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(71) Applicant *(for all designated States except US)*: **SLINGSHOT WIND ENERGY SYSTEMS INC.** [CA/CA]; 115 Millview Crt. SW, Calgary, Alberta T2Y 2W8 (CA).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **TOCHER, Angus, J.** [CA/CA]; 115 Millview Crt. SW, Calgary, Alberta T2Y 2W8 (CA).

(74) Agent: **LAMBERT, Anthony, R.**; Suite 200, 10328 - 81 Ave., Edmonton, Alberta T6E1X2 (CA).

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(54) Title: INTEGRALLY RIBBED ROGALLO WING ARRAY

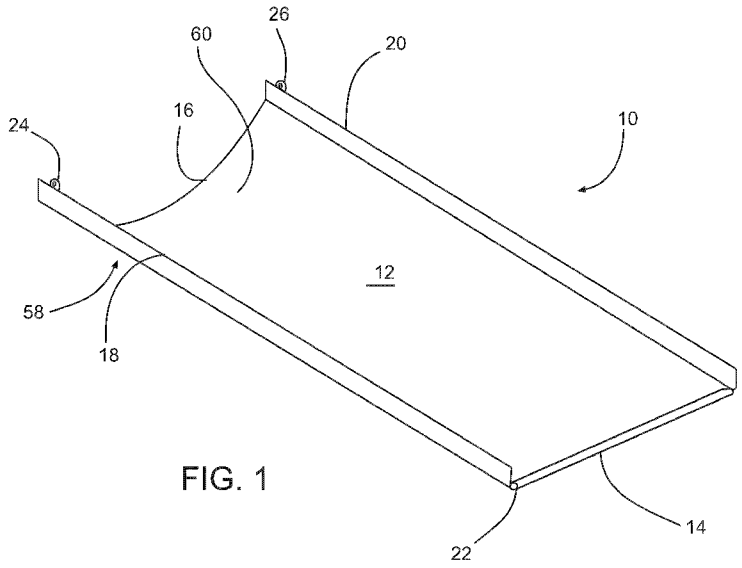

FIG. 1

(57) Abstract: There is a Rogallo wing having an aerodynamic sheet having a leading end and a trailing edge. The trailing edge is curved to form a sheet of increasing concavity away from the leading edge. At least two folded edges extend between the leading end and the trailing edge are on opposed sides of the aerodynamic sheet, the two folded edges comprising integral ribs. A wind energy extraction apparatus comprises one or more concentrator wings that react with a flow of wind to induce a drop in static air pressure that is then used to drive one or more impellors and one or more power converters. The one or more concentrator wings are Rogallo wings.

INTEGRALLY RIBBED ROGALLO WING ARRAY

TECHNICAL FIELD

[0001] This relates to the technical field of Rogallo wings.

BACKGROUND

[0002] A conventional aircraft wing has an upper skin and a lower skin, and is usually made from metal. Due to the two skins, a conventional aircraft wing may be too heavy for certain applications and is more difficult to construct than a wing formed from a single skin. A conventional aircraft wing can be prohibitively expensive and too time consuming to be advantageously used in some applications, such as for example in wind turbines.

[0003] A traditional Rogallo wing is formed from a conical single sail-fabric connected between various supporting ribs. The Rogallo wing is the type of wing that was used in early hang gliders and is now most commonly seen in kids' kites. The Rogallo wing is a simpler design than a conventional aircraft wing, but requires more maintenance and has a shorter life-span than a conventional aircraft wing.

SUMMARY

[0004] In an embodiment there is provided a Rogallo wing, comprising an aerodynamic sheet having a leading end and a trailing edge. The trailing edge is curved to form a sheet of increasing concavity away from the leading end. At least two folded edges extend between the leading end and the trailing edge on opposed sides of the aerodynamic sheet, the two folded edges comprise integral ribs.

[0005] In an embodiment there is provided a plurality of Rogallo wings, each of the Rogallo wings comprising an aerodynamic sheet having a leading end and a trailing edge. The trailing edge is curved to form a sheet of increasing concavity away from the leading end. At least two folded edges extend between the leading end and the trailing edge on opposed sides of the aerodynamic sheet and the two folded edges comprise integral ribs. The plurality of Rogallo wings form an array of interconnected wings.

[0006] In an embodiment, there is provided a wind energy extraction apparatus comprising one or more concentrator wings that react with a flow of wind to induce a drop in static air pressure that is then used to drive one or more impellors and one or more power converters. The one or more concentrator wings comprise Rogallo wings.

[0007] In an embodiment there is provided a method of constructing a Rogallo wing, comprising providing a sheet of material. The sheet of material is bent into a Rogallo wing shape having a leading end and a trailing edge. The trailing edge is curved to form a sheet of increasing concavity away from the leading end. The edges of the sheet of material extending between the leading end and the trailing edge on opposed sides of the aerodynamic sheet are folded to form integral ribs.

[0008] In all of the embodiments incorporating a Rogallo wing with a leading end, the leading end may be, for example, a leading edge.

[0009] These and other aspects of the device and method are set out in the claims, which are incorporated here by reference.

BRIEF DESCRIPTION OF THE FIGURES

[0010] Embodiments will now be described with reference to the figures, in which like reference characters denote like elements, by way of example, and in which:

Fig. 1 is a perspective view of a Rogallo wing with folded edges;

Fig. 2 is a perspective view of an array of Rogallo wings with folded edges;

Fig. 3 is a perspective view of an array of Rogallo wings supported between two support fins;

Fig. 4 is a perspective view of a plurality of Rogallo wings on a wind turbine;

Fig. 5 is a end elevation view of a plurality of Rogallo wings on a wind turbine;

Fig. 6 is a partial perspective view of a plurality of Rogallo wings on a wind turbine;

Fig. 7 is a partial perspective view of a brace supporting a plurality of Rogallo wings on a wind turbine;

Fig. 8 is a partial perspective view of braces and an impellor on a wind turbine with Rogallo wings; and

Fig. 9 is a side perspective view of a plurality of Rogallo wings on a wind turbine.

DETAILED DESCRIPTION

[0011] Immaterial modifications may be made to the embodiments described here without departing from what is covered by the claims.

[0012] Figs. 1 – 3 show Rogallo wings 10. Referring to Fig. 1, the Rogallo wing 10 has an aerodynamic sheet 12 that has a leading end 14 and a trailing edge 16. The leading end 14 may be for example, as shown in Fig. 1, a leading edge, which may be flat for example. In other embodiments, the leading end may be a point. In some embodiments, the leading end 14 has a shorter length than the trailing end 16. The trailing edge 16 is curved to form a sheet of increasing concavity away from the leading edge 14. The concavity may be increased for example gradually, or in steps or other suitable configurations. At least two folded edges 18, 20 extend between the leading edge 14 and the trailing edge 16 on opposed sides of the aerodynamic sheet 12. The two folded edges 18, 20 act as integral ribs of the Rogallo wing 10. In the embodiment shown in Fig. 1, the Rogallo wing has a pan shape, in which the wing has a leading edge 14 that is not curved and a trailing edge 16 that is curved. In some embodiments, curved may mean, for example, stepped, bent, or any type of concave shape. The integral ribs 18, 20 effectively form external ribs of the Rogallo wing. The integral ribs help prevent the structure of the wings from bending when air pressure, such as wind, is applied against the wings. The increasing concavity between the leading edge 14 and the trailing edge 16 also imparts significant strength to the wing panel. The combination of the increasing concavity and the integral ribs together give the required strength to the wing panel to prevent the force of the wind from permanently deforming the external ribs of the wing panels in a storm or very strong wind. The type, strength and thickness of the material used also have an effect on the strength of the wing panel.

[0013] As shown in Fig. 2, the Rogallo wing 10 may have a hollow end 22 at the leading edge 14 of the aerodynamic sheet 12. Hollow end 22 may extend at least partially along the leading edge 14. Hollow end 22 may be formed by, for example, at least one ring or eyelet on leading edge 14. The rings or eyelets may be aligned, for example. In some embodiments, the hollow end 22 may be formed by folding the leading edge 14 back on itself. In some

embodiments, a loop may be attached to each of the two folded edges 18, 20. Loops 24, 26 lie on the folded edges 18, 20 adjacent to the trailing edge 16 of the aerodynamic sheet 12. A wire may be connected through the loops 24, 26 on each of the folded edges. The wire may be, for example a first supporting cable 30 that supports the trailing edge 16 of the aerodynamic sheet by passing through the loops 24, 26. In some embodiments, a wire is disposed through the hollow ends 22 of each of the leading edges 14 of the array of interconnected wings 10. The wire may be, for example, a second supporting cable 32, second supporting cable 32 extending through the hollow ends 22 of the leading edge 14 of the Rogallo wings 10. Adjacent folded edges of adjacent wings may be connected together, by for example rivets 28 that connect the folded edge 20 of one Rogallo wing 10 with the folded edge 18 of an adjacent Rogallo wing. In some embodiments, each folded edge is formed by folding wing 10 once and then optionally folding the formed folded edge portion over top of itself one or more times to give the desired thickness. In some embodiments, the folded edge 18 may be formed by, or reinforced with, a structural angle of metal or other material connected to wing 10. Structural angles are generally formed by extrusion processes, and may be connected to wing 10 by riveting.

[0014] As shown in Fig. 3, support fins 52 are used to support an array 38 of interconnected Rogallo wings 10. Each of the arrays 38 of Rogallo wings may be supported by cables between supporting fins 52. The cables may further comprise at least first supporting cable 30 and second supporting cable 32, the Rogallo wings being supported between first supporting cable 30 and second supporting cable 32 (Fig. 2).

[0015] In Figs. 4 – 9, the Rogallo wings are shown in operation with a turbine 50. In such embodiments, a plurality of Rogallo wings may form the wing members of turbine 50. In Fig. 4, the embodiment illustrated shows a wind energy extraction apparatus comprising one or more concentrator wings 42. The concentrator wings 42 comprise Rogallo wings and react with a flow of wind to induce a drop in static air pressure that is then used to drive one or more impellors 44 and one or more power converters 72 shown encased in housing and connected to the one or more impellors 44. Arrays 38 of Rogallo wings are supported on support fins 52 connected to a fuselage 62. The fuselage 62 is supported on a support pole 40. Each array 38 of Rogallo wings 10 (Fig. 3) acts as a concentrator wing 42.

[0016] In Fig. 6 braces 64, 66 are shown supporting the support fins 52. Braces 64 connect the support fins 52 to the fuselage 62. Braces 66 connect between support fins 52 lying on opposed sides of the fuselage 62. A supporting brace 70 may connect the brace 66 to the fuselage 62 for additional support. Fig. 7 shows a corner support fin 52 supported by braces 62, 64. Fig. 8 shows a support fin 52 connected directly to the top of the fuselage 62. Although one example of a support structure comprising support fins and braces is described here, various different support structures may be used to support the concentrator wings 42.

[0017] The Rogallo wings 10 (Fig. 1) may be made, for example, from aluminum sheeting with one material thickness. In the embodiments shown, the Rogallo wings have no internal ribs. The aerodynamic shape of the wing is created by having a relatively flat leading edge, developing into a pronounced bow shape at the trailing edge of the wing. The aerodynamic sheet replicates the curvature of a conventional wing, but instead uses only one sheet of material. To a point, increasing the degree of bow in the trailing edge of a Rogallo type wing is equivalent to increasing the curvature of a conventional wing.

[0018] The Rogallo wings 10 may be constructed from a single flat sheet of material. The material may be curved into a Rogallo wing shape and then have the edges folded and bent to create an integral or external rib. The combination of the external rib and the natural cupped shape of the Rogallo wing, when made from a solid sheet material such as aluminum, provide a strong, lightweight and inexpensive structure. As shown in Fig. 2, the leading and trailing edges 14, 16 may be supported by cables 30, 32. In other embodiments, stiff members such as rods or pipes may be used to support the Rogallo wings. Other materials other than aluminum may be used to construct the aerodynamic sheets 12. A variety of materials may be used to form the aerodynamic sheets, although factors such as the cost of tooling the materials and level of degradation of the materials due to sun exposure may be considered when choosing a new design, depending on budgetary concerns and whether the wings are to be used in an indoor or outdoor setting. Metals, composites, fiberglass materials and synthetics are examples of types of materials that may be used to form the aerodynamic sheets. Stiff materials are preferable due to their longer life-span and reduced maintenance.

[0019] The arrays 38 (Fig. 4) of Rogallo wings 10 may be installed as a group, using two cables 30, 32 (Fig. 2), one running at the leading edge 14 and one at the trailing edge 16. The

wing may then be installed between two rigid structures, such as the support fins 52 shown in Fig. 4. As long as the cables are tensioned, a full wing is created which does not require internal spars. The use of cables adds to the flexibility of the wings, so that the wings can flex to a degree without damaging the individual Rogallo wing panels. The Rogallo wings have the advantages and simplicity of sailcloth wings but also may be made using durable materials, such as aluminum, to give long life and good durability. The integrals ribs give the aerodynamic sheet structure and form, which allow the wings to be made without internal ribs. In some embodiments internal ribs may be used to give additional support.

[0020] The adjacent folded edges of adjacent Rogallo wings may be connected by means other than rivets 28 shown in Fig. 2. In some embodiments, cables alone may join the individual Rogallo wings together without additional supporting structures. In other embodiments, the adjacent folded edges of the Rogallo wings may be connected by other means such as bolts and screws, or the folded edges may be welded together.

[0021] Referring to Fig. 4, for completeness of disclosure, a description of how a wind turbine 50 having one or more concentrator wings 42 operates follows. Concentrator wings 42 operate fundamentally the same as aircraft wings. The concentrator wings 42 are arrays 38 of Rogallo wings 10. Referring to Fig. 1, each of the Rogallo wings 10 have a first surface 58 that is convex shaped at the trailing edge 16 to accelerate the flow of wind, and a corresponding second surface 60 that is concave shaped on the opposite side of the aerodynamic sheet at the trailing edge 16 that tends to slightly decelerate the flow of wind past the second surface 60. Referring to Fig. 4, first and second concentrator wings 42A and 42B may operate in series to enhance the pressure differential effect created as wind travels over surfaces 58 and 60 (Fig. 1). In order to accomplish this effect, first and second concentrator wings 42A and 42B may be staggered, for example. First concentrator wing 42A induces a lower static pressure region over the first surfaces 58 of the wing that in turn causes an acceleration of the wind flow past the second surfaces 60 of an adjacent second concentrator wing 42B. This in turn causes an increased acceleration of the flow of wind over the first surfaces 58 of the second concentrator wing 42B. In a wind turbine 50, the accelerated flow is used to increase the static pressure differential occurring between opposed sides of the impellors 44. The static pressure gradient between the opposed sides of the

impellor 44 causes the wind to be focused more powerfully to drive impellors 44 and power converters 72.

[0022] The Rogallo wing arrays may be used in different turbine designs. In some embodiments, a turbine may have a single drive impellor 44 connected to a single power converter 72. In some embodiments, a single row of concentrator wings 42 may draw wind across the impellors 44. Also, in some embodiments, the turbine 50 may be connected directly to a power utility pole and be arranged so that power is provided to the utility power.

[0023] In the claims, the word "comprising" is used in its inclusive sense and does not exclude other elements being present. The indefinite article "a" before a claim feature does not exclude more than one of the feature being present. Each one of the individual features described here may be used in one or more embodiments and is not, by virtue only of being described here, to be construed as essential to all embodiments as defined by the claims.

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

1. A Rogallo wing, comprising:

an aerodynamic sheet having a leading end and a trailing edge, the trailing edge curved to form a sheet of increasing concavity away from the leading end; and

at least two folded edges extending between the leading end and the trailing edge on opposed sides of the aerodynamic sheet, the at least two folded edges comprising integral ribs.

2. The Rogallo wing of claim 1 in which the leading end is a leading edge.

3. The Rogallo wing of claim 2 in which the leading edge is flat.

4. The Rogallo wing of claim 1, 2, or 3, in which the leading end further comprises a hollow end extending at least partially along the leading end.

5. The Rogallo wing of any one of claims 1-4 in which the aerodynamic sheet comprises an aluminum sheet.

6. A plurality of Rogallo wings, each of the Rogallo wings comprising:

an aerodynamic sheet having a leading end and a trailing edge, the trailing edge curved to form a sheet of increasing concavity away from the leading end; and

at least two folded edges extending between the leading end and the trailing edge on opposed sides of the aerodynamic sheet, the two folded edges comprising integral ribs; and

in which the plurality of Rogallo wings form an array of interconnected wings.

7. The plurality of Rogallo wing of claim 6 in which the leading end is a leading edge.

8. The plurality of Rogallo wings of claim 6 or 7 in which adjacent wings in the array of interconnected wings have adjacent folded edges connected together.

9. The plurality of Rogallo wings of claim 8 in which the adjacent folded edges of adjacent wings are riveted together.

10. The plurality of Rogallo wings of any one of claims 6 - 9 in which each of the leading ends further comprises a hollow end extending at least partially along the leading end.

11. The plurality of Rogallo wings of claim 10 in which a wire is disposed through the hollow ends of each of the leading ends of the array of interconnected wings.

12. The plurality of Rogallo wings of any one of claims 6 - 11 further comprising a loop attached to each of the two folded edges.

13. The plurality of Rogallo wings of claim 12 further comprising a wire connected through the loops on each of the folded edges.

14. The plurality of Rogallo wings of any one of claims 6 - 13 in which the plurality of Rogallo wings forms the wing members of a turbine.

15. A wind energy extraction apparatus comprising:

one or more concentrator wings that react with a flow of wind to induce a drop in static air pressure that is then used to drive one or more impellors and one or more power converters, the one or more concentrator wings comprising Rogallo wings.

16. The wind energy extraction apparatus of claim 15 in which the Rogallo wings each comprise:

an aerodynamic sheet having a leading end and a trailing edge, the trailing edge curved to form a sheet of increasing concavity away from the leading end; and

at least two folded edges extending between the leading end and the trailing edge on opposed sides of the aerodynamic sheet, the at least two folded edges comprising integral ribs.

17. The wind energy extraction apparatus of claim 16 in which the leading end is a leading edge.

18. The wind energy extraction apparatus of claim 16 or 17 in which each of the one or more concentrator wings comprise an array of Rogallo wings connected together.

19. The wind energy extraction apparatus of claim 18 in which adjacent Rogallo wings in the array of Rogallo wings have adjacent folded edges connected together.

20. The wind energy extraction apparatus of claim 19 in which the adjacent folded edges of adjacent wings are riveted together.

21. The wind energy extraction apparatus of claim 18, 19, or 20 in which each of the arrays of Rogallo wings are supported by cables between supporting fins.

22. The wind energy extraction apparatus of claim 21 in which the cables further comprise at least a first supporting cable and a second supporting cable, the first supporting cable being disposed through a hollow end on each of the leading ends of the array of interconnected Rogallo wings and the second supporting cable being disposed through a loop on each of the two folded edges.

23. The wind energy extraction apparatus of any one of claims 16-22 in which the aerodynamic sheet of each Rogallo wing comprises a metal sheet.

24. The wind energy extraction apparatus of claim 23 in which the metal sheet of each Rogallo wing comprises an aluminum sheet.

25. A method of constructing a Rogallo wing, comprising:
providing a sheet of material;

bending the sheet of material into a Rogallo wing shape having a leading end and a trailing edge, the trailing edge curved to form a sheet of increasing concavity away from the leading end; and

folding the edges of the sheet of material to form integral ribs, the folded edges extending between the leading end and the trailing edge on opposed sides of the aerodynamic sheet.

26. The method of claim 25 in which the leading end is a leading edge.

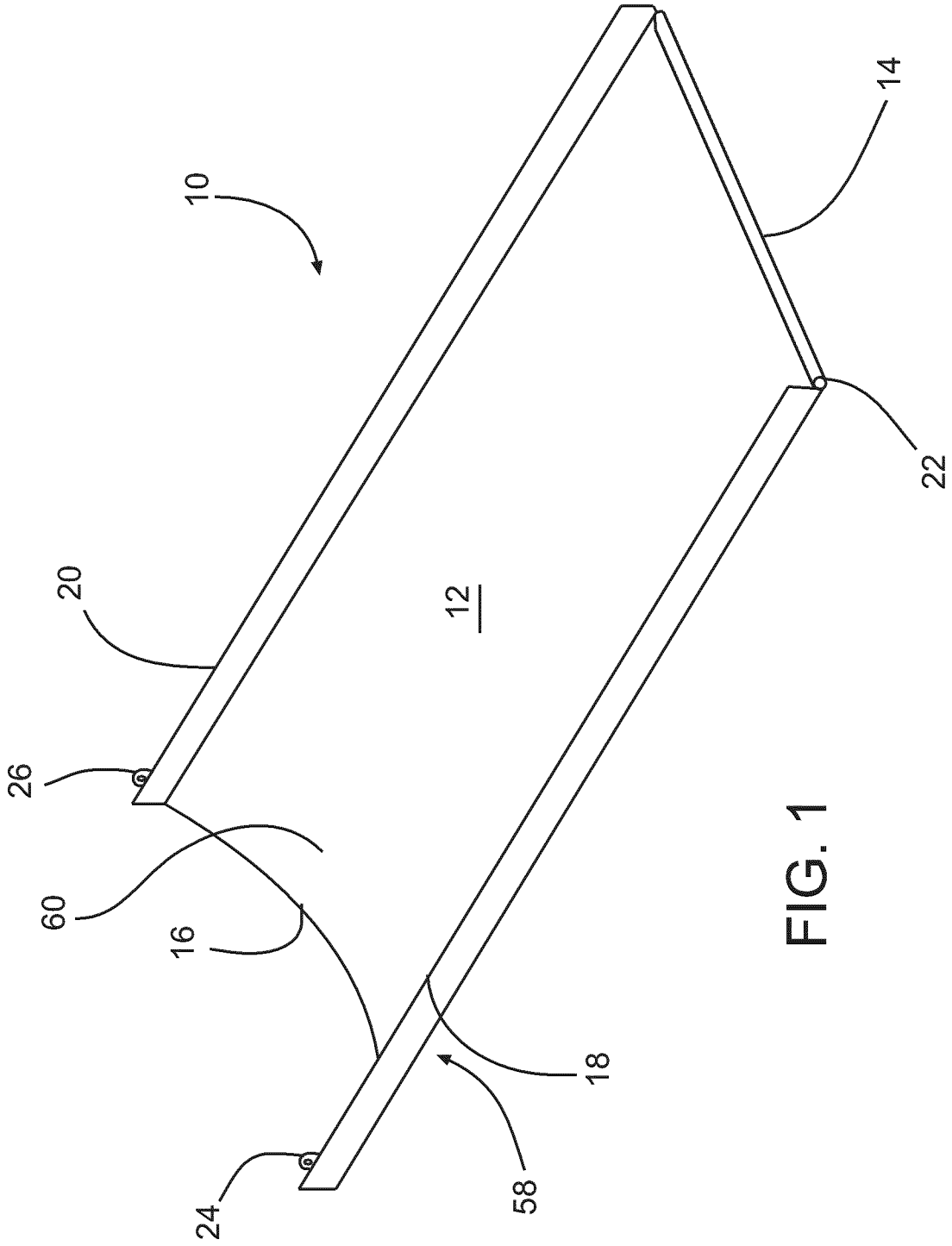

FIG. 1

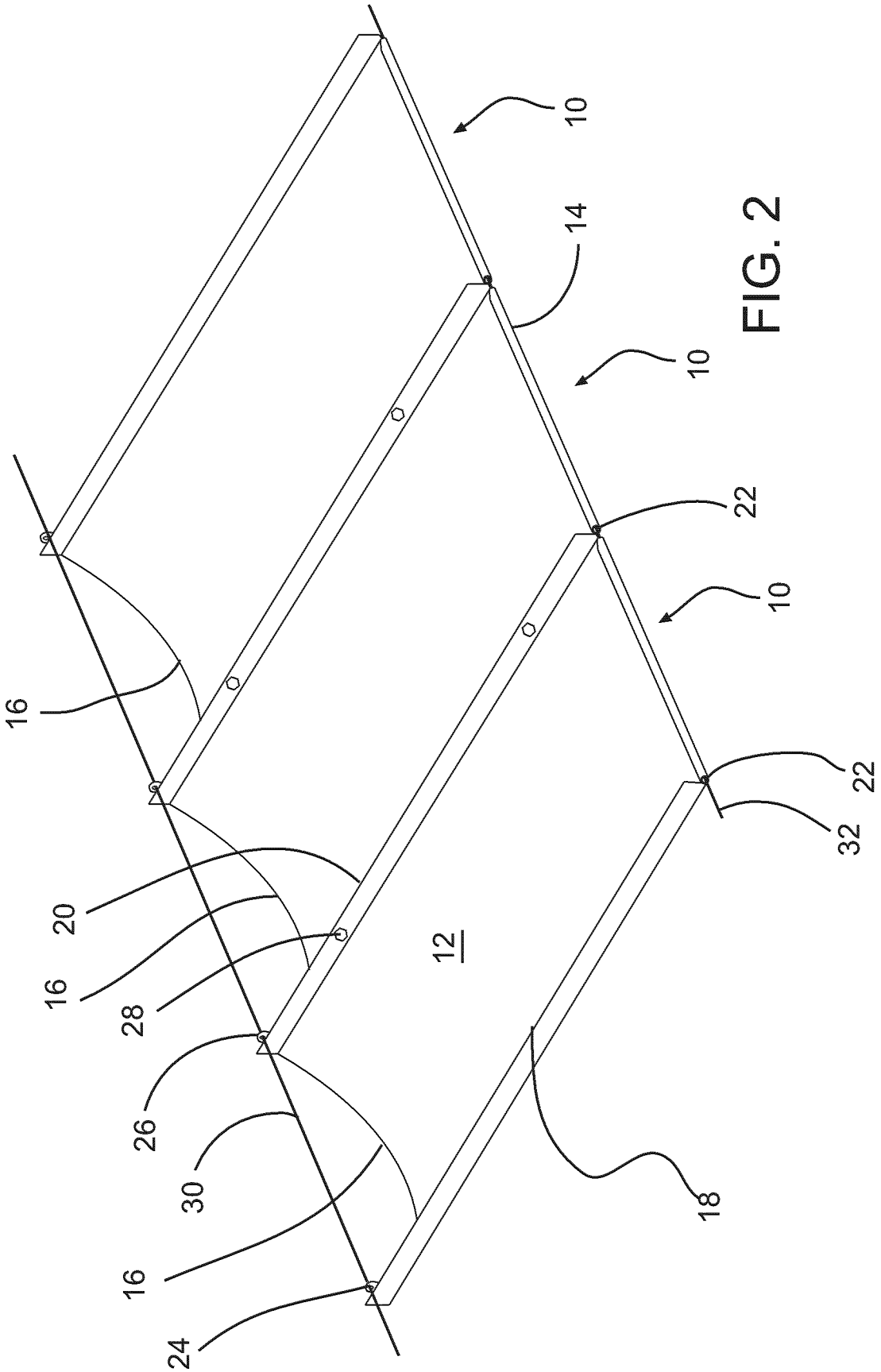

FIG. 2

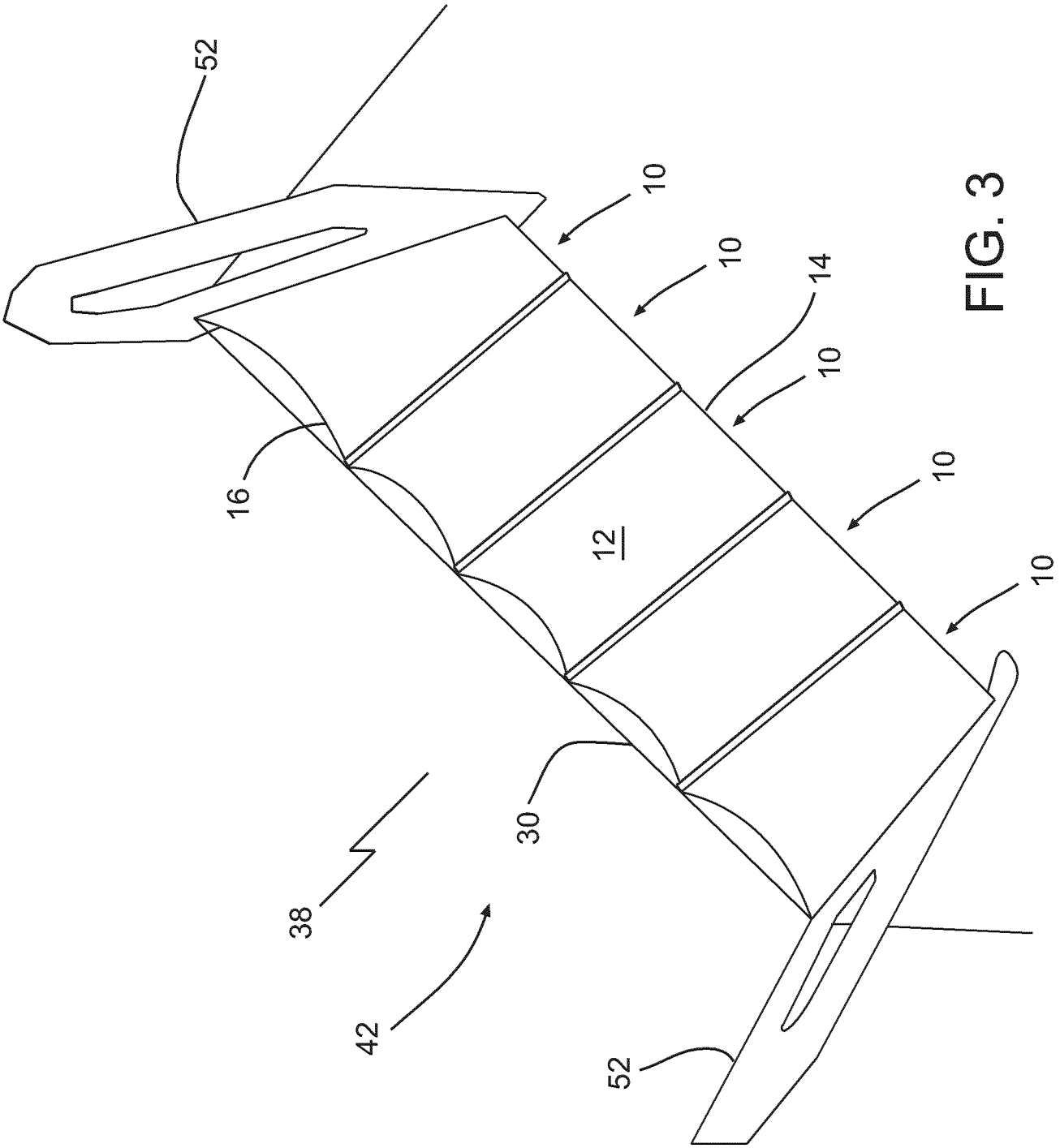

FIG. 3

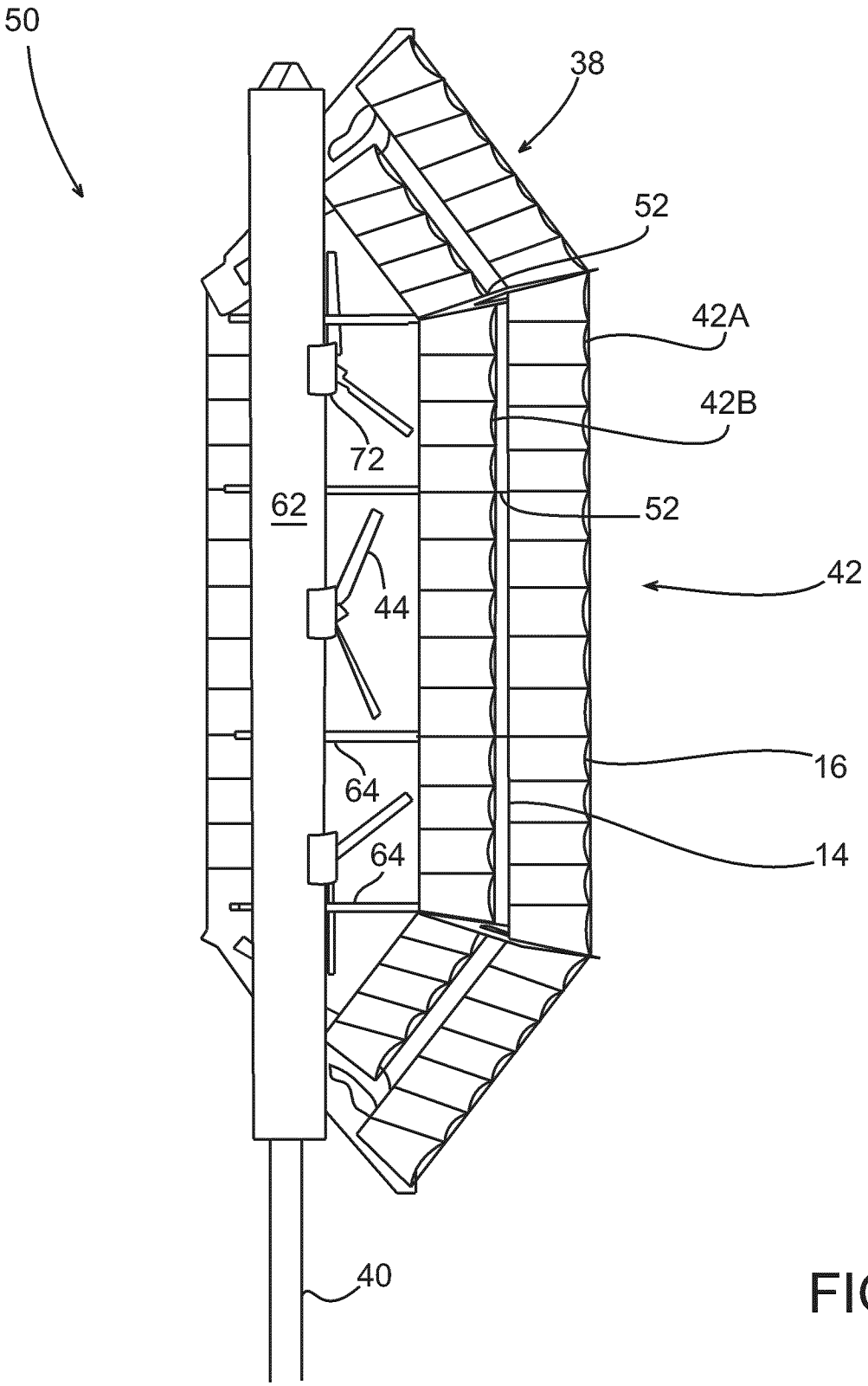

FIG. 4

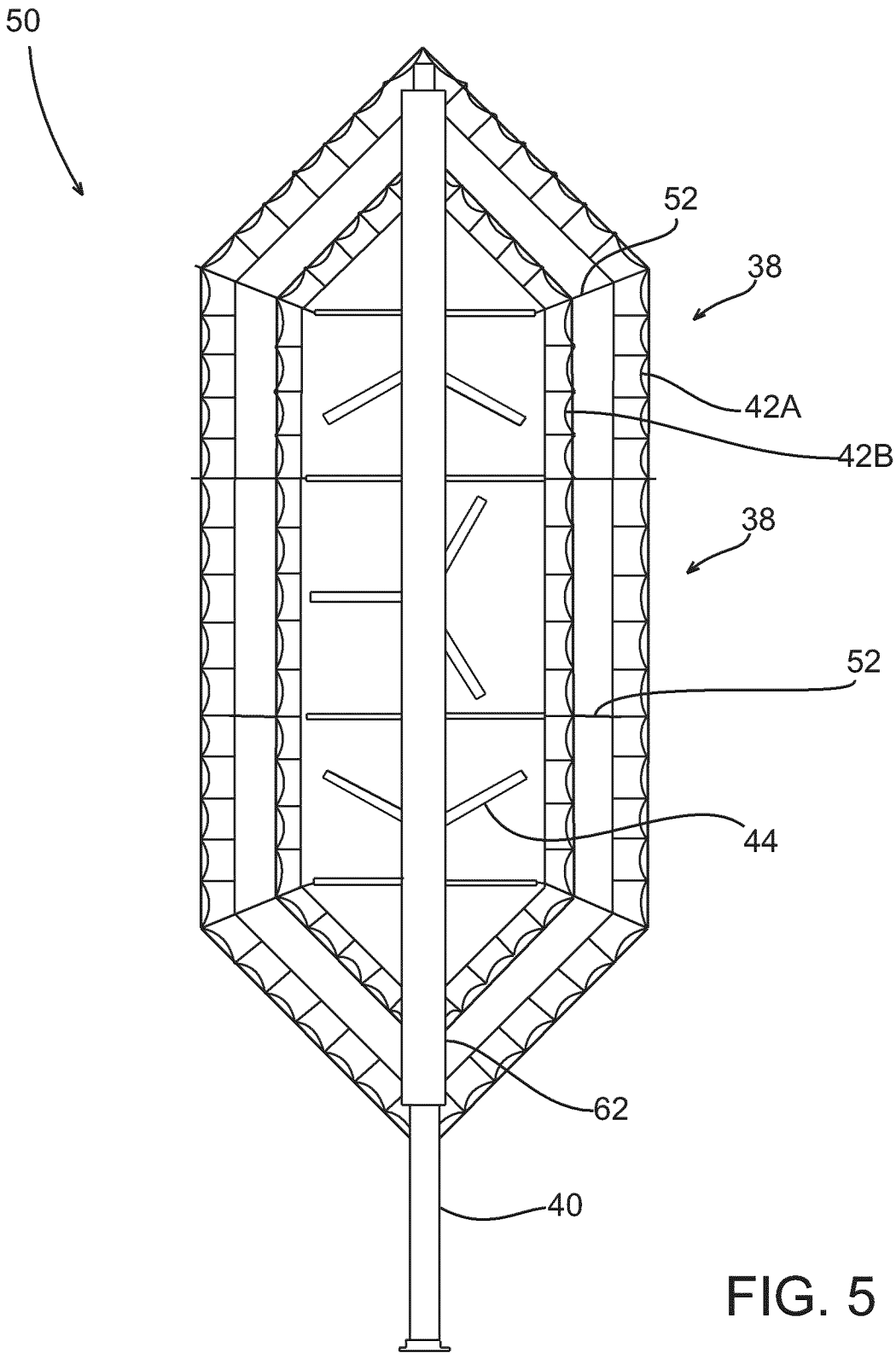

FIG. 5

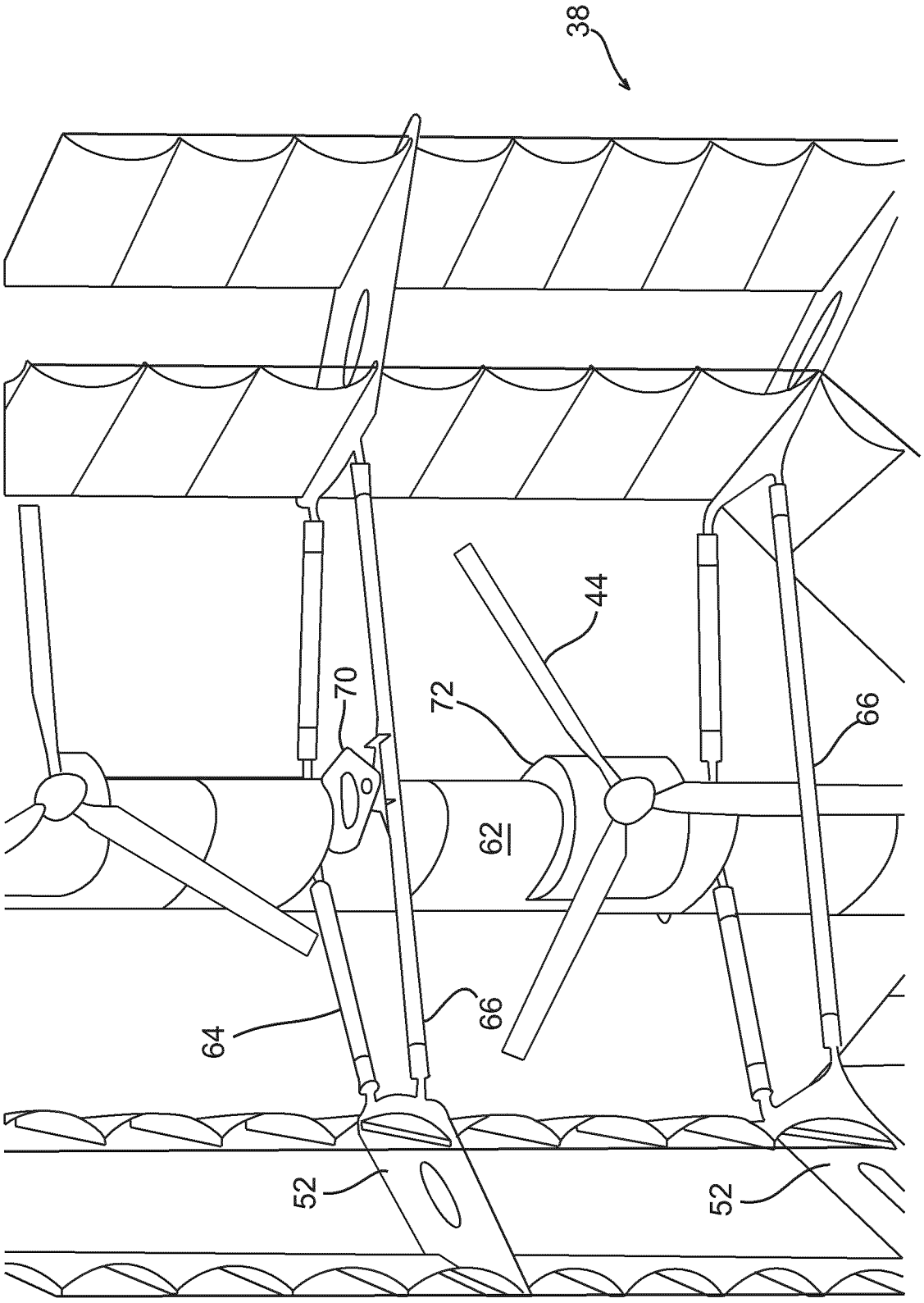

FIG. 6

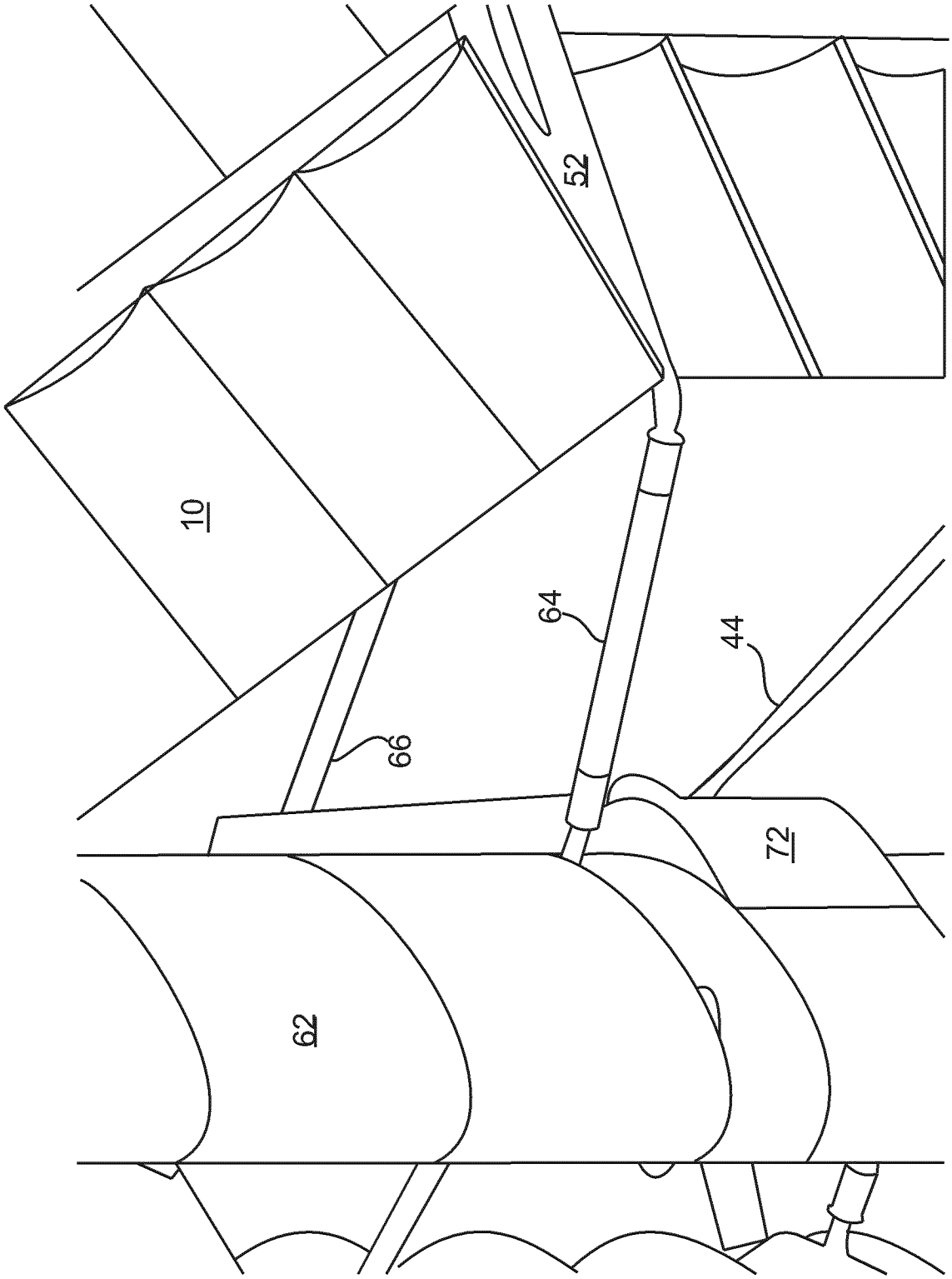

FIG. 7

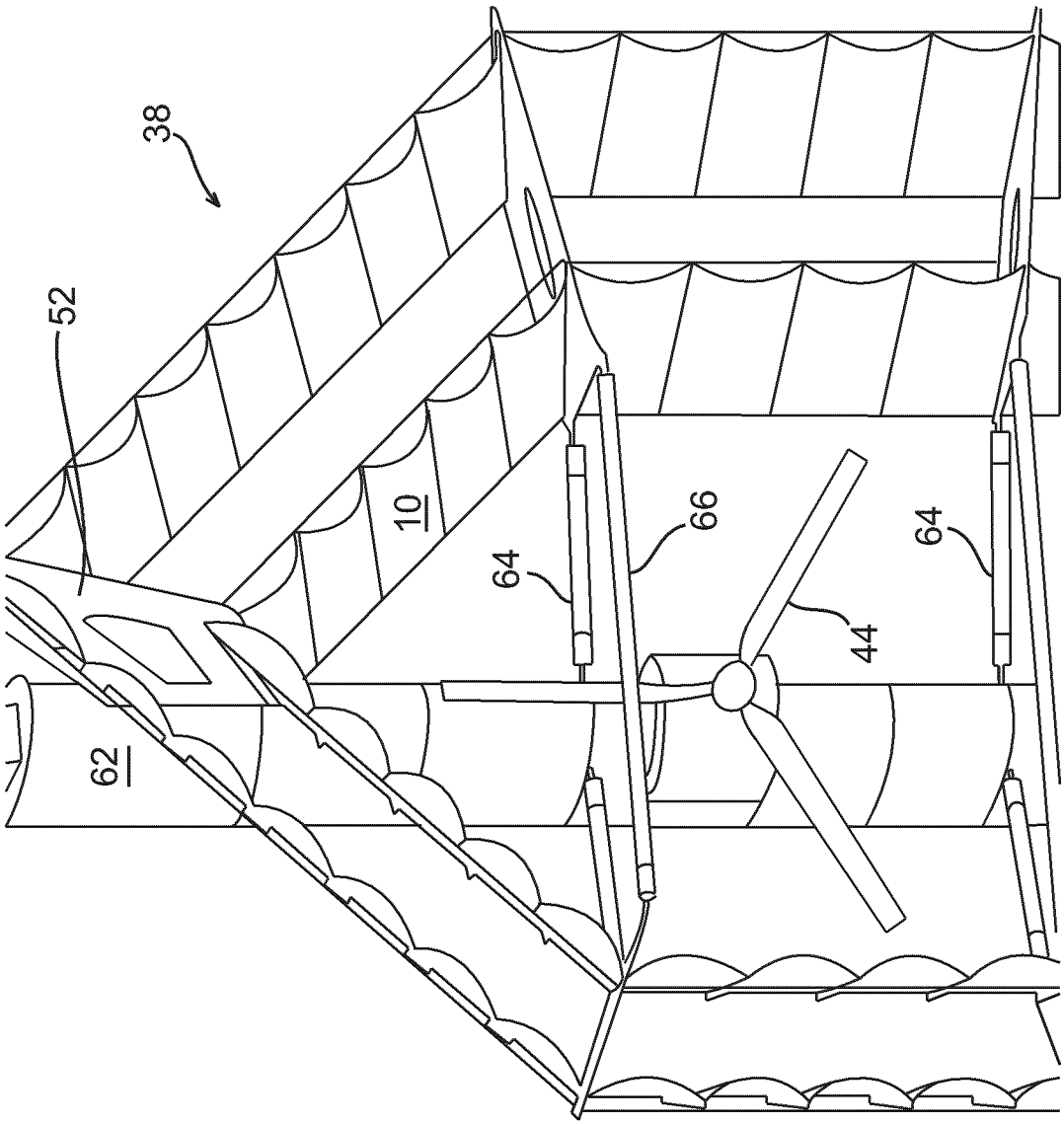

FIG. 8

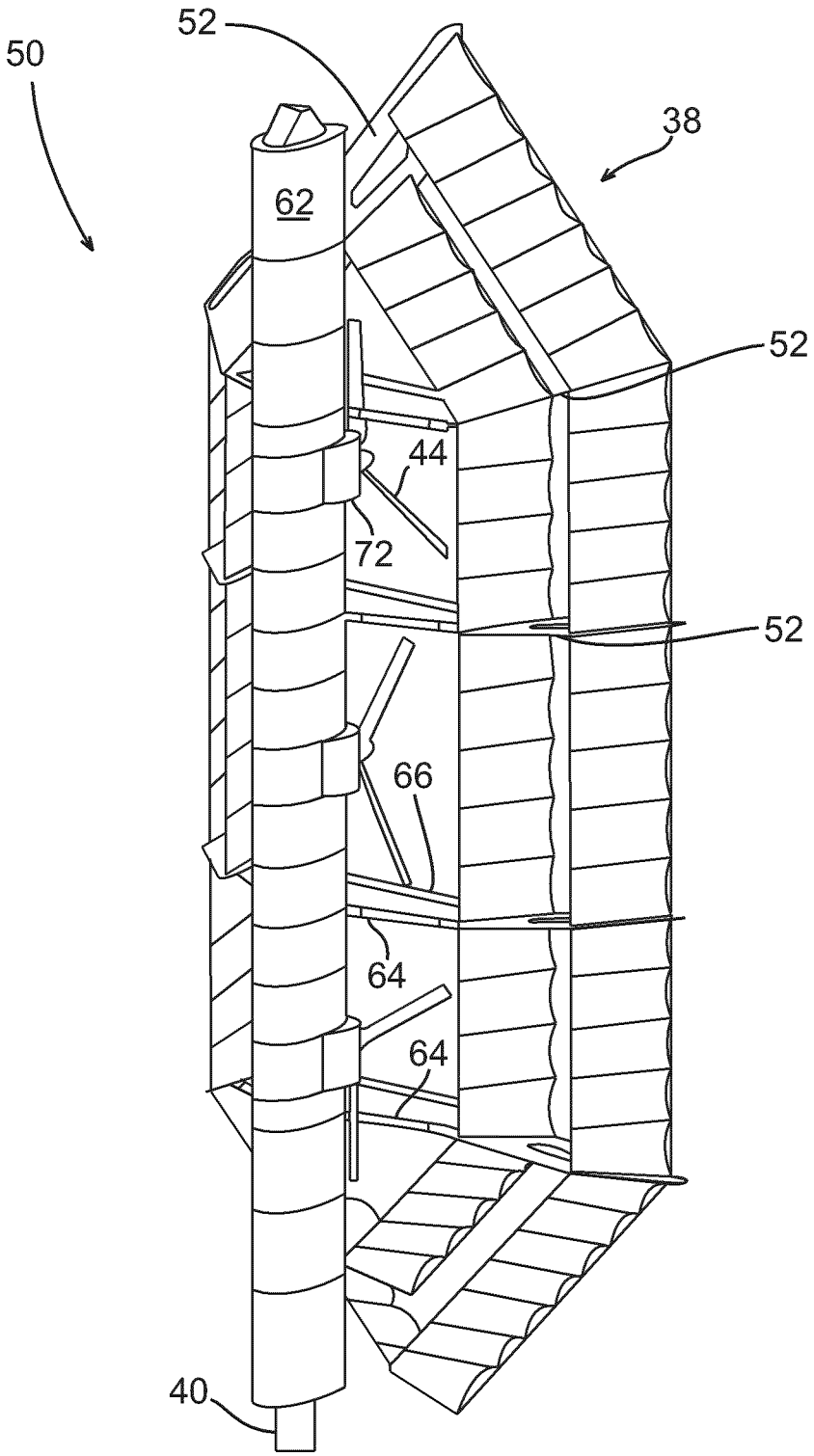

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2009/000976

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B64C 3/26*** (2006.01) , ***A63H 27/18*** (2006.01) , ***B64C 3/00*** (2006.01)
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: ***B64C 3/26*** (2006.01) , ***A63H 27/18*** (2006.01) , ***B64C 3/00*** (2006.01)
USPC: 244/99.11, 244/130, 244/133, 244/900

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Database: Delphion, EspaceNet, Google Patent, USPTO, Canadian Patent Database
key words: "rogallo wing", "aerodynamic sheet", "trailing edge", "folded edge", "integral rib", rib, "delta wing"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant	Relevant to claim No.
X Y	D1: CA 2,188,851A1 (FISHER, J. et al.) 27 April 1997 (27-04-1997) * See Description, p. 5, line 11, to page 15, line 14; Figure 1 *	1-3, 5, 25, 26 9
X Y	D2: US 4,209,148 A (LEMOIGNE, P.M.) 24 June 1980 (24-06-1980) * See Description, col. 2, line 65, to col. 4, line 62; Figures 1 and 8*	1-3, 5, 25, 26 9
X	D3: US 2003/0,042,366 A1 (BRITT, K.D., et al.) 06 March 2003 (06-03-2003) * See Description, paragraph [0051], to paragraph [0062]; Figures 1-2B *	1-2, 6-8, 9, 25-26
Y	D4: US 3,135,483 A (GIRARD, P.F.) 02 June 1964 (02-06-1964) * See Description, col. 2, line 36, col. 3, line 32; Figures 1-4 *	9
Y	D5: US 5,620,153 A (GINSBERG, H.M.) 15-04-1997 (15-04-1997) * See Description, col. 7, lines 1-62, col. 24; Figures 1-2, 4, 5B-5C, 8-9 *	9

[ ] Further documents are listed in the continuation of Box

[X] 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	Date of mailing of the international search report
06 October 2009 (06-10-2009)	22 October 2009 (22-10-2009)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Hong Tin Tiv (819) 956-8720

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the 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. [ ] Claim Nos. :
because they relate to subject matter not required to be searched by this Authority, namely :

2. [ ] Claim 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. [ ] Claim Nos. :
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 :

Group A - Claims 1-14, 25 and 26 are directed to a Rogallo wing and it's method with an aerodynamic sheet and at least two folded edges.

Group B - Claims 15-24 are directed to a wind energy extraction apparatus with one or more concentrator wings.

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 claim Nos. :

4. [X] 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 claim Nos. : **1-14 and 25-26**

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.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2009/000976

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