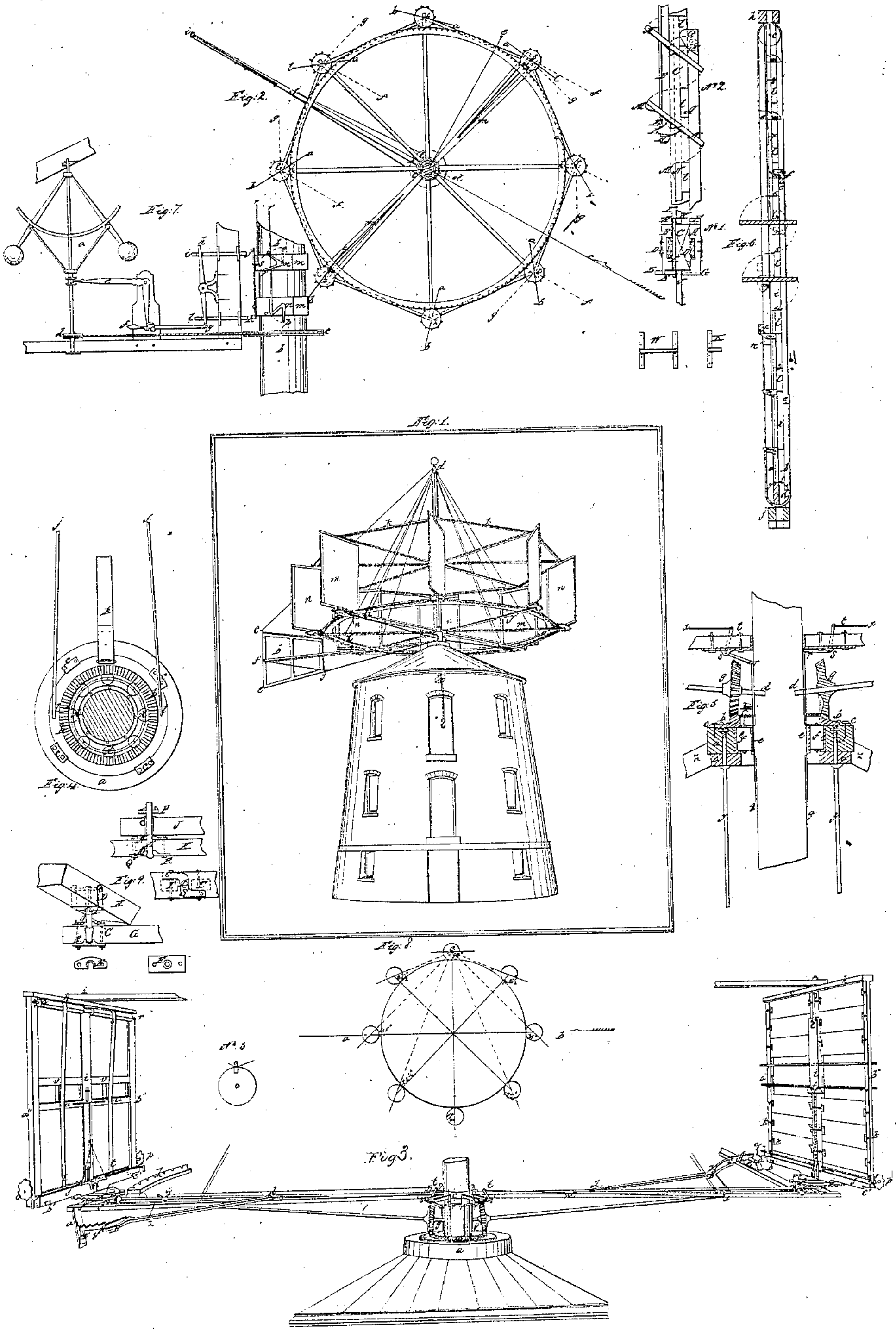
J. M. Van Osdel,

Wind Wheel.

No 2,003. Patented Mar. 12, 1841.



UNITED STATES PATENT OFFICE.

JOHN M. VAN OSDEL, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN HORIZONTAL WINDMILLS, &c.

Specification forming part of Letters Patent No. **2,003**, dated March 12, 1841.

To all whom it may concern:

Be it known that I, JOHN M. VAN OSDEL, of Chicago, in the county of Cook and State of Illinois, have invented a new and Improved Mode of Constructing Wind-Wheels for Mills, of which the following is a specification.

The nature of my invention consists in giving any number of sails or vanes of a horizontal wind-wheel a rotary motion, so that they perform exactly half a revolution upon their own axis while the wind-wheel performs one revolution, the axis of motion in the sails being parallel to the axis of the wind-wheel, the sails turning in a contrary direction to the wheel. I also apply an apparatus which moves only when the wind changes its direction. This apparatus keeps the sails at all times in the same relative position to the direction of the wind. I also apply the common governor-balls to regulate the speed of the wind-wheel by opening or shutting the sails, causing more or less surface to be exposed to the action of the wind, as required.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation.

I first determine the diameter of the wheel and the number and size of the sails necessary for the power required.

In the drawings accompanying this specification I have made the diameter of the wind-wheel twenty-four feet, as shown at 1 5 or 2 6 on Figure 2 of the drawings. I call it the "diameter" of the wheel, measuring from the center of the axis of one sail to the center of the axis of another sail diametrically opposite. The sails are eight in number, placed at equal distances from each other. The size of the sails is in this instance five feet wide and seven feet high. The plane of each sail is therefore a surface of thirty-five superficial feet. The house or mill may be built in any convenient form; but I propose a round or polygonal building, battering-walls with a conical roof to be the kind of building best adapted for windmills.

Fig. 1 of the drawings represents a building on a round plan, three stories high, with a conical roof, to which is applied a wind-wheel on my plan. To construct one of those wheels I proceed to erect a perpendicular shaft of wood or iron and project it upward through the apex of the roof a sufficient height to receive the first tier of arms or levers, being eighteen inches above the apex of the roof; also to receive the second or upper tier of arms, being seven feet five inches from the lower or first tier, the vertical distance between the arms being five inches greater than the height of the sail. The shaft is extended above the upper tier of arms a sufficient height to receive the diagonal suspension-rod *c d*. This rod must be elevated sufficiently to clear the sails of the wheel. I then proceed to fix to the shaft in a truly horizontal position the two tiers of arms, being eight in each tier, placed at equal distances. They may be made either in whole or in part of iron or wood. The arms should be firmly attached to the upright or wind shaft by means of an iron flange, as shown at *c*, Fig. 3, the arms to be retained in their horizontal position by means of the diagonal suspension-rods of iron, which are fastened at the top of the wind-shaft at *d* by means of a strong hook projecting from an iron band on the shaft, which is hooked in the eye on the end of the suspension-rod, the suspension-rod to pass through the arm and be furnished with a nut and screw, (shown at *i j*, Fig. 1,) so that the arm may be raised or depressed at pleasure. The upper tier of arms may be supported in the same manner by suspension-rods, or they may rest on a vertical prop of wood or iron placed between the upper and lower arms. I also place horizontal connecting-pieces between the arms (of wood or iron.) Then connecting-pieces are placed within four or five inches of the outer end of the arms, and should be affixed firmly to the arm by means of a screw-bolt passing through the connecting-piece and through the arm. These connecting-pieces are shown at *k k* in Fig. 1 of the drawings. The lower end of the shaft is furnished with the ordinary step-gudgeon, which should, however, be faced with steel, and turn upon a steel plate in the step to prevent wearing too fast. The apex of the roof should be made of frame-work, either square, round, or polygonal, leaving a sufficient space in the center for the wind-shaft. This frame, being that part of the building against which the shaft is pressed with great weight, should be very permanent. The rafters 2 2, Fig. 5, of the roof are placed against this frame, which prevents any lateral or downward movement of the frame; but the rafters being inclined, the weight pressing against their upper ends inclines them to raise the frame upward. This must be counteracted by ties of wood or iron (shown at *y y*, Fig. 5) connecting the frame with the tie-beams of the roof or girders of the floor. The plan of this frame is shown at *a*, Fig. 4, and a perspective view of it at *a*, Figs. 3 and 1, and a section of this frame is shown at *a a a a*, Fig. 5.

I propose to place friction-rollers around the wind-shaft when it is of large diameter to relieve the friction against the frame *a*. The plan of these rollers is shown at *d d d*, Fig. 4, and an elevation of them at *f f*, Fig. 5. These friction-rollers should be made of cast-iron and be placed between two circular bands of iron *e e e e*, Fig. 5, the outer band being let into the frame *a a*. The other is placed around and secured to the shaft. The outer band is furnished with a horizontal projection at the bottom edge to prevent the rollers from slipping downward. The sails (the construction of which will be shown hereinafter in this specification) are furnished with a toothed wheel about two feet in diameter. These wheels are secured firmly to the bottom rail of the frame of the sail in a horizontal position. The teeth or cogs are placed on the edge of the wheel and are called "spur-gear." The axes of these wheels correspond exactly with the axes of the sails. The wheels may be made of cast-iron, very light, or they will answer a very good purpose made entirely of wood, with wooden cogs or teeth. They should be from one to two inches thick. The sails are furnished with wrought-iron pivots, (or other metal,) placed one at the top and one at the bottom in the center of the width of the sail.

To construct the bottom pivot, let G, Fig. 9, represent the thickness of one of the arms of the wind-wheel, and let H represent the bottom rail of the sail.

B is a cast-iron step for the lower end of the pivot. A plan of this step is shown at F.

A represents the pivot, which is made with a shoulder, which strikes against the plate C and prevents the pivot from rising out of the step B. A plan of the plate C is shown at E. The plate C is placed on the upper side and the step B on the under side of the arm G, and secured by two screw-bolts passing through both plates. The pivot is square where it enters the bottom rail of the sail H.

D is a wrought-iron strap, through which the pivot passes in a square mortise. The ends of the strap D are turned at right angles and extend upward on the vertical sides of the rail. A screw-bolt is made to pass through the rail, the two ends of the strap D, and through a hole in the upper end of the pivot A. The weight of the sail rests upon the pivot by the shoulder formed upon the pivot at I coming in contact with the horizontal part of the strap D.

To construct the upper pivot, J represents the arm of the wind-wheel; K, the top rail of the frame of the sail; L, the pivot. The lower end of the pivot is welded to the plate M.

O is a cast-iron box placed in the arm J, in which the pivot turns.

P is a key secured in the upper end of the pivot L, which prevents its being drawn out by any sudden vibration of the wheel. The plan of the plate M and its position on the rail are shown at S. The plate N is shaped similar to the plate M, the bolts Q R passing through the plates M and N.

To find the position of the sails I divide the circumference of the wheel into as many parts as I intend to have sails, as shown at 1, 2, 3, &c., on Fig. 2. I then draw the line *c d*, which I suppose to be the direction of the wind. At right angles with *c d*, I draw the line *d e*, make *d e* equal to the radius of the wheel, then from *e* as a center draw radiating lines through each of the divisions 1, 2, 3, &c., (there may be any number of sails. I have made eight in this case,) and this radiation of the plane of the sail to the point *e* will be invariable, whether the mill is in motion or at rest. This will be more plainly perceived by inspecting the diagram at Fig. 8. Where the direction of the wind is *a b* and the center of the sail is just passing the point *e*, it will be observed that each sail turns twenty-two and one-half degrees on its own axis while passing over one-eighth of the circumference of the wind-wheel. Therefore it is evident, if the sails have an equable motion imparted to them of one hundred and eighty degrees at the same time they pass one revolution on the wind-wheel, they must during every part of that revolution radiate to the point *e*. I now draw the dotted lines f^3, f^4, f^5, f^7, and f^8, Fig. 2, parallel to the line *c d*, Fig. 2. These dotted lines show the direction of the wind impinging upon the plane of the sails. Then the dotted lines 3^g, 4^g, 5^g, 7^g, and 8^g each drawn at right angles with the arms of the wind-wheel 3^d, 4^d, 5^d, &c., respectively. Thus will the plane of the sails *a b*, Fig. 2, exactly divide the angles made by the dotted lines f^{3g}, f^{4g}, f^{5g}, &c., continually, and this will be the case on any-sized mill with any number of sails whatever. Thus the impulse and resistance are divided by the plane of each sail, which gives the greatest possible effect in moving the wind-wheel.

I shall now proceed to describe the manner in which I impart the required motion to each sail. The arms of the wind-wheel (marked *m m* in Figs. 2 and 3) are double. The ends are joined when they enter the iron flange, and are placed ten inches apart at the outer ends. Two bridging-pieces are framed in this space by being scarfed into the arms and firmly bolted to them. One of those pieces is placed in such a position that the pivot of the sail will rest upon it. The second piece is framed about ten inches inside of the first, and is placed there for the purpose of supporting the arbor of an iron shaft, to be described hereinafter in this specification. These bridging-pieces can be made of wood or iron, being scarfed and secured to the arms in a manner similar to the connecting pieces or braces placed between the arms, as before described in this specification. These bridging-pieces are shown at *f f f f* on Fig. 3. I now suppose the sails to be placed in their proper places on the wind-wheel, resting upon their pivots, as before described. The toothed wheels belonging to the sails are also supposed to be in their proper places, having the bottom pivot of the sail passing through the axis of the toothed wheel. (Observe those wheels are not to be fastened to the sail at this stage of the work, but as soon as the toothed wheels have the required motion imparted to them. Then the sails are to be secured to them in a certain position, which will be described presently.) The toothed wheels are shown at their proper places at 1 2 3 4 5 6 7 8 on Fig. 2. I now construct a rim of wood of sufficient circumference to touch each toothed wheel of the sails at its periphery nearest to the axis of the wind-wheel. The outer circumference of this large rim is furnished with cogs or teeth (spur-gear) to conform to the teeth of the wheels of the sails. The weight of this wooden rim is supported by a small friction-roller secured to the side of the arms by means of pillow-blocks, of wood or iron, secured to the arm, the roller being furnished with an axle which rests in said pillows on proper boxes. The motion of those rollers being very slow, they may be made of wood with an iron axle bearing on wooden boxes. The rim is shown at *h h* on Fig. 2. It is evident that if this rim is made to revolve it will communicate a rotary motion to each toothed wheel touching its circumference. The wooden rim is constructed of white ash or other hard wood in two or more thicknesses, and should be made of sufficient strength to prevent its sagging between the arms. To give this rim the required motion, I proceed to place a rim of cast-iron (or other metal) on the horizontal surface of the frame in the apex of the roof of the mill. This cast-iron rim is furnished with cogs on its upper surface (bevel-gear.) This rim is cast with a flange on its outer circumference about four inches in width. The lower surface of this rim and the periphery of the flange and about an inch of the upper surface of the flange must be made smooth by turning it in a lathe or otherwise. This rim is placed concentric with the axis of the wind-wheel. A plan of this rim is shown at *b b*, Fig. 4, and a section of it at *b b*, Fig. 5, and a perspective view of it at *b* on Fig. 3. This rim is prevented from moving laterally or vertically by the four guides, which may be made of brass, iron, or any other hard metal. Those guides are shown at *c c c c* on Fig. 4, and a section of them is given at *c c*, Fig. 5. Those guides are nicely fitted to the periphery of the flange of the cast-iron rim. The guides have a projection over the upper surface of the flange of about one-half an inch. Those guides are firmly screwed down to the surfaces of the frame *a a*, Fig. 5, and fixed so as to allow the rim to move freely round in a rotary manner, the guides serving to keep the rim in its concentric position to the wind-wheel.

g f on Fig. 3 represent two iron shafts inclined to the horizon, the outer ends being raised and have proper arbors to rest in a box of wood, iron, or other metal. The bridging-piece before mentioned at *f* sustains the bearing of the outer end of this iron shaft. The ends of the iron shafts at *g* have their bearings resting in boxes (of metal) set into (or bolted against) the wind-shaft. These iron shafts may be either square or round, the ends having proper arbors or bearings turned upon them. These shafts are furnished with a pinion at each end, the pinion at *g* being geared to the cast-iron rim *b*, the pinion at *f* being just one-half the size of the pinion at *g*.

The toothed wheels 1 and 5 on Figs. 2 and 3 are furnished with a cog-wheel (bevel-gear) of the same pitch and number of cogs as the cast-iron rim *b*. This cog-wheel is secured to the under side of the toothed wheels 1 and 5 by means of small screw-bolts. The pinions on the end of the iron shaft at *f f* are geared to these cog-wheels.

It is evident that if the cast-iron rim remains stationary and the wind-wheel set in motion, the iron shafts *g f* being carried around with the wind-wheel, the pinions at *g* will be made to revolve, which revolves the iron shaft *g f*, and the pinion at *f* puts the wheels 1 and 5 in motion. The wheels at 1 and 5 cannot revolve without giving motion to the rim *h h* on Fig. 2, and this rim will communicate a like motion to all the wheels geared into it. The sails are now to be secured to the toothed wheels. This is done by causing the wind-wheel to revolve slowly, and as each sail successively arrives at the point *e*, Fig. 2, turn the sail until its plane is at right angles with the line *e d*, and while in this position secure it by two screw-bolts (passing through the bottom rail of the sail and through the cog-wheel) firmly to the sail. It will be necessary to change the position of the sails when the wind changes its direction. This must be done by giving motion to the cast-iron rim *b*, Fig. 3. This motion is effected by means of a vane or large sail of forty-five or fifty superficial feet, of light material, attached to a lever or arm of sufficient length to project the vane beyond the sails of the wind-wheel, as shown at *b* on Fig. 1, and the plan of it at *i j k*, Fig. 2. This vane is attached to the iron rim by means of the strap-hinge on the end of the lever *k*, Fig. 4, (also observe the iron braces *j l* on Figs. 2 and 4.) The vane is supported by the diagonal suspension-rod *c d*, Fig. 1, which is attached to a swivel of brass or other metal at *d*. There is an iron or steel rod inserted into the end of the wind-shaft at *d*. This rod has a collar or shoulder attached to it, on which the swivel rests. Those parts should be made very smooth, and in practice kept well oiled. The lever of the vane is supported by the light iron rod *f g a* on Fig. 1. It will be evident by examining Figs. 1 and 2 that if the wind changes its direction the vane will be forced to move correspondingly, and the cast-iron rim will be made to slide round in its guides *c c*, which imparts motion to the sails and brings them into their former relative position to the direction of the wind.

It is very desirable that all machinery moved for the purpose of manufacturing should be kept in a certain motion, regular and equable in velocity, and as the velocity of the wind is exceedingly variable it is plain that if the same surface of sail be at all times exposed to the wind the machinery attached must have a corresponding variable movement. To regulate this movement, I construct my sails in the following manner: I construct a frame of wood, being composed of three vertical and two horizontal pieces. These frames are shown in perspective at *a″ b″* on Fig. 3, where the piece at *h* represents the top rail of the sail, the piece *j* the bottom rail of the sail. The vertical pieces at *a″*, *i*, and *b″* are mortised and tenoned to the rails *h j*, which inclose two spaces in the form of a parallelogram. These two spaces are opened or closed gradually to suit the velocity of the wind. To do this I have two methods. In one case I close up the spaces in the frame with wooden slats, similar to a blind; in the other, of canvas or other cloth. To make them in slats, I divide the height of the spaces intended to be closed into any number of equal parts, the slats to be equal in width to one of those parts, and as many slats as there may be divisions. The slats are furnished with a pivot at each end. The pivots that rest on the central upright of the frame are joined or made in one piece, so that the slat on one side being moved the pivot will give a corresponding motion to the slat in the other space of the sail. The places for the pivots are shown at *k k k*, Fig. 3. When the mill is in full sail, the slats stand vertically in the frame, and when the sail is reefing they turn on their pivots from a vertical to a horizontal position. The sail opens one slat at a time, commencing in the middle of the height, and will continue to open one slat at every second revolution of the wheel until the true velocity is recovered. In closing again the last slat opened will be the first one shut, the first being last.

To explain fully the operation of the slats, see the enlarged section of a sail at Fig. 6, where *h* represents the top rail, and *j* the bottom rail, of the frame. The thickness of the upright part of the frame is shown at *a b*. The width of the slats is shown by the figures 1, 2, 3, 4, 5, 6, 7, and 8. All the slats are closed except the two at 4 5 6, which are open.

c and *d* are two vertical pulleys placed in the central upright of the frame. The arbor of the pulley at *c* is stationary and the pulley revolves on the axle. These pulleys may be made of wood, two inches thick and six inches diameter, more or less. An endless strap of leather or other material passes over the pulley *c* and under the pulley *d*. Two frames or solid pieces of wood are attached to this strap, and slide in contrary directions. On opposite sides of the central piece of the sail the edges of those pieces are shown at *e f*, Fig. 6. If the pulley at *d* be made to revolve, the strap will cause the pulley at *c* to revolve also and the pieces *e f* will be put in motion, one upward and one downward. The effect which those pieces have upon the slats by this contrary motion will be explained presently.

l l l, Fig. 6, are stops half an inch thick, which may be worked out of the solid or got out separately and fastened upon the edges of the upright pieces of the frame of the sail. These stops are of such a width and placed in such a position as to keep the slats in a vertical position in the frame. The length of these stops is equal to half the width of one slat, less the thickness of the slat. Thus the lower end of the stop will intercept the upper surface of the slat and prevent its turning beyond a horizontal position. Each range of slats is furnished with a cam projecting at right angles with the surface of the slat. These cams are shown at *m m m*, &c. The sliding pieces *e f* strike those cams, and by them the slat is carried from a vertical to a horizontal position. There being eight ranges of slats, four of these cams are one side of the sail and four on the opposite side. (See No. 1 of the drawings.)

G is a section of the central piece *i* of the sail; K and J, the position of the slats; I I, the pivot which connects the slats in the two spaces of the sail.

D D are two guides, made of wood or iron and placed one upon each side of the central piece of the frame. They are grooved into and steady the movement of the slides A and B when the sail is opening.

A is a section of the ascending and B a section of the descending slide. The edge of the descending slide B is rabbeted, as shown at E. As the slide descends, the projecting part of the rabbet E comes in contact with the cam L. (Marked *m m m* on Fig. 6.) This tilts the slat, and the cam L, passing along under the rabbet, prevents the slat from resuming its vertical position until the motion of the slide is reversed. This will more plainly appear by inspecting the figure at No. 2, where C represents the edge of the central piece; B, the rabbeted edge of the descending slide, and the projecting part of the rabbet at E is pressing upon the edge of the cam L and carrying the slat from its vertical to its horizontal position. When the motion of the slide B is reversed, the cam H, No. 1, (which is shaped like the dotted line at H, No. 2,) comes in contact with the under surface of the horizontal slat K and causes it to resume its vertical position. A little piece of wood is placed on the surface of the slat K at the point I. The shape of these pieces is shown at M M, No. 2. They are just the thickness of the diameter of the pivot I, and are placed so as to come in contact with the cam H. When the slide B descends, the slide A ascends. The slide A is not rabbeted like the slide B, but projects its whole thickness about an inch beyond the piece G, as shown at F. No. 1; also, observe the projecting edge of the slide A, No. 2, is pressing against the cam P and turning the slat from a vertical to a horizontal position. When the motion of the slide A is reversed, the cam G, Nos. 1 and 2, comes in contact with the upper surface of the slat and causes it to resume its vertical position. The cam G is made of hard wood and attached to the edge of the slide A, as shown in the drawings. The connecting-pivot of the slats is shown at *w*. The arbor is welded to two transverse straps of iron. Those straps are screwed transversely on the surface of the slat, which greatly strengthens the slat and prevents it from splitting. X represents the pivot for the other end of the slat. This arrangement of the pivot causes the slat to bear hard against the side of the stops *l l* on account of the weight of the slat being on one side of the pivot. When the slats are horizontal, it is balanced on the pivot. Motion is communicated to the pulley *d*, Fig. 6, by means of a small iron shaft and cog-wheels at O P, Fig. 3.

To use canvas or cloth sails instead of wood or iron, I make two cylindric rollers *q r* and *o p*. They are placed horizontally, one at the top and one at the bottom of the sail, and on opposite sides thereof. Each roller is reduced to a smaller diameter where it crosses the central upright *i* of the frame. The upper cylinder has an iron gudgeon fixed in the center of it at each end. Those gudgeons work in wrought-iron boxes secured to the upright pieces of the frame. The gudgeons of the lower cylinder are of sufficient length to receive the cog-wheels *o* and *p*. An enlarged section of one of the cylinders is shown at No. 3. A groove is cut longitudinally in the cylinder about one-half an inch wide and one inch deep. A strip of wood is made to nearly fill up the groove. The groove and strip are well covered with white lead. The end of the canvas is then laid over the groove and the strip pressed, together with the cloth, into the groove. Several slender screws should be put through the strip into the cylinder to keep it firmly in the groove. The corner of the groove should be a little rounded to prevent its cutting the cloth. When the cylinders are moved, the sail parts in the center of its height, and one half rolls up and the other down at the same time. The pieces *u u* and *v v* are attached to the cloth and slide in the frame of the sail by means of a tongue and groove on each side of the division-piece *i*. Endless straps *s t* are passed over the upper cylinder and under the lower one. The straps on one side of the sail are attached to the sliding pieces *u u*, and on the other side to the sliding pieces *v v*. Now if by the cog-wheels the cylinders *o p* are made to revolve it is evident that the straps *s t* will cause the cylinder *q r* to revolve likewise. The cloth will be rolled upon the cylinders, and the slides will be drawn to the top and bottom of the frame. When the motion is reversed, the cylinders unwrap the cloth, and the straps draw the slides *u u* and *v v* together and close the sail.

To make the cog-wheels *o p* revolve, so as to open or shut the sails to suit the motion required, *a*, Fig. 7 is a governor made in the ordinary way; *b*, the wind-shaft. Motion is imparted to the governor by means of the pulley and cord *c d*. When the mill is too fast, the arm *e* of the lever is raised, which causes the connecting-rod *f g* to move from *g* toward *f*. This rod moves the lever *g h*, which causes the cam *i j* to move from *i* toward *j* and the cam *k l* to move from *k* toward *l*. I place around the shaft a polygonal drum, having as many faces as I have sails on the wind-wheel, as shown at *m*. On each face of this drum I place small levers of wrought-iron, the arms of which are bent so as to form an acute angle of fifty-five degrees, as shown at *p n q* and *p n o*. A pin is passed through a hole in the angle of the levers at *n n*, on which the levers move freely. The arms *o n* and *q n* of the levers are connected by the rod *o q*, which have working joints where they are connected; also, the rod *q r* is attached by a working-joint to the lever at *q*. The end of the rod *q r* is turned outward where it joins the lever at *q*, as shown on the side of the shaft at S. The rod *q r* extends upward close to the shaft and passes between the shaft and the friction-band, as shown at *q r* on Fig. 5. The ends of the rod *q r* are attached at *r* to the obtuse-angled levers *r s t* on Fig. 5. These levers are formed of wrought-iron of light construction. They are attached by a pivot to the iron flange, to which the arms of the wind-wheel are secured, as shown at *s s*, Fig. 5. The horizontal rods *t x*, extending along each arm of the wheel, are attached by a working-joint to those levers at *t t*. Now suppose the cam *i j*, Fig. 7, to move from *i* toward *j* until it projects over the drum *m*. It will intercept the lever *o n* and move it from *o* to *p*. This will also move the rod *q r* from *p* to *q*, which moves the lever *r s t*, Fig. 5, and the rod *t x* is drawn toward the shaft.

When the mill is too slow, the lever *e*, Fig. 7, descends and projects the cam *l k* under the drum *m*, which intercepts the lever *p n* and moves it to *o n*, which reverses the motion of the rod *q r* from *q* to *p*. This affects the cog-wheels *o p*, Fig. 3, as follows: I place the cog-wheel *o* about four inches farther from the center of the sail than the cog-wheel on the other end of the shaft at *p*. Then as the sail revolves on its axis the cog-wheels describe two circles, one four inches within and concentric with the other. I then proceed to construct a rack, the plan of which is a segment of a circle whose radius is a mean between the two circles described by the cog-wheels *o* and *p*, (the teeth of this rack are cast-iron,) which is screwed firmly to the wooden stock A, which is supported by the sliding block *e′*, to which it is firmly attached by means of a scarf and bolt. This stock is also firmly bolted to the arm B *d*. This arm is attached to the arm *m* by a bolt, which allows the arm B *d* to move freely. The sliding block *e′* rests upon the upper surface of the connecting-piece *k k*, Fig. 1, between the arms of the wheel. The wooden rim *h* passes under the rack in the space *y*. A small wrought-iron right-angled lever is pivoted on the arm *m* at *x*, from which a short rod is connected to the arm B *d* at *z*. The movement of the rack must be four inches. Therefore when the mill is too fast the rod *t x* is drawn toward the shaft, and consequently the rack is drawn four inches toward the center of the sail and directly in the track of the cog-wheel *p*. The cog-wheel in passing over the rack will come in gear with the teeth on the rack, which will cause the wheel to revolve. The space of time that the sail will be in reefing will depend on the number of teeth in the back. Again, when the mill is too slow the rod *t x* will be driven outward and the rack moved four inches farther from the center of the sail, so as to be brought in contact with the wheel at *v*, which reverses the motion of the shaft *o p* and closes the sail. I also place a small pin at *a′* in the block on which the rack rests, and a notch is cut on the under side of the frame of the sail at *b′*. The side of this notch is so inclined to the circle in which it moves that the pin at *a′* in passing through it draws the rack two inches toward the center of the sail. The notch at *c′* operates the same as the notch at *b*, except that it pushes the rack two inches from the center. When the rack is two inches from either cog-wheel, it is not touched by them, and must be acted upon again by the governor, if necessary. When the wind is too light to run the mill at the required speed, the connecting-rod *f g*, Fig. 7, should be lifted by the hand at *f* and the pin of the lever *e* permitted to pass beyond the notch in the rod *f g*. The lever *g h* should be placed perpendicular and the rod *f g* left resting upon the pin of the lever *e*. In case the wind increases the lever *e* rises and the pin passes into the notch again, ready to operate upon the reefing machinery.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The giving of a rotary motion to the two sails *m m*, Fig. 1, as herein set forth—that is to say, by means of the cast-iron cogged rim *b* (around the vertical shaft of the mill)—and the beveled pinions *g g*, Fig. 3, combined with and moving by the pinions at *f f* (on the ends of the iron shafts *g f*) the toothed wheels 1 and 5 on Figs. 2 and 3, by which the aforesaid sails are made to revolve.

2. In combining with the above driving-wheels 1 and 5 on Figs. 2 and 3 the cogged wooden rim *h h* and the sails *n*, Fig. 1, any number of which may be arranged on the wind-wheel, the whole being constructed and operating combined substantially as set forth.

3. In combination with the above mode of operating the sails *m m* and communicating motion from them to the other sails, as set forth in the two foregoing combinations, the method of changing the positions of the sails to suit the variations of the direction of the wind by means of the vane *b*, Fig. 1, all as herein set forth.

4. The mode of reefing and unreefing the sails, as herein set forth, by constructing the slats composing the sails with cams *m m*, &c., Fig. 6, and combining them in the manner described with the slides *e f*, Fig. 6, the pinions *o p*, Fig. 3, and the movable rack A, the whole being operated through the arrangement of levers and rods specified by the governor-balls.

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