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[Continued on next page]

(54) Title: NOVEL TURBINE BLADE AND TURBINE ASSEMBLY

(57) Abstract: A turbine assembly comprises an anchor plate, at least one turbine blade mounted to the anchor plate and having an elongated blade body having a longitudinal axis parallel to an axis of rotation, and the at least one turbine blade being operable to move between a first position relative to the axis of rotation and a second position relative to the axis of rotation.

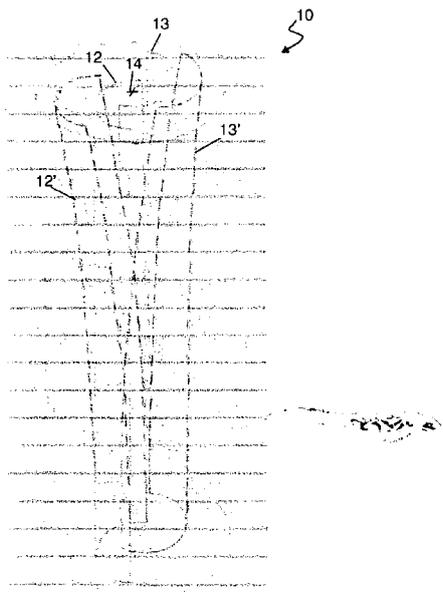


FIG. 1





— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))* — *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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NOVEL TURBINE BLADE AND TURBINE ASSEMBLY

FIELD

[0001] The present disclosure relates to the field of power generation, and more
5 particularly to a novel turbine blade and turbine assembly.

BACKGROUND

[0002] Turbines are the workhorse of the power generation industry. A turbine
converts the kinetic energy of a fluid into the mechanical energy of its rotating blades.
Typically consisting of a number of turbine blades mounted about a central rotating shaft,
10 turbines are used to generate electricity from flowing wind, water, gas, steam, and other
fluids. Turbines can be vertically mounted such as vertical axis wind turbines (VAWT) or
horizontally mounted such as horizontal axis wind turbines (HAWT).

[0003] The Savonius turbine, invented by Sigurd Johannes Savonitjs, is a
primarily drag-type vertical axis wind turbine disclosed in U.S. Pat. No. 1,697,574. It
15 typically uses two half-barrel shaped vanes which are mounted for rotation about a
substantially vertical axis.

[0004] The Darrieus wind turbine is a primarily lift-type vertical axis wind
turbine. This turbine consists of a number of straight or curved vanes typically vertically
mounted about a rotating shaft. This turbine design was invented by Georges Jean Marie
20 Darrieus for which he received a patent, U.S. Pat. No. 1,835,018.

[0005] Conventional turbine blade designs generally incorporate various
modifications and improvement to the Darrieus and Savonius turbine concepts to achieve
more efficiency and higher power-generating capacity. For example, a more recent
improvement of a Darrieus-type turbine includes blades that are helically mounted about

the center shaft, such as the Gorlov helicoid turbine invented by Alexander M. Gorlov in the late 1990's and disclosed in U.S. Patent No. 5,451,137. Another modified Darrieus-type vertical wind turbine was constructed by Edward Lenz, and includes three straight airfoil-shaped blades mounted about a central shaft.

5 SUMMARY

[0006] A turbine assembly comprises an anchor plate, at least one turbine blade mounted to the anchor plate and having an elongated blade body having a longitudinal axis parallel to an axis of rotation, and the at least one turbine blade being operable to move between a first position relative to the axis of rotation and a second position relative
10 to the axis of rotation.

[0007] A turbine assembly comprises at least one turbine blade having a blade body having a longitudinal axis parallel to an axis of rotation, and a cross-section that comprises a leading blade edge, a trailing blade edge, an inner blade face coupling the leading blade edge and the trailing blade edge, an outer blade face also coupling the
15 leading blade edge and the trailing blade edge, and the trailing blade edge having inner and outer cup wings that define a cupped surface. The at least one turbine blade being operable to move between a first position relative to the axis of rotation to a second position.

DESCRIPTION OF THE DRAWINGS

20 [0008] FIG. 1 is a side perspective view of an exemplary embodiment of a turbine assembly 10 showing lateral blade movement according to the present disclosure;

[0009] FIG. 2 is a cross-sectional view of the turbine assemblies shown in FIG. 1 shown superimposed to highlight differences;

[0010] FIG. 3 is a cross-sectional view of the turbine assemblies shown in FIG. 1 shown superimposed to highlight differences;

[0011] FIG. 4 is a cross-sectional view of the turbine assemblies showing various variable parameters discussed in more detail herein;

5 [0012] FIG. 5 is a side view of a turbine assembly according to another exemplary embodiment of the present disclosure;

[0013] FIG. 6 is a side view of a turbine assembly according to another exemplary embodiment of the present disclosure;

[0014] FIG. 7 is a side perspective view of a turbine assembly according to an
10 exemplary embodiment of the present disclosure;

[0015] FIG. 8 is a cross-sectional view of the turbine assembly shown in FIG. 7 according to an exemplary embodiment of the present disclosure;

[0016] FIG. 9 is a side perspective view of a turbine assembly according to another exemplary embodiment of the present disclosure;

15 [0017] FIG. 10 is a cross-sectional view of the turbine assembly shown in FIG. 9 according to an exemplary embodiment of the present disclosure;

[0018] FIG. 11 is a cross-sectional view of an exemplary embodiment of a single turbine blade to illustrate the various parts of the blade;

[0019] FIG. 12 is a side perspective view of a turbine assembly according to yet
20 another exemplary embodiment of the present disclosure;

[0020] FIGS. 13A and 13B are a side perspective view and a bottom plan view illustrating a street application of a turbine assembly according to an exemplary embodiment of the present disclosure;

[0021] FIG. 14 is a side perspective view of a turbine assembly according to yet another exemplary embodiment of the present disclosure; and

[0022] FIGS. 15-23 are cross-sectional views of the turbine assembly according to exemplary embodiments of the present disclosure.

5 DETAILED DESCRIPTION

[0023] FIG. 1 is a side perspective view of an exemplary embodiment of a turbine assembly 10 showing lateral blade movement according to the present disclosure. Turbine assembly 10 includes two exemplary turbine blades 12 and 13 having a semi-circular cross-section situated about a central rotational axis 14 facing each other in an off-set
10 manner. Both blades 12 and 13 are generally half circular arcs facing each other. However, other blade shapes are contemplated herein. The turbine blades 12 and 13 may be securely attached to one or more anchor plate or end plate, where an end plate is fastened to an end of the blades and an anchor plate may be fastened to the blades anywhere along the longitudinal axis such as at mid-point. Certain details of the turbine
15 blade parameters are set forth below in conjunction with references to FIG. 4.

[0024] As shown, the blades 12 and 13 of turbine assembly 10 may be displaced outwardly from the central rotational axis 14 to a second position illustrated by blades 12' and 13'. The blades may be controllably and dynamically moved or tilted in this manner to achieve a predetermined degree of incline and/or distance outwardly from the central
20 rotational axis 14 under certain wind and/or operating conditions. Although the blade movement shown is primarily focused in the top of the blades, it should be understood that both ends of the blades may be displaced to its respective second positions to the same or different distance from the central rotational axis 14. The blades 12 and 13 may

be moved in this manner and controllably and securely locked in the second position until conditions are such that they should be moved again to achieve optimal operations.

[0025] Although turbine assembly 10 is shown with a pair of turbine blades 12 and 13, it should be noted that a turbine assembly may have any number of blades, including a single blade. The number of blades as well as the configuration of the blade displacement may be determined upon the particular application desired (energy generation, propulsion, etc.), the type of fluid environment (e.g., surf, ocean, river, wind), and the orientation of the blades (e.g., horizontal, vertical, or at an angle).

[0026] FIG. 2 is a cross-sectional view of the turbine blades 12 and 13 shown in FIG. 1. FIG. 2 shows the cross-sections near the tops of the turbine blades. It may be seen that the turbine blades 12 and 13 are displaced to a second position illustrated by blades 12' and 13'.

[0027] FIG. 3 is another cross-sectional view of the turbine assemblies 12 and 14 shown in FIG. 1. FIG. 3 shows the cross-sections near the tops of the turbine blades. It may be seen that in this view, turbine blades 12 and 13 are displaced to a second position illustrated by blades 12'' and 13''. The displacement in this example involves an angular displacement to achieve a slight twist the blades. The turbine blades 12'' and 13'' have a simple helix configuration.

[0028] It is contemplated that a suitable mechanism is employed to achieve the displacement of the blades in various dimensions. The mechanism is operable to controllably move the blades in various degrees of displacement and/or to move the blades between one predetermined position and a second predetermined position. Further, the blades can be securely locked in position once the displacement is completed. The mechanism may achieve the blade movements while the turbine assembly is rotating, or

while the assembly is stationary. The mechanism may include conventional electronic circuitry, and electro-mechanical and mechanical components including but is not limited to controllers, drives, solenoids, actuators, motors, pneumatic/hydraulic cylinders, linkages, springs, and sensors, for example.

5 **[0029]** It is contemplated that the turbine blades may have a predetermined shape that has a variable size from one end of the blade to the other end. For example, the diameter of a semi-circular shaped blade may be smaller at one end and larger at the second end, for example. Similarly, the thickness and configuration of the blades may vary from one end of the blade to the other end.

10 **[0030]** FIG. 4 is a cross-sectional view of the turbine blades showing various variable parameters discussed in more detail herein. The exemplary turbine blades are identical and have a generally semi-circular cross-sectional shape. The two blades face each other in an off-set manner. The off-set may be indicated by a parameter, a , in one axis and a second parameter, e , in a second axis, as shown. In one exemplary
15 embodiment, the first gap parameter a is $d/8$ and the second gap parameter e is $3d/8$, where d is the diameter of the semi-circular blades.

[0031] FIG. 5 is a side view of a 3-dimensional rendition of turbine assembly 10 with turbine blades 12 and 13 arranged about a central rotational axis as shown in FIG. 1. The turbine assembly includes a mechanism 16 that is operable to controllably achieve
20 optimal placement of the turbine blades 12 and 13 as described above.

[0032] FIG. 6 is a side view of a turbine assembly 20 with turbine blades 21 and 22 according to another exemplary embodiment of the present disclosure. Turbine blades 21 and 22 are also identical and arranged facing each other in an off-set manner as set forth above. However in this embodiment, the turbine blades have a scalloped top edge.

[0033] FIG. 7 is a side perspective view of a turbine assembly 30 according to another exemplary embodiment of the present disclosure. Referring also to FIG. 8 for a cross-sectional view of the turbine assembly 30, which is shown with three identical turbine blades 32-34 arranged about a central shaft 36. The central shaft and the blades of a turbine are also commonly called a rotor. Each turbine blade 32-34 is elongated and formed in a helical configuration along its respective longitudinal axis. In addition to the helical configuration, each blade 32-34 is preferably twisted along its respective longitudinal axis. The turbine blades 42-44 are wrapped around the central rotational shaft 36. As described above, the blades 32-34 may be controllably and dynamically moved or tilted in this manner to achieve a predetermined degree of incline and/or distance outwardly from the central rotational axis under certain wind and/or operating conditions. For the sake of clarity, structural members such as anchor or end plates, support arms, and/or other devices that provide structural rigidity and attach the turbine blades to the central shaft are not shown in the drawing figures.

[0034] FIG. 9 is a side perspective view of a turbine assembly 40 according to another exemplary embodiment of the present disclosure. Referring also to FIG. 10 for a cross-sectional view of the turbine assembly 40, which is shown with three identical turbine blades 42-44 arranged about a central shaft 46. The central shaft and the blades of a turbine are also commonly called a rotor. Each turbine blade 42-44 is elongated and formed in a helical configuration along its respective longitudinal axis. In addition to the helical configuration, each blade 42-44 is preferably twisted along its respective longitudinal axis. The turbine blades 42-44 are wrapped around the central rotational shaft 46. As described above, the blades 42-44 may be controllably and dynamically moved or tilted in this manner to achieve a predetermined degree of incline and/or

distance outwardly from the central rotational axis under certain wind and/or operating conditions. For the sake of clarity, structural members such as anchor or end plates, support arms, and/or other devices that provide structural rigidity and attach the turbine blades to the central shaft are not shown in the drawing figures.

5 **[0035]** To facilitate the description of the various parts of a turbine blade, references are made to FIG. 11 showing a cross-sectional view of an exemplary embodiment of a single turbine blade 50. A turbine blade 50 generally has an elongated cross-section and comprises a leading blade edge 52 coupled to a trailing blade edge 54 by an inner blade face 56 and an outer blade face 28. The leading blade edge 52 is the
10 portion of the turbine blade that points toward the direction of rotation, and the trailing blade edge 54 is the blade edge that trails the leading blade edge 52 as the turbine blade rotates about the central shaft. The turbine blade is positioned or affixed so that the inner blade face 56 generally points toward the central shaft of the turbine, and the outer blade face 58 generally points away from the central shaft 56. The inner blade face 56 may be
15 generally straight or comprise a concave curve. The outer blade face 58 may be generally straight or comprise a convex curve.

[0036] The trailing blade edge 54 further comprises a cup 60, which is defined by an inner cup wing 62 and an outer cup wing 64. The cup 60 may comprise smooth contours or angular contours. Further, the inclination angle of the cup 60 may be acute or
20 obtuse. The cup 60 may be symmetrical or asymmetrical in shape. The shape and curvature of the cup 60 are designed to reduce flow stagnation and improve fluid flow to the cup. As shown in FIG. 11, the cup 60 of this embodiment is generally asymmetrical with the inner cup wing 62 being substantially longer than the outer cup wing 32. Further, the cup 34 in this embodiment has acute cup inclination angles. The cup depth and

inclination angles can vary depending upon the use, application, and target environment of the turbine. By including the cup 60, the turbine blade 50 has a trailing blade edge 54 that resembles an asymmetric swallow's tail. The trailing blade edge design may be thought of as providing a widened trailing blade edge, and creating a cut-out therein to
5 define a cup to enhance the capture of forces from the flowing fluid on the trailing edge area of the blade.

[0037] The turbine blade cross-section shown in FIG. 11 also illustrates a leading blade edge 52 that has an angular contour with a sharp or acute angle profile. In other embodiments, the leading blade edge may have a smoother or blunt contour. Various
10 embodiments of the turbine blade configuration are shown in FIGS. 16-24 and described below.

[0038] FIG. 12 is a side perspective view of a turbine assembly 70 according to yet another exemplary embodiment of the present disclosure. The turbine assembly 70 comprises three identical turbine blades 72-74 arranged about a central axis. Each turbine
15 blade 72-74 is elongated and formed in a helical configuration along its respective longitudinal axis. In addition to the helical configuration, each blade 72-74 is further twisted along its respective longitudinal axis. As shown in FIG. 12, the width of the blades 72-74 is tapered from a first smaller end 76 of the blade assembly to a second
larger end 77 thereof, so that the blade assembly 70 has a conical profile. Further, the
20 blades 72-74 may be connected together at the smaller end 76. As described above, the blades 72-74 may be controllably and dynamically moved or tilted in this manner to achieve a predetermined degree of incline and/or distance outwardly from the central rotational axis under certain wind and/or operating conditions. This turbine assembly embodiment may be preferable in certain uses, applications, and target environments.

[0039] FIGS. 13A and 13B are a side perspective view and a bottom plan view illustrating a street or arena lamp 80 incorporating a turbine assembly 82 according to an exemplary embodiment of the present disclosure. As shown, the turbine assembly 82 of the street lamp 80 may comprise three turbine blades arranged about a central shaft. The turbine blades are further contained within two end housing components 84 and 86. The housing component 86 further houses a street lamp 88 (better seen in FIG. 13B) that is configured to shine generally downward. The street lamp 80 is typically elevated high above a street or arena surface atop a post or similar structure. The turbine assembly 82 is operable to generate electricity using wind movement and power the street lamp using the generated electricity. The housing component 84 may further incorporate solar panel technology to provide additional power generation capacity.

[0040] FIG. 14 is a side perspective view of a turbine assembly 90 according to yet another exemplary embodiment of the present disclosure. The turbine assembly 90 is a modular implementation of the turbine assembly. The turbine assembly 90 comprises three identical blades 92-94, wherein each blade comprises a plurality of sections or modules. The sections or modules of each blade may be affixed to one another to form an integrated assembly. The construction of the turbine assembly 90 may be easily scalable to different lengths appropriate for different applications and operating environments. This construction may be adapted to any of the blade and turbine designs.

[0041] FIGS. 15-23 are cross-sectional views of the turbine assembly according to exemplary embodiments of the present disclosure. These turbine assembly embodiments share the common characteristic of a cup formation in the trailing blade edge, however, as shown in these figures, the contours, cup inclination angles, lengths, and other parameters may be varied to optimize power generation efficiency and other parameters, such as

visual aesthetics and minimize noise. The differences between the various embodiments may be the shape of the leading blade edge, shape of the cup, the curvature of the cup wings, the thickness of the cup wings, the relative lengths of the cup wings, etc. The same terminology used above is used to describe the parts of the turbine blades.

5 **[0042]** In the cross-sectional view shown in FIG. 15, a turbine assembly 100 comprises three blades situated about a central shaft. The blades comprise a leading blade edge that has a sharp point with the outer cup wing having a generally rounded contour and being significantly shorter than the inner cup wing. The inner cup wing is slightly concave. The cup itself also has a rounded contour. The cup wings have a generally
10 uniform thickness.

[0043] In the cross-sectional view shown in FIG. 16, a turbine assembly 110 comprises three blades situated about a central shaft. The blades comprise a leading blade edge that has a sharp point with the outer cup wing having a generally angular contour and being significantly shorter than the inner cup wing. The inner cup wing is slightly
15 concave. The cup itself also has a contour that echoed the shape and angle of the outer cup wing. The cup wings have a generally uniform thickness.

[0044] In the cross-sectional view shown in FIG. 17, a turbine assembly 120 comprises three blades situated about a central shaft. The blades comprise a leading blade edge that has a sharp point with the outer cup wing having a generally rounded contour
20 and being significantly shorter than the inner cup wing. The inner cup wing is slightly concave. The cup itself also has a rounded contour. The cup wings of the blade have a thicker dimension than those shown in FIGS. 15 and 16, for example.

[0045] In the cross-sectional view shown in FIG. 18, a turbine assembly 130 comprises three blades situated about a central shaft. The turbine assembly 130 is similar

to the turbine assembly 130 shown in FIG. 15. The blades of the turbine assembly 130 comprise a leading blade edge that also has a sharp point with the outer cup wing having a generally rounded contour and being significantly shorter than the inner cup wing. However, the curve at which the outer cup wing extends from the leading blade edge is wider than that shown in FIG. 15. The inner cup wing is slightly concave. The cup itself also has a rounded contour but with a wider cup contour.

[0046] In the cross-sectional view shown in FIG. 19, a turbine assembly 140 comprises three blades situated about a central shaft. The turbine assembly 140 is similar to the turbine assembly 140 shown in FIG. 14. The blades of the turbine assembly 140 comprise a leading blade edge that also has a sharp point with the outer cup wing having a generally rounded contour and being significantly shorter than the inner cup wing. However, the outer cup wing configuration is slightly different than that shown in FIG. 18. The leading blade edge being slightly more obtuse than that shown in FIG. 18.

[0047] In the cross-sectional view shown in FIG. 20, a turbine assembly 150 comprises three blades situated about a central shaft. The turbine assembly 150 is similar to the turbine assembly 120 shown in FIG. 17. The blades of the turbine assembly 150 comprise a leading blade edge that also has a sharp point with the outer cup wing having a generally rounded contour and being significantly shorter than the inner cup wing. However, the outer cup wing has a slightly thinner dimension than that that shown in FIG. 17.

[0048] In the cross-sectional view shown in FIG. 21, a turbine assembly 160 comprises three blades situated about a central shaft. The turbine assembly 160 is similar to the turbine assembly 150 shown in FIG. 20. The blades of the turbine assembly 160 comprise a leading blade edge that also has a sharp point with the outer cup wing having

a generally rounded contour and being significantly shorter than the inner cup wing. However, the outer cup wings extend from the central axis at a slightly different angle than that those shown in FIG. 20.

[0049] In the cross-sectional view shown in FIG. 22, a turbine assembly 170
5 comprises three blades situated about a central shaft. The blades of the turbine assembly 170 comprise a leading blade edge that has a point and the outer cup wing has a smooth rounded profile. The outer cup wing also has a generally angular contour and being significantly shorter than the inner cup wing. The inner cup wing is fairly straight, and the cup has a rounded contour.

10 [0050] In the cross-sectional view shown in FIG. 23, a turbine assembly 180 comprises three blades situated about a central shaft. The blades of the turbine assembly 180 comprise a leading blade edge that also has a sharp angular profile. The outer cup wing also has a generally angular contour and being significantly shorter than the inner cup wing. The inner cup wing is fairly straight, and the cup has a rounded contour.

15 [0051] The turbine assembly of the present disclosure may include one or more blades depending on the use, application, and target environment. The blades may be joined at one or both ends by end caps or plates. In addition or alternatively, one or more support members may be used to attach each turbine blade to the central shaft. The blade spacing, including placement and orientation may vary from that explicitly depicted and
20 described herein to optimize turbine efficiency or other characteristics. Further, the turbine blade surfaces, the platform onto which the turbine blades are mounted, and other parts of the turbine assembly may incorporate solar panel technology to provide additional power generation capacity. In an alternate embodiment, the blade spacing, twist, angle of attack, and other configurations may be dynamically adjustable using

microprocessor controllers according to dynamic environmental conditions and other criteria to optimize efficiency and other operating parameters.

[0052] The turbine blades described herein may comprise any suitable material or combination of materials (such as composites), including carbon fibers, glass fibers, 5 polymers (epoxy, vinyl ester, nylon, etc.), plastics (acrylics, polyesters, polyurethanes, halogenated plastics, etc.), metals, carbon nanotubes, etc. The material may be selected to construct a rigid blade or a flexible (bendable or twistable) blade. The materials may be selected according to the characteristics of the moving fluid in which the turbine is expected to operate. For example, the turbine assembly may operate in open air, 10 directional air, underwater, river, and tidal applications.

[0053] The turbine assembly of the present disclosure may comprise one, two, three, or more generally vertically or horizontally mounted, twisted helical or straight blades with a cup formation in the trailing blade edge. Alternatively, the turbine blades and central shaft may be mounted in an axis generally deviating from the horizontal or 15 vertical axis. As described above, the blade spacing, configuration, and orientation may be modified to satisfy requirements in operational efficiency, aesthetic appearance, and noise generation for the given operating environment. A mechanical mechanism may be employed to vary the position and/or configuration of the turbine blades to optimize for wind and/or operating conditions. The change in position and/or configuration of the 20 blades may effectively expand or contract the volume swept by the turbine blades to achieve certain desired operations.

[0054] The rotating turbine blades can generate energy from a number of different fluids, including air, water and industrial process fluids. Traditionally these turbines are placed on the ground or stationary objects, such as a building, to generate energy from air

movement. The defined turbines can also be placed on an object, such as a buoy or a boat, into the air to capture kinetic energy from the air's movement and also placed on the object into the water to capture kinetic energy from the water's movement due to current. The turbine can be used to harvest artificially created or secondary fluid movement, such as capture of wind created by moving objects such as cars and humans, water wake created by ships and fish, fluid movement created by mechanical movement of fluid such as an exhaust fan or industrial process, or secondary fluid movement created by a natural phenomenon such as air moving out of a cave or escaping from an underwater ground fissure.

10 **[0055]** The turbines can be used as a product component to generate energy used by the product, such as inclusion of turbine as a component in an overhead street light or in a cell tower to provide electrical energy for direct use within the street light or cell tower. In addition, the inclusion of a turbine within a product also allows for energy to delivered by the product to other uses, such as energy not used by the cell tower to be moved to a secondary storage facility for future use or onto the grid for delivery to other locations and uses.

20 **[0056]** The turbines also create a secondary flow as fluid leaves the turbine, creating the opportunity for the fluid and its kinetic energy to be directed for reuse, such as locomotion or propulsion of an object. The movement of the turbine blade, such as revolutions per minute, can be used to measure and detect fluid characteristics such as flow rate and viscosity.

[0057] The features of the present invention which are believed to be novel are set forth below with particularity in the appended claims. However, modifications, variations, and changes to the exemplary embodiments described above will be apparent to those

skilled in the art, and the turbine assembly and blade described herein thus encompass such modifications, variations, and changes and are not limited to the specific embodiments described herein.

WHAT IS CLAIMED IS:

1. A turbine assembly comprising:
an anchor plate;
at least one turbine blade mounted to the anchor plate and having an elongated
5 blade body having a longitudinal axis parallel to an axis of rotation; and
the at least one turbine blade being operable to move between a first position
relative to the axis of rotation and a second position relative to the axis of rotation.
2. The turbine assembly of claim 1, wherein the second position varies from
10 the first position in the amount of inclination angle measured from the axis of rotation.
3. The turbine assembly of claim 1, wherein the second position varies from
the first position in distance from the axis of rotation.
- 15 4. The turbine assembly of claim 1, wherein the second position varies from
the first position in an amount of twist of the blade body.
5. The turbine assembly of claim 1, wherein the second position varies from
the first position in an amount of helical twist of both blade bodies about the axis of
20 rotation.
6. The turbine assembly of claim 1, further comprising a second anchor plate.
7. The turbine assembly of claim 1, wherein the blade body comprises a
25 plurality of solar electricity-generating panels.
8. The turbine assembly of claim 1, wherein the turbine blades have semi-
circular shape in cross-section.
- 30 9. The turbine assembly of claim 1, wherein a second end of the turbine
blades comprises a scalloped edge.

10. The turbine assembly of claim 1, further comprising at least one second turbine blade mounted to the anchor plate at a predetermined configuration from the first turbine blade including a first off-set in a first axis and a second off-set in a second axis, having an elongated blade body having a longitudinal axis parallel to an axis of rotation, and the at least one second turbine blade being operable to move between a first position relative to the axis of rotation and a second position relative to the axis of rotation.

11. The turbine assembly of claim 1, wherein the blade body is generally helical along the longitudinal axis.

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12. The turbine assembly of claim 1, wherein the blade body is generally twisted about the longitudinal axis.

14. The turbine assembly of claim 1, wherein the blade body comprises a plurality of modular sections.

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15. The turbine assembly of claim 1, wherein the blade body is mounted along a generally vertically-oriented axis.

16. The turbine assembly of claim 1, wherein the blade body is mounted along a generally horizontally-oriented axis.

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17. The turbine assembly of claim 1, wherein the blade body cross-section comprises:

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a leading blade edge;

a trailing blade edge;

an inner blade face coupling the leading blade edge and the trailing blade edge;

an outer blade face also coupling the leading blade edge and the trailing blade edge; and

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the trailing blade edge having inner and outer cup wings that define a cupped surface.

18. A turbine assembly comprising:

at least one turbine blade having a blade body having a longitudinal axis parallel to an axis of rotation, and a cross-section that comprises:

a leading blade edge;

5 a trailing blade edge;

an inner blade face coupling the leading blade edge and the trailing blade edge;

an outer blade face also coupling the leading blade edge and the trailing blade edge; and

10 the trailing blade edge having inner and outer cup wings that define a cupped surface; and

the at least one turbine blade being operable to move between a first position relative to the axis of rotation to a second position.

15 19. The turbine assembly of claim 18, wherein the blade body is generally helical along the longitudinal axis.

20 20. The turbine assembly of claim 18, wherein the blade body is generally twisted about the longitudinal axis.

21. The turbine assembly of claim 18, wherein the blade body comprises a plurality of modular sections.

25 22. The turbine assembly of claim 18, wherein the blade body is mounted along a generally vertically-oriented axis.

23. The turbine assembly of claim 18, wherein the blade body is mounted along a generally horizontally-oriented axis.

30 24. The turbine assembly of claim 18, wherein the blade body is mounted along an axis generally deviating from the horizontal and vertical axes.

25. The turbine assembly of claim 18, wherein the blade body comprises a plurality of solar electricity-generating panels.

26. The turbine assembly of claim 18, wherein the inner and outer cup wings
5 resemble a swallow tail.

27. The turbine assembly of claim 18, wherein the second position varies from the first position in the amount of inclination angle measured from the axis of rotation.

10 28. The turbine assembly of claim 18, wherein the second position varies from the first position in distance from the axis of rotation.

29. The turbine assembly of claim 18, wherein the second position varies from the first position in an amount of twist of the blade body.

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30. The turbine assembly of claim 18, wherein the second position varies from the first position in an amount of helical twist of both blade bodies about the axis of rotation.

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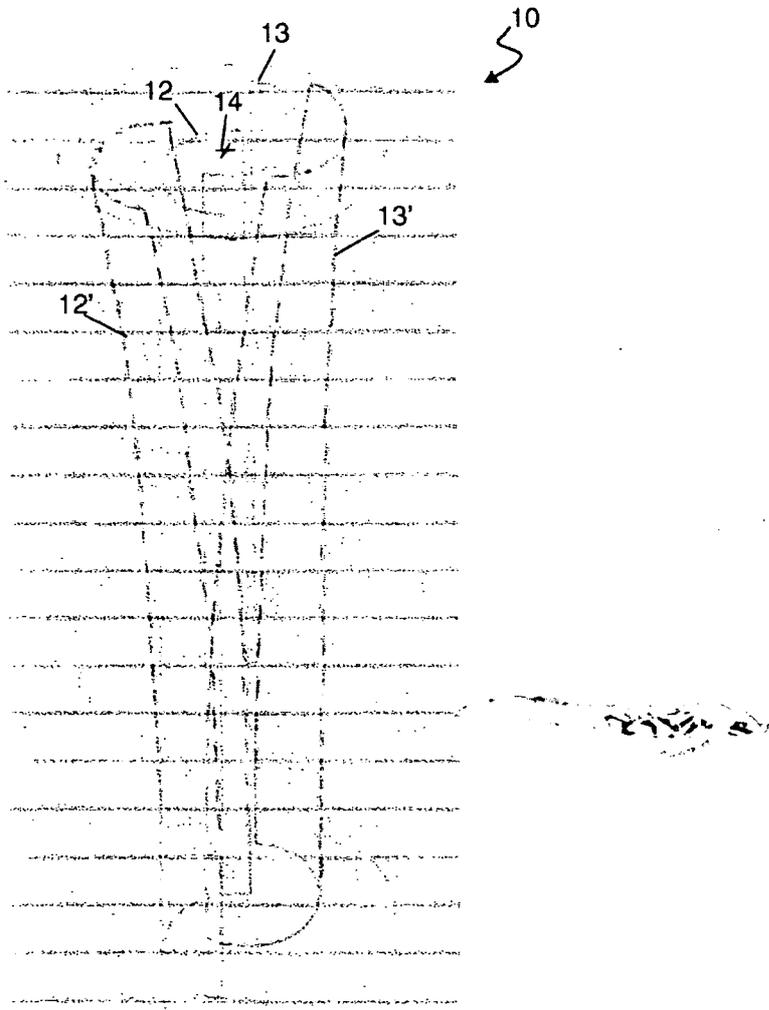


FIG. 1

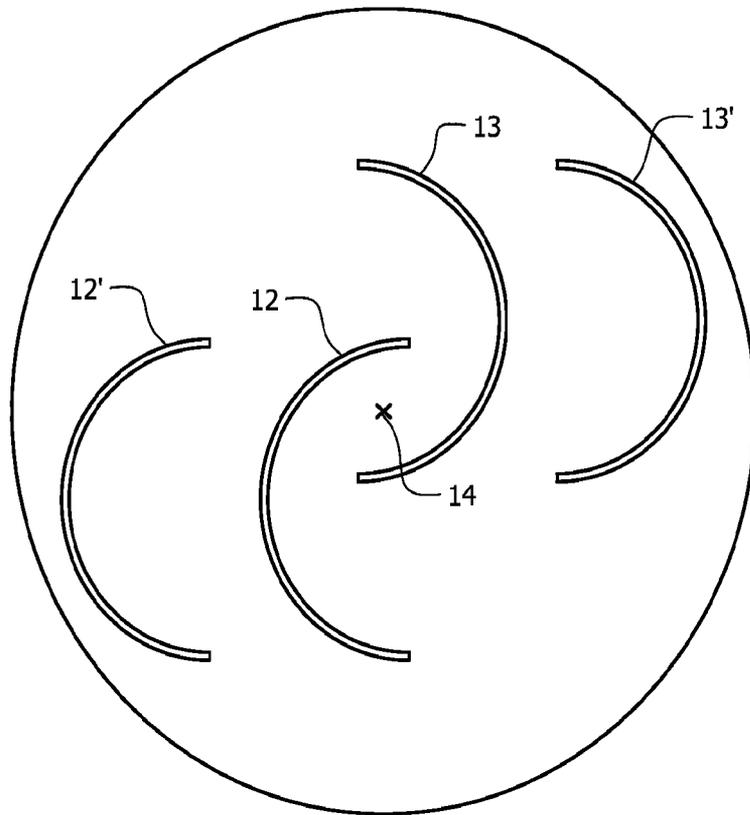


FIG. 2

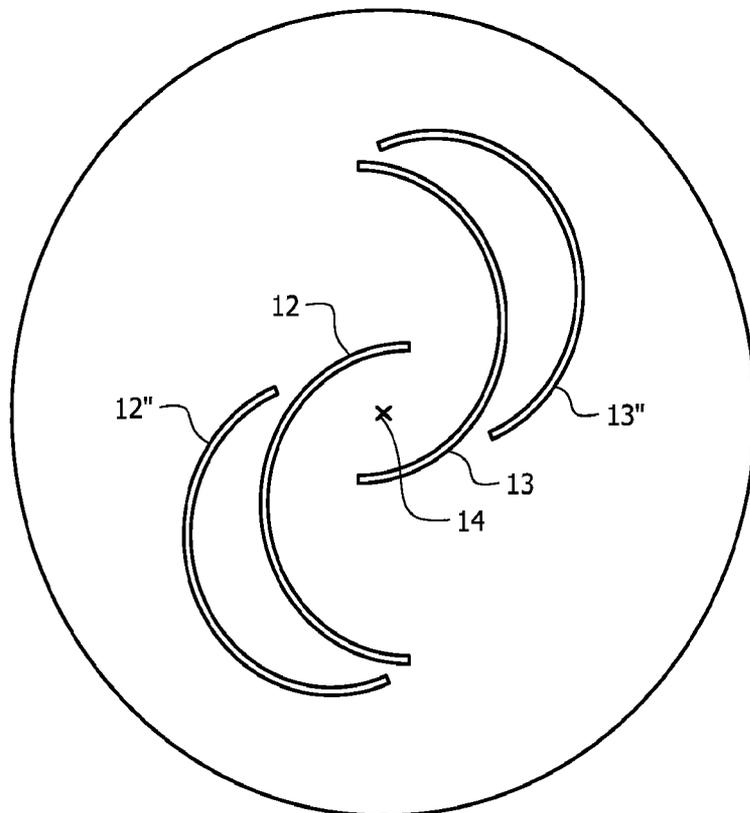


FIG. 3

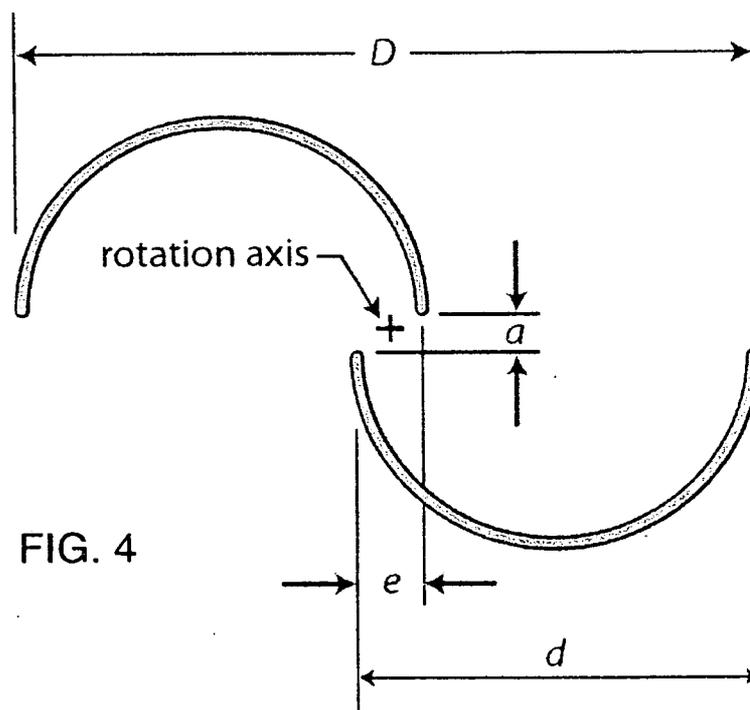


FIG. 4

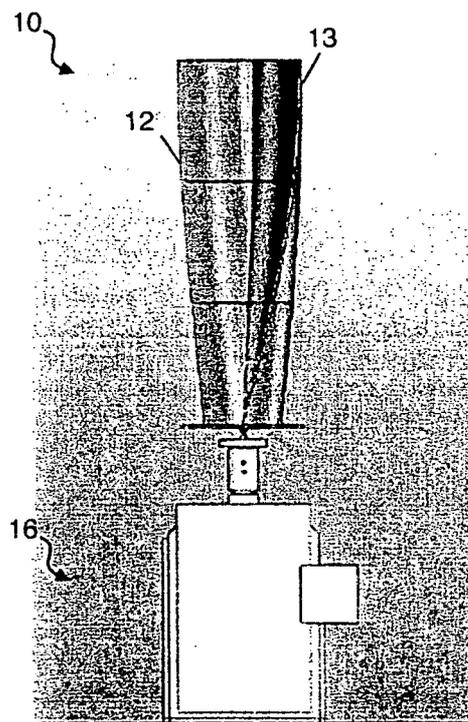


FIG. 5

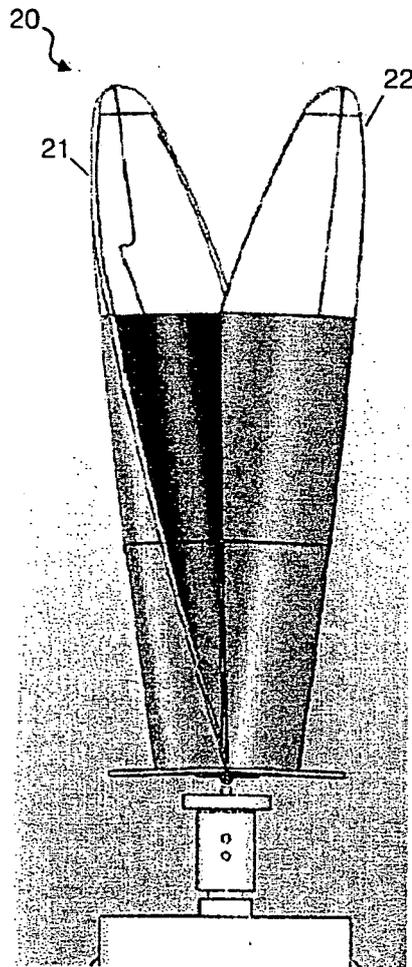


FIG. 6

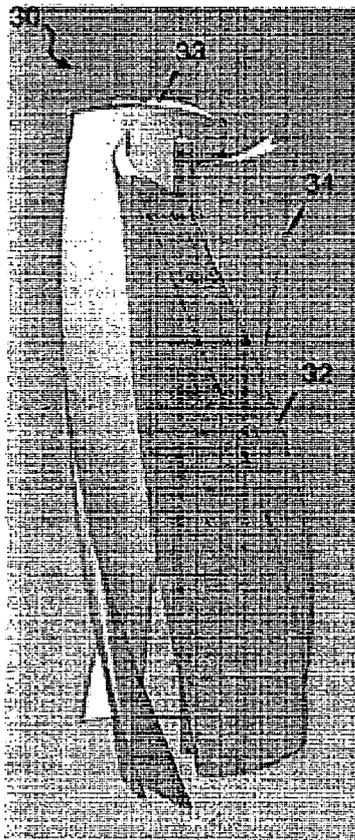


FIG. 7

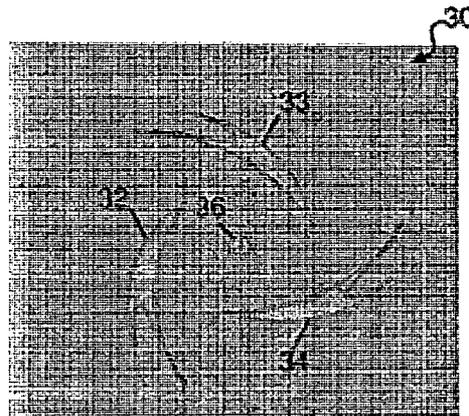


FIG. 8



FIG. 9

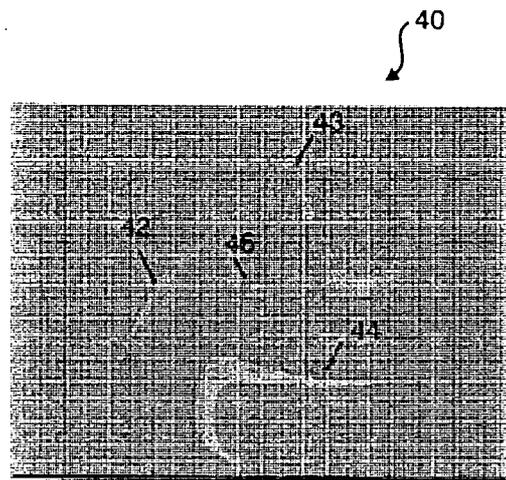


FIG. 10

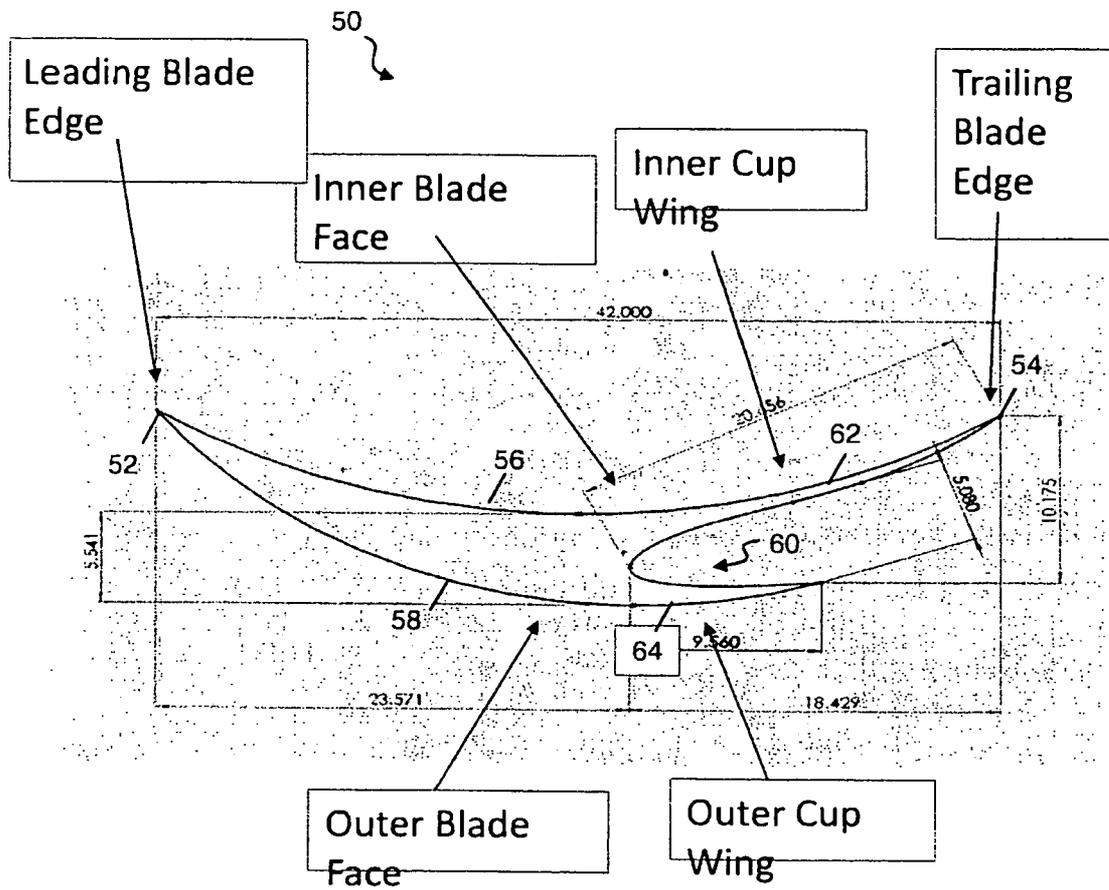


FIG. 11

70

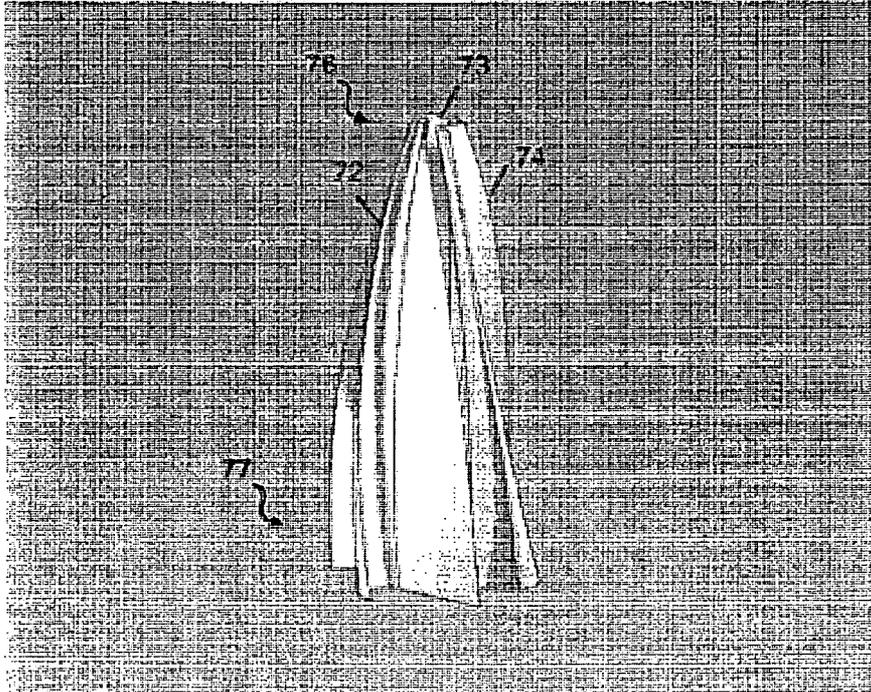
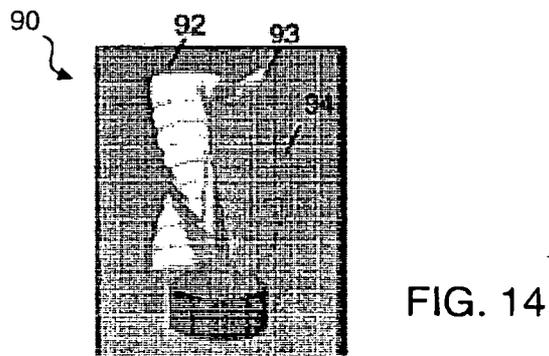
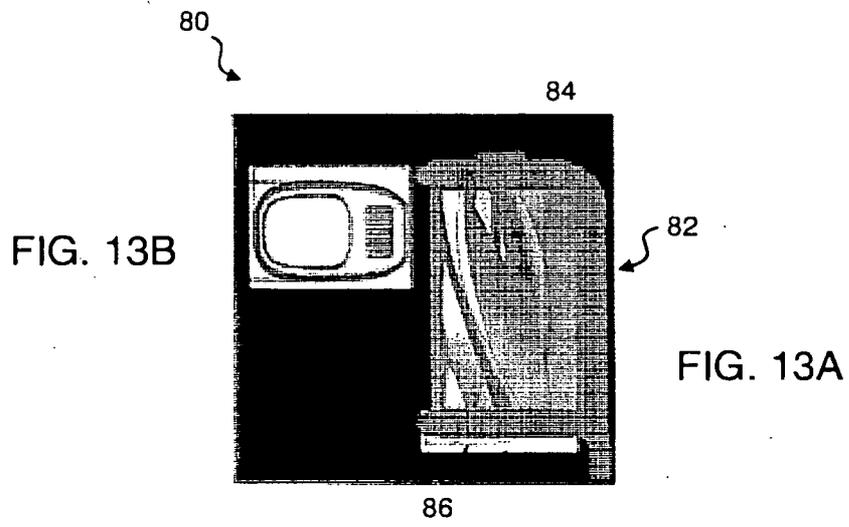


FIG. 12



11/13

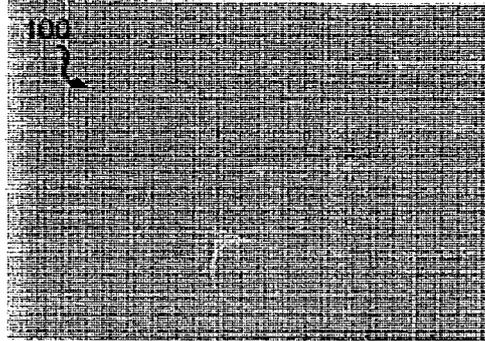


FIG. 15

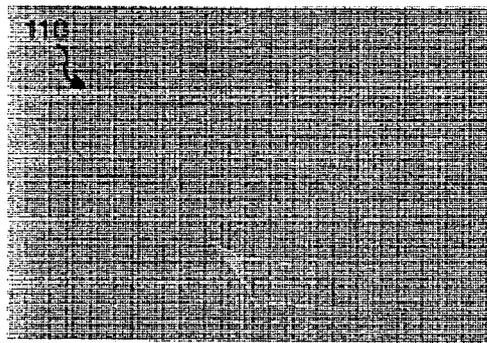


FIG. 16

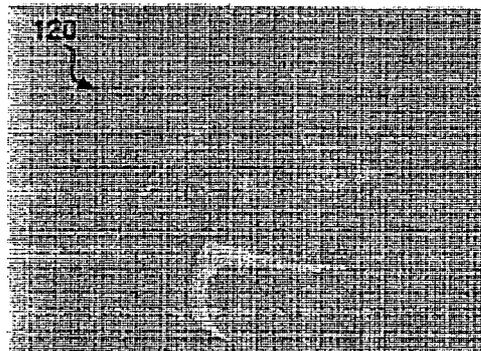


FIG. 17

12/13

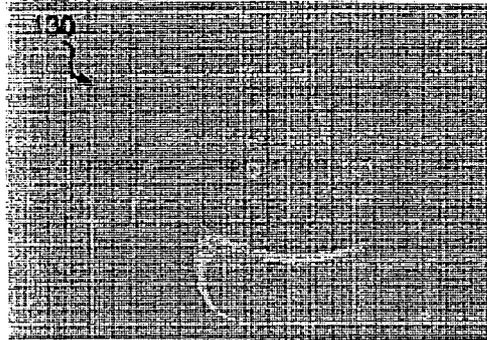


FIG. 18

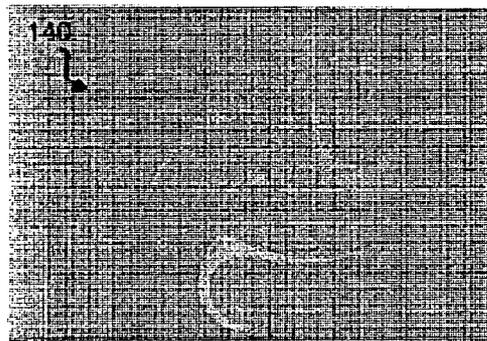


FIG. 19

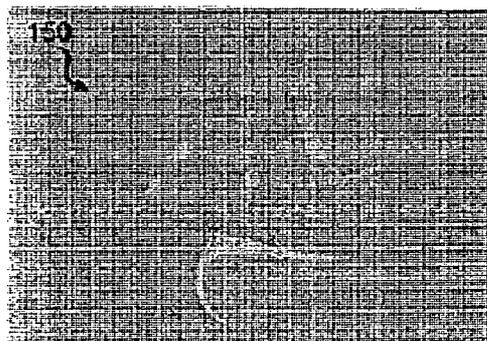


FIG. 20

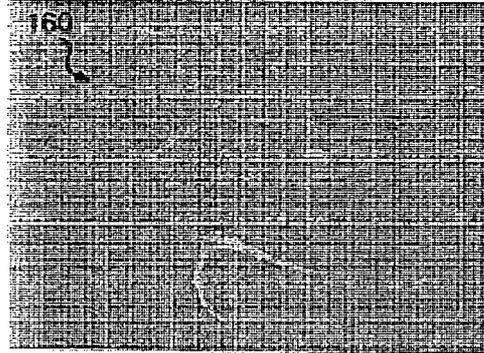


FIG. 21

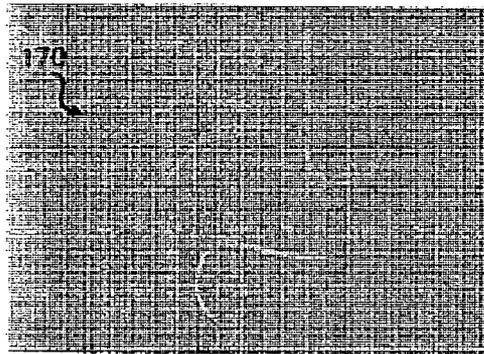


FIG. 22

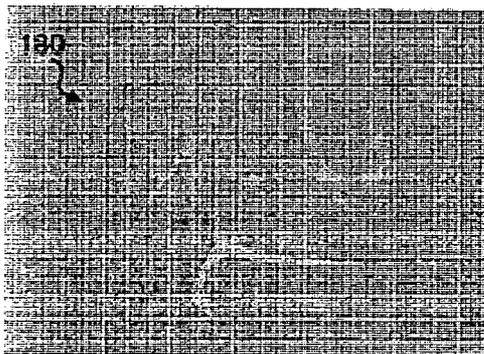


FIG. 23

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/045254

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F03D 3/00 (2013.01)

USPC - 415/4.4

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - F03D 3/00, 3/02, 3/06, 7/06 (2013.01)

USPC - 29/889.7; 290/44, 55; 415/4.1, 4.2, 4.4, 907; 416/132B, 176, 197A, 197R

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

CPC - Y02E 10/74 (2013.01)

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

PatBase, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2,596,726 A (RYDELL) 13 May 1952 (13.05.1952) entire document	1, 3, 6, 8, 10, 14, 15
--		
Y		2, 4, 5, 7, 9, 11, 12, 16-30
Y	WO 2011/039404 A1 (NURMIA) 07 April 2011 (07.04.2011) entire document	2, 24, 27
Y	GB 2474080 A (SAEED) 06 April 2011 (06.04.2011) entire document	4, 5, 11, 12, 19, 20, 29, 30
Y	GB 2460389 A (POPPLE) 02 December 2009 (02.12.2009) entire document	7, 25
Y	US 2012/0061522 A1 (SULLIVAN et al) 15 March 2012 (15.03.2012) entire document	9, 16, 23
Y	US 2010/0322770 A1 (SHEINMAN) 23 December 2010 (23.12.2010) entire document	17-30

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"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

25 October 2013

Date of mailing of the international search report

07 NOV 2013

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