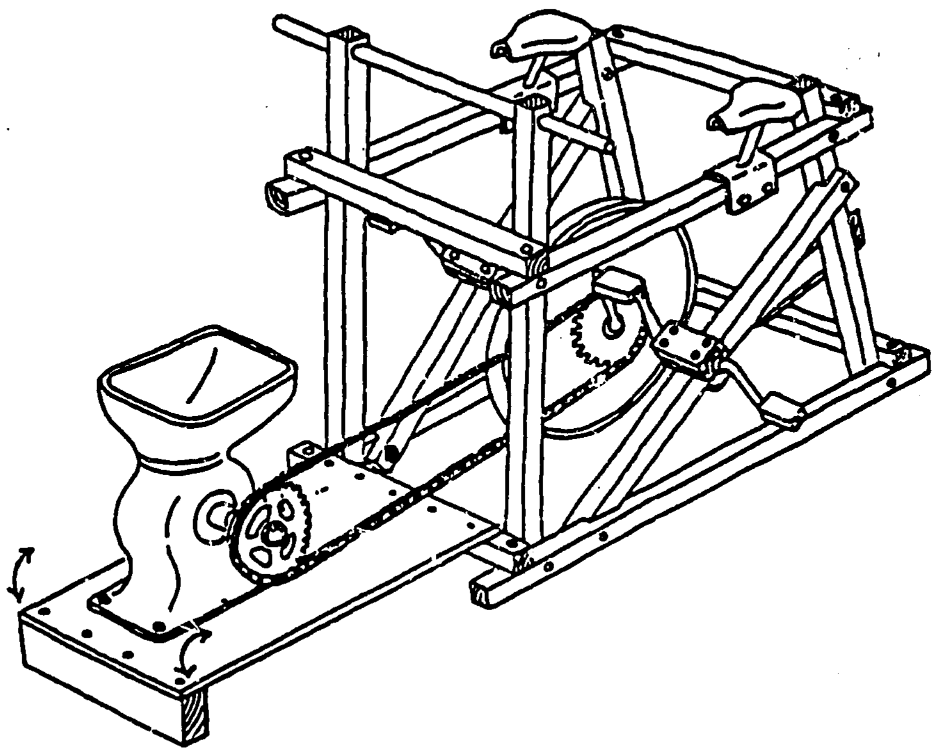
THE DYNAPOD:
A PEDAL POWER UNIT

by ALEX WEIR



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A PEDAL POWER UNIT

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This book is one of a series of manuals on renewable energy technologies. It is primarily intended for use by people in international development projects. The construction techniques and ideas presented here are, however, useful to anyone seeking to become energy self-sufficient.

THE DYNAPOD:

A PEDAL POWER UNIT

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THE DYNAPOD:
A PEDAL POWER UNIT

I. WHAT IT IT IS AND WHAT IT IS USED FOR

Pedal power is simple, efficient, and practical. Its most familiar use is the bicycle for personal or cargo transportation. But pedals can also power small stationary machines.

A person can generate four times more power (1/4 horsepower) by pedaling than by hand-cranking. At the rate of 1/4hp, continuous pedaling can be done for only short periods of about 10 minutes. However, pedaling at half this power (1/8hp), can be sustained for around 60 minutes. Pedal power enables a person to drive devices at the same rate as that achieved by hand-cranking, but with far less effort and fatigue. Pedal power also lets one drive devices at a faster rate than before (e.g., winnower), or power devices that require too much power for hand-cranking (e.g., thresher).

Bicycles can be adapted to drive such devices, but the net result is inefficient. It is cheaper in initial and maintenance costs to use a properly designed and constructed dynapod.

A dynapod is a portable pedaling apparatus that consists of a stand, saddle, handlebar, pedals, and sprocket wheel. The name comes from the Greek words for "power" and "foot." Dynapod power varies according to the size and fitness of the operator and the length of time spent pedaling.

The two-person dynapod (see Figure 1) has been attached to a grain mill, but the unit can be adapted to a wide variety of uses. These include agriculture, small-scale industrial processes, and electrical generation.

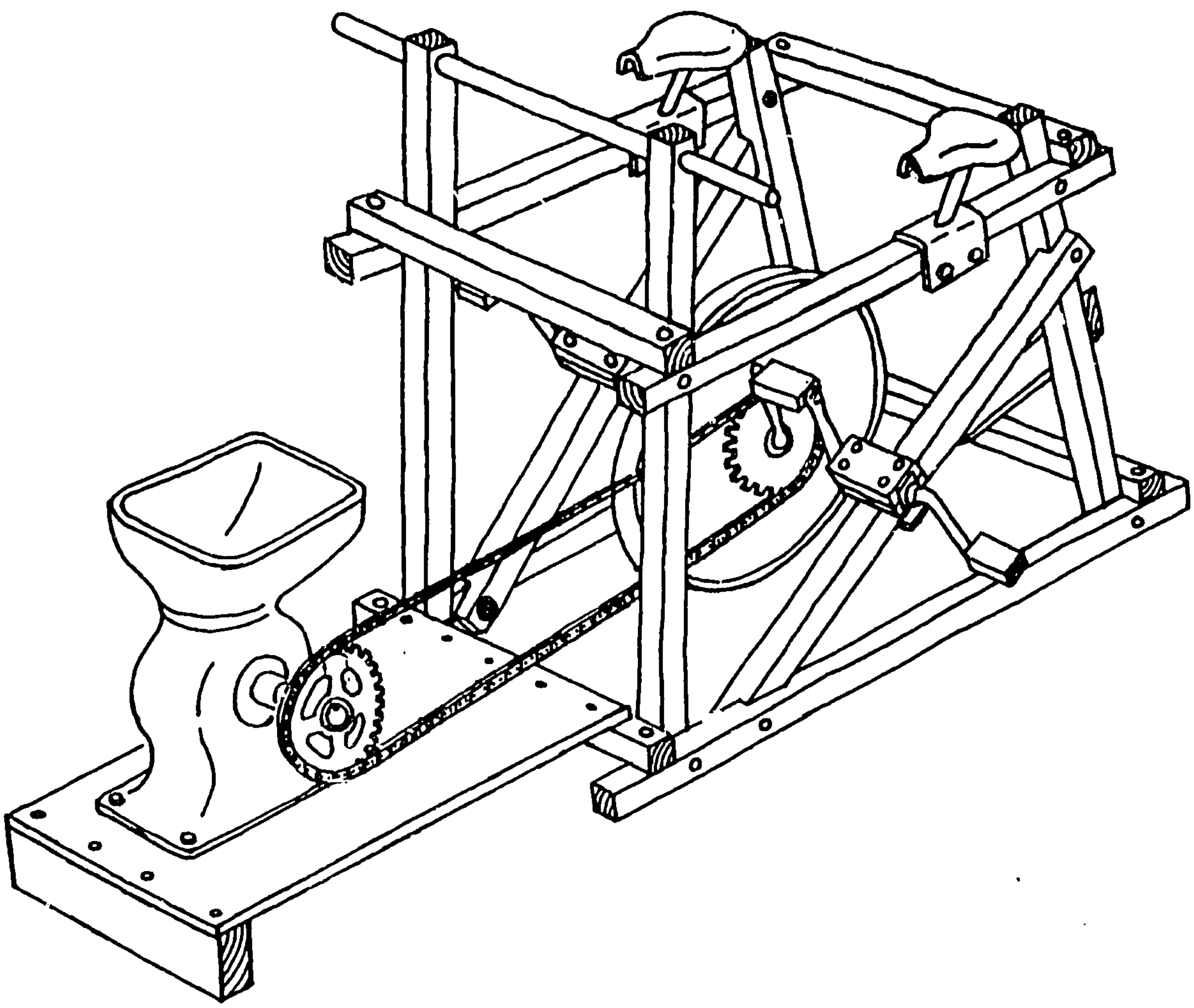


Figure 1. Two-Person Dynapod with Chaindrive and Mill on Mounting Platform

WINCH

The dynapod can be used as a winch to lift or hoist equipment. It can also be used to power a stationary winch for plowing, cultivating, harrowing, etc. The dynapod-powered winch moves the needed tool through the field along a cable. This has proved successful in situations where soil conditions, weather, or the slope of the land make it difficult for humans and animals to work the land directly.

The dynapod-powered winch (Figure 2) can be moved sideways easily. But the weight of the operator (or operators) provides sufficient anchorage. The same advantage of portability and stability applies to other applications such as hauling boats up a beach or landing.

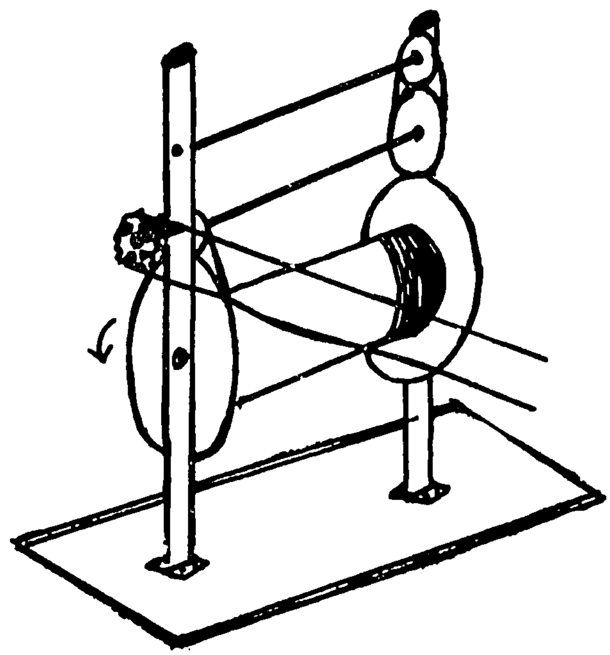


Figure 2. Winch

WATER PUMPING

The dynapod is suited for a wide range of water lifting operations. It can do low-lift pumping, raising 1250 liters per minute [330 gallons per minute (gpm)] through a 30cm (12") distance, or 125 liters per minute [33gpm] through a 3m (118") distance. It can be attached to a modern version of the Persian wheel or Chinese water bucket. For high-lift needs of 40 liters per minute through 10m (11gpm through 29.5') or 125 liters per minute through 30m (3.3gpm through 88.5'), the dynapod can power a reciprocating deep-well pump through a crankshaft and rod.

FANS AND BLOWERS

A properly designed, pedal-powered fan can also be used for winnowing or grain drying. This is useful when other energy sources are scarce.

AIR COMPRESSOR

Pedal power can also be used for air compression. The amount of air compressed with such limited power may appear small. But it can be sufficient to operate certain types of paint sprayers or crop dusting equipment.

OTHER PEDAL POWER APPLICATIONS

- Cassava graters
- Coffee pulpers
- Coffee/grain hullers
- Cracking of oil palm nuts
- Fibre decorticaters--sisal, manila, hemp, etc.
- Threshers
- Balers
- Potter's wheels
- Flexible shaft drive for portable grinders, saber saws, band saws, and other equipment that use reciprocating motion
- Tire pumps
- Sewing machines
- Electrical generation--60-200 watts, e.g.--for film strips or slide projectors. A minimum of 100 watts can be provided by one man for 1/2 hour or more.

II. DECISION FACTORS

Advantages:

- Parts are easily available in areas where bicycles are common.
- Simple to build and operate.
- Relatively little maintenance.
- Adaptable to a variety of situations where hand, motor, or animal power is now used.
- Portable--can be assembled and disassembled easily.
- Relatively inexpensive. The dynapod is much cheaper than gasoline or diesel engines, and repair and maintenance are simpler.

Considerations:

- Operation time must allow for rider fatigue.
- Wood bearings have to be replaced periodically.
- Metal lathe required for some parts.
- Maintenance of chain and gears requires some skill and care.

COST ESTIMATE*

$40-$100 (US) including materials and labor (1980).

*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? Or, 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 dynapod built and used in Senegal. But it is even more important to have a full narrative about the dynapod 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 II.

IV. PRE-CONSTRUCTION CONSIDERATIONS

TYPES

There are three kinds of dynapods: 1) A one-person dynapod that utilizes belt drive. It can be built either with or without chaindrive, and costs about $40 (US). 2) A two-person dynapod, costing approximately $60-$100 (US). It can be pedaled either by one person at a time, or by two people together. It is also possible to fit a special adaptor so that a direct shaft drive leads off the unit and powers a flour mill or other machine. (When this is done, only one person can pedal at a time.) 3) A one-person dynapod, costing approximately $50 (US), has belt drive, chain drive, and direct drive. It is very similar to the two-person dynapod.

Because the two-person dynapod offers more versatility than the other models, construction plans are presented here for the two-person model.

POWER TRANSMISSION

There are three ways to transmit power from the pedals and crank. The choice depends upon the machinery to be driven. The dynapod is easily adapted from one type of drive to another.

- Direct drive, which provides a ratio of one to one (1:1), is useful when a lot of torque is needed at a slow speed. Good for chain pumps, etc.

- Chain drive, using a bicycle chain and sprocket, can give ratios of 1:1 (with a full-size chain sprocket); 1.5:1

(child's bike chain sprocket); or 3:1 (using bicycle rear sprocket). Good for grinders, threshers, etc.

- Belt drive and pulleys to give ratios of 2.2:1 to 10:1. Good for winnowing fan, spraying equipment, electrical generation, etc.

Use of each of these transmissions requires that special adaptors be built. A full explanation of this is found on page 30.

V. CONSTRUCTION REQUIREMENTS

MATERIALS

Timber

16m of 5cm X 5cm timber cut to the following dimensions:

- 2 - 99.5cm length for Top Horizontal (TH) Supports
- 2 - 120.5cm lengths for Bottom Horizontal (BH) Supports
- 2 - 116cm lengths for Front Vertical (FV) Supports
- 2 - 89.5cm lengths for Rear Vertical (RV) Supports
- 4 - 101.4cm lengths for Top and Bottom Traverses
- 2 - 110.5cm lengths for Bearing Supports
- 1 - 63cm length for strut
- 1 - 2.5cm dia wooden rod (broomstick)

Bolts

All bolts are 10mm dia hexagon-headed (HH) bolts. In addition to the bolts and nuts given below, 50 washers and 34 nuts will be needed if locknuts are used.

- 16 - 12.5cm long (bottom and top horizontal supports)
- 6 - 10cm long (bearing supports, vertical supports and strut)
- 8 - 7.5cm long (top horizontal supports and saddle brackets)

Machined Parts

- 43cm - mild steel bar, 3cm (OD)
- 38cm - mild steel bar, 2.5cm (OD)

Bicycle Parts

- 5 - Left-hand bicycle cranks
- 1 - Right-hand bicycle crank and chainwheel
- 6 - Cotter pins
- 2 - Bicycle pedals
- 2 - Spoke flanges (hubs)
- 36 - Spokes (length to suit rim dia)
- 1 - Used or new bicycle wheel rim (66cm dia)*
- 2 - Bicycle saddles
- 2 - Bicycle saddle brackets

Miscellaneous Parts

- Bicycle chain - one and a half
- V-belting
- Cardboard
- Mortar (16kgs sand and 8kgs cement)
- Rim tape (rubber strip or tape)
- Cotter pins (6)

TOOLS

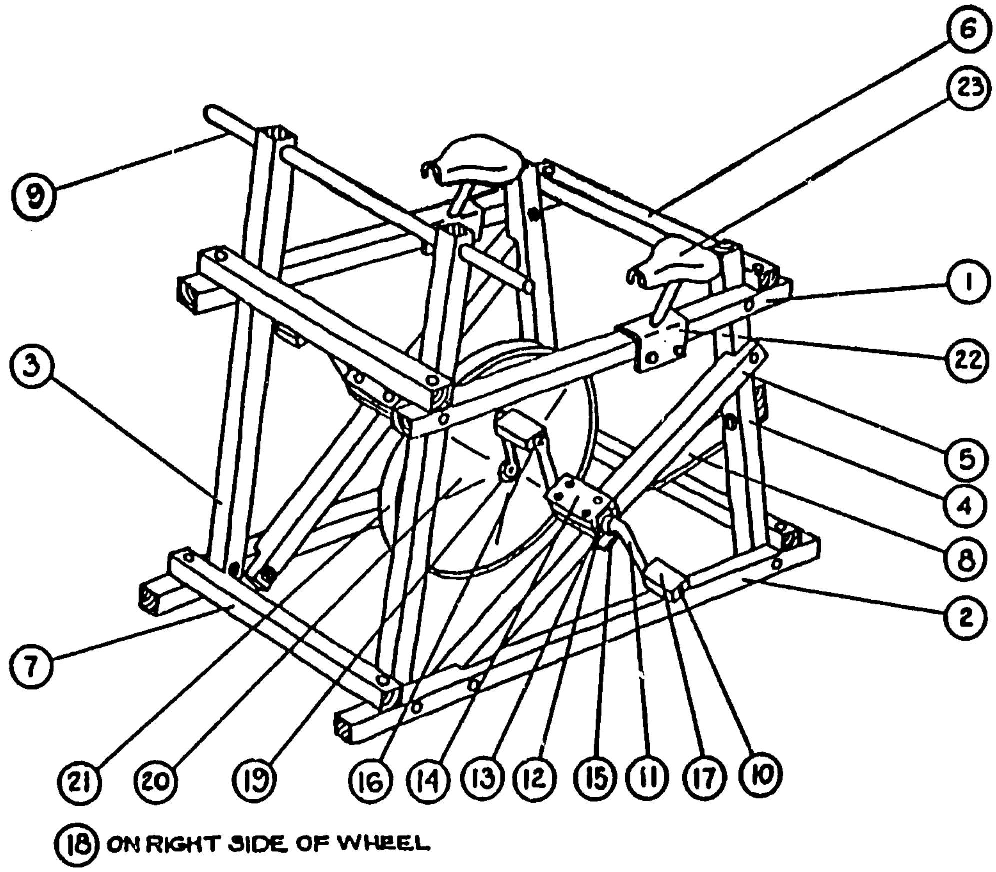
- Metal lathe to produce spindles and pedal rods, preferably with chucking capability for the bearing spindles (25mm holes)

- Steel rule

---

*Old bicycle rims that are unsuitable for bicycles can be used for the pulleywheel on the dynapod. Bent rims can be straightened to make the rim suitable for use. Rims can be "trued" by placing the tire hub in a vise and spinning the wheel. Hammer the rim where necessary. Loosen or tighten the spokes to further adjust the spin.

- Micrometer (0-25mm)
- Hacksaw
- Hammer
- Welding equipment (AC or DC with 4mm dia electrodes; or oxygen acetylene welder)
- Drill - with 14mm dia capacity
- Drill bits - 12mm and 14mm
- Center punch
- Adjustable wrench
- Vise
- Flat file
- Tap and die set (M-12) for cutting thread or pedal rod ends, and for producing flats on spindle ends)
- Tape measure
- Wood saw
- Small round file for cleaning out 10mm dia holes
- Large round file for 25mm holes
- Cement trowel
- Knife



Part No.	Description	Quantity
1	Top horizontals	2
2	Bottom horizontals	2
3	Front verticals	2
4	Rear verticals	2
5	Bearing members	2
6	Top traverses	2
7	Bottom traverses	2
8	Strut	1
9	Broomhandle-handlebars	1
10	Left-hand bicycle pedals	2
11	Left-hand bicycle cranks	5
12	Thrust washers	4
13	Bearing spindles	2
14	Bearing blocks	2
15	Bearing block clamping plates	2
16	Pedal rods	2
17	Wood pedals	2
18	Right-hand crank and sprocket	1
19	Pulley-wheel spindle	1
20	Concrete flywheel (2 parts sand to 1 part cement)	1
21	Bicycle rim (660mm dia)	1
22	Saddle brackets	2
23	Bicycle saddles	2

Figure 3. Dynapod Parts List

VI. CONSTRUCTION OF A TWO-PERSON DYNAPOD

Please read through carefully several times before assembling.

FRAME COMPONENTS

- Take 5cm X 5cm lumber and cut individual frame pieces to the dimensions given in Figures 4 through 10. Mark and drill holes in each frame piece and set pieces aside.

NOTE: All dimensions are in centimeters (cm), except where otherwise noted.

Material: 5cm X 5cm wood
No. Required: 2

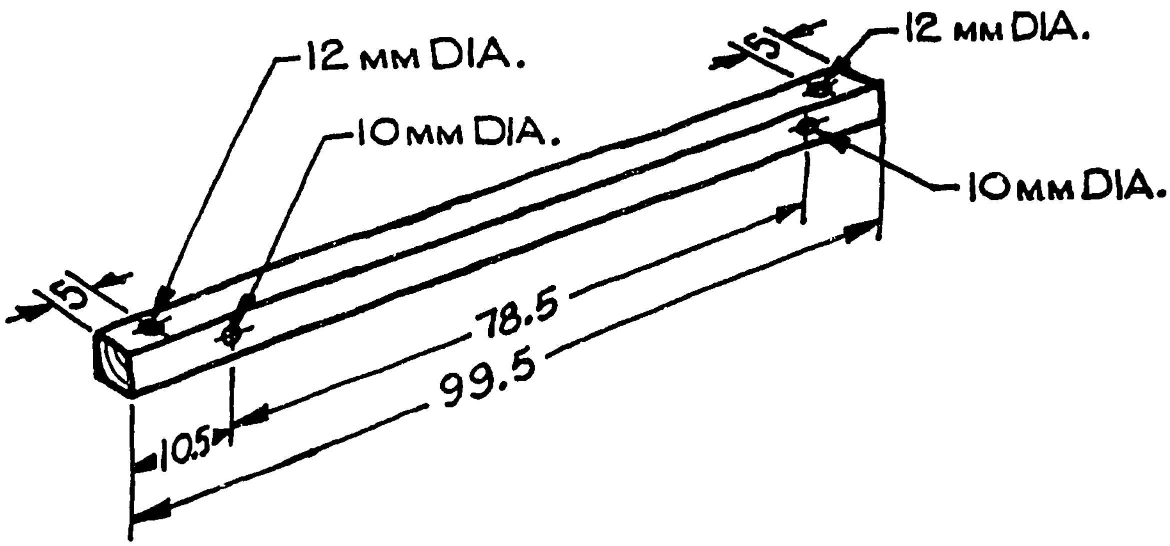


Figure 4. Top Horizontals

Material: 5cm X 5cm wood
No. Required: 2

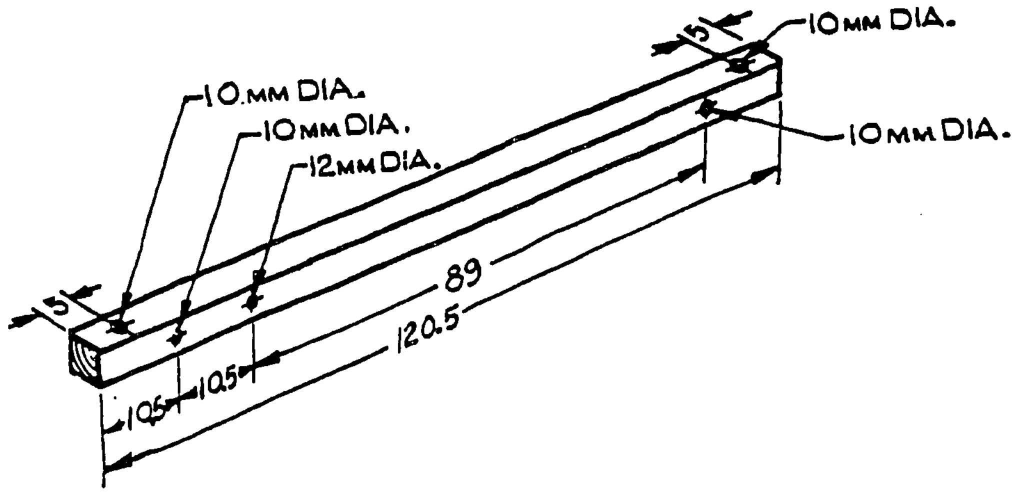


Figure 5. Bottom Horizontals

Material: 5cm X 5cm wood
No. Required: 2

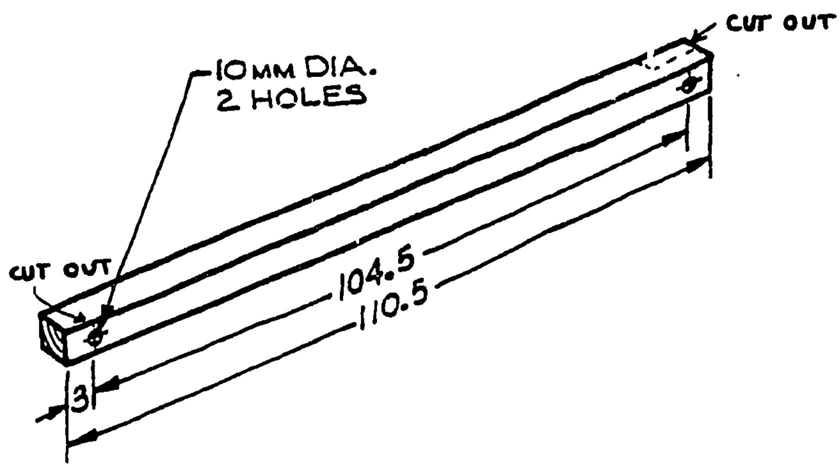


Figure 6. Bearing Member

Material: 5cm X 5cm wood
No. Required: 1

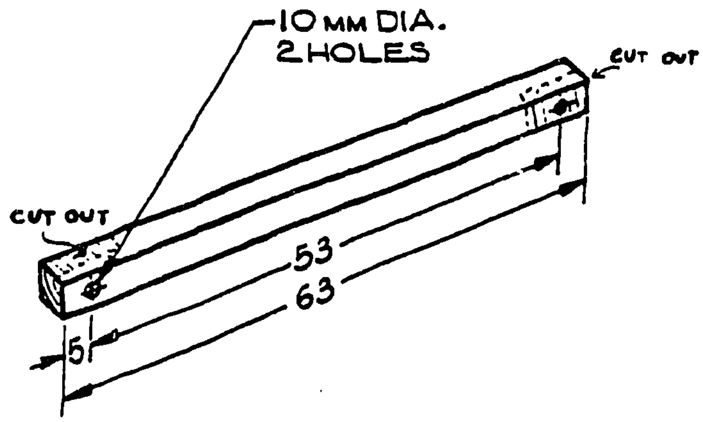
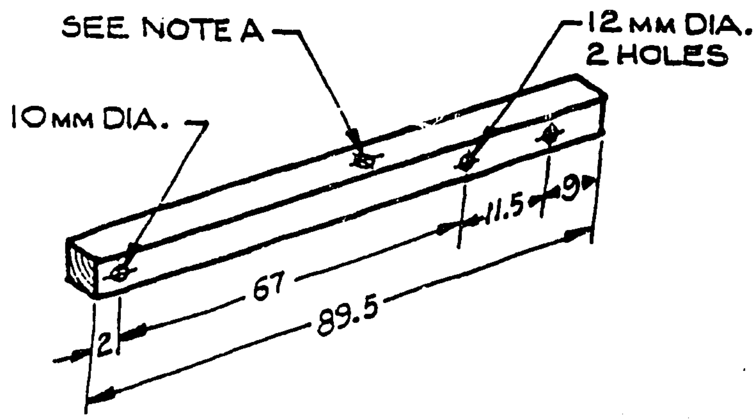


Figure 7. Strut

Material: 5cm X 5cm wood
No. Required: 2



Note: Drill 12mm diameter hole in one rear vertical only. Drill at assembly.

Figure 8. Rear Vertical

Material: 5cm X 5cm wood
No. Required: 2

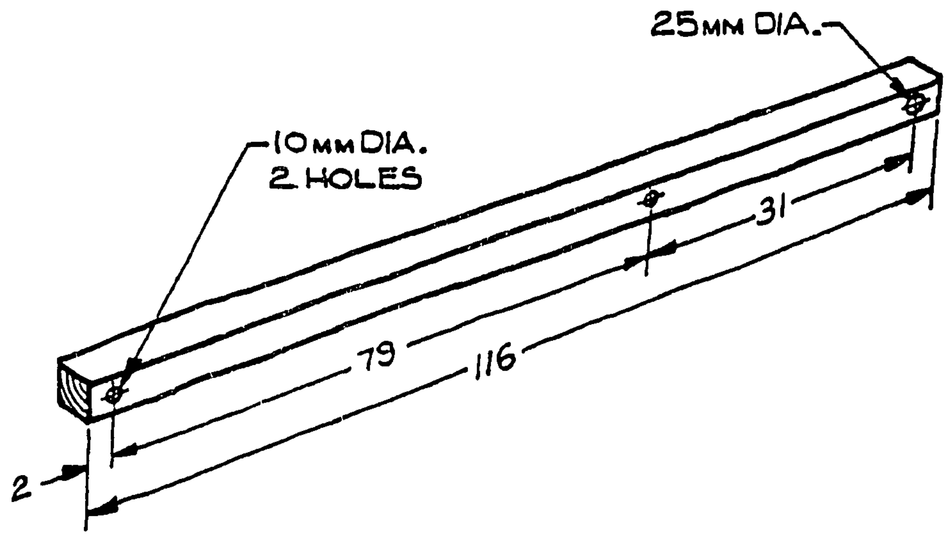
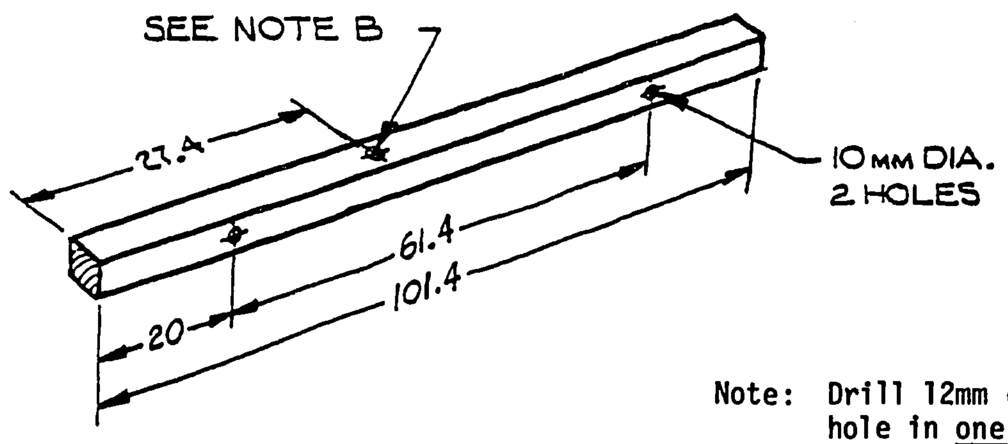


Figure 9. Front Verticals

Material: 5cm X 5cm wood
No. Required: 4, see Note



Note: Drill 12mm diameter hole in <u>one</u> bottom traverse <u>only</u>.

Figure 10. Top and Bottom Traverses

SPINDLES, SADDLE BRACKET, PEDAL, AND PULLEY WHEEL COMPONENTS

- Use welding equipment with cutting attachment--or use metal hacksaw--to cut out the thrust washers (Figure 11), saddle bracket plates (Figure 12), and bearing block clamping plates (Figure 13).
- With a pencil, mark the hole centers and bending lines.
- Drill holes.
- Cut saddle bracket tubes to size.
- Bend saddle brackets with hammer, using a vise.
- Hammer saddle brackets into their final shape around a 5cm X 5cm piece of lumber.
- Mount and weld tube to saddle bracket. Set aside.

NOTE: Measurements in millimeters (mm) except where otherwise noted.

Material: 3mm mild steel plate
No. Required: 4

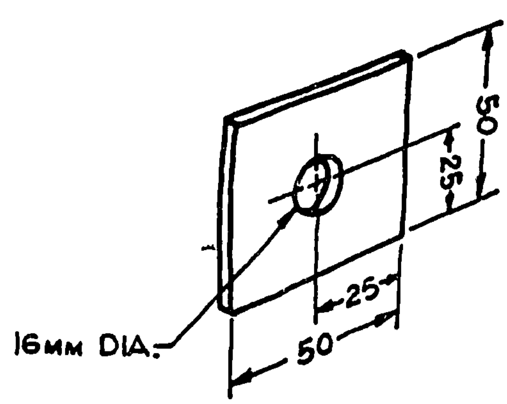
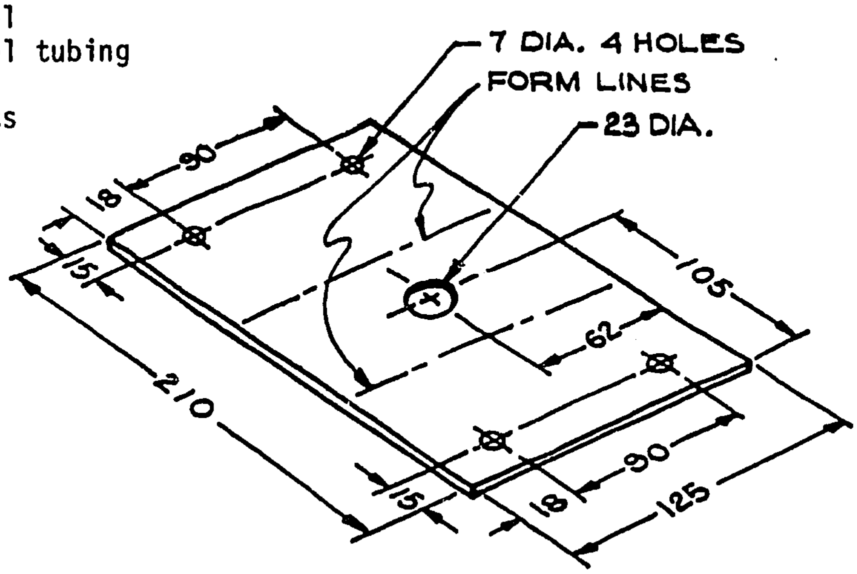


Figure 11. Thrust Washer

Material: 3mm mild steel
22.1 dia steel tubing

No. Required: 2 brackets



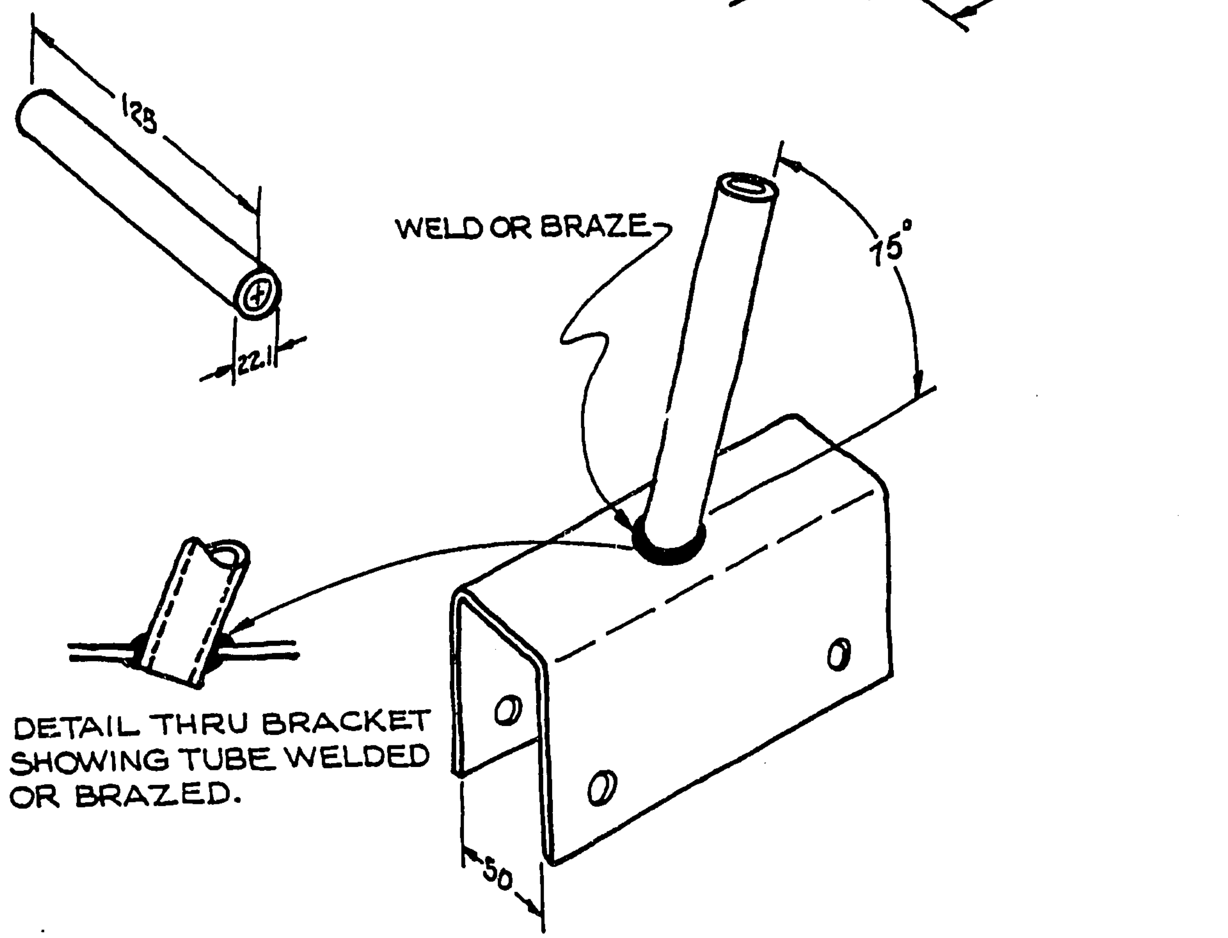


Figure 12. Saddle Bracket

Material: 3mm mild steel
No. Required: 2

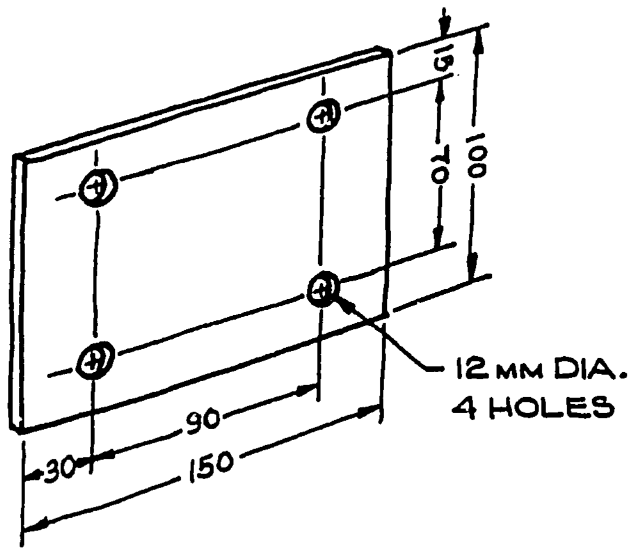


Figure 13. Bearing Block Clamping Plate

- Use a metal lathe with 25mm and 30mm dia chucking capacity. Turn the three spindles and the two pedal rods to the dimensions in Figure 14 and 15.

Material: mild steel
No. Required: 2

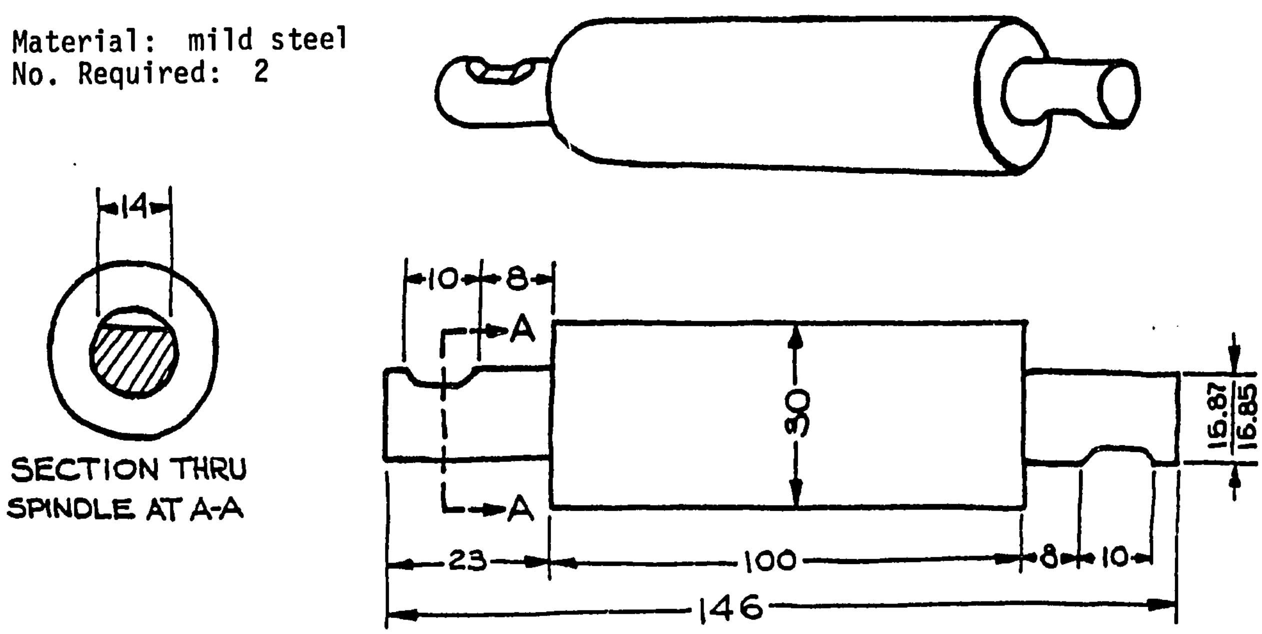


Figure 14. Bearing Spindle

Material: mild steel
No. Required: 1

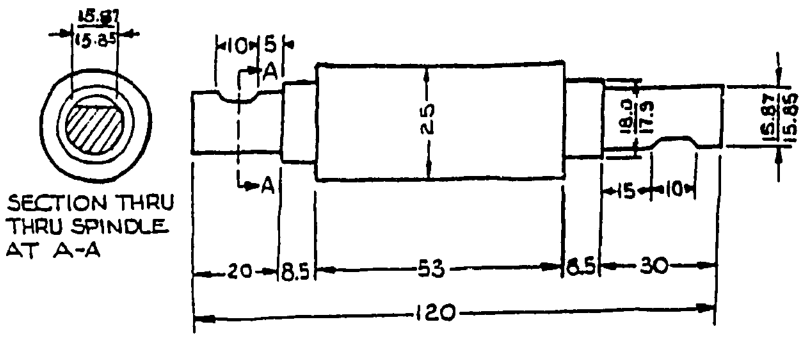


Figure 15. Pulleywheel Spindle

- File flat sections onto spindle ends. Great care must be taken so that the flats are as near 180° to each other as possible. They should also be exactly the right length (approximately 14mm). This can be checked by assembling the spindle to a crank. It may be better to leave the flats slightly short and, if necessary, file them longer when assembling.

  (If using the dynapod for direct drive with both clockwise and counterclockwise movement, one end of each bearing spindle must be made longer (see page 30).

- Cut M-12 threads on both ends of the pedal rods (2) with the dies and wrench (see Figure 16). Set aside.

Material: mild steel
No. Required: 2

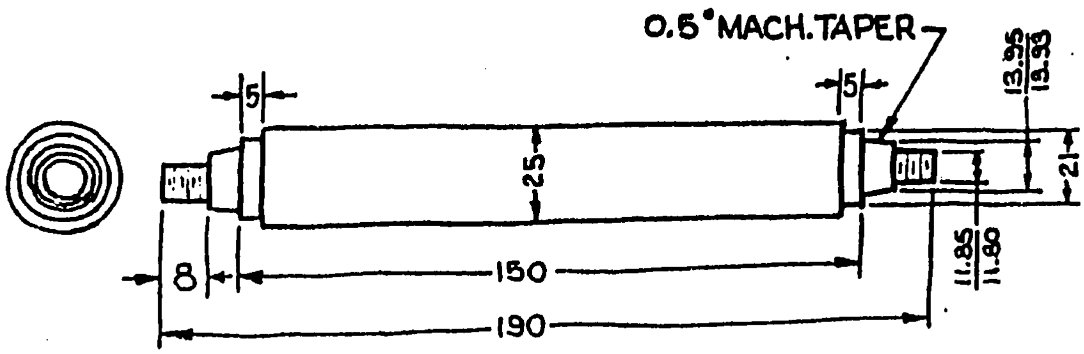


Figure 16. Pedal Rod

- Cut wooden pedals to length (see Figure 17). Drill a 26mm dia hole the entire length of the pedal. If necessary, file out the hole.

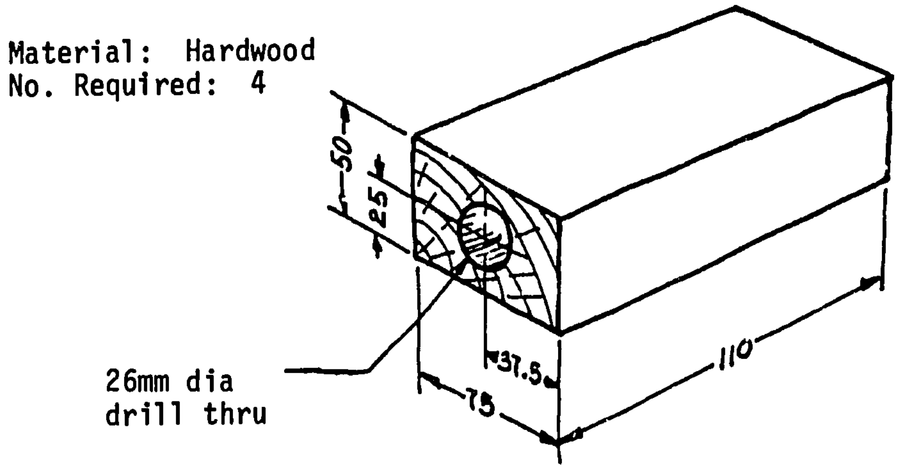


Figure 17. Wooden Pedals

- With the 14mm bit, drill out the threads in the right-hand crank and three of the left-hand cranks (see Figure 18). (Old cranks with worn threads can be used here, if available.)

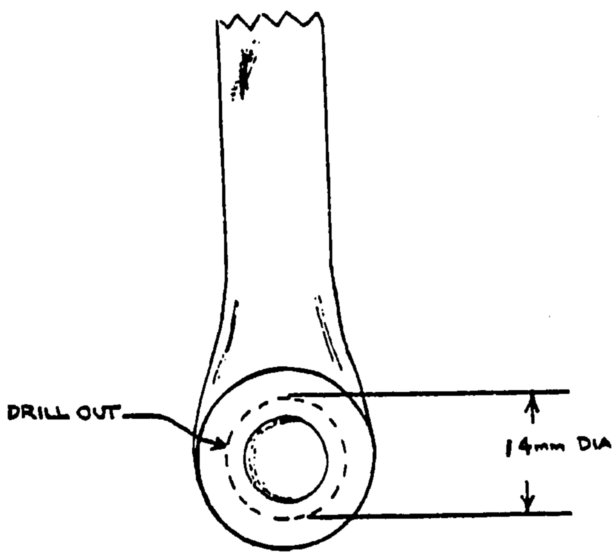


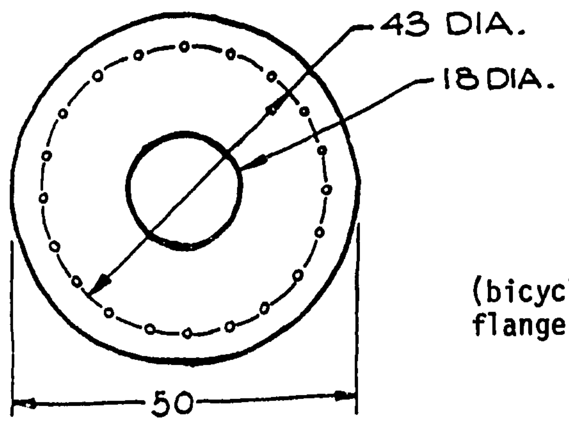
Figure 18. Bicycle Crank -- Bottom Section

- Slide wooden pedals onto the pedal rods. With a hammer and a short piece of 15mm dia pipe, tap the four cranks onto the tapped ends of the pedal rods. DO NOT damage the thread at the ends of the pedal rods.

- Fasten 12mm dia nuts onto the ends of the pedal rods.

- Cut two spoke flanges from the old bike rim, or made as shown in Figure 19.

Material: 2mm sheet steel
No. Required: 2



(bicycle rear hub flanges may be used)

Figure 19. Spoke Flange Blank

- Fit them onto the pulleywheel spindle (see Figure 20), 53mm apart, as on a normal bicycle rear hub. Weld the spoke flanges to the spindle. Keep the spoke holes undamaged so that the spokes can be reinserted.

Material: Mild steel
No. Required: 1

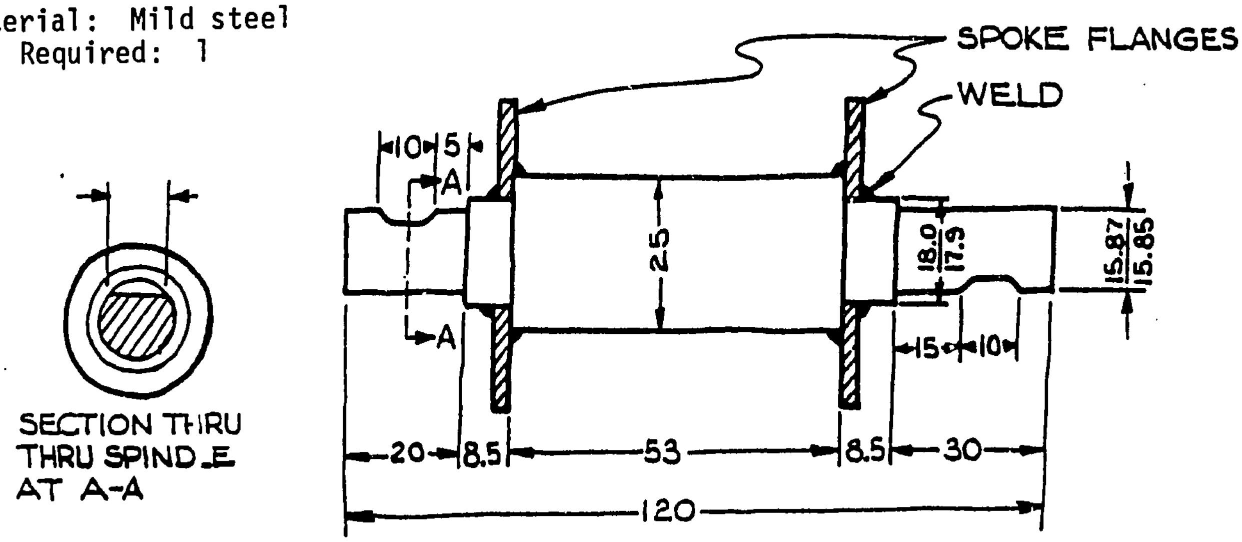


Figure 20. Pulleywheel Spindle

Two different types of spoke flanges may be used with two different types of pulleywheel spindles. These are: (a) cold-drawn spoke flanges taken from a dismantled rear hub (in this case a 30mm dia spindle); or (b) homemade spoke flanges. These can be made easily with a punch and drill, using another spoke flange as a pattern. The pulleywheel spindle itself can be made from 25mm dia bar, as with the pedal rods. In either case, the dimensions of the pulleywheel spindle remain the same, except for the inside diameter.

BEARINGS

- Cut bearing blocks to the dimensions given in Figure 21.

Material: Wood
No. Required: 2

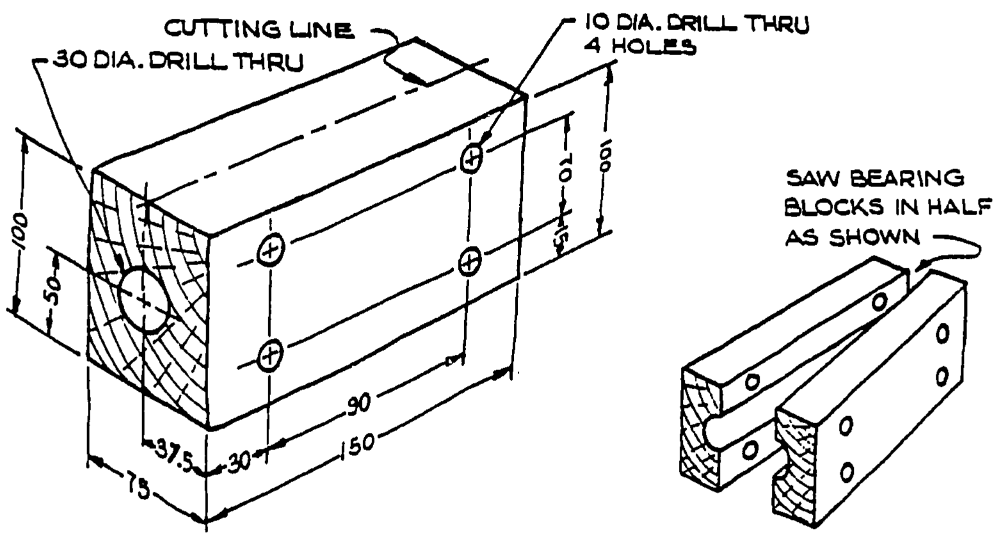


Figure 21. Wooden Bearing Block

- Join the bearing clamping plate to the bearing block and drill through the four holes.

- Drill a 30mm dia hole through the wood block as shown in Figure 21 above. Mark a cutting line around the block and saw in half.

- Boil the bearing blocks gently in old engine oil or vegetable oil for 20 minutes or more--until the bubbles coming from the wood become very small. The wood blocks must be weighted to keep them below the surface of the oil.

- Remove the oil container from the heat source. Allow the blocks to cool slowly while they are still below the surface of the oil. This prevents the blocks from cracking.

ASSEMBLE THE MAIN DYNAPOD STRUCTURE

- Bolt together two sets of pre-cut front vertical, rear vertical, top horizontal, and bottom horizontal wood members. When passing a 10mm dia bolt through a 10mm diam hole and a 12mm dia hole, it is easier to drive the bolt into the 10mm hole before attaching the 12mm wood section.

- Bolt the bearing members to the two side frames.

- Bolt the two side frames together with the top and bottom traverse sections.

- Bolt the strut section to the bottom traverse, and drill a 10mm dia hole through the rear vertical. Bolt the strut to the rear vertical post.

PULLEYWHEEL ASSEMBLY

- File smooth any rough edges or spots to prevent damage to the pulleywheel belt that will be attached later.

- Remove all the spokes from the rim.

- Take the pulleywheel spindle with hub flanges attached and reinsert the spokes into the flanges.

- Reattach the rim to the pulleywheel spindle with the spokes. It is preferable to use a rim with 40 spokes to correspond with the 40 holes in the rear hub flange (see Figure 19 on page 24).

- Connect the left-hand crank with the bearing spindle, the pedal rod unit, and the pulleywheel spindle and rim. From the rim, working toward the right, fit the other pedal rod unit to the right bearing spindle. That spindle attaches to the right bicycle crank, as shown in Figure 22.

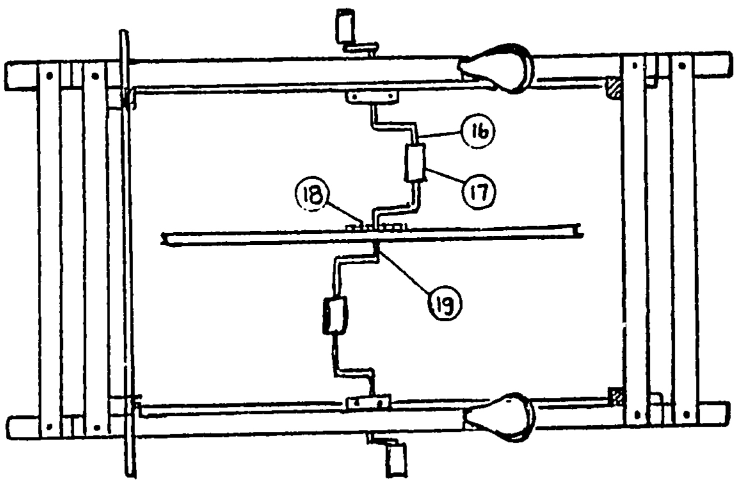


Figure 22. Top View

- Be sure that the right-hand crank and chain wheel are attached to one end of the pulleywheel spindle.

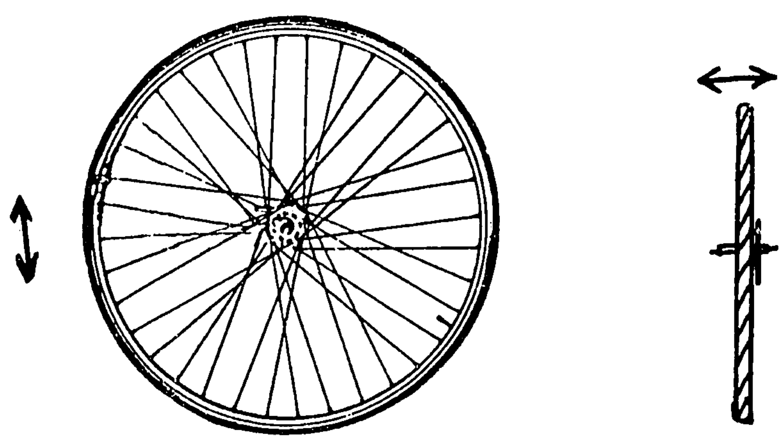
- Fit the thrust washers to the bearing spindle ends before fitting the cranks.

- Hammer the six cotter pins in place.

- Attach the bearing shaft unit to the bearing members with the wooden bearing blocks. The half-blocks should be separated by one or two washers. This makes up for the wood lost when sawing them in half.

- Test the pulleywheel for even running and smooth fit. Some uneven spinning is almost certain to occur. It can be remedied easily by adjusting the spokes. A spoke may be too long or too short for the hole it occupies. It may be necessary to move it to another hole. After fitting as many spokes as possible, any left over without a rim hole can be removed or cut off with a pair of pliers.

- Tune the spokes first for vertical concentricity of the rim, and then for lateral concentricity (see Figure 23).



Vertical Lateral

Figure 23. Rim Concentricity

- Once the wheel is reasonably concentric, tighten all the spokes to approximately the same tightness. They should all make roughly the same sound when struck with a fingernail or metal object.

- Be sure to saw or cut off any spoke ends that stick out from the rim. This protects the rim tape.

- Attach the rim tape.

- Turn the dynapod frame on one side. Concrete is now going to be added to the wheel. This will make the wheel heavier. A heavier wheel is harder to get going, but it then provides more power with less effort. Think of the potter's wheel.

- Fit pieces of cardboard between the spokes. The idea is to partition the wheel completely from the rest of the dynapod. The wheel should be separated completely, from its hub to its rim.

- Mix half the sand and cement. The ratio is two parts sand to one part cement. Add water until the mixture becomes thick and resembles paste.

- Fill the wheel with concrete. Be sure to cover the spokes. Use only as much concrete as necessary to cover the spokes and fill the inside of the bicycle rim. If too much concrete is used, the wheel becomes too heavy, it cannot be supported. More cement can be added later if necessary.

- Remember that the concrete at the outside of the wheel is much more effective for the flywheel effect than concrete at the center of the wheel.

- Let the cement set for 24 hours before turning the frame to the other side. Now repeat the procedure, allowing enough clearance next to the chain wheel for the chain.

- Cut a suitable length of wooden rod. Drive it through the two 25mm dia holes in the front verticals.

- Position and mark the saddle brackets on the top horizontal supports. Remove the brackets. Chisel or drill away some of the support to provide clearance for the bottom end of the saddle bracket tube.

- Clamp the saddle brackets in position and fit the saddles. If more vertical adjustment is desired, some of the saddle bracket tube can be sawed off.

- Fit the belt or chain by removing one bearing half-block from one side, then refitting. The bottom section of bearing block can be prevented from slipping during this procedure by driving a small nail into the bearing member just below the block.

DIRECT DRIVE

This form of power transmission gives the high torque necessary for a flour mill or grain thresher, without the problems associated with chain drive. Because of shaft alignment problems, a flexible coupling (see Figure 24) is usually needed.

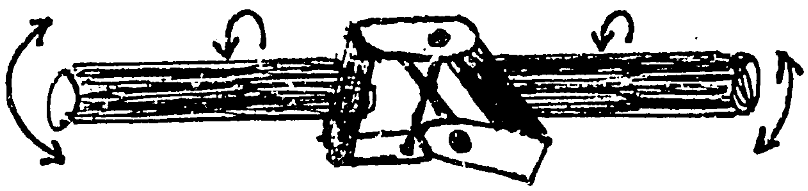


Figure 24. Flexible Coupling

When the dynapod is to be used for direct drive, it is necessary to make a special adaptor as shown in Figure 25. If both clockwise and counterclockwise drive are needed, one end of each bearing spindle must be made longer. The 15.88mm dia must be made 40mm long instead of 23mm long. The only disadvantage of the direct drive is the expensie of a flexible coupling.

All dimensions are in millimeters unless otherwise indicated.

Material: Mild steel
No. Required: 1 each

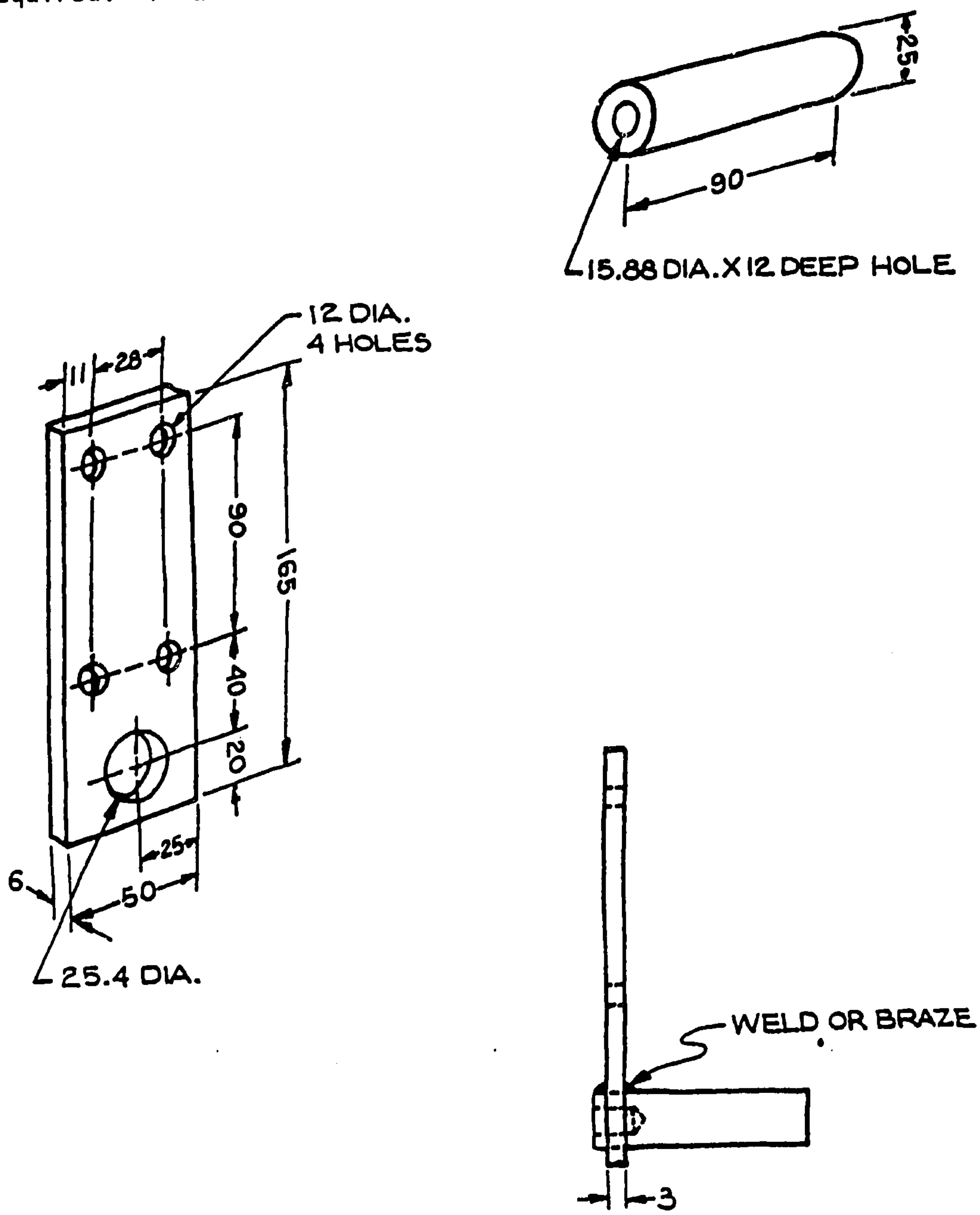


Figure 25. Direct Drive Adapter

All dimensions are in millimeters unless otherwise indicated.

Material: 3mm sheet steel
No. Required: 5

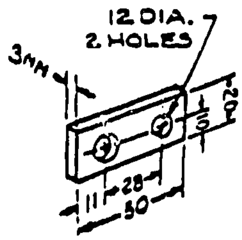


Figure 26. Outer Clamping Plate

Material: 3mm sheet steel
No. Required: 3

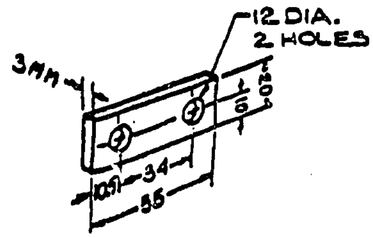


Figure 27. Inner Clamping Plate

Material: Make from Outer
Clamping Plate
No. Required: 4

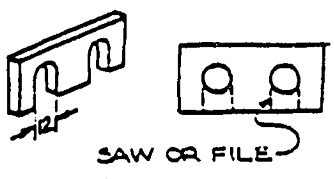


Figure 28. Outer Spacers

Material: Make from Inner
Clamping Plate
No. Required: 2

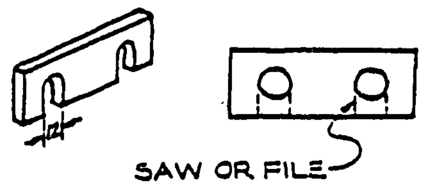


Figure 29. Inner Spacers

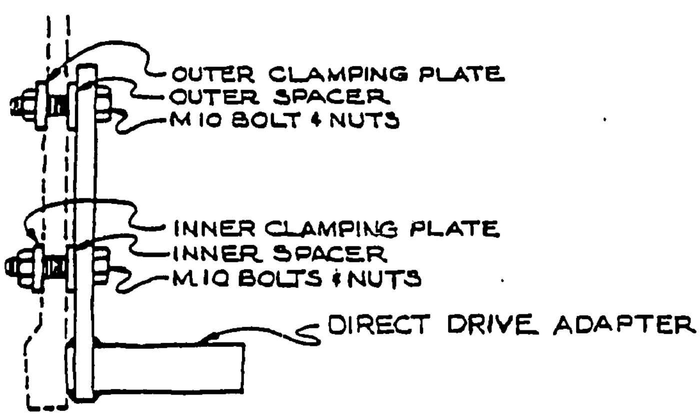
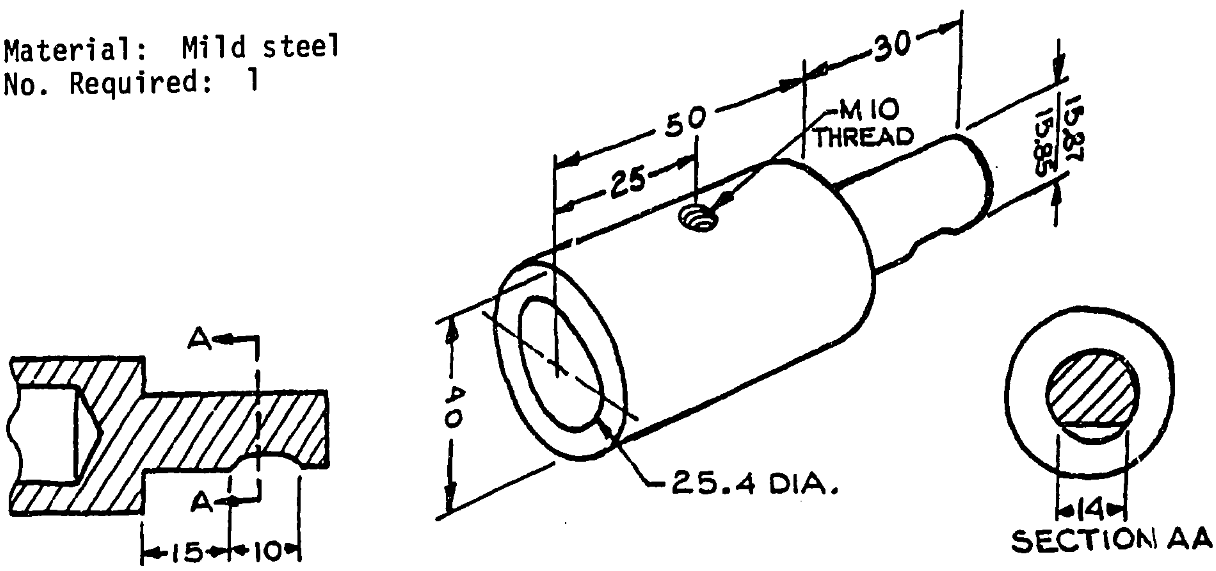


Figure 30. Mounting Arrangement for Adapter

CHAIN DRIVE

Approximately 1.5 bicycle chains are needed. They can be joined by two links. The chain can be halved by driving out one of the link rods with a hammer and punch (or nail). A modified chainwheel is fitted by an adaptor (see Figure 31) to the device to be powered.

Material: Mild steel
No. Required: 1



All dimensions are in millimeters unless otherwise noted.

Figure 31. Chainwheel Adapter

The chainwheel is modified by cutting off the crank and fixing it to the adaptor with a cotter pin. The adaptor is then held to the machine's shaft by a setscrew. The machine's shaft has to be drilled 6mm deep in order to prevent the setscrew and adaptor from slipping.

Because the chainwheel on the dynapod is slightly off center, the chain tends to tighten and slacken once per revolution. This may cause the chain to come off the chainwheels. The problem can be remedied by mounting the device to be driven (e.g., flour mill) on a flexible platform, as shown Figure 32. In this way, the device to be powered moves back and forth only slightly, thus maintaining chain tension.

Note: The dynapod chainwheel is shown on the left-hand side for clarification only.

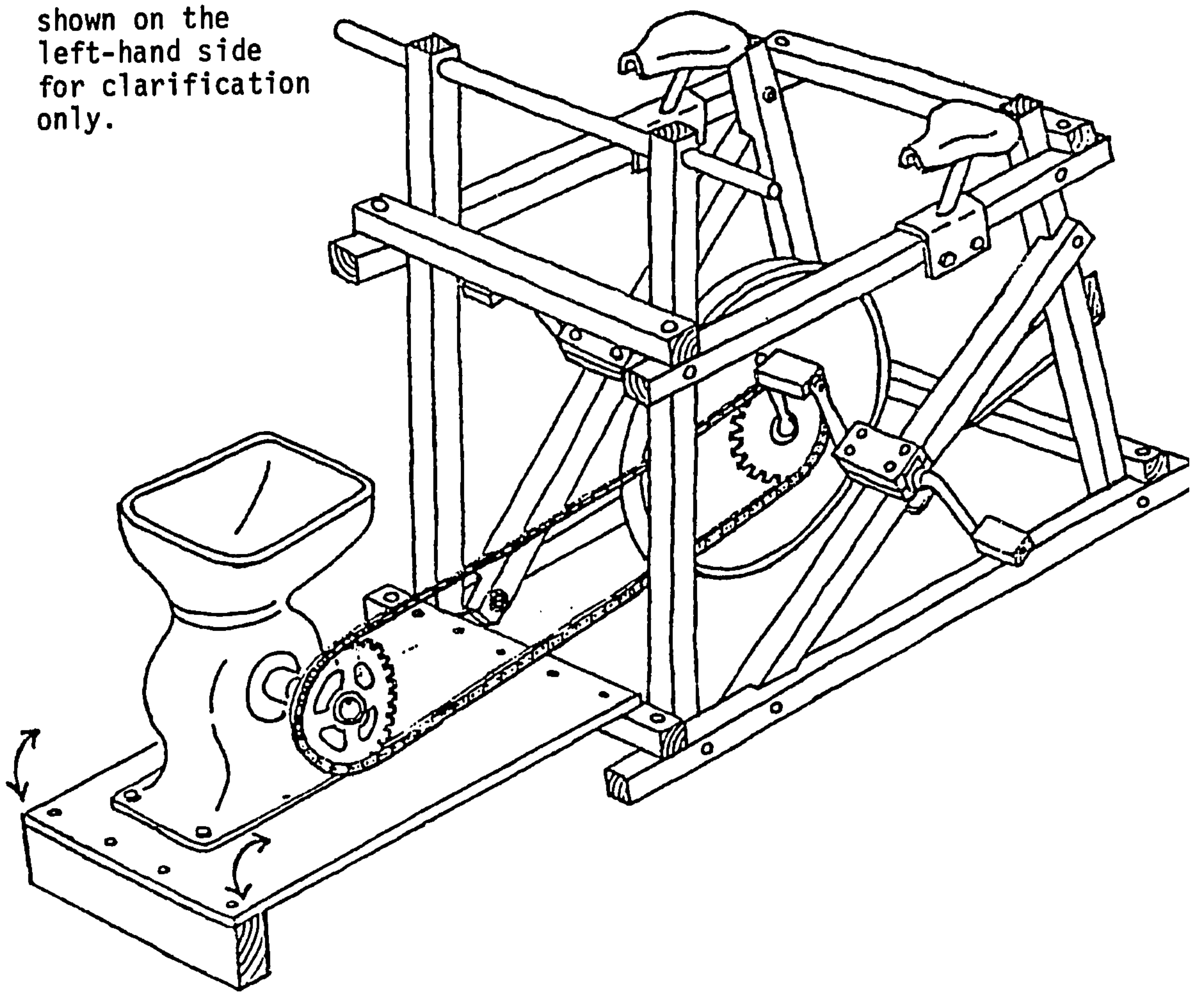


Figure 32. Dynapod with Chaindrive Mill on Mounting Platform

BELT DRIVE

Approximately 3 meters of 10mm-wide belt is needed. The following kinds can be used:

- Ordinary rope spliced to form a continuous belt.
- Conventional V-belting of appropriate length. The grip on the pulley is better than with rope drive.

"Optimat" belting (West Germany). This is similar to conventional V-belting, but has holes at 5mm intervals and is joined by a special fastener. It can be cut to any length and is unfastened easily.

- "Brammer" belting--short overlapping lengths of rubber connected by steel rivet-like fasteners at approximately 1cm intervals. It can be fastened and unfastened at any length. But the fasteners tend to damage the pulley, especially if the metal is soft, as with aluminum (Brammer V-Link Belting Ltd., Hudson Road, Leeds 9, United Kingdom).

- Eaton V-Belting--hollow polyurethane tubing that can be cut to the required length. It is joined by an aluminum fastener or fused together by gentle heat. The grip on pulleys is very good but unfastening with a conventional fastener is impossible. Figure 33 shows a fastener made of mild steel that will unscrew. Fasten this to the belting in a normal way and unfasten by unscrewing. Be sure to pretwist belt before refastening. (W.G. Eaton, Ltd., 18 Freeman Street, Birmingham, United Kingdom.)

Material: Mild steel
No. Required: 1 each part

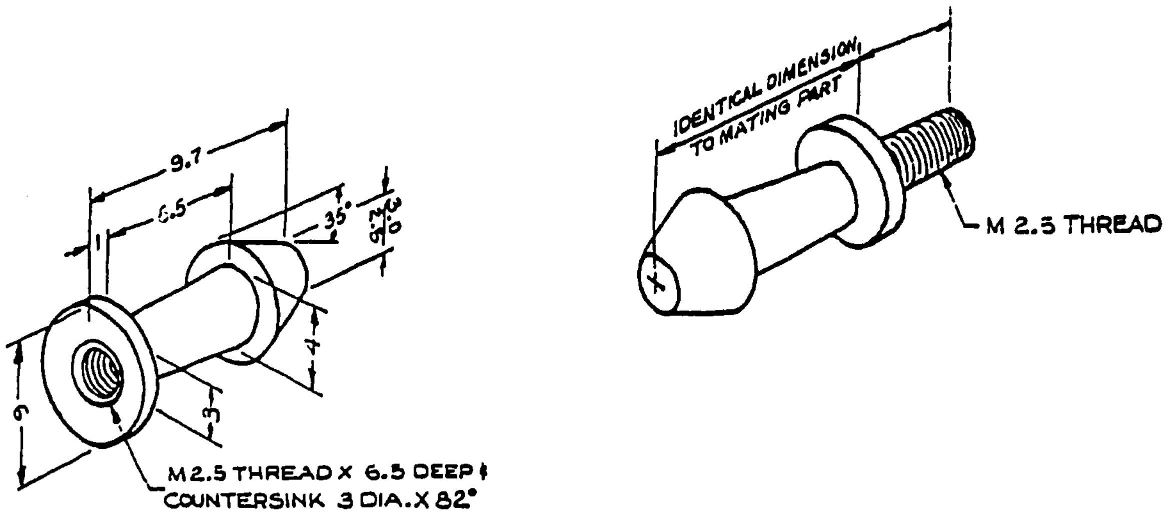


Figure 33. Modified Eaton V-Belting Fastener

All of these belts work well, but the Eaton belting is most satisfactory for a wide range of power transmissions. A pulley needs to be attached to the device to be operated. The pulley is usually attached with a setscrew.

VII. MAINTENANCE

The only wearing parts of the dynapod are the bearing blocks and the pedals. Wooden pedals can be replaced by split wood pedals screwed together. Apart from this, there may after a year or so be fatigue failure at highly loaded points, e.g., where the cranks join the pedal-rods or the spindle ends.

If wear occurs on the bearing blocks, remove some of the washers from between the blocks. If more wear occurs, remove wood from the faces of the half-blocks. use a wood file. If the hole wears outwards, make and fit new blocks.

After some time the flat areas on the spindles will wear. It may be necessary to weld the spindles to the cranks.

Check regularly the nuts and bolts holding the wood frame together. They tend to work loose after a time. This problem can be solved in three ways:

- Use two nuts on each bolt instead of one.
- Use more expensive, self-locking nuts.
- Flatten the threaded end of the bolts with a hammer after the nut has been tightened. This stops the nut from falling off if it loosens, but prevents the bolt from being re-used.

Oil all moving parts on a regular basis to keep parts moving freely and reduce wear.

VIII. DICTIONARY OF TERMS

ADAPTED--Changed or modified to fit a particular situation or need.

AXIS--A straight line about which a body or a geometric figure rotates or may be supposed to rotate.

BRACE--A piece of material that serves as a tie or strut to reinforce or support weight or pressure.

BRAZE--Light welding together of two pieces of metal using solder.

CONCENTRIC WHEEL--A wheel having its axis of revolution centered or balanced.

COUNTERSINK--To enlarge the top part of a hole so that a screw or bolthead will lie flush or below the surface.

DIA (Diameter)--The thickness or width of a round object.

DIES--Devices for cutting out, forming, or stamping material; for cutting threads on screws or bolts.

DYNAPOD--A pedal-powered device using human feet for energy.

ECCENTRIC WHEEL--A wheel having its axis of revolution displaced from its center so that a reciprocating motion occurs.

ECCENTRICITY--Deviation from the normal, conventional, or expected.

FITTINGS--Devices with which surfaces are adjusted or adapted to each other such as in a machine or collection of parts.

FLANGE--A protruding rim or edge as on a wheel or a pipe, used to strengthen an object, hold it in place, or attach it to another object.

FLYWHEEL--A heavily-rimmed rotating wheel used to minimize speed variation in a machine subject to fluctuation in drive and load.

HACKSAW--A saw consisting of a tough, fine-toothed blade stretched taunt in a frame, used for cutting metal.

HANDLEBAR--A curved metal steering bar, as on a bicycle.

ID (Inside Diameter)--The distance of a straight line connecting two sides of the interior of a cylinder and passing through the center of the cylinder.

MICROMETER--Any device for measuring minute distance, especially one based on the rotation of a finely threaded screw.

OD (Outside Diameter)--The distance of a straight line connecting two sides of the exterior of a cylinder and passing through the center of the cylinder.

OPTIONS--Something chosen or available as a choice.

POTTER'S WHEEL--A device composed of a revolving, treadle-operated horizontal disc upon which clay is shaped manually.

SETSCREW--A screw often without a head, used to hold two parts in a position relative to each other without motion.

SPACER--A washer or similar device used to separate two or more adjoining surfaces.

SPINDLE--Any of various mechanical parts that revolve or serve as axes for larger revolving parts, as in a lock or axle.

SPOKE--One of the rods or braces that connect the hub and the rim of a wheel.

STATIONARY--Fixed in a position, not moving.

STRUT--A bar or rod used to strengthen a framework.

TAP--A tool for cutting an internal screw thread.

THRESHER--A machine that beats the stems and husks of grain or cereal plants to separate the grain or seeds from the straw.

TORQUE--A turning or twisting force.

TRAVERSE--To travel across, over, or through; a structural crosspiece.

VERSATILITY--Having varied uses or applications or serving many functions.

WINCH--A stationary motor-driven or hand-powered hoisting machine having a drum around which a rope or chain winds as the load is lifted or moved.

WINNOWER---A machine used to separate the chaff from grain or seed by means of a current of air.

IX. 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

*At 62 degrees Fahrenheit (16.6 degrees Celsius).

X. FURTHER INFORMATION RESOURCES

Darrow, Ken and Pam, Rick. Appropriate Technology Sourcebook. Volunteers in Asia, Stanford, California, 1976. Chapter on pedal power contains a list of several publications dealing with the subject. Each publication is evaluated for its usefulness, especially in a developing country situation. Has no real plans outside of its book reviews.

Dar Es Salaam Liberation Support Group. Transport Bicycle. Dar Es Salaam Liberation Support Group, PO Box 2099, Dar Es Salaam, Tanzania.

Intermediate Technology Development Group. Cassava Grinder. ITDG, 9 King Street, Covert Gardens, London SC2E 8HN, England; or American distributor: International Scholarly Book Services, PO Box 555, Forest Grove, Oregon 97116 USA.

Intermediate Technology Development Group. Treadle Operated Peanut Thresher--Complete Technical Drawing #20. Five 24" X 36" sheets of technical drawings with 3 pp of instructions. ITDG, 9 King Street, Covert Gardens, London SC2E 8HN, England; or American distributor: International Scholarly Book Services, PO Box 555, Forest Grove, Oregon 97116 USA.

International Rice Research Institute. Diaphragm Pump. Available to serious groups from International Rice Research Institute, Agriculture Engineering Department, PO Box 933, Manila, Philippines.

Marks, Vic. (ed.). Cloudburst. Wayne Island, British Columbia, Canada, Cloudburst Press, 1973. Has a short section on a treadle-driven lathe. Contains plans for building the lathe described. The treadle principle could be adapted for other uses as well.

McCullogh, James C. (ed.). Pedal Power. Rodale Press, Emmaus, Pennsylvania, 1977. Probably the most complete work on the subject. Has several useful designs for various pedal operated machines as well as a new dynapod design. Also has chapters on the history and future of pedal power.

SPATF. Thresher for Rice and Other Small Grains. SPATF, Office of Village Development, PO Box 6937, Boroko, Papua New Guinea.

VITA. "Bicycle Powered Pump," Vita Technical Bulletin #27. VITA, 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822 USA.

VITA. "Foot Powered Wood Lathe," VITA Technical Bulletin #26. VITA, 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822 USA.

Weir, Alex. Pedal-Powered Thresher and Winnower. Available from Alex Weir, Facility of Agriculture, University of Dar Es Salaam, Box 643, Morogoro, Tanzania.

APPENDIX I

DECISION MAKING WORKSHEET

If you are using this as a guideline for using the Dynapod 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.

Volunteers in Technical Assistance
3706 Rhode Island Avenue
Mt. Rainier, Maryland 20822 USA

CURRENT USE AND AVAILABILITY

- Are bicycles widely used in the area? If so, for what? Is pedal power a familiar concept?
- Are other pedal-powered technologies in use? If so, are they agricultural (grain threshers and winnowers) or other (cargo vehicles for goods and people)?
- If pedal power is not used widely, what are the limiting factors? Are there cultural reasons for the lack of acceptance of pedal power, e.g., women will not straddle a pedal-powered machine? Or is it a lack of knowledge of the range of pedal-power technologies?

IDENTIFY THE APPROPRIATE TECHNOLOGY

- Is there a choice between a pedal-power application and another renewable energy technology? For example, if the need is for pumping water for irrigation, is that need best filled by a pedal-powered pump? Or could it be filled by a windmill? Which would cost more? Some considerations are:

  - Initial costs of materials and labor for each technology.
  - Social and cultural tradeoffs.
  - Maintenance costs.
  - Durability.

- A dynapod requires more human labor than do some other applications. For example, a pedal-powered irrigation pump may not be as desirable as a windmill-powered pump, even if it costs less at first.

- Are there current technologies that could be adapted easily to pedal power, e.g., grain threshers that can be pedal-powered rather than hand-powered?

- If bicycles are not currently repaired in the community--even though bicycles are available--is such a business feasible? If such a business is feasible, what effect would it have on the introduction of pedal-power technology? Is there a possibility here for a small business enterprise?

NEEDS AND RESOURCES

- Based on current methods and techniques, particularly in agriculture and transport, which areas most need attention?

  - Does the local population consider pedal power an important need? Why or why not--and how do you know?

  - If they don't consider pedal power important, how much response can you expect to your efforts.

- Has any local person, particularly someone in a position of authority, expressed any interest in this technology? If so, can someone also be found to help introduce the technology? Are there local officials who could be tapped as resources?

- What current pedal power technologies exist to respond to the needs identified?

- Are bicycles and/or other pedal-power units available and manufactured locally? Are bicycles repaired locally? Are parts available? Are tools and materials available?

- 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?

  - Some aspects of the dynapod project require someone with experience in metalworking and/or welding.

  - Estimated labor time for full-time workers is:

    - 12 hours skilled labor
    - 24 hours unskilled labor

  - If this is a part-time project, adjust the times accordingly.

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

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

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

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

FINAL DECISION

- How was the final decision reached to go ahead--or not to go ahead--with this technology?

APPENDIX II

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 much very specific information. This kind of detail can often be monitored most easily in charts (such as the one below).

<u>CONSTRUCTION</u>

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

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- 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.

MAINTENANCE

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

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

Helical Sail Windmill

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 for Tropical Climates

Solar Water Heater

Solar Still

Making Charcoal: The Retort Method

Solar Grain Dryer

Animal-Driven Chain Pump

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

Publications Service
Volunteers in Technical Assistance
3706 Rhode Island Avenue
Mt. Rainier, Maryland 20822 USA