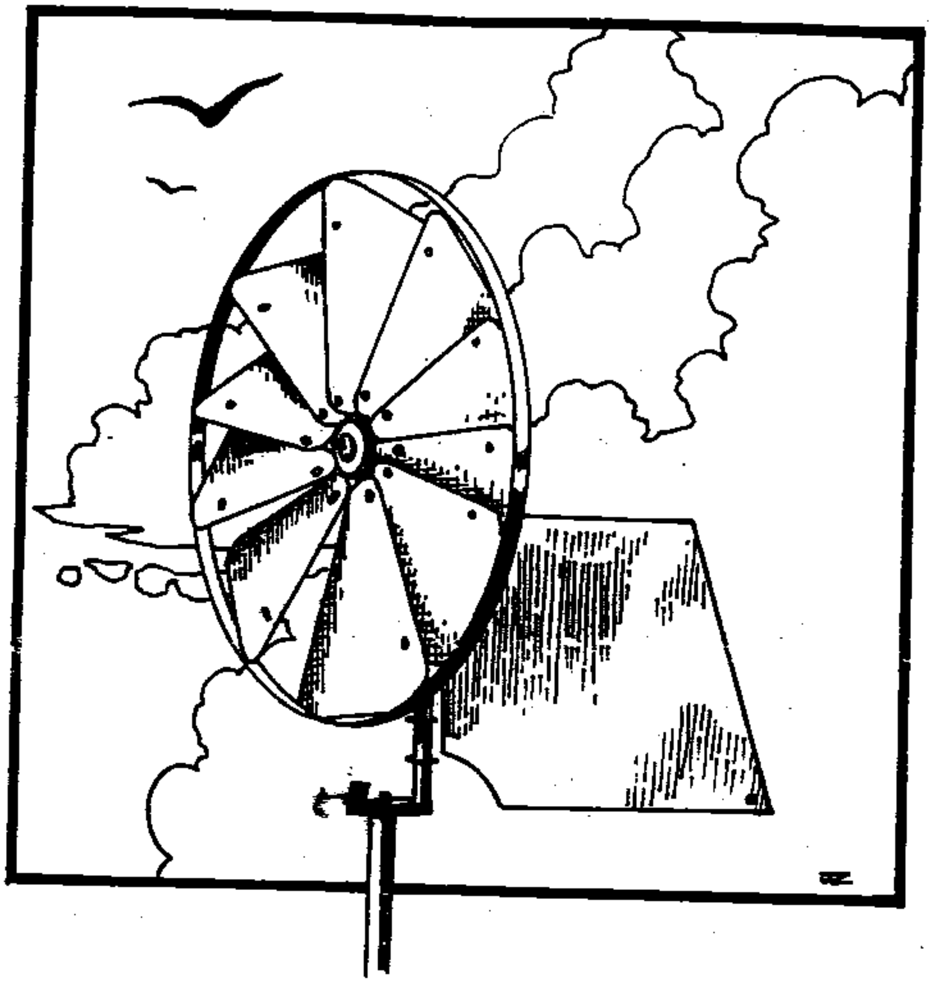
D.I.Y. PLAN NO.1

BICYCLE WHEEL WINDMILL



This plan describes how engineers at the Centre for Alternative Technology made an electricity-generating multi-blade windmill from a dyna-hub bicycle wheel. This machine produces a maximum of 5 Watts and about 150 WattHours over a week, although this output will of course vary widely depending on wind availability at the site and the tower height. It could be used for teaching or experimental purposes, or for battery charging for powering electric fences or lamps.

The plans, compiled from engineers' notes, are largely a report of our own experience of building such a machine, with diagrams, some specific instructions, and tips for alternative methods and approaches. They are not prescriptive in every detail, but we hope they will provide inspiration for DIY enthusiasts and for CDT and science students undertaking practical projects.

The multi-blade (American) windmill is a slow-turning machine with fairly high torque, and with a blade tip speed roughly equal to that of the wind. The one we have made begins to charge a 6 volt battery in a 3 m/s (6mph) wind, or a 12 volt battery at 4 m/s (8mph). It should withstand at least Force 8 gales.

Two versions are described. The simpler version leaves the vanes at a fixed angle. The second version incorporates an extra belt device for (manually) varying the pitch of the blades to increase its value for teaching and experimental purposes.

1. MATERIALS, TOOLS AND COSTS

MATERIALS

Cycle wheel and dynahub - for rotor.
In our experience, new cycle wheels with dynahubs are now difficult to find but it should still be possible to get one second-hand. The construction should not result in irreversible damage, so for school project work it is possible to use the same one again and again. Three wheels here at CAT have been re-used many times on educational courses.

Sheet metal - for vanes and tail.
Approx. 1 sq.m. (10 sq.ft) of 0.5-1mm (26-20SWG) thick sheet.
Almost any material will do: aluminium, tin, zinc, galvanised iron, or even cardboard if the machine is just a model for dry-weather use.

Scrap iron - for mounting.
0.5m of approx. 5mmx50mm strip (1'10"x¼"x2")

Old cycle hub - for mounting.
Front or rear, without 3-speed

Aluminium tube (ex-T.V. aerial) or wood dowel - for tail spar
Two 0.5m pieces, about 12mm dia (1'10"x½")

Scaffold pole or wooden pole - for tower.

Aluminium glazing bar - for variable pitch device only.

Nuts and Bolts
35 M4x25mm (4BA x1", 3/16" Whitworth etc.) or pop rivets 4mm or 5mm (5/32" or 3/16")

Self-tapping screws
6 No.8 x 25mm (No.8 x 1")

Diodes - for converting output to DC.
4 x 1 amp 200V PIV

Cardboard - for template.

TOOLS

Basic metalwork tools (no power tools needed) plus:

Tin snips (essential) or guillotine (very helpful)
Pop rivetter (optional, but very desirable time-saver)
Drill capable of 10mm (3/8") holes in mild steel, and 5mm (3/16") holes for pop rivets.

COSTS

It is difficult to estimate costs accurately as it is possible that many items may be found as scrap. However, as a rough guide, it could cost £10-£15, including the purchase of a second-hand

2. ROTOR CONSTRUCTION

Adjusting the spokes (Fig. 1)

The vanes of the windmill are carried by the spokes of the cycle wheel. The wheel we used had 9 pairs of spokes on each side of the hub.

To fasten the vanes conveniently we needed some spokes to be radial, which they were not, so we adjusted every other of the 18 spokes on the side away from the dynahub.

We unscrewed every other spoke on the side away from the dynamo - one at a time to avoid upsetting the balance of the wheel. We used a vice to hold the wheel in a horizontal position by gripping the end of the spindle (use soft jaws to avoid damaging the thread).

Each spoke was clipped off about 12mm (½") from the hub end, re-bent into a hook and reinserted into another hole in the hub, in such a way that the spoke was then a RADIUS of the wheel, and re-fastened. There's no need to tighten them too well at this stage - they'll have to be undone later when assembling the vanes.

Making the vanes (Fig. 2)

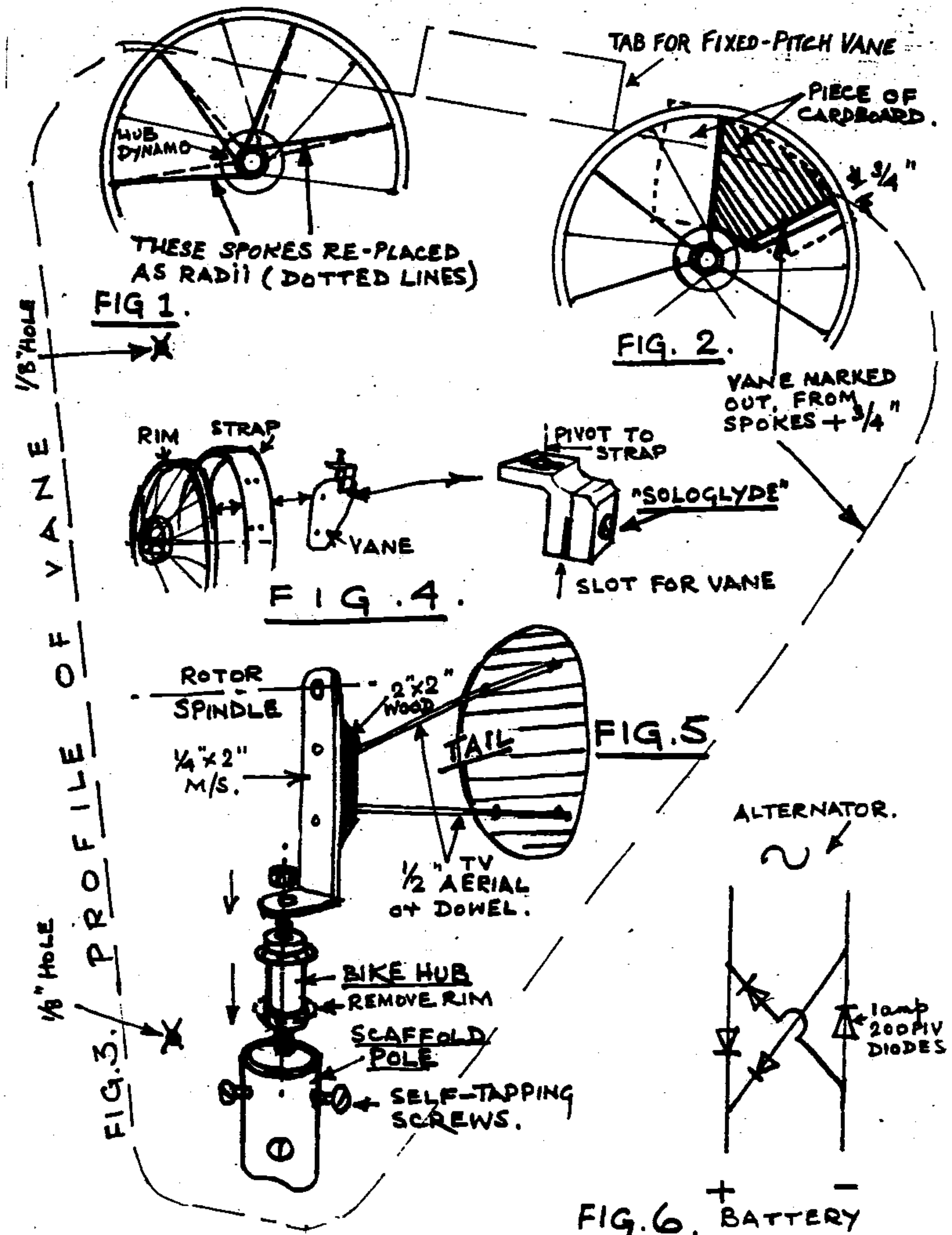
To make a template from a piece of cardboard, we marked out the area between 2 adjacent (radial) spokes, making an isosceles triangle truncated at the apex (hub end). Thus the 9 vanes, if laid flat, would form a complete circle - but don't cut them out yet!

As the vanes are to be angled, they should be increased in width to present as large an area as possible to the wind, without overlapping each other. The conflicting factors are large vane area (for good starting torque) against overlapping of vanes (drag when running). Our compromise was to add 20mm (3/4") to one side. If you don't want to build a variable pitch device (see next section) leave a tab on your cardboard template as shown. Round off the corners, resulting in a template such as ours shown in Fig. 3.

We used this template to cut out 9 identical vanes from the sheet metal. For good balance when assembled this should be done accurately.

A hole, as marked in Fig. 3, was drilled in each vane, for threading onto the spokes.

5 WATT WIND GENERATOR.



The vanes were then threaded onto the 9 radial spokes (having undone them once more, one at a time). We tightened each nut equally - you can tell by the squeak how equal they are (the lighter the spoke, the higher the pitch).

At this point we had 9 vanes at all angles. There are two ways of finishing the rotor:

(i) For a fixed-vane windmill you will have left a tab on each blade: drill through the tab and the rim of the wheel, and pop-rivet the blade to the rim. Do it so that the vane angle is fixed at about 30°-35° to the rim.

(ii) Alternatively, you can attach the vanes in such a way that you can (manually) alter the pitch of the 9 vanes simultaneously, as described in the following section.

Variable pitch device (Fig. 4)

If the machine is to be used for teaching purposes, the scope for experiment can be increased by using this variable pitch device which allows the blades to be set at different angles to the rim. Ease of starting, power output and efficiency will all be influenced by changing this angle.

Our method was to wrap a 75mm (3") wide piece of the sheet metal around the rim of the wheel so that, by bolting the joint of the band, it was free to slide like a loose tyre around the rim. It was held by either pop rivets or bolts to stop it moving backwards and forwards, in a position as far forward over the vanes as possible.

To this band the top edges of the vanes were attached. We used a 25mm (1") length of aluminium glazing bar, with a deep slot that went over the vanes. By sawing and bending it, and drilling a pivot hole, it allowed the vane to feather as the band was rotated around the rim.

Subsequently we found a plastic 'SWISH SOLOGLIDE' curtain rail bracket to be the ideal solution. It also has a screw with which to clamp the vane, once ideal pitch had been determined.

The pivot holes in the band must be drilled exactly equally round the rim. Mark them off accurately by first marking the band where the spoke ends meet the rim, then, using a T-square, transfer the mark down to a consistent depth from the edge of the rim. Assemble, making sure that everything moves freely.

3. MOUNTING AND TAIL (Fig. 5)

Ideally, a mild steel strap, about 6mm x 50mm x 500mm (¼" x 2" x 1'8"), with 10mm (3/8") holes drilled 400mm (1'3") apart, and bent as shown. Almost any oddment of scrap iron of the approximate length, with holes drilled appropriately, will do: we used an ex-P.O. corner bracket.

A cycle hub served as a mounting bearing. Possibly a cycle front fork assembly could be used instead. We cut off one hub flange so that it would fit into the end of a scaffold pole, and fastened it with self-tapping screws through holes drilled in the the pole. The short leg of the bracket was then threaded over the spindle and screwed with a suitable nut.

Another method is to drill a hole into a block of wood, 4" or more long, and shaped so that it will jam tightly when knocked into the top of a scaffolding pole. A long bolt or threaded rod goes through the strap, a large washer and into the hole in the wood. Lots of grease will allow the generator to yaw into the wind.

We made the tail by boring 12mm (½") holes into a 150mm (6") piece of 50mm x 50mm (2" x 2") wood, at angles such that, if the wood were bolted to the back of the mounting strap and 12mm dowels or tubing driven into the holes, the dowels would spread to hold a tail about the same size as the rotor (600mm).

4. ELECTRICS (Fig. 6)

The dynahub is an alternator. This is satisfactory for filament lamps of 6-12v, but to re-charge a battery a rectifier is needed. We made ours from four 1 amp 200 PIV diodes: IN4003, IN4004 or IN4005. Alternatively you can use a bridge rectifier, where the bits are embedded in plastic, ready for connection.

FURTHER INFORMATION

A wide range of books and information sheets on windpower and other renewable energy sources is available from the CAT bookshop, including the following:

Wind Energy (introductory information sheet)	50p
Wind Energy Resource List (further contacts, equipment suppliers and suggested reading)	50p

For a fully annotated booklist and details of our mail order service please send 5 second-class stamps to CAT at the address below.

The original DIY Plan 1 was prepared for the Centre by John Eyles in 1978. This revision was compiled by the Information Service at CAT. The details provided have been given in good faith and are believed to be correct at the time of printing.

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