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(71) Applicant: **ANYTIME POWER LTD.** [IE/IE]; Main Street, Granard, County Longford (IE).

(72) Inventors: **SMYTH, James**; Tirlahood, Stradone, Co Cavan (IE). **SMYTH, Peter**; Main Street, Granard, Co Longford (IE). **SMYTH, David**; Main Street, Granard, Co Longford (IE). **SMYTH, Gerard**; 24 Higginstown Woods, Granard, Co Longford (IE). **SMYTH, Andrew**; 61 Main Street, Darkley, Co Armagh Armagh (GB).

(74) Agent: **FRKELLY**; WATERWAYS HOUSE, GRAND CANAL QUAY, DUBLIN, D02 PD39 (IE).

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(54) Title: A WIND TURBINE BLADE ASSEMBLY

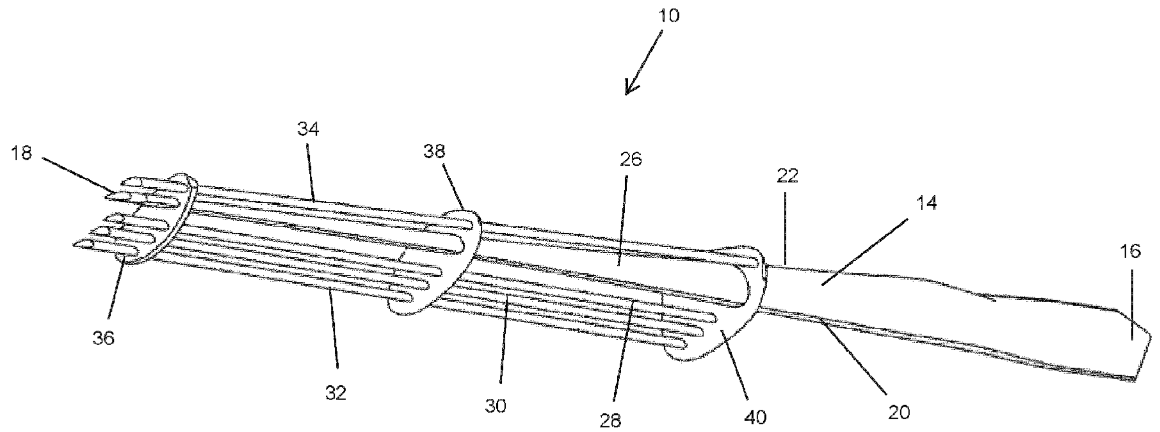

Fig. 2

(57) Abstract: The present invention is concerned with a wind turbine blade assembly, and in particular to a blade assembly including a primary blade having a leading edge and a trailing edge between which are defined a pressure side and a suction side, and an array of auxiliary blades mounted in spaced relationship to the pressure side, trailing the leading edge and extending substantially parallel to a longitudinal axis of the primary blade.

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[Continued on next page]

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A Wind Turbine Blade Assembly

Field of the invention

This invention relates to a wind turbine blade assembly, and in particular to a blade assembly including a main blade and an array of auxiliary blades which is adapted to extract greater power from the oncoming wind.

Background of the invention

As we move into a world where climate change has become a very real or tangible issue there is now more than ever a clear understanding that the planet needs significantly more renewable energy from sources such as solar and wind. Solar panels have seen substantial improvements over the last 20 years both in conversion efficiencies in power generation and cost point of power produced. However in wind power generation a conventional three bladed horizontal axis turbine has not seen the same level of development in blade optimisation and therefore efficiency of operation in the same 20 year period. There is therefore significant scope for improvement in blade design in order to provide improved efficiencies and therefore increased power generation.

In the natural world aerodynamic efficiency is evident in many areas, and for example various types of birds fly long distances in different formations such as “V” or “delta” formations, with studies showing this as a way to conserve energy. This concept has been adopted in aviation and aeronautics, with aeroplanes also often flying in different formations to conserve fuel and it is therefore an object of the present invention utilise the same effect in a novel wind turbine blade assembly with optimised aerofoil patterns incorporated into an optimised array of blades to provide improved power extraction efficiencies when used with an otherwise conventional horizontal axis wind turbine..

Given that the aerofoil profile of the wings of birds in such a flight formation or the aerofoil profile of the wings of an aeroplane in such a flight formation expend less energy in flight and are therefore more efficient as an overall formation, it is an objection of the invention to utilise this improved efficiency in wind turbine blade design.

In particular this increase in efficiency is achieved by staggering the leading edge of adjacent wings in the formation resulting and it is an object of the invention to utilise such an arrangement to generate additional power by exposing additional staggered blades to the oncoming wind to present a greater blade area while minimising the resistance to flow by reducing the pressure drag on the staggered blades.

It is therefore an object of the present invention to provide a wind turbine blade assembly having an efficiency greater than existing wind turbine blade by utilising an array of blades in a particular formation.

US2014/0271216 discloses a horizontal axis wind turbine include a number of main blades, each of which is augmented with one or more secondary blades mounted to the main blade. In one embodiment a single secondary blade is mounted to the main blade in a position rotationally ahead of the main blade relative to the direction of operational rotation, and also positioned axially behind the main blade in an area in which air has not been disturbed by the main blade. The single secondary blade is mounted to a suction side of the main blade. In another embodiment one secondary blade is mounted to a suction side of the main blade while another secondary blade is mounted to a pressure side of the main blade. In a further embodiment a pair of secondary blades are mounted in a stacked configuration to a suction side of the main blade. The secondary blades due not overlap or overlie the main blade and are always positioned axially spaced from the main blade in order to achieve the desired positioned of the secondary blades in an area of undisturbed airflow.

Summary of the invention

According to the present invention there is provided a wind turbine blade assembly comprising a primary blade having a leading edge and a trailing edge between which are defined a pressure side and a suction side; a first auxiliary blade mounted in spaced relationship to the pressure side, trailing the leading edge and extending substantially parallel to a longitudinal axis of the primary blade, a second auxiliary blade mounted in spaced relationship to a pressure side of the first auxiliary blade trailing a leading edge thereof, and a third auxiliary blade mounted in spaced relationship to a pressure side of the second auxiliary blade trailing a leading edge thereof.

Preferably, the wind turbine blade assembly comprises at least one auxiliary blade mounted in spaced relationship to the suction side of the primary blade, leading the leading edge and extending substantially parallel to a longitudinal axis of the primary blade.

Preferably, the at least one auxiliary blade has a chord length less than the chord length of the primary blade.

Preferably, the chord length of the at least auxiliary blade is between 20% and 100% of the chord length of the primary blade.

Preferably, the at least one auxiliary blade has a length less than the length of the primary blade.

Preferably, the length of the at least one auxiliary blade is between 20% and 100% of the length of the primary blade.

Preferably, the at least one auxiliary blade is mounted over a tip section and a mid section of the primary blade.

Preferably, the primary blade and the at least one auxiliary blade comprise a twist along the length thereof.

Preferably, the wind turbine blade assembly comprises at least one tertiary blade securing the at least one auxiliary blade to the primary blade.

Preferably, the wind turbine blade assembly comprises three tertiary blades spaced from one another along the longitudinal axis of the blade.

Preferably, the at least one tertiary blade is configured to generate lift directed towards a root of the primary blade.

Preferably, the at least one tertiary blade is configured to generate, during rotation of the blade assembly, an amount of lift sufficient to substantially offset the centrifugal force experienced by the blade assembly during said rotation.

Preferably, the wind turbine blade assembly comprises a plurality of modular sections defined between adjacent tertiary blades.

Preferably, the first auxiliary blade at least partially overlaps the main blade in an axial direction.

Preferably, each auxiliary blade located on the pressure side of the main blade at least partially overlaps each immediately adjacent auxiliary blade located on the pressure side of the main blade.

Preferably, the auxiliary blades comprise a different material to the main blade.

According to a second aspect of the present invention there is provided a wind turbine comprising an array of the wind turbine blade assemblies according to the first aspect of the invention.

<u>Brief description of the drawings</u>

The present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 illustrates a perspective upstream view of a wind turbine according to an aspect of the present invention;

Figure 2 illustrates a perspective view from an upstream perspective of a wind turbine blade assembly according to an aspect of the present invention and forming part of the wind turbine of Figure 1;

Figure 3 illustrates an alternative perspective view of the wind turbine blade assembly shown in Figure 2;

Figure 4 illustrates the wind turbine blade assembly of Figures 2 and 3 with a plurality of tertiary blades omitted; and

Figure 5 illustrates three tertiary blades which form part of the wind turbine blade assembly shown in Figures 2 to 4, in isolation from a primary and auxiliary blades of the blade assembly.

Detailed description of the drawings

Referring now to the accompanying drawings there is illustrated a wind turbine blade assembly, generally indicated as 10, for use on an otherwise conventional horizontal axis wind turbine 12, most preferably one including three of the blade assemblies 10 as illustrated in Figure 1, although it will be appreciated that this number may be varied as required to suit the particular design and/or function of the wind turbine 12.

Referring to Figure 2 the blade assembly 10 comprises a primary blade 14 which is preferably of relatively conventional design, and may be manufactured from any suitable material or combination therefore, for example carbon composite or the like. The primary blade 14 may be of any suitable size and shape to suit a particular application. For conventional large scale horizontal axis wind turbine applications, whether land or sea based, the primary blade 14 may for example be somewhere in the region of 50m to 100m in length. The primary blade 14 will preferably include a twist along the length thereof, namely along a longitudinal blade axis AA or longitudinal direction in order to provide the optimum angle of attach at each point along the working length of the blade 14. The chord length and/or aerofoil cross section of the primary blade 14 may also varies from a root 16 to tip 18 as is well known in the art and no further detail is therefore considered necessary regarding this aspect of the design of the primary blade 14.

The primary blade 14 comprises a leading edge 20 and a trailing edge 22 between which are defined a pressure side 24 and a suction side 26, again as is well known in the art. In use the leading edge 20 faces into the oncoming wind which flows around the primary blade 14 causing an increase in pressure over the pressure side and a reduction in pressure over the suction side 26, the net effect of which is the generation of lift in order to cause the primary blade 14 to rotate around the axis of the turbine 12 in order to generate power. Airflow is generally considered to move in an “axial direction”, namely substantially parallel to an axis of rotation RR of the blade assembly 10 of the turbine.

Mounted to the primary blade 14 are a plurality of auxiliary blades, and in the preferred embodiment a first auxiliary blade 28 mounted adjacent and in spaced parallel relationship to the pressure side 24 of the primary blade 14; a second auxiliary blade 30 mounted parallel and in spaced relationship to the first auxiliary blade 28; a third auxiliary blade 32 mounted parallel and in spaced relationship to the second auxiliary blade 30; and a fourth auxiliary blade 34 mounted adjacent and in spaced parallel relationship to the suction side 26 of the primary blade 14. The auxiliary blades 28, 30, 32, 34 are preferably secured to the primary blade 14 by means of a plurality of tertiary blades, and in the preferred embodiment illustrated a first tertiary blade 36 adjacent the tip 18, second tertiary blade 38 longitudinally spaced from the first tertiary blade 36 in the direction of the root 16, and a third tertiary blade 40 longitudinally spaced from the second tertiary blade 38 in the direction of the root 16. The configuration and operation of the tertiary blades 36, 38, 40 will be described in greater detail hereinafter.

Returning to the auxiliary blades, the first auxiliary blade 28 is mounted above and at least partially overlapping in the axial direction the pressure side 24 of the primary blade 14. As a result the leading edge of the first auxiliary blade 28 is positioned to be trailing or downstream of the leading edge 20 of the primary blade 14 during rotation thereof and relative to the oncoming wind, but leading the trailing edge 22 such as to at least partially overlap or overlie the pressure side of the main blade 10. The amount of overlap and/or offset between the first auxiliary blade 28 and the main blade 10 will be determined by the operating parameters of the wind turbine 12, and most notably by the speed or rotation of the blade assembly 10 and/or the speed of the oncoming wind. The relative position of the first auxiliary blade 28 preferably varies along length of main blade 14, with a greater offset towards the root 16. The position of the first auxiliary blade 28, overlapping the pressure side of the main blade 10, places the auxiliary blade 28 in an area of the air flow that is disturbed by the main blade 10. The auxiliary blade 28 is therefore positioned to augment that area of airflow, as detailed hereinafter.

The first auxiliary blade 28 has a chord length less than or equal to the chord length of the primary blade 14, and in a preferred embodiment has a chord length of between 20% and 100% of the chord length of the primary blade 14, more preferably between 20% and 50%. The length of the first auxiliary blade 28 is preferably selected to cover the majority of the lift generating portion of the primary blade 14, and as a result preferably does not extend to adjacent the root 16, although this may vary if required for functional or structural reasons. In a preferred embodiment the first auxiliary blade 28 has a length in the longitudinal direction of between 20% and 100% of the length of the primary blade 14 but again the dimensions may be varied as required. It is for example possible that one or more of the auxiliary blades 28, 30, 32, 34 is connected directly to the hub of the turbine 12.

The second auxiliary blade 30 is positioned relative to the first auxiliary blade 28 in a similar configuration, with a leading edge trailing or downstream of the leading edge of the first auxiliary blade 28 but leading or upstream of the trailing edge of the first auxiliary blade in order to be at least partially overlapping in the axial direction, with the second auxiliary blade 30 substantially parallel and spaced from the pressure side of the first auxiliary blade 28. Again the exact position, size and configuration of the second auxiliary blade 30 may vary and will be determined to a large extend by the performance requirements of the wind turbine 12.

The third auxiliary blade 32 is likewise positioned relative to the second auxiliary blade 30, with a leading edge trailing or downstream of the leading edge of the second auxiliary blade 30 but leading or upstream of the trailing edge of the second auxiliary blade in order to be at least partially overlapping in the axial direction, the third auxiliary blade 32 parallel and spaced from the pressure side of the second auxiliary blade 30.

The fourth auxiliary blade 34 is located over the suction side 26 and is positioned with a leading edge leading or upstream of the leading edge 20 of the primary blade 14 such that the array of auxiliary blades 28, 30, 32, 34 together with the primary blade 14 form a stepped or so called “delta” array with the fourth auxiliary blade 34 being the most forwardly or upstream blade and each subsequent or immediately adjacent blade being offset in the downstream direction. This arrangement can help to reduce drag on the downstream blades, leading to greater wind loading hitting the blades which is then resolved into lift and drag components and the delta formation lends itself to keeping the pressure and friction drag to a minimum (similar to bird or aeroplane formations) resulting in grater lift and more power for same wind speed.

As noted above the exact position, size and configuration of the auxiliary blades 28, 30, 32, 34 will vary depending on the overall dimensions and configuration of the blade assembly 10, in addition to the particular application in which the blade assembly 10 is employed and/or desired operating/performance characteristics such as optimising lift, minimising drag, overall system weight, modularity, etc. As the auxiliary blades 28, 30, 32, 34 are secured to the primary blade 14 via the tertiary blades 36, 38, 40 the auxiliary blades 28, 30, 32, 34 do not require a root which is load bearing and modified for mounting to a hub or the wind turbine 12. As a result the auxiliary blades 28, 30, 32, 34 can have a relatively constant cross section and/or wall thickness in order to allow weight optimisation, as the auxiliary blades 28, 30, 32, 34 are not load bearing to the same extent as the primary blade 14. The auxiliary blades 28, 30, 32, 34 may as result comprise a different material or grade of material to the main blade 10 due to the different functional requirements thereof. The auxiliary blades 28, 30, 32, 34 may have a constant aerofoil cross section along the length thereof, or the cross section may vary according to requirements. In addition, the auxiliary blades 28, 30, 32, 34 may include a twist along the length therefore corresponding to any twist on the primary blade 14, thereby maintain a relatively parallel alignment between each set of adjacent blades in order to reduce turbulent airflow therebetween.

The provision of the auxiliary blades 28, 30, 32, 34 acts to minimise the solidity of the rotor formed by rotation of the blade assembly 10 while increasing the effective depth of the cutting edge of the blade assembly 10 (in the oncoming wind direction) and in doing so will generate an increased wind load force which defined by the lift force and drag force, and by reducing the total drag force resulting in an overall greater lift force. The degree of overlap of the auxiliary blades 28, 30, 32, 34 is selected to take the blade rotation speed into consideration.

In the array of auxiliary blades 28, 30, 32, 34 at least one of the blades may be structurally designed as a load bearing member to transfer the wind loading back to the hub of the wind turbine 12 during operation of the wind turbine 12. In this way the remaining auxiliary blades 28, 30, 32, 34 can be made non-load bearing and thus lighter in weight. The wind loading is therefore transferred from the other lighter weight auxiliary blades 28, 30, 32, 34 through the at least one load bearing auxiliary blades 28, 30, 32, 34, through the tertiary blades 36, 38, 40 to the primary blade 14. Some of aerofoil blades that make up a formation blade are of different lengths for different formations.

Preferably but not essentially the aerofoil profile of the auxiliary blades 28, 30, 32, 34 will have the same or lower angle of attack to that of a conventional optimised blade utilised in horizontal type wind turbines. This is to ensure extra pressure drag of the combined blade assembly 10 is kept to minimum compared to the extra lift generated due to the “delta” formation.

Turning to the tertiary blades 36, 38, 40 the primary function is structural, namely to retain the auxiliary blades 28, 30, 32, 34 on the primary blade 14 and to transfer the wind generated forces (lift and drag) from the auxiliary blades 28, 30, 32, 34 to the primary blade 14 to be transferred to the hub of the turbine 12. The exact number of tertiary blades required will be largely dictated by the length of the auxiliary blades 28, 30, 32, 34 and the amount of load to be transferred to the primary blade 14. While a single tertiary blade could provide the necessary mounting function, at least two and preferably the three tertiary blades 36, 38, 40 are provided. In the embodiment illustrated each tertiary blade 36, 38, 40 comprising a primary opening 42 through which the primary blade 14 extends, and four auxiliary openings 44 through which the respective auxiliary blade 28, 30, 32, 34 extend. It will of course be understood that any other suitable interface may be employed, although the exemplary arrangement minimises or eliminates the use of additional fixtures which may introduce turbulence. An adhesive or the like may be employed to secure the tertiary blades 36, 38, 40 to the primary blade 14 and auxiliary blades 28, 30, 32, 34.

While the primary function of the tertiary blades 36, 38, 40 is structural, given the application it is preferable that the tertiary blades 36, 38, 40 are aerodynamically optimised. In a most preferred arrangement the tertiary blades 36, 38, 40 have an aerofoil cross section, and referring to Figure 5 define a pressure side 46 facing the tip 18 and a suction side 48 facing the root 16 of the primary blade 14. With such a configuration the tertiary blades 36, 38, 40 will themselves generate lift, and in the direction of the root 16 of the primary blade 14 thereby at least partially offsetting the centrifugal force generated by rotation of the blade assembly 10. The aerofoil profile, size and positioning of the tertiary blades 36, 38, 40 may be varied as required in order to establish desired performance characteristics. By providing the tertiary blades 36, 38, 40 as aerofoils and with appropriate spacing between adjacent tertiary blades 36, 38, 40 the auxiliary blades 28, 30, 32, 34 to be stronger, lighter/or thinner while not compromising on blade strength or excessive pressure or friction drag generated. Therefore the depth of the blade in the direction of the wind is increased while keeping the weight of the blade to a minimum while maximising the blade area cutting the wind.

This design will result in the blade going faster at the same wind speed taking the generator required torque force for a given power output into account.

The invention is not limited to the embodiment described herein but can be amended or modified without departing from the scope of the present invention.

Claims

1. A wind turbine blade assembly comprising a primary blade having a leading edge and a trailing edge between which are defined a pressure side and a suction side; a first auxiliary blade mounted in spaced relationship to the pressure side, trailing the leading edge and extending substantially parallel to a longitudinal axis of the primary blade, a second auxiliary blade mounted in spaced relationship to a pressure side of the first auxiliary blade trailing a leading edge thereof, and a third auxiliary blade mounted in spaced relationship to a pressure side of the second auxiliary blade trailing a leading edge thereof.

2. The wind turbine blade assembly of claim 1 comprising at least one auxiliary blade mounted in spaced relationship to the suction side of the primary blade, leading the leading edge and extending substantially parallel to a longitudinal axis of the primary blade.

3. The wind turbine blade assembly of any preceding claim in which the at least one auxiliary blade has a chord length less than the chord length of the primary blade.

4. The wind turbine blade assembly of claim 3 in which the chord length of the at least auxiliary blade is between 20% and 100% of the chord length of the primary blade.

5. The wind turbine blade assembly of any preceding claim in which the at least one auxiliary blade has a length less than the length of the primary blade.

6. The wind turbine blade assembly of claim 3 in which the length of the at least one auxiliary blade is between 20% and 100% of the length of the primary blade.

7. The wind turbine blade assembly of any preceding claim in which the at least one auxiliary blade is mounted over a tip section and a mid section of the primary blade.

8. The wind turbine blade assembly of any preceding claim in which the primary blade and the at least one auxiliary blade comprise a twist along the length thereof.

9. The wind turbine blade assembly of any preceding claim comprising at least one tertiary blade securing the at least one auxiliary blade to the primary blade.

10. The wind turbine blade assembly of claim 9 comprising three tertiary blades spaced from one another along the longitudinal axis of the blade.

11. The wind turbine assembly of claim 9 or 10 in which the at least one tertiary blade is configured to generate lift directed towards a root of the primary blade.

12. The wind turbine blade assembly of claim 11 in which the at least one tertiary blade is configured to generate, during rotation of the blade assembly, an amount of lift sufficient to substantially offset the centrifugal force experienced by the blade assembly during said rotation.

13. The wind turbine blade assembly of any of claims 9 to 12 comprising a plurality of modular sections defined between adjacent tertiary blades.

14. The wind turbine blade assembly of any preceding claim in which the first auxiliary blade at least partially overlaps the main blade in an axial direction.

15. The wind turbine blade assembly of any preceding claim in which each auxiliary blade located on the pressure side of the main blade at least partially overlaps each immediately adjacent auxiliary blade located on the pressure side of the main blade.

16. The wind turbine assembly of any preceding claim in which the auxiliary blades comprise a different material to the main blade.

17. A wind turbine comprising an array of the wind turbine blade assemblies according to any of the preceding claims.

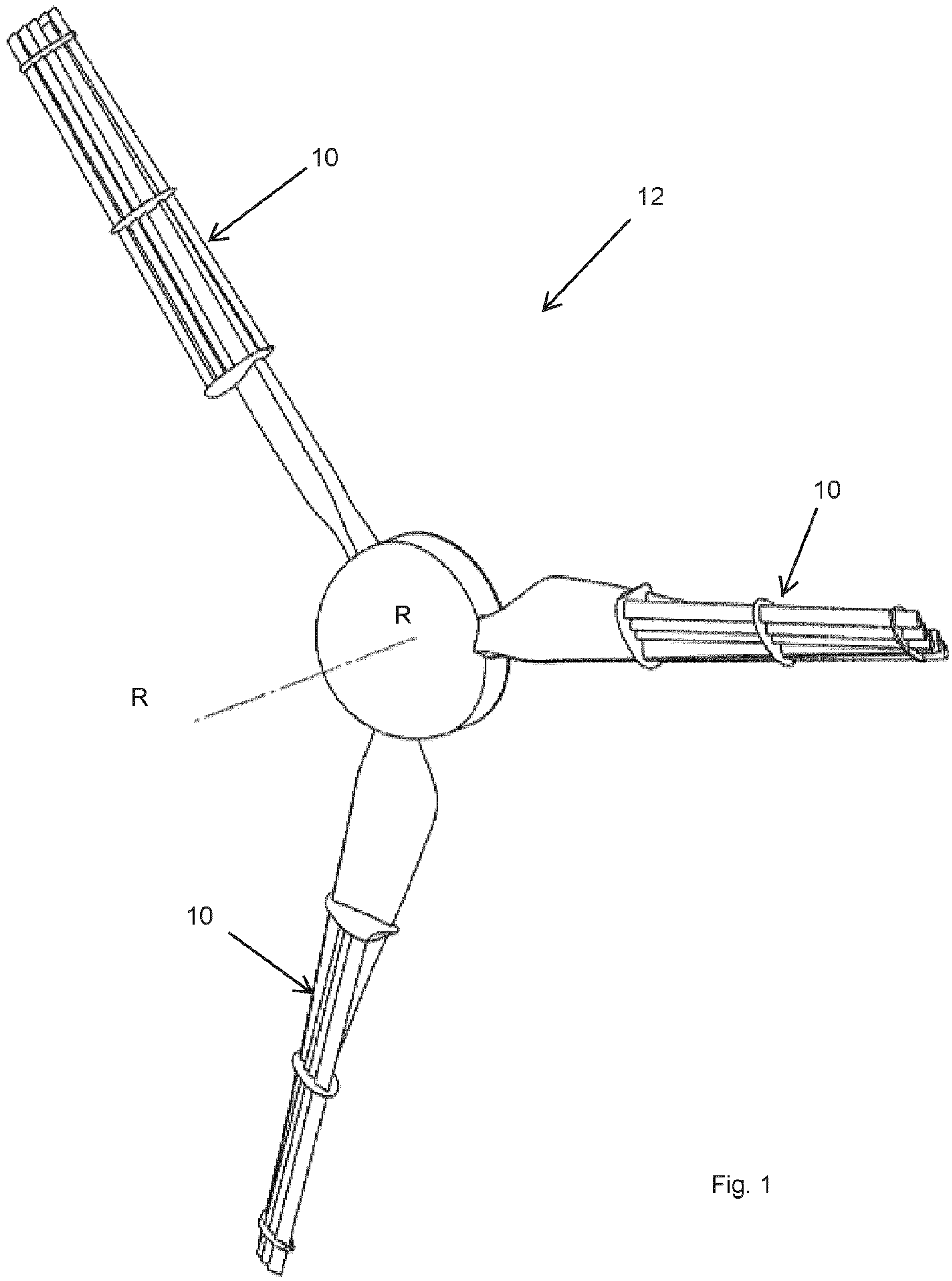

Fig. 1

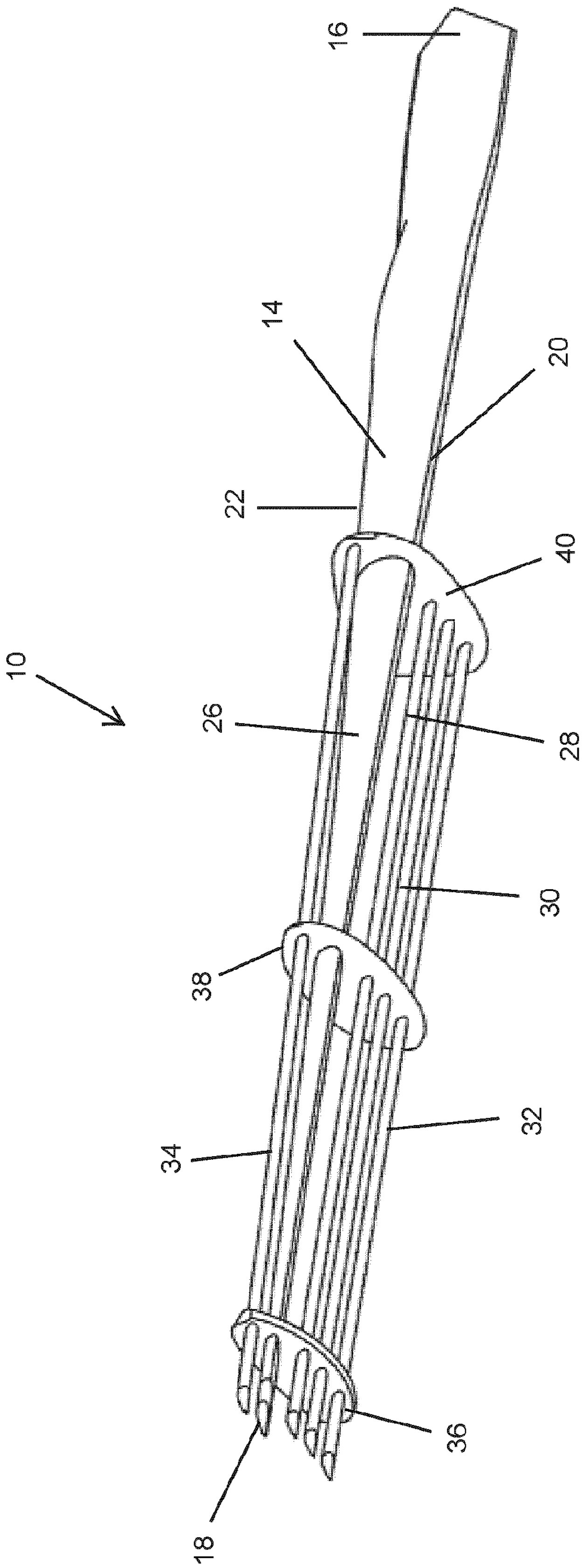

Fig. 2

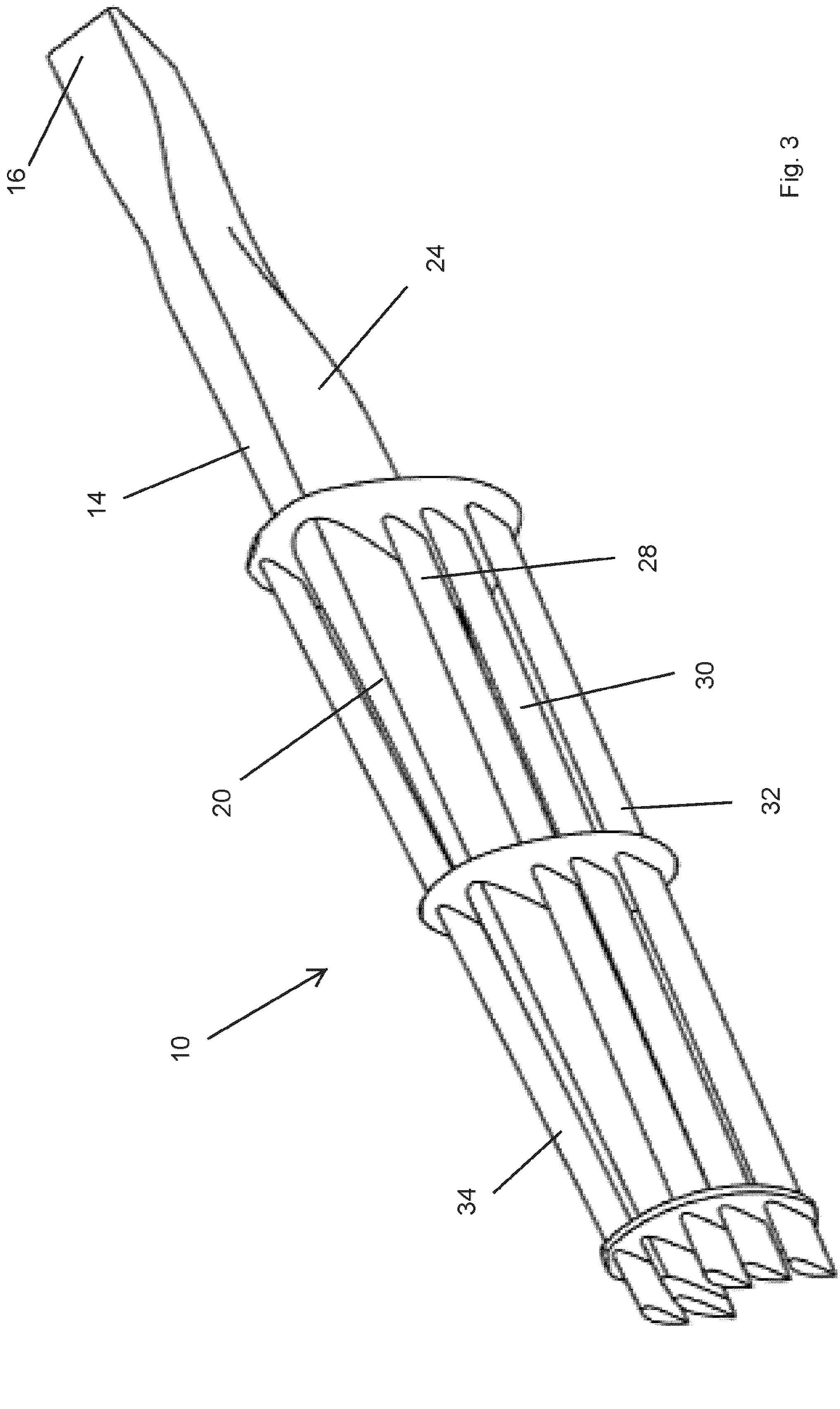

Fig. 3

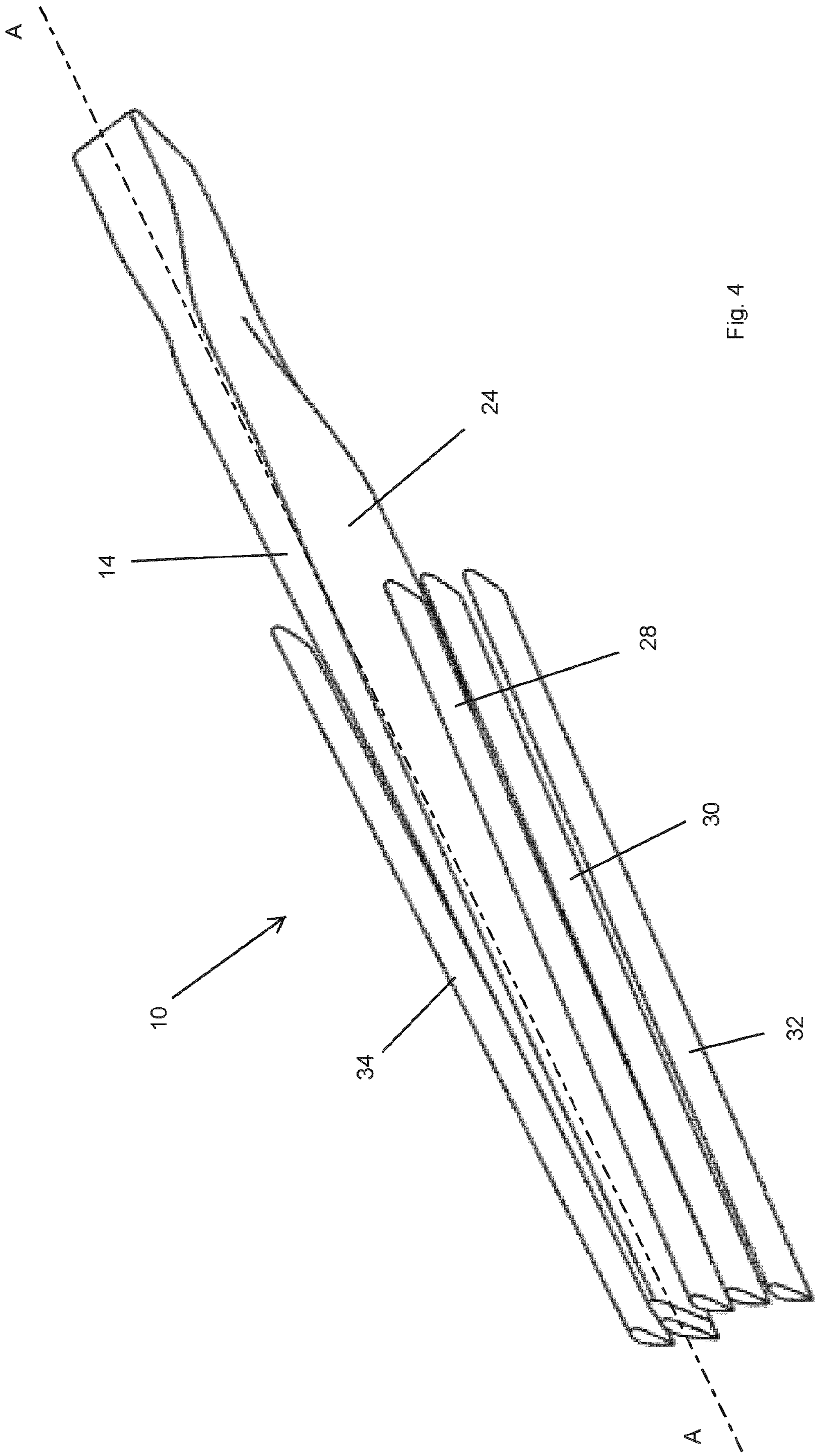

Fig. 4

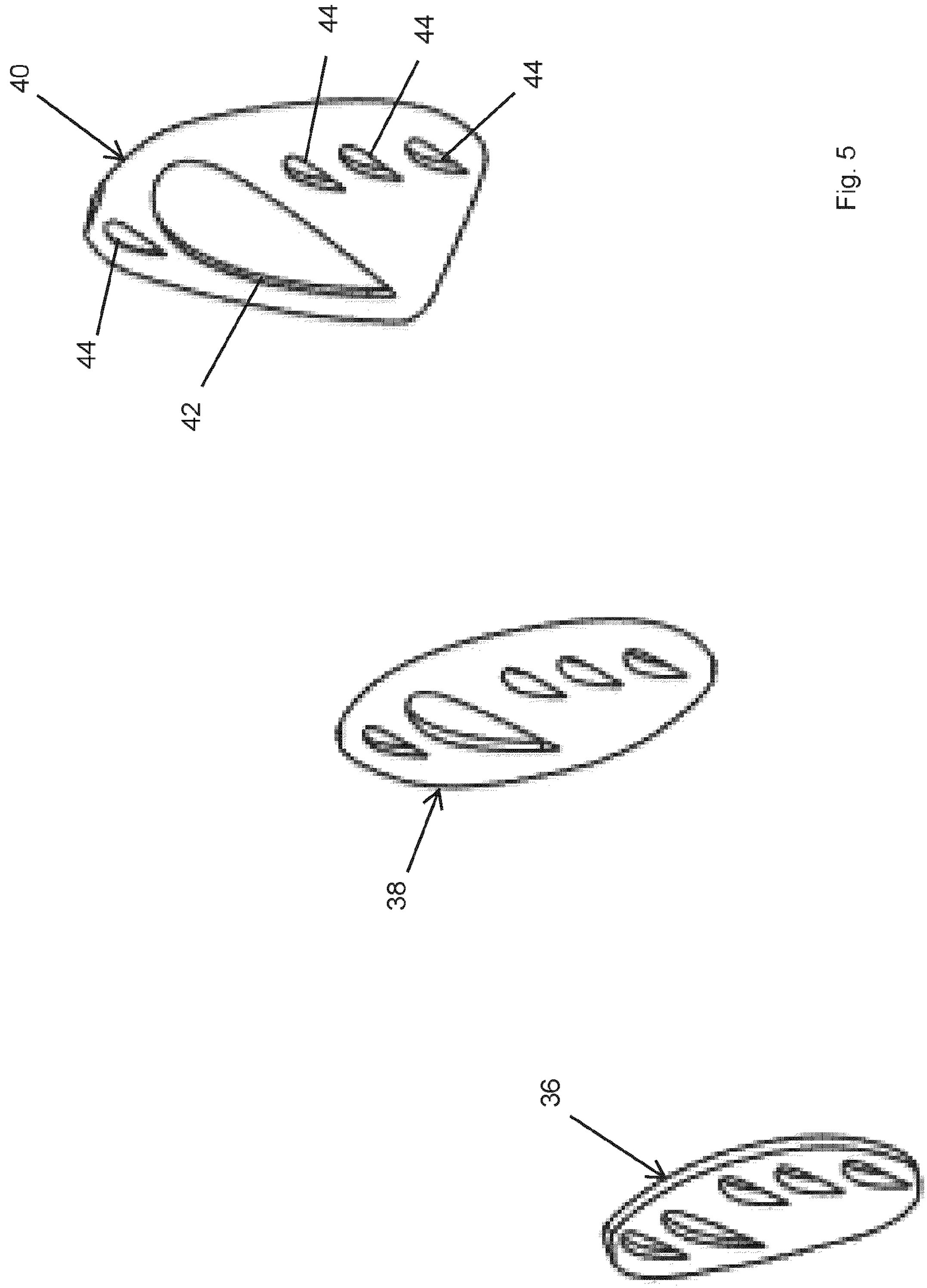

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/066653

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D1/06
ADD.

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)
F03D

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2014/162312 A1 (WINDFIRE B V [NL]; REINHOLD COHN AND PARTNERS [IL]) 9 October 2014 (2014-10-09) claim 1; figure 2	1,7,9, 10,14, 15,17 2-6,8, 11-13,16

Y	US 2014/271216 A1 (SYROVY GEORGE J [US]) 18 September 2014 (2014-09-18) paragraphs [0065], [0066], [0071]; figures 14, 15	2,8,11, 12,16

Y	US 2015/275856 A1 (TAHAR SIAVASH TALEBI [DK] ET AL) 1 October 2015 (2015-10-01) figure 30 paragraph [0082]	3-6

Y	EP 3 179 093 A1 (WINFOOR AB [SE]) 14 June 2017 (2017-06-14) paragraph [0088]; figures 3,4	13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 August 2024	03/09/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Król, Marcin

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/066653

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 2014162312	A1	09-10-2014	NONE			
US 2014271216	A1	18-09-2014	NONE			
US 2015275856	A1	01-10-2015	CA	2926381	A1	17-04-2014
			DK	2906819	T3	06-06-2017
			EP	2906819	A1	19-08-2015
			ES	2626450	T3	25-07-2017
			PL	2906819	T3	31-08-2017
			US	2015275856	A1	01-10-2015
			WO	2014056507	A1	17-04-2014
EP 3179093	A1	14-06-2017	CN	108368823	A	03-08-2018
			DK	3387251	T3	09-03-2020
			EP	3179093	A1	14-06-2017
			EP	3387251	A1	17-10-2018
			US	2019024629	A1	24-01-2019
			WO	2017097677	A1	15-06-2017