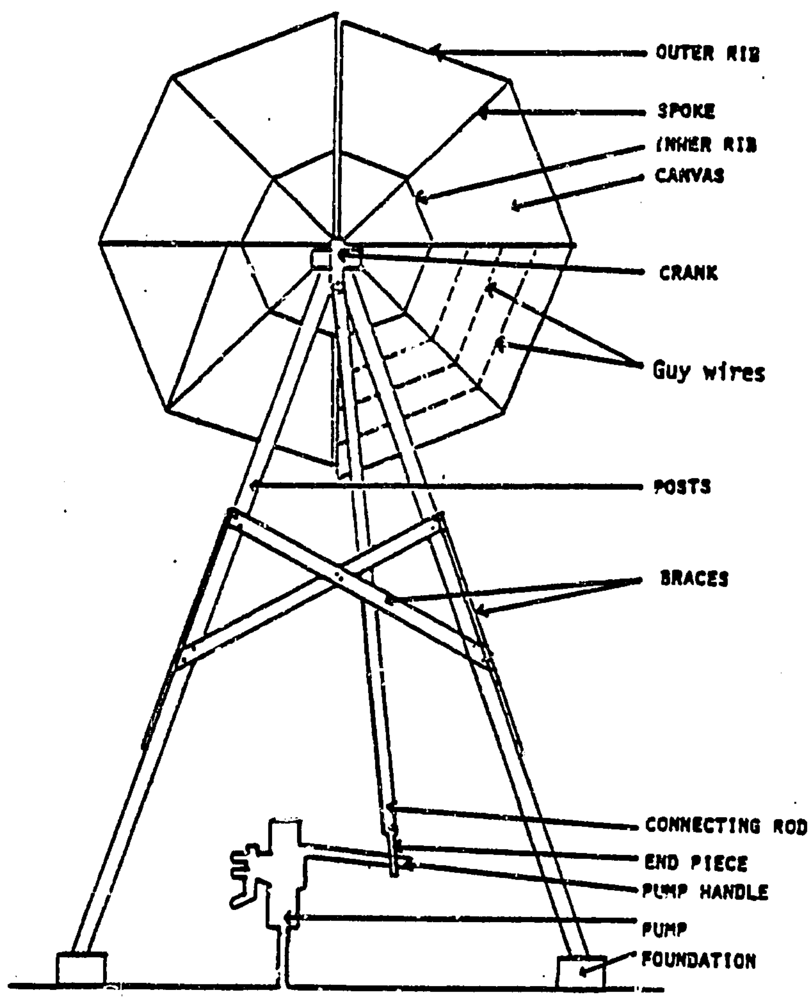
HELICAL SAIL WINDMILL



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HELICAL SAIL WINDMILL

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I. WHAT IT IS AND HOW IT IS USEFUL

The Helical Sail Windmill is a type of windmachine with cloth sails arranged spirally around the axis of the rotor.

Originally built by a Peace Corps Volunteer in 1963, it was known then as the Lewis Sawali Windmill. Although working models were built, there were many structural weaknesses. In 1968, another Peace Corps Volunteer, with financial help from the mayor of Santa Barbara, Iloilo, Philippines, constructed a windmill from the same design but substituting stronger parts and prefabricated sections. The windmill has been known since that time as the Santa Barbara Windmill.

The Helical Sail Windmill is well suited for pumping water. It can be placed over a well to provide continuous pumping, or used to pump water from a stream, providing a continuous flow of about 30-41 liters (8-11 gallons) per minute. This is usually an adequate amount of water for domestic and small farm use.

The windmill is most suitable in areas where the wind blows along a single directional axis, such as in the Philippines where the wind comes from either the northeast or the southwest.

As presented here, the windmill has heavy canvas sails with a diameter of 305cm (119"). The tower is made of wood and consists of a double "A-frame" about 488cm (192") high on a concrete base about 305cm (119") square. The axle is steel; the spokes are angle iron. Some carpentry and welding skills are required for construction.

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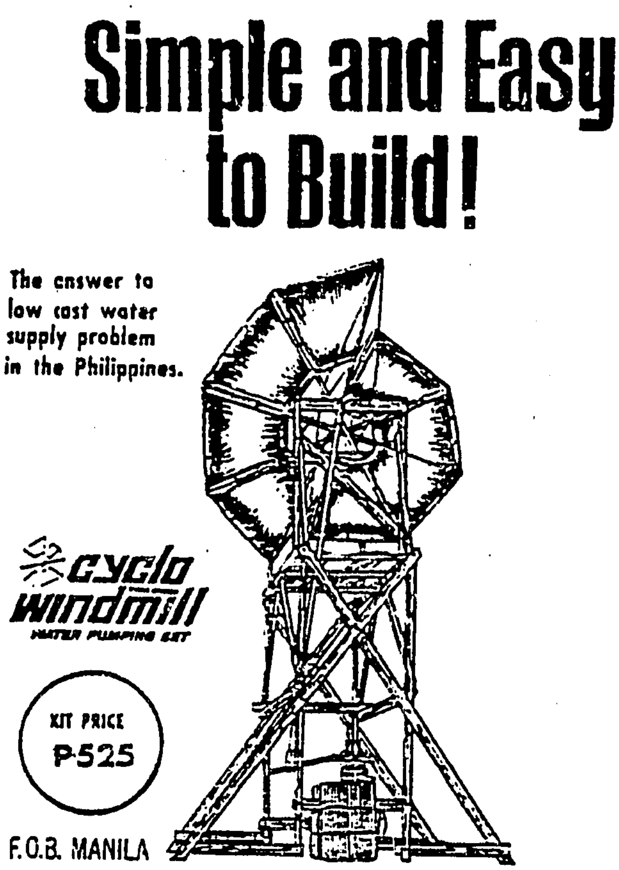
Advertisement in the Philippines Free Press, September 13, 1968:



CYCLO WINDMILL water pumping set gets you water anytime, anywhere. Its simple design of screw type helical vanes makes the sails rotate with wind from any direction. You are assured of continuous water flow--from 8 up to 10 gallons per minute.

Most ideal for domestic (household) water needs, irrigation needs for small areas or plots, or for dairy, piggery, or poultry needs!

Simple and easy to build, the CYCLO WINDMILL pumping set is sold as a kit complete with component parts, bolts, cables, clips, and shallow well pump with foot-valve, except water piping and wood parts for the tower. A deep well pump cylinder is available at an extra cost.

II. DECISION FACTORS

Applications:

- Water lifting and pumping.
- Irrigation.
- Operation of hand-powered agricultural processing machinery such as winnower or thresher.

Advantages:

- Low cost.
- Easy to build.
- Simple operation.

Considerations:

- Requires attention when operating.
- Designed to be used where wind blows from one or two directions on a regular basis.
- Requires the use of metal bearings which may not be available locally.
- Canvas sails need replacement periodically.

COST ESTIMATE*

$50 to $100 (US) including labor and pump mechanism.

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*Cost estimates serve only as a guide and will vary from country to country.

III. MAKING THE DECISION AND FOLLOWING THROUGH

When determining whether a project is worth the time, effort, and expense involved, consider social, cultural, and environmental factors as well as economic ones. What is the purpose of the effort? Who will benefit most? What will the consequences be if the effort is successful? And if it fails?

Having made an informed technology choice, it is important to keep good records. It is helpful from the beginning to keep data on needs, site selection, resource availability, construction progress, labor and materials costs, test findings, etc. The information may prove an important reference if existing plans and methods need to be altered. It can be helpful in pinpointing "what went wrong?" And, of course, it is important to share data with other people.

The technologies presented in this manual have been tested carefully, and are actually used in many parts of the world. However, extensive and controlled field tests have not been conducted for many of them, even some of the most common ones. Even though we know that these technologies work well in some situations, it is important to gather specific information on why they perform properly in one place and not in another.

Well-documented models of field activities provide important information for the development worker. It is obviously important for a development worker in Colombia to have the technical design for a machine built and used in Senegal. But it is even more important to have a full narrative about the machine that provides details on materials, labor, design changes, and so forth. This model can provide a useful frame of reference.

A reliable bank of such field information is now growing. It exists to help spread the word about these and other technologies, lessening the dependence of the developing world on expensive and finite energy resources.

A practical record keeping format can be found in Appendix V.

IV. PRE-CONSTRUCTION CONSIDERATIONS

While it is relatively inexpensive and easy to construct, the windmill does have several possible disadvantages which should be considered very carefully.

First, a provision must be made to disconnect the pump when it is not needed; otherwise, it could pump the well dry.

Second, a potential disadvantage, at least in some geographical areas, is that the mill has no braking system or feathering mechanisms to turn it out of the wind. In places such as the Philippines where the wind is most often very steady, the problem is not too great. But if heavy winds or storms are predicted, it will be necessary to remove the sails from the ribs so that the mechanism can turn freely in the wind.

Well before beginning construction, it is important to know how much water must be pumped and for what purposes. If more water than 41.8 liters (11 gallons) per minute is needed, a different windmill probably should be constructed. In addition, the purpose and the quantity needed affect the choice of the pump and the cost of the entire effort.

If digging a well is necessary, note that the type of well influences the type of windmill needed; the combination of well and windmill influences the choice of pump. And so on. All of these factors should be considered carefully before construction begins.

SITE SELECTION

As mentioned earlier, the windmill can be placed over the water source, or it can power a pump connected to a river by a pipe. The area surrounding the windmill should be free of all obstacles that might interefere with the wind. A cleared area should extend at least 30 meters (33 yards). If obstructions are impossible to avoid, the windmill tower can be made higher. For each 91.5cm (36") of additional height required, add 91.5cm (36") to the connecting rod and 99cm (39") to each leg. The foundation should be spaced 30.5cm (12") further apart for each 91.5cm (36") of additional height. No further adjustment is required.

If the windmill is to face a northeast-southwest direction, then the pump assembly must be set up so that the pump handle operates on a north<u>west</u>-south<u>east</u> axis, perpendicular to the wind direction. If possible, the pump should be chosen before construction begins. One good pump for use with this windmill is a self-priming, double-action piston pump. The pump handle is attached to the windmill by an eccentric cam rod. The concrete foundation is easier to construct after the windmill is completed.

MATCHING POWER TO WATER YIELD

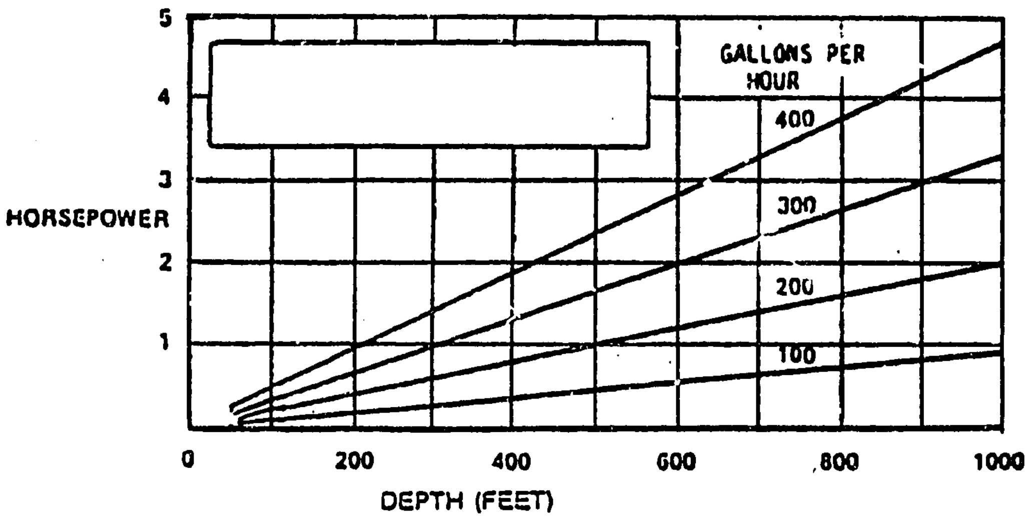
How can we measure the amount of power from the windmill required to pump water? On the next page is a standard table for calculating the water yield that matches the horsepower being produced by a windmill. If we know what the wind speed is (see page 10), the formulas already given allow us to calculate the horsepower required to pump a given amount of water per hour to a given height. All of this information combined will allow us to go back and calculate the size of the windmill required to pump the water under normal wind conditions.

An area has a 122-meter (400-foot) well yielding 105 liters (400 gallons) of water per hour that meets the livestock and domestic needs for a rural village. By using either of the charts of the table on the following page, we see that 105 liters (400 gallons) per hour at a 122 meter (400 foot) depth requires about 1.9 horsepower.

The horsepower a windmill produces at a given wind speed depends on the diameter of the rotor. You cannot change the

FLOW RATE		100	200	300	400
HEIGHT	50	.05	.10	.16	.24
	100	.09	.20	.33	.47
	200	.18	.40	.66	.94
	400	.36	.80	1.3	1.9
	600	.54	1.2	1.9	2.8
	800	.72	1.6	2.6	3.8
	1000	.90	2.0	3.3	4.7

HORSE POWER



From bottom of well to top of discharge point for the water (top of storage tank if present)

Table 1: Horsepower, Depth of Well, Flow Rate

wind pattern in your area; you can only calculate how much power you can expect to get using different size rotors.

You may find that you need very little horsepower in a low-lift application. You can use the formulas presented here to determine approximately how big your windmill should be or how many windmills of the size presented are needed.

WIND MEASUREMENT

The above calculations can be done reliably if you know what the wind speed is apt to be in your area. However, there are very little reliable data presently available concerning wind speed, except at airports, in any country.

Windspeed is measured with an anemometer. If you cannot afford to buy and maintain an anemometer, you can make one that will be reasonably accurate (see Figure 1). Some kind of lightweight (but solid) plastic cups are needed. If these cannot be found, the next best thing to use are cone-shaped cups, which you may have to make yourself. The counter on this anemometer could be a plastic bicycle odometer (mileage indicator). Production of a number of these low-cost anemometers would be a great help in a regional wind power development project.

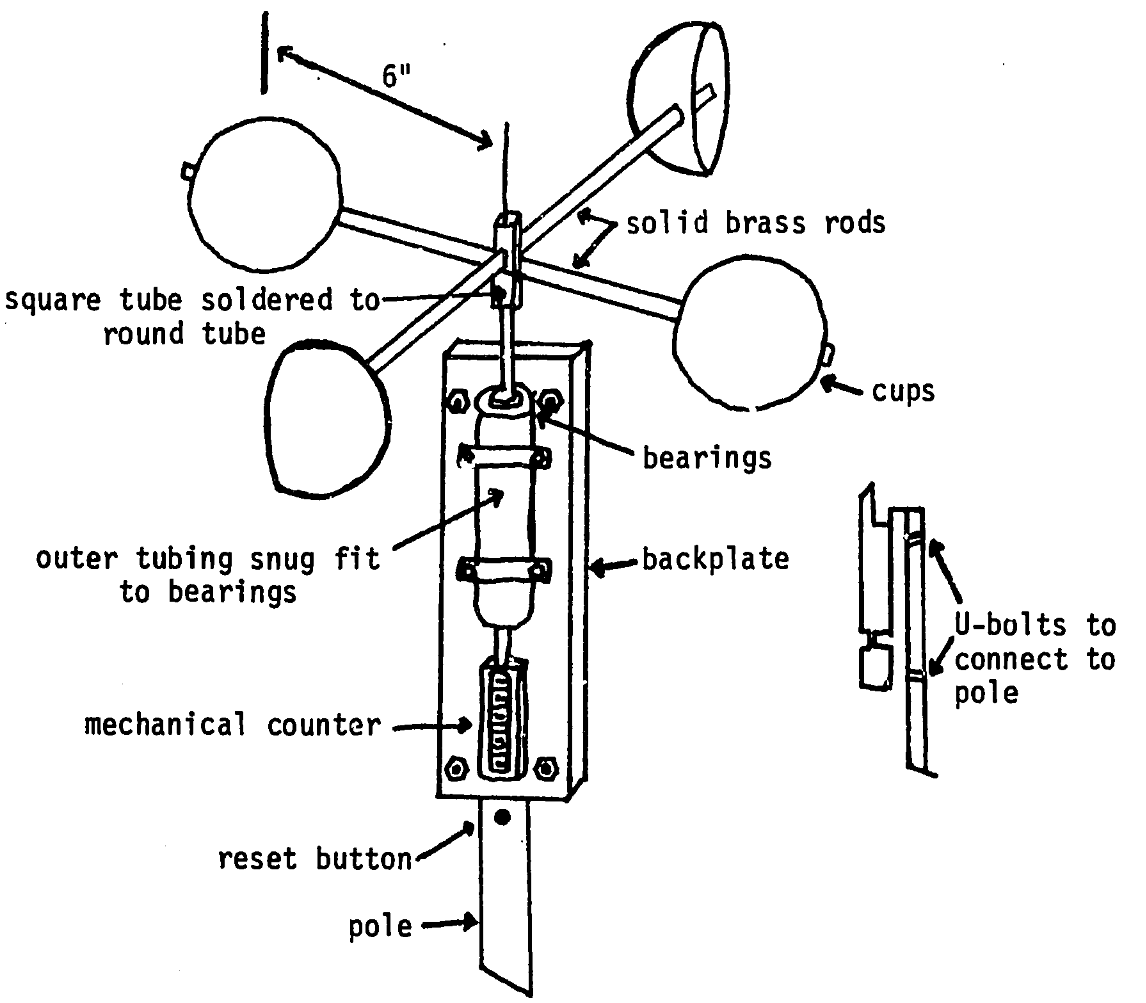


Figure 1: A Home-built Cup Anemometer for Measuring Average Wind Speeds

The rotational speed of the anemometer is proportional to wind speed. This means that the number appearing on the counter in any time period will be proportional to the average wind speed. The count can be recorded every day or every few hours. If there is a regular time of day when the wind always blows, you may want to measure this separately.

The only difficulty is to match the numbers on the counter with a known measure of wind speed. The easiest way would be to run it next to a borrowed commercial anemometer, and simply compare the results. Since you probably can't borrow a commercial anemometer, you can instead attach your home-built anemometer to a pole tied to a car or truck. The pole should be long enough for the anemometer to reach the height intended for the windmill rotor.

At a time when there is no wind, make several test drives at a steady speed. This will give you a good estimate of the proper relationship between the numbers on the counter and the wind speed. For example, you drive a steady 15 miles per hour for five minutes. The counter reads 1240. Multiply this by 60/5 to get the expected count for one hour at 15 mph (1240 X 60/5 = 14880). Therefore, one hour of 15 mph wind would produce something close to 14880 on the counter. If you are using a car's odometer with 1/10 mile as the smallest unit (when used with a bicycle) it will require about 80 revolutions to add one unit. Thus you might get only 15 units on the counter after driving five minutes at 15 mph. In this case, 180 units on the counter would represent one hour of 15 mph wind.

MATERIALS

<u>For Cement Footings</u>--grade "B" concrete 1:2-1/2:5

- 2 bags cement (approximately 90 lbs each)
- 1/4 cubic meter (8.8 cubic feet) sand
- 1/2 cubic meter (17.7 cubic feet) gravel
- 4 pieces 6.5mm X 5cm X 60cm (1/4" X 2" X 24") post straps

Wood--grade 3 lumber except where specified

- 4 pieces, 7.5cm X 10cm X 488cm (3" X 4" X 16') (for posts)
- 2 pieces, 2.5cm X 10cm X 427cm (1" X 4" X 14') (for braces)
- 6 pieces, 2.5cm X 10cm X 366cm (1" X 4" X 12') (for braces --2 pieces optional)
- 1 piece, 5cm X 5cm X 488cm (2" X 2" X 16'), grade 2 or better (for connecting rod)
- 4 pieces, .5cm X 10cm X 60cm (2" X 4" X 24") (to cover holes of footings

Bolts--complete with nut and washer unless otherwise specified*

- 20 cap screws, 9.5mm X 2.5cm (3/8" X 1") with lock washers and double nuts (spokes)
- 16 carriage bolts, 9.5mm X 10cm (3/8" X 4") (Frame A)
- 20 carriage bolts, 9..5mm X 12.5cm (3/8" X 5") (Frame B)
- 8 carriage bolts, 9.5mm X 5cm (3/8" X 2") (Frame C)
- 8 machine bolts, 1.25cm X 25.4cm (1/2" X 10") plus 8 extra washers (Frame D)
- 6 machine bolts, 9.5mm X 7.5cm (3/8" X 3") (locking bolts) (Frame E)
- 8 carriage bolts, 9.5mm X 12cm (3/8" X 4") (footings) (Frame F)

NOTE: If optional bar brace is used, add four more 9.5mm (3/8") diameter X 10cm (4") carriage bolts and four more 9.5mm (3/8") diameter X 12.5cm (5") carriage bolts or use nails to secure each brace.

Hardware

- 2 2.5cm (1") self-aligning ball bearings with revolvable case.

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*In many parts of the world, nuts and bolts may be available only in English measurements.

- 2 bearing bolts, 10cm (4") long
- 1 2.5cm (1") cold-rolled steel rod, 244cm (96") long (axle)
- 1 1.25cm X 305cm (1/2" X 10') ordinary round bar (angle braces)
- 3 6.5mm X 508cm (1/4" X 20') ordinary round bar (ribs)
- 1 kg (2.2 lbs) #16 wire
- 5 3mm X 2.5cm X 2.5cm X 61cm (1/8" X 1" X 1" X 24") angle iron
- 5 3mm X 2.5cm X 2.5cm X 305cm (1/8" X 1" X 1" X 10') angle iron
- 10 "U" bolts (or jeep spring clips) 3.8cm (1-1/2") inside diameter
- 1 9.5mm X 5cm X 90.5cm (3/8" X 2" X 36") flat bar

Miscellaneous

- 1 91.5mm X 11.5m (36" X 38') heavy weight canvas or tent cloth
- 88 #1 or #2 canvas grommets (eyelets)
- 1 6.5mm X 28.5m (1/4" X 93.5') hemp rope or jute
- coal tar (creosote), approximately 7.6 liters (2 gallons)
- rustproof paint, approximately 1 liter (1 quart)
- canvas protector or ordinary paint, 1.5 liter (1-2 quarts)

For Connecting Rod

- 1 machine bolt, 1.6cm (5/8") diameter X 7.5cm (3") with 3 nuts and 1 lock washer
- 1 ball bearing assembly, Honda part #6003 (see text for substitution)
- 1 2.5cm (1") inside diameter pipe, 10cm long
- 6 9.5mm X 7.5cm (3/8" X 3") machine bolts with nut (coarse thread)

Pump

- self-priming double-action piston pump
- materials for plumbing and reservoir, as required

TOOLS

- Hand drill
- Wood and metal bits
- Wrenches
- Pliers
- Punch (for eyelets)
- Hammer
- Level
- Saw

V. CONSTRUCTION

The windmill is constructed in several sections--the tower, the axle, and the sails. These parts are assembled in place and concrete footings are then poured. The construction is not difficult, but must be done carefully. Read all the instructions before beginning to build the windmill.

THE TOWER

Build the Frame

- Cut 30.5cm (12") off the end of each of the four 7.5cm X 10cm X 488cm (3" X 4" X 16') wooden posts. Save for later use.

- Place two of the posts (which are now 7.5cm X 10cm X 457.5cm [3" X 4" X 15']) on the ground so that they are 305cm (10') apart at the bottom and touching at the top. Where they touch, plane off a few inches so that the two pieces meet evenly over an area of from 7.5cm to 10cm (3" to 4"). Secure temporarily to prevent movement.

- Repeat this same procedure with the other two posts.

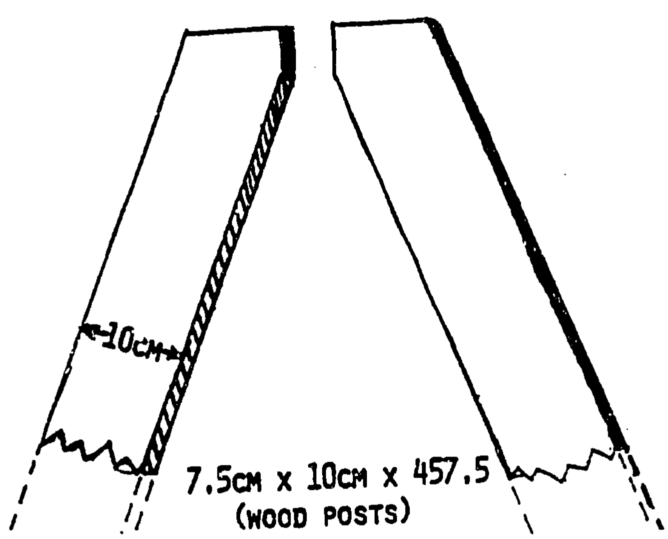

Figure 2. Frame posts

- Plane off corners so that the bottom of the frame will be flat against the ground.

- Cut the two pieces of 2.5cm X 10cm X 427cm (1" X 4" X 14') wood in halves. These pieces will be used as braces.

- Attach the braces to the A-frame sections as shown in Figure 3. Braces should be between 160cm and 180cm (63" and 71") from the top of the frame. <u>Bolt permanently</u> the two braces attached to the A-frame section that will be <u>opposite</u> the connecting rod. Nail braces on the other A-frame section until it is clear that the connecting rod will not strike it when in operation. Be sure the legs of the frame remain 305cm (10') apart.

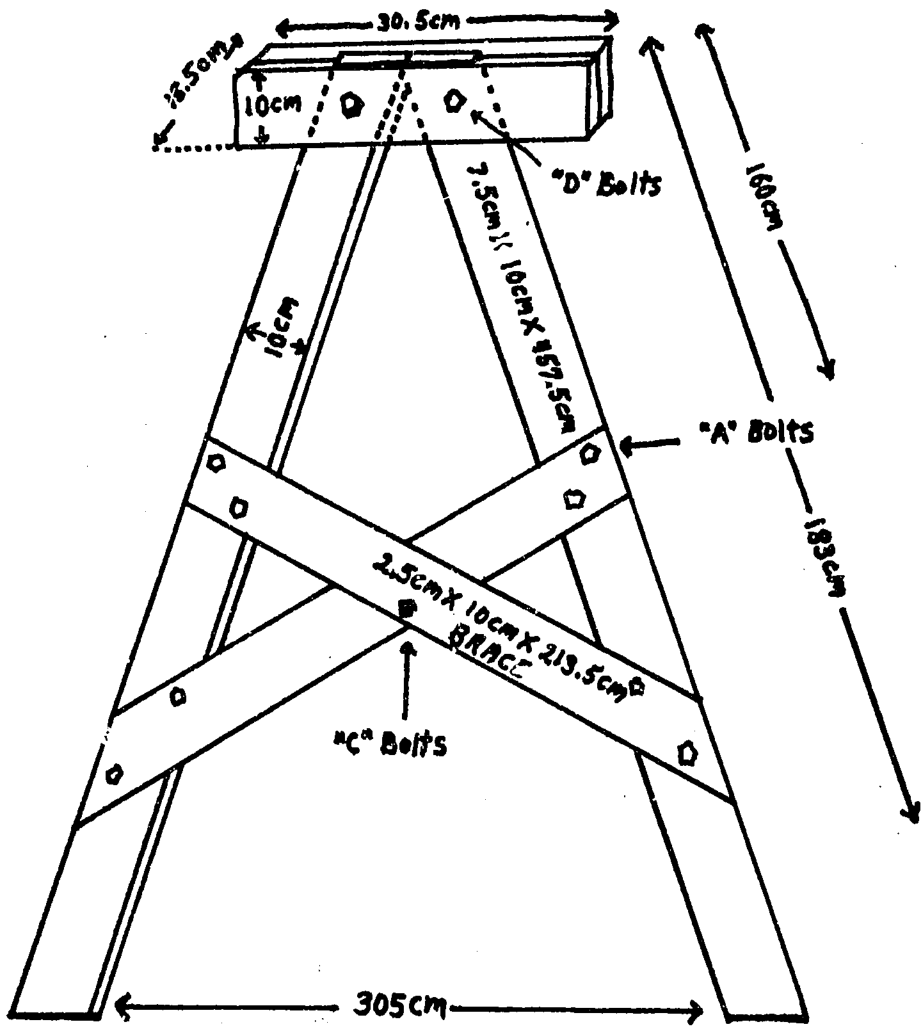

Figure 3. Frame assembly

- Take the 30.5cm (12") pieces saved from the 488cm-long posts. Cut recesses in each one to fit the top of the A-frame (see (Figure 4). These are the wood bearing blocks. Each block consists of two cut-out pieces, placed recess to recess at the top of the A-frame.

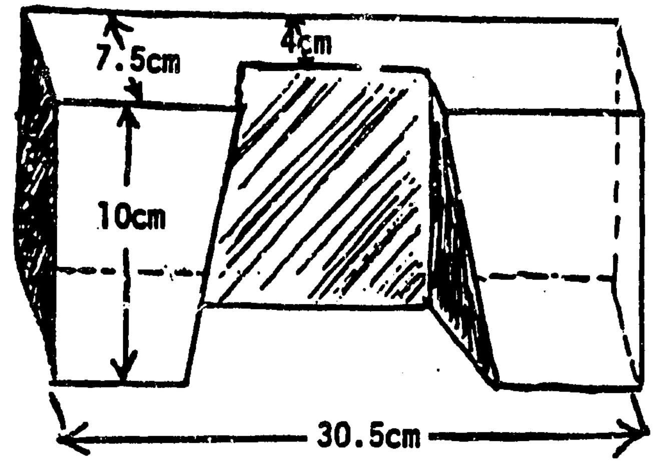

Figure 4. Wood bearing block

- Drill holes through both sections of block and the A-frame. Secure the wooden bearing blocks to the A-frames with two 1.25cm X 25.4cm (1/2" X 10") machine bolts (D), two nuts and four washers. Two bolts will suffice (see Figure 5). The bearing will be attached to the inside wooden bearing block after the frame is erected.

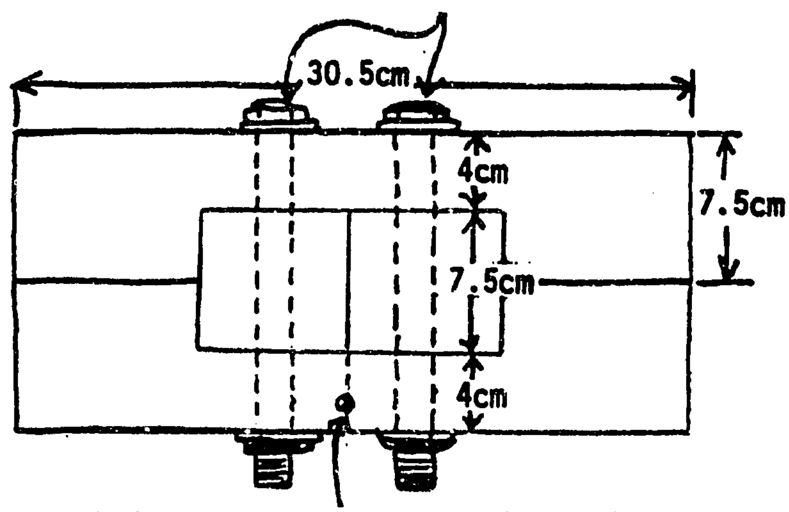

Figure 5. Bearing block assembly--top view

- Mark the <u>middle</u> of the inside wooden bearing block when the blocks are in place. Measure the length and then the width of the block to find the exact middle of both measurements. This mark will be used to position the bearings.

- Repeat entire procedure for the other A-frame.

Erect The Frame

- Nail all four 2.5cm X 10cm X 366cm (1" X 4" X 12') pieces to one A-frame as shown in Figure 6.

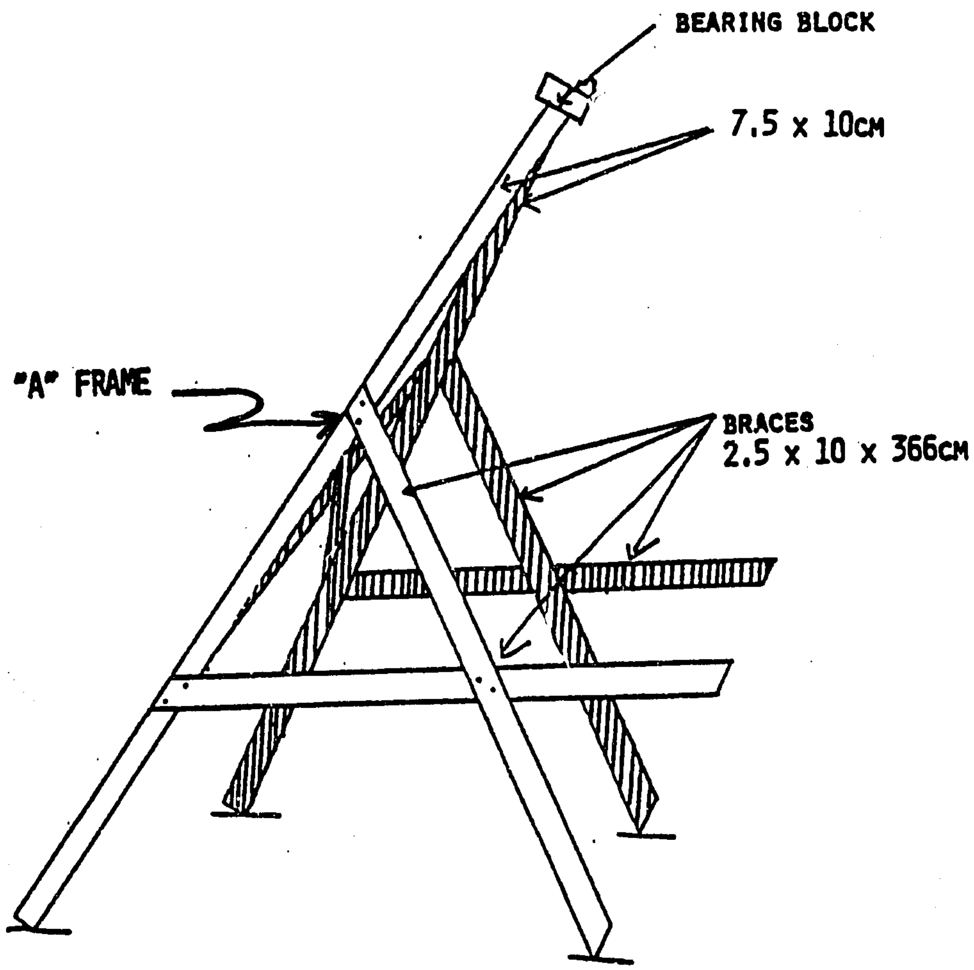

Figure 6. The frame

Do not nail a brace any closer to the top than 160cm (63"), nor any further from the top than 183cm (72").

- Bring the other A-frame up to meet the side braces. Check that the distance between all legs is 305cm (10') and the distance between the tops of the A-frames is 203cm (80"), as measured between the marks made earlier on the exact middle of the inside wooden bearing block.

- Secure the braces which connect the two A-frames with (B) carriage bolts (see Figure 7).

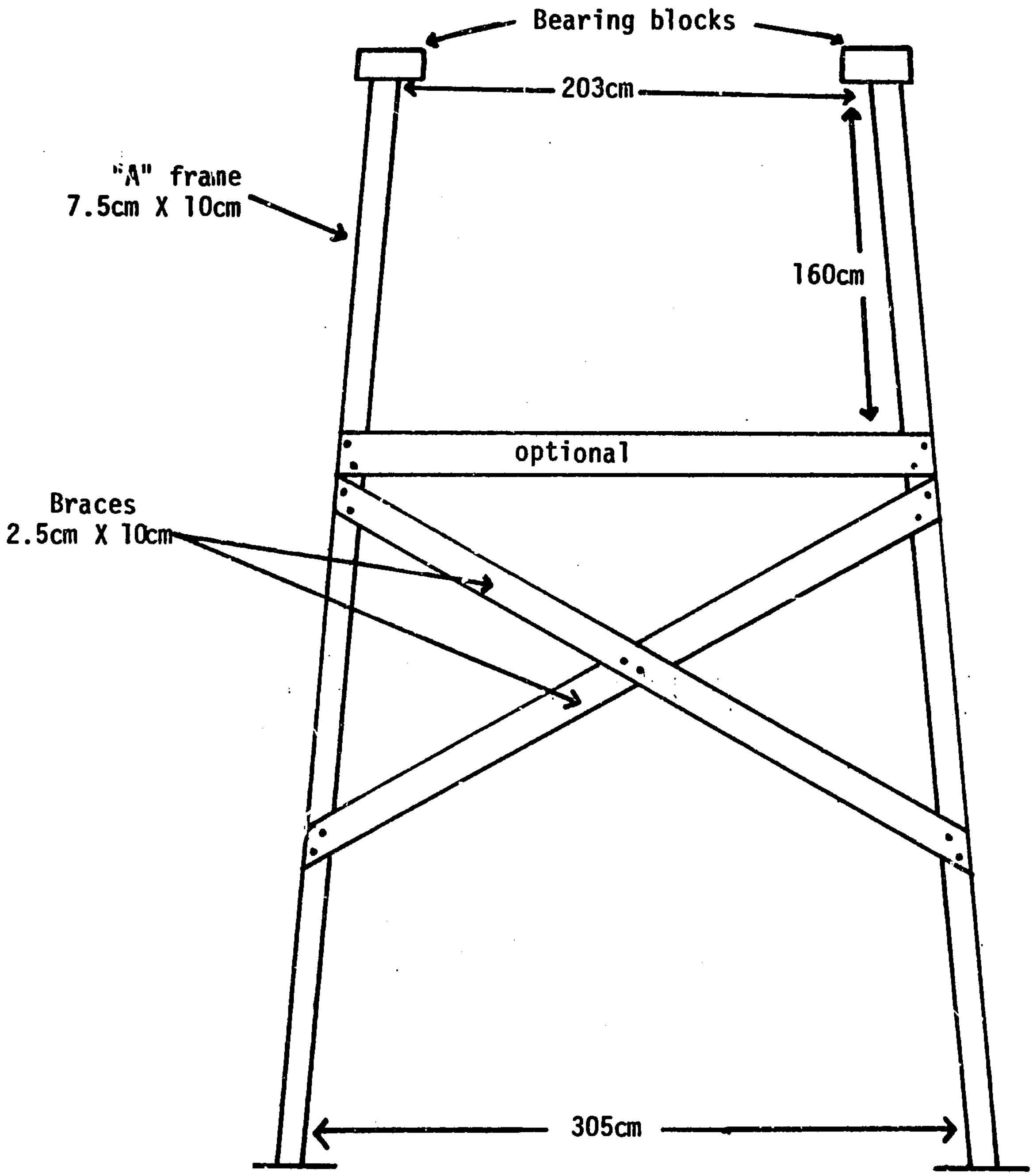

Figure 7. Support braces

- Join center crossing with (C) carriage bolts.

- Add stability (optional) by placing 2.5cm X 10cm (1" X 4") boards around the entire structure. Keep these braces 160cm below the top of the A-frame (see Figure 7 on previous page).

- Put the erected frame in place. With the self-aligning bearings, chalk, string, and level in hand, climb to the top of the A-frame.

- Find the center of each wooden bearing mount on the top of each of the A-frames.

- Attach the string so that it passes between the two points and secure it slightly beyond. This is the alignment for the bearing (see Figure 8).

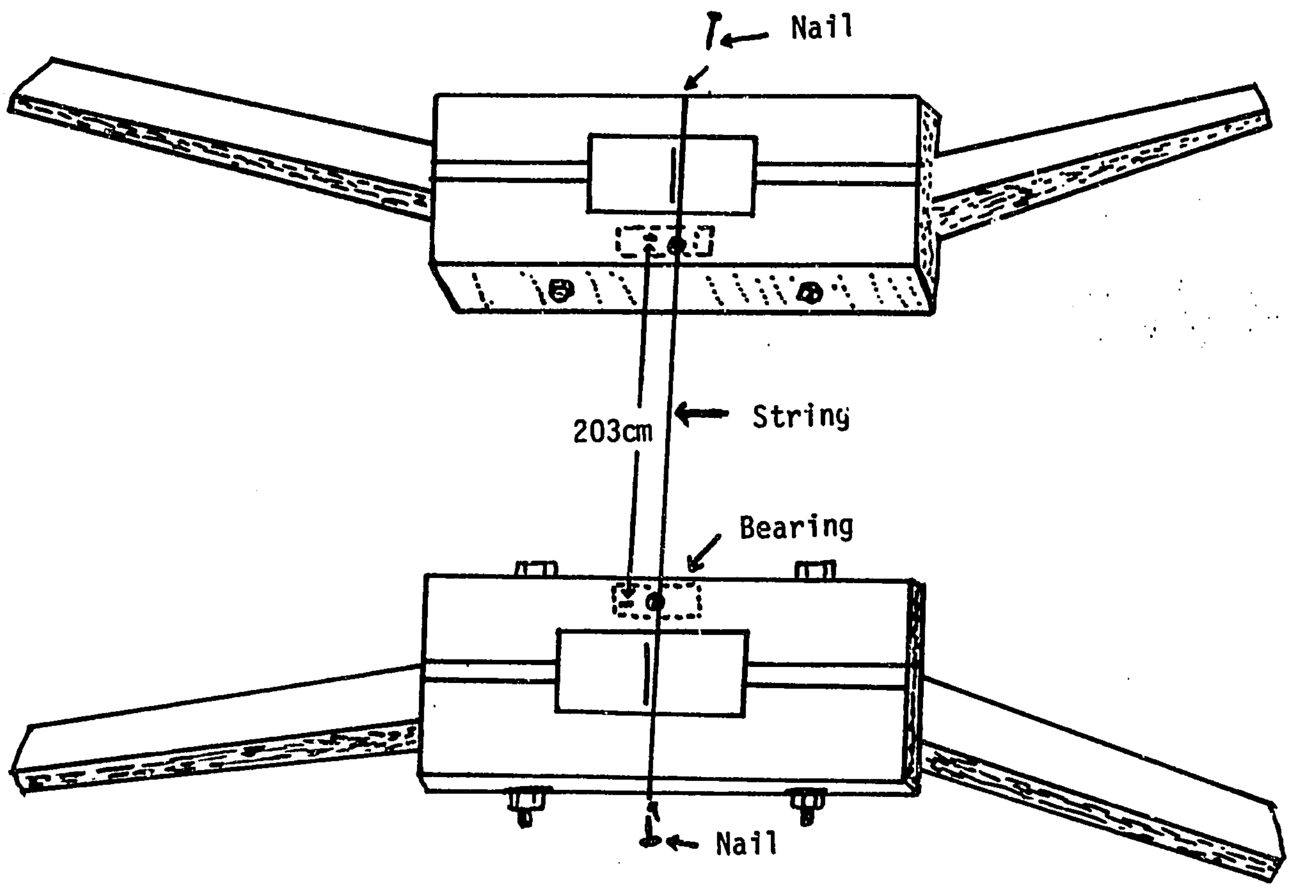

Figure 8. Bearing alignment

- Use the level to ensure that the bearing sits square. Shims can be placed beneath each bearing if needed to level the bearing.

- Drill the two 1.25cm (1/2") holes with the bearing centered on the wooden block and aligned with the string.

- Make sure the bearings are facing inward while drilling.

THE AXLE

Construct the Axle

Important: Follow directions and measurements carefully; this is a critical piece.

- Cut the 1.25cm (1/2") round bar into 61cm (24") lengths.

- Cut five 61cm (24") lengths of 2.5cm (1") angle iron. Cut the rest of the angle iron into 305cm (10') lengths. There are now five pieces of 1.25cm X 61cm (1/2" X 24") round bar, five pieces of 2.5cm X 61cm (1" X 24") angle iron, and five pieces of 2.5cm X 305cm (1" X 10') angle iron.

- Measure and mark 35cm (14") from both ends on the 2.5cm (1") diameter steel axle rod. Then mark off the remaining center portion into 43.5cm (17") lengths. This will give welding points (as shown in Figure 9).

- Use electric arc welding equipment. Make all welds strong.

- Take the first 61cm (24") angle iron length and weld it (centered) to the spot on the 2.5cm (1") steel axle rod.

- Keep the open side of the V toward the axle.

- Repeat at spot five placing the angle iron parallel to number one but on the reverse side of the axle.

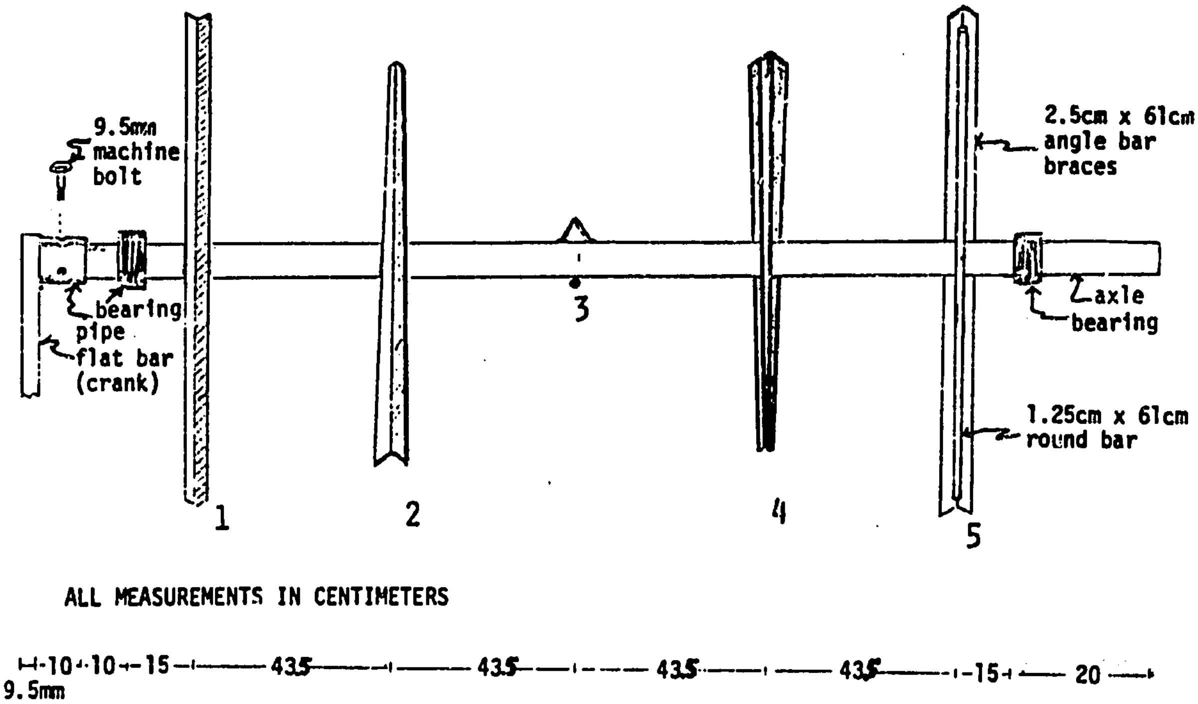

Figure 9. Welding points on axle

- Weld the #3 angle iron (center spot) perpendicular to #1 and #5. Weld the #2 angle iron 45° from the first (but still at right angles to the axle), arranged so the angle iron seems to "walk" around the axle from spot #1 to spot #3. Weld the #4 iron 45° off of #5, but 90° off of #2, not parallel to it, so the irons continue their "walk" (see Figure 10).

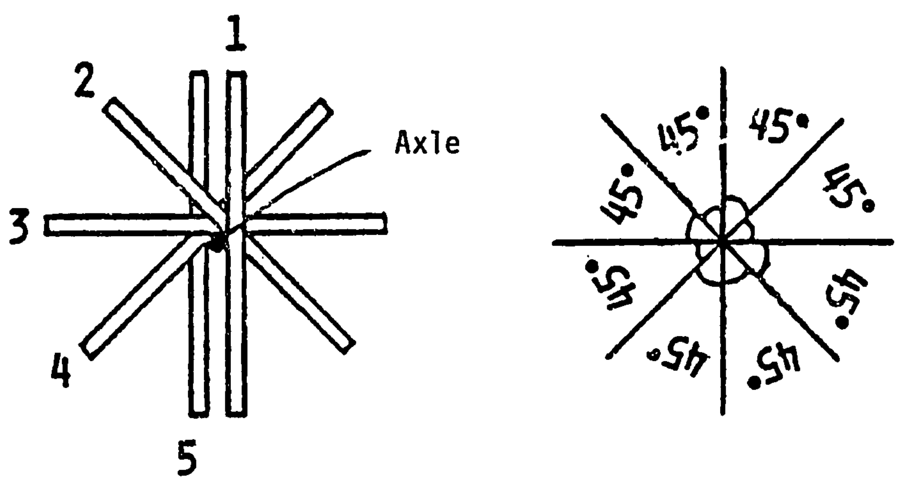

Figure 10. Axle--end view

. Bend the 1.25cm (1/2") diameter bars to fit as shown in Figure 11, then weld the center and two ends. (If you plan to construct a number of windmills, it might be easier to construct a wooden rig to get this spacing. Plans for this rig are given in Appendix III.)

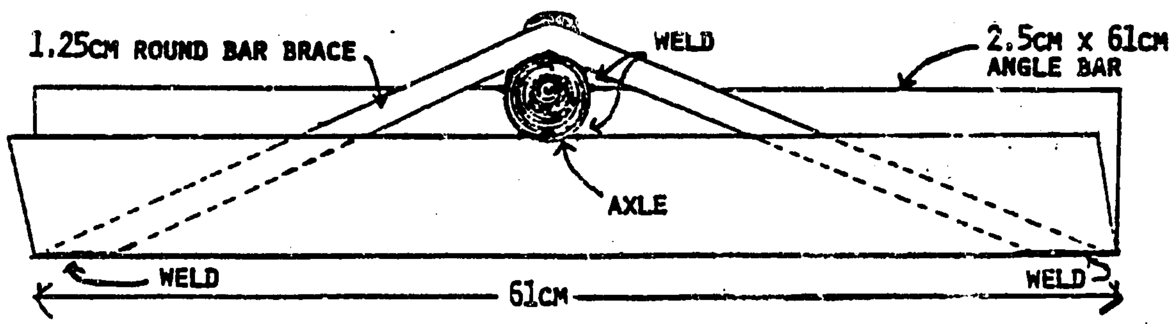

Figure 11. Axle with bar brace

Construct the Spokes

. Weld four 9.5mm X 2.5cm (3/8" X 1") diameter cap screws to each 305cm (10') angle irons. Tightly weld one cap screw on the inside of the V at each end and one 91.5cm (37") from each end (see Figure 12).

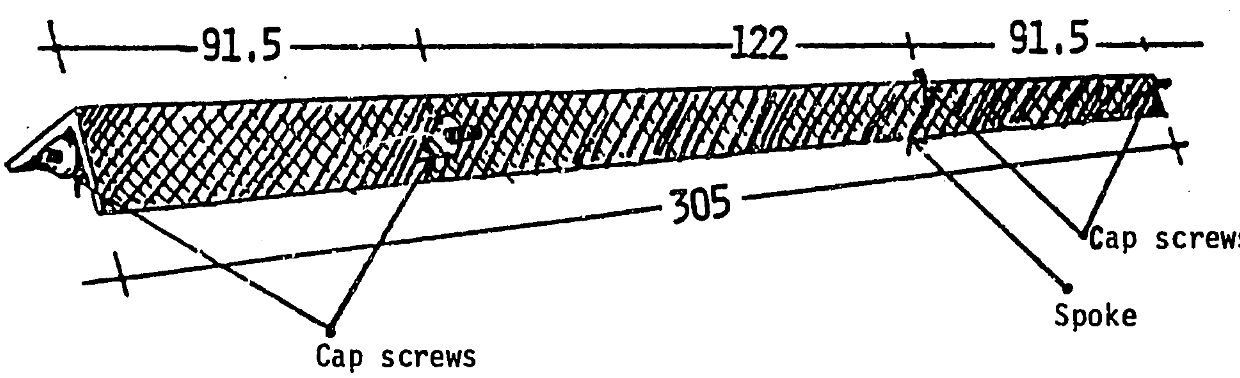

Figure 12. Cap screw locations

. Using two "U" bolts, attach the spoke (the long angle iron) to each angle iron already welded to the axle (see Figure 13).

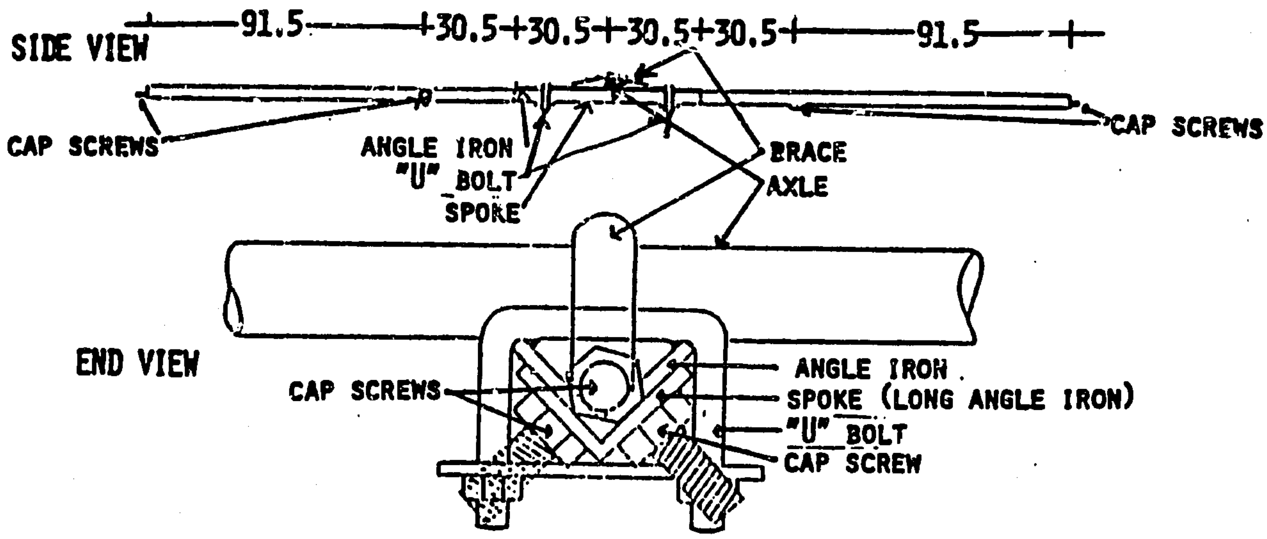

Figure 13. Spoke attachment to axle

Construct the Ribs

- Take the 6.5mm (1/4") round bar and cut it to the proper lengths for ribs. The outer ribs will span the outside circumference of the spokes. The inner ribs will span the inner circumference of the spokes. The sails will be attached to these ribs.

- Make eight long ribs and eight short ribs (as in Figure 14).

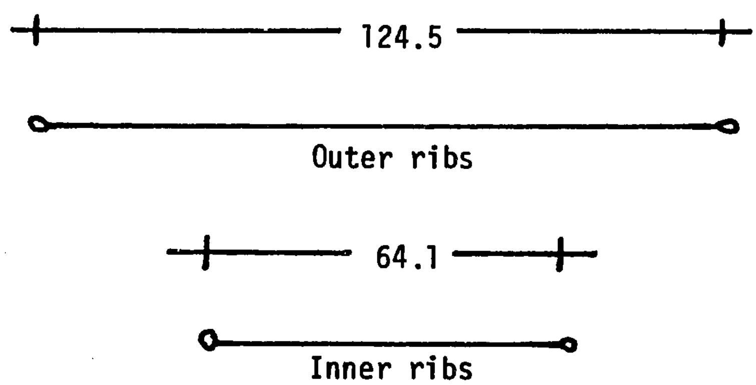

Figure 14. Ribs for sails

- Bend the ends of each rib into loops. The loops should be small enough to attach to the cap screws, using a lock washer.

THE SAILS

Making the Canvas Sails

- Preshrink the canvas and rope before cutting. Do this by soaking overnight in water and then drying in the sun.

- Cut the canvas as shown in the sail cutting pattern below (Figure 15).

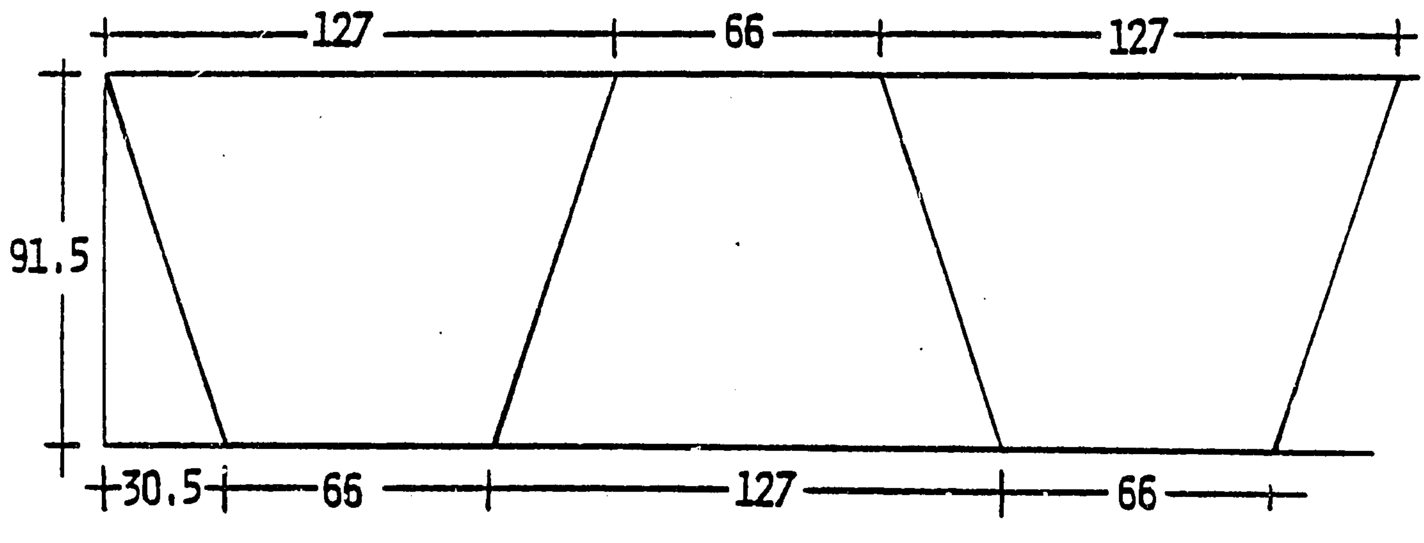

Figure 15. Sail cutting pattern

- Use excess canvas to reinforce the seams.

Sew the rope into the seams to make them stronger, and place the grommets (eyelets) as shown in Figure 16.

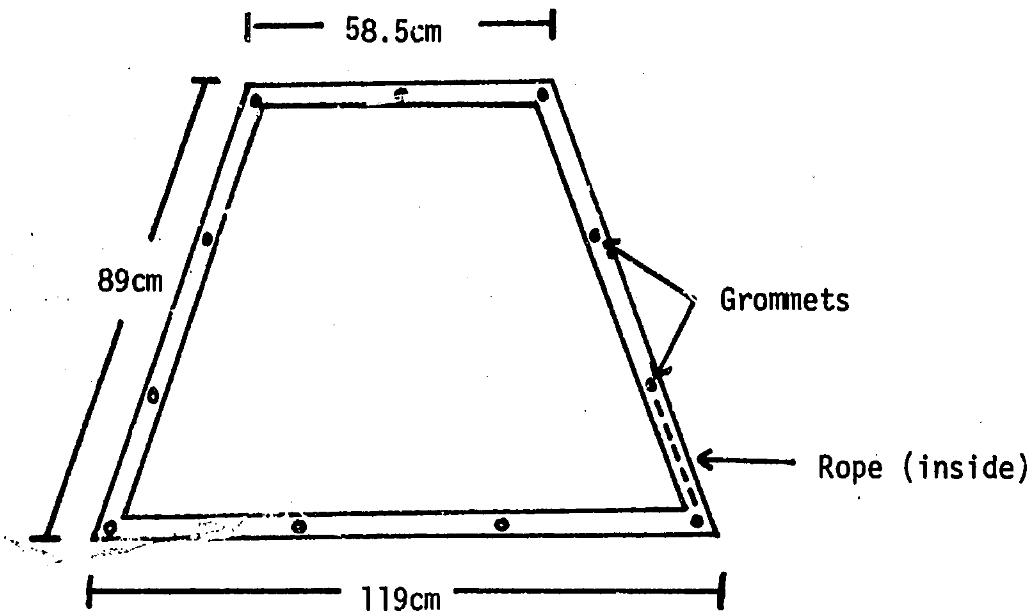

Figure 16. Placement of grommets

- Cover both sides of the canvas with a canvas protector or paint for longer life of the sails.

- Attach the sails to the spokes and ribs by wrapping several turns of wire through the grommet and around the metal ribs. Fasten the wire securely.

Guy Wires

- Place the 16 gauge guy wire across the face of the canvas to support it and act as a wind brace as shown in Figure 17.

All dimensions in centimeters

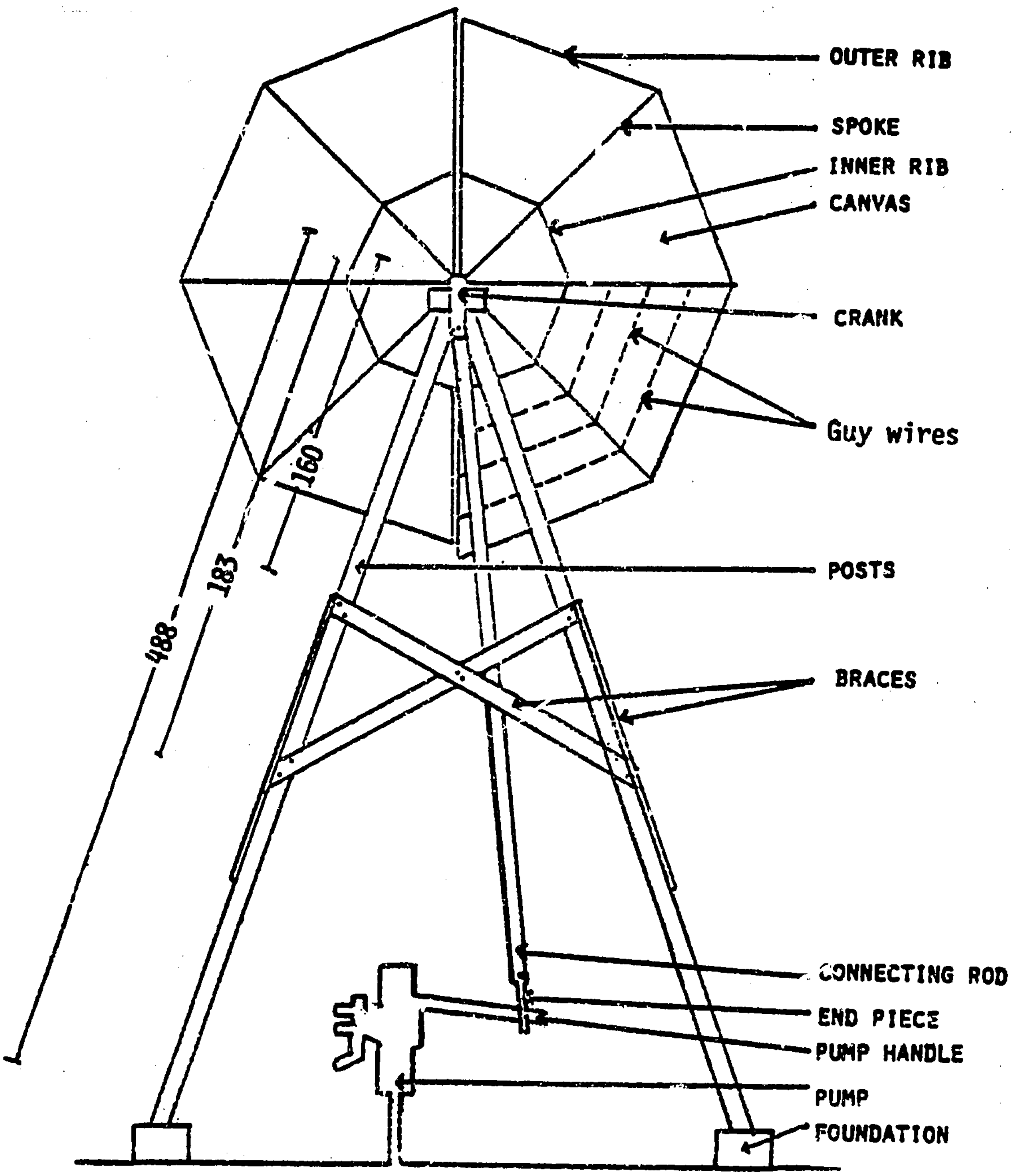

Figure 17. Guy wire placement

Tension Wires

- Place the 18 gauge tension wires at the ends of the #1 and #5 spokes (both ends). Run the wire to the #3 spoke, and to the axle (see Figure 18). This is the last step before completion of the windmill axle unit.

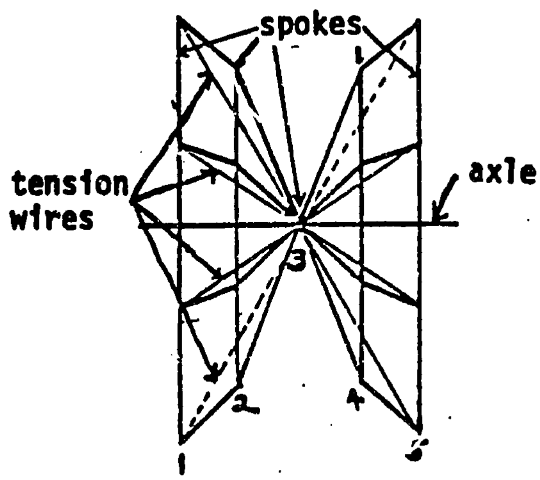

Figure 18. Tension wire arrangement

Construct the Connecting Rod Assembly

- Cut 9.5mm X 5cm X 90.5cm (3/8" X 2" X 36") flat bar into three pieces of 20cm (8") each and one piece of 30.5cm (12").

- Drill holes in the bars as shown in Figure 19.

- Weld the ball bearing assembly very carefully around the 1.6cm (5/8") hole in bar "A." Make sure the inside diameter will accommodate the 1.6cm (5/8") machine bolt that goes through it. This bearing assembly may be a replacement part from a Honda motorcycle. However, if such a bearing is not available, substitute it by using two additional layers of flat bar with a 1.6cm (5/8") hole drilled through it. This will act only as a bushing and may not last as long as a bearing assembly.

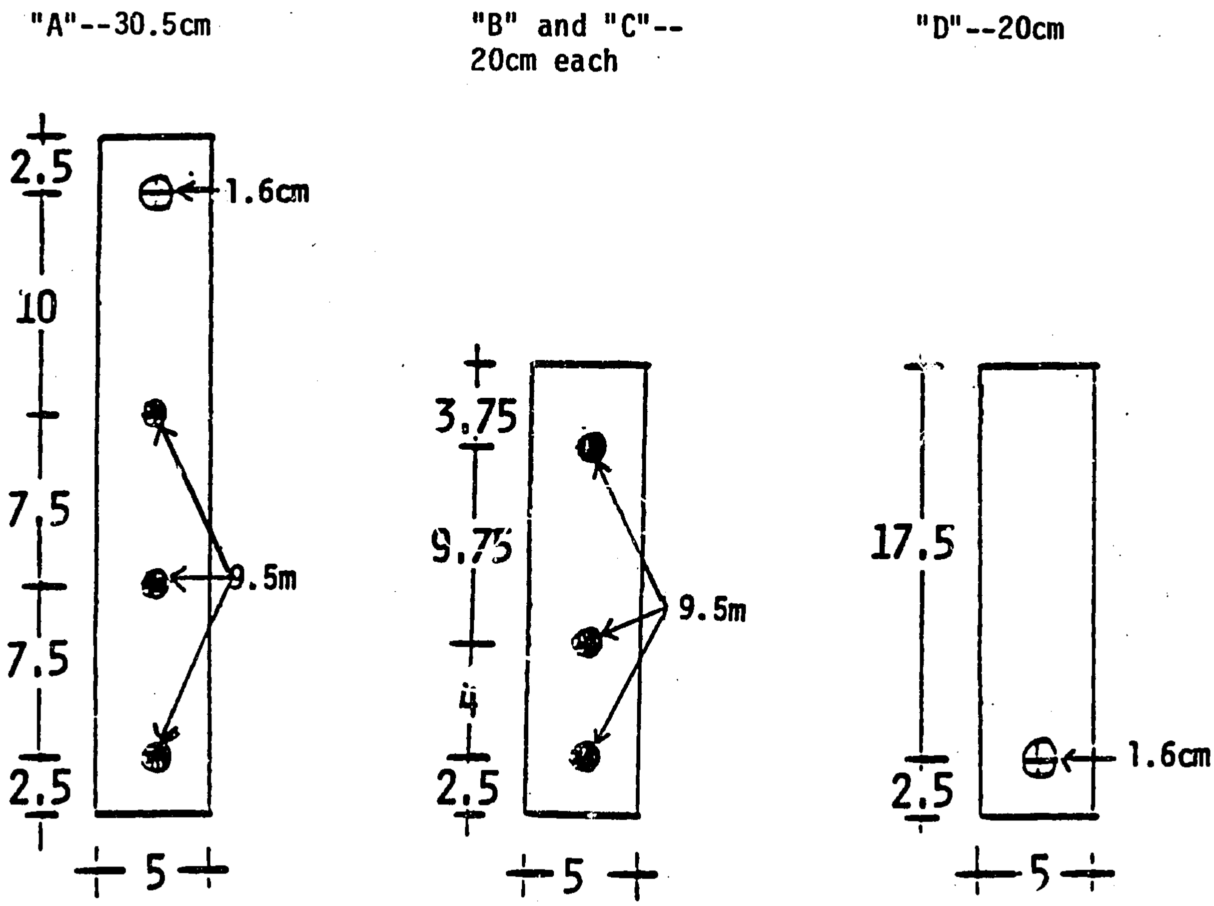

Figure 19. Placement of holes

- Weld a 10cm (4") piece of 2.5cm (1") inside diameter pipe onto the opposite end of the 1.6cm (5/8") hole which has been drilled in bar "D" (see Figure 20).

- Drill three equally-spaced 9.5mm (3/8") holes in the pipe to hold the locking bolts. The locking bolts (E) can be any replacement part available, though they should not be too long. Another way to

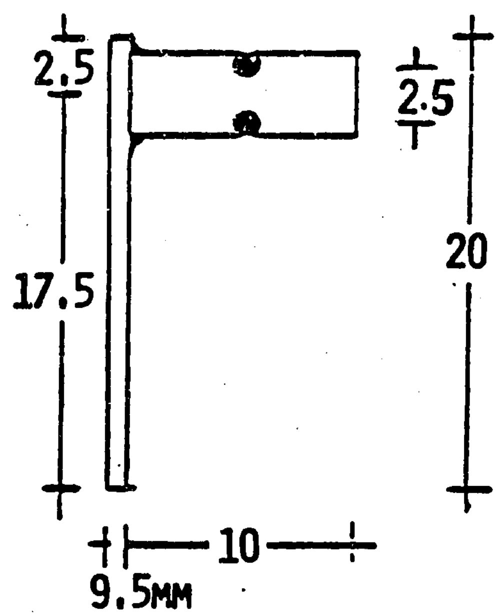

Figure 20. Weld pipe to bar

secure the axle to the pipe is to drill a 6.5mm (1/4") hole directly through the axle and place a nail or cotter pin through it. However, this is not as strong and will not last.

- Use the 5cm X 5cm X 488cm (2" X 2" X 16') wood for the rods. This piece of lumber must be at least grade 2 quality. Since it is impossible to determine the exact location from the hole to the pump without first mounting the windmill and pump together, do not cut any excess off until you are sure of the exact distance. This distance is measured from the bottom stroke of the axle to the "down" position of the pump handle.

- Begin assembling the connecting rod by bolting the 'D' bar to the 'A' bar using the 1.6cm (5/3") machine bolt. The lock nuts lock the bolt to the flat bar 'D' while the bearing assures smooth operation and therefore should not be tight. Keep this critical point well greased, as well as the bolt through the pump handle, and check periodically for wear.

- Bolt bar 'A' to the wooden rod using three of the 9.5mm X 7.5cm (3/8" X 3") machine bolts.

- Drill three 9.5mm (3/8") holes in the pump handle itself (see Figure 21). Using holes closer to the pump will give more water per stroke but fewer strokes; holes further away will give less water per stroke but more strokes.

- Use the remaining three 9.5mm X 7.5cm (3/8" X 3") machine bolts to attach flat bars 'B' and 'C' to the bottom of the assembly rod and attach the pump handle to the flat bars. This must be done after the windmill axle unit is installed on the frame and the distance is exact.

ASSEMBLY

- Nail a board near the top of the windmill frame from one A-frame to the other to raise the windmill. Throw a rope

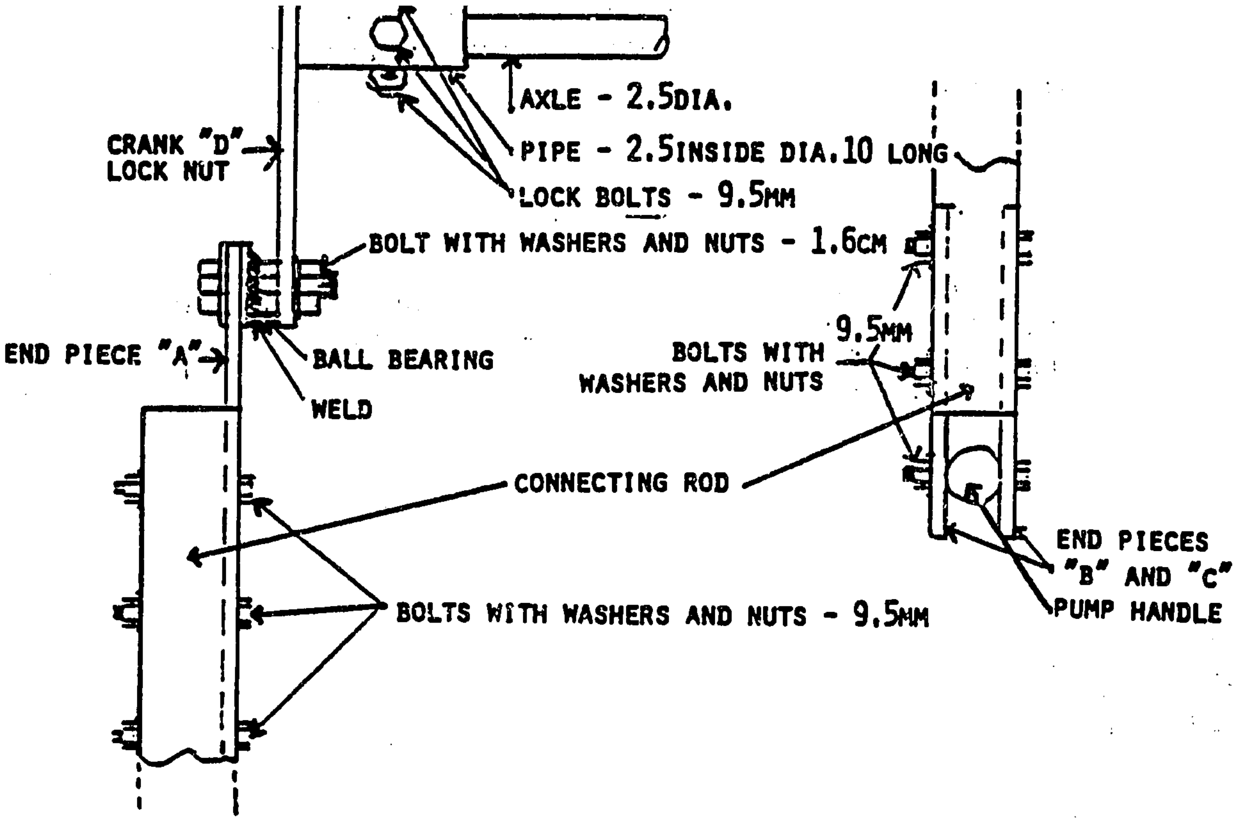

Figure 21. Connecting rod assembly

over it and attach it to the axle unit. Hoist it up very carefully.

- Place the bearings on the windmill axle. Bolt the bearings in the holes drilled when the wooden bearing blocks were assembled. Use two 9.5mm X 12cm (3/8" X 5") carriage bolts for each wooden block. Make sure the washers and lock nuts face inward.

- Attach the connecting rod assembly to the axle.

- Bolt the braces with the remaining 'A' carriage bolts. There should be no obstruction between the braces and the connecting rod.

- Paint all the metal parts with lead paint and all wooden parts with coal tar. Operate in a 6-9 kph (4-6mph) breeze.

The windmill is very efficient. Be certain to have an overflow pipe returning extra water to the well if a reservoir is used --or the windmill may pump the well dry.

THE FOOTINGS

Once the windmill is assembled the footings can be poured to anchor the windmill to the site (as shown in Figure 22). Be sure to align the frame with the water pump.

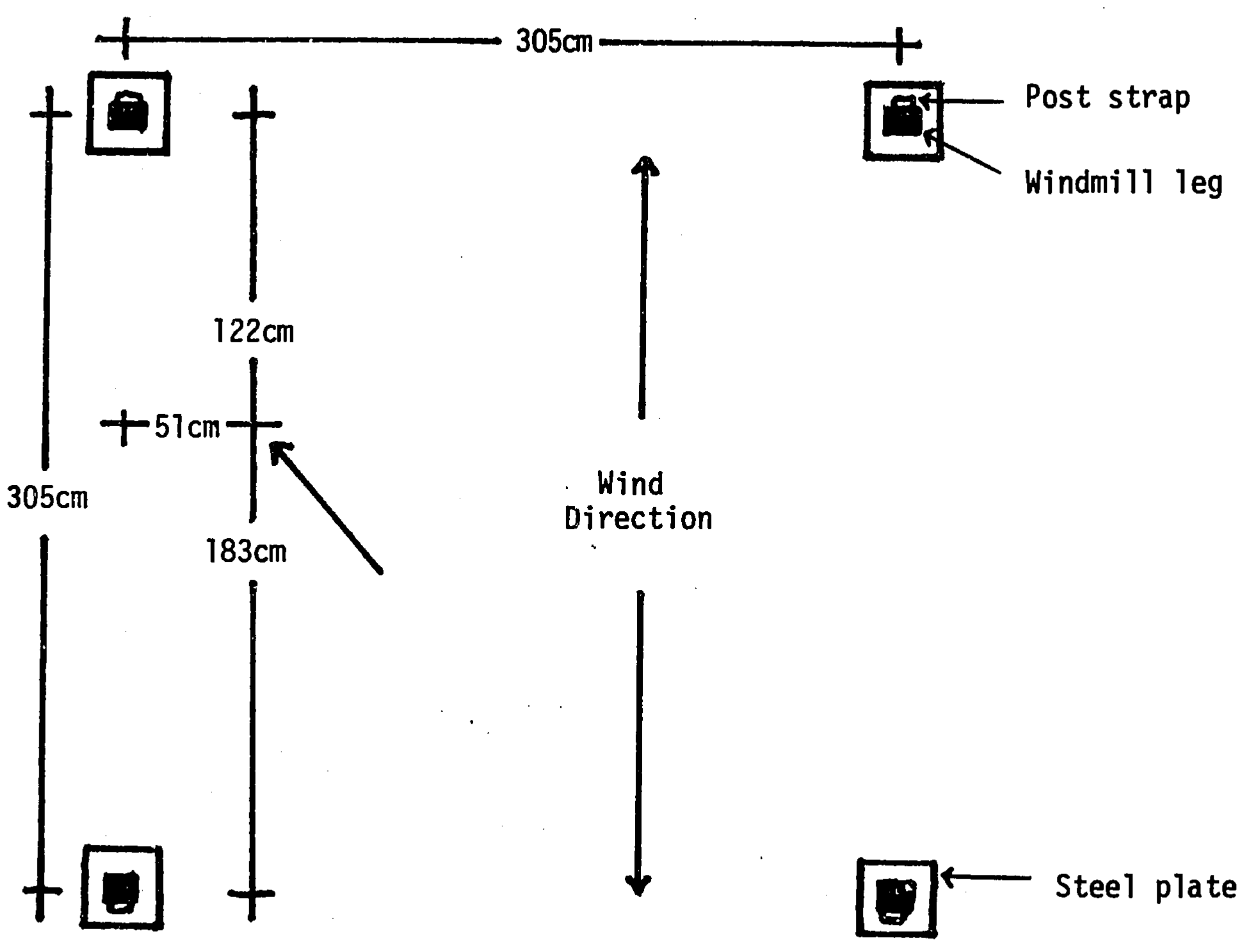

Figure 22. Foundation plan

- Hammer a wooden stake into the soil to mark the position of each leg of the frame.

- Move the frame enough so that the holes for the concrete footings can be dug.

- Dig four holes 40cm (16") square, 60cm (24") deep.

- Place 5cm X 10cm X 60cm (2" X 4" X 24") boards over the holes; move and center the frame on the boards over the holes.

- Make sure that the frame is level at all four corners. You may have to place rocks under the boards to make it level.

- Mix the concrete in a ratio of one part cement to 2.5 parts sand to 5 parts gravel. Add enough water to mix ingredients into a thick mud-like consistency. Mix thoroughly.

- Pour concrete into the holes up to the bottom of each 5cm X 10cm X 60cm (2" X 4" X 24") board.

- Insert one 6.5mm X 5cm X 60cm (1/4" X 2" X 24") steel plate 30cm (12") in each hole. Move the steel plate so that it matches the angle of each leg (see Figure 23).

- Allow the cement to dry for two to three days. Tilt the frame and remove the 5cm X 10cm X 60cm (2" X 4" X 24") boards.

- Reposition the frame and drill two 9.5mm (3/8") holes through the metal plate and leg of the windmill.

- Attach each leg to a metal plate using 9.5mm (3/8") diameter, 12.5cm (5") long carriage bolts.

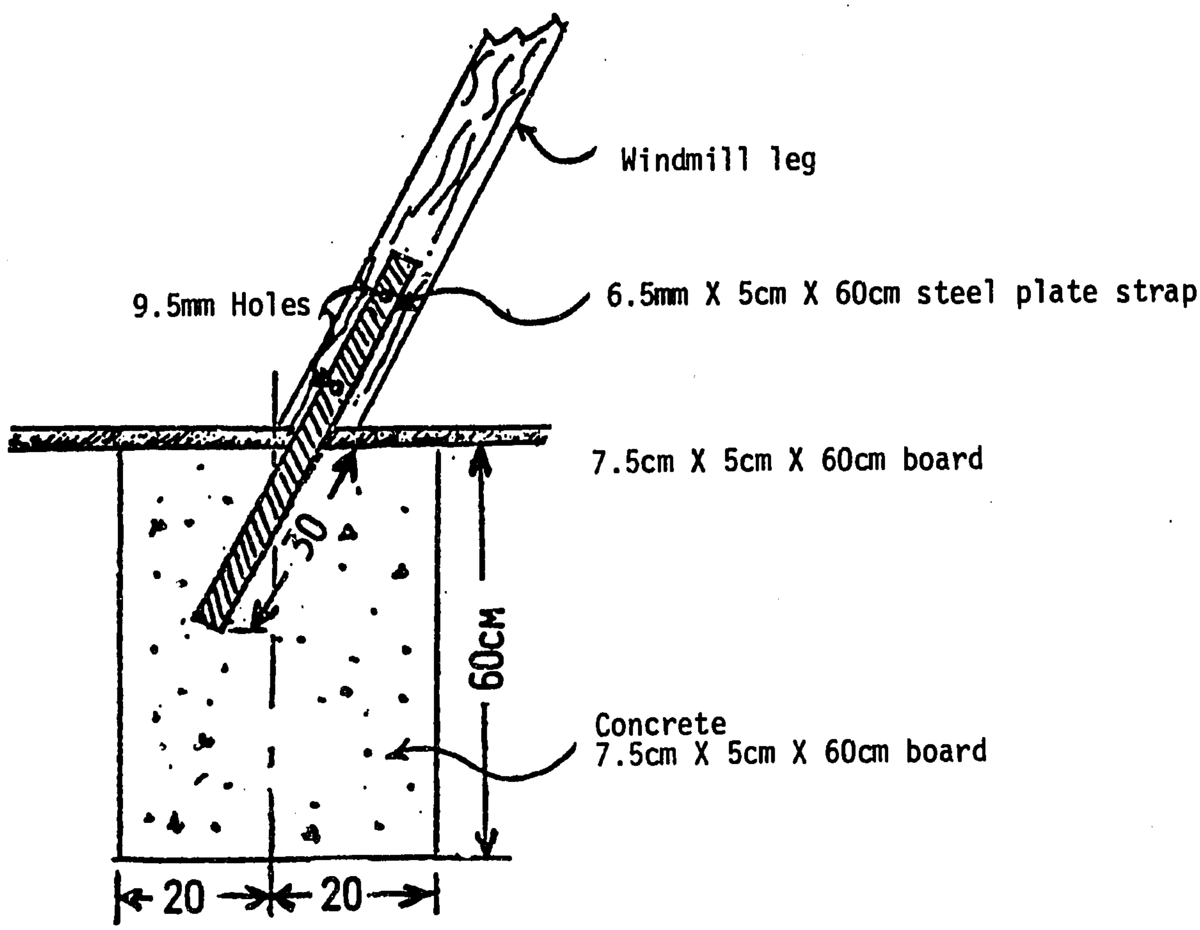

Figure 23. Steel plate support strap

MAINTENANCE

With proper attention and maintenance the Helical Sail Windmill will last for many years. It should be checked daily to make sure everything is working properly. The axle and connecting rod assembly will have to be oiled occasionally, and the canvas sails will have to be replaced after two or three years.

BECAUSE THE WINDMILL HAS NO BRAKING SYSTEM FOR HIGH WIND USE, THE CANVAS SAILS HAVE TO BE DISMANTLED MANUALLY IN HIGH WINDS OR THE AXLE ASSEMBLY WILL BEND AND THE SAILS WILL RIP.

VI. FURTHER INFORMATION RESOURCES

Appropriate Technology Unit. "Considerations for the Use of Wind Power for Borehole Pumping," leaflet, 15 pp. AT Unit Report, 1976. Send nominal sum for postage to Appropriate Technology Unit, Christian Relief and Development Association, PO Box 5674, Addis Ababa, Ethiopia. An introduction to the basic considerations for the use of multi-blade windmills for water pumping. Explains the importance of site selection, rotor design, and the other major components along with the criteria that affect these choices. No plans or detailed information is given.

Barbour, E. The Homemade Windmills of Nebraska, 1898, 78 pp. (reprinted 1976). Available from Farralones Institute, 15290 Coleman Valley Road, Occidental, California 95465 USA.

Bossel, H. Low Cost Windmill for Developing Nations, booklet with dimensional drawings, 40 pp. Available from VITA. Construction details for a low-cost windmill are presented. The windmill produces one horsepower in a wind of 6.4 m/sec (14.3 mph), or two horsepower in a wind of 8.1 m/sec (18.0 mph). No precision work or machining is required, and the design can be adapted to fit different materials or construction skills. The rotor blades feather automatically in high winds to prevent damage. A full-scale prototype has been built and tested successfully. Performance data is included. The windmill is best used to transmit mechanical energy, but also can be connected to a generator.

Brace Research Institute. How to Construct a Cheap Wind Machine for Pumping Water, 1956 (revised 1973), 13 page leaflet. MacDonald College of McGill University, Ste. Anne de Bellevue, Quebec, Canada, from Brace Institute.

Burke, B. and Meroney, R. Energy From the Wind, 1975, annotated bibliography, 180 pp. Available from Publications, Engineering Research Center, Foothills Campus, Colorado State University, Fort Collins, Colorado 80521 USA.

Fraenkel, Peter. Food From Windmills, 1975, 75 pp. This book is to be recommended to anyone doing work on the design of low-cost windmills for irrigation. It thoroughly covers the work of the American Presbyterian Mission on adapting the Cretan sail windmill for use in an isolated area of Ethiopia. Available from International Technology Development Group (ITDG), 9 King Street, Covent Garden, London WC2E 8HN, United Kingdom. Also available from VITA, 3706 Rhode Island Avenue, Mount Rainier, Maryland USA 20822.

Heronemus, W. A Survey of the Possible Use of Windpower in Thailand and The Philippines, 1974, 75 pp. plus appendix, on request from Agency for International Development, Washington, DC 20523 USA; or from National Technical Information Service (Accession No. PB-245 609/3WE, N'74.

Kozlowski, Jozef A. Savonius Rotor Construction, 1977. A comprehensive manual on the construction and use of a Savonius rotor wind machine. Has two designs, each one with detailed instructions. Also contains a section on hooking up a generator. A highly practical book. Available from VITA, 3706 Rhode Island Avenue, Mount Rainier, Maryland USA 20822.

Merriam, M. "Is There a Place for the Windmill in the Less-Developed countries?", 1972, 21 pp. paper. This is an excellent paper--important reading for anyone seriously considering the use of windmills in developing countries. The author lists the most important considerations in choosing to build a windmill, including the most favorable circumstances for a variety of power needs. Four prevailing types of windmills are briefly examined (the Dutch, American multi-vane, propellor, and Savonius Rotor), and the power and other characteristics of each design are briefly compared. There are several tables, drawings, and appendices with supporting information. Free on request from the East-West Center, 1777 East-West Road, Honolulu, Hawaii 96822 USA.

New Alchemy Institute. "A Water-Pumping Windmill that Works," Journal, No. 2, 1974, 7 pp. An article with plans from the New Alchemy Institute, PO Box 432, Woods Hole, Massachusetts 02543 USA.

Sahores, J. Sahores Windmill Pump, 1975, 80 pp. booklet. $6.00 from Commission on the Churches' Participation in Development, World Council of Churches, 150 Route de Ferney, 1211 Geneva 20, Switzerland.

Simonds, M. and Bodek, A. Performance Test of Savonius Rotor, 1964. A technical report with charts and graphs of the test results. Available from the Brace Research Institute, MacDonald College of McGill University, Ste. Anne de Bellevue, Quebec, Canada

United Nations. Proceedings of the United Nations' Conference on New Sources of Energy, 1961, Volume 7 on wind power, 408 pp. The seven-volume "Proceedings" were originally printed in 1964 and were reprinted in 1974. They are expensive and hard to find. Try The United Nations, Sales Section, Room LX-2300, New York, New York 10017 USA. Some major libraries have copies. The relevant material in Volume 7 (the only volume dealing with wind power) is as follows: a) studies of wind behavior and investigation of suitable sites for wind-driven plants (15 articles); b) the design of windpower plants (11 articles); c) the testing of windpower plants (four articles); and d) recent developments and potential improvements in windpower utilization (13 articles), including: "Small Radio, Powered by a Wind-Driven Bicycle Dynamo," by Stam, Tabak, and van Vlaardingen, 5 pp.; "Adaptation of Windmill Designs, With Special Regard to the Needs of Less Industrialized Areas," by Stam, 9 pp.; "Windmill Types Considered Suitable for Large-Scale Use in India," by Nilakantan Ramakrishnan and Venkiteshwaran, 7 pp.

Wolff, Ben. Wind Energy Bibliography, 1974, 66 pp. booklet. Available from Windworks, Box 329, Route 3, Mukwonago, Wisconsin 53149 USA.

VII. CONVERSION TABLES

UNITS OF LENGTH

1 Mile	= 1760 Yards	= 5280 Feet
1 Kilometer	= 1000 Meters	= 0.6214 Mile
1 Mile	= 1.607 Kilometers	
1 Foot	= 0.3048 Meter	
1 Meter	= 3.2808 Feet	= 39.37 Inches
1 Inch	= 2.54 Centimeters	
1 Centimeter	= 0.3937 Inches	

UNITS OF AREA

1 Square Mile	= 640 Acres	= 2.5899 Square Kilometers
1 Square Kilometer	= 1,000,000 Square Meters	= 0.3861 Square Mile
1 Acre	= 43,560 Square Feet	
1 Square Foot	= 144 Square Inches	= 0.0929 Square Meter
1 Square Inch	= 6.452 Square Centimeters	
1 Square Meter	= 10.764 Square Feet	
1 Square Centimeter	= 0.155 Square Inch	

UNITS OF VOLUME

1.0 Cubic Foot	= 1728 Cubic Inches	= 7.48 US Gallons
1.0 British Imperial Gallon	= 1.2 US Gallons	
1.0 Cubic Meter	= 35.314 Cubic Feet	= 264.2 US Gallons
1.0 Liter	= 1000 Cubic Centimeters	= 0.2642 US Gallons

UNITS OF WEIGHT

1.0 Metric Ton	= 1000 Kilograms	= 2204.6 Pounds
1.0 Kilogram	= 1000 Grams	= 2.2046 Pounds
1.0 Short Ton	= 2000 Pounds	

UNITS OF PRESSURE

1.0 Pound per square inch	= 144 Pound per square foot
1.0 Pound per square inch	= 27.7 Inches of water*
1.0 Pound per square inch	= 2.31 Feet of water*
1.0 Pound per square inch	= 2.042 Inches of mercury*
1.0 Atmosphere	= 14.7 Pounds per square inch (PSI)
1.0 Atmosphere	= 33.95 Feet of water*
1.0 Foot of water = 0.433 PSI	= 62.355 Pounds per square foot
1.0 Kilogram per square centimeter	= 14.223 Pounds per square inch
1.0 Pound per square inch	= 0.0703 Kilogram per square centimeter

UNITS OF POWER

1.0 Horsepower (English)	= 746 Watt = 0.746 Kilowatt (KW)
1.0 Horsepower (English)	= 550 Foot pounds per second
1.0 Horsepower (English)	= 33,000 Foot pounds per minute
1.0 Kilowatt (KW) = 1000 Watt	= 1.34 Horsepower (HP) English
1.0 Horsepower (English)	= 1.0139 Metric horsepower (cheval-vapeur)
1.0 Metric horsepower	= 75 Meter X Kilogram/Second
1.0 Metric horsepower	= 0.736 Kilowatt = 736 Watt

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*At 62 degrees Fahrenheit (16.6 degrees Celsius).

TEMPERATURE

°F = (9/5 X °C) + 32°

°C = 5/9 X (°F - 32°)

Example: How many °C = 77°F?
5/9 X (77°F - 32°) = 25°C

ENERGY

100 Calories = .396 BTU

100 Watts = .134 Horsepower

1 Kilowatt-hour = 3413 BTU

1 BTU (British Thermal Unit) = 252 calories

1 Horsepower = 746 watts (.746 kw)

COMMON ABBREVIATIONS

millimeter (mm)
centimeter (cm)
meter (m)
kilometer (km)
gram (gm)
kilogram (kg)

inch (")
foot (ft or ')
ounce (oz)
pound (lb)
horsepower (hp)
British Thermal Unit (BTU)

SPEED

1 mile per hour (mph) = 0.45 m sec

1 m/sec = 2.24 miles per hour (mph)

APPENDIX I

USEFUL DATA AND DESIGN FORMULAS

POWER IN THE WIND

Power in the wind = Velocity^3 X Area

Velocity = wind speed

Area = area swept by the windmill blades when turning (πr^2, where r = radius of wind rotor)

If we use actual units of power, wind speed, and area, we get:

Power = .0012 X V^3 X A

where Power is measured in foot-pounds per second (ft-lbs/sec)

V (wind speed) is measured in feet per second (ft/sec)

A (area) is measured in square feet (ft^2)

If we want to measure power in horsepower, instead of ft-lbs/sec, we need to know that:

1 horsepower = 550 ft-lbs/sec

Therefore,

$$\text{Horsepower} = \frac{.0012 \times V^3 \times A}{550}$$

Horsepower = .0000022 X V^3 X A

With any known wind speed and rotor diameter, we can now figure the amount of horsepower in the wind passing through the machine. Only a part of this power can be captured by a windmill. The theoretical limit of the power that can be extracted by a windmill is 59% of the power in the wind. Considering the friction losses and other inefficiencies in the windmill, we can expect the windmill to capture only 10-30% of the energy in the wind.

POWER OBTAINED BY THE WINDMILL

If we take the formula for horsepower and include an efficiency factor E (a measurement of the efficiency of our windmill in converting wind power into pumping power), we can get a realistic figure for the actual power we will obtain at a particular wind speed:

$$\text{Horsepower} = .0000022 \times (KV)^3 \times A \times E$$

where V = wind speed

K = a constant to adjust the units of V (if V is in mph, K = 1.47; if V is in ft/sec, K = 1.0)

A = swept area of the windmill, measured in ft^2 (= πr^2 where r = radius of windmill rotor)

E = efficiency factor (for practical purposes, our design has an efficiency factor of about 25)

Thus the horsepower of the 16.5 ft diameter windmill, in a 20-mph wind = $.0000022 \times (1.47 \times 20)^3 \times (\pi \times 8.25^2) \times .25 =$ 3.0hp.

NOTE: For metric units the formula for horsepower is: Horsepower = $.000236 \times (KV)^3 \times A \times E$.

Where V is measured in meters/sec the formula for horsepower is: K= 3.28; A is measured in m^2

APPENDIX II

GLOSSARY

ABUNDANT--very plentiful; more than sufficient.

ACCESS HOLE--a hole in one part that allows you to get inside to change or lubricate another part.

ADEQUATE--sufficient; enough.

ALIGNED--to be in a straight line.

ALIGNMENT--arrangement in a straight line.

ALTERATIONS--changes.

ANCHOR PINS--pieces of metal placed in the concrete foundation that connect the windmill tower legs to the foundation.

ANEMOMETER--a device for measuring wind speed.

AXES--more than one axis.

AXIS--a straight line on which an object rotates.

AXLE--a rod on which a wheel turns.

BACK PRESSURE--pressure in the opposite direction to the flow of water.

BARREN--without much plant life.

BEARING HOUSING--a pipe that holds the bearings in position.

BORE HOLE--a hole in the ground made by drilling, for a pump.

BORING--drilling.

BRACE--support.

BRAZED--joined by melting metal.

BURRS--tiny rough pieces of metal.

BUTT WELD--to weld end to end.

CLAMP--hold together firmly.

CLEARANCE--open space between two parts.

CONSTRAINTS--limitations, boundaries.

CONVERT--change into.

COUNTER BALANCE--a system in which one weight balances another, making both easier to move.

CROSS BAR--a bar or pipe which connects two other pipes.

CROSS BRACES--supports which go across the main supports.

CROSS BRACING--a set of supports that go across and strengthen the main supports.

CROSS SECTION--a view of a part as if that part were cut in half.

DATA--information.

DEFLECTION--movement away from the normal position.

DIA.--diameter. The thickness or width of something.

DIAPHRAGM PUMP--a pump that operates as a flexible wall collapses and expands.

DIES--tools used in cutting threads on steel rod to make bolts.

DRILL PRESS--a workshop machine for making holes at a precise angle (usually 90 degrees) in metal or wood.

DRIVE MECHANISM--the part of a windmill that operates the pump; in this windmill either the eccentric wheel or crank alteration.

DURATION--the time that a thing continues.

ECCENTRIC WHEEL--a wheel in which the axle is not at the center point; in this windmill, as the wheel turns, the axle moves up and down.

ENLARGE--make bigger; make larger.

FABRICATION--construction; manufacture.

FITTINGS--small parts used to join, adjust, or adapt other parts.

FLANGE--a collar on a wheel to hold it in place and give it strength; specifically, a collar on the eccentric wheel of this windmill.

FLUX (BRAZING)--a substance used to help metals fuse together.

FOUNDRY--the process of melting and molding metals.

FRICTION-DRIVE--a power system in which power is transferred from one part to another by forcing the two parts to rub together.

FRICTION LOSSES--power (energy) losses due to the rubbing of parts against each other, creating small amounts of heat.

GALVANIZED--metal covered with zinc to protect it from rust.

GREASE (verb)--to lubricate; to put grease on something.

GREASE NIPPLES--small metal fittings through which grease can be pumped; for example, to lubricate bearings inside a pipe housing.

GRINDING WHEEL--a workshop tool that has a wheel with a hard, rough side used to smooth or remove small amounts of metal from a tool or part; also, the wheel portion of this tool.

GUSSET--a triangular metal brace for reinforcing a corner or angle.

GUST--a sudden, strong rush of air.

GUSTING--blowing in sudden, strong rushes of air.

GUY WIRES--cables that strengthen the sides and keep them in position.

HACKSAW--a hand saw for cutting metal.

HOUSING--a frame, or pipe for containing and supporting some part or mechanism.

HUB EXTENSION--a piece of pipe which sticks out from the front of the hub and provides a place to attach guy wires to strengthen the blades.

INERTIAL FORCES--for this windmill, forces which tend to make the windmill remain stopped if it is already stopped, or tend to make it keep moving in a particular direction if it is already moving in that direction.

INSERT--to put inside something.

ISOMETRIC VIEW--a method of drawing figures in which three dimensions are shown not in perspective, but all dimensions are shortened to give the impression of proper relative size.

JACK (car or automobile)--a device which can lift the heavy weight of a car a short distance off the ground.

LINKAGE--a part that connects two other parts.

LOAD--the weight to be lifted by the windmill pump rod.

LOAD BEARING SURFACE--the surface supporting the entire weight of the windmill superstructure and the pump system.

LUBRICATION--application of grease to make slippery or smooth, or to prevent wear.

METAL-WORKING LATHE--a workshop machine which can cut circular shapes out of metal.

MILLING--the grinding, cutting or processing of metal.

MODIFIED--changed slightly.

NIPPLE--a piece of metal with a small opening through which water or grease can be forced.

OBSTACLE--barrier; something that gets in the way.

ODOMETER--a simple counting device that records the distance a vehicle has traveled.

OPTIMUM--best.

OPTIONS--choices, possibilities.

PARALLEL ALIGNMENT--two axes lined up exactly parallel to each other.

PERPENDICULAR--at a 90 degree angle.

PIPE FITTINGS--small pieces of threaded pipe used to connect two longer pieces.

PITCH ADJUSTMENT--adjustment of the angle at which the blades are attached.

PIVOT--turn on an axis.

PLUNGER--the part of a diaphragm pump that moves up and down.

PRECISE--exact.

PUMP ROD--the steel rod going from the top of the windmill to the top of the pump mechanism.

PUMP STROKE--the distance the pump piston travels between its highest and lowest points.

PUNCH--to knock a hole in a piece of metal using a hammer and a sharp tool.

RADIAL GUY WIRES--guy wires connecting the blade tips to the hub extension to strengthen the blades.

RECIPROCATING PUMP--a pump in which the movement of a piston up and down forces the water up.

REMOTE AREAS--areas difficult to get to from outside.

RIGID--stiff.

ROCKER ARM--a support mechanism which turns on a shaft at one end and moves up and down at the other end.

ROTARY MOTION--turning, rotating.

ROTARY POWER--poower provided by a turning shaft.

SEALED BALL BEARINGS--ball bearings in which lubrication is not required.

SEASONED HARDWOOD--hardwood that has been cut and allowed to dry for a long time.

SEGMENT--piece of something.

SHEAR BLOCK--two pieces of wood which clamp two pieces of pump rod; under normal conditions this connects the pump rod pieces, but under greater stress one of the pieces will pull out of the block.

SHIM--a thin piece of metal or wood used for filling space or leveling.

SNUG--close fit.

SOCKET--a piece or part into which something fits.

SPACER--a piece of metal used to fill space so that two pieces will come together at the right point, or clear each other.

SPEEDOMETER--a device in a car which measures the speed at which the car is traveling.

SPOT BRAZE--to braze in small spots.

SPOT WELD--to weld in small spots.

STRESS--force acting on a part that tends to strain or alter its shape.

STRUT--a brace; a support which resists pressure.

SUPERSTRUCTURE--structure built on something else; all of a building above the foundation.

SWEPT AREA--the circle made by the blades of a windmill as they turn.

TABS--small pieces of metal that are bent for some purpose.

TACK WELD--to weld temporarily with a small amount of material.

TAP--to cut threads on the inside of a hole in a nut, pipe, or piece of metal.

TERRAIN (rough)--land that is difficult to move through.

THERMAL WINDS--winds caused by the heating of the ground by the air.

THREADING EQUIPMENT--tools that can cut thread into metal rods to make bolts.

TORQUE--the force that acts to produce rotation; a twisting force.

TRIANGULAR--having three straight sides.

TRIPOD--a support having three legs.

TURBULENCE--irregular motion of air.

U-BOLT--a U-shaped bolt with threads and nuts at both ends.

UNEVENNESS--roughness, irregularity.

VARNISHED--covered with a paint-like substance made of resins dissolved in oil for protection from damage by the weather.

VERTICAL AXIS--an axis that follows a line straight up and down.

WEAR RING--one of two pieces of steel rod bent to form a ring. The rings rub against each other as the windmill pivots in the wind.

WELDING ROD--a special rod of metal that is melted during the welding process when two pieces of metal are joined.

WIND ROTOR--the turning wheel and blades of the windmill.

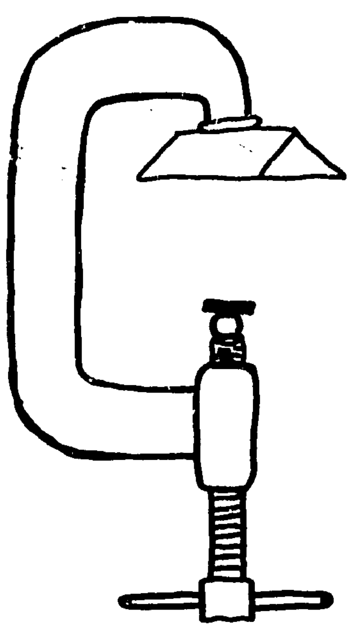
APPENDIX III

WELDING RIG

If you plan to construct more than one windmill, you may want to build a welding rig. The use of the rig can cut down considerably on the construction time.

PARTS LIST

- 5cm X 10cm X 13m
- 2.5cm X 10cm X 9.5m
- 1.5cm plywood 122 cm X 152cm (approximately)
- Special "C" clamp (includes 1.9cm angle bar 10cm long)



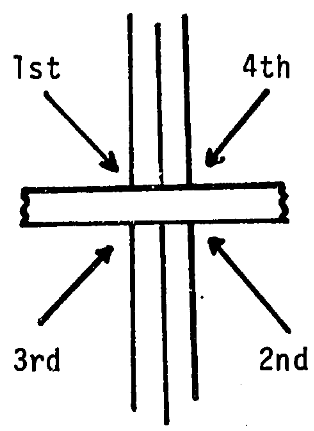
Special "C" clamp: Standard "C" clamp (15cm) with angle iron welded as shown to fit over shaft

This fixture does need exacting construction as all stations must be parallel with each other except for station #3 which must be 45° from the rest.

If available, scrap lumber may be used, or if desired, angle bars instead of wood. Wood expands and contracts somewhat with changes in temperature and humidity, but should be all right for the purpose intended.

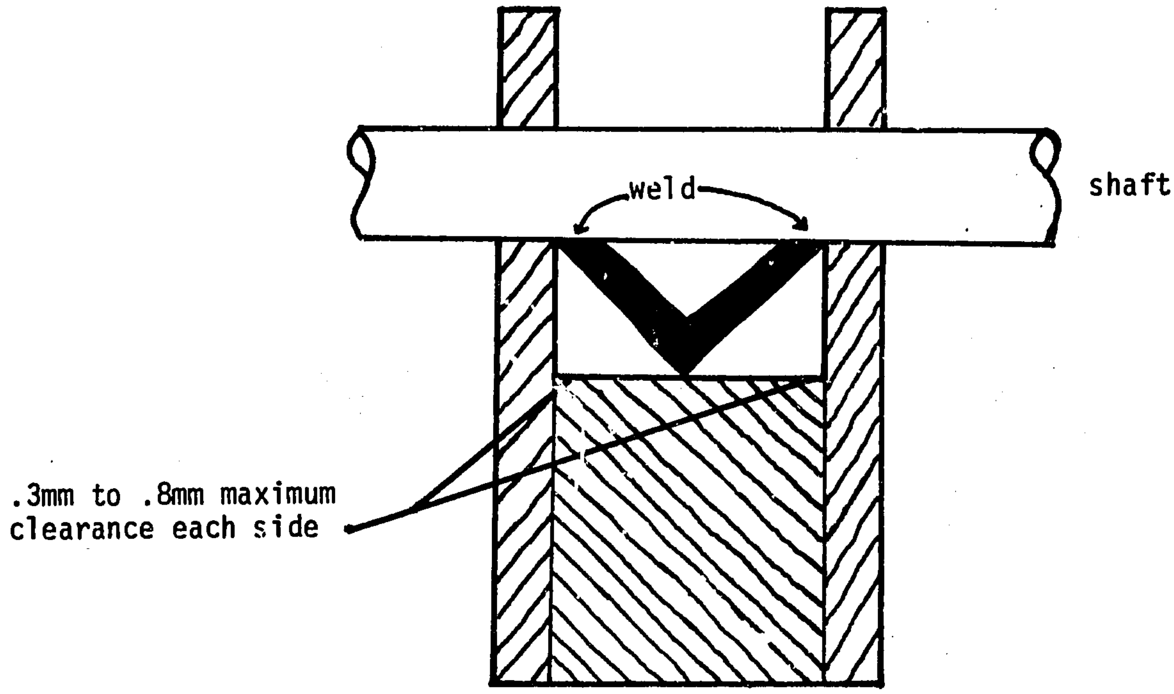
PROCEDURE TO USE THE FIXTURE

- Place a sail support arm in guide slot in station #2 and push it against the stop.
- Place the main support shaft in the shaft guide slots in stations #1 and #3 so that the end of the shaft is exactly 35.5cm (14") from the center of station #2.
- Lock arm and shaft together with special "C" clamp.
- Tack weld as shown in the welding schedule.



Tack Welding Schedule

- Remove the clamp after the third tack and complete #4 as shown.



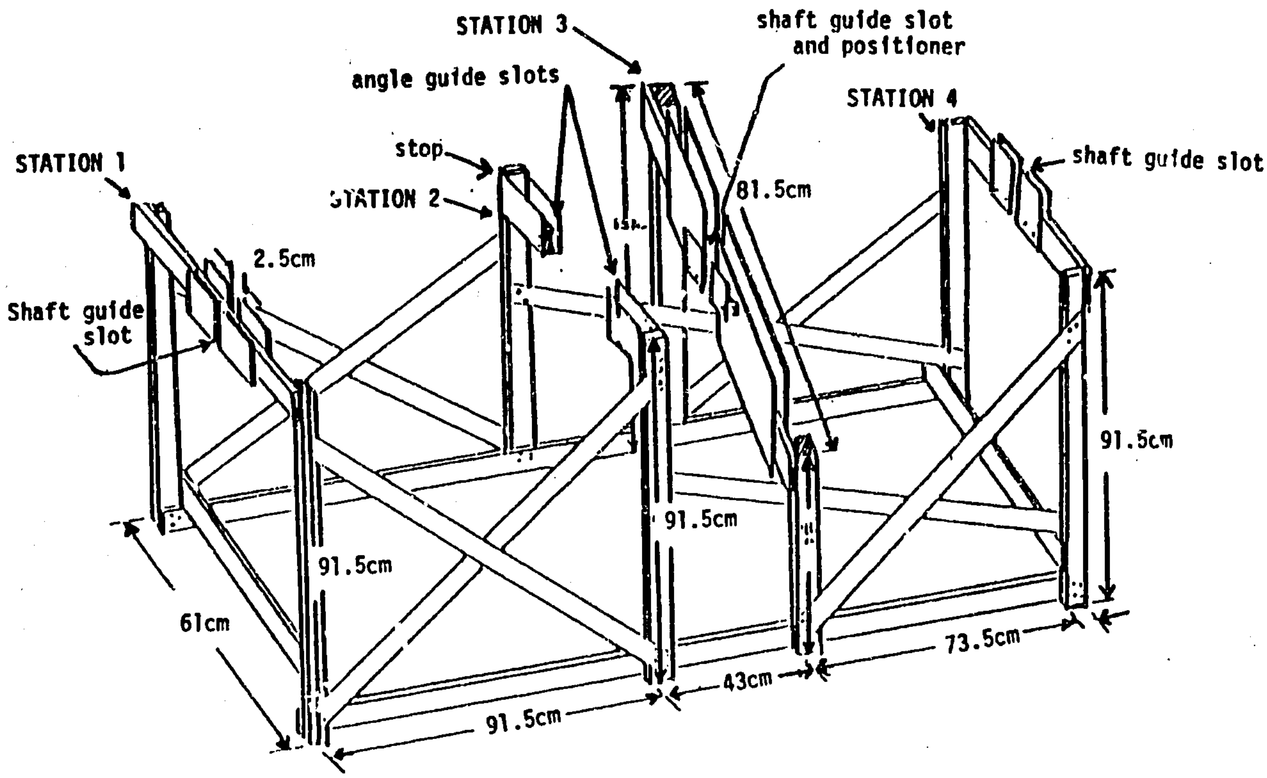
End view of Station 2 with angle and shaft in place

- Repeat the weld schedule as in the previous step, but apply enough weld metal to make a finished weld joint.

- Remove the shaft and arm from station #2, rotate 45°, and place in station #3. Slide another arm under the shaft in station #2 up to the stop and clamp the arm and shaft together.

- Repeat the last four steps until all arms have been welded.

The following page shows a completed welding fixture.



Welding fixture

All Horizontal and Vertical sections--5cm X 10cm
All Braces--2.5cm X 10cm
Member at Station 3 is at 45° to horizontal (5cm X 10cm)
Boards forming guide slots can be 1.5cm thick plywood

APPENDIX IV

DECISION MAKING WORKSHEET

If you are using this as a guideline for using the Helical Sail Windmill in a development effort, collect as much information as possible and if you need assistance with the project, write VITA. A report on your experiences and the uses of this manual will help VITA both improve the book and aid other similar efforts.

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CURRENT USE AND AVAILABILITY

- Are there current wind data summaries available from government or private sources for the area? If not:
  - Measure wind speed and track for a period of time so that seasonal variations are known and can be accounted for.
  - Track the directions in which the wind blows and the daily and seasonal variations in direction.
  - Are wind machines of any type used in the area currently? If so, learn more about them--type, performance data, function, costs, etc.
- If wind energy is not currently harnessed, what seems to be the reason? Are there cultural or social reasons? For

example, is it a problem to find the "right" land upon which to build a windmill?

- Is lack of knowledge of the potential for wind energy use a limiting factor? If so, what can and should be done about it?

NEEDS AND RESOURCES

- What are current needs for pumping water and generating electricity which might be met by a wind machine? Pay particular attention to agricultural and domestic needs for pumping water; these are areas where current state-of-the-art in wind technology is particularly applicable.

- Is the wind a particularly reliable resource in the area? For example, if the wind blows quite steadily in one direction, wind energy may be a greater potential resource in that area.

- Given the state-of-the-art information, what materials and resources would be available locally and/or easily for windmill manufacture? Could needed parts be manufactured locally?

- Is there a possibility of providing a basis for small business enterprise?

- What kinds of skills are available locally to assist with construction and maintenance? How much skill is necessary for construction and maintenance? Do you need to train people? Can you meet the following needs?

  - Estimated labor time for full-time workers is:

    - 16 hours skilled labor
    - 40 hours unskilled labor
    - 1 hour welding

- Do a cost estimate of the labor, parts, and materials needed.

- If a wind machine seems indicated, what are the real costs of the technology? Include such things as pumps and piping. If a well is necessary, has it already been constructed?

- Would the technology require outside funding? Are local funding sources available to sponsor the effort? How will the project be funded?

- How much time do you have? When will the project begin? How long to complete the project? Are you aware of holidays and planting or harvesting seasons which may affect timing?

- How will you arrange to spread knowledge and use of the technology?

IDENTIFY POTENTIAL FOR INTRODUCTION OF WIND TECHNOLOGIES

- Has any local person, particularly someone in a position of authority, expressed the need or expressed considerable interest in wind power technology? If so, can someone be found to help the technology introduction process?

- Are there local officials who could be involved and tapped as resources?

- How will you get the community involved with the decision of which technology is appropriate for them?

- Is there a choice to be made between building a windmill and introducing a different type of alternative energy technology? For example, if one need is for water to be pumped from a river or a well to irrigate a field, would the better technology be a wind machine, a hydraulic ram, or perhaps a pedal-powered pump? Which would "cost" more after balancing: 1) initial costs of materials and labor for each technology, 2) social and cultural trade-offs, and 3) maintenance and operation costs, and so on?

- Would a local cooperative or small business be able to introduce the wind technology as part of its efforts? Such an approach would solve sponsorship questions and/or, if the right business is selected, ensure local ownership of the technology.

FINAL DECISION

- How was the final decision reached to go ahead with this technology, or why was it decided against?

APPENDIX V

RECORD KEEPING WORKSHEET

CONSTRUCTION

Photographs of the construction process, as well as the finished result, are helpful. They add interest and detail that might be overlooked in the narrative.

A report on the construction process should include very specific information. This kind of detail can often be monitored most easily in charts (such as the one below).

Labor Account

Name	Job	Hours Worked M T W T F S S	Total	Rate?	Pay?
1					
2					
3					
4					
5					
		Totals			

Materials Account

Item	Cost	Reason Replaced	Date	Comments
1				
2				
3				
4				
5				
Totals (by week or month)				

Some other things to record include:

- Specification of materials used in construction.
- Adaptations or changes made in design to fit local conditions.
- Equipment costs.
- Time spent in construction--include volunteer time as well as paid labor, full- and/or part-time.
- Problems--labor shortage, work stoppage, training difficulties, materials shortage, terrain, transport.

OPERATION

Keep log of operations for at least the first six weeks, then periodically for several days every few months. This log will vary with the technology, but should include full requirements, outputs, duration of operation, training of operators, etc. Include special problems that may come up--a damper that won't close, gear that won't catch, procedures that don't seem to make sense to workers, etc.

MAINTENANCE

Maintenance records enable keeping track of where breakdowns occur most frequently and may suggest areas for improvement or strengthening weakness in the design. Furthermore, these records will give a good idea of how well the project is working out by accurately recording how much of the time it is working and how often it breaks down. Routine maintenance records should be kept for a minimum of six months to one year after the project goes into operation.

Labor Account

	Name	Hours & Date	Repair Done	Also down time Rate?	Pay?
1					
2					
3					
4					
5					
			Totals (by week or month)		

Materials Account

	Item	Cost Per Item	# Items	Total Costs
1				
2				
3				
4				
5				
			Total Costs	

SPECIAL COSTS

This category includes damage caused by weather, natural disasters, vandalism, etc. Pattern the records after the routine maintenance records. Describe for each separate incident:

- Cause and extent of damage.
- Labor costs of repair (like maintenance account).
- Material costs of repair (like maintenance account).
- Measures taken to prevent recurrence.

OTHER MANUALS IN THE ENERGY SERIES

Small Michell (Banki) Turbine: A Construction Manual

Overshot Water-Wheel: Design and Construction Manual

Wood Conserving Stoves: Two Stove Designs and Construction Techniques

Three Cubic-Meter Bio-Gas Plant: A Construction Manual

Hydraulic Ram Pump for Tropical Climates

Solar Water Heater

Solar Still

Making Charcoal: The Retort Method

Solar Grain Dryer

The Dynapod: A Pedal-Power Unit

Animal-Driven Chain Pump

For free catalogue listing these and other VITA publications, write to:

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