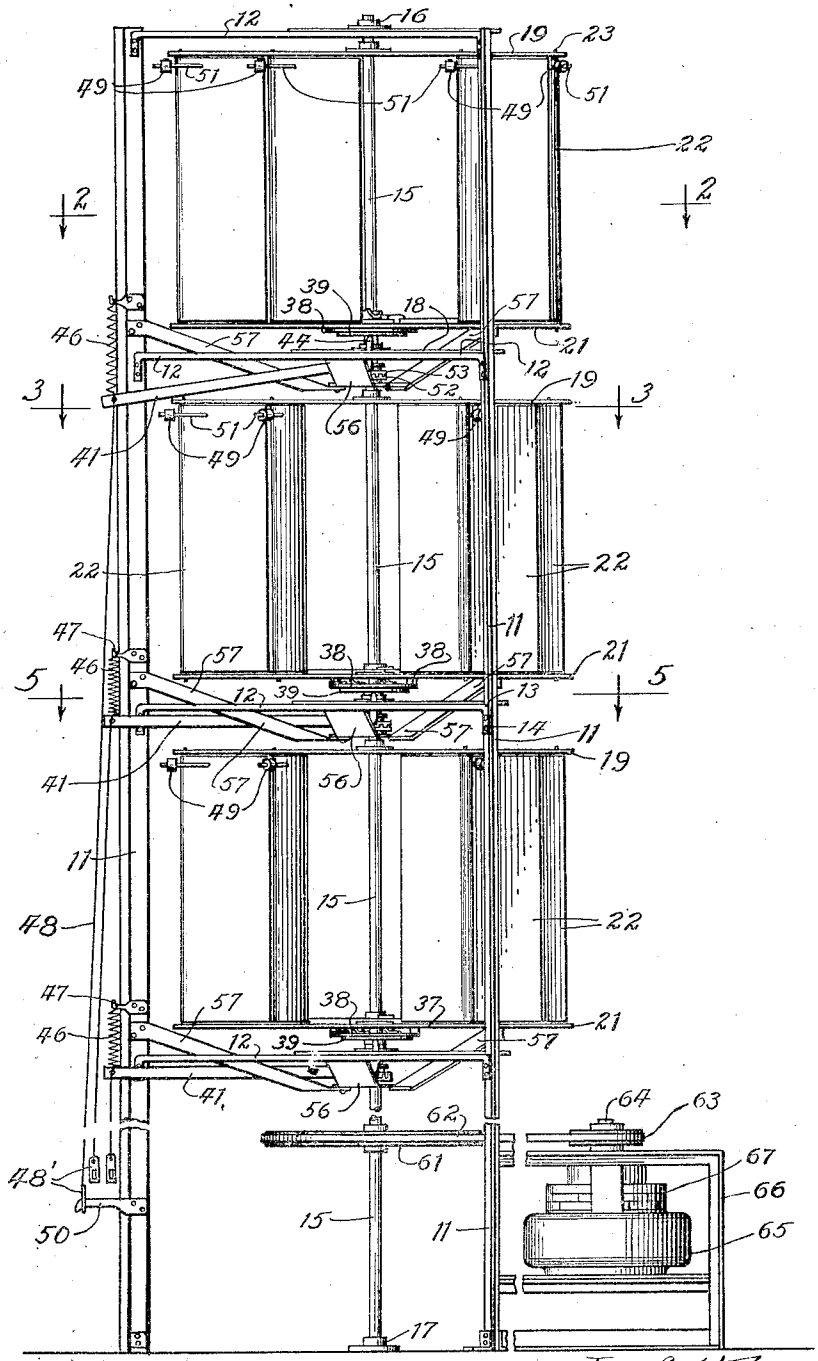
Dec. 27, 1927. 1,654,165

D. E. FELT

WINDMILL

Filed June 18, 1924 4 Sheets-Sheet 1

Fig-1



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WINDMILL

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Fig-2.

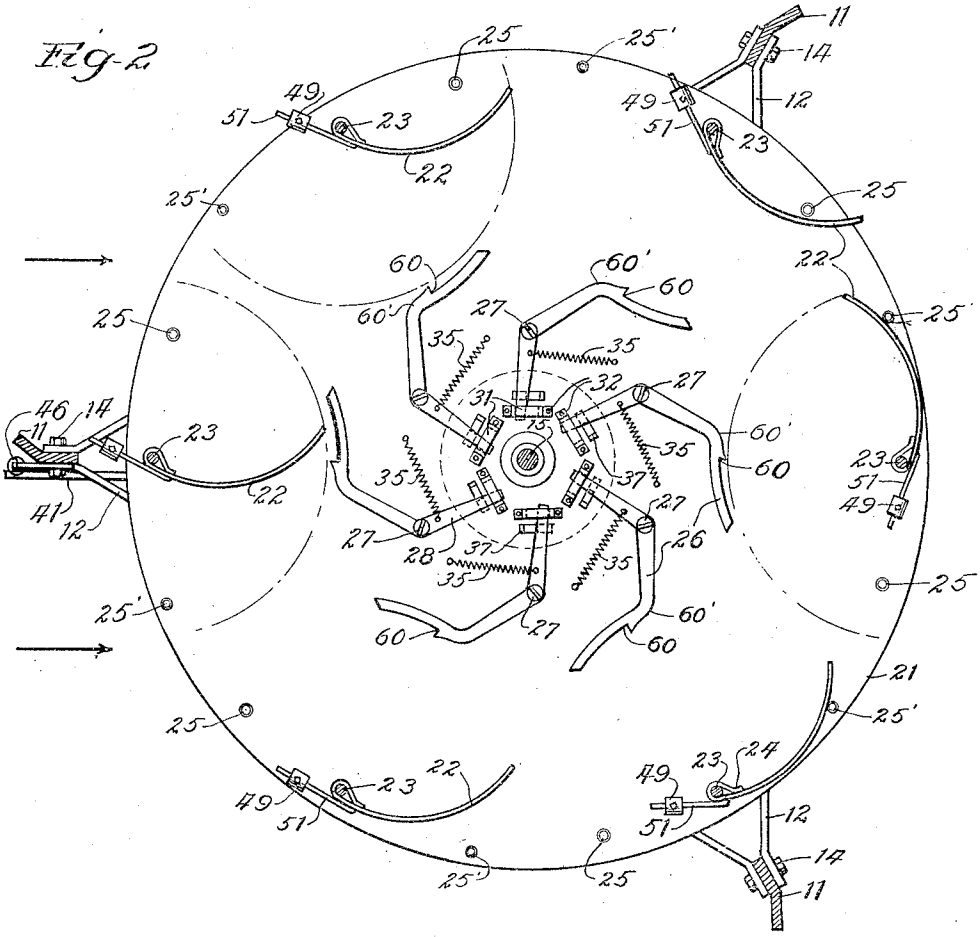
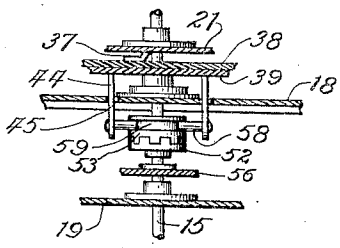


Fig-7



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WINDMILL

Filed June 18, 1924 4 Sheets-Sheet 3

Fig-3

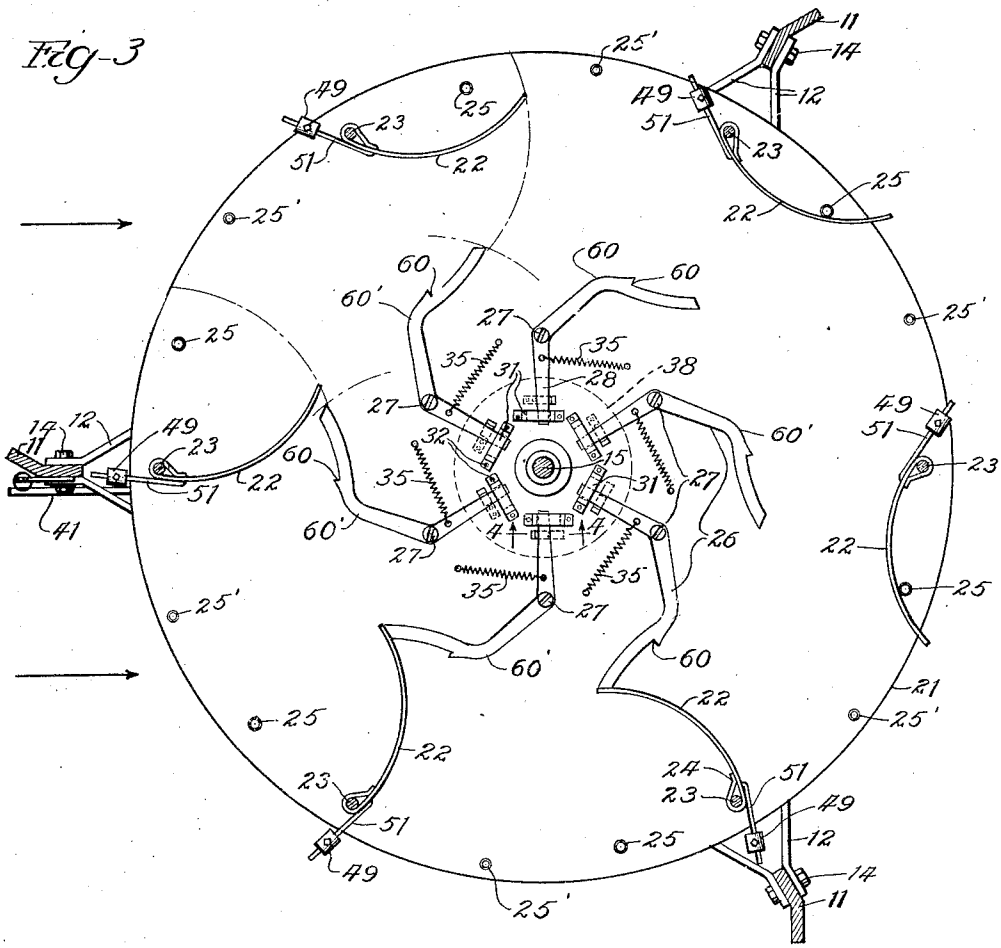
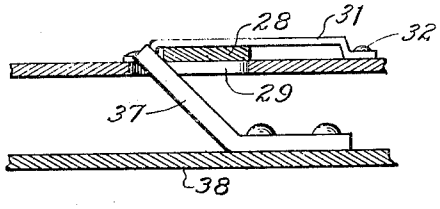


Fig-4



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WINDMILL

Filed June 18, 1924 4 Sheets-Sheet 4

Fig-5

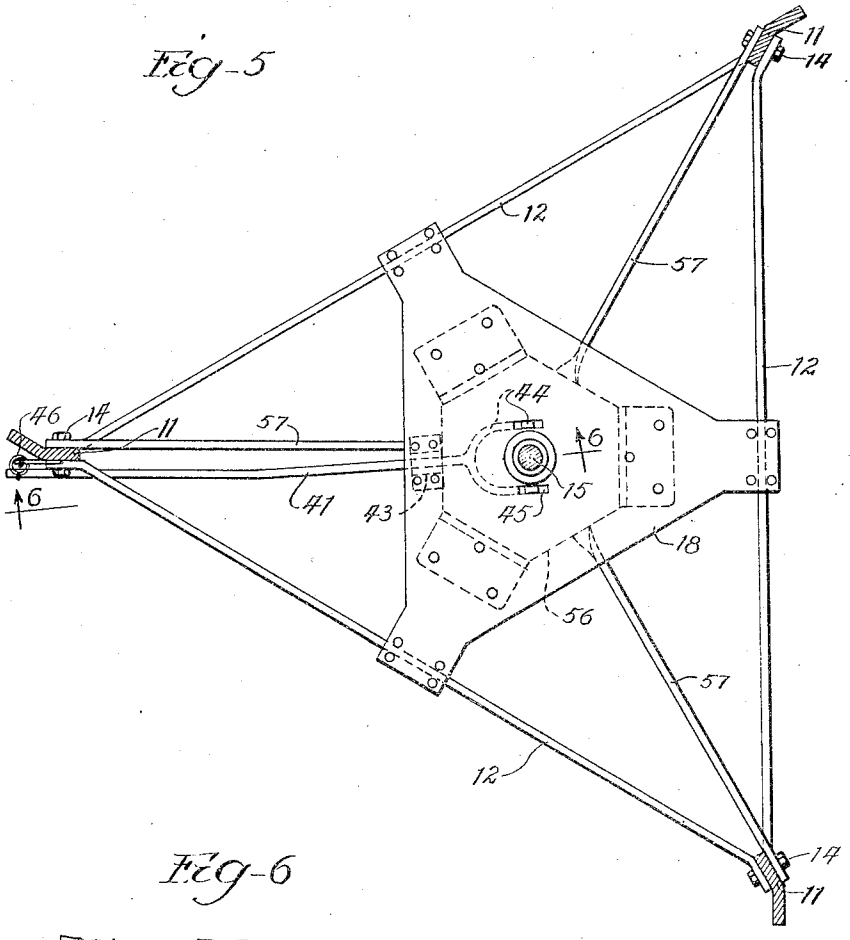
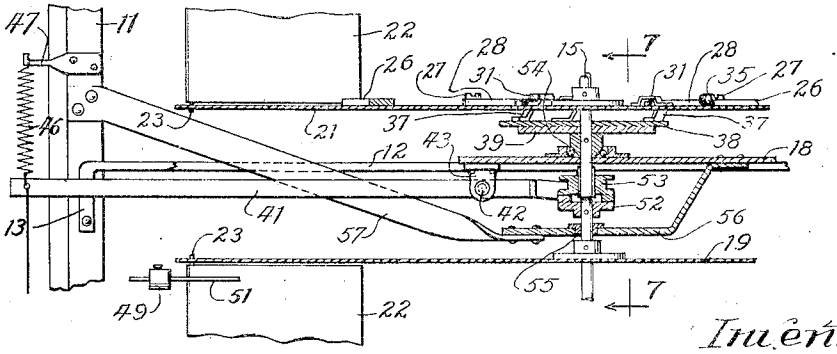


Fig-6



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Patented Dec. 27, 1927. 1,654,165

UNITED STATES PATENT OFFICE.

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WINDMILL.

Application filed June 18, 1924. Serial No. 720,748.

My invention relates to windmills of the vertical axis type adapted either for pumping or for generating power, and the object of the invention, broadly, is to increase the efficiency and practicability of such apparatus, both with regard to construction and principles of operation.

The general construction of the windmill provided by the invention consists of a frame, or tower, preferably of triangular form, within which one or more paddle wheels are mounted for rotation under the influence of the wind, and the invention resides primarily in the means by which the paddles of said wheel, or wheels, are mounted and controlled, though certain features of novelty are also present in other parts of the construction and plan of operation.

A very valuable feature of the invention is in the hinging of the paddles at their outer edge, which obtains certain marked advantages in operation which will presently appear. With the paddles so mounted, they are subject to effective wind pressure throughout the greater part of their rotation around the axis of the wheel and they feather much more satisfactorily than if they were hinged at their inner edge, or medially. Hinging the paddles in this manner also contributes materially to the functioning of the speed governing device to be later described and to starting the mill up after it has been thrown out of operation. This hinging of the paddles at their edges also eliminates the presence of a projecting blade surface on the opposite sides of the pivotal point. In other words, there is no short tail surface projecting from the opposite side of the pivotal point of the blade.

An important object of the invention is to provide such a device that will utilize a greater volume of wind passing therethrough than has been possible heretofore. This is accomplished by arranging and constructing vanes or paddles so that they will be controlled by centrifugal force and so that they will have the effect of a turbine throughout the major part of a revolution.

A further object of the invention is the provision of a wind engine which may be thrown out of the wind to a large extent when not in operation, thus overcoming the principal objection heretofore attributed to vertical axis mills, namely that they run continuously whether or not their service is needed and, therefore, soon wear out. The mechanism employed for this purpose permits the stopping of the mill in convenient manner, provision being made for causing the paddles, or vanes, of the rotatable wheel to assume a position which not only stops the rotation of said wheel, but also relieves the wheel and tower from excessive wind pressure, thus rendering it possible to use a light frame structure which will offer minimum obstruction to the free passage of the wind to and from the vanes of the wheel.

The invention also contemplates the provision of means for governing the speed of the mill so that it will not race in a high wind—a feature of very great importance, since all mills of this general type, of which I am aware, have been subject to this difficulty of racing, which is very objectionable, particularly in generating electricity.

It is also an object of the invention to provide a construction which utilizes, in most practical manner, the advantages of the vertical axis type of windmill, among which the following may be mentioned: By using a vertical shaft, the great loss of power attendant upon the use of miter gears to transmit power from the wheel down to the ground, may be avoided without placing the generator at the top of the tower—the only means heretofore attempted by manufacturers, so far as I am aware, for avoiding this difficulty. The vertical axis construction also makes it possible to employ a wheel of small diameter and long axis in order to attain relatively high speeds, which are desirable in generating electricity and also in pumping where the elevation is slight and a screw or helicoidal tube is used for raising the water, it being, of course, possible to use a larger diameter when a slow speed is desirable. Another advantage is that such a mill will operate regardless of the direction in which the wind blows, being always orientated and thus avoiding the use of a fan and other complicated mechanism for rotating the mill to present the proper face to the wind.

Another object of my invention resides in the arrangement whereby a plurality of mill units may be vertically superimposed so as to be clutchable to the given vertical power shaft, whereby these units may be independently clutched or connected to this shaft.

Numerous other objects and advantages of the invention will be apparent as it is better understood from the following de-

scription, which, taken in connection with the accompanying drawings, discloses a preferred embodiment thereof.

Referring to the drawings,

Figure 1 is a side elevation, partially broken away, of a windmill apparatus in which my invention is embodied, one of the units thereof being shown out of action and the others set to operate;

Fig. 2 is a plan view of one of the paddle wheels, being taken transversely through the frame substantialy upon the section line 2—2 of Fig. 1 and showing the arrangement of the parts when the wheel is not operating;

Fig. 3 is a similar view, taken substantially upon the line 3—3 of Fig. 1 and showing the arrangement of the parts when the wheel is operating;

Fig. 4 is an enlarged sectional view, taken substantially upon the line 4—4 in Fig. 3;

Fig. 5 is a transverse sectional view, taken substantially upon the line 5—5 in Fig. 1 and showing the throw-out and clutch operating lever;

Fig. 6 is an enlarged sectional view, taken substantially on the line 6—6 of Fig. 5; and

Fig. 7 is a detail sectional view, taken substantially upon the vertical line 7—7 of Fig. 6.

The tower, in the present instance, is of triangular form and comprises angular uprights 11, connected by horizontal bars 12, which are turned down at their ends, as indicated at 13, and secured to said uprights by means of bolts 14. The mill preferably consists of a plurality of separate units arranged upon a sectional vertical shaft 15, which is journaled in bearings 16 and 17 at the top and bottom of the structure and in triangular reinforcing plates 18 disposed between the different units of the mill and secured at their corners to the bars 12 (see Fig. 5).

The different units consist primarily of wheels formed by upper and lower members 19 and 21, which are secured at their center to a section of the shaft 15 and have hinged thereto, near their periphery, the vanes or paddles 22 which operate in the wind and produce rotation of the wheel. These members are shown on the drawings as solid disks, though it is contemplated that spoked or open wheels might be used quite as advantageously, if desired. Said paddles 22 are pivoted upon shafts 23, extending through and secured to the upper and lower members 19 and 21. It will be noted, from an inspection of Fig. 3, that in the construction here illustrated, the paddles or vanes operate almost wholly within the periphery of the members 19 and 21 and that the pivot point is, therefore, at the outer edge thereof. Said paddles are preferably formed of sheet metal and are curved, as indicated in Figs. 2 and 3, the edges thereof being bent around the shafts 23 and back upon the body, as indicated at 24.

Referring now to Figs. 2 and 3, the relative positions of the vanes when the wheel is out of the wind and when it is operating may be observed. Assuming that the wind is blowing in the direction indicated by the arrows in Fig. 3, the paddles 22 (except those returning against the wind) will be disposed with their inner ends in contact with fixed stops 25 or the ends of levers 26 which may be of any suitable shape and are preferably of bell-crank shape as shown are pivoted at 27 on the upper surface of the member 21 and correspond in number to the number of said paddles 22. The arc described by the inner edges of the paddles as they feather when returning against the wind is indicated by dotted lines in Fig. 3, and it will be seen that this arrangement causes said paddles to be subjected to effective wind pressure throughout the major portion of their travel about the axis of the wheel. With the wind blowing as indicated, the vanes or paddles on the windward side are against the levers 26 and form baffles, the angle of which gradually increases as they travel about the center of the mill until they present a full face to the wind, and then gradually decreases until they are substantially in line with the wind. After passing the point at which the paddles are in line with the wind, the wind engaging behind the paddle, which is free to turn about its pivot, swings the paddle outwardly and against the fixed stop 25. The motion of the paddle between the stop 26 and the fixed stop 25 is controlled by the centrifugal action of the weight 49 which is of sufficient weight to slow down this action so that the motion of the paddle will be gradual, the paddle coming in contact with the fixed stop 25 substantially at the position shown in Fig. 3 or later. This operation accomplishes a reversal of the paddle so that it forms a baffle to the wind on the return side of the wheel and assists in turning the mill until after the position shown at the upper right hand side of Fig. 3. From the position just mentioned around to the windward side the vane merely feathers in the wind and gradually returns to the position against the stop 26 at the windward side of the mill. From the above description it will be noted that throughout the first 90 degrees of revolution a turbine effect is obtained, which gradually develops into direct pressure and that throughout the next 90 degrees the direct pressure gradually develops into a turbine, and at approximately 180 degrees the blade reverses and a turbine effect is obtained throughout approximately 60 degrees more of revolution, and since the shifting of the blade on the side of the mill op

posite the windward side is not idle but is so arranged that the motion of the paddle being counteracted by the weight is transferred through the shaft 23 to the mill and force is exerted in the direction of rotation thereof. By this arrangement approximately 250 degrees of revolution of each blade is effective and a greater power may be obtained from a given volume of wind with a small unit.

When it is desired to stop the mill, the levers 26 are moved from the position shown in Fig. 3 to that shown in Fig. 2, which permits all the paddles, except those on the lee side of the wheel, to feather at the same time, thus offering slight obstruction to the wind and relieving the wheel from effective pressure. The strain on the tower is also greatly reduced. The arc described by the inner ends of the paddles when thus permitted to feather is indicated by dotted lines in Fig. 2, the limits of this arc being the stops 25 at one end and stops 25′ (the purpose of which will presently appear) at the other end. It will be obvious that, regardless of the way in which the wind blows, said paddles may feather in the manner and with the results just indicated. This is a very important advantage, since it permits of the use of a lighter frame and avoids danger of the structure being torn to pieces in a gale.

The manner in which the levers 26 are controlled to stop the mill and to throw the paddles out of the wind will now be described, reference being had particularly to Figs. 3, 4 and 6. Said levers 26 have inner extensions 28 disposed above apertures 29 in the member 21 (see Fig. 4), the ends of said extensions being disposed beneath straps 31 having their ends turned down and secured to said member 21, as indicated at 32. Said extensions 28 normally are held against the side walls of said straps by means of springs 35 secured at one end to said extensions and at the opposite end to studs 36 upstanding from the disk 21. This disposes the levers 26 in the path of the paddles 22 and provides for the operation of the latter in the manner previously described. When it is desired to throw the paddles out of the wind, said levers are acted upon by means of inclined fingers 37, extending through the apertures 29 and secured to the upper surface of a vertically movable disk 38. Said disk is slidably mounted upon the shaft 15 above a supporting disk 39 and said disks are adapted to be lifted together by means of a throw-out and clutch operating lever 41 pivoted at 42 to a depending ear 43 on the plate 18 (see Fig. 6) and having a bifurcated, upwardly turned inner end portion 44 extending through slots 45 in said plate 18 and adapted to contact with the under surface of said disk 39 (see Fig. 7). The outer end of said lever 41 is normally held in raised position by means of a spring 46 secured thereto at one end and secured at its opposite end to a hook 47 provided upon one of the uprights 11. A wire, or cord 48 is secured to the outer end of each lever 41 and carries at its lower end an apertured strip 48′ adapted to hook over a projection 50 provided near the base of one of the uprights 11 to hold the lever down against the tension of the spring 46. When said lever is drawn downwardly, the disk 38 and fingers 37 are raised, said fingers, in rising through the apertures 29, having a cam action upon the lever extensions 28, forcing them against the tension of the springs 35 to the position shown in Fig. 2. This promptly brings the wheel to substantial rest, in which condition it remains until the lever 41 is again raised.

When it is desired to again start operation of the wheel, the appropriate wire 48 may be released, allowing the lever 41 to assume the normal raised position which withdraws the fingers 37 from engagement with the lever extensions 28 and permits the springs 35 to restore the levers 26 to the operative position of Fig. 3. Such of the paddles as are at this time swung around beyond the ends of said levers 26 must obviously be moved back to the position of Fig. 3, and this is accomplished in a short time by the wind itself acting upon the paddles and forcing the levers 26 inwardly against the tension of the springs 35 to provide clearance. The levers 26 are curved inwardly at 60′ and are formed with notches 60, which serve to retain the paddles 22 in contact with said levers in the event that said paddles strike against the levers but do not move them sufficiently to produce the necessary clearance. With the paddles held in said notches, the wind blowing thereagainst will help to rotate the wheel. From this position, the paddles, when suitably presented to the wind, may readily be moved past the ends of the levers and into the position of Fig. 3. Furthermore, the stops 25′ are provided to hold said paddles within the circumference of the wheel, in order that they may be readily restored to this position.

In order to control the speed and power of the mill and prevent racing in a high wind, I provide governing means, comprising weights 49 carried upon supporting rods 51 projecting from the outer edge of the paddles. Said weights may be positioned at desired distance from the paddles and when the wheel attains a predetermined rate of peripheral speed, the weights by centrifugal action serve to regulate the action of the paddles and to increase the range of action thereof. With this simple form of governing mechanism, a degree of uniformity of speed, which is highly desirable in generating electricity, is obtained and the apparatus

is protected from the results of excessive speed.

The machine as shown in the drawings is, for certain uses, preferably constructed of a plurality of units, each involving independent paddle wheels and controlling mechanism. In order that the different units may be used separately or in unison, I employ clutch mechanism associated with each throw-out lever 41, and perhaps best illustrated in Figs. 1, 6 and 7. The shaft 15 is formed in sections and clutch members 52 and 53 are secured to the adjacent portions of said sections between the different units of the mill. The lower end of each shaft section is journaled in suitable bearings 55 provided in bearing plates 56 secured to the under side and extending downwardly from the plates 18. Said bearing plates are supported from the uprights by means of twisted bars 57, bolted at their outer ends to the uprights 11 and secured at their inner ends to the under surface of said plates 56. Referring now particularly to Fig. 7, it will be noted that the inner bifurcated end of the lever 41 is provided with inwardly extending pins 58, engaging in a groove 59 in the clutch member 53. Depression of the outer end of said lever 41, therefore, results in lifting said clutch member 53, which is splined on its shaft section, out of engagement with the member 52, disconnecting the wheel next above from the next lower section of the power shaft. This movement of the lever 41, as has been heretofore stated, also stops the wheel, permitting the vanes 22 to feather and thereby relieving the wheel and tower from excessive wind pressure.

The shaft 15, at its lower end, carries a pulley 61, over which takes a belt 62 driving a smaller pulley 63 mounted on an armature shaft 64 of a generator 65, which is positioned in a frame 66 on the ground. The armature 67 of said generator has been diagrammatically shown in Fig. 1 and it is contemplated by the present invention that this armature may be of relatively large diameter so that the peripheral speed thereof may be definitely related to the peripheral speed of the wheels formed by the disks 19 and 21. The ratio may be obtained by appropriate relative sizes of the pulleys 61 and 63 and by the diameter of the armature, the approximate relation, in the present instance, being on the basis of three revolutions of the armature 67 to one of the wheel.

It should be noted that a further distinct advantage occurs from the hinging of the vanes 22 at their outer edge, since this overcomes the difficulty heretofore experienced of having the vanes returned on one side of the mill against the wind, with consequent great loss of power.

The frame, or tower is constructed in such manner as to offer slight interference with the wind approaching the wheel, thus making it possible to use relatively light construction materials and also avoiding the danger of being blown to pieces in a gale. In the construction here shown, the frame is of triangular form and the uprights 11 extend radially with respect to the wheel so that the wind will either pass between said uprights, or, if it strikes directly thereagainst from one of the angles of the triangle, the surface encountered will be small and will offer slight obstruction to the free passage of the wind to and from the wheel.

It is thought that the invention and many of its attendant advantages will be understood from the foregoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention, or sacrificing all of its material advantages, the form hereinbefore described being merely a preferred embodiment thereof.

I claim:

1. A windmill, comprising, a support, a rotatable member having a vertical axis in said support, a plurality of curved vanes pivoted at their outer edges to said member and disposed about the circumference of said member so as to be accessible to the wind from all points about such circumference and devices constructed and arranged to be operatively associated with said vanes, whereby said vanes are adapted to receive power from wind passing through the mill throughout a major portion of a revolution of said rotatable member.

2. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member, and devices rigidly attached to the vanes opposite their hinges and adapted to control the vanes by centrifugal action to receive power from wind passing through the windmill throughout the major portion of a revolution of said rotatable member.

3. A windmill, comprising, a support, a rotatable member having a vertical axis in said support and open to the wind at all points, a plurality of curved vanes hinged at their peripheries to said member and means for controlling said vanes, whereby the wind pressure acts on said vanes with both direct and turbine effect during the travel of said vanes around the axis of said member.

4. A windmill, comprising, a rotatable member, having a vertical axis, a plurality of vanes pivoted to said rotatable member and adapted to rotate said member in the wind, and means for governing the speed of rotation of said member, said means comprising devices rigidly attached to said vanes

and arranged to resist movement of the vanes with respect to said rotatable member by centrifugal action.

5. A windmill, comprising, a rotatable member having a vertical axis, a plurality of vanes pivoted at their edges in said wheel for the operation thereof and having a plurality of operating positions, fixed and movable stops for holding the vanes in a plurality of operating positions, and movable stops for holding said vanes in another operating position, said movable stops being movable from the path of movement of the vanes to permit said vanes to feather in the wind and offer substantially equal and relatively slight obstruction thereto.

6. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes hinged to said member and operable in the wind to rotate the latter, means for limiting the movement of said vanes to cause them to remain in the wind, and means for shifting said last-mentioned means to permit substantially all the vanes to feather when operation of the mill is not desired.

7. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed outer stops for said vanes, pivoted levers disposed inwardly from said stops and adapted to limit the inward movement of the vanes, and means for turning said levers upon their pivots to move them to non-obstructing position permitting substantially all the vanes to feather in the wind when it is desired to stop the operation of the mill.

8. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed outer stops for said vanes, pivoted levers disposed inwardly from said stops and adapted to limit the inward movement of the vanes, spring means for holding said levers normally in obstructing position, and a vertically movable controlling device for shifting said levers to non-obstructing position permitting substantially all the vanes to feather in the wind when it is desired to stop the operation of the mill.

9. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed outer stops for said vanes, pivoted levers disposed inwardly from said stops and adapted to limit the inward movement of the vanes, spring means for holding said levers normally in obstructing position, and a manually operable device for shifting said levers to non-obstructing position permitting substantially all the vanes to feather in the wind when it is desired to stop the operation of the mill.

10. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed outer stops for said vanes, bell-crank levers disposed inwardly from said stops and adapted to have one arm thereof normally positioned in the path of movement of said vanes to maintain the latter in the wind, and manually operable means adapted to act upon the other arms of said levers to move the latter to non-obstructing position permitting substantially all the vanes to feather in the wind when it is desired to stop the operation of the mill.

11. A windmill, comprising a vertical shaft, a rotatable member mounted on said shaft, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed outer stops for said vanes, movable inner stops adapted to normally confine said vanes within a limited path of movement, means for moving said inner stops to non-obstructing position permitting substantially all the vanes to feather in the wind, and a clutch device associated with said last-mentioned means for disconnecting said rotatable member from said shaft.

12. A windmill, comprising a vertical shaft, a plurality of rotatable wheels mounted on said shaft, wind vanes hinged to said wheels near the periphery thereof, means for confining said vanes within a limited path of movement to maintain them in the wind, means associated with each of said wheels for releasing said vanes to permit them to feather in the wind, and a clutch device associated with each of said last-mentioned means for disconnecting the associated wheel from said shaft.

13. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed stops on said member at the opposite sides of the pivot points of the vanes, and means arrangeable in the path of movement of said vanes as they would normally feather between said stops for holding the vanes in the wind, one of said stops cooperating with said last-mentioned means for holding the vanes in the wind and the other assisting in restoring the vanes to operative position when the mill is started up after being out of operation.

14. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed outer stops for said vanes, pivoted levers disposed inwardly from said stops and adapted

to be moved to and from position obstructing the movement of the vanes whereby to maintain said vanes in the wind or to permit the vanes to feather when operation of the mill is not desired, said levers being notched at their outer ends and being yieldable under pressure of the vanes to permit the latter to be restored to operative position after said levers have been set to cause the mill to operate.

15. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes hinged to said member adjacent the periphery thereof, spaced means for controlling said vanes to produce effective pressure in at least two positions, and means for governing the movement of the vanes between said spaced means to control the speed of rotation of said member.

16. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes pivoted to said member near to the periphery thereof, spaced means for controlling said vanes to produce effective pressure in at least two pivotal positions, and means for governing the movement of the vanes between said spaced means to control the speed of rotation of said member, said means comprising devices adapted to control the movement of said vanes between the spaced means by centrifugal action.

17. A windmill comprising a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member, and means rigidly attached to the vanes opposite their hinges and arranged to have relatively slight wind resistance and relatively great centrifugal action, and to control the speed of rotation of said rotatable member.

18. A windmill, comprising a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member, and means rigidly secured to the vanes and extending opposite the hinges thereof adapted to control the speed of said rotatable member by controlling the operating movement of the hinged vanes.

19. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame and a plurality of vanes hinged at their edges to said rotatable member, and means for controlling and regulating the speed of said rotatable member, said means, comprising, adjustable balancing weights rigidly attached to the vanes and positioned opposite the pivots thereof.

20. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame and a plurality of vanes hinged at their edges to said rotatable member, and means for adjusting the speed of said rotatable member, said means, comprising, an arm secured to the vanes and extending across the pivot thereof and a balancing weight attachable to said arm at varying distances from said pivot.

21. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member, and means for regulating the speed of said rotatable member, said means comprising balancing weights rigidly secured to the vanes and extending opposite the pivots thereof.

22. A windmill, comprising, a frame, a rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member, and means for regulating and assisting in the rotation thereof, said means comprising devices rigidly attached to the vanes and adapted to control the movement thereof about their hinges by centrifugal action.

23. A windmill, comprising a rotatable member having a vertical axis, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed stops on said member at the opposite sides of the pivot points of the vanes and in the path of movement thereof, and means arrangeable in the path of movement of said vanes as they would normally feather between said stops for holding the vanes in the wind.

24. A windmill, comprising, a frame and rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member and a weight attached to each vane, said weight being constructed and arranged to shift in a horizontal plane when acted upon by said centrifugal force, whereby to automatically cause a pivotal movement of said vane.

25. A windmill, comprising, a frame and rotatable member having a vertical axis in said frame, a plurality of vanes hinged at their edges to said rotatable member, a weight for each vane, fixed and shiftable stops for each vane, said shiftable stops being capable of movement so as to be out of contact with said vanes in one position and to be movable into contact with said vanes to form rigid abutments, whereby to cause the wind acting on said vanes to rotate said member at a substantially uniform speed.

26. A windmill, comprising, a rotatable member having a vertical shaft, a plurality of vanes pivotally secured to said member and operable in the wind to rotate the latter, fixed and movable stops on said member, a clutch for connecting said rotatable member to said vertical axis and means for shifting said clutch and said movable stops.

27. A windmill, comprising, a support, a rotatable cage having a vertical axis on said support, said cage being open to the wind

from all sides and a plurality of vanes having one edge of each vane pivotally mounted on said cage, said vanes being relatively thin and being curved so as to be substantially cradle shape in cross-section and a plurality of stops on said cage for determining certain positions of said vanes.

28. A windmill, comprising, a rotatable cage open to the wind from all sides and having a vertical axis, a plurality of vanes pivotally mounted at their edges to said cage, said vanes being curved and devices constructed and arranged to cooperate with said vanes, whereby to produce effective wind pressure of alternately direct and turbine effect upon said vanes throughout the major portion of their travel around the axis of said cage.

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