A Practical Working Windmill

To complete the series of small windmills suitable for amateur workmanship, a really practical machine, capable of "power" production on a moderate scale, remains to be described. It is thought that a mill of 10-feet diameter, while probably taxing to the fullest the constructive ability of any average reader, might well be attempted by a serious worker with happy results. In this instance, while preserving the general principle of simplicity, completeness has been aimed at, and castings and forgings are adopted throughout without hesitation. This certainly involves some pattern-making, which, however, should be within the scope of any one able to carry out the necessary machining of the castings. Some readers may be willing—and able—to reduce this part of the labour by adopting makeshift details, but it should be remembered that such a method is hardly more advisable than it would be in the case of building any other motor—say a steam-engine—for power production.

The rating for a 10-foot windmill would be about ¼ H.P., which probably appears small for the amount of work involved and the material employed. It is, however, a conservative estimate, and is based on the standard 16-mile breeze, which holds good for something like 8 hours per day on two-thirds of the days in the year. Manufacturers probably rate a mill of this size much higher, and as long as no wind-velocity is stated, they may fairly claim to be correct. All practical modern windmills, however, are constructed with automatic gear so that with any given velocity of wind a maximum output is obtained, and any increase in the wind is more or less counteracted by the action of the automatic gear. It follows therefore that if our 10-foot mill is set to produce say ½ H.P., it can only do this with a wind of much higher velocity than 16 miles per hour, which is also much more rare. Nevertheless, it will be quite within the maker's power to get as much as this and more out of his machine, if he so desires and the wind is there. It will be merely a question of altering the controlling weight, but will also involve very much heavier stresses on the machine. This point must be borne in mind.

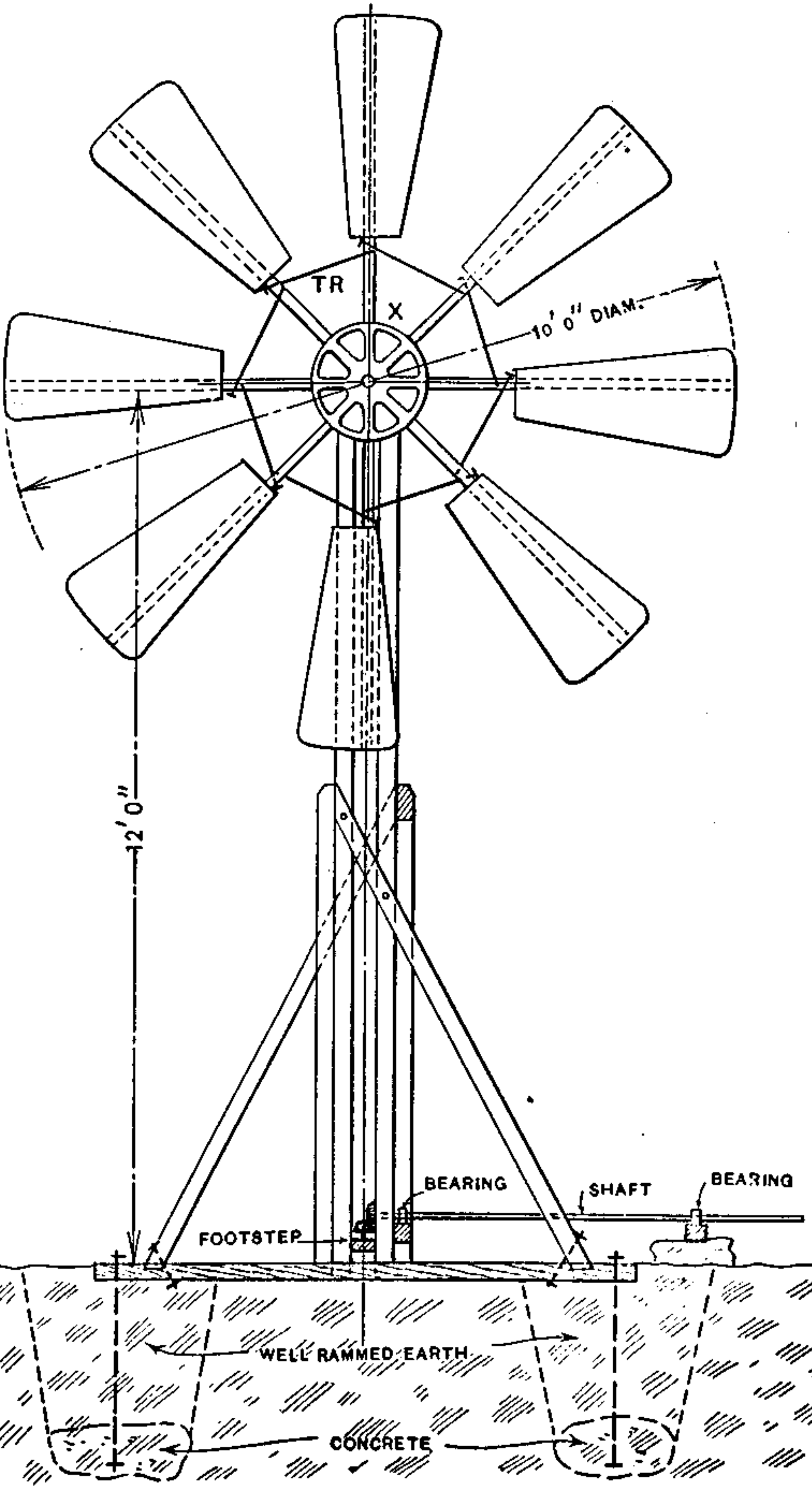


Fig. 48.—Front Elevation of 10-foot Windmill.

A general elevation is given in fig. 48, to a scale of $\frac{1}{4}$ inch to the foot. The tower is built up of four 3 inches × 3 inches vertical members, 12 feet high, each placed at the corners of a square, with 4-inch space between each pair of uprights. These uprights are well braced by struts, also of 3 × 3 timber, starting below the circle of vanes, one strut on each side, and each bolted to two uprights, as shown. The lower ends of struts are lodged into two horizontal diagonals, which are halved over each other at their crossing so as to lie level. The lower ends of uprights with a little shaping will also fit alongside these diagonals and must be securely bolted to them with $\frac{1}{2}$-inch bolts. Bolts or straps must also secure the diagonals to the feet of struts. Four $\frac{3}{4}$-inch bolts not less than 3 feet long must be carried down at the four ends of the horizontal members, into pockets of rough concrete of 2 or 3 cubic feet each. The holes above the concrete must be then very firmly filled in and rammed, and if the ground is soft or yielding, a greater depth and more concrete must be employed. It is perhaps needless to insist on the importance of having all this timber, but especially that in contact with the ground, thoroughly well tarred, or better still, properly creosoted, and all bolts should be galvanised. Large thick washers under the nuts of the $\frac{3}{4}$-inch bolts are required.

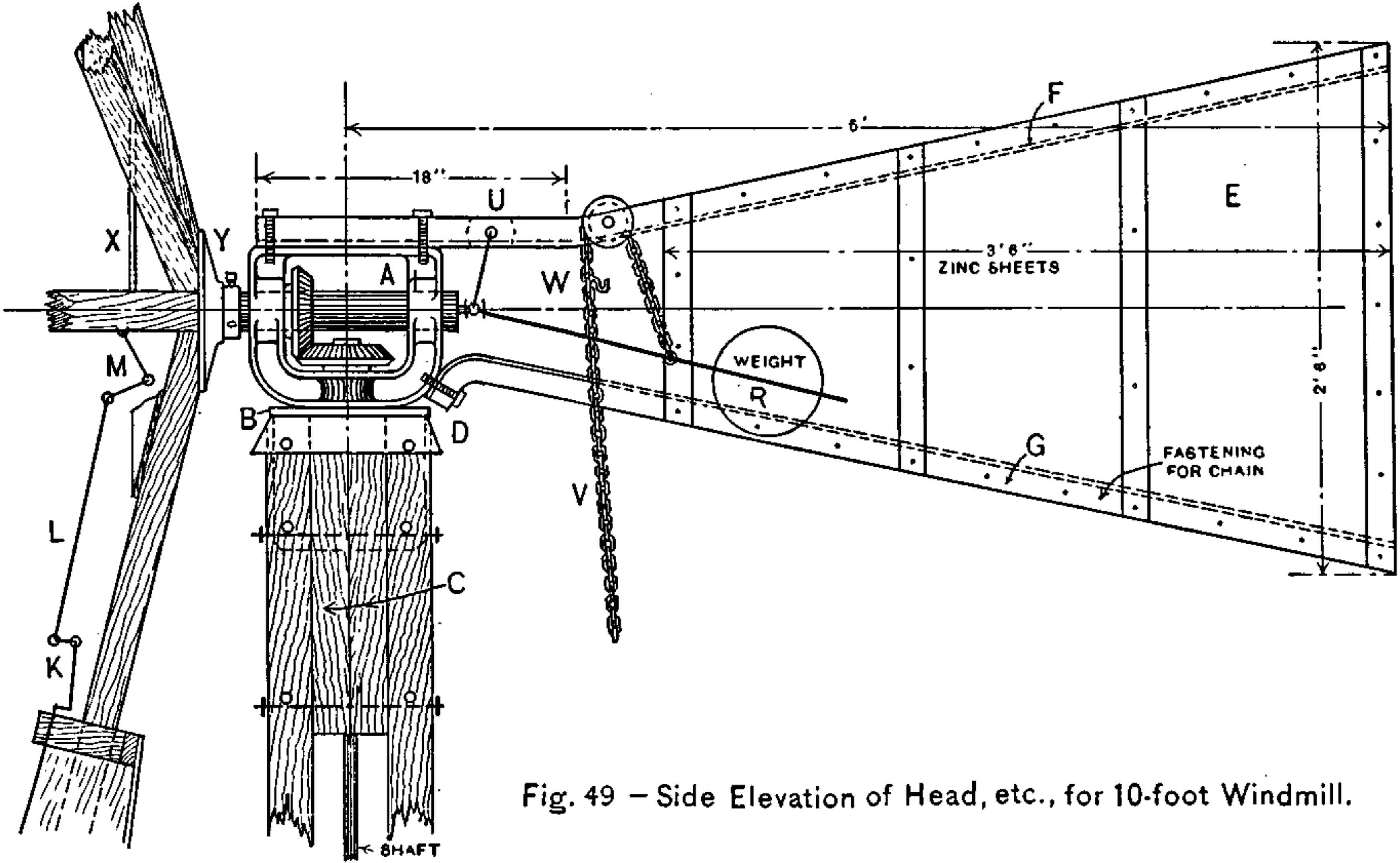
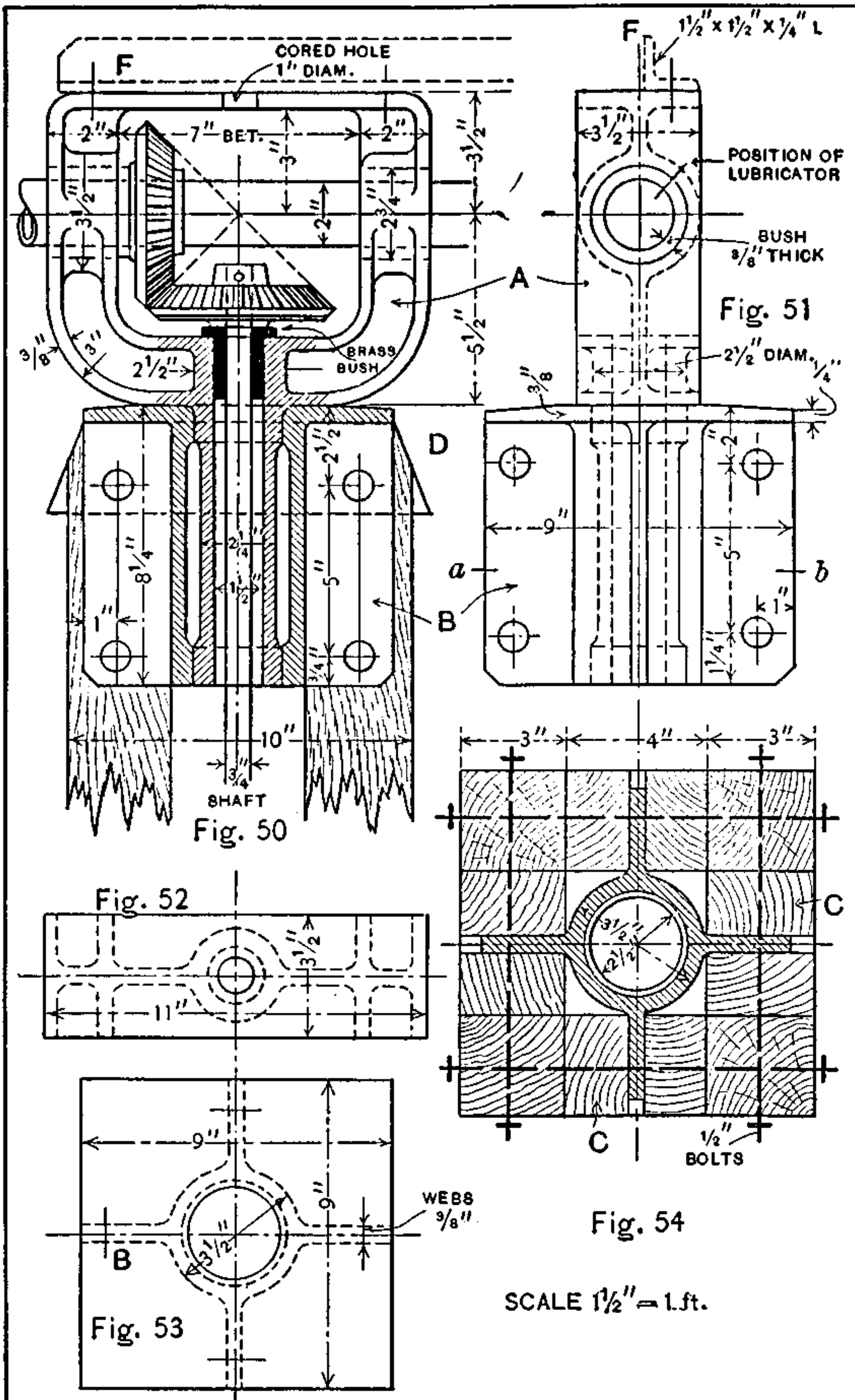


Fig. 49 – Side Elevation of Head, etc., for 10-foot Windmill.



Figs. 50 and 51.— Two Views of Movable Head Casting and Bearing Casting.
Fig. 52.— Plan of Movable Casting. Fig. 53.— Plan of Fixed Casting.
Fig. 54.— Section Plan on *a b*, showing Vertical Timbers.

A more detailed side elevation of the head, tail, and part of the arms is given in fig. 49, to a scale of $\frac{3}{4}$ inch to the foot. This shows the movable head casting A carried on the bearing casting B. Both these are detailed still further, to a scale of $1\frac{1}{2}$ inches to the foot in figs. 50 to 54, and require little explanation. The stem of A is of course turned to ride easily in the bored hole in B, and is fitted with brass bushes for axle and for vertical shaft. The casting B is securely bolted to the tops of the 3×3 uprights with $\frac{1}{2}$-inch bolts, care being taken to get it truly upright and central with the timbers. Packing pieces, C, in figs. 49 and 54, are used to ensure correct spacing. Note should be taken of the sheet of zinc or lead, D, figs. 49 and 50, which is first laid on tops of uprights, with suitable hole in middle to allow stem of B to pass, and is then dressed down, as shown, to throw all water from the timbers. It should hang clear of the latter to avoid capillary action.

The tail, employed to keep the mill up to the wind, is also shown in fig. 49 at E. It is carried by two light angles, $1\frac{1}{2}$ inches × $1\frac{1}{2}$ inches × $\frac{1}{4}$ inch, F and G, which are bolted respectively to the top and bottom of head casting A with $\frac{3}{8}$-inch bolts. The position of these angles is indicated (in dotted lines) in figs. 50 and 51 at F. A sheet of zinc forms the tail surface and is riveted to angles with $\frac{1}{4}$-inch rivets about $4\frac{1}{2}$ inches' pitch. Four stiffeners of $1\frac{1}{4}$ inch × $\frac{1}{8}$-inch hoop-iron run vertically across the surface, dividing it into three equal spaces. Both angles and stiffening strips should be galvanised.

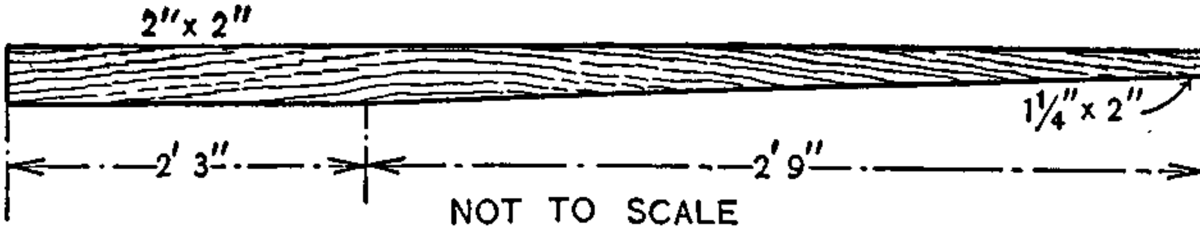


FIG. 55.—Shaping of Arm or Whip.

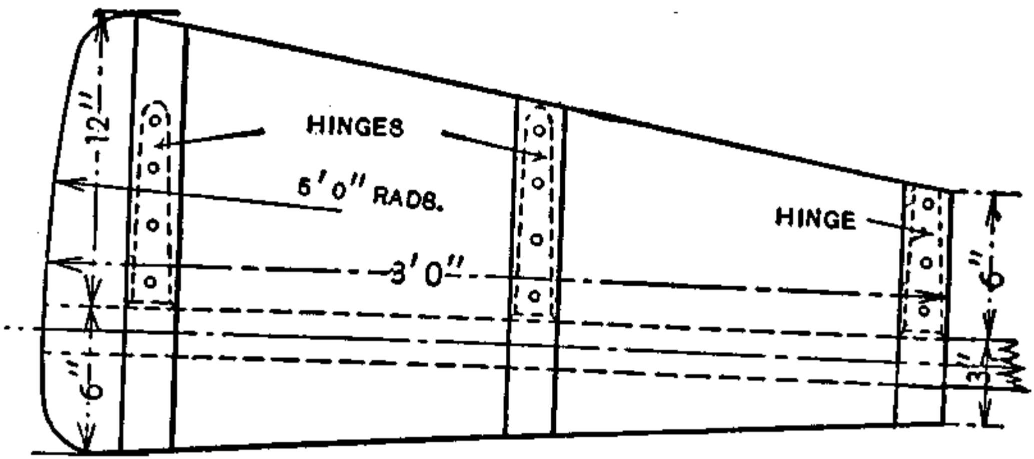


FIG. 56.—Outline of Sail for 10-foot Windmill.

The shaping of one of the eight arms for the vanes is shown in fig. 55, and the outline of sail in fig. 56. The assembling of these parts is indicated in fig. 49, but it is necessary to turn to fig. 57 to see in greater detail not only the method of fixing but also the formidable-looking array of levers and rods constituting the automatic gear. Every one of the eight sails has its independent set of levers to actuate the central sliding rod, but while it must be admitted this means a rather long list of troublesome details, the complication is much more apparent than real, and is largely due to the difficulty of rendering in a drawing the working of levers that do not lie in the same plane. The reader is therefore asked to study with some care these drawings, which the author for his part believes to be presented as simply as possible. All that has really to be remembered is that the wind impinging on an unbalanced sail attempts to turn it on its hinges, as shown in plan in fig. 58.

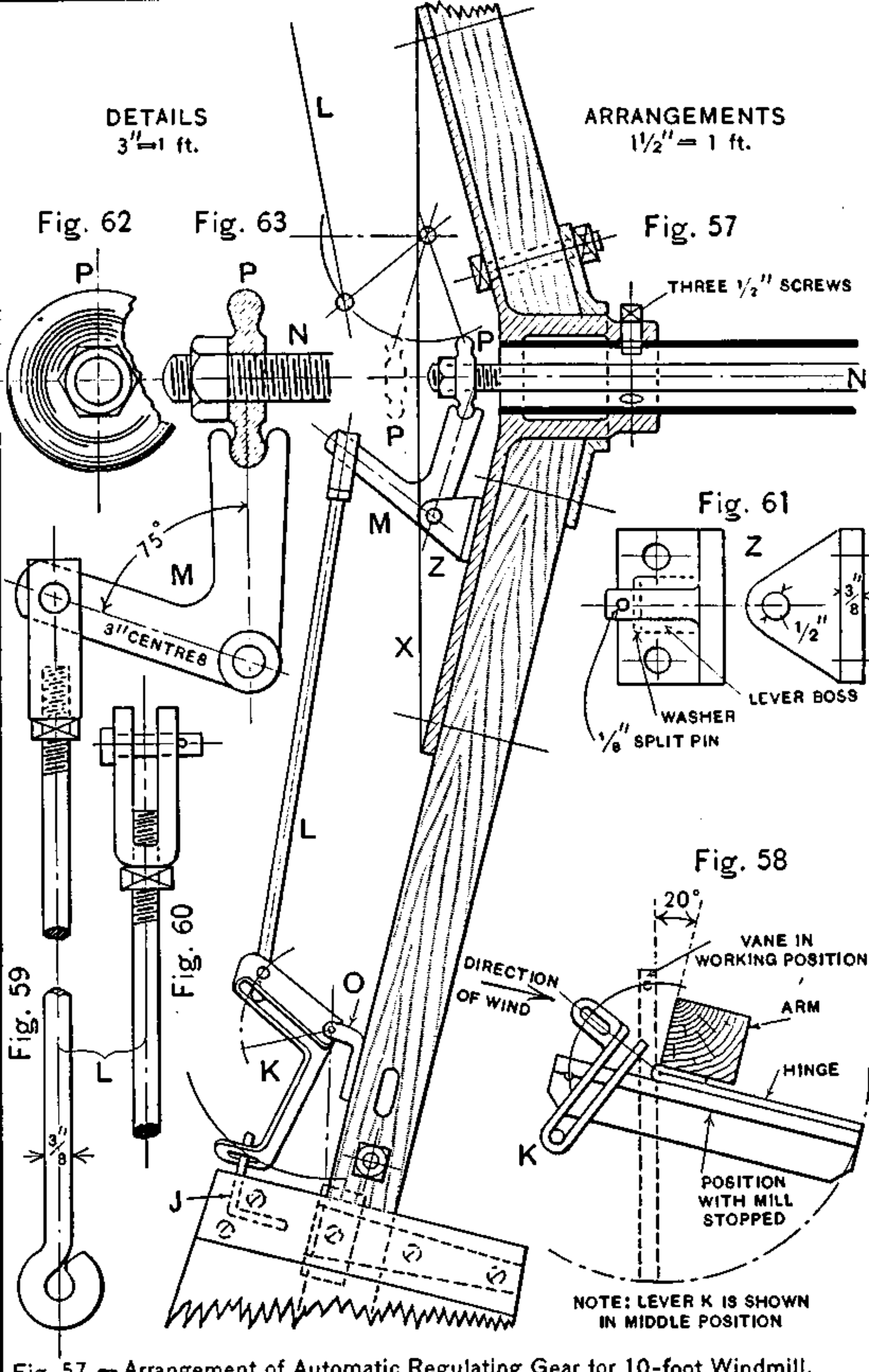


Fig. 57.—Arrangement of Automatic Regulating Gear for 10-foot Windmill.
Fig. 58.—Plan of Inner End of Sail, showing extreme positions.
Figs. 59 and 60.—Two Views of Push Rod L and Lever M. Fig. 61.—Pin Bearings for Levers M. Figs. 62 and 63.—Turned Nut on Sliding Rod N.

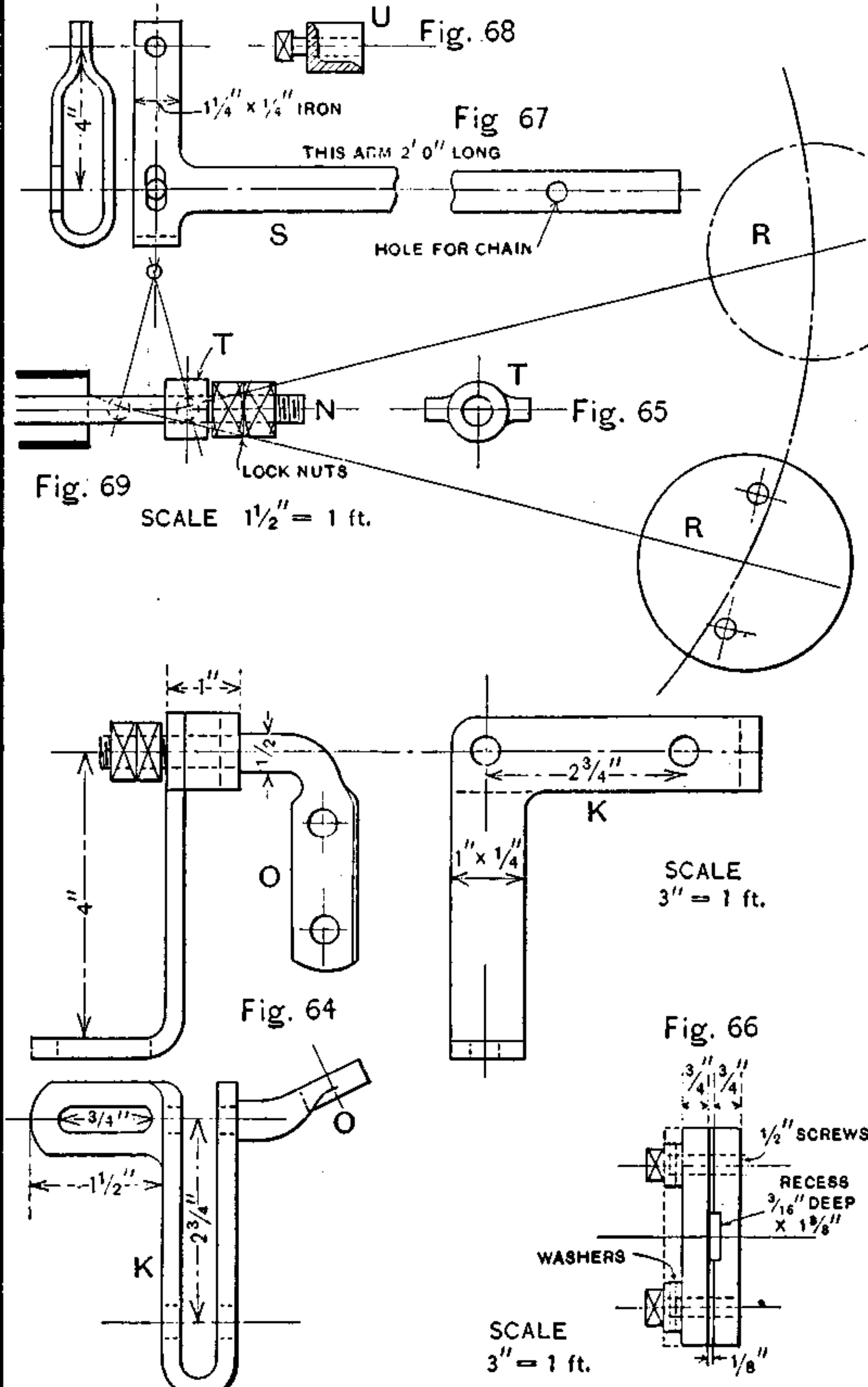


Fig. 64.—Three Views of Crank K. Fig. 65.—End View of Pin Bearing. Fig. 66.—End View of Weight R. Fig. 67.—Side and End Views of Weight Lever. Fig. 68.—Section of Angle F with Stiffening Block. Fig. 69.—Tail End of Sliding Rod and Pin Bearing.

Regarding now the short side of sail (the so-called "leading sail"), it of course describes an arc of rather less than a right angle, until it lies flat in the plane of the wind's direction. The chord of this arc, or rather of that described by a projecting pin J (a piece of $\frac{5}{16}$-inch rod bent as shown), forms the path of the lower arm of lever K, fully drawn in fig. 64, the other arm of which, being at right angles, must move vertically up and down as compared with the sail movement. This actuates the $\frac{3}{8}$-inch rod L (detailed in figs. 59 and 60), which in its turn works lever M. As before indicated, the planes of movement of the levers K and M are not coincident, but while this makes their representation on paper less easy, it in no way affects the object, which is to produce on the sliding rod N an in-and-out movement according to the amount of the wind's pressure. The lever K is supported at the special angle required (seen in plan in fig. 58) by a bracket O (fig. 64) bolted to arm. The top arm of lever is made with a return end in order to give a long bearing, and bottom end slotted to allow the necessary play for the pin J, due to the path of the latter being an arc.

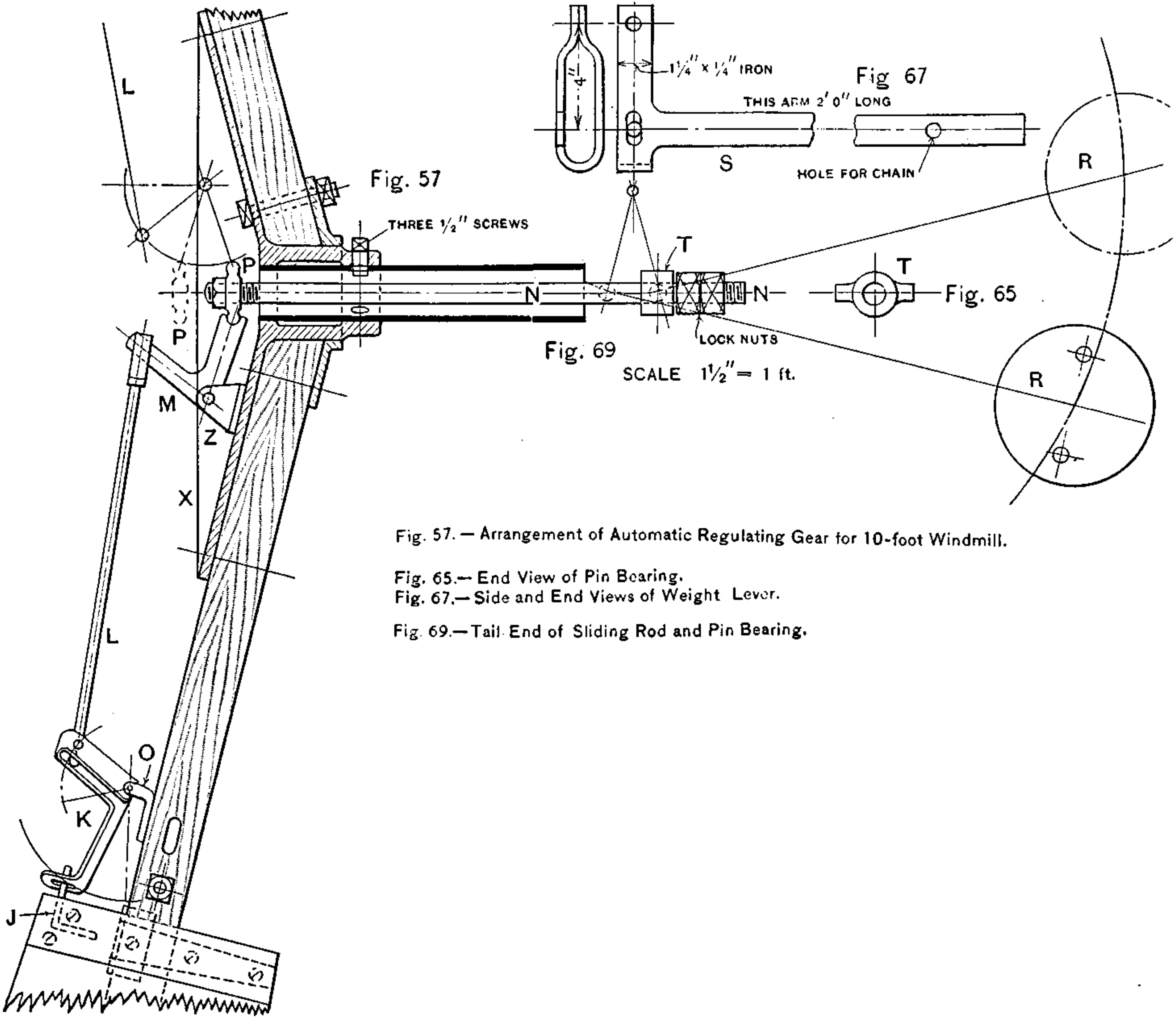


Fig. 57. — Arrangement of Automatic Regulating Gear for 10-foot Windmill.

Fig. 65.— End View of Pin Bearing.
Fig. 67.— Side and End Views of Weight Lever.

Fig. 69.— Tail End of Sliding Rod and Pin Bearing.

Fig. 58

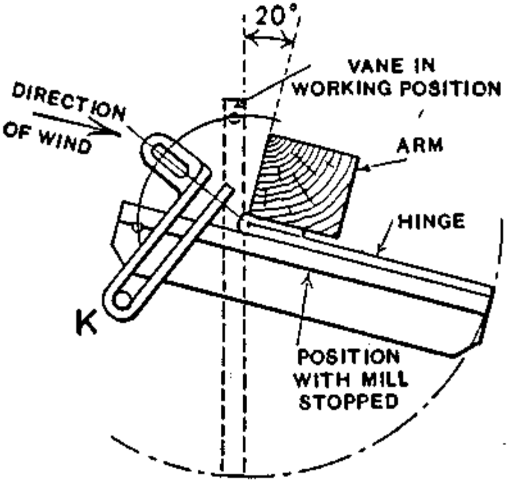
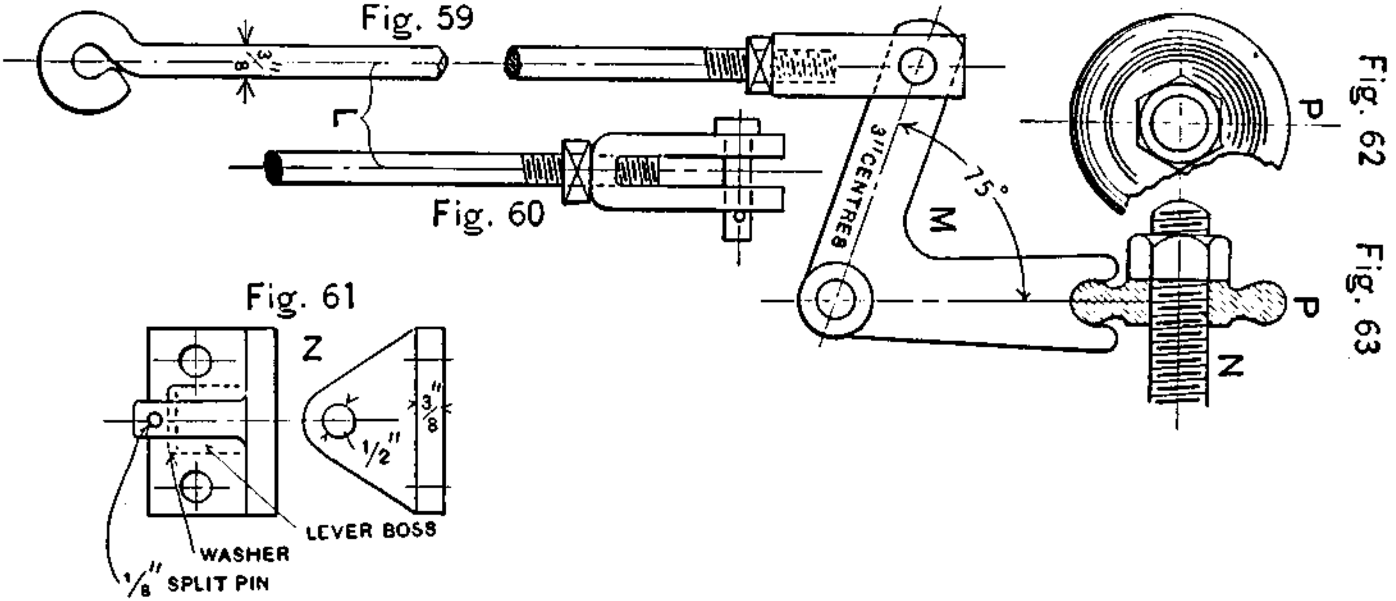


Fig. 58. — Plan of Inner End of Sail, showing extreme positions.



Figs. 59 and 60. — Two Views of Push Rod L and Lever M. Fig. 61. — Pin Bearings for Levers M. Figs. 62 and 63. — Turned Nut on Sliding Rod N.

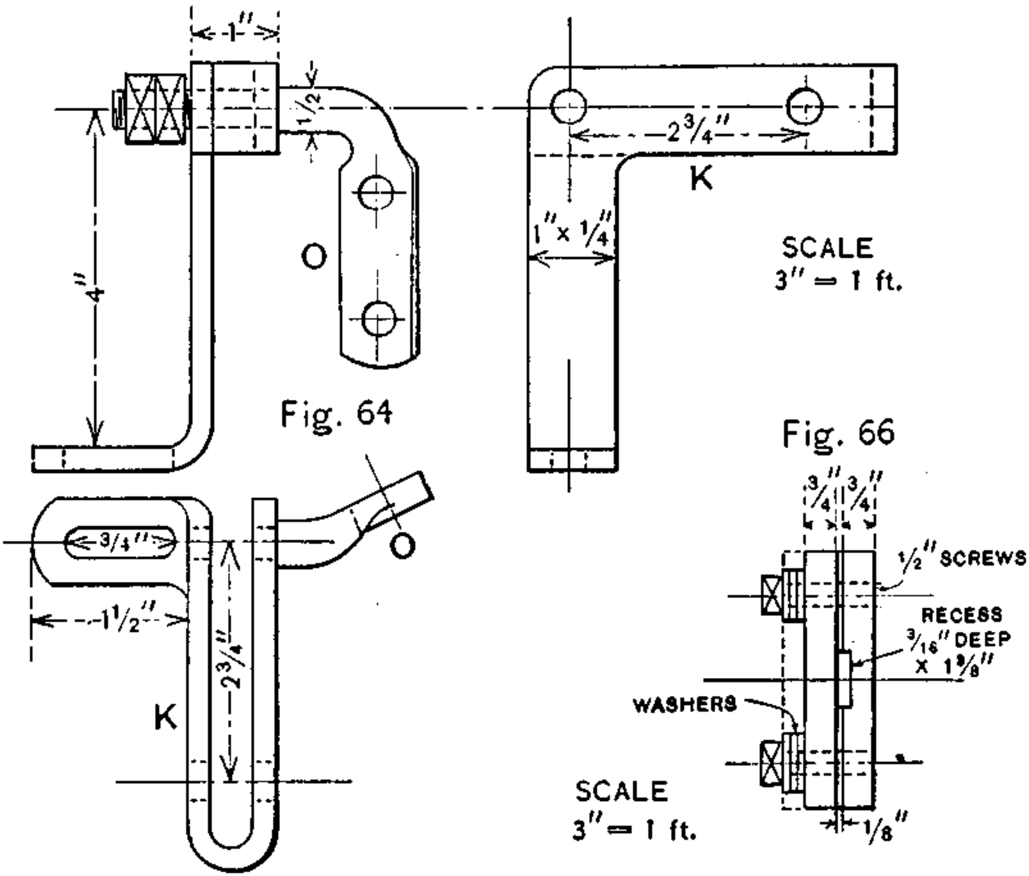


Fig. 64.—Three Views of Crank K.
Fig. 66.—End View of Weight R.

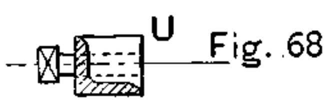


Fig. 68.—Section of Angle F with Stiffening Block.

Returning now to the sliding rod N, it will be seen that the motion of the eight levers M is transmitted to it through the special turned nut P, figs. 62 and 63. The various possible positions of the forked end of lever require that the section of this "nut" be turned to the curves shown. A lock-nut on the outer side enables P to be screwed up to the most suitable position, and there secured in place by the lock-nut.

Examination will show that the tendency of any wind action on the sail is to force rod L nearer the centre of mill, and so to drive rod N to the right as looked at in figs. 49 and 57. This has to be met at the other end of N by the counteraction of a weight, R, carried by a cranked lever, S, indicated in a diagram in fig. 49, and more fully in figs. 67 and 69. The lever, the short end of which is doubled or looped (see left-hand view in fig. 67) in order to pass on both sides of the loose pin bearing T, is hung from the upper tail-angle F by a ½-inch screw, a securer bearing being obtained for this by tapping into the block U, which is riveted to angle, see section, fig. 68. The arrangement of end of rod N and pin block T is more clearly shown in fig. 69. Fig. 65 gives an end view of pin bearing, T.

The weight, R, should be cast double, one piece having a slot or recess cast on one side as shown in fig. 66. It is difficult to fix on the exact weight that may be required, as this depends not only on the views of the maker as to the power which he desires the mill to exert at its maximum, but also on the friction of the numerous joints in levers. It is, however, recommended that a trial be made with a weight of about 10 lbs., corresponding with the full lines in the drawings given. If the mill sails are found to open too easily with this weight—which is, however, doubtful—it can be shifted further along the lever arm, or if even this is found insufficient, another disc can be added as shown dotted on the left in fig. 66. A light galvanised chain, running over a pulley in top angle of tail and hanging with a loop to within 6 feet of the ground level, is used to lift weight when the owner desires to stop the mill, this action, of course, opening all the sails so as to present only their edges to the wind. The other end of chain is looped back to a point near outer end of tail to avoid entanglement with uprights or running shaft. A hook attached to chain in proper position, W, can be hitched under lower angle of tail by taking chain sideways a little and so hang the weight up for any length of time.

SCALE 1½" = 1 FT.

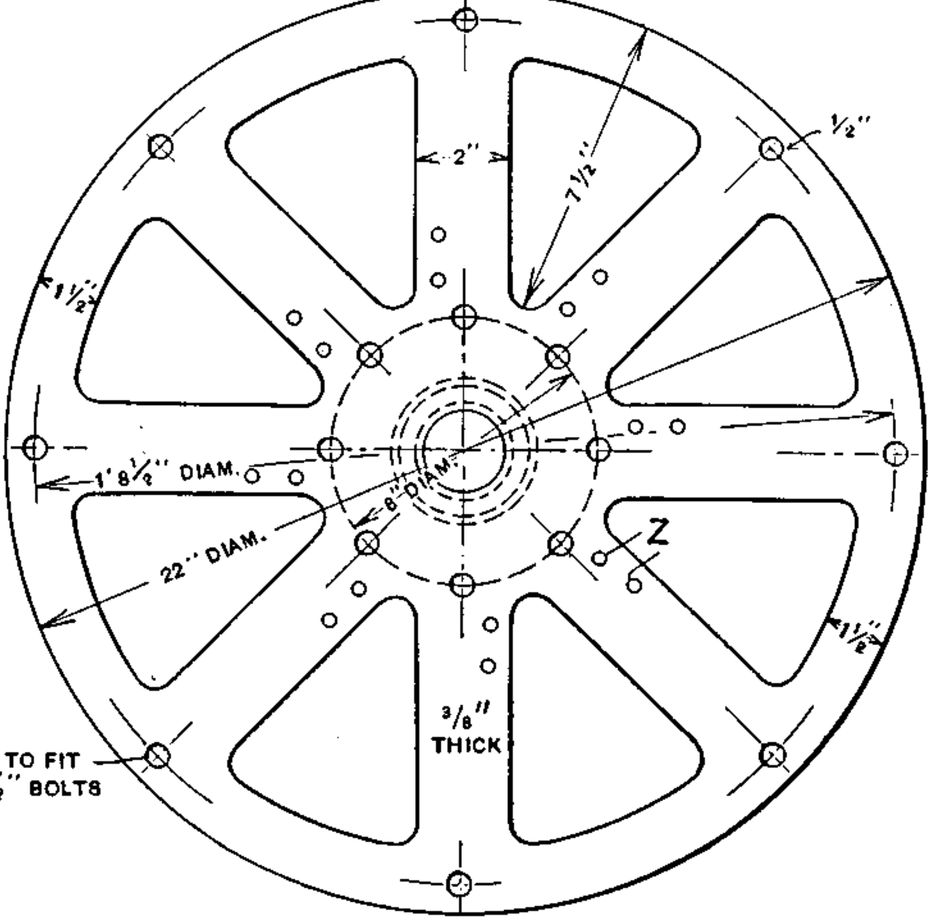


Fig. 70

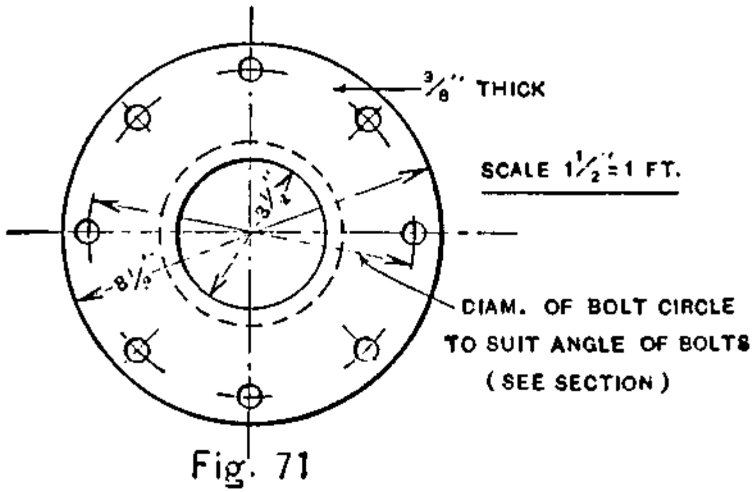


Fig. 71

Fig. 72 — Straining Rods for Arms.

The automatic action and its details should now be fairly clear, and the remaining parts of the mill are simple. The large central casting, X, appears in several figures, notably in section in fig. 57 and in front elevation in fig. 70. It is undoubtedly the most serious undertaking in the whole construction and must probably be "put out" into the hands of professionals. It should not, however, be a costly item, and if made as indicated will go far to making the mill a practical job. This casting carries the eight arms and makes secure connection to the axle. It is backed up in its support of the arms by the smaller annular casting Y, fig. 71, which is bored to fit well over turned part of X: Three very well-fitted ½-inch screws at 120° secure the boss to shaft, a good tight fit between shaft and casting being essential. These screws must not project inside the shaft far enough to touch the sliding rod N.

The casting X carries also the eight little brackets Z for the levers M. These brackets are of cast iron and may be "American" in character in so far that the pins form part of the casting, a file probably being a good enough tool to finish them.

A little further stiffening of the sail-arms is obtained by the use of the tension-rods TR, detailed in fig. 72. These are only ¼-inch galvanised rods one end turned over for an inch at right angles and the other screwed and lock-nutted. The tension put on these must be even and not too great; but they, as well as other screws and bolts in the machine, will probably require tightening up once or twice when the weather has had its effect on the timber.

A word is required in reference to this latter item. The arms should certainly be wrought from good sound seasoned ash. The sails can hardly be formed of better timber than Californian redwood (*Sequoia semper virens*), which can be obtained in wide boards. They will be ½ inch thick with the edges chamfered off both sides. Three battens, 2 inches × 1¼ of sound hardwood (ash, bluegum, etc.) must be well screwed across, and the hinges, three in number, will come opposite these, on the other side of sail. These hinges should be of the strongest make of T shape, galvanised. They are shown in the plan, fig. 58.

So far the axle has hardly been mentioned. It is, however, a very simple matter, being nothing but a piece of 2-inch (outside diameter) steel steam-pipe, preferably solid drawn, and quite $\frac{1}{4}$ inch thick. It should be true to begin with, so that the very lightest skimming in the lathe will make it a good journal. It carries the usual bevel-wheel, indicated in figs. 49 and 57, and gearing with another of the same size on the vertical shaft. Both wheels are 4 inches on inner diameters, but may be more or less if required, the casting A being altered if necessary. The vertical spindle would be a piece of $\frac{3}{4}$-inch cold rolled steel shafting, and should have bearings also at bottom end and half-way down the tower, presuming the spindle is carried down to the ground as shown in fig. 48. A pair of bevel-wheels is also required to transmit power to a horizontal shaft.

One or two points in conclusion deserve remark. First, that all possible metal parts should be either galvanised or of sheet zinc. The castings will most probably be only painted. They should be "pickled," freed from rust and especially from dirt and grease, and painted with good red lead paint well rubbed in. It is better still to warm the castings to about 100° Fahr. when putting the first coat on. Three coats of the red lead paint, thinly put on, and a finishing coat of grey or black paint are required to make a good job. The woodwork, it has already been remarked, should be tarred or creosoted. This does not apply to the arms and vanes, all of which require the usual painting in most thorough fashion. The most suitable paint is pure white lead with a dash of ochre.

Steps, formed from any suitable timber, say 3×2 inches, should be nailed up at least two sides of the verticals to enable the owner to reach the head of mill for oiling, etc.

A mill of this power, especially if used to drive a lathe or other workshop tools, should have a simple cut-out device—such as a sliding coupling actuated by a handy cord or chain, so as to throw the mill out of gear in case of an accident. A brake is not so necessary, as the automatic gear is designed as much as possible to keep the machine at uniform speed. Under normal output this speed should be from 80 to 100 revs. per minute, varying slightly according to the setting of the sails. These, in their flattest position—that is, with a light wind—should lie at an angle of about 20° to the plane of revolution of the wheel.