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(54) **Title**: IMPROVED WIND ENERGY DEVICE

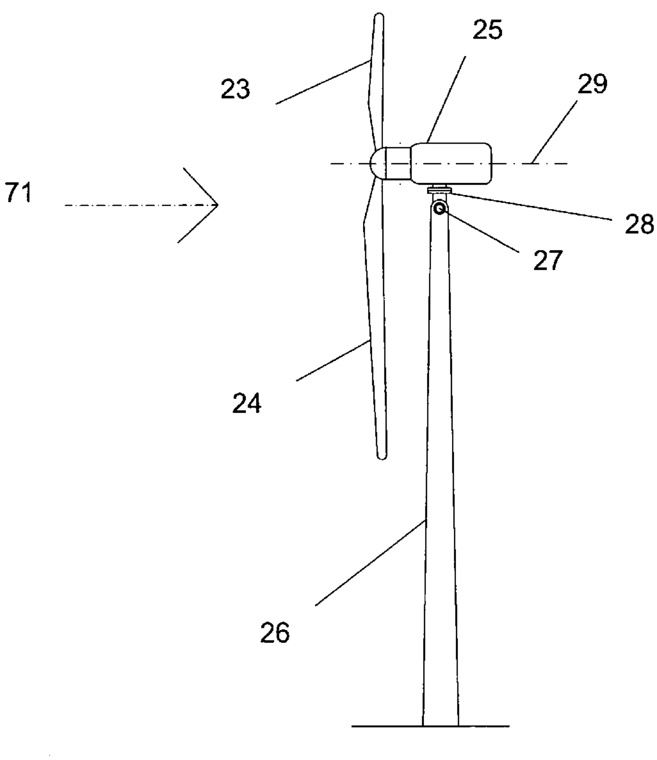

FIGURE 4

(57) Abstract: An improved wind turbine is proposed employing a horizontal axis rotor mounted on a tower support system. The control system for the turbine can control not only the yaw angle of the nacelle and the pitch angle of the blades, as in conventional systems, but also the tilt angle of the rotors, adding a previously not available control parameter that can significantly increase operating efficiency in the presence of winds that are not perfectly horizontal, which is a common occurrence. The resulting system can provide significantly higher energy generation and therefore reduce the cost per kW-hour generated from wind power.

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IMPROVED WIND ENERGY DEVICE

DESCRIPTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/208,751, filed February 28, 2009, which is hereby incorporated by reference and made a part hereof.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable.

TECHNICAL FIELD

[0003] The subject invention is related to the industry of alternative energy production and more specifically the industry of wind turbines to generate electricity from the wind.

BACKGROUND OF THE INVENTION

[0004] Wind turbines are well known mechanical devices used for hundreds of years to perform various mechanical works. The application and use of wind turbines to generate electricity was a natural and obvious application of turbines as soon the need for and availability of electricity uses was developed. Since the initial uses of turbines for generating electric power first appeared, many improvements and efficiencies have been applied to turbine technology.

[0005] Traditional turbines have at least one rotor blade mounted on a hub rotating about a horizontal axis. The turbine unit is usually fixed to the top of a tower structure and is capable of being rotated about the axis of the tower (yaw) in order to align with the direction of the wind. Most modern wind turbines of the current state of the art employ three rotor blades.

[0006] The ever increasing need for energy, combined with environmental concerns for alternative energy systems, provides the catalyst for more development and investment in wind power technology than ever before in the history of wind turbines.

[0007] Development trends in wind energy technology include off-shore installations, some of which are floating, while others are setting on the ocean floor. Other wind technologies include installing the turbines into kites, gliders, blimps, and/or other systems operating at altitudes above the earth while being tethered to the ground.

[0008] Wind energy technology is very important because it is environmentally clean and in virtually unlimited supply. Harnessing the wind for power consumption is a multi-billion dollar industry and the trends suggest and represent that a larger portion of the total power produced each year is produced from wind systems than the previous year. It is projected by some that this increasing production rate will last for many years to come. At the present time only a small percent of the total power generated comes from renewable alternative sources such as wind power generating systems.

[0009] Demands for wind generated power have lead to many governments of countries and states to put legislative policies in place regarding renewable power generation such as wind power. There are many countries that want to increase renewable energy generation from 5% of the total power produced to 10%, 20 % or even more. Scotland has announced plans for 50% energy from wind. The USA is considering a 20% minimum energy production from alternative energy. As a result, there is massive demand worldwide for wind turbines. Turbine manufacturers cannot meet the demand for turbine units. Many new turbine unit orders are booked years in advance and/or backlogged.

[0010] One possible solution to meet the demand would be to design and manufacture a wind turbine that can provide more power than current turbines, which usually reach only about 3 to 5 MW capacity. This invention makes that possible.

[0011] Another issue is the still relatively high cost of electricity generated from wind. There is increasing global pressure to reduce the cost of power and reach grid parity (match the cost of fossil fuel based energy). Alternative energy remains more expensive to produce than fossil fuel based systems. The present invention makes a major contribution in that area too.

[0012] Finally, another important issue regarding wind energy is the fact that many areas of the world are effectively running out of space for turbine installations. This is especially true in many European countries, with the best wind locations already taken. There is a real and present need to replace many existing aging turbines with new machines that can provide more power, and that can provide that power more efficiently than previous installations. With installation space at a premium and the high cost of leasing or buying space for turbines, a more space-effective solution is needed. The present invention makes a major contribution in that regard.

SUMMARY OF THE INVENTION

[0013] In order to get more power and reduce cost per KW, the wind industry has been trying to grow the size of rotors. It is well known that the amount of power generating capability increases with rotor diameter. Therefore, turbine technology and manufacturing companies continue to push the limits of rotor diameter. Turbine units have been manufactured with rotor diameters over 120 meters. However, many problems are also introduced as rotor diameter increases. Rotor size alone is not the solution. The subject invention increases efficiency of energy generation from wind.

[0014] One problem turbines must overcome is the ability to initiate rotation. The force required to overcome the mass of the rotors at rest and initiate rotation is a greater force than is required to maintain the rotation after it has begun. Therefore the cut-in wind speed is a very important design consideration for a turbine. This is especially important as rotor diameters of turbines increase in size because the cut-in speed also becomes significantly increased. The force required to initiate rotation of the rotors is such that low wind speeds may not be enough to get the turbine unit moving. The subject invention addresses this problem by making it possible to tilt the turbine up or down to better confront the actual direction of the wind which allows the turbine to be oriented in the direction that requires the least wind speed to start rotation.

[0015] The reason modern turbines lack a tilting mechanism is because the tilting movement in a conventional turbine would cause the rotor blades to clash with the tower mast when tilted down to adjust the turbine to ascending winds. The subject invention provides a structure and/or mechanism where this problem is eliminated so that a tilting mechanism can be used without any danger of rotor clash.

[0016] Conventional prior art wind turbines provide a yaw adjustment system to rotate the machine into the general direction of the wind stream. In addition, conventional prior art wind turbines provide a pitch adjustment system to trim the rotor blades to take better advantage of the wind speed. These two adjustment systems are also used to help provide defensive adjustments for the turbine when it is subjected to destructive winds. The subject invention provides another degree of adjustment for the turbine to make more efficient energy conversion of the wind and also provides another defensive adjustment in response to destructive winds.

[0017] A key innovative feature of this invention is the ability to tilt the rotors when the wind is not perfectly horizontal. Modern wind turbines are conventionally equipped with a yaw mechanism that allows the nacelle to turn around a vertical axis in order to orient themselves advantageously against the wind. However, they have no way to adjust their position around a horizontal axis, which is what is required for best orientation with respect to an ascending or descending wind, which is a common occurrence. Current turbines lack adjustability to this key parameter – in other words, a key needed knob is missing to adjust to this additional degree of freedom of the wind. As a result, current wind turbines operate under suboptimal conditions in ascending or descending winds. The subject invention improves the efficiency of the turbine by providing an additional degree of adjustment. Higher efficiency in the turbine means more power can be generated by the turbine for a given set of conditions which results in lower power cost per kW of electric power.

[0018] As briefly mentioned previously, conventional wind turbines can optimize their operation by: a) rotating the blade about its longitudinal axis, called pitch adjustment, to optimize the angle of attack of the wind on the turbine blades, and b) rotating the whole nacelle (and the rotor along with it) in the direction of the wind, called yaw or azimuth adjustment. Great improvements in efficiency have been achieved that way. However, there is another parameter that has not been addressed yet: the fact that the wind is not always blowing perfectly horizontal.

[0019] The current invention allows the turbine to tilt the rotor downward or upward depending on the wind direction. That provides another parameter and another degree of freedom (called axis in robotics) to the turbine, giving it a substantially increased efficiency. It's like going from a 2 axis robot to a 3 axis robot – huge difference. Therefore, the subject invention allows the wind turbine to operate in a three dimensional mode, while the conventional turbines provide only adjustment in two dimensions.

[0020] The wind is often streaming upwards or downwards relative to the horizontal plane, and can change significantly during the day or night, during the different seasons, etc. In many cases turbines are intentionally located on hills or other elevated position, where the wind is diverted upwards and dramatically accelerated in the process. The turbine gets accelerated wind, but in the "wrong" direction due to the bias path of the wind stream relative to the rotors. The subject invention addresses this problem by providing the turbine with a tilting mechanism.

[0021] Wind farms are large areas with turbines clustered or located and placed in an array or grid pattern throughout the area. There are rules of thumb that pertain to how much distance should be placed between turbines so that turbulence in the wind stream caused by the operation of one turbine will not interfere with the operation of adjacent turbines. Most wind farms with clustered turbine arrays are located on relatively level ground. Other wind farms employ a linear array by locating a single line of turbines along a shore line or across the ridge of a hill. An increasing number of wind farms are being established out at sea. In all of the above scenarios, wind farms suffer from the problem of all the turbines operating inefficiently because the wind stream varies orientation with the horizontal plane. As a result, the inefficiency of one turbine is multiplied by the total number of all the turbines operating in the wind farm. The subject invention addresses this problem with the tilting feature.

[0022] Installation on a ridge and hill top is a desirable location for turbine placement in a linear wind farm due to the accelerated wind speeds rising up from the lower elevations. However, as mentioned previously, the horizontal axis orientation of the rotors significantly limits the efficiency at which ridge top turbines can operate. As a result, few if any turbines are located down the hillside below the ridge, not because these are more difficult installation locations, but rather because they are not ideal wind locations for the turbine even though the wind speeds are often substantially greater than the open flat areas where wind farms are generally located. A turbine located on the side of a hill with a relatively steep slope suffers two major problems with the wind stream. First, the basic direction of the wind stream is oriented significantly bias to the horizontal rotor axis. Second, wind that passes through the turbine will be obstructed by the presence of the upward sloping terrain and as such the hillside terrain behind the turbine further dilutes the efficiency of the turbine. The subject invention addresses this problem by providing a tilting mechanism to the turbine allowing it to orient itself to be more horizontal relative to the slope of the hillside terrain. This feature is important because hillside land does not usually command the high cost of relatively level open areas. In many countries, the best sites for wind farms have been taken and established, however, with the subject invention, areas that have been passed by in the past for consideration of locating a wind farm now become advantageous. Since the large areas of hillsides and sloped terrain usually cost less to acquire and/or lease, the overall cost for a wind farm can be reduced dramatically. In addition, since the wind speeds are usually accelerated on the sloped terrains, the potential energy generating output capacity for a cluster of turbines arrayed on a sloped terrain wind farm would be greater than that of the same turbines arrayed in a conventional level wind farm.

[0023] It is a well known phenomenon that wind streams do not always blow in a horizontal orientation. Airplanes suffer from non-horizontal wind shear. Most weather forecasts include modern Doppler radar data which includes details of winds blowing in various directions during sever weather.

[0024] Any time the wind stream is not blowing along the horizontal plane, the rotors are effectively sweeping through the wind with a bias slice. It is likely that the wind stream is not blowing along a path parallel to the horizontal plane most of the time and only occasionally the wind streams are actually on a horizontal plane. As a result, conventional turbines spend most of their working hours sweeping with less than efficient bias slice rotation. Therefore, conventional turbines spend the majority of their operational life rotating inefficiently because of the bias slice rotation.

[0025] Other advantages and features of the subject invention will be apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] To understand the present invention, it will now be described by way of example, with reference to the accompanying drawings in which:

[0027] Figure 1 is a front view of a conventional prior art turbine;

[0028] Figure 2 is a side view of the turbine of Figure 1;

[0029] Figure 3 is a partial blown up view of the turbine of Figure 1;

[0030] Figure 4 is a side view of one embodiment of the invention;

[0031] Figure 5 is a partial blown up view of the turbine of Figure 4;

[0032] Figure 5a is a partial blown up view of the turbine of Figure 4;

[0033] Figure 6 is another side view of the embodiment of Figure 4;

[0034] Figure 7 is another side view of the embodiment of Figure 4;

[0035] Figure 8 is a partial side cross-sectional view of an embodiment of the invention;

[0036] Figure 9 is a partial side cross-sectional view of an embodiment of the invention;

[0037] Figure 10 is a side view of another embodiment of the invention;

[0038] Figure 11 is a side view of the embodiment of Figure 10, with the rotor tilted;

[0039] Figure 12 is a side view of the embodiment of Figure 10, with the rotor tilted;

[0040] Figure 13 is a side view of another embodiment of the invention;

[0041] Figure 14 is a side view of another embodiment of the invention, such as an offshore embodiment;

[0042] Figure 15 is a side view of the embodiment of Figure 14, with the rotor tilted;

[0043] Figure 16 is a side view of another embodiment of the invention;

[0044] Figure 17 is a front view of the embodiment of Figure 16, with the rotor tilted;

[0045] Figure 18 is a side view of another embodiment of the invention;

[0046] Figure 19 is a side view of the embodiment of Figure 18, with the rotor tilted;

[0047] Figure 20 is a side view of the embodiment of Figure 18, with the rotor tilted;

[0048] Figure 21 is a side view of another embodiment of the invention;

[0049] Figure 22 is a side view of the embodiment of Figure 21, with the rotor tilted;

[0050] Figure 23 is a side view of the embodiment of Figure 21, with the rotor tilted;

[0051] Figure 24 is a side view of an installation of a turbine;

[0052] Figure 25 is a side view of an installation of another turbine with the turbine tiled down; and,

[0053] Figure 26 is a side view of an array of turbines.

DETAILED DESCRIPTION

[0054] **Figure 1** shows a front view of a conventional prior art turbine. Generically, **10** is a schematic representation of the sweep area of the three rotor blades **12, 13** and **14,** which are arrayed around hub **16**. The nacelle **15** is the machine house, which contains the hub, gearbox, generator, yaw motor, anemometer, mechanical brake, main drive shaft, yaw bearing, controller, wind vane, rotor hub, rotor blade pitch mechanism, and other components, all mounted on tower mast **11**.

[0055] Modern turbines work when the rotor blades respond to passing wind streams causing the turbine to rotate. The blades can be rotated around their longitudinal axis using a blade pitch mechanism located in the hub to optimize their angle with respect to the wind.

[0056] The entire nacelle and rotor is turned to face into the wind to further take advantage of wind speed using a yaw mechanism. The yaw mechanism usually includes a system of gears and electric motors (the so called yaw or azimuth motors) which cause the nacelle to rotate around the tower. A controller monitors the wind direction and a host of other parameters and initiates the yaw mechanism as needed to keep the rotor facing into the wind.

[0057] As the rotor blades sweep through the air, they turn a central shaft in the nacelle which is connected to a gear box. The gear box is connected to the generator to produce electric power. A shaft between the generator and the gear box includes a brake mechanism which is used to stop the rotor from turning and/or to slow it down to maintain a certain speed.

[0058] The controller monitors wind speed and wind direction and makes adjustments to the two basic mechanisms it has to control turbine operation: a) the pitch of the blades, and b) the yaw. In the future through this invention there will be a third key mechanism: the tilt mechanism, which is not available today.

[0059] **Figure 2** shows a side view of the same conventional prior art as shown in **Figure 1**.

~~[0060]~~ **Figure 3** shows the nacelle **15** or machine house with a schematic representation of its internal components. Rotor blades **14** sweep through the air connected at the root of the blade at the hub **16**. The rotational motion turns a shaft in the nacelle which is connected to gear box **17**. Gear box **17** is connected to generator **18** by a second shaft to produce electric power. Some types of generators, typically called direct-drive generators, eliminate the need for a gear box. In such a case (not shown in this Figure) the slow shaft would connect directly with the direct-drive generator.

[0061] **Figure 4** shows a first embodiment of the subject invention. The rotor (of which two of the 3 blades are shown, blades **23** and **24**) is located a greater distance from tower **26** than in conventional turbines. This will probably require that some of the internal components of the nacelle **25** are moved backwards, to achieve a weight balance about the tower. The nacelle **25** is rotatably mounted on the tower at pivot point **27**. The yaw mechanism **28** is shown mounted on the tower, but it obviously could be mounted at a higher altitude in the nacelle (as it is usually done in conventional turbines). The direction of the wind is represented by arrow **71**, which is shown as horizontal, and therefore appropriate for the current position of the rotor.

[0062] **Figure 5** is a focused, larger view of **Figure 4**, showing the tilting pivot point **27** and the yaw mechanism **28**.

[0063] **Figure 5A** shows that the position of the yaw mechanism and the tilt mechanism relative to each other can be reversed. In Figure 5A the tilt mechanism is closer to the nacelle than the yaw mechanism, which is the opposite of the situation shown in Figure 5. This reversal is possible only if the tower has a symmetrical shape with respect to its longitudinal axis. If the tower has a non-symmetrical shape, the embodiment of Figure 5A becomes necessary.

[0064] **Figure 6** shows that the wind direction **72** has changed, now pointing upwards. This is a common occurrence due to temperature fluctuations in the atmosphere. The response of the turbine is to tilt down in order to make the nacelle and the rotor axis parallel to the wind, maximizing power generation. There is a limitation to the amount of downward angle the turbine is able to tilt due to the proximity of the rotors to the tower. Variations on the theme of the subject invention, discussed later, include alternative tower structures which provide additional clearance for the rotors when tilted downward.

[0065] **Figure 7** shows that the wind direction **73** has changed again, blowing now downwards. The turbine reacts by tilting and pointing itself upwards, to maximize power generation. There is a greater degree of freedom to tilt upward than to tilt downward because the tower is not in the way.

[0066] **Figure 8** shows one of many possible implementations of the invention. **Figure 8** shows only part of the mechanisms (the yawing mechanism) in order to keep the drawing simple and easy to understand. The other mechanism (tilting) has been added in **Figure 9**. **Figure 8** shows the nacelle **50**, the tower **51** and the nacelle pedestal **53**, which is rotatably attached to the nacelle through bearing **52**. The pedestal **53** is also rotatably attached to the pivot point **58** on the tower.

[0067] **Figure 8** also shows some of the details of one possible embodiment of the yawing mechanism: gear **55** is concentrically fixedly attached to the tower and is in mesh with gear **56**, which is driven by electric motor **57**, which is attached to the nacelle. When the motor turns, the whole nacelle rotates around pedestal **53**. **54** is an attachment point for the tilting mechanism, which is not shown in **Figure 8** for clarity purposes.

[0068] **Figure 9** is basically the same view as **Figure 8**, except that the tilting mechanism has been added. Gear **61** is rotateable attached to the tower pivoting point **60**, and meshes with gear **62**, which is driven by electric motor **63**. The gear **61** is also rotatably attached to the nacelle pedestal at point **64**. When the motor turns, the nacelle tilts around the tilting pivot point **60**.

[0069] Those skilled in the art will appreciate that the mechanisms described represent only one of the possible embodiments of this invention. Also, electric motors have been used for the descriptions above, but the actuation could also be hydraulic, pneumatic or through other means.

[0070] **Figure 10** shows an embodiment with a modified tower (or nacelle pedestal) that provides increased clearance distance between the rotor and the tower, in order to be able to substantially tilt down the rotor without coming too close to the tower. The tower or the pedestal used as attachment between nacelle and tower has a bend at an appropriate angle that moves the rotor forward away from the tower.

[0071] **Figure 11** shows this embodiment with the rotor tilted down.

[0072] **Figure 12** shows this embodiment with the rotor tilted up.

[0073] **Figure 13** shows a tiltable wind turbine according to this invention with a counterweight **81** to compensate for the varying angular positions of the nacelle and the rotor. The counterweight **81** can also be made movable along support **82**, so that all the weight can be held in equilibrium regardless of the tilting angle of the turbine.

[0074] **Figure 14** is another embodiment showing an off-shore version of the tiltable turbine of this invention. A platform **91** is used for access and maintenance. The wavy line is the sea level. The tower is mounted on a base like a tripod for stability. Of course other mounting systems can be used, like a single pylon, two legs, four legs, etc. The wind direction **71** is basically horizontal.

[0075] **Figure 15** shows the same off-shore version shown in **Figure 14**, except the wind direction has changed. With wind direction **73**, the turbine adjusts its angle for maximum power generation.

[0076] **Figure 16** shows another embodiment of the subject invention with a tilting mechanism and a counterweight **81**. When the wind is blowing in a horizontal direction **71**, the counterweight **81** is in an appropriate location on support **82** for this configuration to provide balance for the turbine.

[0077] **Figure 17** shows the same embodiment depicted in **Figure 16** except that the wind **72** is in an upward direction which the turbine has tilted down to confront. In this configuration counterweight **81** is appropriately adjusted in position on support **82** to maintain balance for the turbine.

[0078] **Figures 18, 19,** and **20** introduce another embodiment of the subject invention featuring an esthetic tower and support system for the nacelle. A hook like portion **84** on the tower forms an upper portion of the tower support system providing sufficient clearance for the rotors when the turbine is tilted downward. Yaw mechanism **83** forms a junction between the upper portion and lower portion of the tower support system. The wind direction **71, 72,** and **73** represent a horizontal, upward, and downward direction respectively, for which the turbine is shown to have adjusted appropriately to confront the wind stream efficiently.

[0079] **Figures 21, 22,** and **23** introduce another embodiment of the subject invention featuring an esthetic tower and support system for the nacelle. A curved portion on tower **85** forms a support system providing sufficient clearance for the rotors when the turbine is tilted downward. Yaw mechanism **83** is located on the underside of the nacelle. The wind direction **71, 72,** and **73** represent a horizontal, upward, and downward direction respectively, for which the turbine is shown to have adjusted appropriately to confront the wind stream efficiently.

[0080] **Figure 24** shows a typical prior art turbine as shown in **Figures 1** and **2** installed on a ridge top. Typical accelerated upward wind is depicted with an angle which is not horizontal or parallel to the horizontal axis **88** through the rotor. As a result, the rotor sweeps through the wind stream with an inefficient bias slice and can not take advantage of the available wind resource.

[0081] **Figure 25** shows the same installation site on a ridge top except the turbine is equipped with a tilting mechanism. The turbine is shown tilted with axis **88** aligned to efficiently confront the upward accelerated wind resource.

[0082] **Figure 26** shows a sloped hill or mountain terrain with an array of turbines installed for a wind farm. Prior art conventional turbines are not well suited for sloped terrain installations because they can not tilt to take advantage of the upward winds and because the sloped terrain behind the turbine inhibits proper air flow past the turbine. The subject invention provides for turbines to be spaced apart appropriately to prevent interference from turbulence between rotors. Each turbine is enabled to tilt appropriately to confront the accelerated wind stream rising upward. The subject invention allows wind farms to take advantage of sloped terrain which is usually less costly to acquire and/or lease for wind farm operations than open level terrain.

[0083] Advantages of the Invention

[0084] One advantage of the subject invention is a turbine with a **tilting mechanism** to provide tilting of the rotors to more efficiently confront the wind direction.

[0085] Another advantage of the subject invention is that the tilt feature employed by the turbine provides a **lower cut-in wind speed** for establishing initial rotation by tilting to confront the wind at the most direct angle.

[0086] Another advantage of the subject invention provides one **additional degree of freedom** to optimize power generation (angle of rotor relative to tower). This advantage provides a major advantage in power generation. Wind streams are typically not perfectly horizontal, and often are at a substantial degree from a horizontal line. Utilizing the tilting feature, a typical conventional turbine that adjust in two dimensions (2D) is **improved to adjust in three dimensions (3D).** The advantage of the subject invention to tilt upward and downward to better confront the wind stream is a major advantage in efficient use of the turbine. The consequence is better operating efficiency and **higher power generation**.

[0087] Another advantage of the subject invention is the provision of a tower support system with sufficient **clearance for the rotor sweep** when the turbine in tilted downward to confront the wind.

[0088] Another advantage of the subject invention is that the tilting feature and ability provides the turbine with a **new defensive adjustment to avoid destructive winds**.

[0089] Another advantage of the subject invention is that a turbine unit enabled with a tilting means provides an opportunity for a wind farm to **increase total energy capacity production** on ridge tops and hillside installations. This advantage is accomplished by taking advantage of the tilting mechanism to **efficiently confront thc upward winds on sloped terrains**.

CLAIMS

What is claimed is:

1. An electrical generation system to generate electricity from wind energy, comprising at least the following subsystems, in functional combination:

a tower to provide the necessary altitude for favorable wind velocities;

a nacelle attached to the tower, substantially near to or at the top of the tower, said nacelle being able to rotate around a first yaw axis which is substantially parallel to the tower axis, and also around a second tilting axis which is substantially perpendicular to the tower axis;

a rotor rotateable at the nacelle around a rotor axis of rotation and comprising a rotor hub and at least one rotor blade, said blade rotatably attached at or near its root to the rotor hub;

a transmission and a generator in the nacelle, to raise the rotational speed and then convert the rotational energy of the rotor into electric energy;

a pitching mechanism in each rotor hub or in each nacelle that can rotate the blade about a blade axis of adjustment which is substantially longitudinal to the blade, in order to adjust the blade's angular position to prevailing wind conditions and desired operating conditions;

a yawing mechanism that can rotate the nacelle, in order to orient the rotor in the desired direction, such as frontally against the wind for maximum power generation or at a different angle in the presence of extreme winds or to park the turbines for maintenance;

a tilting mechanism that can rotate the nacelle and its rotor around the yaw axis in order to achieve the desired angle of attack of the wind when the wind direction is not perfectly horizontal, such as upwards winds and downwards winds, thus providing one more key degree of freedom in the adjustment of the turbines for maximum energy generation, which is a new degree of freedom not available prior to this invention;

a brake system to stop the tower at the desired yaw position at the desired angle;

a brake system to stop the blade at the desired pitch angle position;

a brake system to stop the rotor tilting position at the desired angle;

an information system based on sensors and information collecting devices to detect, monitor and measure the status of the key operating parameters of the subsystems, status of components, environmental conditions such as wind conditions, grid requirements, and other relevant parameters; and,

a control system that can receive and process the information generated from the information system, and react by issuing the necessary commands that control the subsystems, such as changes in yawing, pitching, tilting, braking, etc.

2. System of claim 1, wherein the system also includes an information system based on sensors and information collecting devices to detect, monitor and measure the status of the key operating parameters of the subsystems, status of components, environmental conditions such as wind conditions, wind direction, wind speed, wind angle relative to the horizontal plane, grid requirements, and other relevant parameters, and a control system that can receive and process the information generated from the information system, and react by issuing the necessary commands that control the subsystems, such as changes in yawing, pitching, tilting, braking, etc.

3. System of claim 1, wherein the tilting mechanism provides another defensive adjustment for the turbine to employ to avoid destructive winds

4. System of claim 3, wherein the combination of yaw, pitch, and tilting provides an improved defensive system by which the turbine is able to adjust in three dimensions to avoid destructive winds

5. System of claim 1, wherein the at least one rotor blade is fixedly attached to the hub, eliminating the need for a pitching mechanism, and instead relying on stall as a control method for the blade.

6. System of claim 1, wherein some of the brake systems are friction-based brakes, such as friction disk brakes

7. System of claim 1, wherein some of the brake systems are of the positive engagement type

8. System of claim 1, wherein the rotor has been moved forward to create enough space between the rotor and the tower when the rotor is tilted down

9. System of claim 1, wherein the rotor can be tilted down

10. System of claim 1, wherein the rotor can be tilted up

11. System of claim 1, wherein the tilting mechanism is based on a gear based mechanism

12. System of claim 1, wherein the tilting mechanism is based on hydraulic, pneumatic or other type of actuation

13. System of claim 1, wherein the tower has a bend in either the upper portion of the tower structure an/or the lower portion of the tower to provide clearance for the rotor sweep to avoid rotor blade clash with the tower supports

14. System of claim 1, wherein a counterweight is attached to provide balance of weights around the tower

15. System of claim 14, wherein the counterweight position can be adjusted while the turbine is in operation to adjust to current operating conditions

16. System of claim 14 wherein the counterweight is based on transferring a fluid from one area of the structure to another

17. System of claim 14, wherein at least one counterweight is movable to vary its leverage in order to adjust the balance according to different positions of the turbine and different wind conditions

18. System of claim 1, wherein the tower includes a first bottom section attached to a foundation at the ground and a second top section which is rotatably attached to the bottom section, so that the carrier structure can be fixedly attached to the top section of the tower and still allowing the carrier structure to rotate about the axis of the tower.

19. System of claim 1, wherein the system is an off-shore application with a tiltable rotor unit mounted on a tower mast, with said tower mast either resting on, inserted into or embedded in the floor of a body of water such as the ocean or a lake.

20. System of claim 19 wherein the off-shore system is not resting on the floor of a body of water, but instead on a floating body or structure, including a vessel or other structure supported primarily or partially by buoyancy.

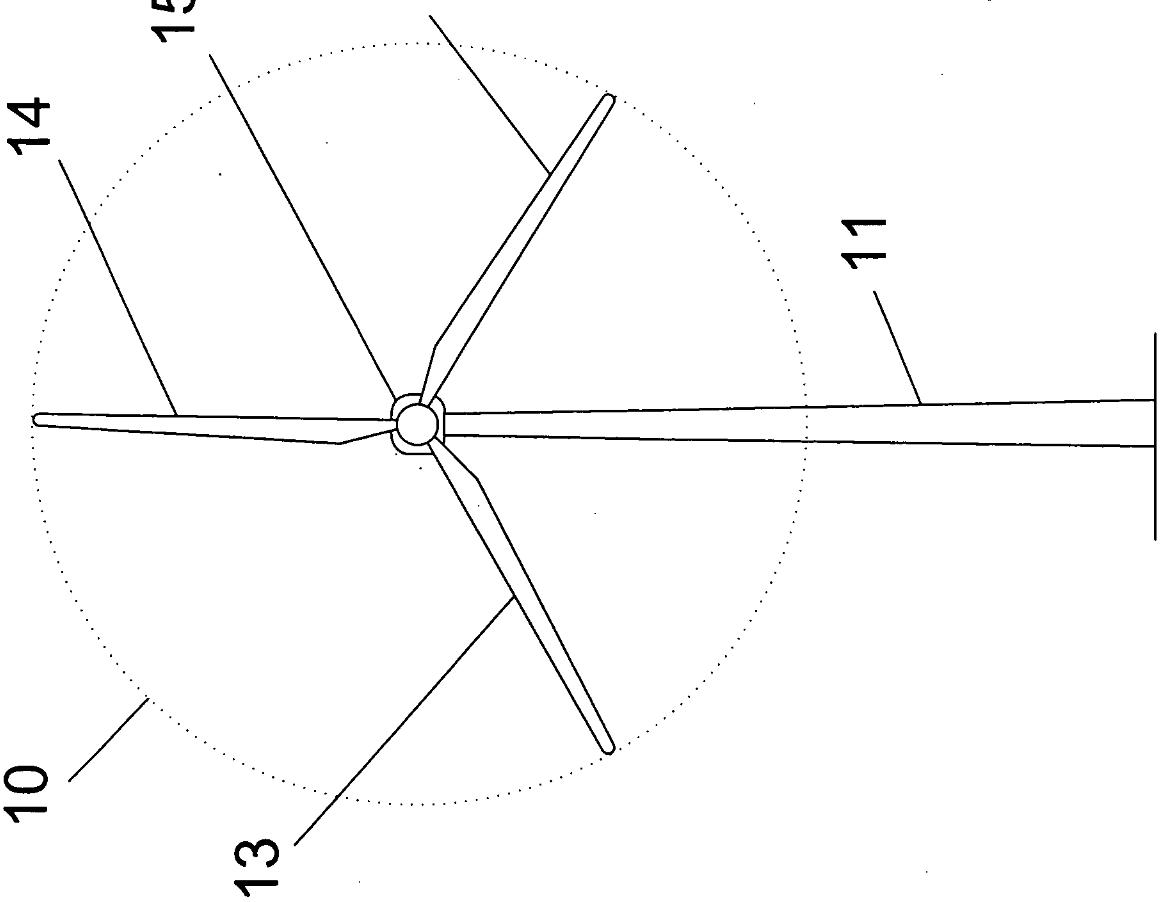


FIGURE 1

Prior Art

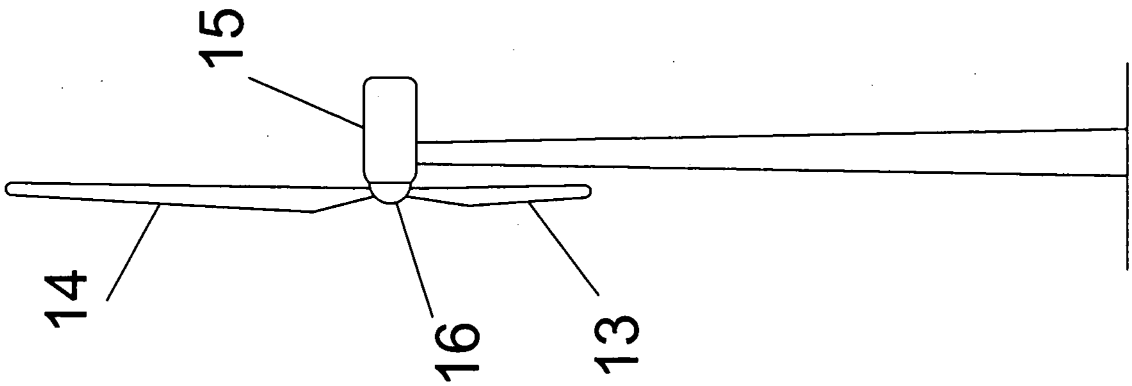


FIGURE 2

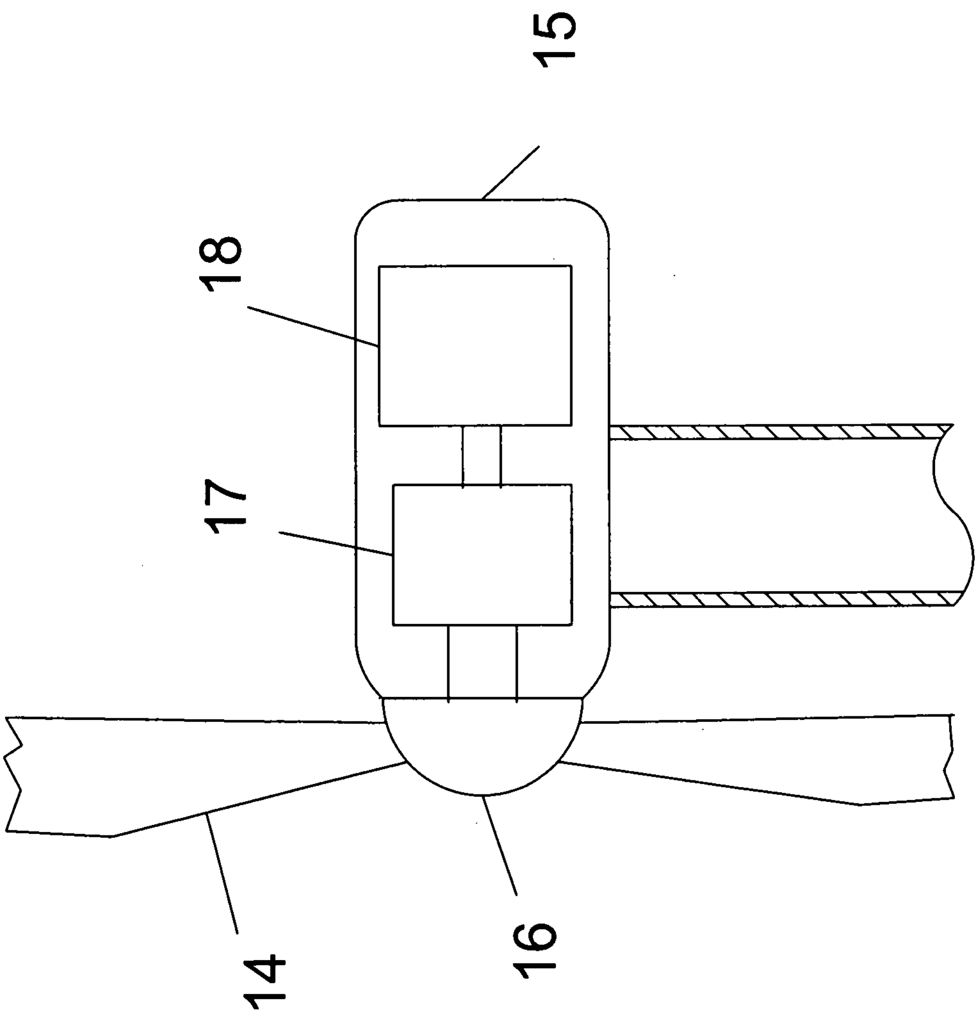


FIGURE 3
Prior Art

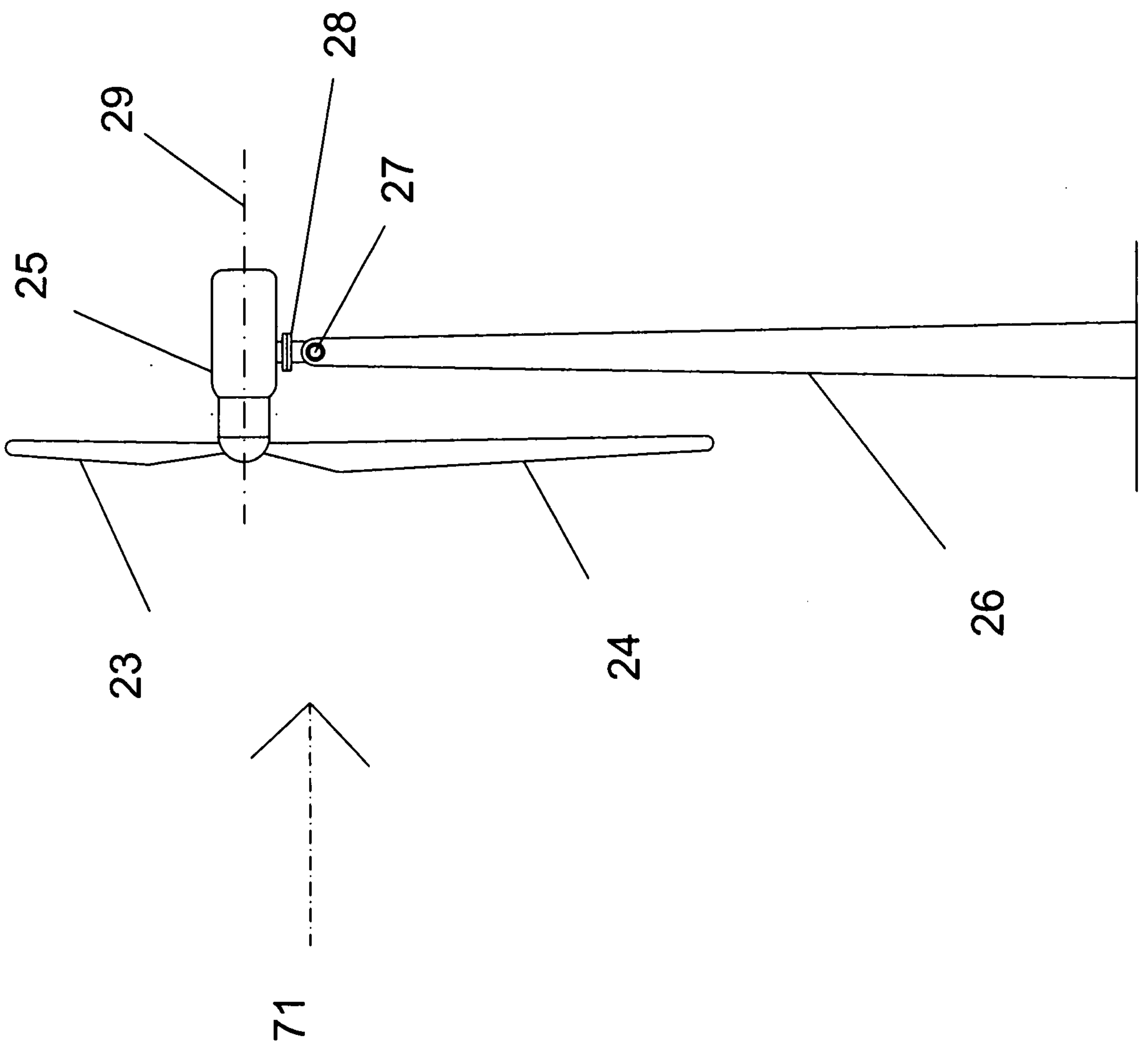


FIGURE 4

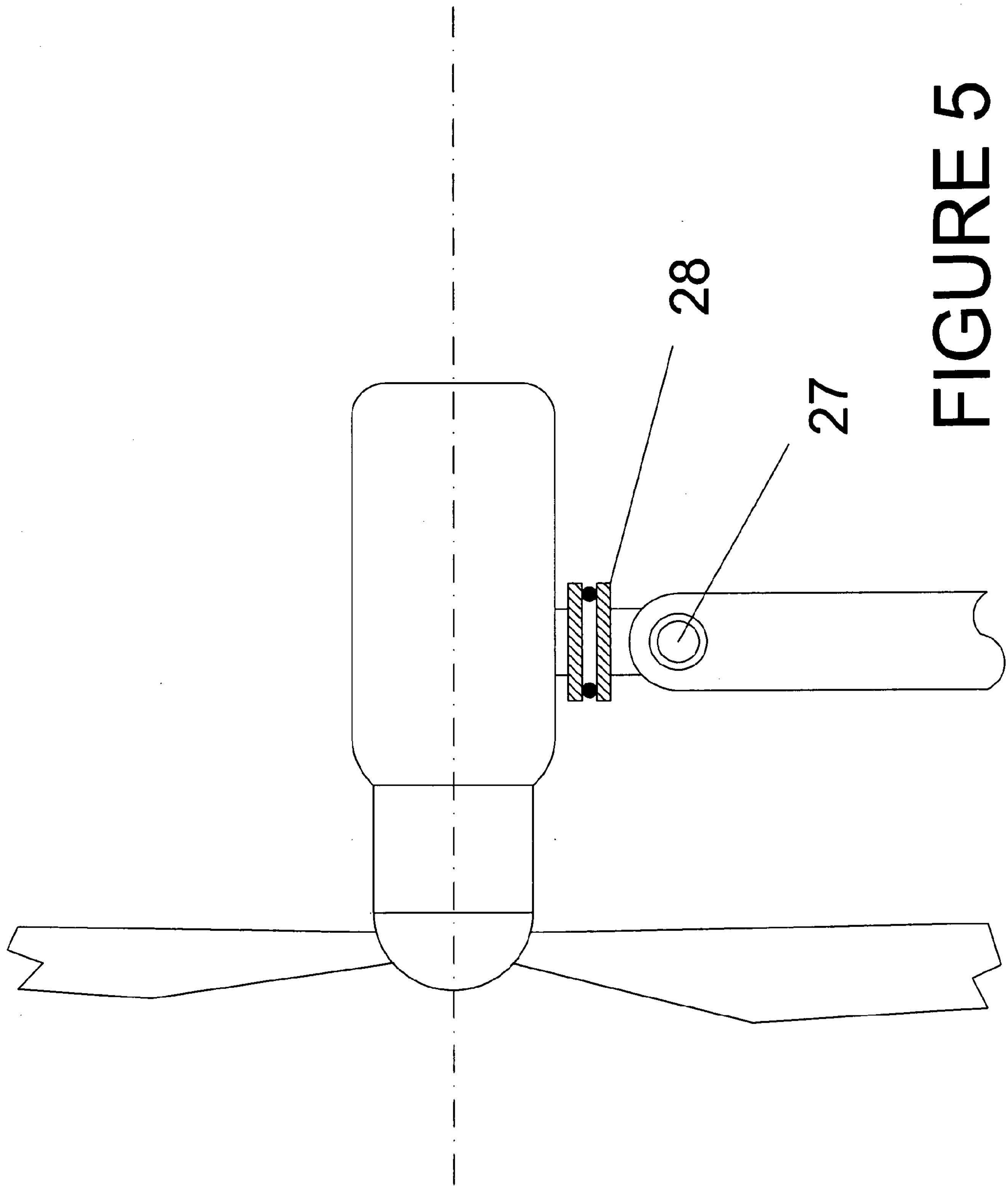


FIGURE 5

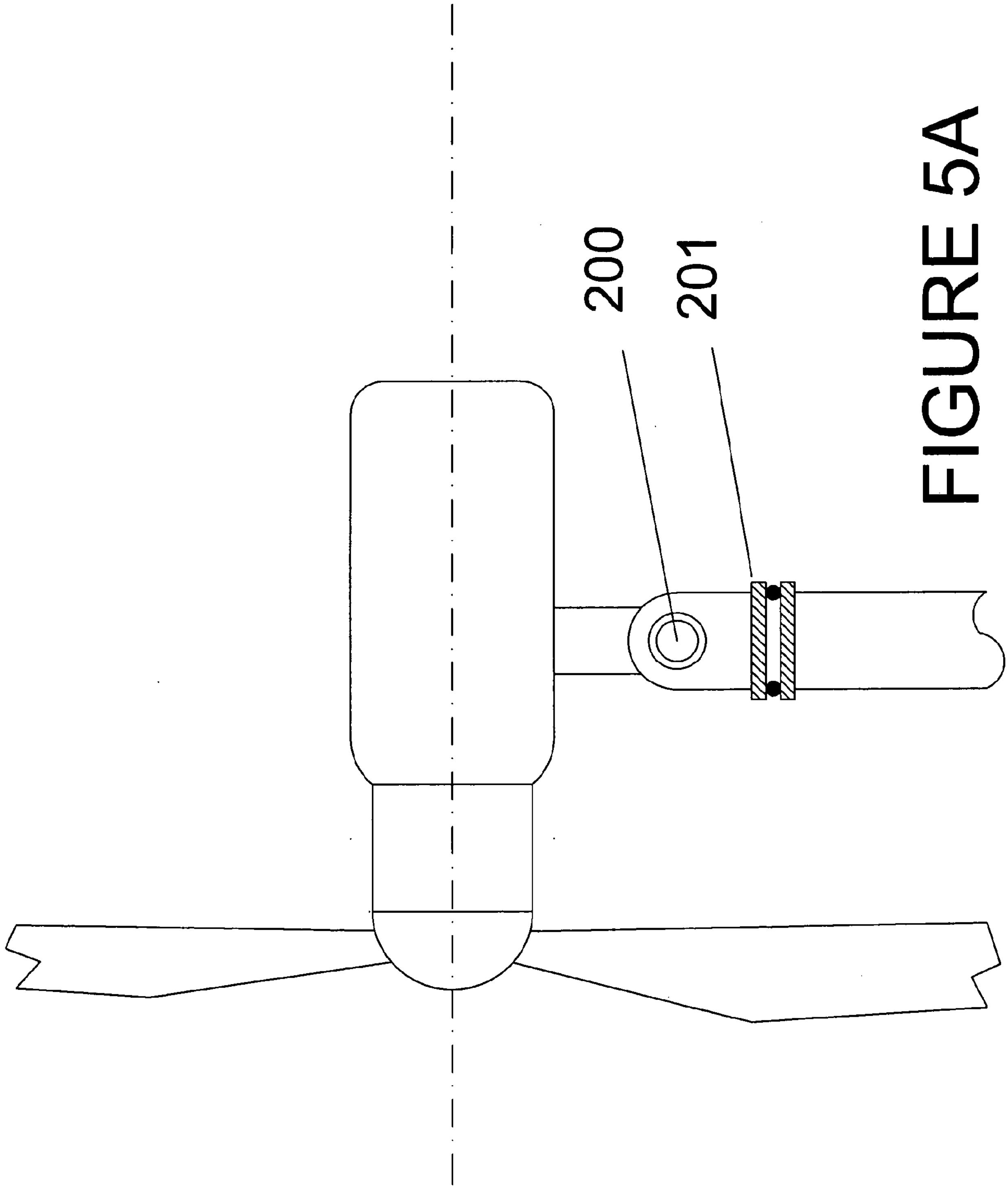
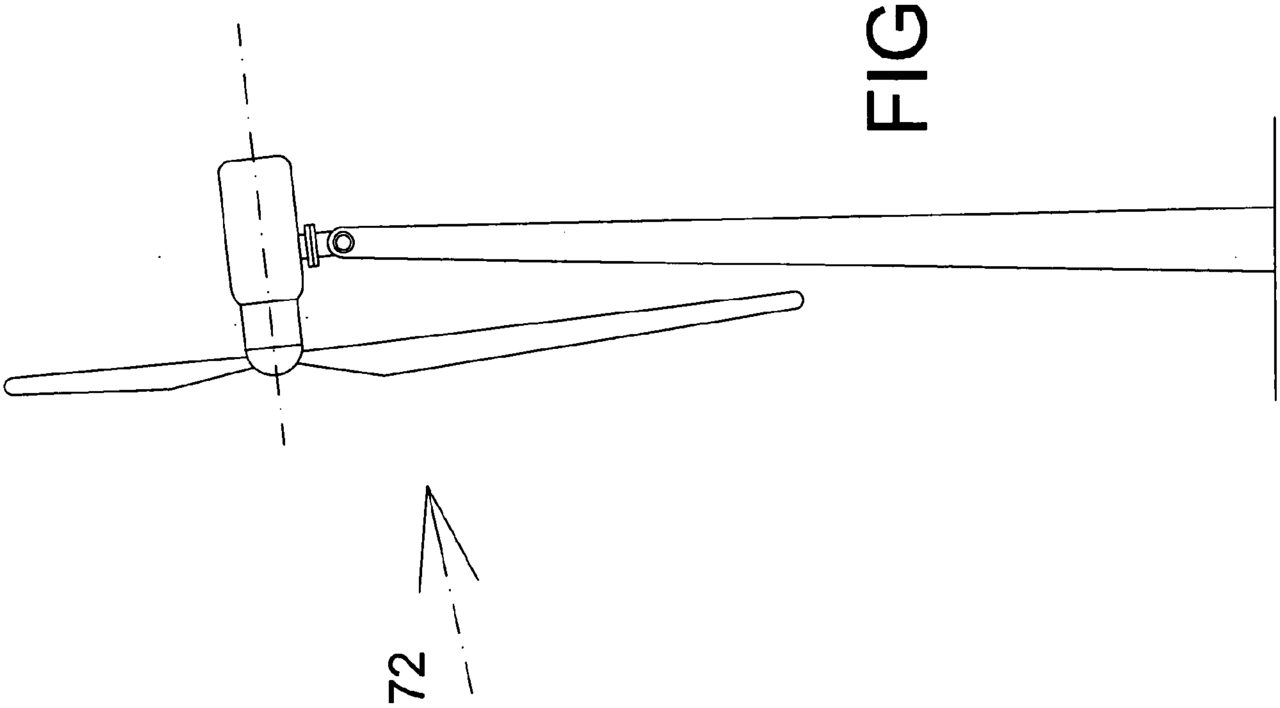


FIGURE 5A

FIGURE 6



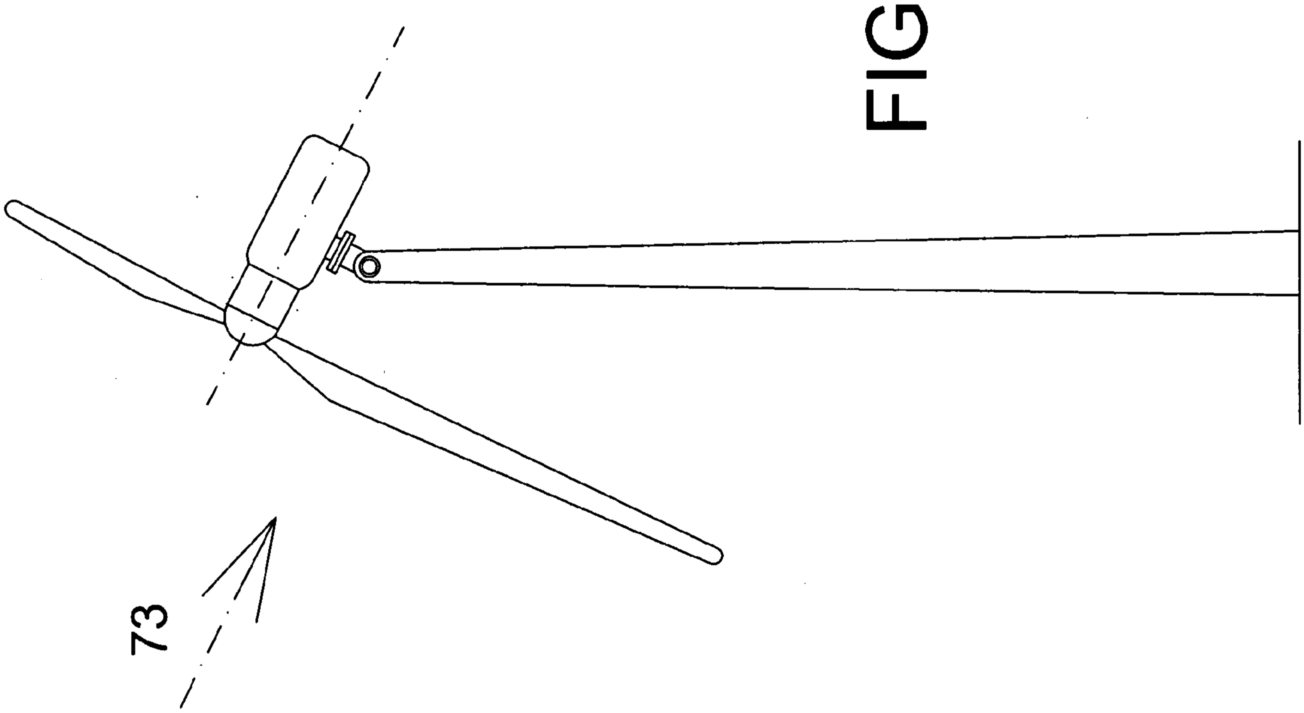


FIGURE 7

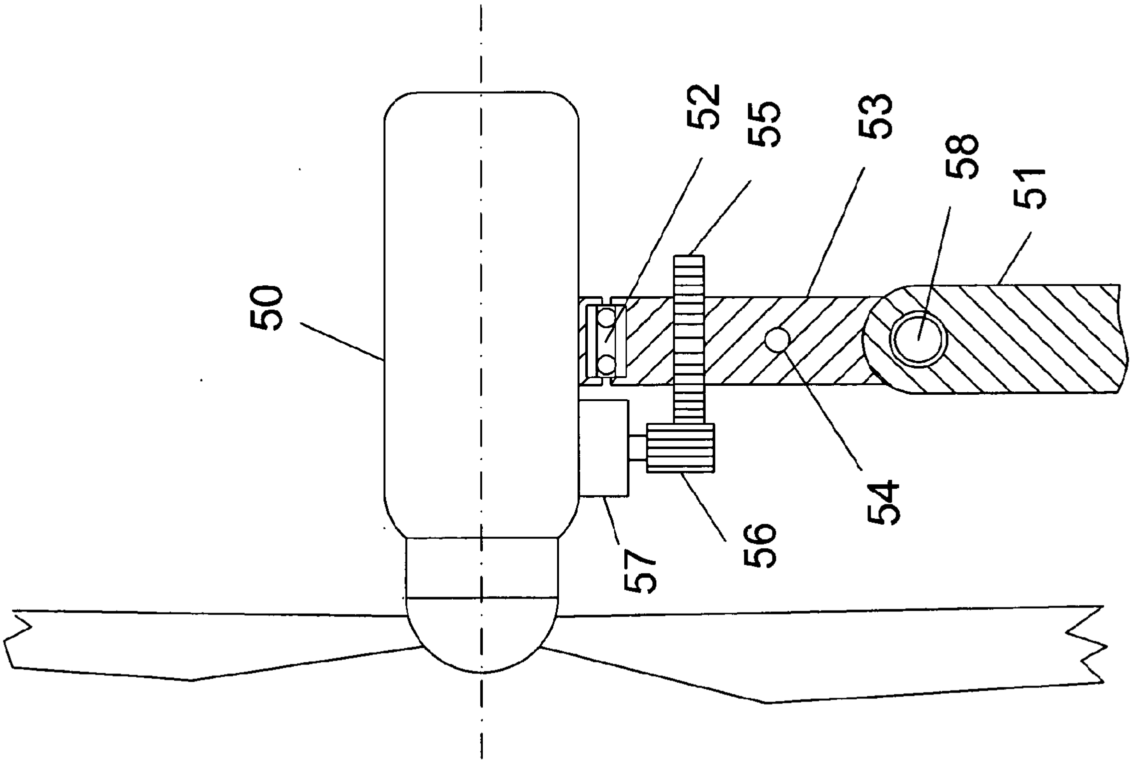


FIGURE 8

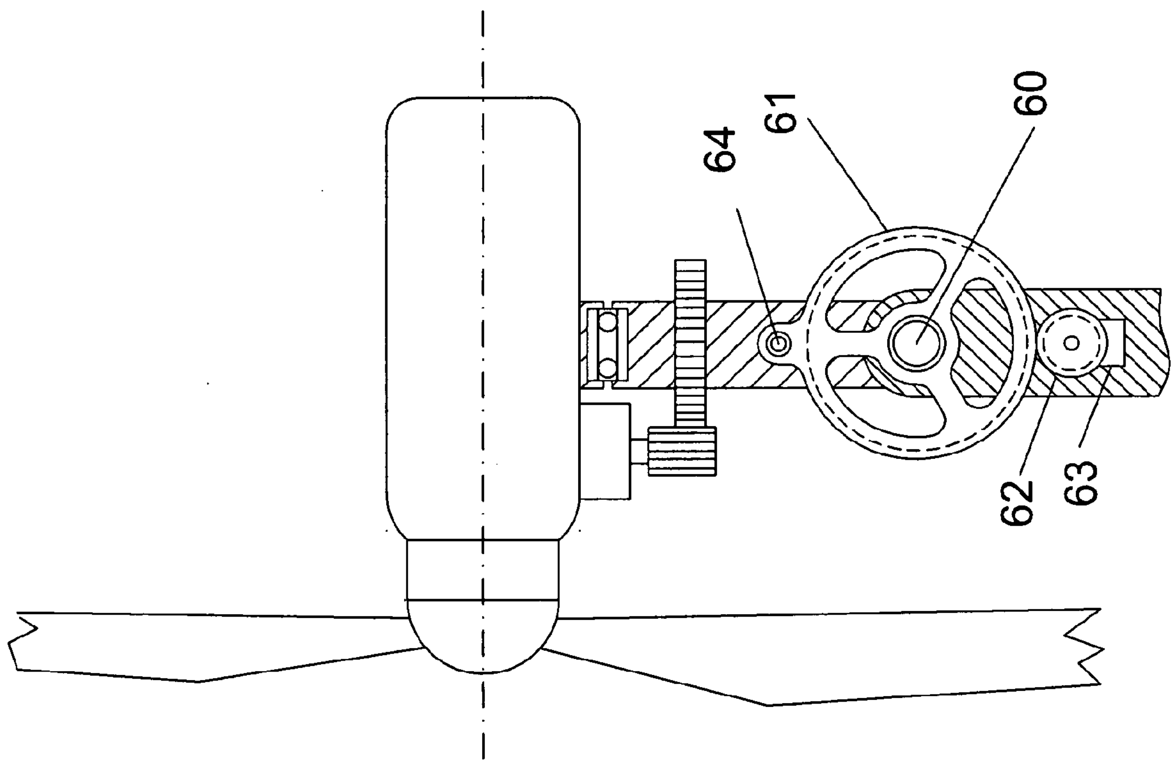


FIGURE 9

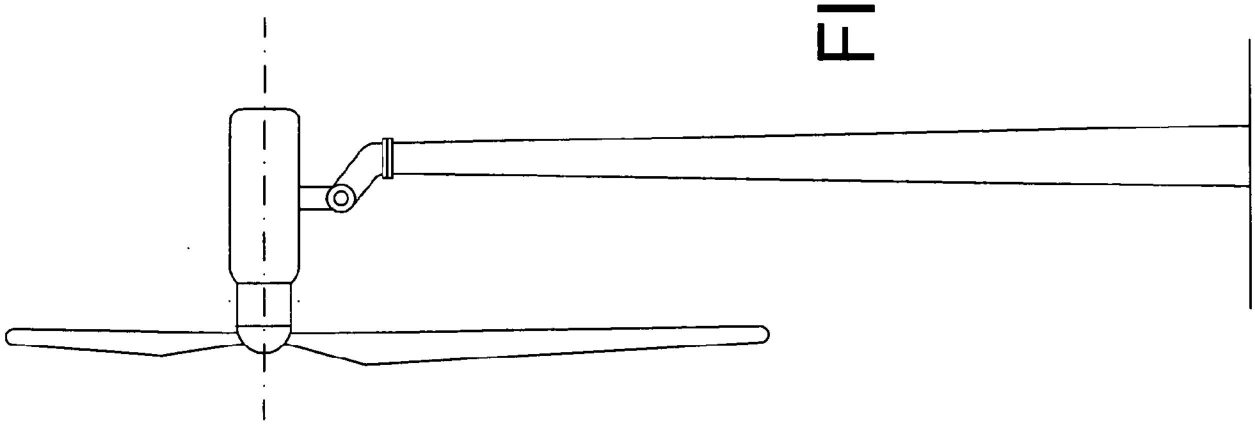
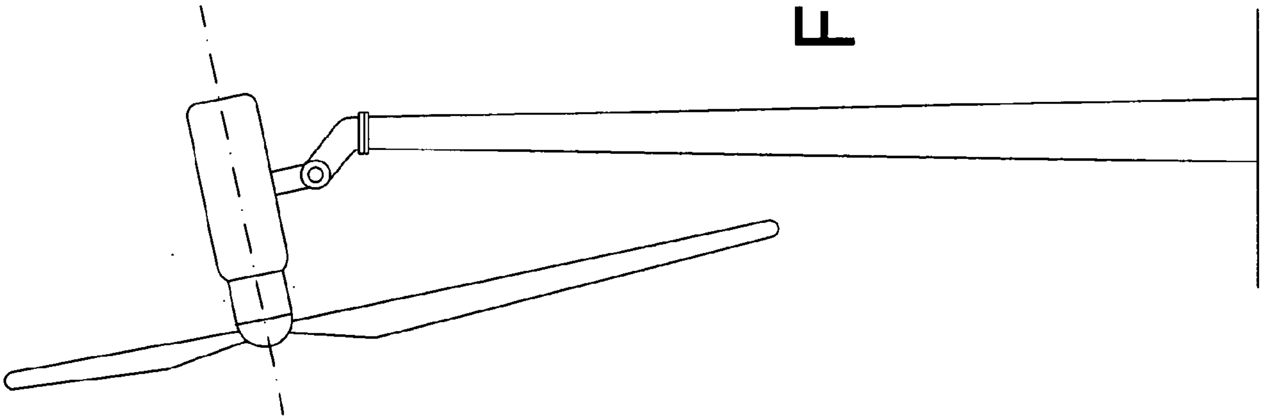


FIGURE 10

FIGURE 11



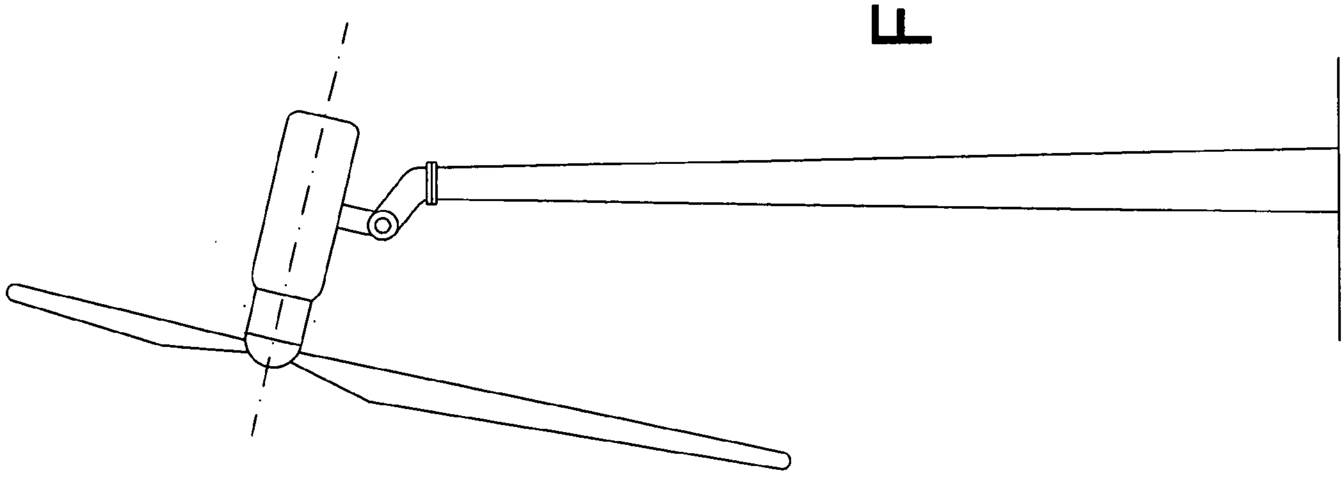


FIGURE 12

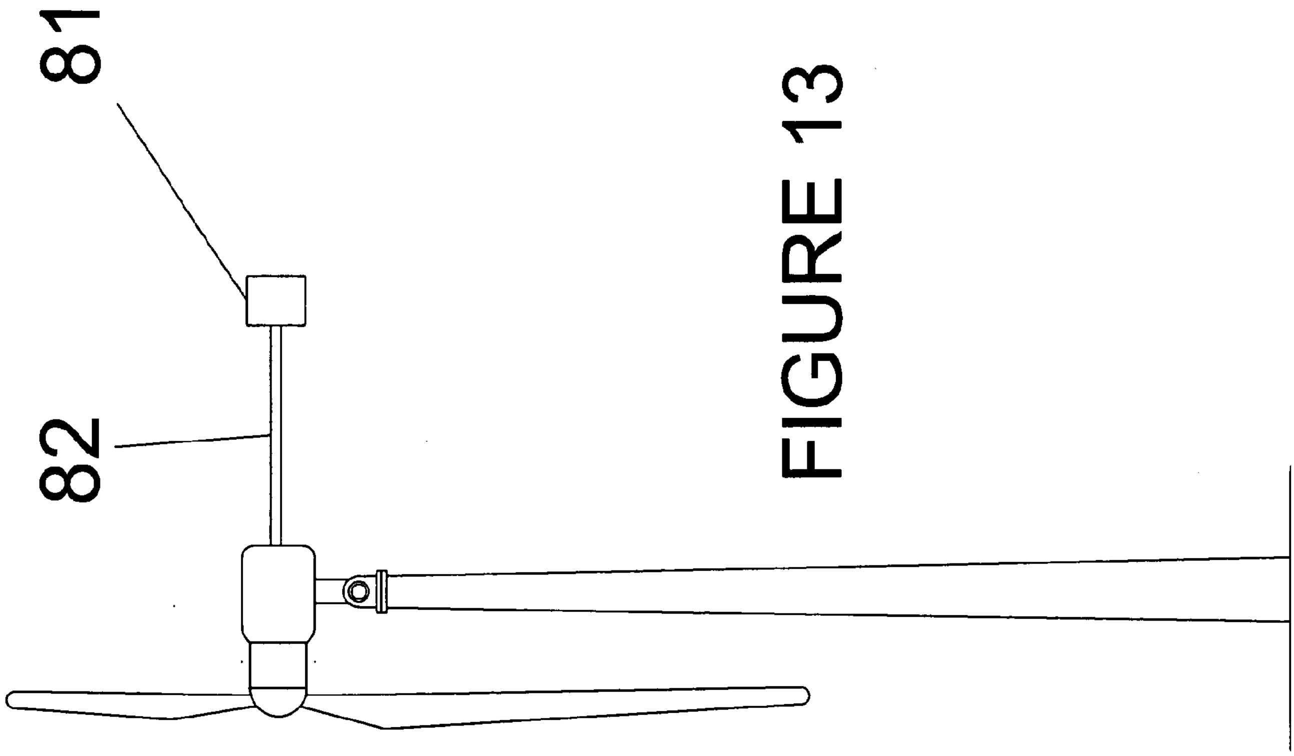


FIGURE 13

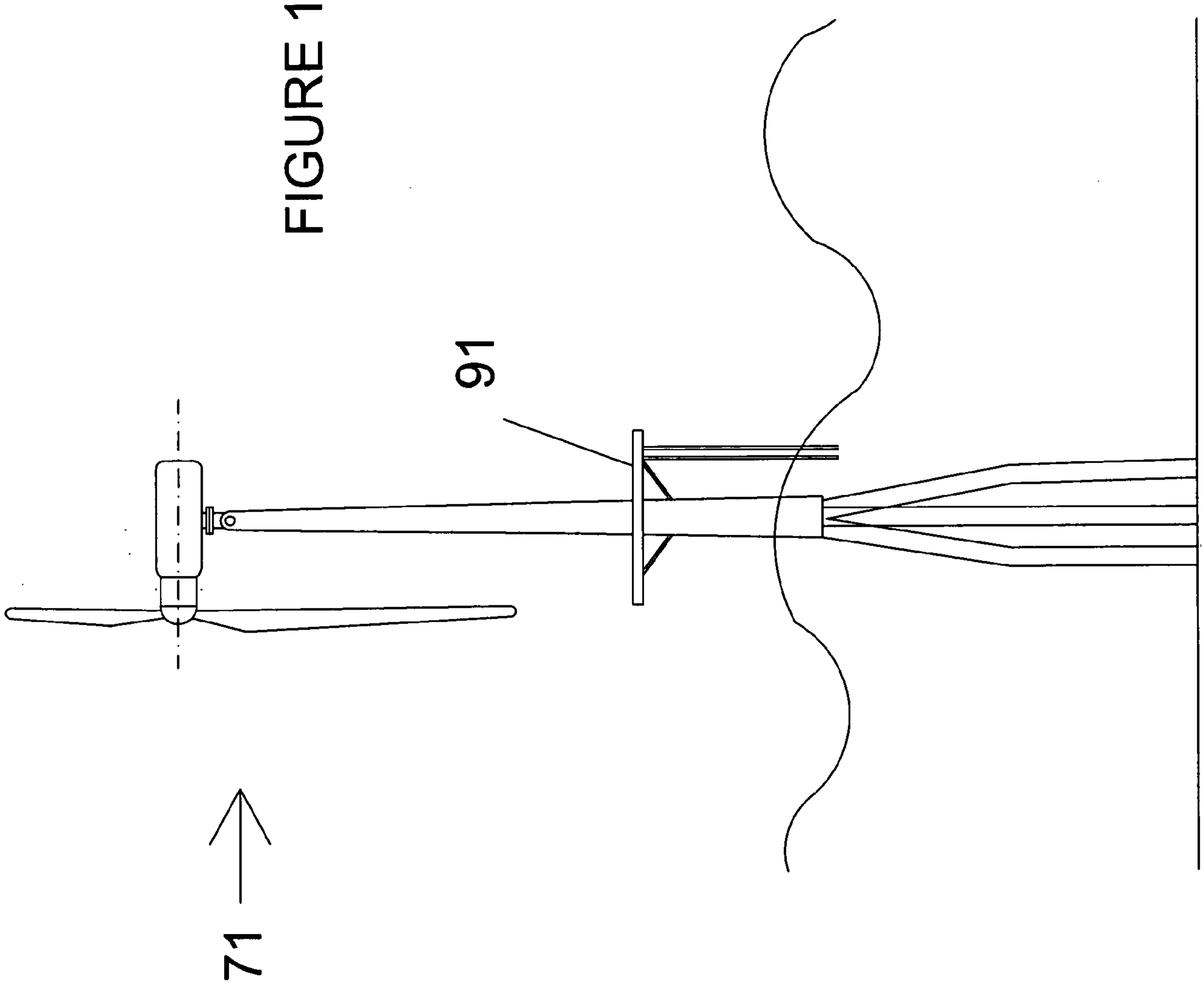


FIGURE 14

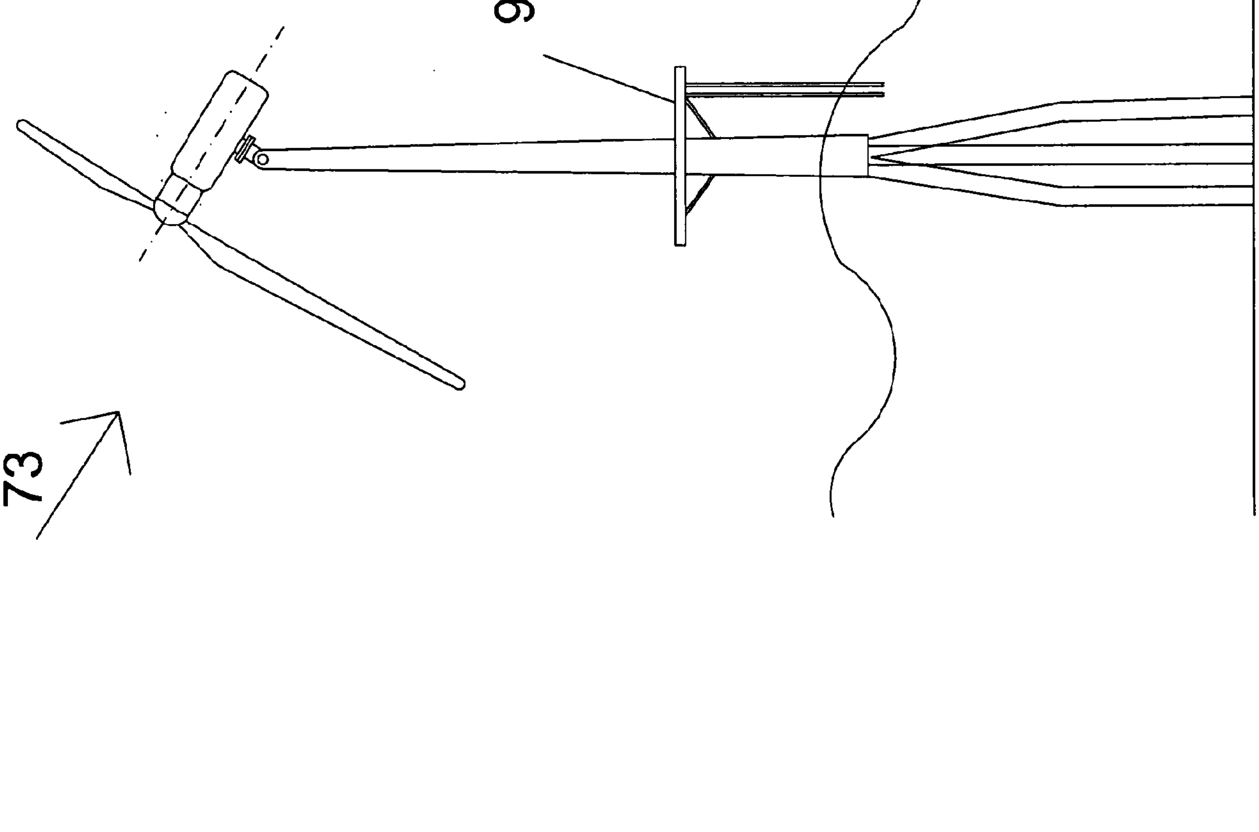


FIGURE 15

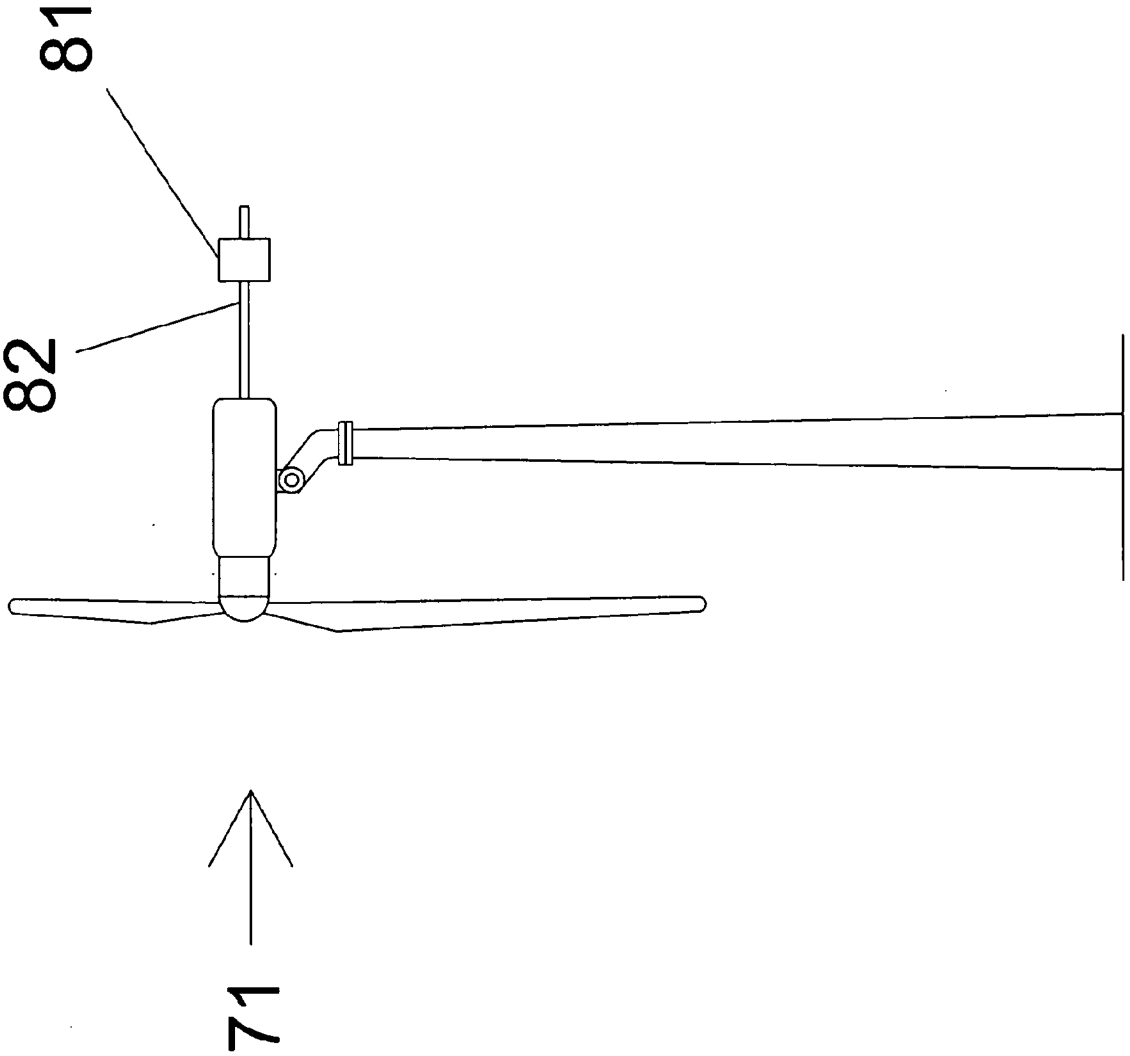


FIGURE 16

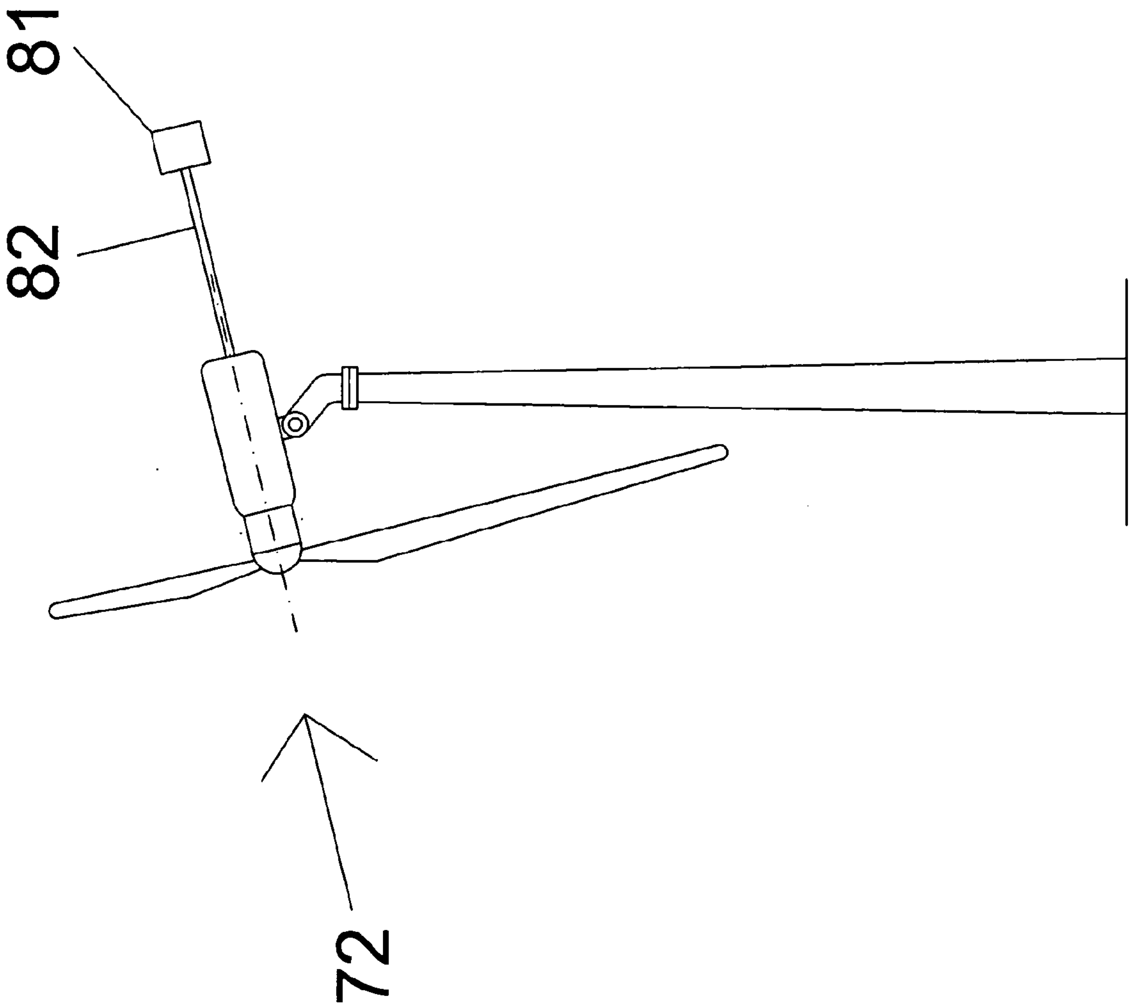


FIGURE 17

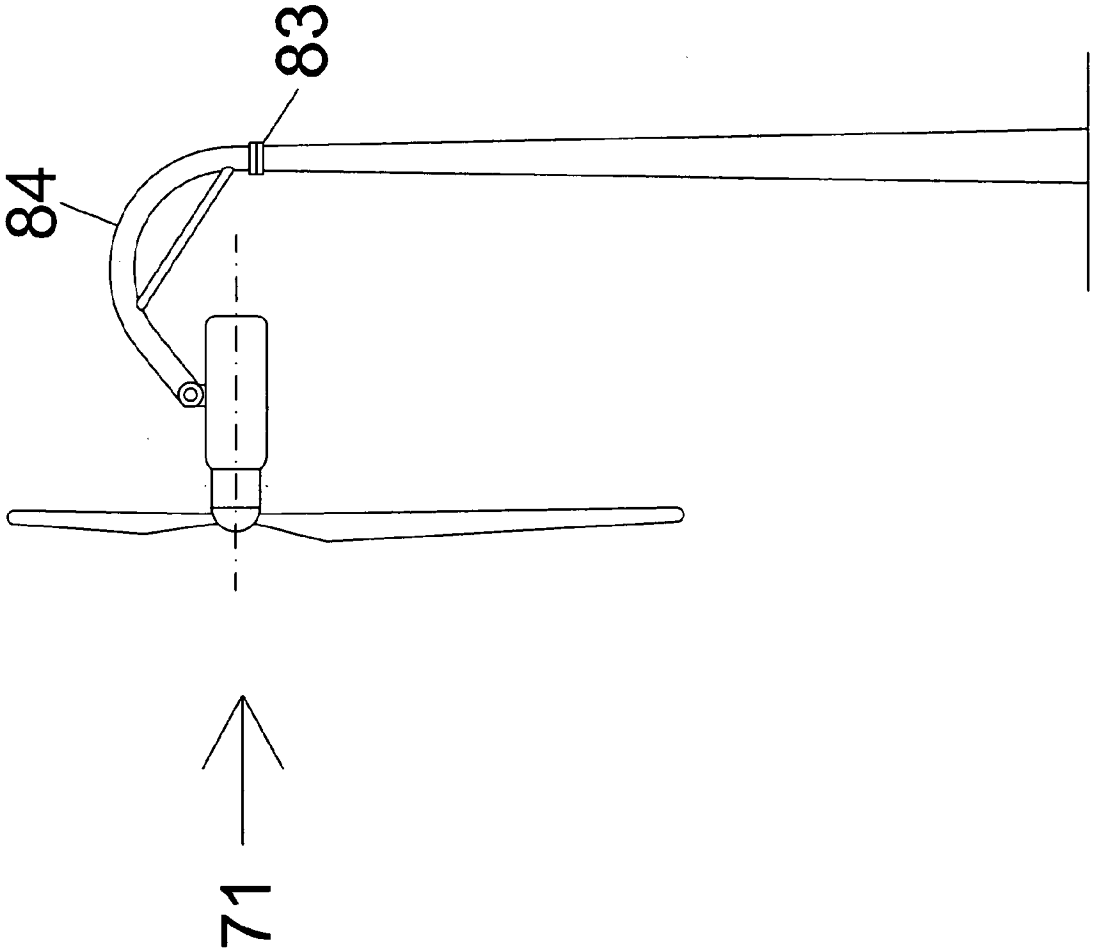


FIGURE 18

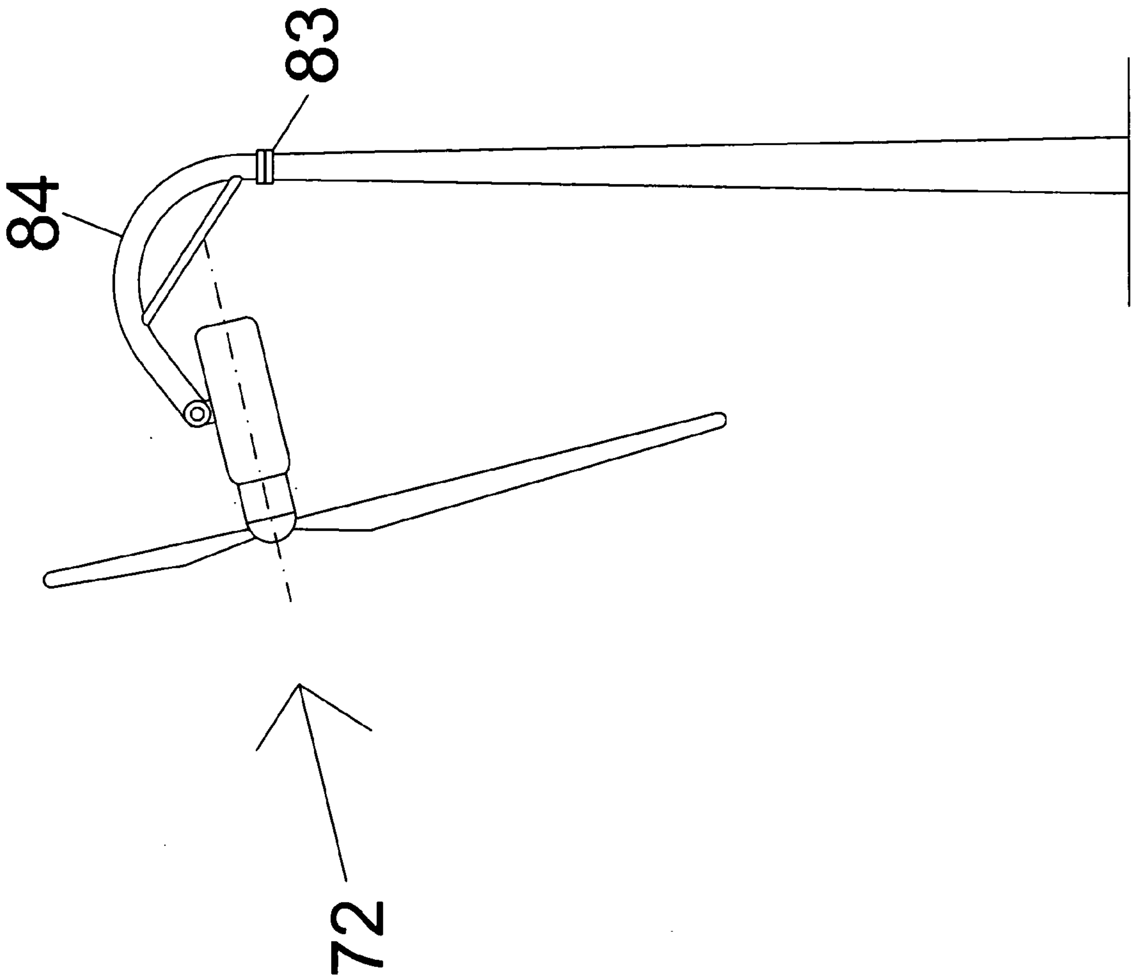


FIGURE 19

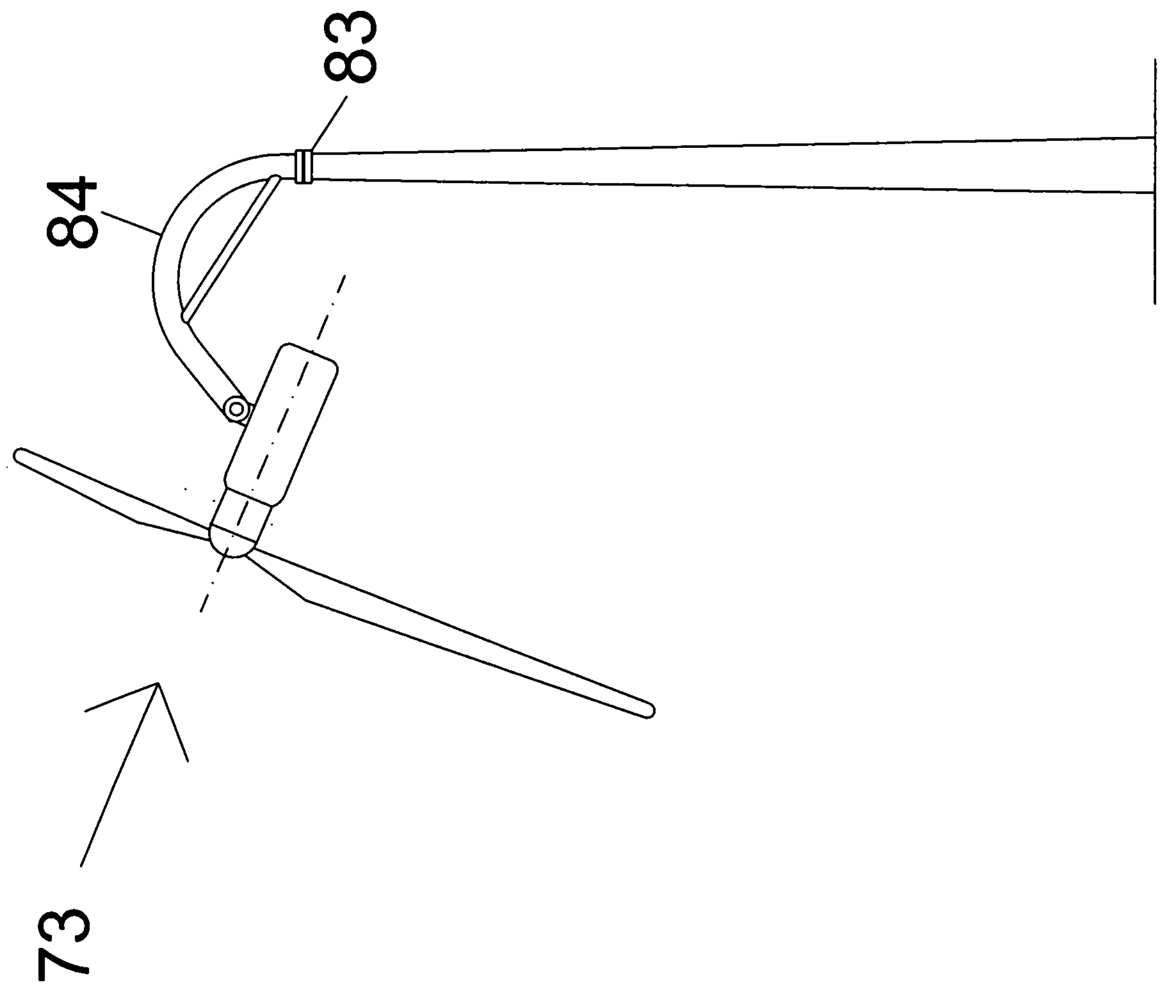


FIGURE 20

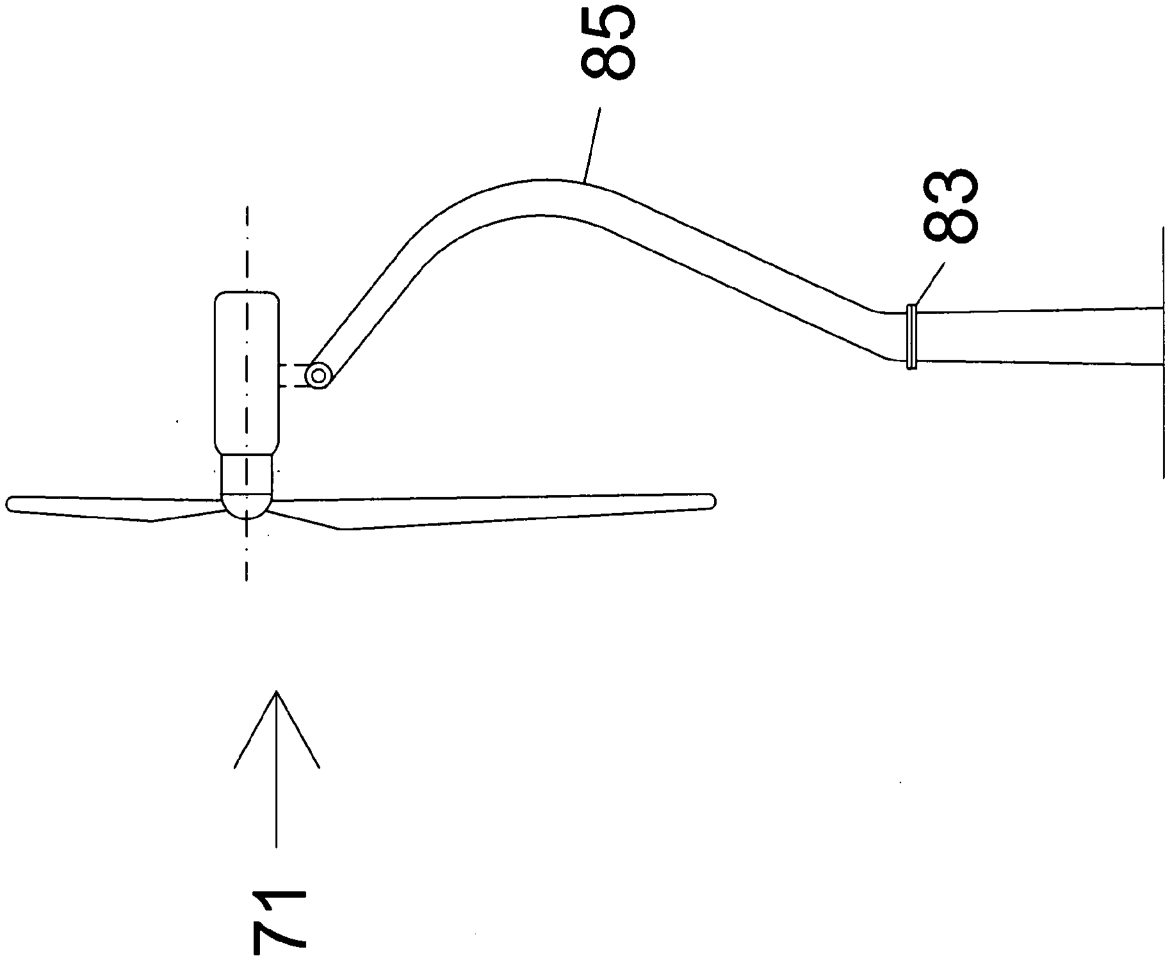


FIGURE 21

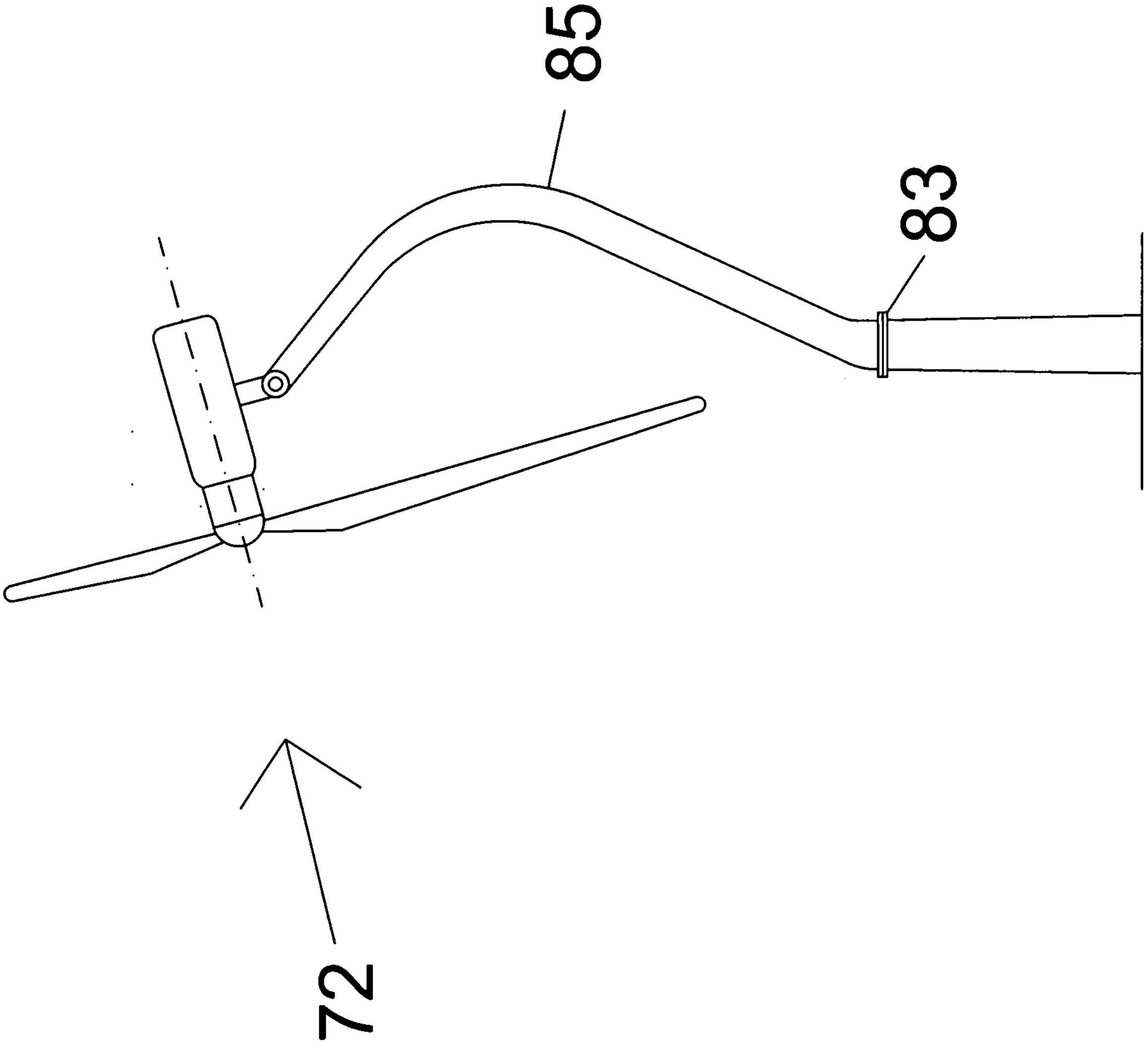


FIGURE 22

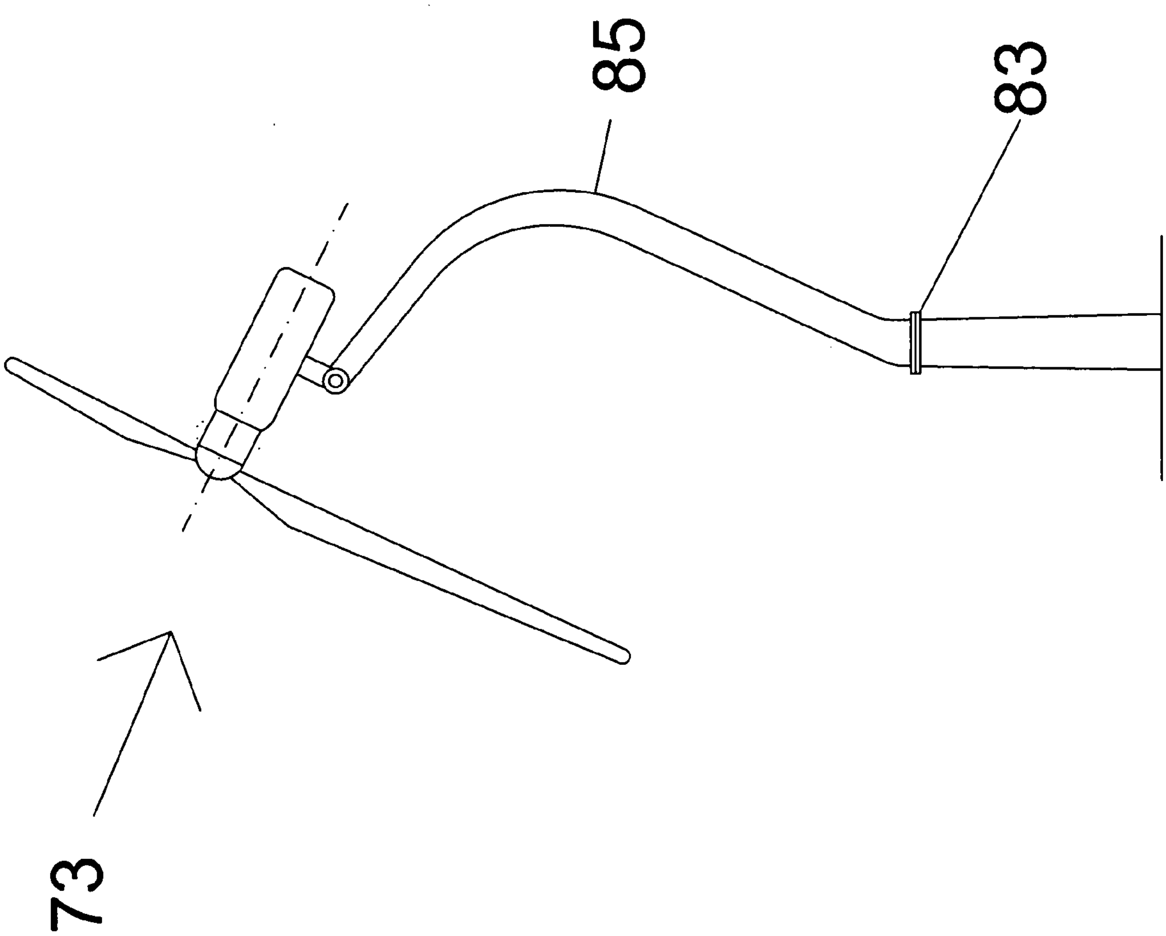


FIGURE 23

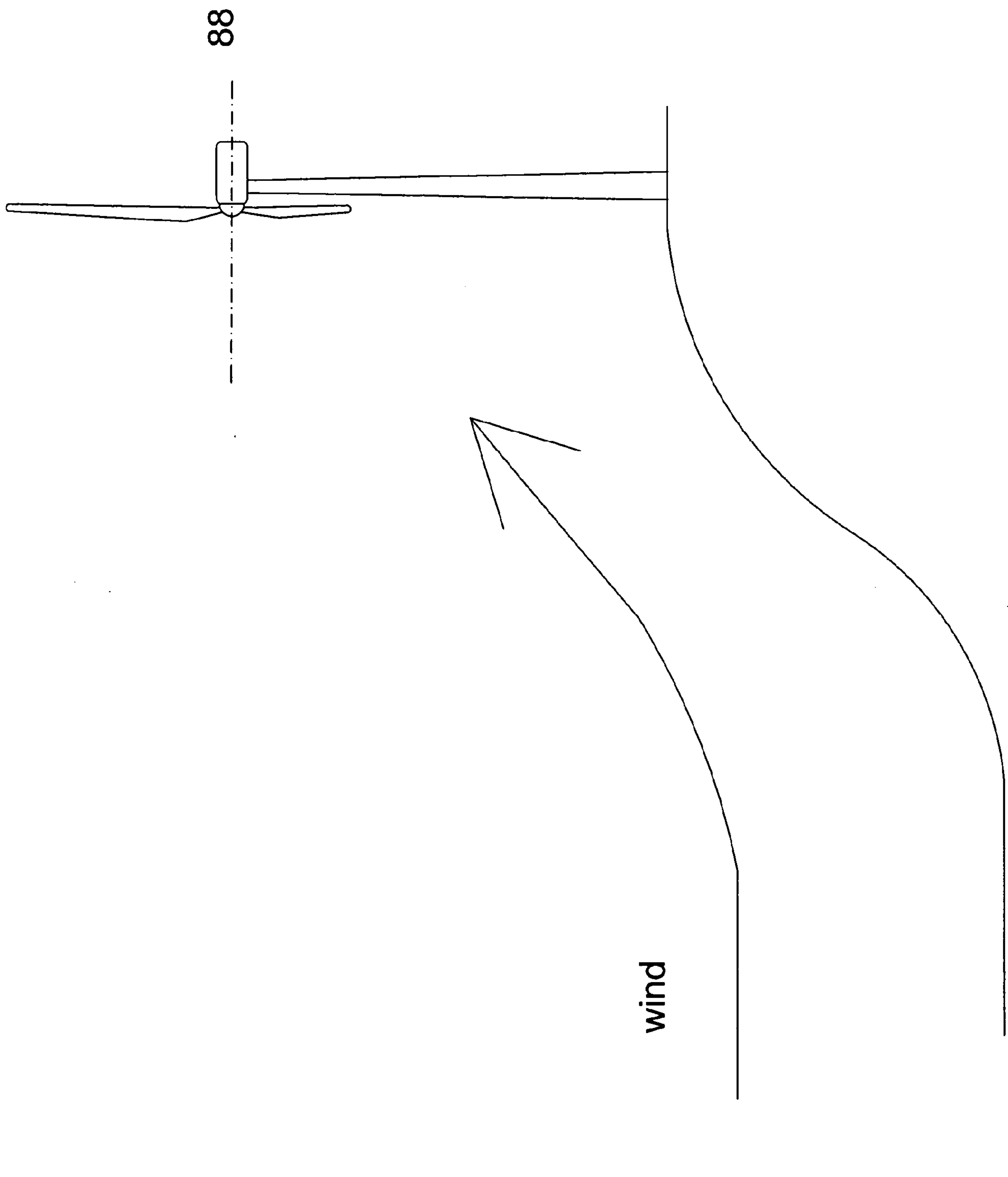


FIGURE 24

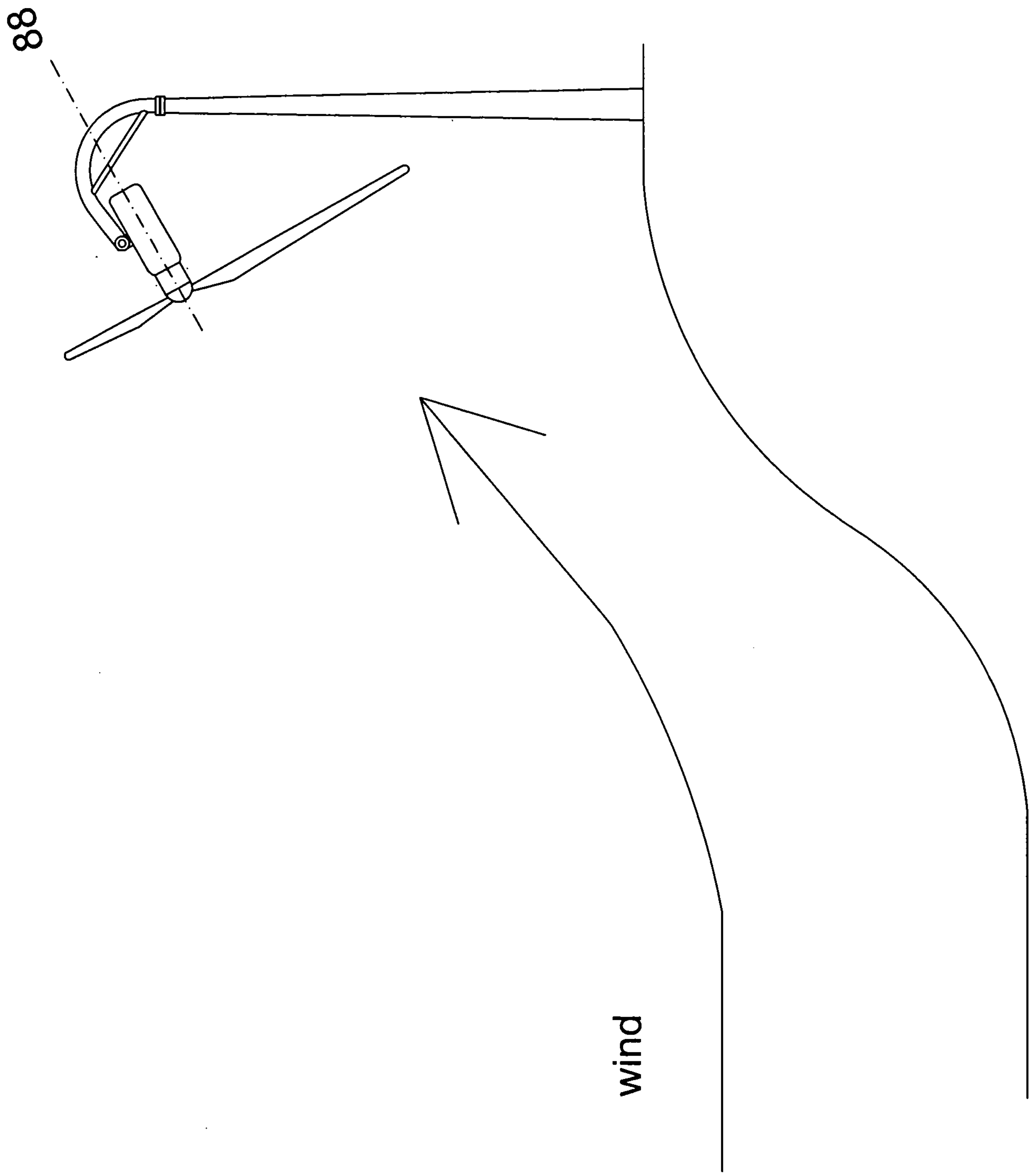


FIGURE 25

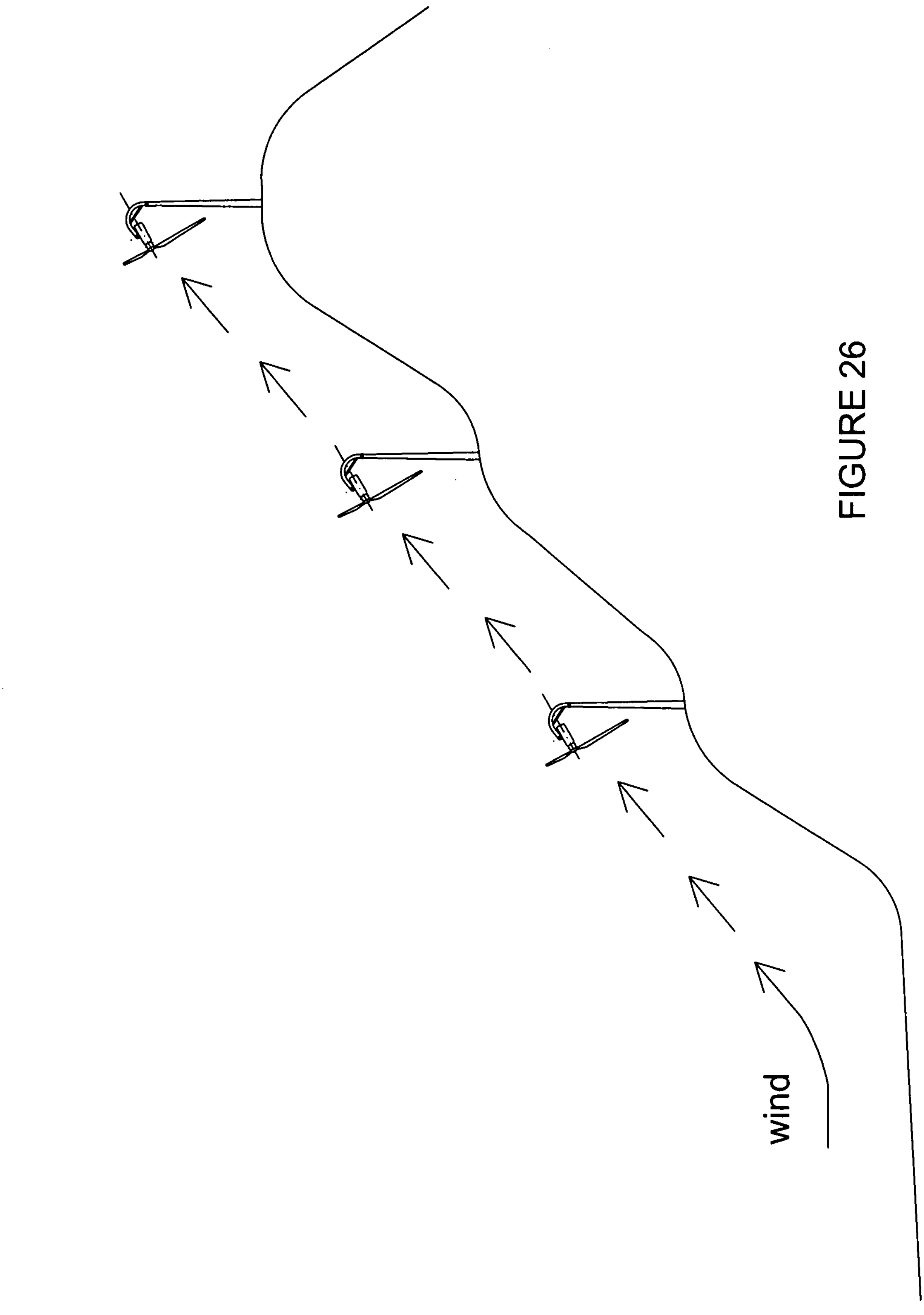


FIGURE 26

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 10/00329

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B63H 1/10 (2010.01)
USPC - 416/36
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)
USPC - 416/36

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 52/27, 40; 290/44, 55; 415/4.1-4.3; 416/9-10, 16, 31, 36, 40, 131-132 (keyword limited - see below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(PGPB,USPT,EPAB,JPAB), Google Scholar
Search Terms Used: wind, turbine, horizontal, axis, tilt, pitch, yaw, brake, float, sea, lake, ocean, floor, bed, hydraulic, fluid, counterweight

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0120801 A1 (ANTOUNE et al.) 24 June 2004 (24.06.2004) entire document, especially; para [0002]-[0023], [0043]-[0044]; Fig. 1, 6	1-20
Y	US 2004/0076518 A1 (DRAKE) 22 April 2004 (22.04.2004) entire document, especially; para [0003]-[0018]	1-20
Y	US 2007/0138021 A1 (NICHOLSON) 21 June 2007 (21.06.2007) entire document, especially; para [0060]-[0075]	11, 15-17, 19-20
A	US 2006/0159550 A1 (NAGAO) 20 July 2006 (20.07.2006) entire document	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
19 March 2010 (19.03.2010)

Date of mailing of the international search report
30 MAR 2010

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PCT OSP: 571-272-7774