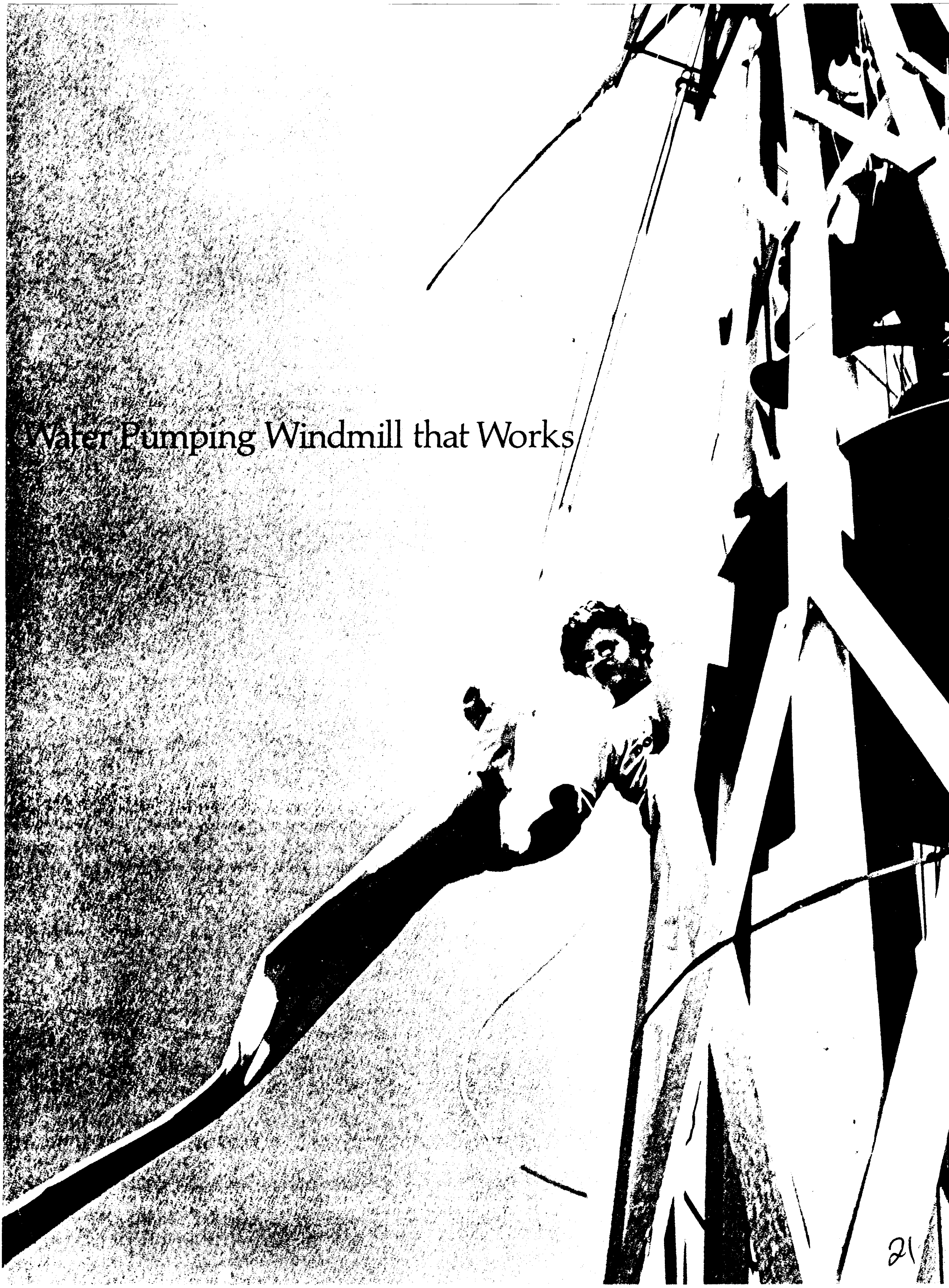
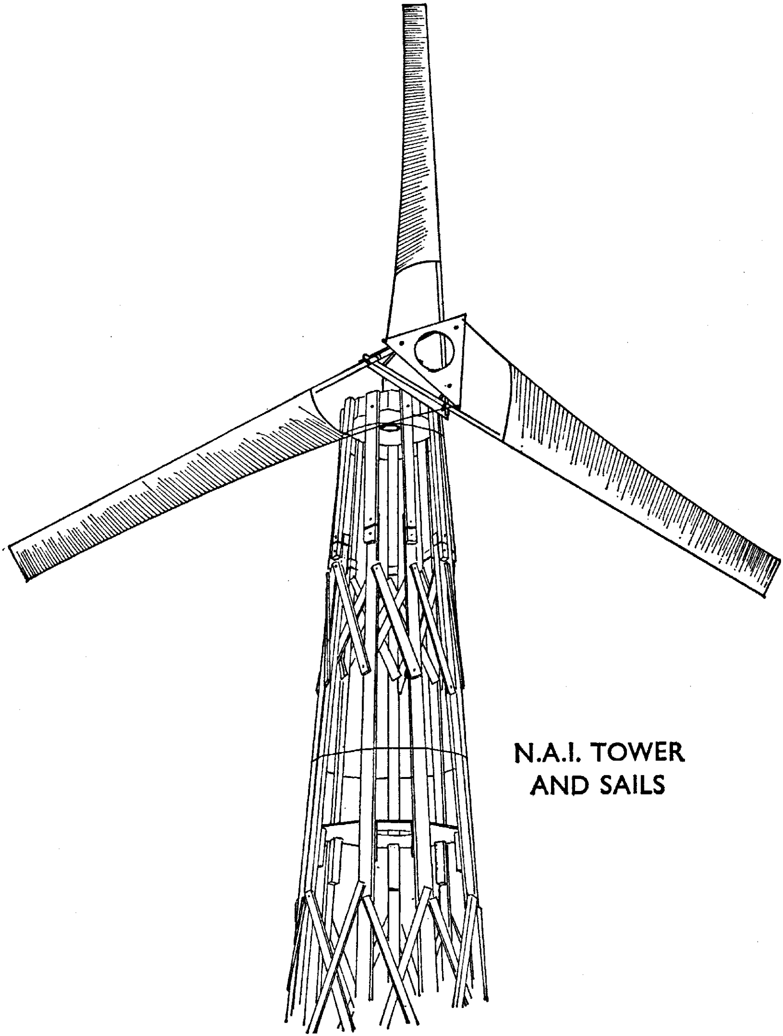
Water Pumping Windmill that Works



The best design I know is for a 26-foot high tower built by the New Alchemy Institute-East on Cape Cod and fully described in the *Journal of the New Alchemists*, No. 2. The basic structure is made from 8 lengths of 4 × 2 timber each 26 feet long (all timber must be treated with wood preservative). The 2 platforms are fixed to the tower by nailing down into short lengths of 4 × 2 bolted to the main uprights (with eye bolts, on the centre platform, to provide a fixing for the guy wires). The NAI wires run inside the tower but anchoring them outside would in my view provide a better hold. The tower is tapered to a shape given by making the top platform an octagon 28 inches across and the centre one a circle of 48 inches diameter. The main uprights are fixed at the bottom with large bolts to 8 bits of telegraph pole 6 feet long driven deep into the ground. The top half of the tower is braced with 16 40-inch lengths of 1 × 3, and the bottom half with 16 58-inch lengths.

Such a tower (this one was designed for a 18-foot diameter sail machine) will give pretty good service. Bits of wood attached up the lee side will make a safe ladder, and some more pieces mounted all round about 3 feet from the top will give an easy toe-hold for working on the machine. If you want even more strength (and who doesn't?) the price of a third platform will be miniscule and help out of all proportion to its cost.



N.A.I. TOWER
AND SAILS

Photo by Alan L. Pearlman

This windmill consists of three cloth sails attached to three tubular steel masts which are fastened to a triangular plywood hub. The center of the hub is bolted to the end of an automobile crankshaft which spins in bearings mounted on top of a steel ball-bearing turntable. The bearing turntable unit, which allows the windmill to rotate so that the sails are always perpendicular to the wind, is mounted at the top of an eight-legged tower which is firmly guyed and braced. A piston rod connected to the crankshaft transfers power through a reciprocating vertical steel pipe which runs from the top to the bottom of the tower where it operates a high capacity piston-type water pump.

The tower legs are bolted at the base to eight telephone pole sections which are firmly buried in the ground to prevent the tower from blowing over in heavy winds. This windmill is designed to remain operational and to withstand storm conditions. Ideally the cloth sails should be removed if severe wind conditions are anticipated. Our windmill was built to supply circulating water to a series of twenty experimental aquaculture ponds. It was required that the water in each pool be replaced once each day. Water pumping trials showed a yield of 250 gallons per hour in a 6 mph wind with 18' diameter blades applying power to a 3" diameter pump through a 3½" stroke.

7.481 gallons/ft^3

$$\frac{250 \text{ gph}}{7.5 \text{ g/ft}^3} = 33.3 \text{ ft}^3\text{/hr}$$

33.3 ft^3/hr x 8 hr = 266.4 ft^3 in 8 hr.

This figure is lower than the calculated pumping capacity of the windmill.

Because of this we recommend that a crankshaft with a greater stroke or a pump of a larger diameter piston be used. A new mill that we have just completed uses 2 No. 350 cast iron pumps mounted in tandem (Mid-West Well Supply Co., Huntley, Illinois).

Parts

PARTS SHOWN ARE NOT DRAWN TO SCALE

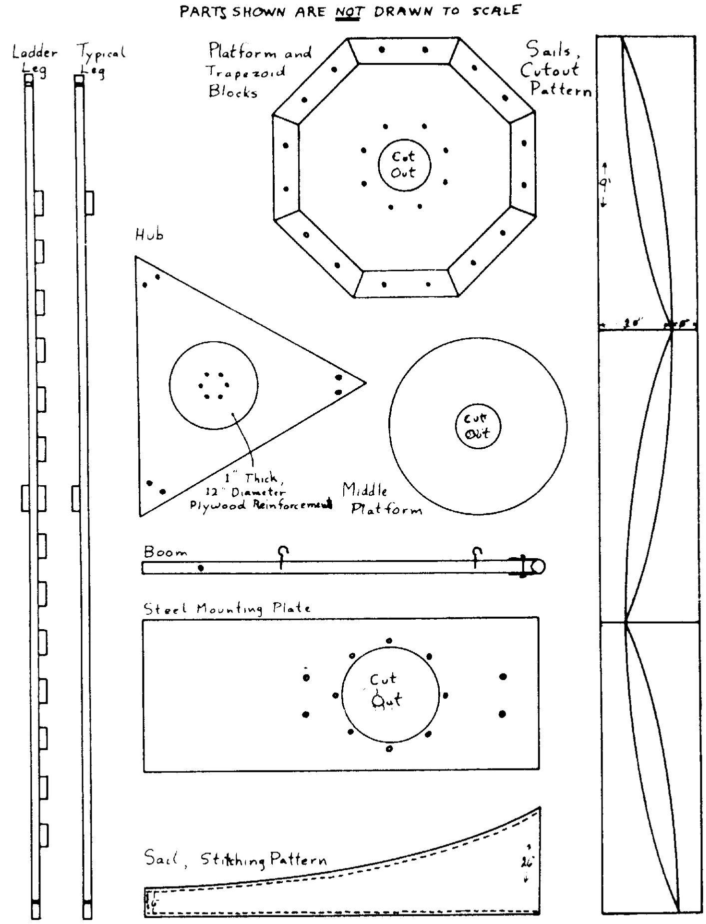


Photo by Alan L. Pearlman

Parts

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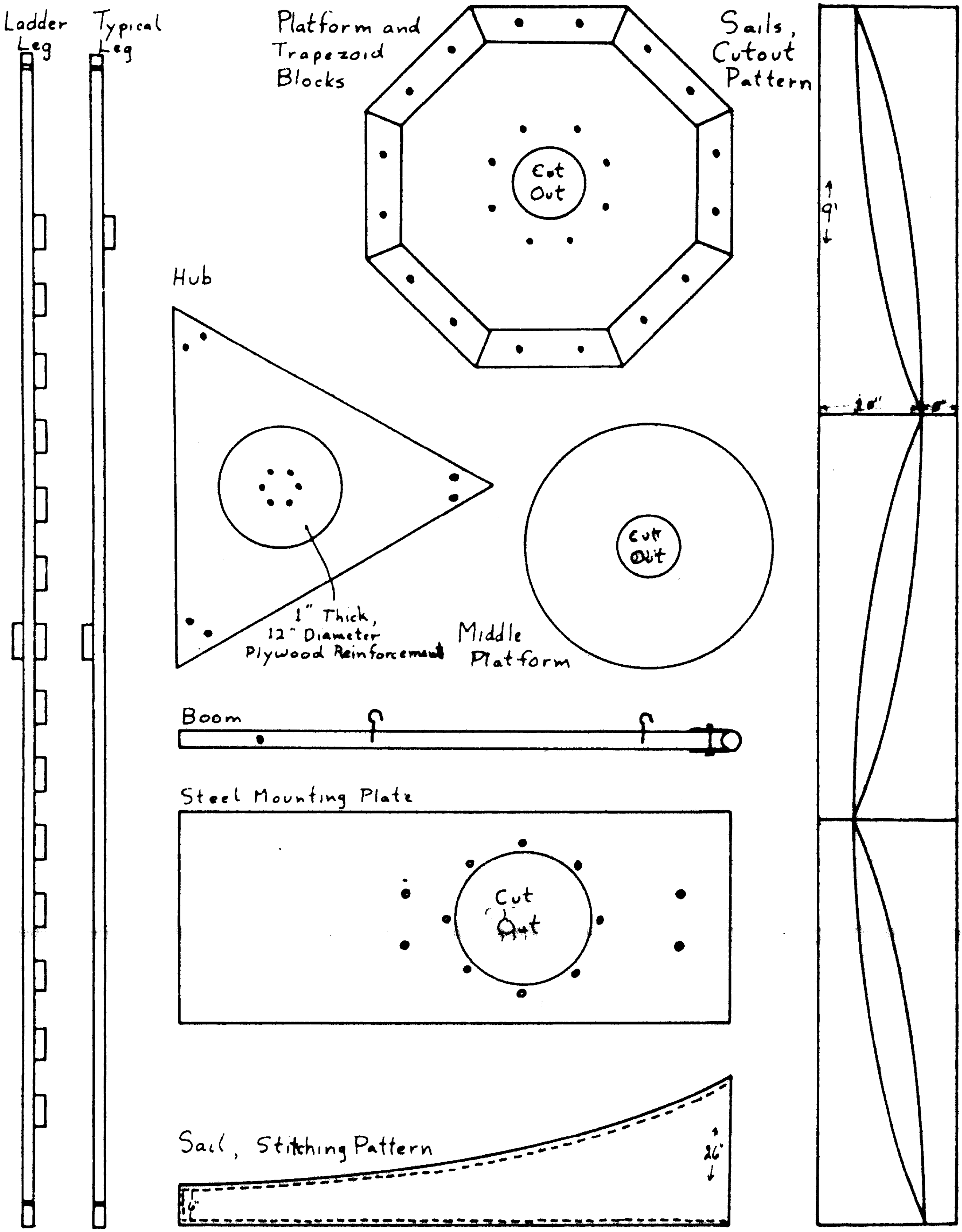
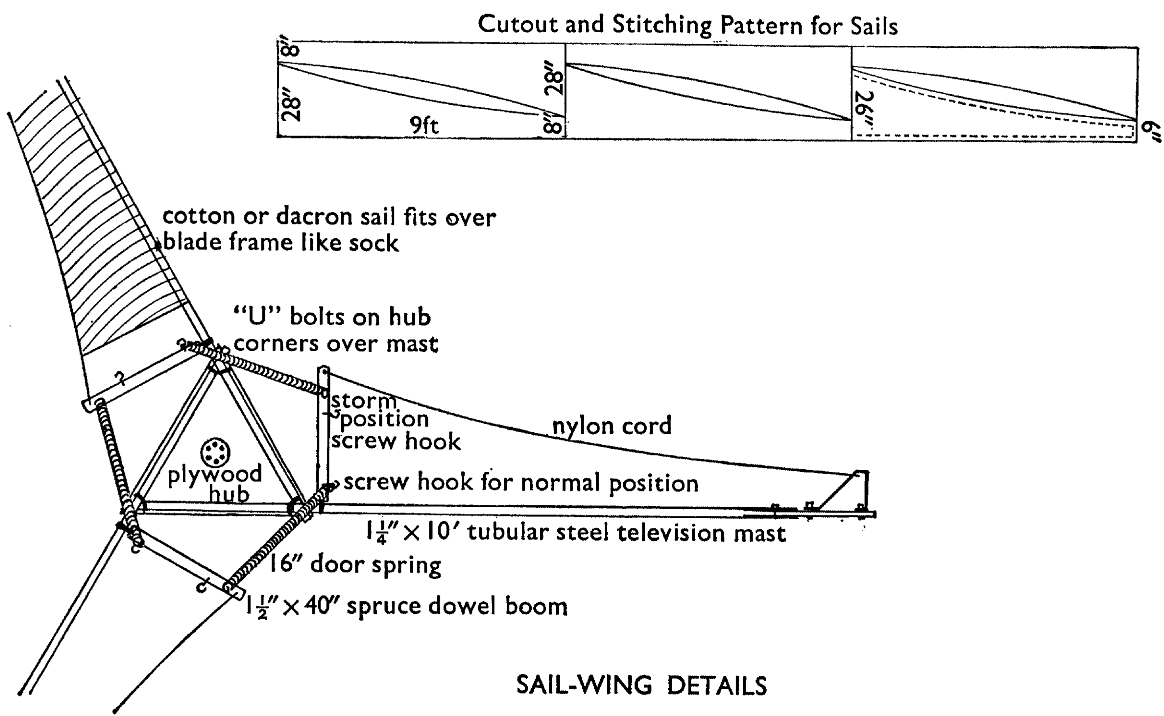
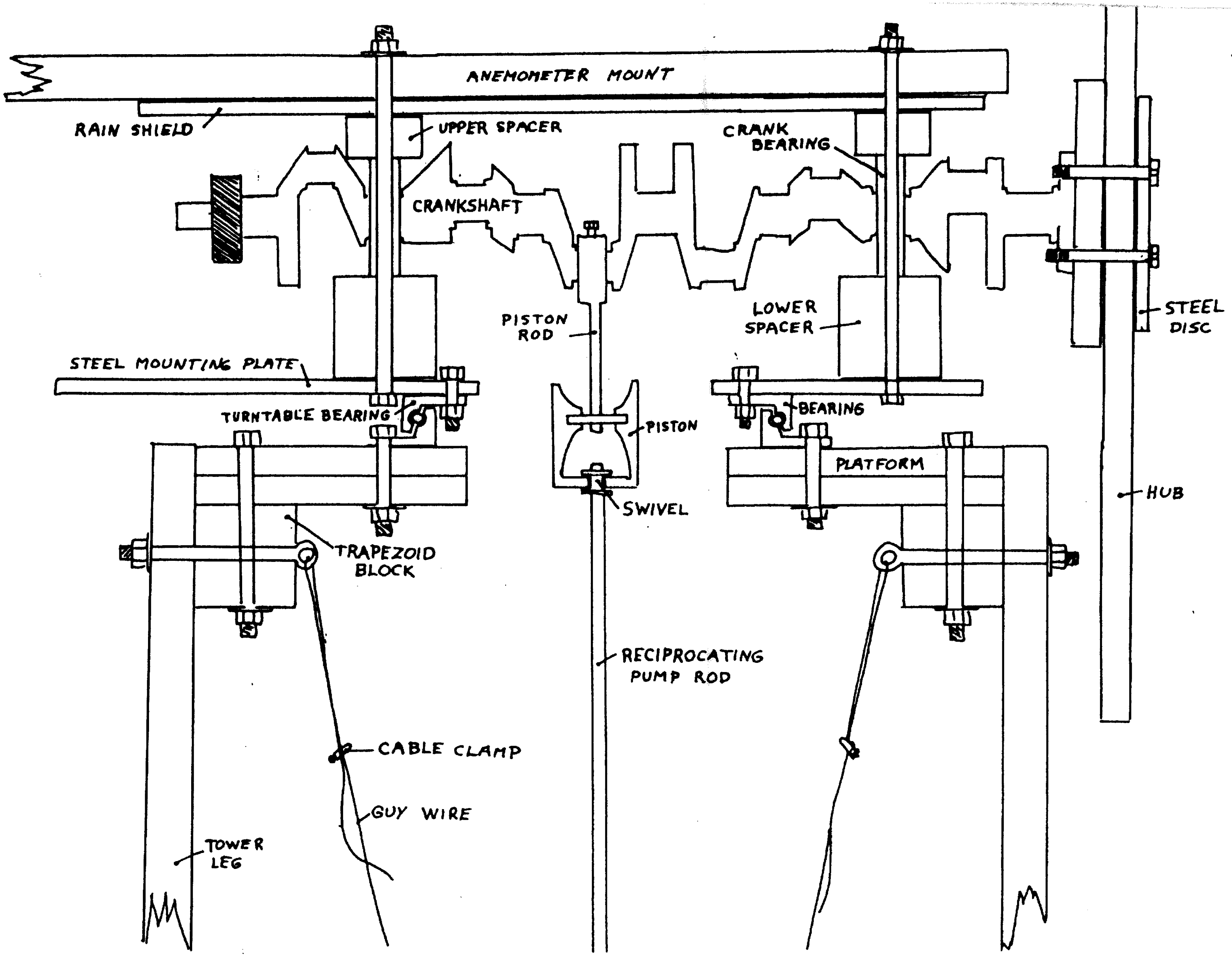
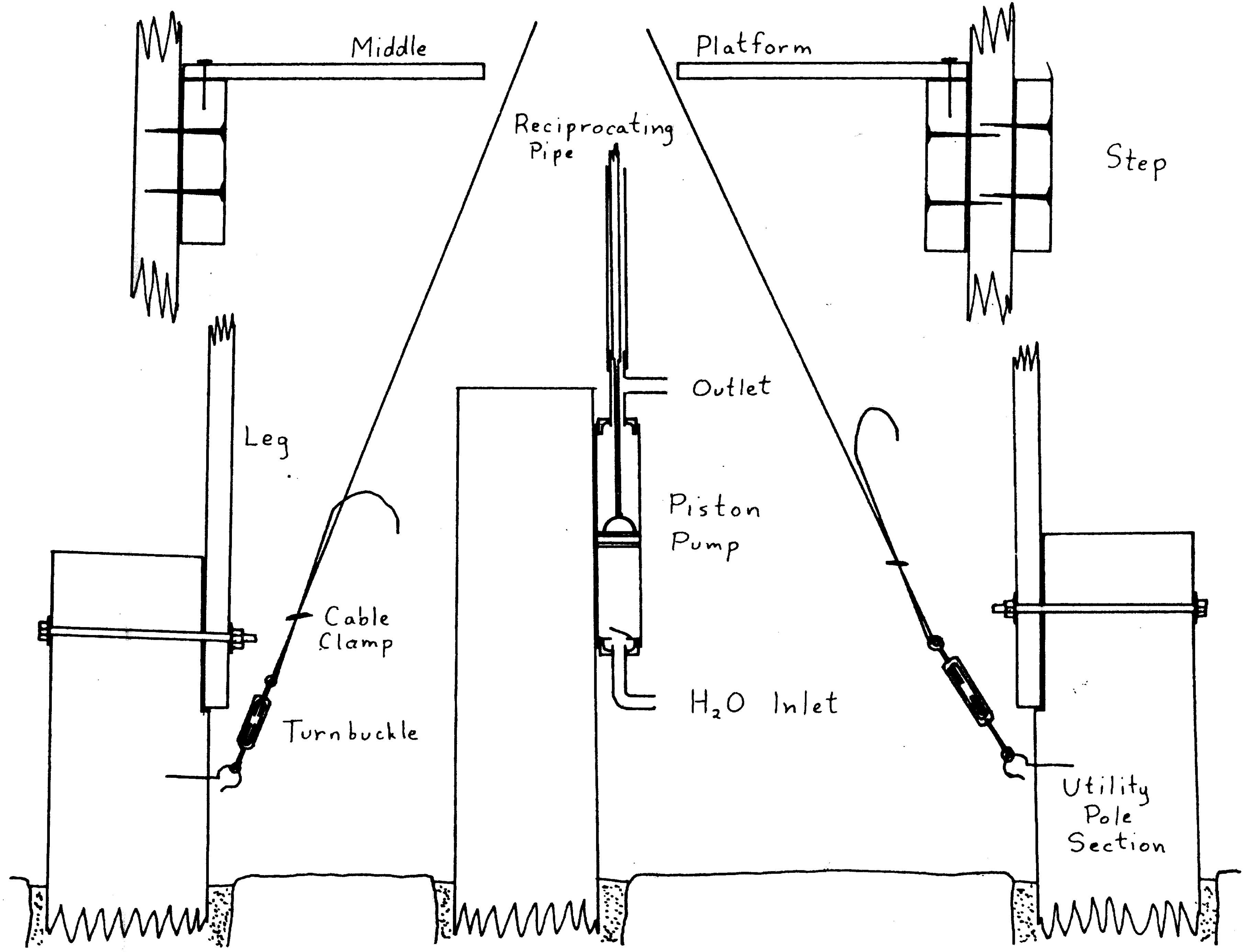




SAIL-WING DETAILS


ANEMOMETER MOUNT
RAIN SHIELD
UPPER SPACER
CRANK BEARING
CRANKSHAFT
PISTON ROD
LOWER SPACER
STEEL DISC
STEEL MOUNTING PLATE
TURNTABLE BEARING
BEARING
PISTON
PLATFORM
SWIVEL
HUB
TRAPEZOID BLOCK
RECIPROCATING PUMP ROD
CABLE CLAMP
GUY WIRE
TOWER LEG


Middle
Platform
Reciprocating Pipe
Step
Outlet
Leg
Piston Pump
Cable Clamp
H2O Inlet
Turnbuckle
Utility Pole Section

Materials in Order of Assembly:

BASE

8 - 6' sections utility pole (or railroad ties), concrete optional depending on hole depth

8 - 12"x ½" galvanized machine bolts, 8 nuts, 16 washers

8 heavy galvanized screw hooks to secure turnbuckles to base

TOWER AND TOP PLATFORM

8 - 26' x 2" x 4" spruce for tower legs

8 - 8" pieces 2" x 4" spruce to secure middle platform to inside of legs

16 - 8" pieces 2" x 4" spruce for ladder steps on outside of one leg

8 - 8" pieces 2" x 4" spruce for foot holds around top of tower

½ gross 2½" No. 10 galvanized wood screws

2 - 1" thick, 28" wide plywood octagons for top platform

1 - 10' x 3½" x 3½" spruce for making 8 wooden trapezoid blocks to secure platform to legs

16 - 7" x ½" galvanized machine bolts, 16 nuts, 32 washers, to secure trapezoid blocks to platform

8 - 6" x ½" galvanized eye bolts, 8 nuts, 16 washers, to secure top of tower legs to trapezoid blocks and to provide attachment for top of guy wires

16 - 27' lengths of t-v antennae guy wire for internal guying of tower

32 cable clamps to form loops at ends of guy wires

Several strong persons and 100' strong rope required to set tower in place, gin pole helpful

1 - 48" diameter ½" plywood disc for middle platform

16 guy wire turnbuckles

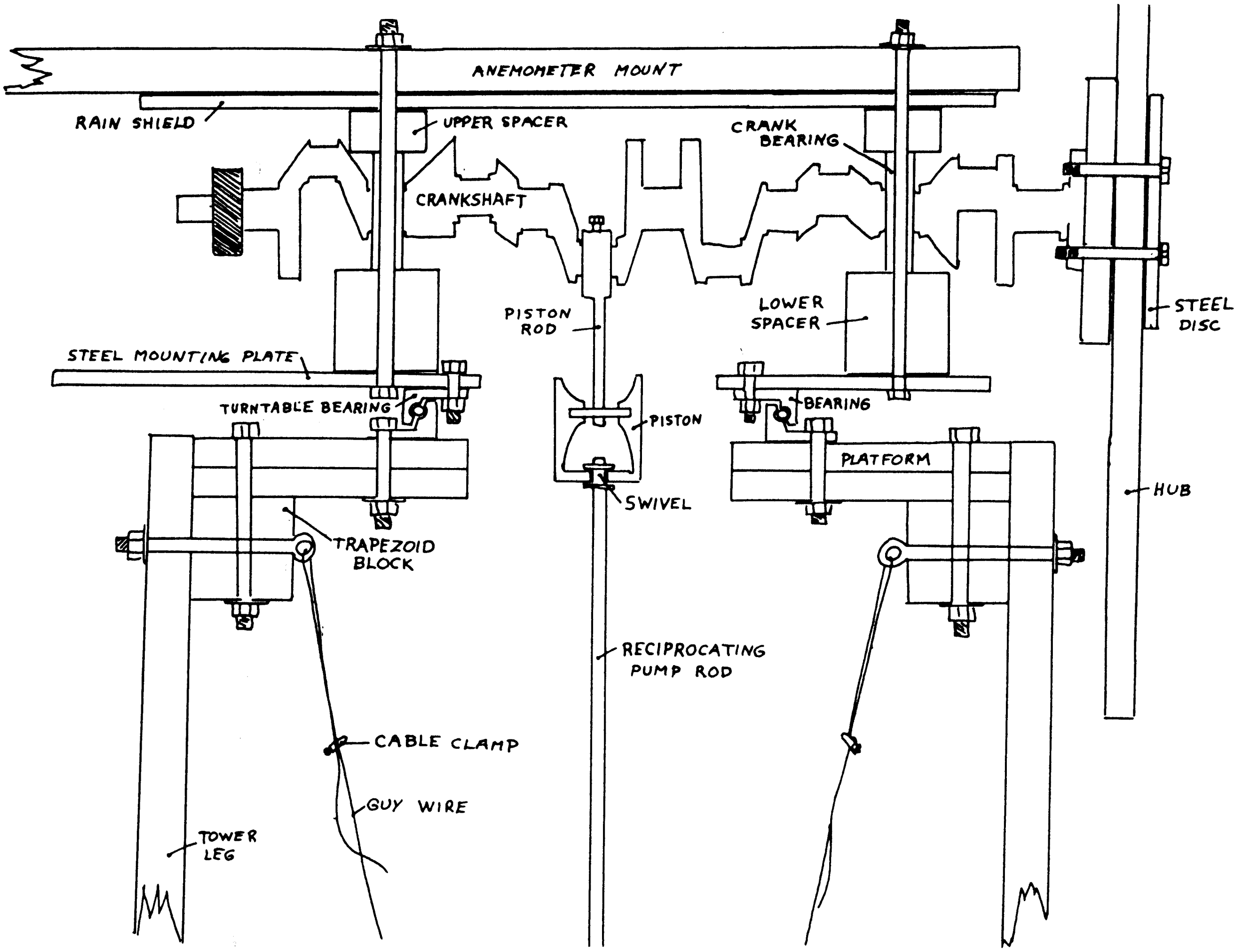
16 - 56" pieces 1" x 3" spruce for lower bracing of tower

1 - 8' piece ½" nylon rope with eye splices and safety clips (for safety line)

At least one capable person who is not afraid of heights

16 - 40" pieces 1" x 3" spruce for upper bracing of tower

1 gross 12 penny galvanized screw nails to fasten bracing to tower legs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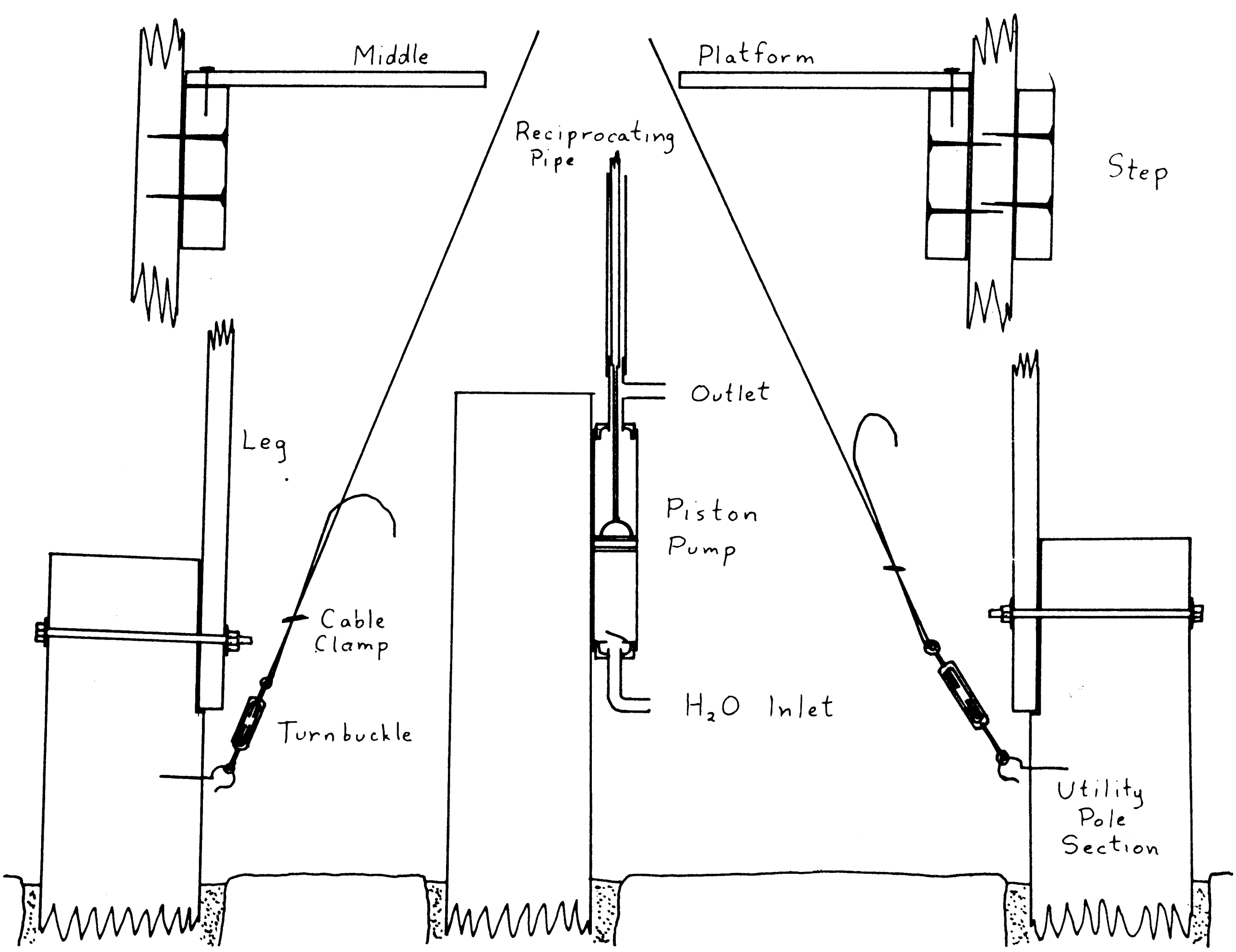
Middle
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Turnbuckle
Utility Pole Section

TURNTABLE AND DRIVELINE UNIT

1 - Model No. M4-12P4 series 1000 Econotrak bearing (9" inside diameter) from Rotek Inc., 220 West Main Street, Ravenna, Ohio 44266 (about $129.00) with 6 holes (½" diameter) bored equidistantly in both top and bottom bearing ring segments

1 - 36" x 14" x ½" steel plate for mounting crankshaft on top of turntable bearing. A hole approximately 9" in diameter must be made in this plate through which the piston rod extends to connect with reciprocating rod

6 - 1¼" x ½" galvanized machine bolts, 6 nuts, 6 spring lock washers to secure steel mounting plate to top of turntable bearing

1 large stroke auto or truck crankshaft with 4 of its bearing retainers. An 8 cylinder crankshaft is preferable.

2 - 6" x 3½" x 3½" spruce blocks for lower bearing spacers

2 - 8" x 1½" x 3½" spruce blocks for upper spacers

1 - 36" x 14" x ½" plywood for rain shield

1 - 8' x 1½" x 3½" spruce for anemometer mount

4 - 12" x ½" galvanized machine bolts to secure anemometer mount, rain shield, upper spacer crankshaft, bearings and lower spacer to the steel mounting plate, 4 nuts, 4 washers and 4 lock washers

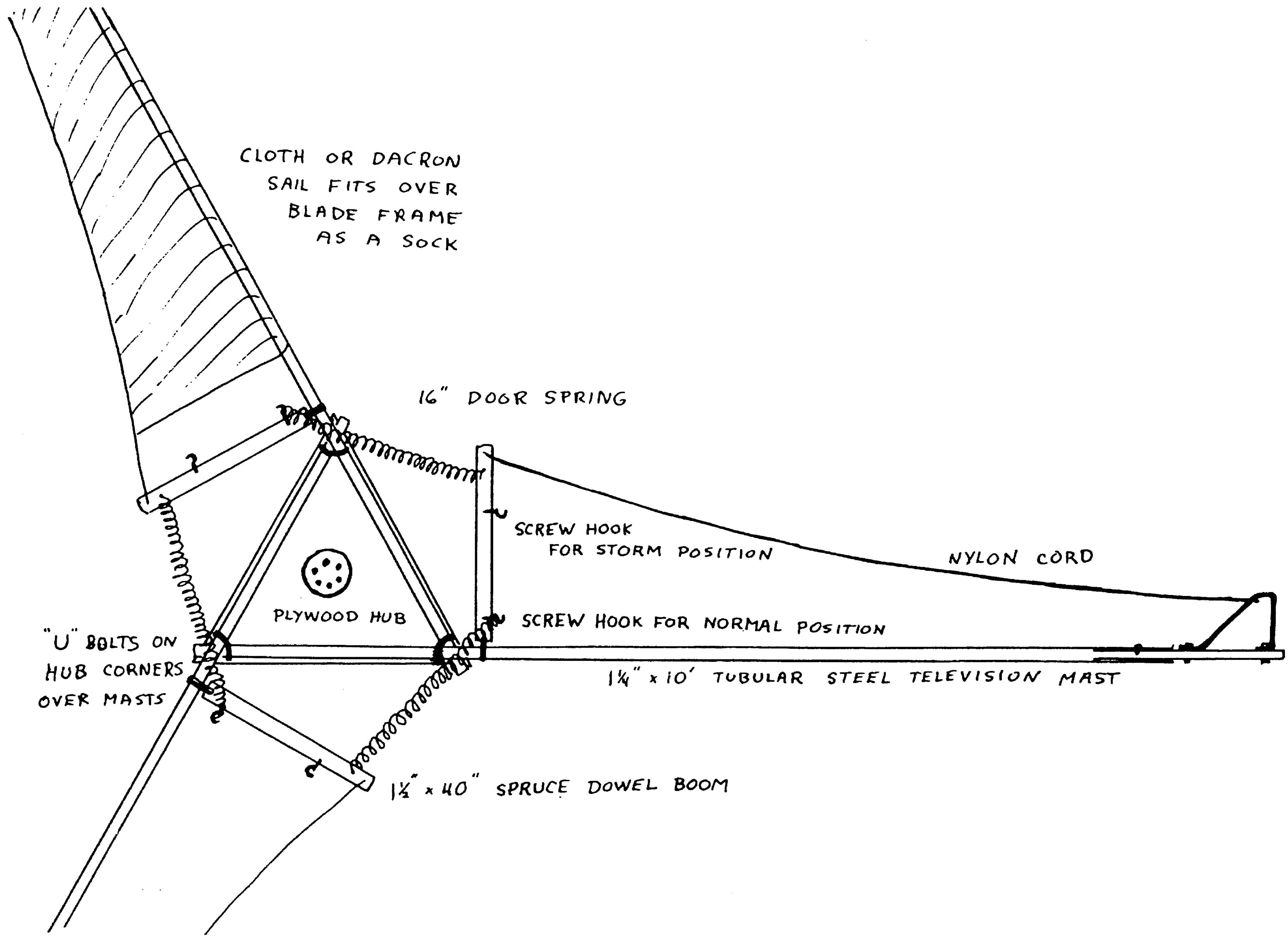
6 - 3" x ½" galvanized machine bolts to secure bottom of bearing to platform, 6 nuts, 6 washers, 6 spring lock washers

1 piston and piston rod unit to connect crankshaft to vertically-reciprocating pipe

1 - 20' length ½" galvanized pipe to connect piston at top to pump at bottom

4 - ½" pipe thread screw collars and 2 - ½" inside diameter heavy polyethylene washers to secure top of pipe in hole in head of piston for swivel mount

1 adaptor to connect ½" pipe threads to 3/8" machine threads on pump rod



CLOTH OR DACRON
SAIL FITS OVER
BLADE FRAME
AS A SOCK
16" DOOR SPRING
SCREW HOOK
FOR STORM POSITION
NYLON CORD
PLYWOOD HUB
SCREW HOOK FOR NORMAL POSITION
"U" BOLTS ON
HUB CORNERS
OVER MASTS
1¼" x 10' TUBULAR STEEL TELEVISION MAST
1½" x 40" SPRUCE DOWEL BOOM

HUB-BLADE UNIT

1 - 1" thick plywood equilateral triangle 30" on each edge for hub

1 - 12" diameter 1" thick plywood circle to reinforce center of hub

1 - 9" diameter ½" thick steel disc to reinforce center of hub (from hole in steel mounting plate)

3 - 10' long 1¼" tubular steel t-v antennae masts for windmill masts (arms)

3 - 1½" spread "U" bolts made from 3/8" threaded rod to secure masts at hub corners

3 - 1½" inside diameter galvanized steel pipe sections 6" long to prevent "U" bolts from crushing masts

6 wooden wedges 12" long, 1½" wide, 1" thick at fat end to adjust coning angle of masts to prevent collision with tower

3 - 2' x 1" steel tubing for mast extensions

3 - ¼" thick, 1" wide 21" steel straps for tip of mast extensions

12 - 1½" x 3/8" machine bolts to attach steel straps to tip of mast extensions, 12 nuts, 12 spring lock washers

3 - 2" cotter pins to secure mast extensions within masts

3 - 32" pieces 1" spruce dowel for booms at base of masts

3 - 1" x 8" medium gauge galvanized sheet metal strips to secure booms to masts

3 - 16" door springs for automatic pitch control

9 medium screw hooks to secure door springs to booms

3 - 12' long pieces nylon cord to form trailing edges of sail blade frames

9 yards muslin, cotton or dacron sail material

PUMP UNIT

1 - 8' section utility pole (or railroad tie) set in ground off center of line of travel of vertically-reciprocating pipe (pump cylinder is mounted on this)
1 Model No. 81 brass-lined pump cylinder No. 380-1-3021 from Demster Industries Inc., P. O. Box 848, Beatrice, Nebraska 68310 (about $45.00), or any large diameter piston pump or Model No. 350 Shallow Well Cast Iron Cylinder from Mid-West Well Supply Co., Huntley, Illinois (about $18.50).
1 "T" joint for outlet of pump
1 - 1¼" check valve for bottom of intake pipe
Adequate 1¼" plastic piping for inlet and outlet of water

TOOLS NEEDED

Bit brace, chisel, cross-cut wood saw, hammer, level, open-end wrench set, paint brushes, post-hole digger, screwdrivers, sewing machine, shovel, socket wrench set, 9/16" wood bit, and wood clamps; *Optional:* electric drill (heavy duty), high speed drill set, jig saw, skill saw, and ½" steel strapping and tensioning tool from Signode Corp.

OTHER SUPPLIES NEEDED

1 gallon white exterior primer paint, 1 gallon exterior paint, 1 quart black Rust Oleum paint, Weldwood or Borden's 2-part plastic resin wood cement, all-weather farm grease, and silicone sealing compound

OPTIONAL ITEMS

1 anemometer (recording)

1 water meter

Water storage tank(s)

Most parts are available at any lumberyard, hardware store, auto junk yard and t-v supply store. Only the water pump and turntable bearing are "send away for" items. Total cost (less tools and labor) is less than $300.00 in U. S.

Note on scrounging: It is usually cheaper and more expedient to ask persons directly responsible for the article desired; i. e., the yard foreman, truckdriver, stockboy, job foreman, etc., not the purchasing agent or factory superintendent.

— *Marcus M. Sherman*

POSTSCRIPT

Testing of the mill: Since the article was prepared we have had an opportunity to test the sailwing windmill for ruggedness and pumping ability.

The windmill, with the cotton sail blades of 18' diameter, did indeed pump 250 gallons per hour in 6 mph winds. The water was pumped up 14' from a lake below the windmill. Our calculations and direct observations indicated that our pump was considerably undersized for the windmill. A larger stroke or a larger diameter piston pump would have been desirable. Our latest sailwing windmill, with sails designed by Merrill Hall, has two pumps mounted side by side (see drawing of advanced backyard fish farm mill) and we may yet add additional pumps.

Cotton versus dacron sails: During the winter trials the cotton sails did not stand up to continuous operation through storms and high winds. We decided to try dacron sails as dacron is a much longer-lived material, holds its shape better, does not absorb water during rains and is much stronger and lighter than cotton.

Photo by Alan L. Pearlman

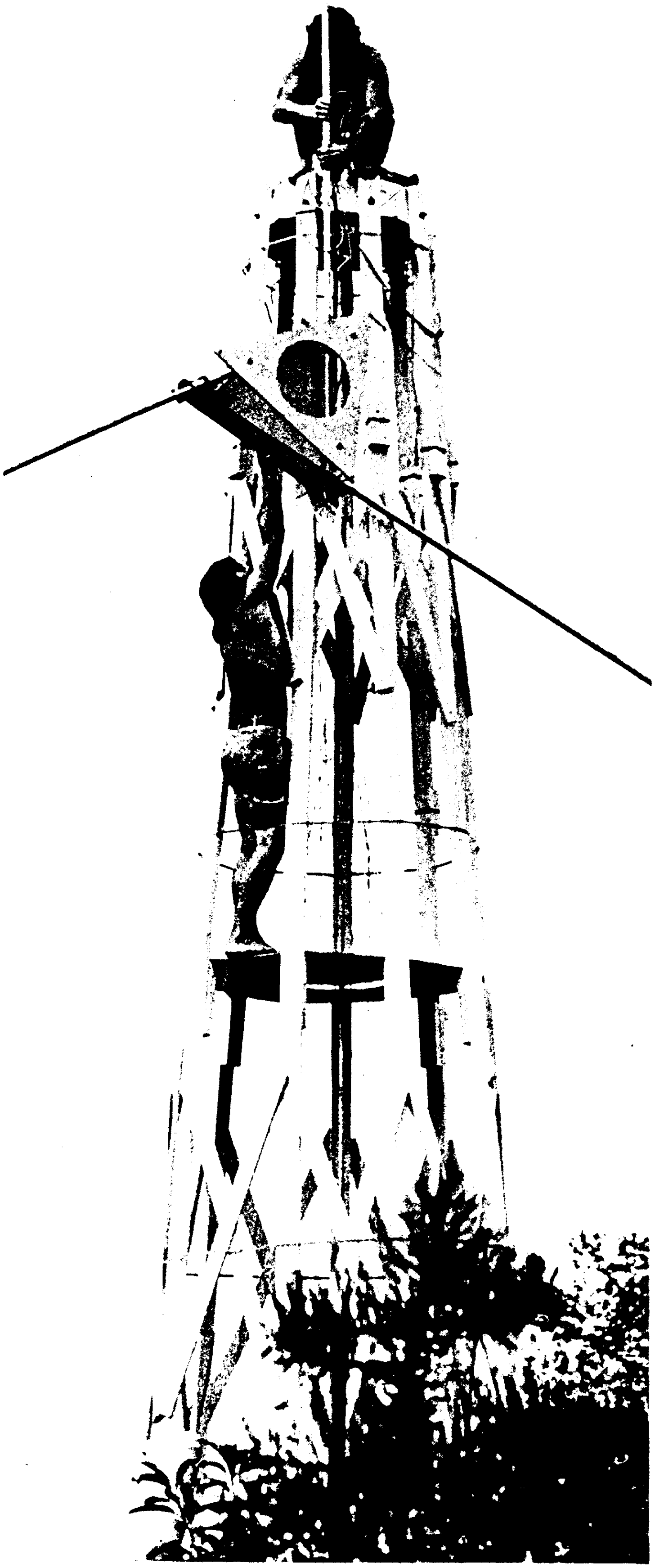


Photo by Alan L. Pearlman

These are important factors when it comes to the design of large sailwings.

Merrill Hall made us a set of 3.8 oz. dacron sails to Marcus Sherman's design. From visual observations they seem to perform better than the cotton sails did. They are steadier and have a better configuration while driving in heavy winds.

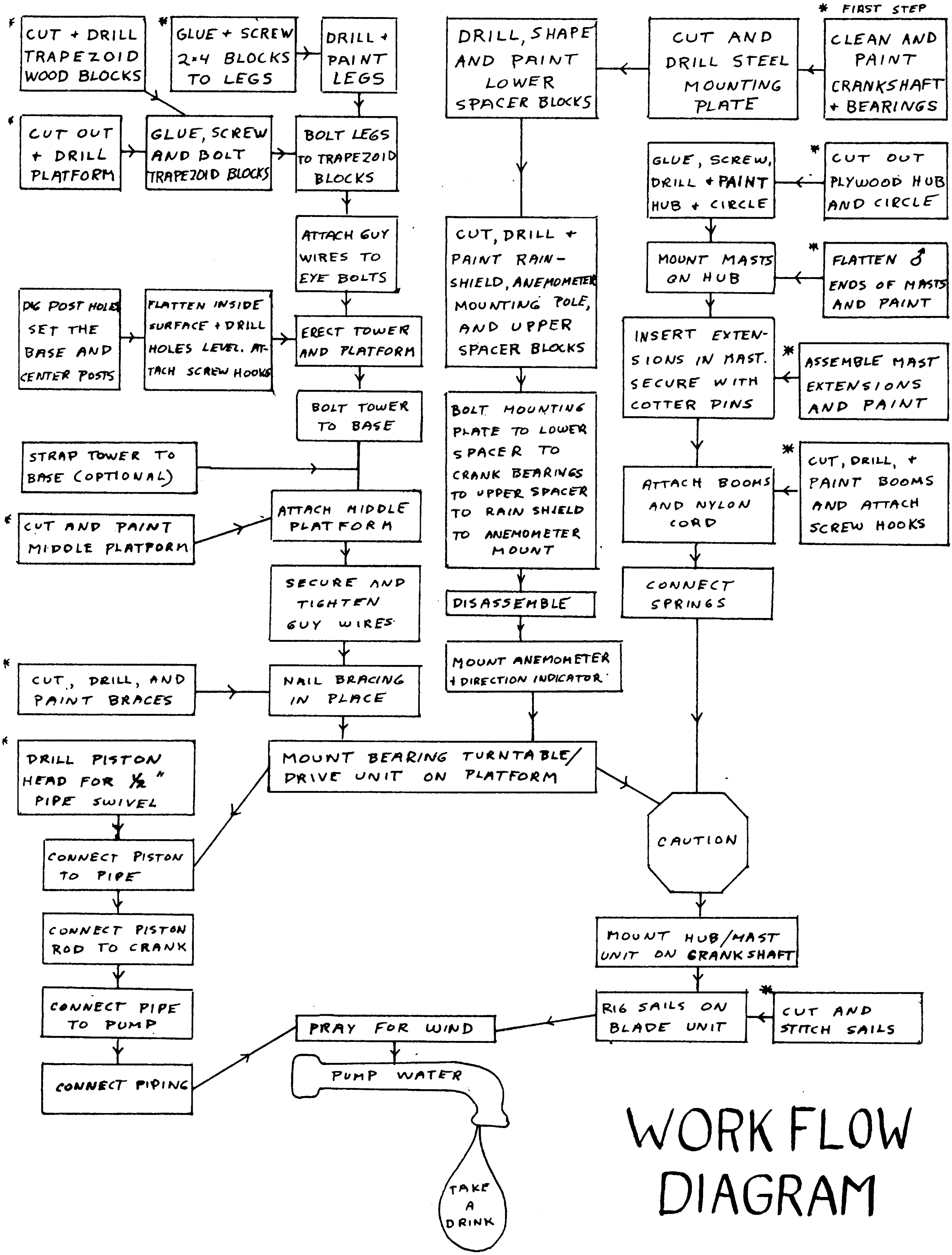
It was not long before we had a chance to test the dacron sails. With the feathering springs set in their storm position (see sailwing diagram) the mill came through a force nine gale (40 knots-plus winds) and continued to pump throughout the storm. The next gale arrived a few days later accompanied by freezing rain. This time we decided to leave the feathering springs in their full working position. The mill, to our great pleasure, was still pumping when the storm abated. The strong sails and Marc's spring feathering system have vindicated themselves, and since the last gale, a number of severe storms have been weathered.

Post Postscript

We have recently learned that dacron is not superior to cotton for use in tropical areas, although coloured dacron has proved more durable than white.

Problems: During high winds, bolts and screws, including those on the end of the crankshaft, shake themselves loose. We replaced the hub bolts with longer ones so that lock washers and nuts could be placed on the crankshaft side of the hub. If you plan to have your windmill operate during high winds, we advise that you do not skimp; get quality materials and build it to last a long time, perhaps even a lifetime.

The windmill as accomplice and ally: Our sailwing windmill with its bright red sails has brought us an immense amount of satisfaction. Having it around makes us feel better, and there is something almost magic about working with the wind. At the bottom of the tower with the wind passing through the rigging, one is carried off to the plains of Crete and to distant shores where men first used the wind to drive their vessels and embark upon the unknown.



WORK FLOW DIAGRAM

* JOBS ARE FIRST IN SEQUENCE