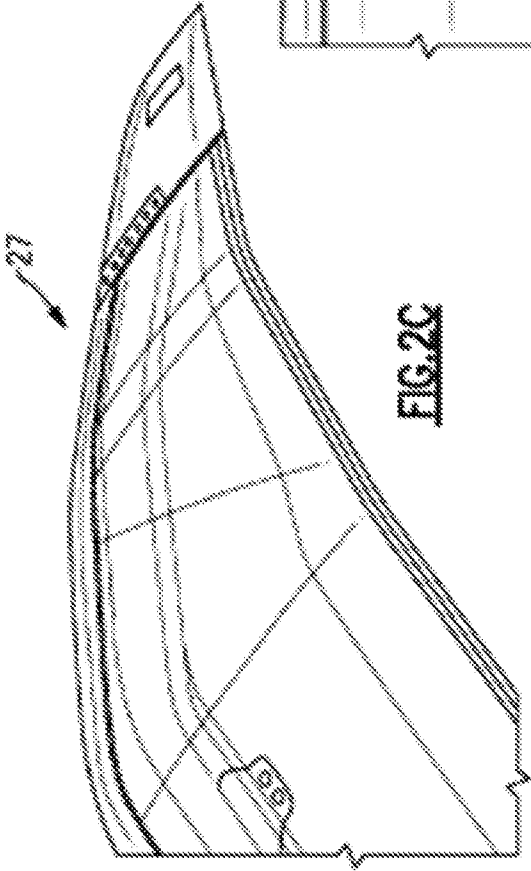


FIG. 2C

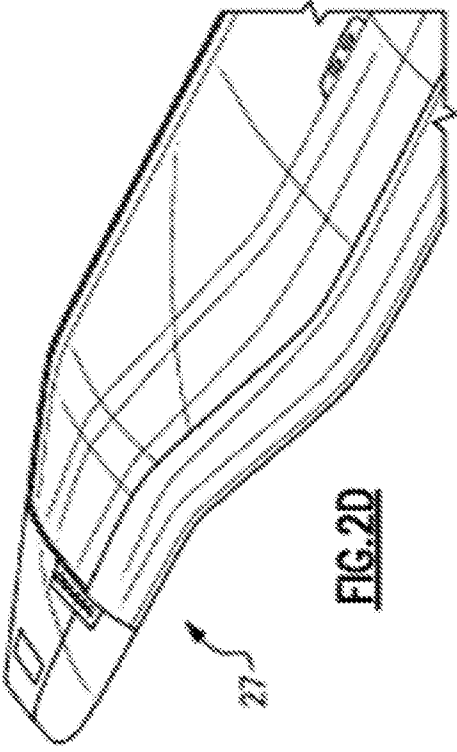


FIG. 2D

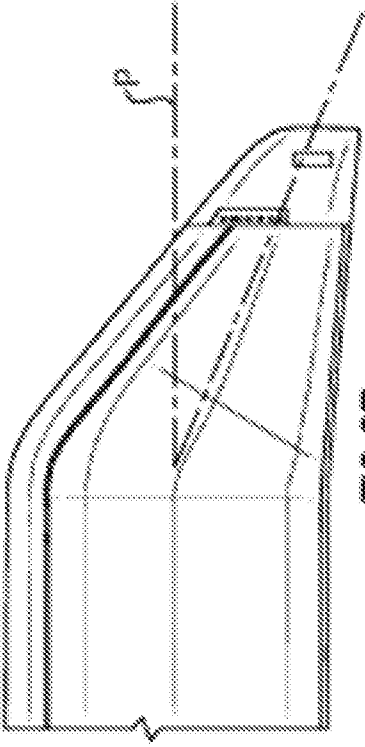


FIG. 2E

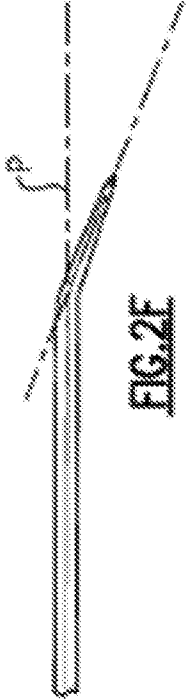


FIG. 2F

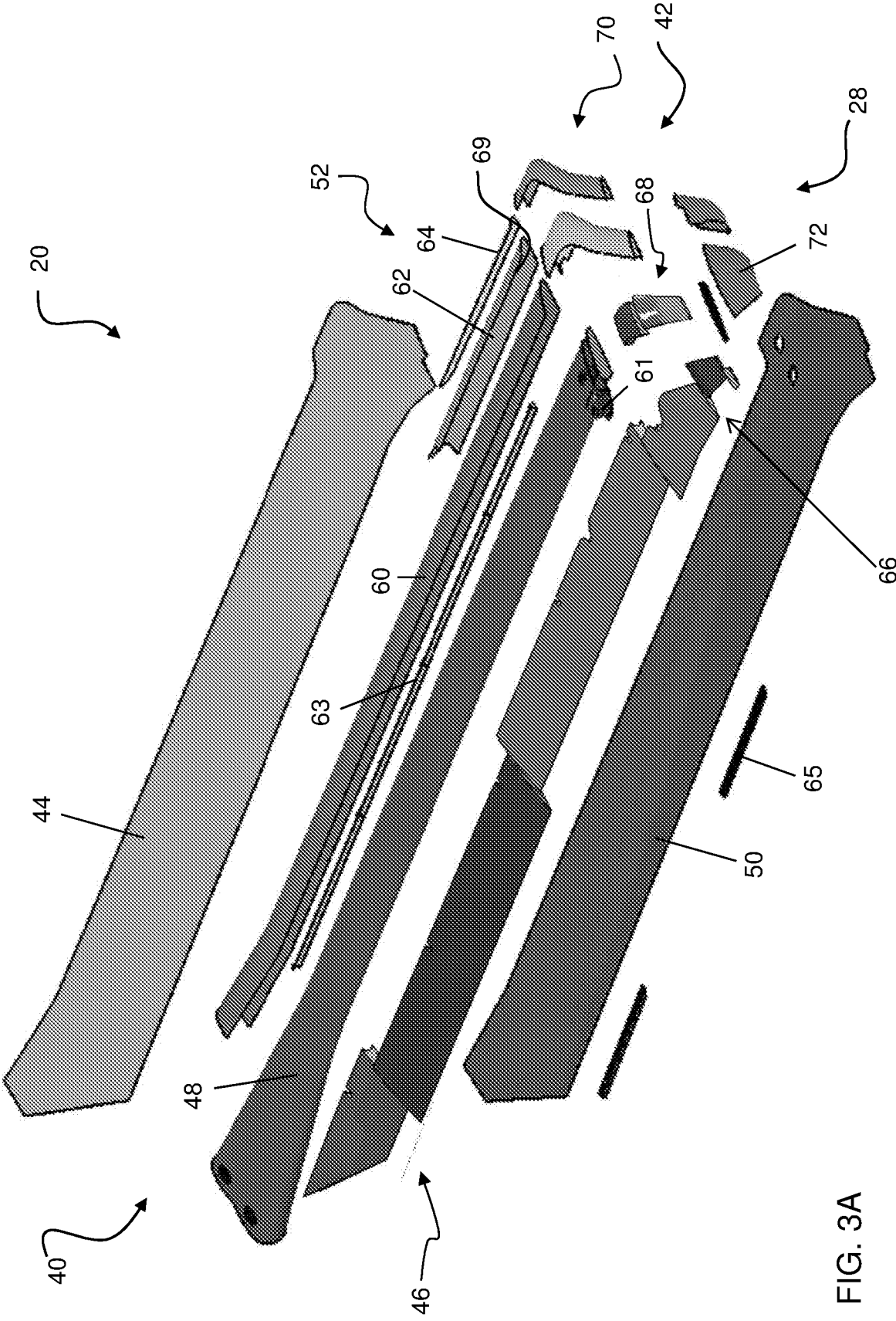


FIG. 3A

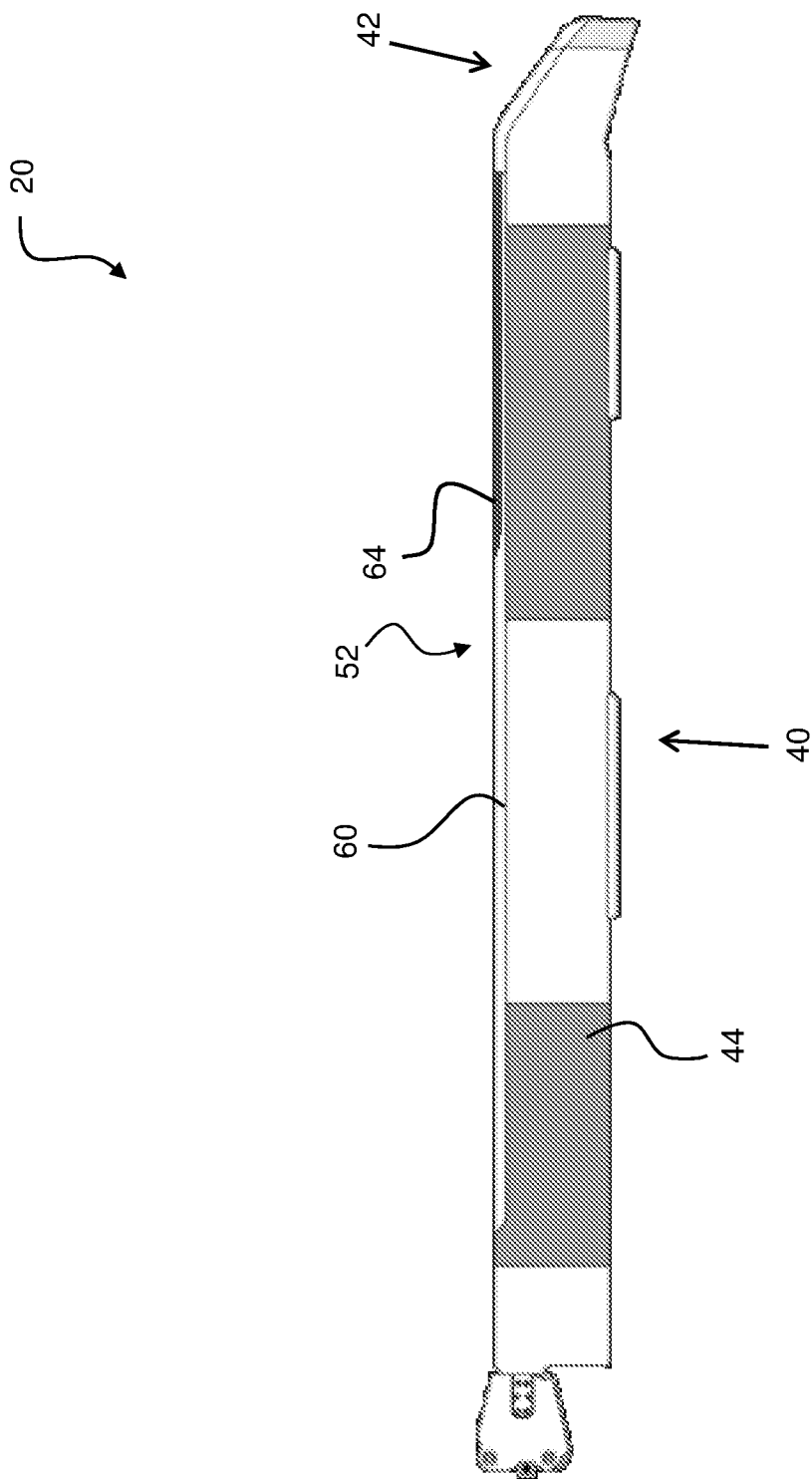


FIG. 3B

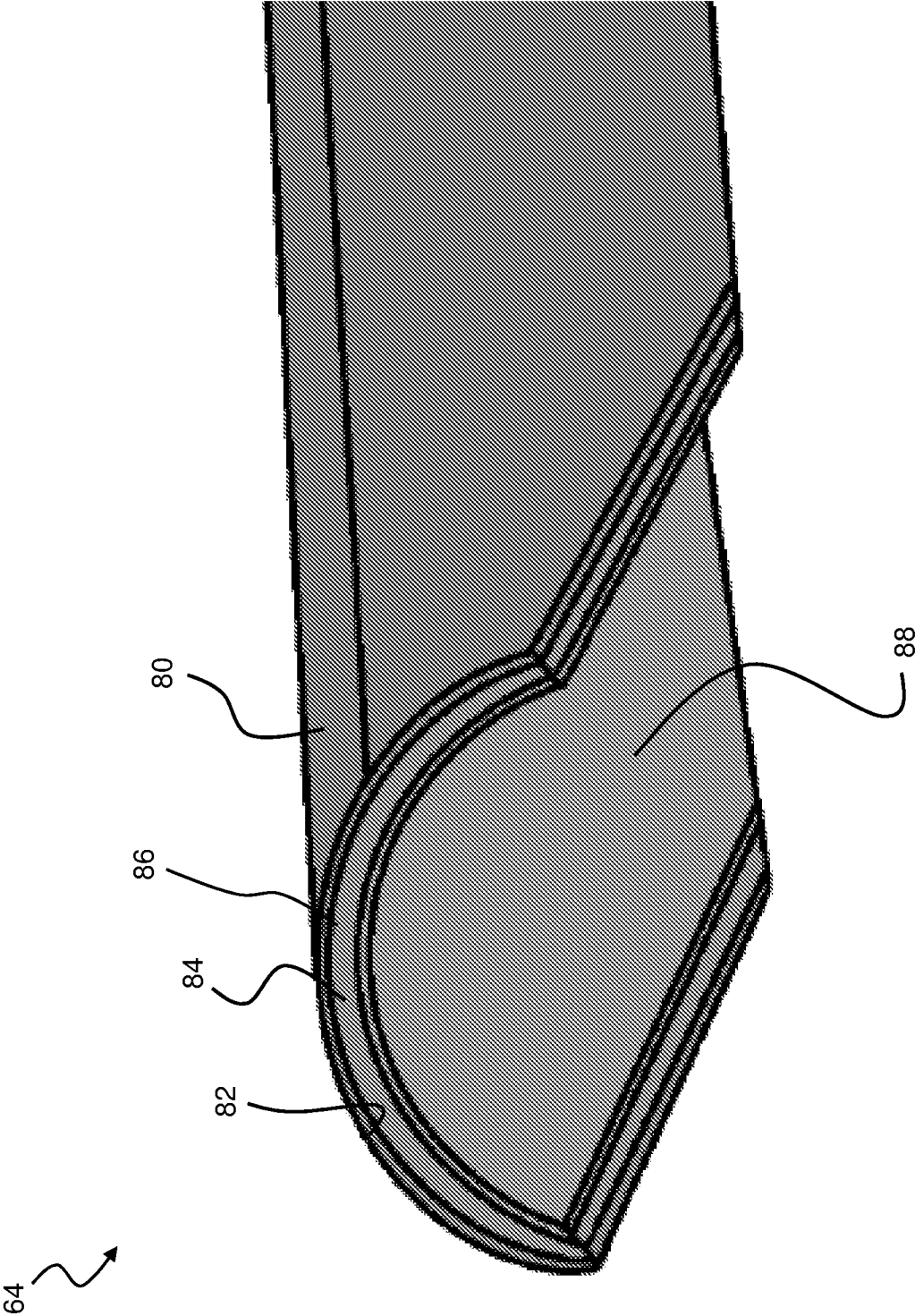


FIG. 4

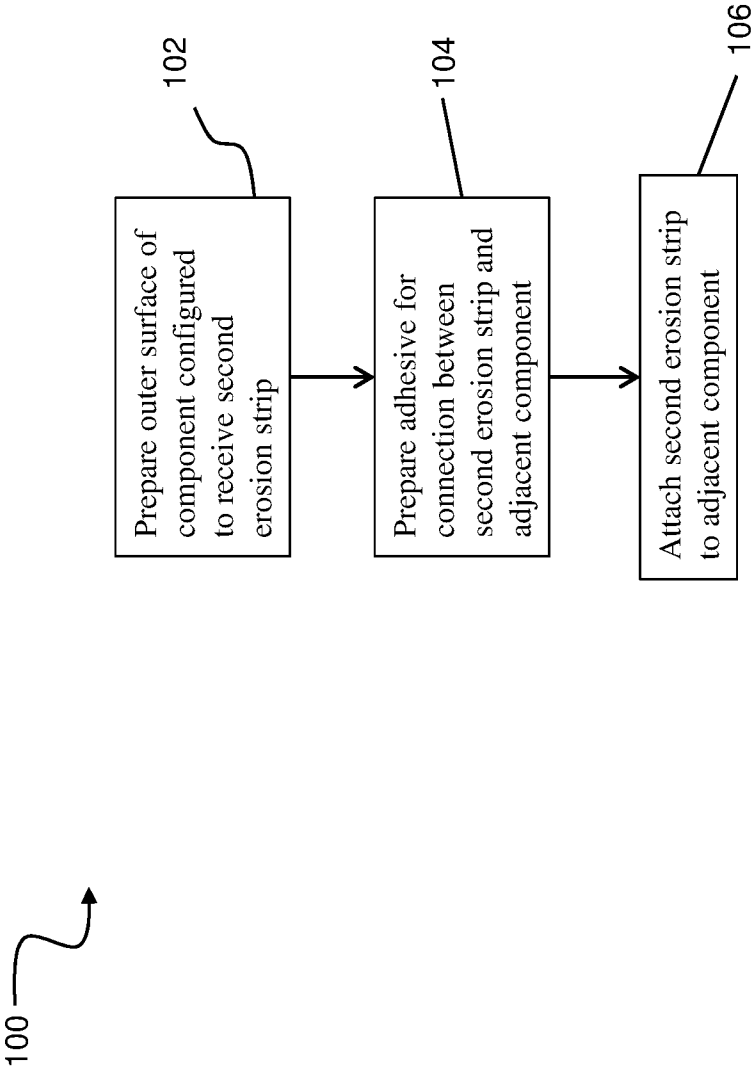


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/013526

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F01D 5/14 (2016.01)

CPC - F01D 5/14 (2016.02)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - B29C 73/04; B64C 11/26; F01D 5/00, 5/14, 5/28 (2016.01)

CPC - B29C 73/04; B64C 11/26; F01D 5/00, 5/14, 5/28 (2016.02)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 29/402.09, 889.71; 156/94, 245, 285, 310; 416/224 (keyword delimited)

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

Patbase, Google Patents, Google, Google Scholar

Search terms used: strip, protect, aircraft, helicopter, plane, leading edge, protective, elastomer, epoxy, rotor, blade, vulcanized, sleeve, sheath, rubber

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,542,820 A (EATON et al) 06 August 1996 (06.08.1996) entire document	13-15
---		---
Y		1-4, 7-9
Y	US 8,500,410 B2 (DE MOURA et al) 06 August 2013 (06.08.2013) entire document	1-4, 7-9
A	US 2013/0101432 A1 (HARRIS JR et al) 25 April 2013 (25.04.2013) entire document	1-4, 7-9, 13-15
A	US 2004/0253108 A1 (SCHMALING et al) 16 December 2004 (16.12.2004) entire document	1-4, 7-9, 13-15
A	US 5,908,522 A (LOFSTROM et al) 01 June 1999 (01.06.1999) entire document	1-4, 7-9, 13-15

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03 March 2016

Date of mailing of the international search report

29 MAR 2016

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/013526

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 5, 6, 10-12
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.