(12) UK Patent Application (19) GB (11) 2617460 (13) A

(43) Date of A Publication **11.10.2023**

(21) Application No: **2303678.3**

(22) Date of Filing: **13.03.2023**

(30) Priority Data:
(31) **2203463** (32) **13.03.2022** (33) **GB**

(71) Applicant(s):
Keymac Packaging Systems Limited
(Incorporated in the United Kingdom)
Unit 28b Burnett Business Park, Gypsy Lane, KEYNSHAM, Bath and North East Somerset, BS31 2ED, United Kingdom

(72) Inventor(s):
Albert Bradley

(74) Agent and/or Address for Service:
Bryers LLP
Office 5, Bristol & Bath Science Park, Dirac Crescent, Emerson's Green, Bristol, BS16 7FR, United Kingdom

(51) INT CL:
F03D 3/06 (2006.01) ***F03D 3/04*** (2006.01)
F03D 15/10 (2016.01)

(56) Documents Cited:
EP 1806500 A1 **WO 2010/151060 A2**
CN 209704760 U **CN 201810496 U**
CN 111456897 A **JP 2003049760 A**

(58) Field of Search:
INT CL **F03D**
Other: **SEARCH-PATENT**

(54) Title of the Invention: **Wind turbine apparatus**
Abstract Title: **Wind turbine with cuboidal casing and means to control orientation of blades**

(57) Wind turbine comprising cuboidal casing (fig.1,20) and plurality of turbine blades 50 coupled to output shaft (fig.4,40). The casing may be cubical and may define chamber (fig.3,22) for air flow from inlet (fig.1,24) to outlet. A portion (fig.1,26) of chamber may be tapered. A fin (fig.3,38) may be used for orientation. There may be three blades spaced 120 degrees apart, each blade may have aerofoil profile. The output shaft may be oriented horizontally and/or transverse to wind flow. Each blade may be coupled to output shaft by control gears 52 to adjust orientation of blades during rotation. The control gear may orient blades normal to wind flow when blade moves in direction of wind flow. The control gears may orient the blades to move upwards/downwards in direction of rotational travel. Control gears may orient the blades to be parallel to direction of wind flow when moving in opposite direction to wind flow. Control gears may enable rapid transition between blade orientation. Blades may be coupled to output shaft via planetary gearing, which may comprise control gears coupled to idler gear 54. Power take-off device (fig.1,60), case mesh, pedestal (fig.1,30), wheels (fig.7,70), may be included. Turbine may be part of array.

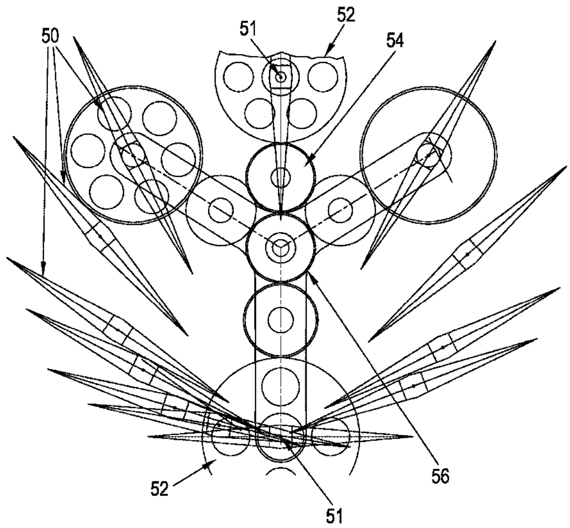

Fig. 5

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2617460 A

30 05 23

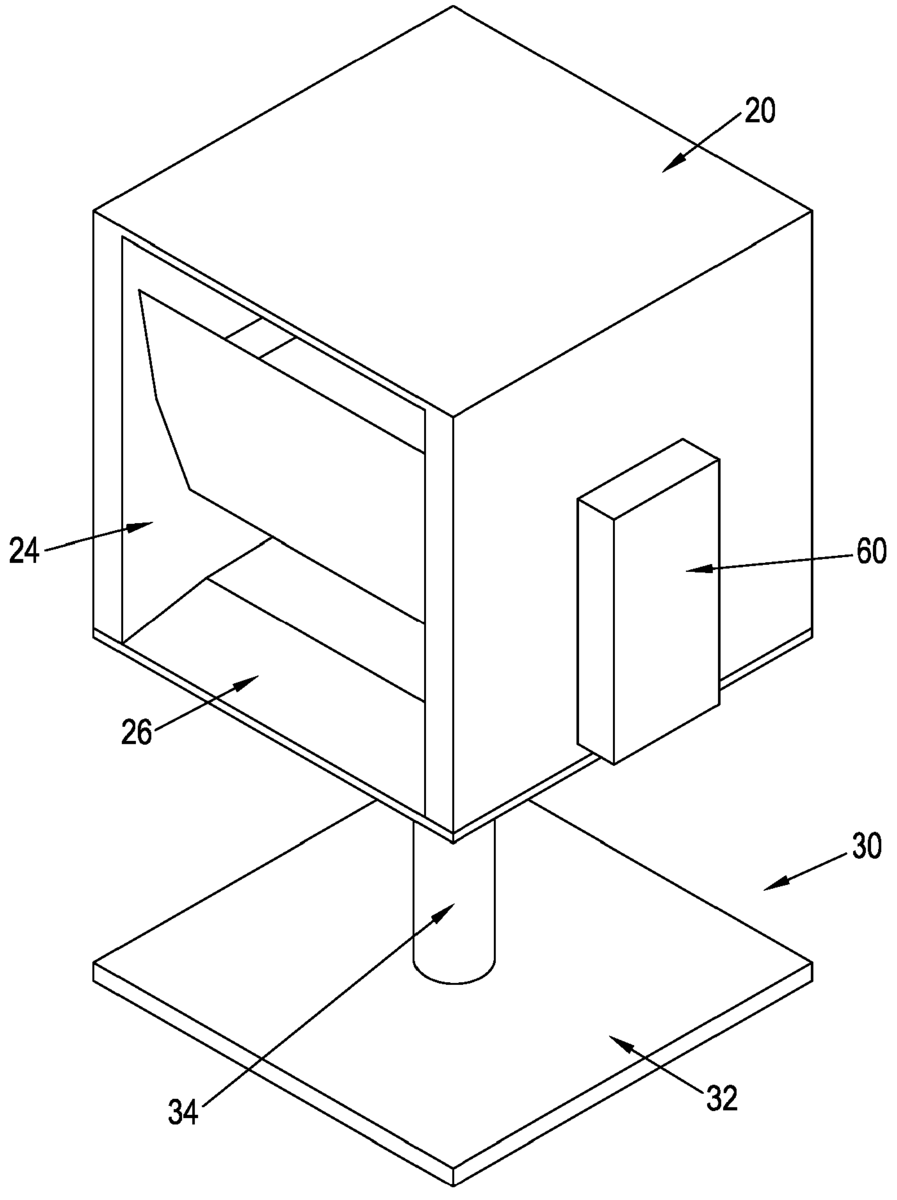

Fig. 1

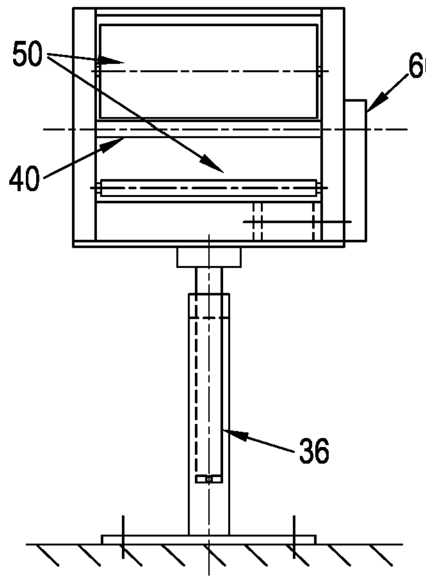

Fig. 2

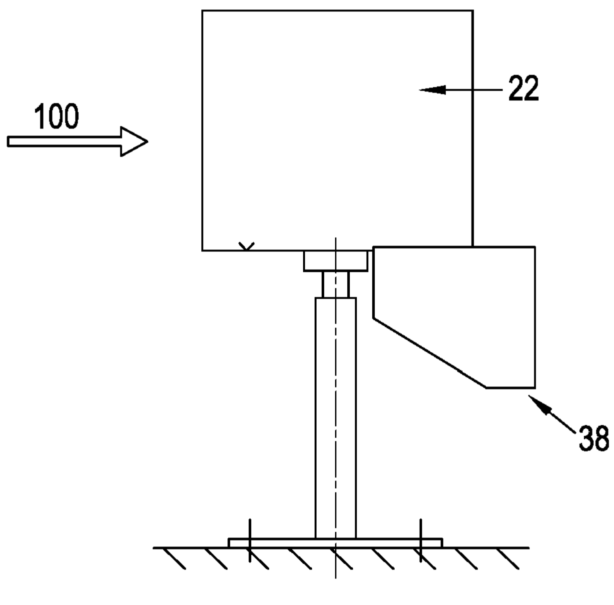

Fig. 3

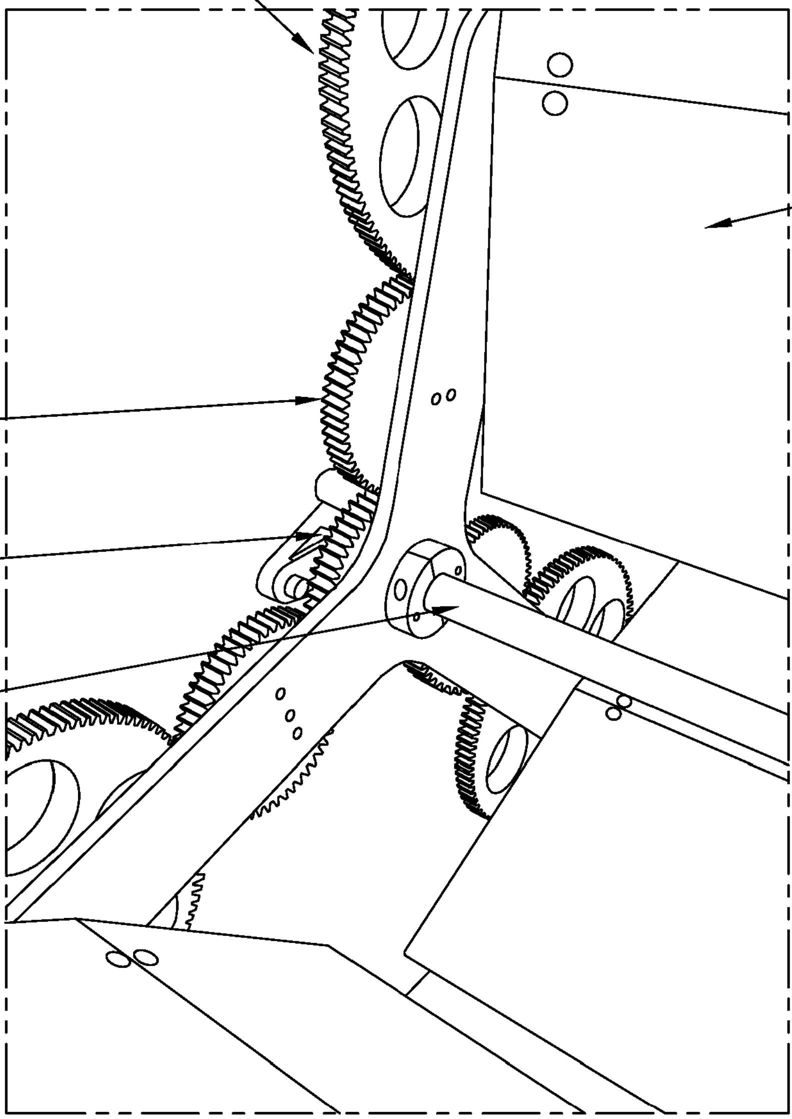

Fig. 4

30 05 23

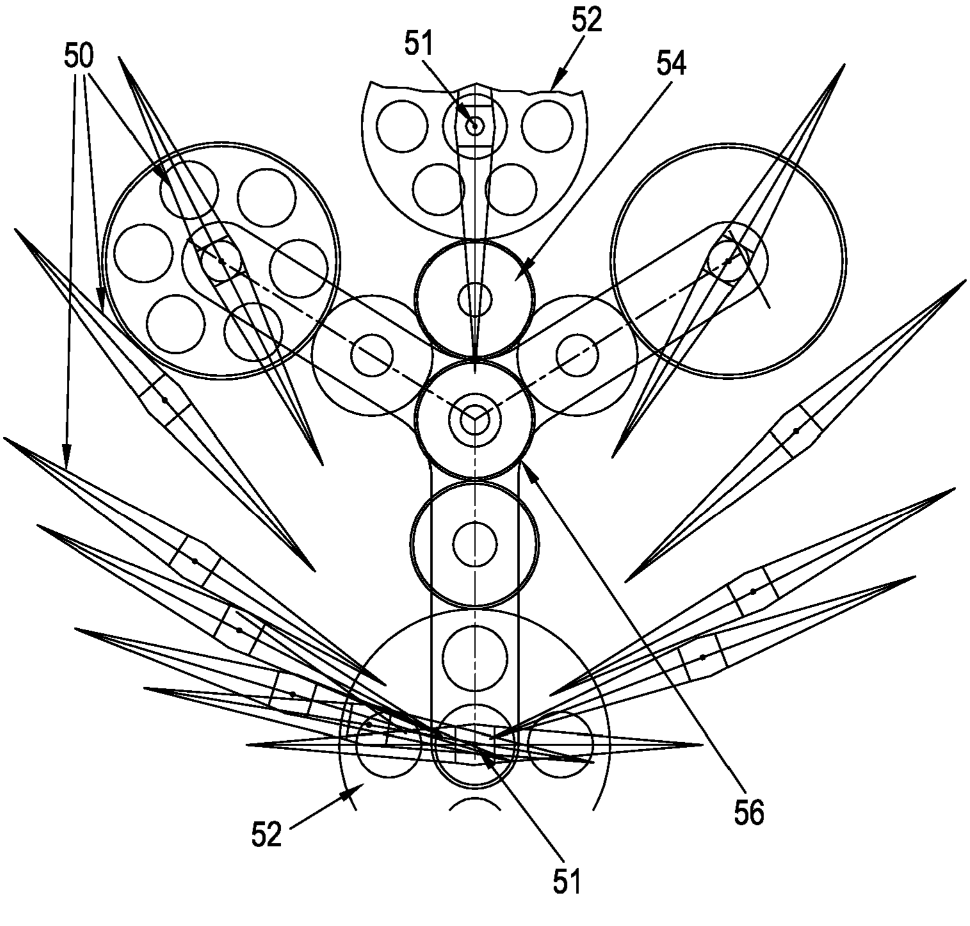

Fig. 5

30 05 23

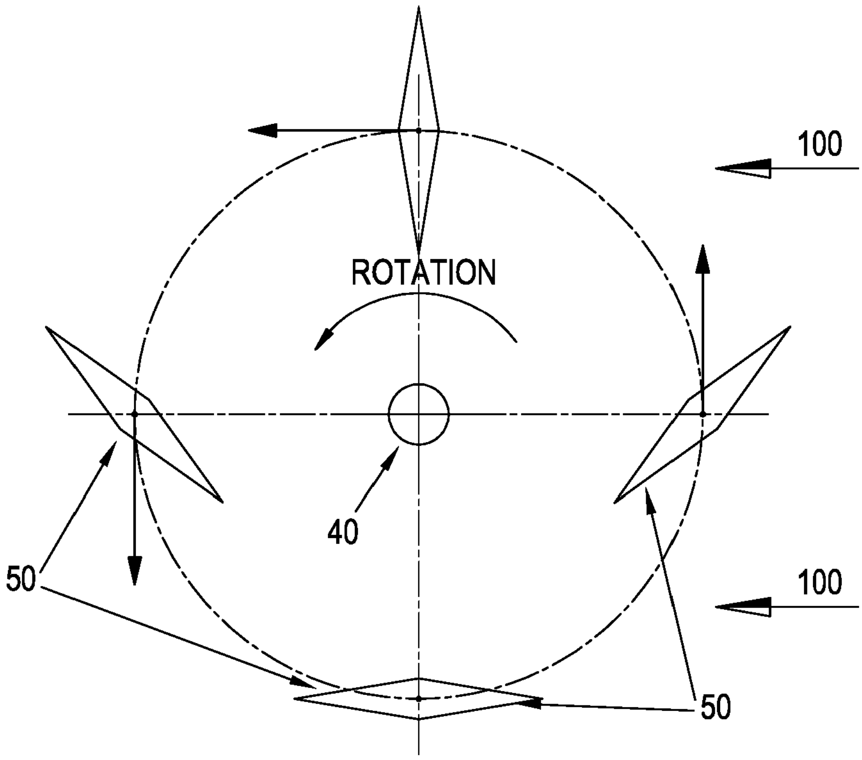

Fig. 6A

30 05 23

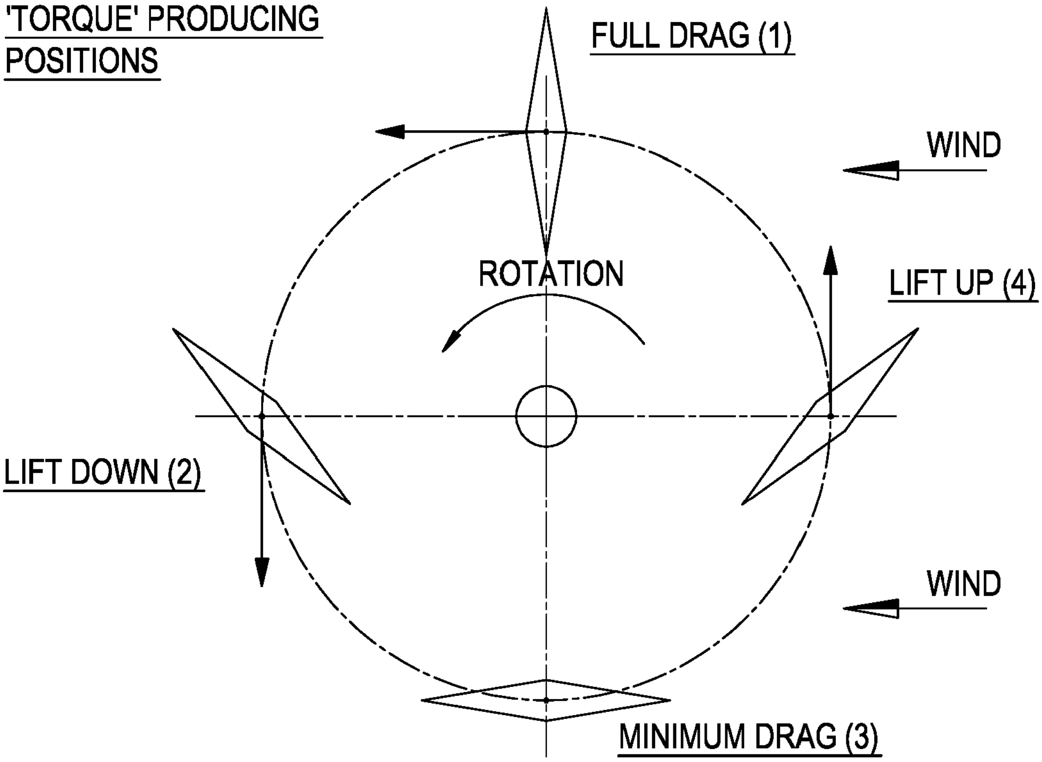

Fig. 6B

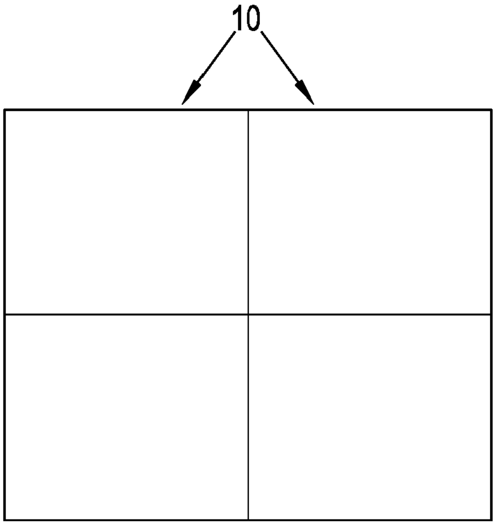

Fig. 7A

30 05 23

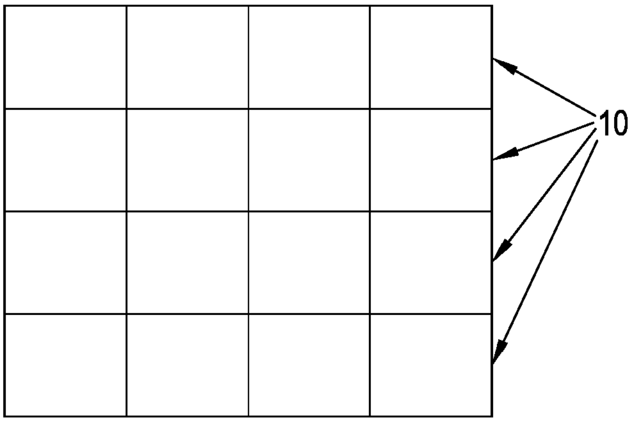

Fig. 7B

30 05 23

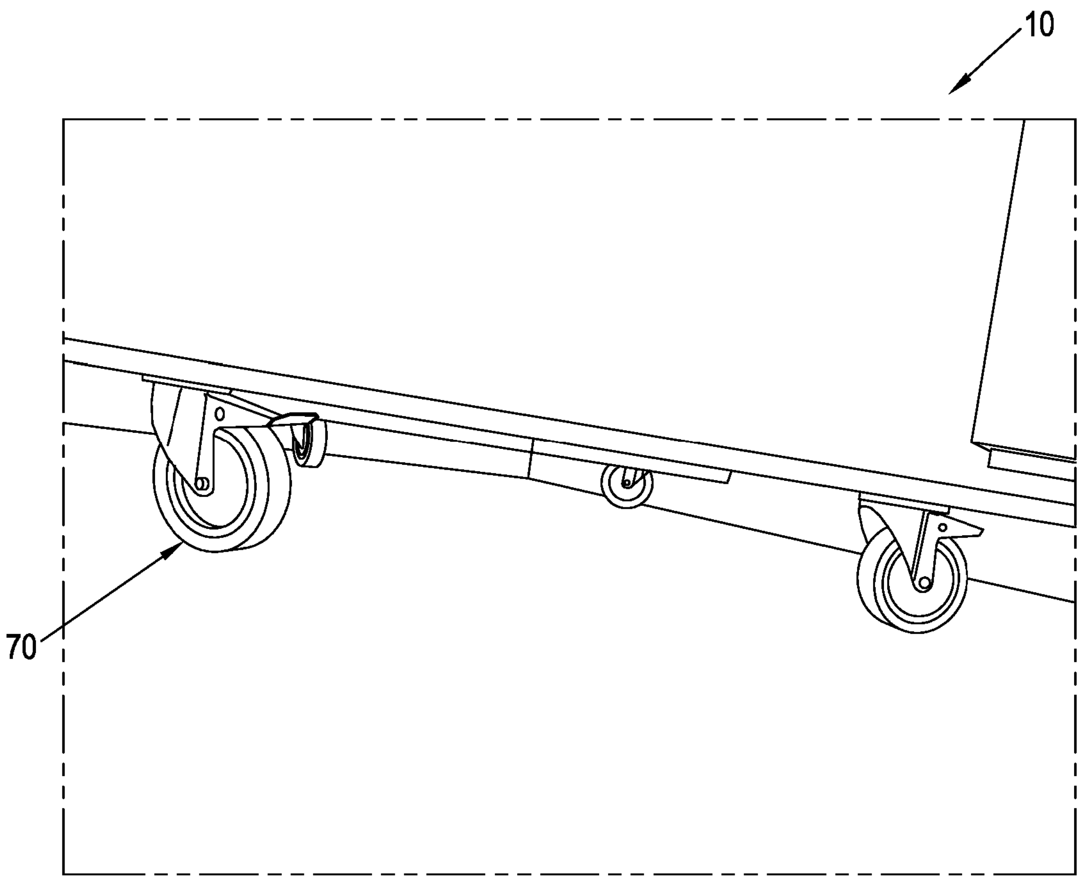

Fig. 8

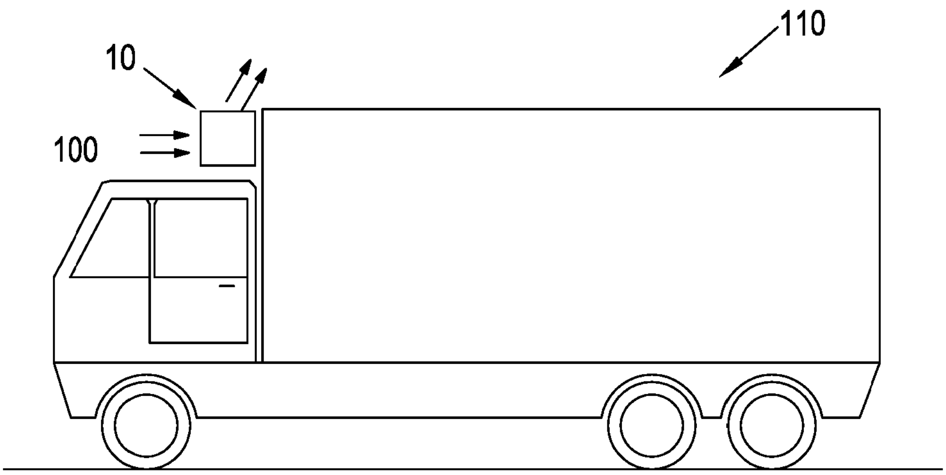

Fig. 9

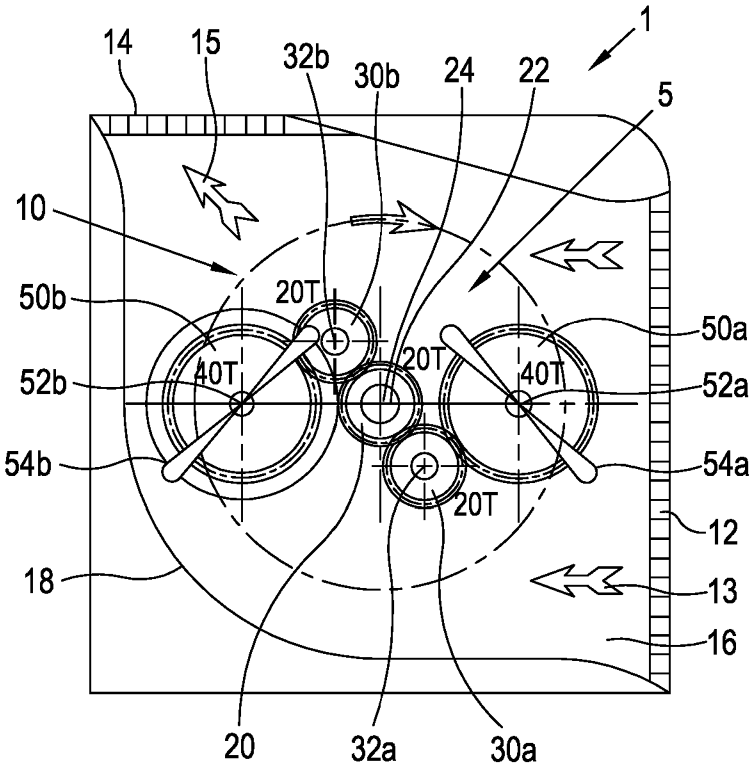

Fig. 10A

30 05 23

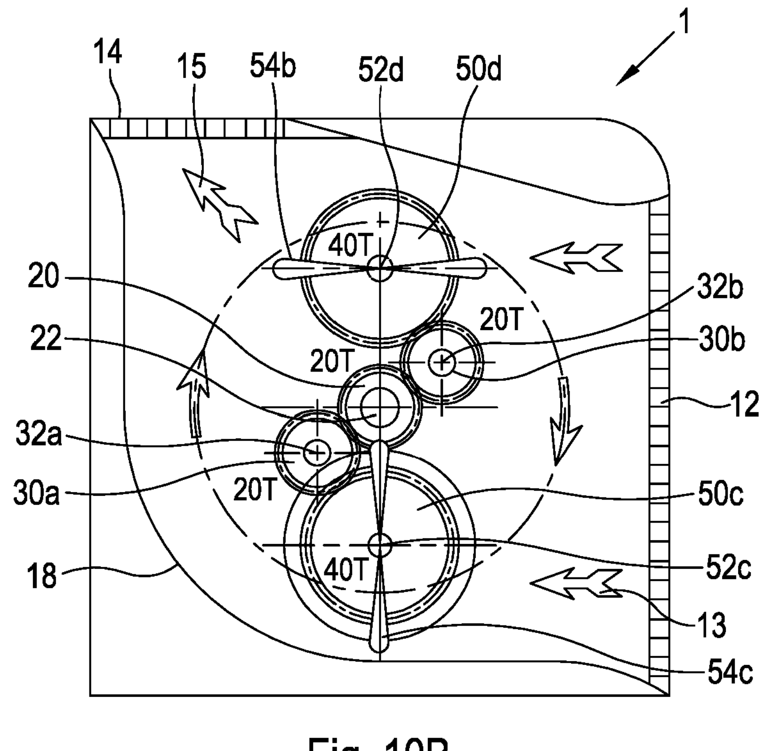

Fig. 10B

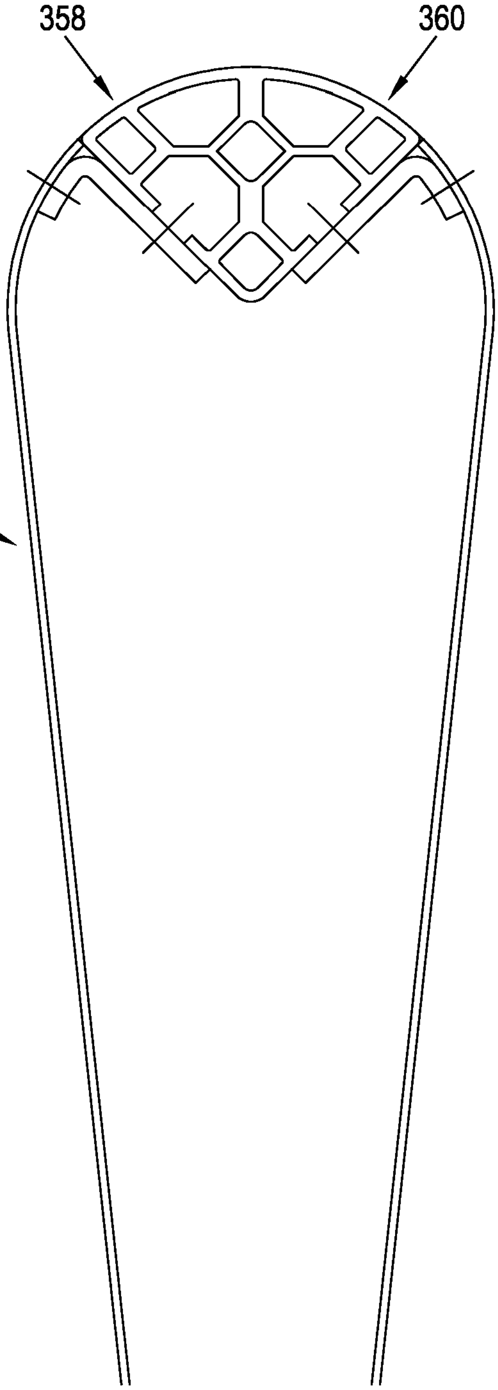

Fig. 11

30 05 23

30 05 23

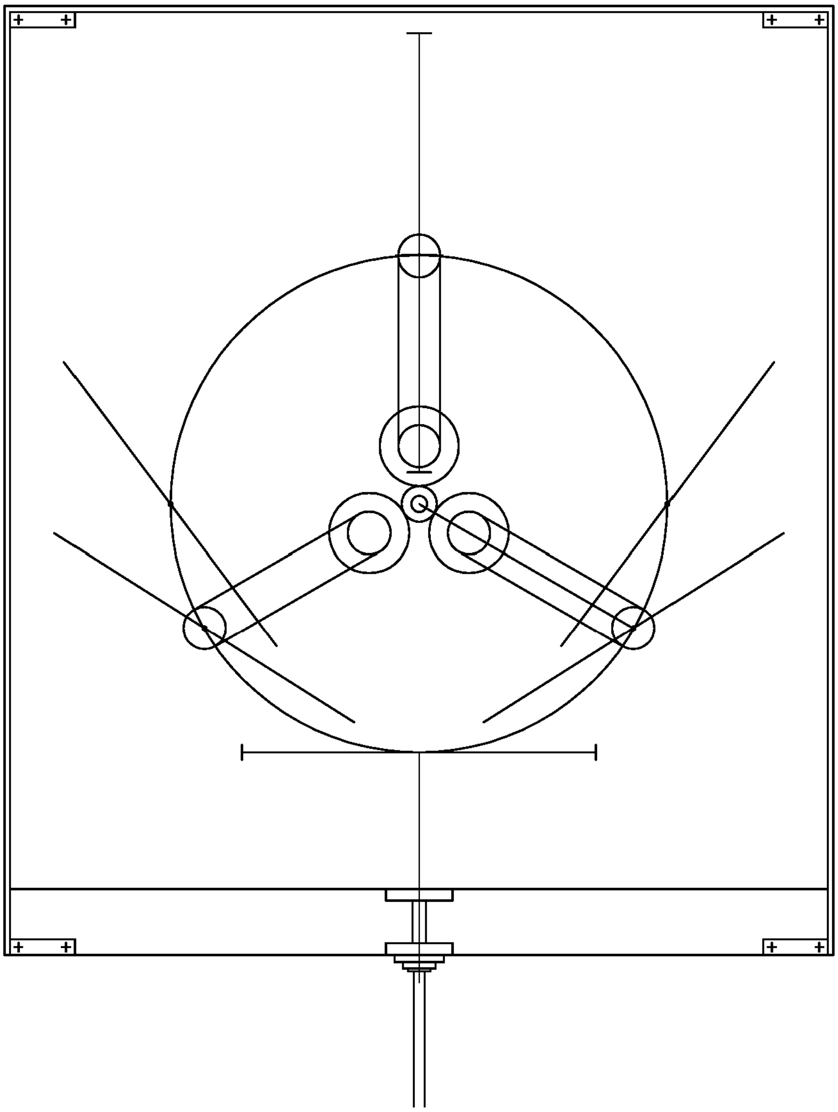

Fig. 12

WIND TURBINE APPARATUS

The present invention relates to wind turbine apparatus. In particular, but not exclusively, the present invention relates to small or micro wind turbine apparatus for small-scale or domestic applications.

It is known to provide small wind turbines, typically produce between 500 W and 10 kW of power, to provide power for a boat, caravan, refrigeration unit, or heat pump compressor or the like. These devices typically use a direct drive generator and use a fin to point into the wind. The turbine blades are usually 1.5 to 3.5 metres in diameter. The majority of small wind turbines are horizontal-axis and lift type devices. Being lift type devices, the blades tend to only produce torque for rotating the output shaft when the blades are at particular rotational positions relative to the wind flow. This can cause the arrangement to be imbalanced which can cause unwanted vibrations.

For the majority of small wind turbines, the wind flow is unconfined as the device is uncased. For devices that do have a casing, they are typically irregular in shape. Also, the devices have a pre-set power rating. If this becomes inadequate for a user, the whole device must be replaced with a more powerful device.

It is desirable to provide an improved small wind turbine which can be modular and part of a set of devices. One or more devices can be added to the set if more power is required.

It is desirable to provide an improved small wind turbine which is stackable.

According to an aspect of the present invention there is provided a wind turbine comprising: a casing; and a plurality of turbine blades coupled to an output shaft, the blades and output shaft provided within the casing, wherein the casing is substantially cuboidal.

According to a further aspect of the present invention there is provided a small wind turbine comprising: a casing having an air inlet and an air outlet and adapted to confine and direct air flowing into the air inlet and towards the air outlet; and a plurality of turbine blades coupled to an output shaft, the blades and output shaft provided within the casing, wherein the casing is substantially cuboidal.

The casing may be substantially cubical.

The casing may define a chamber through which air flows from the air inlet to the air outlet.

The casing may constrain the wind flowing from the inlet to the outlet.

The air inlet or a portion of the chamber may be tapered or flared such that air is funnelled as it approaches a turbine blade.

The wind turbine may include a fin for orientating the wind turbine such that it is normal to the wind flow direction. The fin may be coupled to the casing.

The wind turbine may include three turbine blades coupled to the output shaft.

Each blade may be positioned about the shaft at approximately 120 degrees relative to each of the other blades.

Each blade may have an aerofoil profile.

The output shaft may be horizontally orientated.

Each turbine blade may be coupled to the output shaft by one or more control gears. One or more control gears may be adapted to control the orientation of the blade as it rotates about the output shaft.

One or more control gears may be adapted to maintain the orientation of the blade such that it is substantially normal to the wind flow direction for at least a first portion of the rotational travel of the blade. The first portion of the rotational travel of the blade may be when the blade is moving in the direction of the wind flow. At this orientation, the blade provides a maximum resistance to wind flow and so it moved in the direction of the wind flow using the drag effect.

One or more control gears may be adapted to maintain the orientation of the blade such that the wind flow causes the blade to be moved downwards due to the lift effect for at least a second portion of the rotational travel of the blade. The second portion of the rotational travel of the blade may be when the blade is moving in the direction of the wind flow and moving downwards. At this orientation, the blade acts as an aerofoil in the wind flow and so it moved downwards by the wind flow using the lift effect.

One or more control gears may be adapted to maintain the orientation of the blade such that the wind flow causes the blade to be moved upwards due to the lift effect for at least a third portion of the rotational travel of the blade. The third portion of the rotational travel of the blade may be when the blade is moving in the opposite direction to the direction of the wind flow and moving upwards. At this orientation, the blade acts as an aerofoil in the wind flow and so it moved upwards by the wind flow using the lift effect.

One or more control gears may be adapted to maintain the orientation of the blade such that it is substantially parallel to the wind flow direction for at least a fourth portion of the rotational travel of the blade. At this orientation, the blade provides a low or minimum resistance to wind flow.

One or more control gears may be adapted to rapidly transition of the orientation of the blade from one of the first, second, third or fourth portion of the rotational travel to another of the first, second, third or fourth portion of the rotational travel.

The turbine blades may be coupled to the output shaft by planetary gearing.

Each blade may be mounted to a control gear. Each control gear may be coupled to the output shaft via an idler gear.

The wind turbine may include a power take off device coupled to or forming part of the output shaft.

A plurality of slats, mesh or the like may be provided at the air inlet to inhibit objects entering the casing.

The wind turbine may include a pedestal for raising the height of the casing.

A plurality of wind turbines may be provided. The plurality of wind turbines may be in a stacked arrangement.

Each of the plurality of wind turbines may be connectable to a common power take off device.

The wind turbine may include wheels or castors such that it is transportable.

The wind turbine may be mountable to a vehicle for powering one or more components of the vehicle. A vehicle provided with one or more wind turbines formed in accordance with the present invention is contemplated.

A further aspect provides a small wind turbine comprising: a casing having an air inlet and an air outlet and adapted to confine and direct air flowing into the air inlet and towards the air outlet; and a plurality of turbine blades coupled to an output shaft, the blades and output shaft provided within the casing, wherein the casing is substantially cuboidal.

The casing may be configured so that multiple wind turbines can be placed together, in vertical and/or horizontal arrays.

Where multiple wind turbines are provided a common power take-off may be provided for at least some of the turbines.

A further aspect provides a set of small wind turbines, wherein: each wind turbine comprises: a casing having an air inlet and an air outlet and adapted to confine and direct air flowing into the air inlet and towards the air outlet; and a plurality of turbine blades coupled to an output shaft, the blades and output shaft provided within the casing, wherein the casing is substantially cuboidal, and wherein: the set of small wind turbines are arranged in a stacked configuration.

In some aspects and embodiments a (passive) fin is provided for orientating the turbine to be normal to the wind direction,

In some aspects and embodiments a pedestal is provided upon which the casing can rotate.

In some aspects and embodiments a turbine can rotate on a stand.

Some aspects and embodiments provide or relate to an (active) rotor assembly including a motor and sensor.

Different aspects and embodiments of the invention may be used separately or together.

Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with the features of the independent claims as appropriate, and in combination other than those explicitly set out in the claims.

The present invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a small wind turbine in accordance with a first embodiment of the present invention;

Figure 2 is a front view of the wind turbine of Figure 1;

Figure 3 is a side view of the wind turbine of Figure 1;

Figure 4 is an example of a gearing arrangement;

Figure 5 is an illustration of the orientation of a blade of the wind turbine of the type shown in Figure 1 as the blade rotates about the output shaft;

Figures 6A and 6B illustrate angular orientations of a blade during operation;

Figure 7 (a) and (b) are diagrammatic views of a set of wind turbines in accordance with a second embodiment of the present invention and in a stacked configuration;

Figure 8 shows an embodiment of the present invention provided with castors;

Figure 9 shows a vehicle provided with a wind turbine formed in accordance with the present invention;

Figures 10 A and 10B illustrate a further embodiment;

Figure 11 shows a section of a turbine blade formed in accordance with the present invention; and

Figure 12 is a further example of a gearing arrangement.

Example embodiments are described below in sufficient detail to enable those of ordinary skill in the art to embody and implement the systems and processes herein described. It is important to understand that embodiments can be provided in many alternate forms and should not be construed as limited to the examples set forth herein.

Accordingly, while embodiments can be modified in various ways and take on various alternative forms, specific embodiments thereof are shown in the drawings and described in detail below as examples. There is no intent to limit to the particular forms disclosed. On the contrary, all modifications, equivalents, and alternatives falling within the scope of the appended claims should be included. Elements of the example embodiments are consistently denoted by the same reference numerals throughout the drawings and detailed description where appropriate.

The terminology used herein to describe embodiments is not intended to limit the scope. The articles “a,” “an,” and “the” are singular in that they have a single referent, however the use of the singular form in the present document should not preclude the presence of more than one referent. In other words, elements referred to in the singular can number one or more, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “includes,” and/or “including,” when used herein, specify the presence of stated features, items, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, items, steps, operations, elements, components, and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein are to be interpreted as is customary in the art. It will be further understood that terms in common usage should also be interpreted as is customary in the relevant art and not in an idealized or overly formal sense unless expressly so defined herein.

Referring first to Figure 1, there is shown a small wind turbine 10. The wind turbine 10 comprises a casing 20 which is cuboidal and has six sides each of about 1 m^2 in area and defining an inner chamber of about 1 m^3 in volume. The casing 20 defines an internal chamber 22 and has an air inlet 24 at the front face which is just less in area that the area of the casing 20 and also may have an air outlet (not shown), for example at the rear face having the same or similar area. It is to be understood that the wind turbine 10 could be provided having various dimensions (and power ratings) either smaller or larger than this embodiment.

The casing 20 confines and directs air flowing into the air inlet and towards the air outlet. As seen in Figure 1, a portion 26 of the chamber 22 is tapered so that air entering the chamber 22 is funnelled.

In the embodiment of Figures 1 to 4, the wind turbine 10 includes a pedestal 30 for raising the height of the casing 20. The pedestal 30 comprises a horizontal base 32 and a vertical and cylindrical mounting pole 34. The casing 20 is rotatably mounted to the mounting pole 34 via a bearing 36 so that the casing 20 can easily rotate relative to the mounting pole 34.

The wind turbine 10 includes a fin 38 (seen in Figure 3) for orientating the wind turbine 10 such that it is normal to the wind flow direction 100. The fin is connected to the rear of the casing 20.

An output shaft 40 is rotatably mounted in a horizontal and transverse (to the wind flow direction 100) orientation in a central region of the chamber 22. Three turbine blades 50 are coupled to the output shaft 30. Each blade 50 is positioned about the shaft at 120 degrees relative to each of the other blades. Each blade 50 has an aerofoil profile.

Each turbine blade 50 is mounted on a blade shaft 51. Each blade shaft 51 is coupled to the output shaft 40 by a control gear 52. Each control gear 52 is coupled to an idler gear 54 which is itself coupled to a central gear 56 which is fixedly mounted to the output shaft 40. This is shown in Figure 4. The control gears are adapted to control the orientation of the blades 50 as they rotate about the output shaft 40.

The planetary gearing is configured to control the orientation of the blades 50 as they rotate about the output shaft 40. This is shown in Figure 5 which shows the orientation of a single blade 50 at different rotational positions. Also, Figure 6 shows the single blade and its orientation when it is at the topmost, lowest and each most lateral positions (this figure is not to scale).

When the blade 50 is at a topmost position it is substantially vertical. Indeed, as seen in Figure 4, the blade 50 is fairly vertical for around 45 degrees of rotation on either side of this topmost position due to the gearing. During this first portion of rotational travel, the orientation of the blade 50 is substantially normal to the wind flow direction for at least a of the blade. Particularly at the topmost position, the blade 50 therefore provides a maximum resistance to wind flow and so it moved in the direction of the wind flow 100 using the drag effect.

When the blade 50 is at one of the lateral positions it is at an oblique angle to the direction of wind flow 100. At the left lateral position (as shown in Figure 5), the blade is starting to move downwards. During this second portion of rotational travel, the aerofoil profile of the blade produces a lift effect which causes the blade 50 to be moved downwards and so contributes to rotation of the output shaft 40.

At the right lateral position (as shown in Figure 5), the blade is starting to move upwards. The blade 50 is again at an oblique angle to the direction of wind flow 100 but is inverted relative to the left lateral position. During this third portion of rotational travel, the aerofoil profile of the blade produces a lift effect which causes the blade 50 to be moved upwards and so again contributes to rotation of the output shaft 40.

When the blade is at a lowest position it is substantially horizontal and substantially parallel to the wind flow direction. The blade 50 is fairly horizontal for around 45 degrees of rotation on either side of this lowest position due to the gearing. During this fourth portion of rotational travel, the blade 50 is moving in the opposite direction to the direction of the wind flow 100. However, at this orientation, the blade 50 provides a minimal resistance to wind flow.

In between this first and second portions of rotational travel, the orientation of the blade is quickly transitioned between the orientations described above. Also, the blade 50 is feathered for this fifth portion of rotational travel so that the blade 50 provides a low resistance to wind flow.

As described above, the blade 50 contributes to rotation of the output shaft 40 at each of the first, second and third portions of rotational travel (and provides little or no hindering of rotation during the fourth portion of rotational travel) by utilising multiple aerodynamic effects (drag, lift downwards and lift upwards). It has been found that this arrangement is very well balanced and results in very low levels of vibration and noise during operation.

The wind turbine 10 includes a power take off device 60 coupled to the output shaft 40.

Slats are provided at the air inlet 24 to inhibit objects entering the casing. This could be debris carried by the wind or birds attempting to enter the device.

The wind turbine 10 can be formed using steel, such as stainless steel or aluminium. Components which undergo stressing during operation could be formed from a composite material such as a carbon fibre material.

Figure 7 (a) and (b) show a set of wind turbines in accordance with a second embodiment of the present invention. Like features are provided with like reference numerals. Each of the wind turbines 10 is substantially the same as the first embodiment except that they do not include the pedestal 30. Rather, the wind turbines 10 are in a stacked and close packed configuration. This arrangement takes advantage of the cuboidal shape of each wind turbine 10 to provide a modular set.

Figure 7 (a) shows four stacked wind turbines 10. This arrangement is only twice the height and width of a single unit but provides four times the power of a single unit. Figure 7 (b) shows sixteen stacked wind turbines 10. This arrangement is only four times the height and width of a single unit but provides sixteen times the power of a single unit. Each of the wind turbines 10 can have their own power take off device 60 or they can all be connectable to a common power take off device.

A user can choose a stacked configuration that meets the user's needs. Should this become inadequate in future, the user can simply add more units to the arrangement.

Figure 8 shows a lower portion of a wind turbine in accordance with a third embodiment of the present invention. Like features are provided with like reference numerals. This embodiment is similar to the first two but it can be see the unit is mounted on castors 70. It is therefore easily transportable.

Figure 9 shows a wind turbine in accordance with a fourth embodiment of the present invention. In this embodiment the wind turbine 10 is mounted to a high portion of a vehicle 110. Air flow over the top of the vehicle 110 cause the wind turbine 10 to rotate. This could be used for the likes of vehicle refrigeration or battery charging. In this embodiment, the air outlet has been modified such that it is at a top portion of the casing 20.

A further embodiment of the invention is shown in Figure 10A. A cross section of a turbine 1 is shown, having a rotor assembly 5 housed within a duct 16, the duct having an inlet 12 and an outlet 14. The duct 16 has a curved wall 18 to divert the input airflow 13 through an angle. The rotor assembly 5 comprises a carrier 10 which is fixedly mounted on a rotor shaft 22, both of which are rotatable around a central axis 24. The rotor shaft 22 passes through the fixed gear 20 which remains stationary while the rotor shaft 22 and the carrier 10 turn. Two drive gears 50a, 50b are rotatably mounted to the carrier 10 by respective drive shafts 52a, 52b. Vanes 54a, 54b are mounted on and fixed to respective drive shafts 52a, 52b. Vane 52a is shown in the maximum upstream position within the duct, and vane 526 is shown in the maximum downstream position within the duct. The drive shafts 52a, 52b rotate around axes parallel to and spaced from the axis of the rotor shaft 22. Intermediate gears 30a, 30b are rotatable mounted on the carrier 10, each gear 30a, 30b being rotatable about a respective axis I 32a, I 32b parallel to and spaced from that of the axis of the rotor shaft 22. The intermediate gears 30a, 30b connect the drive gears 50a, 50b to the fixed gear 20. The gear ratio of the fixed gear to the drive gears 50a, 50b is 2:1 so that the vanes 54a, 54b only rotate 180° for every 360° rotation of the carrier. In this embodiment, the drive gears 50a, 50b have 40 teeth, and the intermediate gears 30a, 3013 and the fixed gear have 20 teeth each. The drive gears 50a, 50b and the intermediate gears 30a, 30b form a double planetary gear system around a sun gear, the fixed gear 20.

Figure 10B shows the turbine 1 of Figure 10A after the rotor assembly 5 has rotated by 90 degrees around the rotor shaft 22. Vanes 52c and 52d are at intermediate points between the maximum upstream and maximum downstream positions.

The pressure applied to the vanes 54a and 54b by the inlet airflow 13 causes the carrier 10 to rotate around the central rotor axis. The vanes 54a, 54b cannot freely rotate with the airflow due to the engagement of the drive gears 50a, 50b, with the fixed gear 20 via the belt drives 40a, 40b. The rotation of the carrier 10 relative to the fixed gear 20 therefore causes rotation of the drive gears 50a, 50b. The gear ratio of the fixed gear 20 to drive gears 50a, 50b is 2:1 so that the vanes 54a, 54b only turn through 180° for every 360° rotation of the carrier 10. This vane rotation causes the vane at the intermediate point 52d travelling against the airflow to be substantially parallel to the inlet airflow 13. This gives the vane a feathered effect, reducing the drag on the vane when it is travelling against the direction of the inlet airflow 13. The vane at the intermediate point 52c travelling with the airflow is therefore held substantially perpendicular to the inlet airflow 13. As the vanes rotate with the carrier around the central axis 24, each vane is turned such that its angular position stays substantially transverse the airflow path throughout the length of the curved duct wall 18. The inlet airflow 13 is not parallel to the outlet airflow 15 due to the shape of the curved duct wall 18 (although further ducting may be provided to achieve this). The combination of the wall 18 and the angular position of the vane therefore allows a greater frontal area to face the airflow through the duct 16.

The duct confines and directs the airflow to turn through an angle such to reduce the variation in the frontal area as the vanes move from a point in their orbit in which they move with the airflow towards a point moving against the airflow. The duct outlet airflow may not be parallel to the duct inlet airflow.

The turbine may be provided in the form of a cuboidal unit which is provided with wheel or other rolling support means.

The turbine blade 250 of Figure 11 is provided with a curved/hemispherical end 358 and a tapering body 359. In this embodiment a generally triangular end section 360 (shaped like a circular sector) which is separate from and connected to the body (which is formed with a corresponding recess).

Although illustrative embodiments of the invention have been disclosed in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiments shown and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims and their equivalents.

CLAIMS

1. A wind turbine comprising a casing and a plurality of turbine blades coupled to an output shaft, the blades and output shaft provided within the casing, wherein the casing is substantially cuboidal.

2. A wind turbine as claimed in Claim 1, wherein the casing is substantially cubical.

3. A wind turbine as claimed in Claim 1 or 2, wherein the casing defines a chamber through which air flows from the air inlet to the air outlet.

4. A wind turbine as claimed in Claim 3, wherein the air inlet or a portion of the chamber is tapered or flared such that air is funnelled as it approaches a turbine blade.

5. A wind turbine as claimed in any preceding claim, including a fin for orientating the wind turbine such that it is normal to the wind flow direction.

6. A wind turbine as claimed in any preceding claim, including three turbine blades coupled to the output shaft.

7. A wind turbine as claimed in Claim 6, wherein each blade is positioned about the shaft at 120 degrees relative to each of the other blades.

8. A wind turbine as claimed in any preceding claim, wherein each blade has an aerofoil profile.

9. A wind turbine as claimed in any preceding claim, wherein the output shaft is horizontally orientated.

10. A wind turbine as claimed in any preceding claim, wherein the output shaft is orientated generally transverse to the wind flow direction.

11. A wind turbine as claimed in any preceding claim, wherein each turbine blade is coupled to the output shaft by one or more control gears.

12. A wind turbine as claimed in Claim 11, wherein one or more control gears are adapted to control the orientation of the blade as it rotates about the output shaft.

13. A wind turbine as claimed in Claim 12, wherein one or more control gears are adapted to maintain the orientation of the blade such that it is substantially normal to the wind flow direction for at least a first portion of the rotational travel of the blade, thus causing movement of the blade due to drag effect of the wind flow.

14. A wind turbine as claimed in Claim 13, wherein the first portion of the rotational travel of the blade occurs when the blade is moving in the direction of the wind flow.

15. A wind turbine as claimed in any of Claims 12 to 14, wherein one or more control gears are adapted to maintain the orientation of the blade such that it is caused to move upwards or downwards but in the direction of rotational travel due to a lift effect of the wind flow for one or both of a second and a third portion of the rotational travel of the blade.

16. A wind turbine as claimed in any of Claims 12 to 15, wherein one or more control gears are adapted to maintain the orientation of the blade such that it is substantially parallel to the wind flow direction for at least a fourth portion of the rotational travel of the blade, thus providing a low or minimum resistance to wind flow.

17. A wind turbine as claimed in Claim 16, wherein the fourth portion of the rotational travel of the blade occurs when the blade is moving in the opposite direction to the direction of the wind flow.

18. A wind turbine as claimed in any of Claims 12 to 17, wherein one or more control gears are adapted to rapidly transition the orientation of the blade from one of the first, second, third or fourth portion of the rotational travel to another of the first, second, third or fourth portion of the rotational travel.

19. A wind turbine as claimed in any preceding claim, wherein the turbine blades are coupled to the output shaft by planetary gearing.

20. A wind turbine as claimed in Claim 19, wherein each blade is mounted to a control gear, and wherein each control gear is coupled to the output shaft via an idler gear.

21. A wind turbine as claimed in any preceding claim, including a power take off device coupled to or forming part of the output shaft.

22. A wind turbine as claimed in any preceding claim, including a plurality of slats or a mesh provided at the air inlet to inhibit objects entering the casing.

23. A wind turbine as claimed in any preceding claim, including a pedestal for raising the height of the casing.

24. A wind turbine as claimed in any preceding claim, including wheels or castors for transporting the wind turbine.

25. A wind turbine array comprising a plurality of wind turbines as claimed in any preceding claim.

Intellectual Property Office

Application No:	GB2303678.3	**Examiner:**	Joe Mahoney
Claims searched:	1-25	**Date of search:**	3 August 2023

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-3,5,6,8,11-25	CN 111456897 A (ANHUI) - See figures 1-3,8 and WPI abstract accession number 2020-726603
X	1-25	WO 2010/151060 A2 (HONG) - See in particular figures 1, 3 and 7 and EPODOC abstract.
X	1-6,8-25	CN 201810496 U (RENLIN) - See figures 1, 4 and 7 and EPODOC abstract.
X	1-8,21-25	CN 209704760 U (LUO) - See figures 1 and 2 along with EPODOC abstract.
X	1-6,8-25	JP 2003049760 A (MATSUMOTO) - See figures and EPODOC abstract.
X	1-6,8-25	EP 1806500 A1 (BERNAL) - See figures and paragraphs [0043],[0048]

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F03D

The following online and other databases have been used in the preparation of this search report

SEARCH-PATENT

International Classification:

Subclass	Subgroup	Valid From
F03D	0003/06	01/01/2006
F03D	0003/04	01/01/2006
F03D	0015/10	01/01/2016