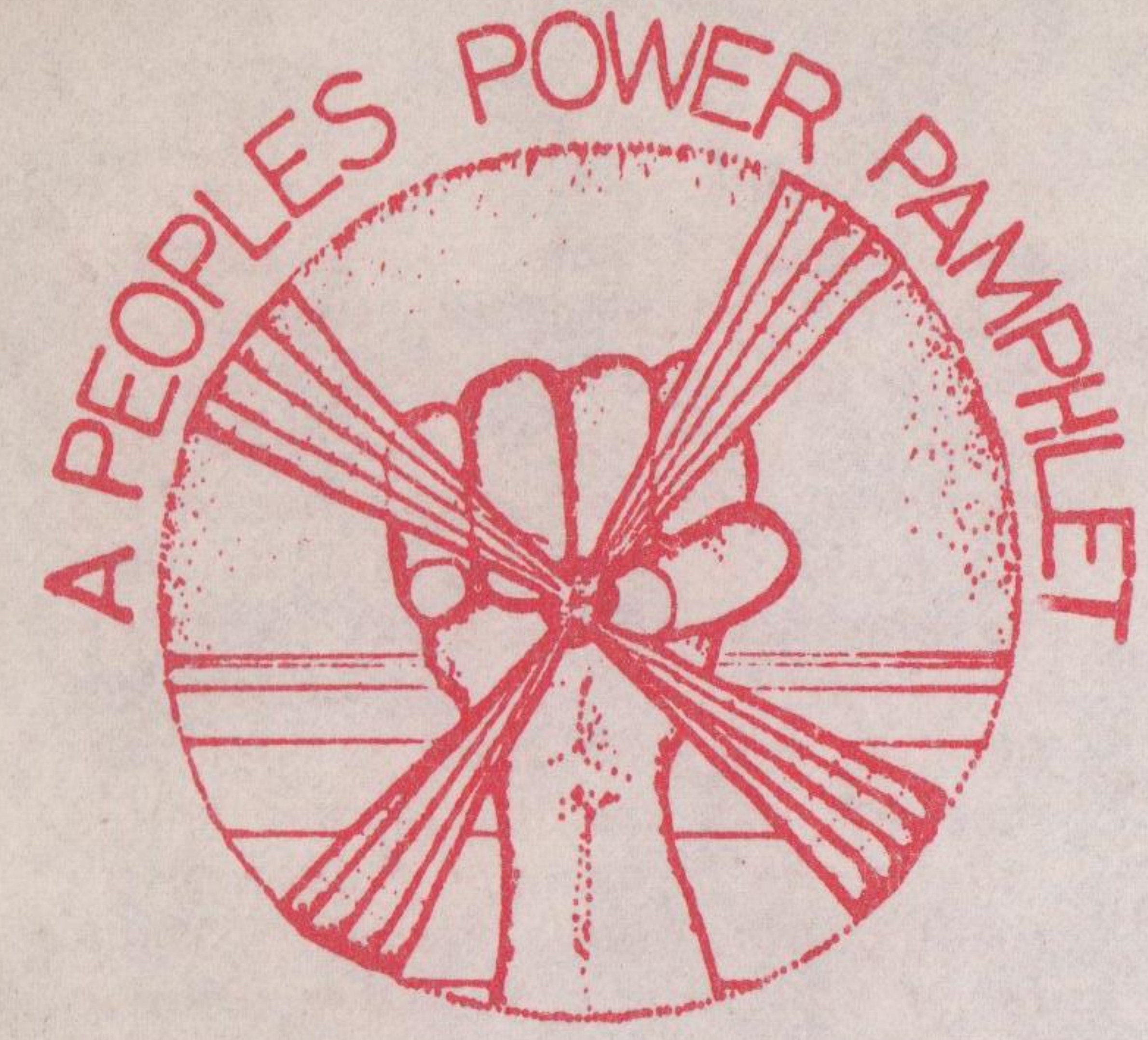
# The Beaufort Scale

| Land observations | Speed mph | Force | Description |
|---|---|---|---|
| Smoke rises vertically | less than 1 | 0 | Calm |
| Light drift of smoke | 1–3 | 1 | Light air |
| Wind felt in face, leaves rustle | 4–7 | 2 | Slight breeze |
| Leaves in motion, light flag extended | 8–12 | 3 | Gentle breeze |
| Small branches move, litter, dust, leaves lifted | 13–18 | 4 | Moderate breeze |
| Small trees sway | 19–24 | 5 | Fresh breeze |
| Large branches in motion, telegraph wires whistle | 25–31 | 6 | Strong breeze |
| Whole trees in motion, difficult to walk against wind | 32–38 | 7 | High wind |
| Twigs break off trees | 39–46 | 8 | Gale |
| Chimney pots and slates blown off roofs | 47–54 | 9 | Strong gale |
| Trees uprooted, severe structural damage | 55–63 | 10 | Whole gale |
| Windmill blown away | 63+ | | |








written and drawn by Bruce Haggart

## the street farmers

# WINDWORKERS MANUAL

There is virtually no end of possibilities in windmill types or ways which wind energy can be made to work. The devices discussed here are modest but are known to be effective. The builder will see that it is not essential that the precise procedures described here are followed—innovation and invention become second nature to those contemplating construction.

Essential for the maintenance-free running of wind devices are good bearings. For the size of those described here, bicycle or motorcycle parts are eminently suitable. Often it seems more prudent to make bicycles from cycle parts, so strip down cars if you prefer. A subsequent manual will be issued dealing with larger wind devices where car parts become essential for sturdiness and safety.

No attempt has been made to give instructions about calculating the output you expect, nor has the usual measure of efficiency been evaluated. These considerations seem more fitting to marketing and alienated production systems, and as you can't sell the wind, consider anything you can build yourself from scrap materials and that gives you light and power to be alchemic rather than efficient. Do it and see, but don't expect to run factories off them.

## CATCHING THE WIND AND STORING IT

A windmill harnesses windpower and makes it usable by rotating shafts and/or gears. Less of the energy is wasted if it is used directly: to pump water, lift weights or drive some tool or appliance. But since it is not always convenient to regulate work to windy periods, the wind-generated mechanical energy can be transformed into electrical energy for storage by means of a generator.

If DC electricity is generated, it can be stored in one or more batteries. (But unavoidable energy losses occur when one form is transformed into another—converting from, say, mechanical to electrical back to mechanical may leave you with only a fraction of what you started with.) Energy can also be stored by lifting heavy weights over relatively short heights and lowering the weights over a geared pulley driving whatever is to be driven.

Other methods of storing wind energy include the storage of heat generated either by friction deliberately created between the rotating wind shaft and a block in a tank of water, or by driving a heat pump (from an old compressor-operated refrigerator). The use of wind to compress air is another convenient method more suitable to larger mills, as is the tried and tested proposition of electrically splitting water into its constituent hydrogen and oxygen for reconstitution in a fuel cell.

## GENERATION OF ELECTRICAL CURRENT

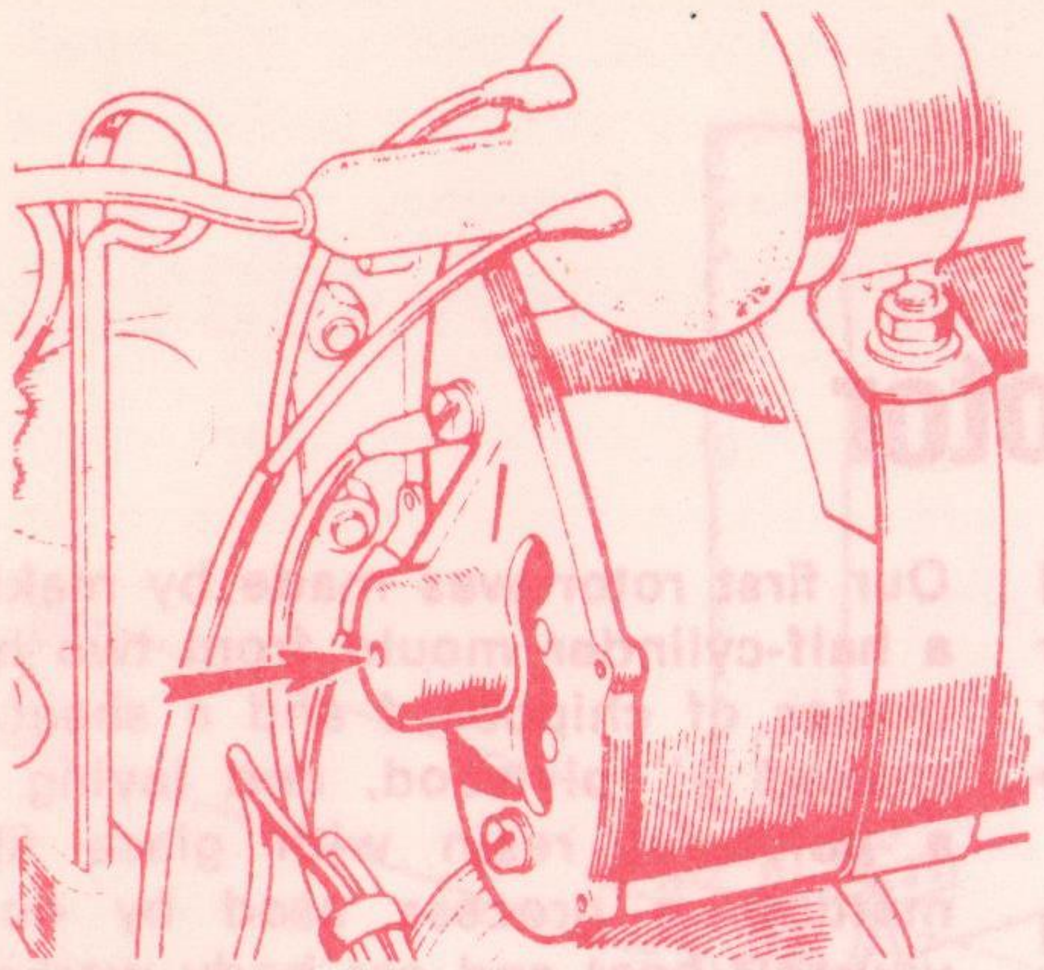
The most readily available generators can be found in cars, either in the form of a dynamo or an alternator. This means using a 6 or 12 volt electrical system and car batteries can be used singly or coupled in parallel to store the electricity for use when the wind's not blowing. Anyone familiar with car electrics will be quick to understand the 12v system; those unfamiliar and who want to look further into this should talk to friendly rally freaks or car electricians or try reading *Automobile Electrical Maintenance* by Arthur W. Judge (Pitman Paperbacks, £2.00) as comprehensive and easy-to-follow a book on the subject as I have found.

## DYNAMOS OR ALTERNATORS

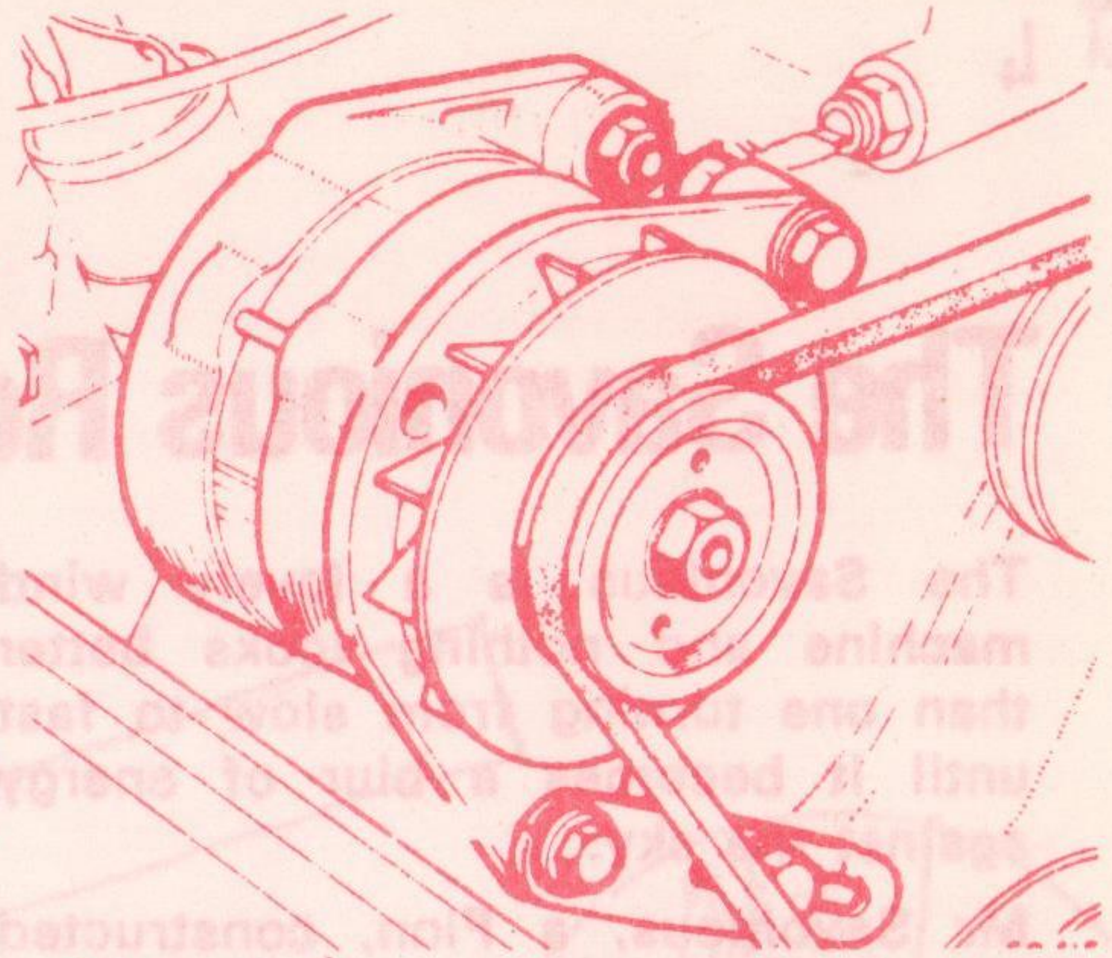
The difference between a dynamo and an alternator is that in the dynamo the magnet is static and wire will rotate, whereas in an alternator it is the magnet that rotates, which means less resistance and simpler bearings. The alternator produces AC electricity which is rectified to DC by a transistorised rectifier built into modern alternators. Essentially the alternator is the answer for wind-generated electricity. They start charging at about 600 rpm without any modification. It makes no difference whether it is rotated clockwise or anti-clockwise and offers less resistance to turning than the unmodified dynamo.

A new alternator can cost about £25, but car scrappers will sell them in very serviceable condition from £4-£7. Most commercial vehicles have them, and the sportier type of cars usually have one to drive their vast array of headlights.





dynamo



alternator

Dynamos, on the other hand, while not to be discounted, generally have "cut-in" speeds (the rpm they start a full charge at) well above that achieved by an ungeared windmill. 6v dynamos usually have slower cut-in speeds and are more suitable. The modern 12v dynamos cut in at about 900 rpm but often give a charge when connected to a 6v battery. Such a combination charges at 4 amps in winds that would not cause the same dynamo to cut in on a 12v circuit, and generally both the armature of the dynamo and cells of the battery are protected from overheating.

## CHOICE OF DYNAMO

Even new dynamos are much cheaper than alternators and most abandoned cars have a serviceable dynamo. In choosing one, clues to whether they are slow or fast can be found in their shape. A slow one will have a larger diameter and shorter length, and its armature will be wound by thinner wire (usually 18swg)

Test the dynamo by winding about two yards of cord round its axle and give it a strong, steady pull. Slow dynamos will rotate evenly at a slow speed after the initial jerk while fast dynamos will continue to gather speed using more cord before evening out at a higher rev speed. It is possible to convert high speed to slow speed dynamos by removing the smaller, third or regulation brush and/or rewiring the coils, decreasing the number of winds so that less resistance is offered.

Another possible source of generating equipment is any electric motor, which if turned mechanically will generate electricity.

The use of a 6 or 12v DC system implies that normal 240v AC wiring and appliances cannot be used. However, a range of lighting fittings and appliances or adapters to 240v appliances have been developed for boats, cars and caravans. The wiring for a DC system should be based on car electrical wiring. Ammeters and voltmeters from car instrument panels can be pirated and used to monitor the electricity produced and used. A device called a Dynomotor costing about £6-£8 accepts a 12v DC charge and gives a 240 AC output rendering it suitable for certain situations where 12v appliances cannot be used.

# The Savonious Rotor

The Savonious is a lovely wind machine and nothing looks better than one turning from slow to fast until it becomes a blur of energy against the sky.

Mr Savonious, a Finn, constructed the vertical axis windmill named after him in 1910. 2,500 years earlier the Chinese had used vertical axis sail mills.

The rotor consists of a cylinder split down the middle, each half being displaced so that the space between the inner edges is about one-third the diameter of the cylinder. A cylinder of 3' diameter would form a rotor 5' wide with a space of 1' between the inner edges.

Because it is vertically mounted, no orientating device is necessary to keep the rotor blades in the direction of the wind. A phenomenon known as the Magnus effect acts to increase the rotation as a low pressure is created on the leeward side of a spinning cylinder which sucks it round faster.

## THE ROTOR

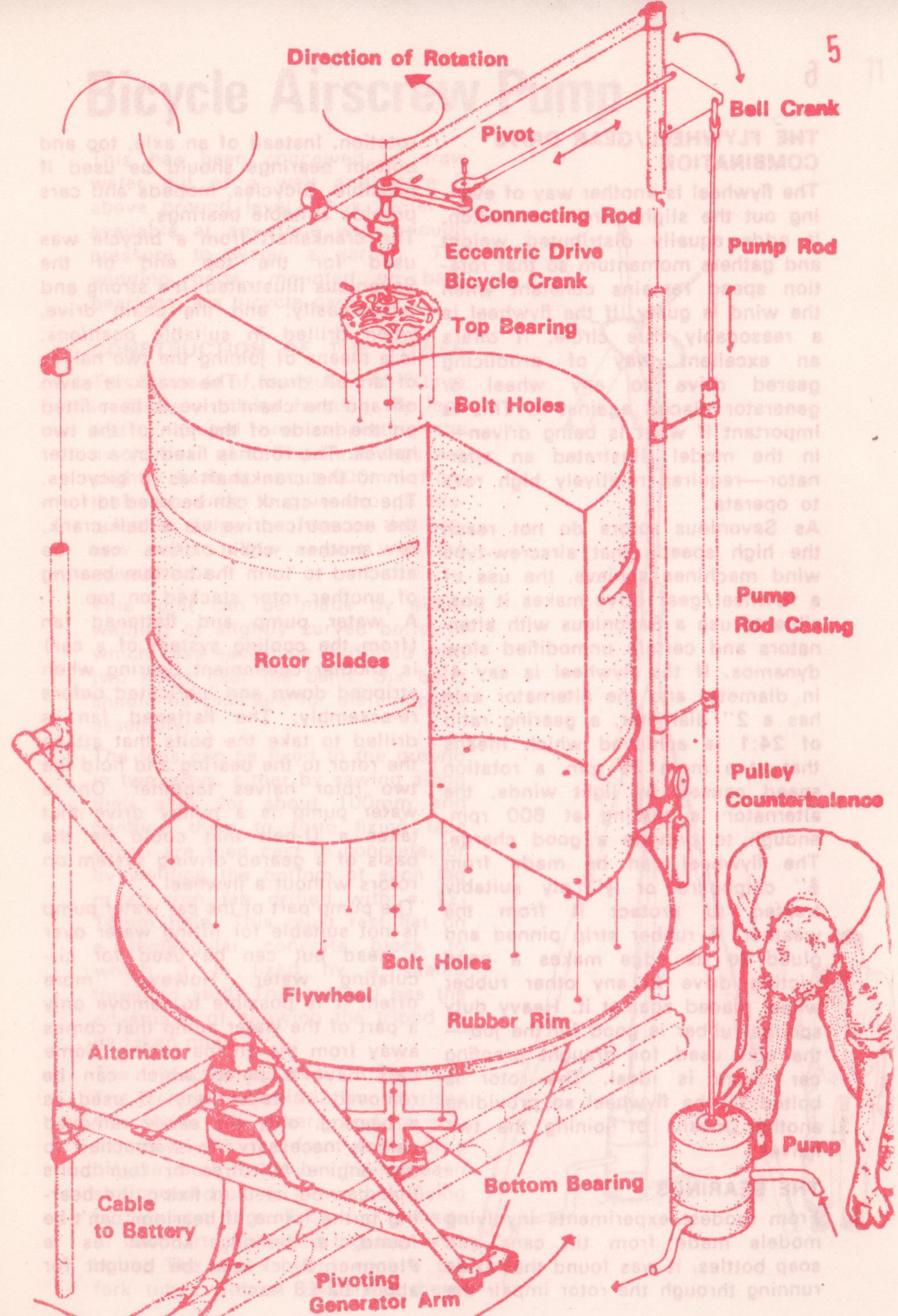
The rotor part of the machine can be made from a 45 gallon oil drum. Best find one that has been used for wine or anything that means it is not necessary to clean out the remains of oil from it. A quick and easy way of splitting an oil drum is by using an electric jig saw with a metal cutting blade. This takes about 15 minutes. It is possible to use a combination of cold chisel, hacksaw and metal shears if you are not daunted by the prospect.

Our first rotor was made by making a half-cylinder mould from two half circles of chipboard and a sheet of soaked ¼'' plywood, and laying up a polyester resin with glass fibre matting, a process used by do-it-yourself boat and car body workers.

The same mould can be used many times and the rotors produced this way are ideal, being very strong and light. A rotor 4' high by 4' wide weighed about 15 lbs and cost about £7 in raw materials. Glass fibre is best worked in the outdoors during the summer where the smell is least objectionable. It occurred to me, however, that the mould was quicker to make than the casting and a similar construction could be used for the actual rotor, although I don't know how it would behave in use. Canvas sails could also be used in conjunction with light timber, alloy tube or wire framing.

However you decide to make the rotor, it is important that it is equally balanced to avoid vibration at high speeds. A rotor made of two half cylinders tends to lurch round when rotating. This may only be a visual illusion but if a taller rotor is possible, then four half cylinders can be used making two rotors stacked one on top of the other so that the rotor of the lower part is at right-angles to the rotor of the upper (see diagram). It's also possible to produce a twisting motion between the upper and the lower rotor by fitting them so that one rotates clockwise and the other anti-clockwise. This doubles the rpm achieved by each rotor.





## THE FLYWHEEL/GEAR DRIVE COMBINATION

The flywheel is another way of evening out the slight lurch in rotation. It adds equally distributed weight and gathers momentum so that rotation speed remains constant when the wind is gusty. If the flywheel is a reasonably true circle, it offers an excellent way of producing geared drive to any wheel or generator placed against it. This is important if what is being driven—in the model illustrated an alternator—requires relatively high revs to operate.

As Savonious rotors do not reach the high speeds that airscrew-type wind machines achieve, the use of a flywheel/gear drive makes it possible to use a Savonious with alternators and certain unmodified slow dynamos. If the flywheel is say 4' in diameter and the alternator axle has a 2" diameter, a gearing ratio of 24:1 is achieved which means that at a mere 25 rpm, a rotation speed caused by light winds, the alternator is turning at 600 rpm, enough to provide a good charge. The flywheel can be made from ¾" chipboard or ½" ply suitably treated to protect it from the weather. A rubber strip pinned and glued to its edge makes a good friction drive to any other rubber wheel placed against it. Heavy duty sponge rubber is good for the job—the sort used for draught proofing car doors is ideal. The rotor is bolted to the flywheel so providing another means of joining the two halves.

## THE BEARINGS

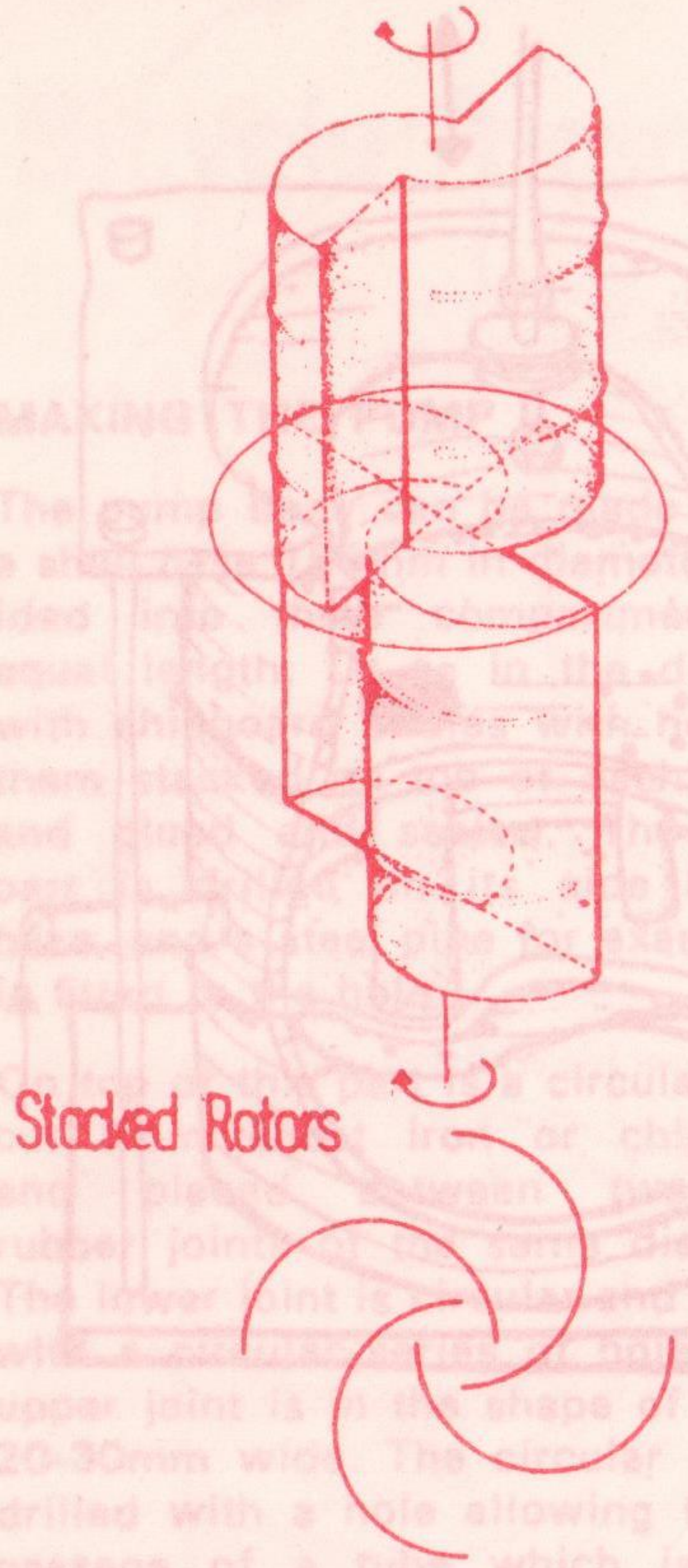
From modest experiments involving models made from tin cans and soap bottles, it was found that axles running through the rotor impair the rotation. Instead of an axle, top and bottom bearings should be used if possible. Bicycles, mopeds and cars provide suitable bearings.

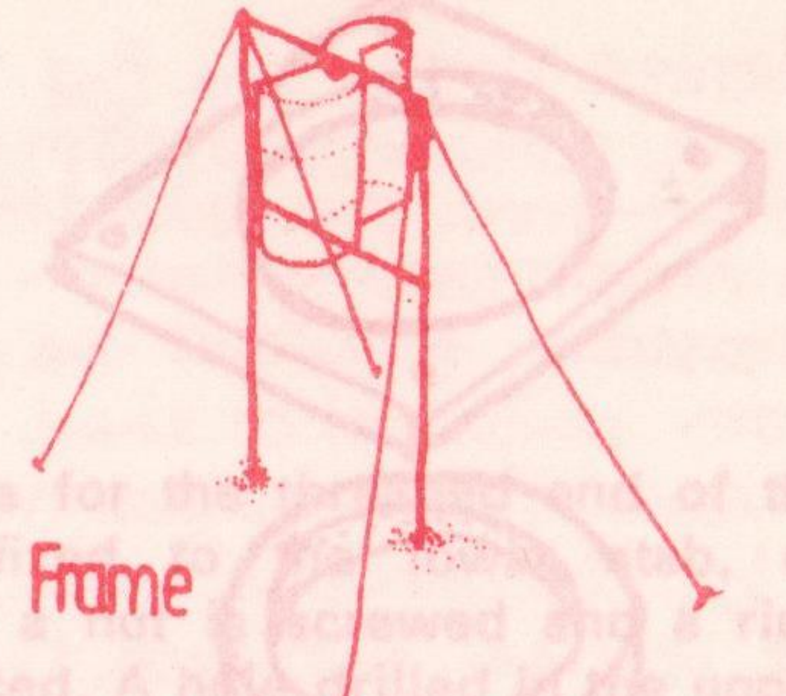
The crankshaft from a bicycle was used for the top end of the Savonious illustrated. It's strong and turns easily, and the chain drive, when drilled in suitable positions, is a means of joining the two halves of an oil drum. The crank is sawn off and the chain drive is best fitted on the inside of the join of the two halves. The rotor is fixed by a cotter pin to the crankshaft as in bicycles. The other crank can be used to form the eccentric drive via a bell crank, or another chain drive can be attached to form the bottom bearing of another rotor stacked on top.

A water pump and flattened fan (from the cooling system of a car) is another convenient bearing when stripped down and lubricated before re-assembly. The flattened fan is drilled to take the bolts that attach the rotor to the bearing and hold the two rotor halves together. On a water pump is a pulley drive that takes a U-belt that could be the basis of a geared driving system on rotors without a flywheel.

The pump part of the car water pump is not suitable for lifting water over a head but can be used for circulating water. However, more often, it is possible to remove only a part of the water pump that comes away from the engine casing. Some cars have a pump which can be removed in its entirety. If used as a bearing, only the easily removed part is necessary. It is attached to the engine by three or four bolts that can be used in fixing the bearing to the frame. If bearings can't be found, a bearing known as a Plummer Block can be bought for about £2-£3 each.







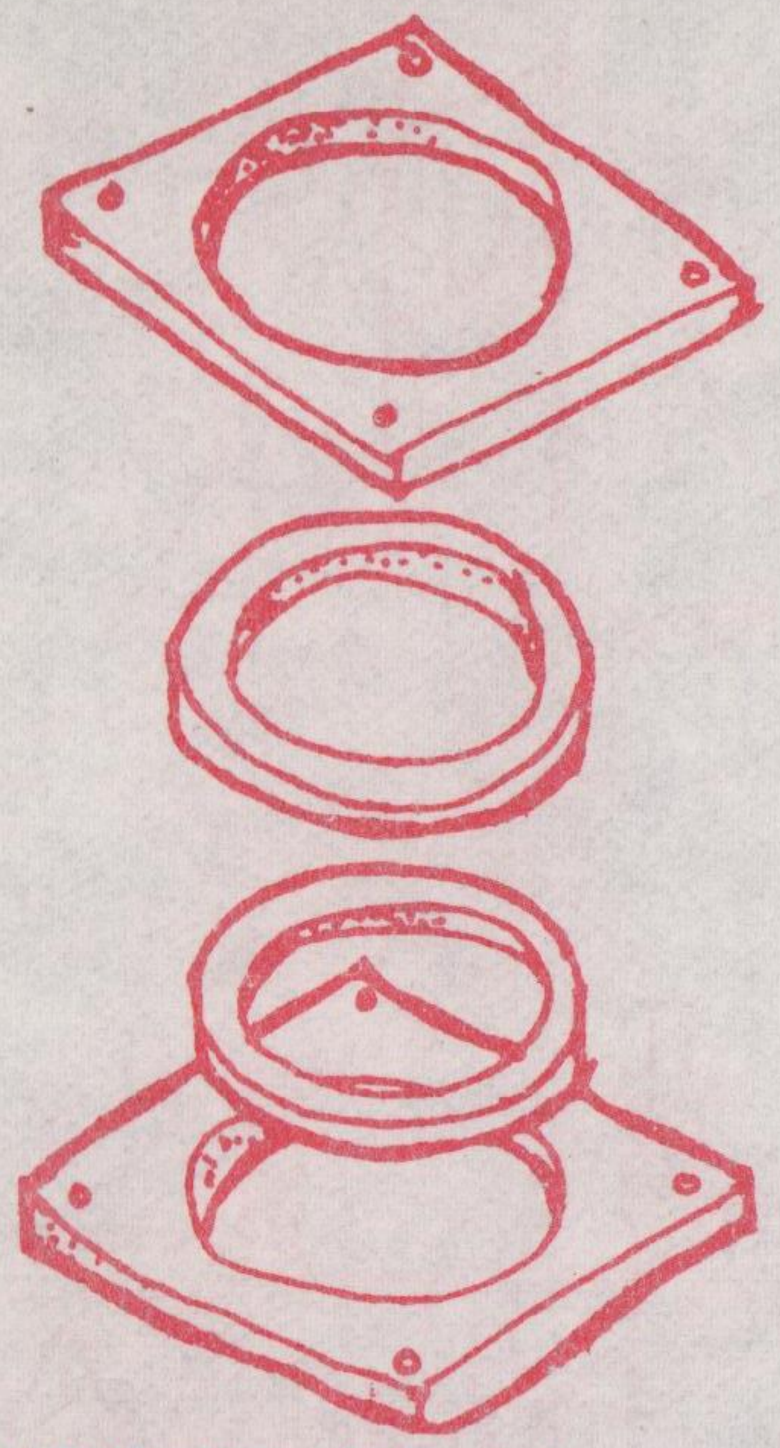
## THE FRAME

Timber as strong as you can get, 4" x 2" or even better 6" x 2" or 4" x 4". Floor joists from demolished buildings are good for the job or, if you can get hold of it, scaffolding is ideal. Whether using timber or scaffolding, an H frame closed at the top and guyed with rope should be erected. Check that the uprights are indeed vertical, but more important that the cross-members are horizontal. If the frame is attached to the ground, dig holes and cement the posts in before guying.

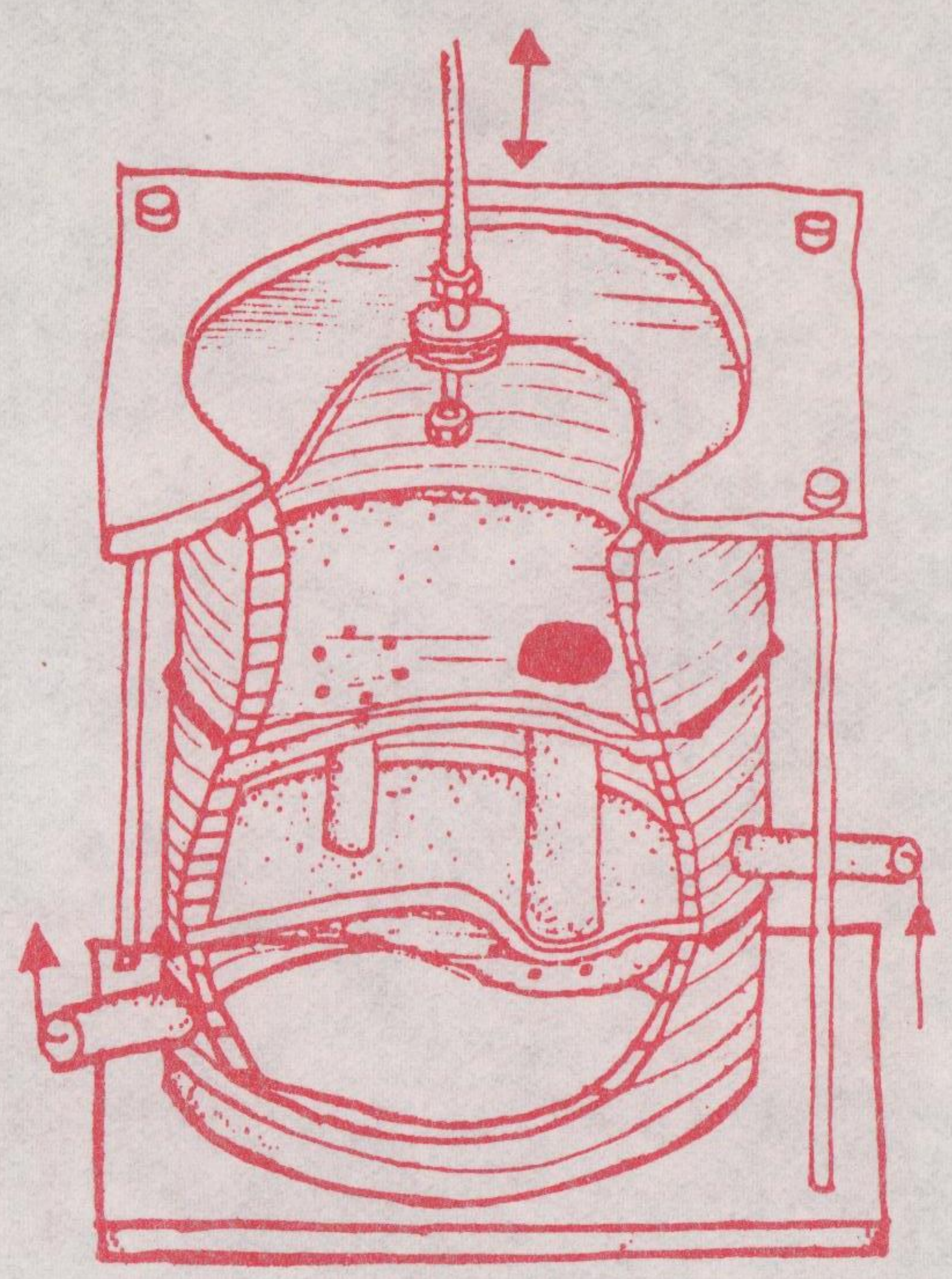
The rotor should be erected as high as possible as wind is less turbulent and stronger as height increases.

In built-up areas, it is probably worth considering erection on roofs or between the gables of neighbouring houses. We put one on a fairly exposed site about 15' off the ground attached to the side of our house. It rotates when the wind is otherwise not perceptible. In a breeze that is felt in your hair, the rotor is spinning rapidly.

Test your rotor by erecting low at first. Check for plumb by hanging a weight on a string from the centre of the top bearing and adjusting the position of the rotor so that the weight hangs over the centre of the bottom bearing. If you are confident about security, which you should be, there is nothing finer than just sitting waiting for the first breeze to set the rotor in motion. The rest of the day can easily be spent just watching it turn . . . Enjoy it.



PUMP CHAMBER ASSEMBLY

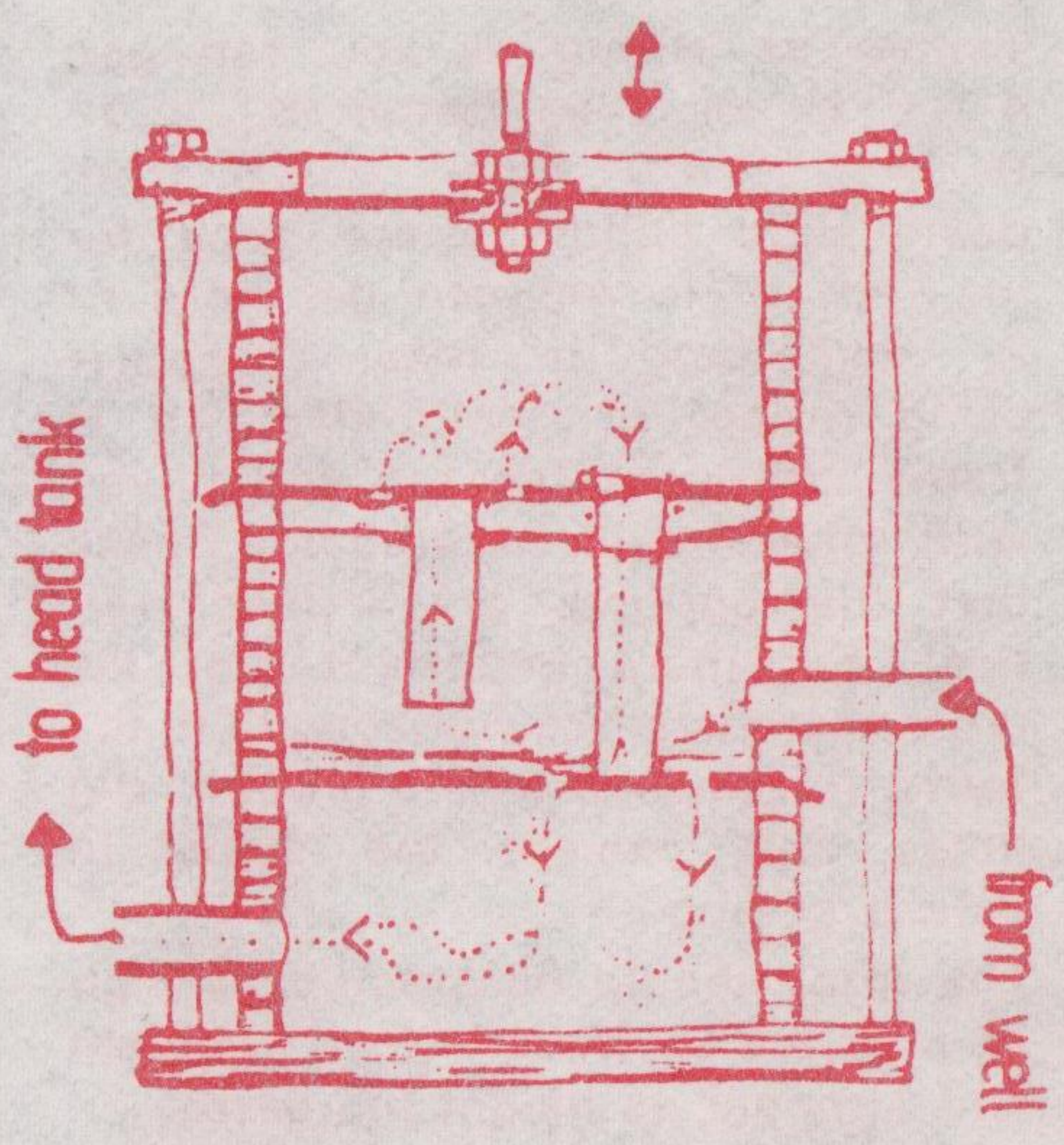


## HOW IT WORKS

When the membrane is attached to the top, an intake is produced and the upper joint comes off the upper circular slab. The water is sucked by the tube connected to the middle compartment thus filling the upper compartment. Meanwhile a partial vacuum occurs in the middle compartment thus attracting the piped water from the well.

When the membrane goes back to its original position, the water in the upper compartment is sent to the lower one by means of the tube which joins them together and gradually fills it up. The water then travels to a tank through a pipe. Both joints drilled with holes act as stoppage valves by lying flat on the circular slabs when needed.

All that remains to be done is to build the complete assembly near enough to the well in order to have the shortest possible length for the piping.




Section



## MAKING THE PUMP

The pump body can be made out of a shell case 155mm in diameter, divided into three compartments of equal length. Or as in the diagram with chipboard circles with holes in them stacked on top of each other, and glued and sealed. The lower part is drilled on its side by the base, and a steel pipe for exacuation is fitted to the hole.

On top of this part is a circular slab, cut from sheet iron or chipboard and placed between two soft rubber joints of the same diameter. The lower joint is circular and drilled with a circular series of holes. The upper joint is in the shape of a ring 20-30mm wide. The circular slab is drilled with a hole allowing for the passage of a tube which is fixed to it. The free end of this tube is threaded and then closed by two screw nuts. The tube can come from a water installation or from the front forks of a cycle.

The lower opening of the tube must coincide with the series of the holes drilled in the rubber joint to allow for drainage.

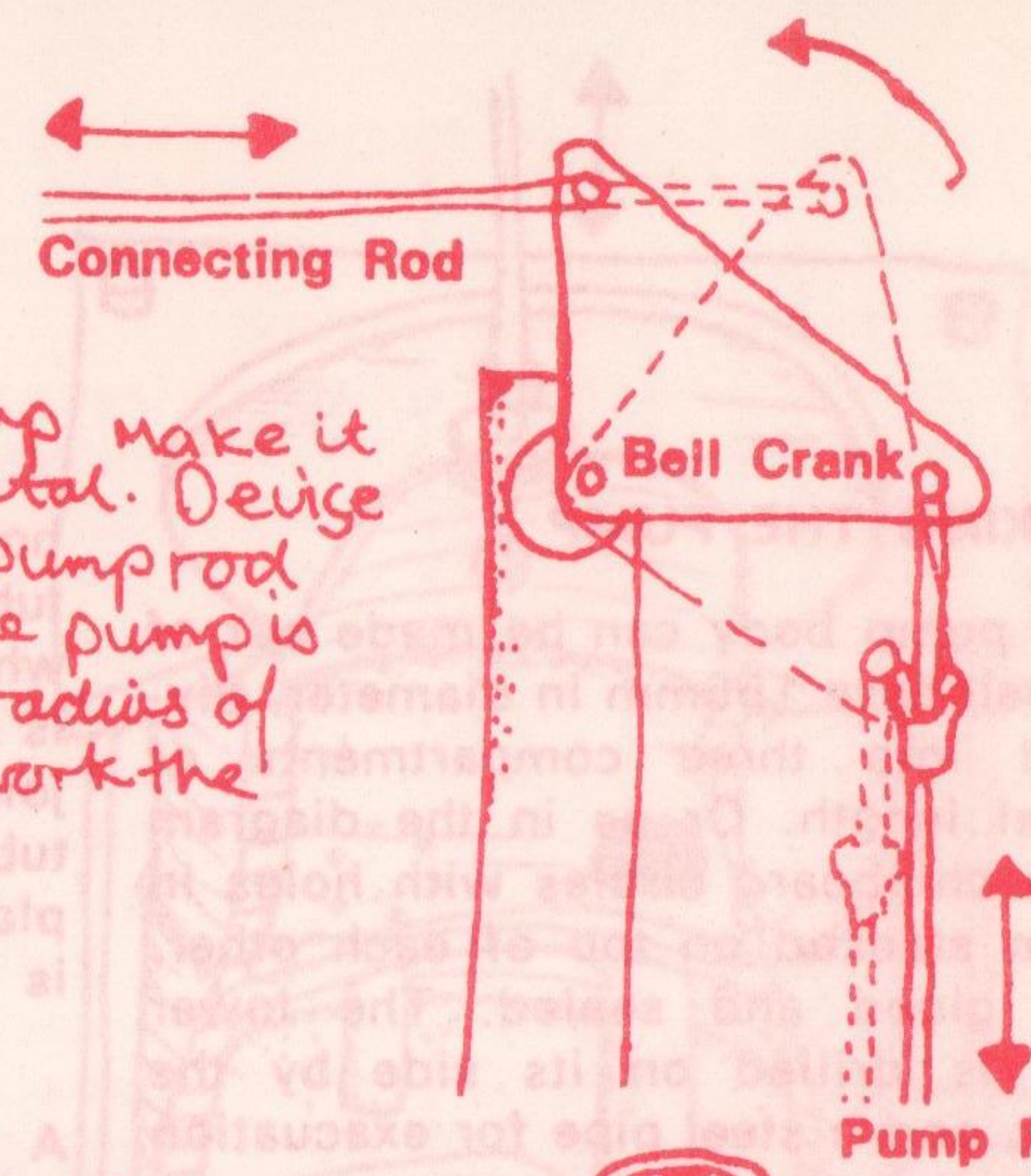
The middle compartment of the case, already fitted with its joints, is placed on the circular slab. A second joint in the shape of a ring is set up, together with a circular slab and another joint itself drilled with a series of holes. Both joints are identical to the first two but are inversely arranged.

The circular slab is drilled with two holes and its length is calculated so that its lower end stops 10mm from the first circular slab. The second hole is for the threaded end of the tube fixed to the lower stab, on which a nut is screwed and a ring is placed. A hole drilled in the upper joint allows for the passage of the tube. A second supporting ring is placed and the complete assembly is tightened with a screw nut.

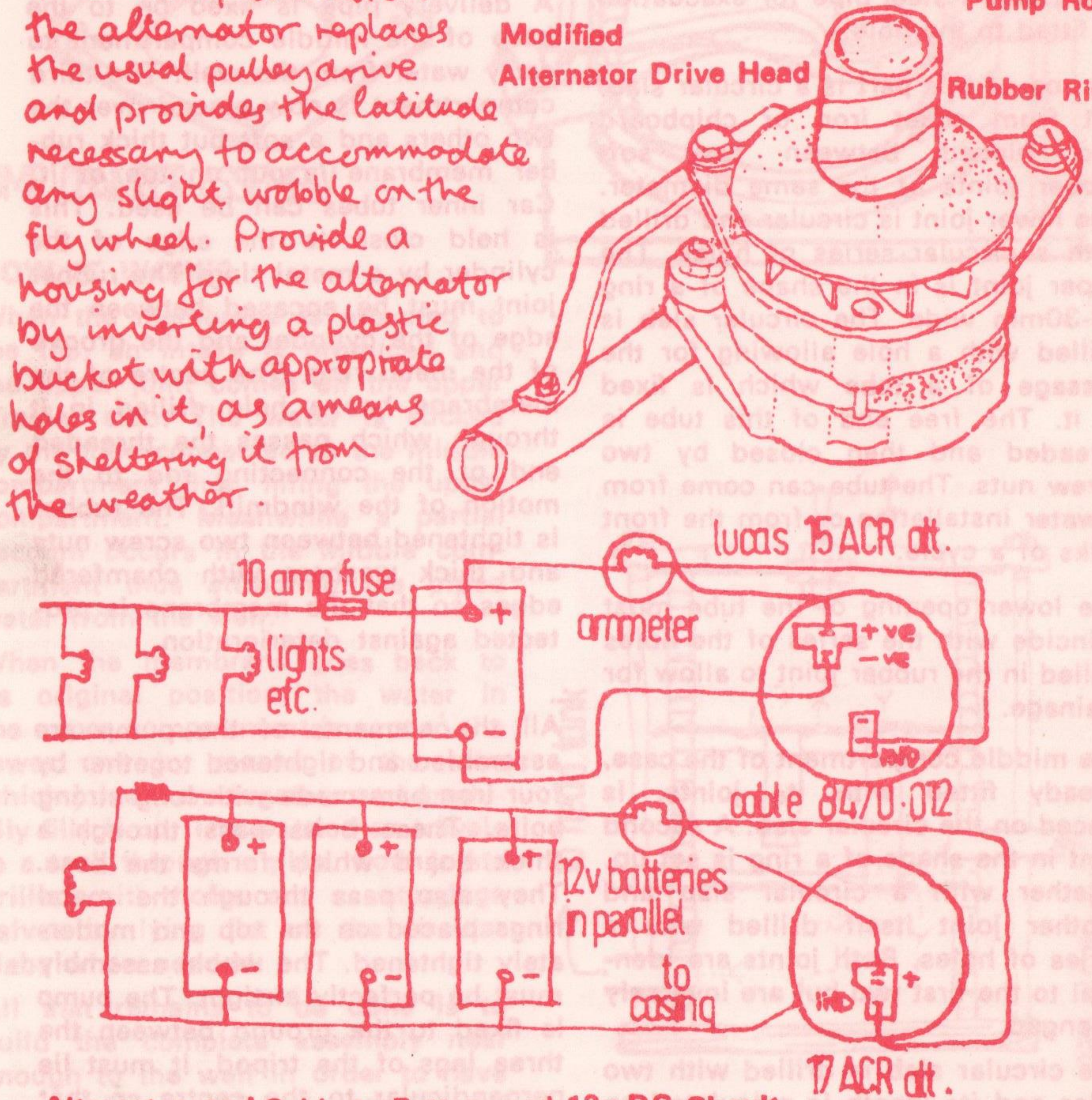
A delivery pipe is fixed on to the base of the middle compartment to carry water from the well. The third compartment is now placed over the two others and a soft but thick rubber membrane is put on top of it. Car inner tubes can be used. This is held close to the edge of the cylinder by a metal ring. The rubber joint must be encased between the edge of the cylinder and the groove of the metal ring. The centre of the membrane has a hole drilled in it through which passes the threaded end of the connecting rod to the motion of the windmill. The rubber is tightened between two screw nuts and thick washers with chamfered edges so that the membrane is protected against deterioration.

All the elements of the pump are assembled and tightened together by four iron bars made with long strong bolts. These bolts pass through a thick board which forms the base. They also pass through the metal rings placed on the top and moderately tightened. The whole assembly must be perfectly airtight. The pump is fixed to the ground between the three legs of the tripod. It must lie perpendicular to the centre so that the transmission rod stands perfectly vertical.

FURTHER NOTES: the Bell crank converts rotational motion from the eccentric to reciprocating motion necessary to drive the pump. Make it from plywood or sheet metal. Devise a means that enables the pump rod to be disconnected when the pump is not in use. Establish the radius of the eccentric suitable to work the pump by trial and error.




The modified head on the alternator replaces the usual pulley drive and provides the latitude necessary to accommodate any slight wobble on the flywheel. Provide a housing for the alternator by inverting a plastic bucket with appropriate holes in it as a means of sheltering it from the weather.




**Alternator and Cable to Battery and 12v DC Circuit**



# Bicycle Airscrew Pump

This has been conceived to draw water out of a well and store it above ground level. Thus, water is available at any time with enough pressure to water a garden. The winding parts, mounted on ball-bearings, are bicycle parts.

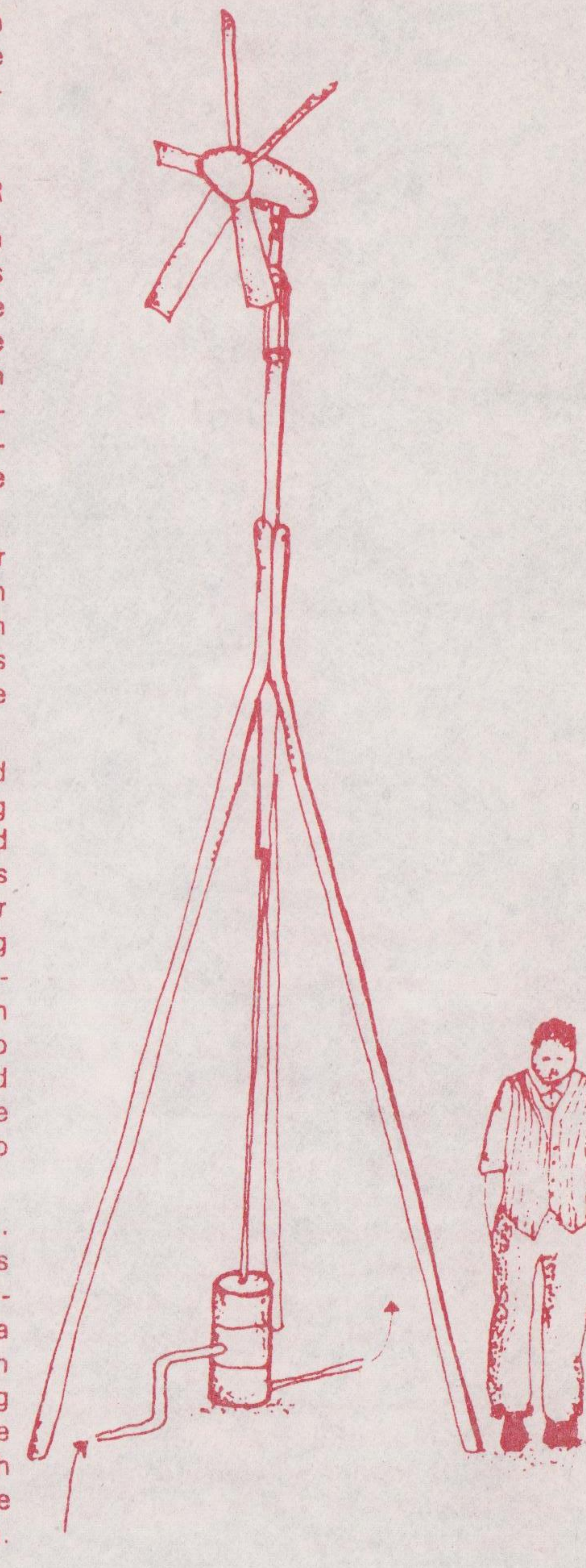
### CONSTRUCTION OF THE TOWER

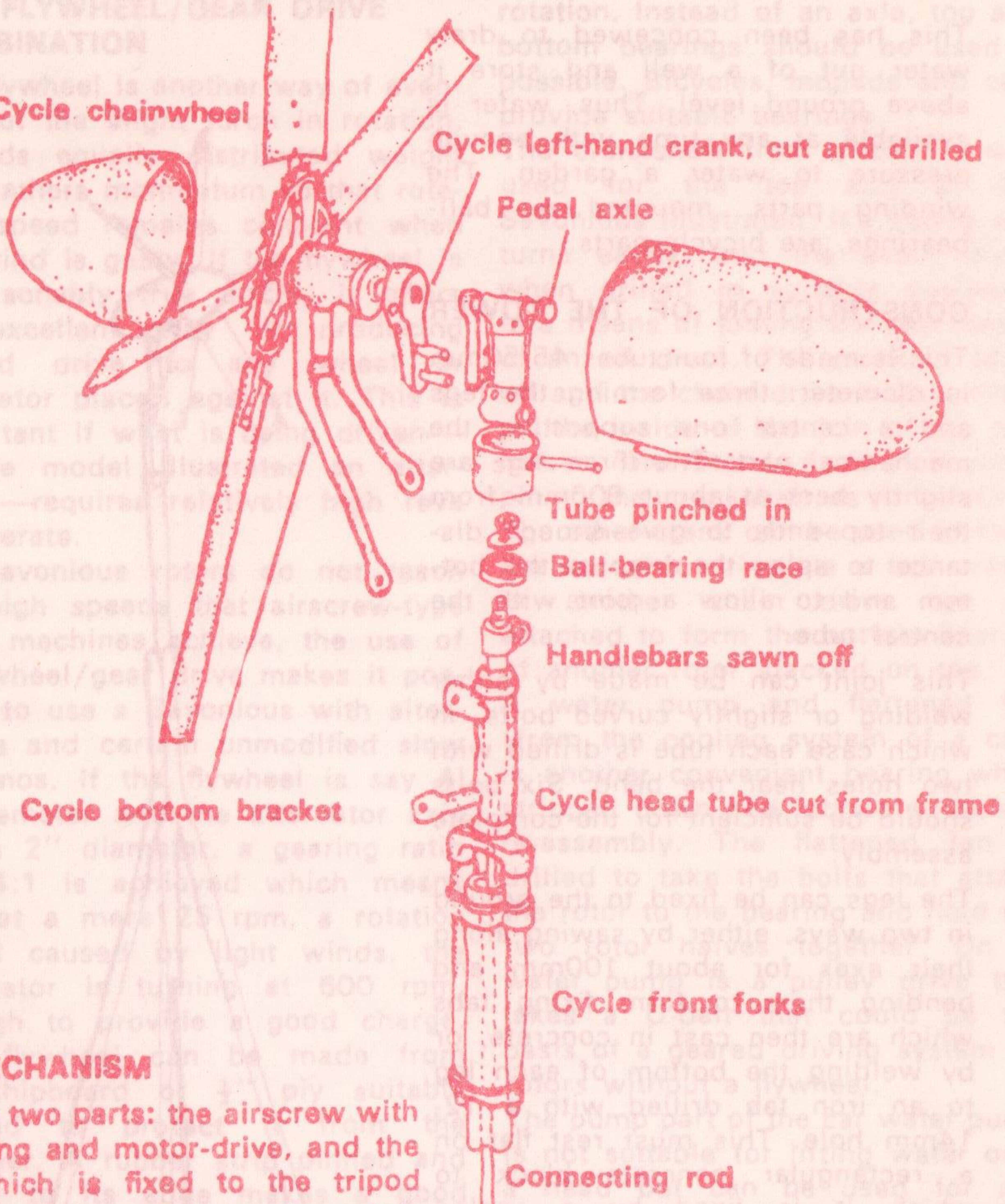
This is made of four tubes 45-50mm in diameter: three forming the legs and a central one supporting the mechanical part. The three legs are slightly bent at about 600mm from their top ends to give enough distance to splay the legs at the bottom and to allow a joint with the central tube.

This joint can be made by either welding or slightly curved bolts, in which case each tube is drilled with two holes near the bend. Six bolts should be sufficient for the complete assembly.

The legs can be fixed to the ground in two ways, either by sawing along their axes for about 100mm and bending them to form fixing tabs which are then cast in concrete, or by welding the bottom of each leg to an iron tab drilled with a 12-14mm hole. This must rest flat on a rectangular concrete block to which it is fixed by a sealed threaded stud. This method has the advantage of allowing the tripod to be taken down.

The leg tubes are about 3.3m long. The central tube is 2.1m. It rises 1m above the others and is surmounted with the front forks of a bicycle, both fork tubes having been straightened out to allow their fixing by two iron rings. Each ring is made of two parts tightened together with bolts. The iron should encase the fork tubes without squashing them.





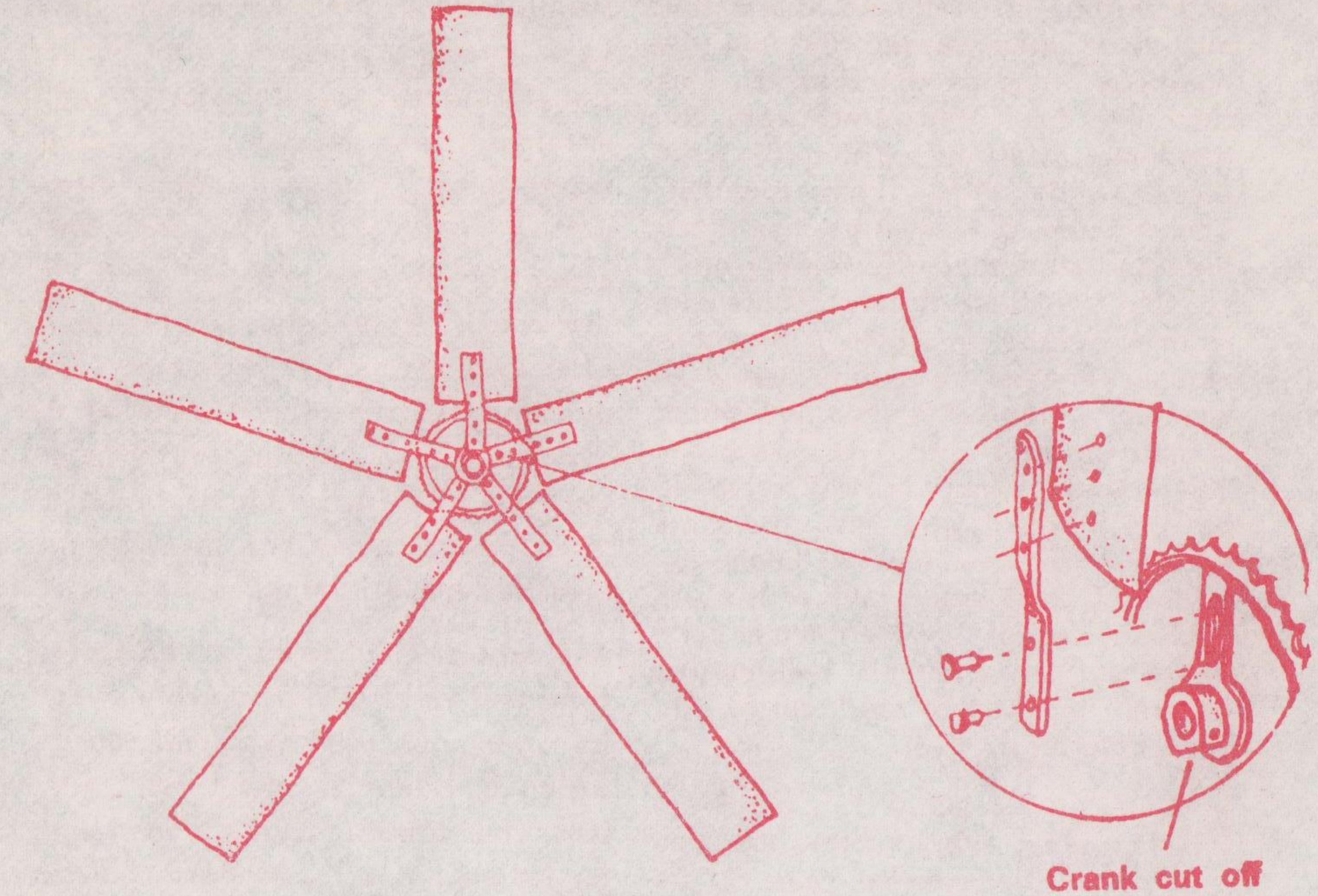

## THE MECHANISM

This has two parts: the airscrew with its bearing and motor-drive, and the pivot which is fixed to the tripod and allows the airscrew to rotate into the wind.

The pivot is formed by the main tube of the forks in which the front tube of the frame revolves. This has been separated from the rest of the frame by sawing through the tubes which terminate in it, leaving enough length for the fixing of the mechanism. The cycle headset ball-bearing mounting has been kept as it was. It should be cleaned, greased and adjusted so that it rotates easily without any play.

The bearing of the airscrew is made from the rear forks of a bicycle frame from which only both horizontal tubes and the bottom bracket have been kept. The tubes are bent, as shown, near the small brace which separates them and then cut to different lengths to bolt on to the stubs of the tubes protruding from the pivot of the forks. To join these two pairs of tubes, they must be flattened and then drilled to accept bolts.






The pedal axle, used for the mounting of the airscrew, must revolve freely and the ball-bearings be adjusted accordingly. The chainwheel has five projections, each of them allowing for the mounting of one blade of the airscrew. The blades are made of aluminium sheet 1.5mm thick, 700mm long and 140mm wide. They are bulged along their longtitudinal axis which produces a hollow of about 20mm in the middle of their width. Each blade is riveted to a piece of metal which has previously been twisted through 45° at its centre. Two holes are drilled in the other end of the piece of metal. They must be separated by a distance equal to the length of the slot in the projection of the chainwheel thus providing a tight fit. The blades are at an angle of 45° to the axis of rotation of the airscrew.

The total diameter of the airscrew should be 1.6m. The tubes supporting the bearings must not foul the rotating blades.

The pedal crank on the chainwheel side of the axle is discarded. The crank which has been retained is cut into two parts: the one supporting the pedal should be 20mm shorter than the part connected to the crankwheel axle. The former part has a slot cut which allows it to be fixed to the latter part of the axle.

Eccentricity is obtained by altering the position of the shorter part on the bolts. The pedal, now free from its sheet-iron case, is used as a winch handle for the transmission device—a rod made from a thin tube 4.15m long.

The tube is threaded at both ends and its top end is closed by a screw nut. It is then passed through the handlebar tube of the bicycle. This tube has been separated from the handlebar itself by cutting the cast piece which joins them together. The outside of the tube has been filed and smoothed with emery cloth so that it slides freely inside the front fork tube, in which it was previously blocked by a long screw as well as a conical screw nut which spread its split end. The screw has been removed and is now replaced by the transmission rod, the hole for the pas<sup>s</sup>.ge having been enlarged. The threaded part of the rod sticking out of the handlebar tube is closed by a small ball-bearing blocked by washer and screw nut (see diagram).

In spite of the screw nut blocking, this mounting should allow the free rotation of the external case of the bearing, necessary so that the transmission of the reciprocating motion takes place despite the changes in direction of the airscrew and to ensure that the transmission rod does not pivot on itself.

The bearing is joined to the winch handle of the airscrew spindle by a very ,small connecting rod which transforms the rotary motion into a reciprocating motion. This rod is made from sheet-iron 2mm thick with a clamp made from the same sheet-iron at each end which fix to the winch handle and the pin axle. This axle fits tightly in a tube. The blocking of the inside bearing is achieved by roughening the edge of the tube and distorting its lining at three points above the level of the bearing with a blunt graver.

The whole mechanism is protected from bad weather by a cowling made from an old car headlight on to which is riveted a sheet-iron cylinder. The cowling is cut underneath for its mounting. A similar headlight is fixed to the centre of the airscrew. It continues the cowling and gives an overall aerodynamic shape. Should This prove difficult, the same shape can be formed in glass fibre.



# Bicycle Airscrew Generator