SSERC
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

Science & Technology Equipment News

Number 8 Winter 1995-96

For teachers in Primary schools and of S1/S2 Science & Technology courses

In this issue we leave Earth and Space (well, you know what we mean) and visit some other, as yet ill charted, corners of the National Guidelines on Environmental Studies 5-14. The theme in this issue is windpower. As suggested for Issues 6 and 7 teachers and others are invited also to tease out some of the practical ideas presented here and match them to relevant parts of the Guidelines. Elements of both science and technology are included in what follows although we have made no attempt artificially to separate them. Other aspects of Environmental Studies such as People and Place and People in the Past are again touched upon. Some scientific units are mentioned. There are opportunities for activities in mathematics.

Wind, windpower and windmills

In the temperate zones of Europe wind has much to recommend it as a source of energy. It is inexhaustible, renewable, clean and free. The amount of potential energy in the wind, energy that can be made to do useful work, is about three times the Earth's annual electrical energy usage.

From the same television pictures it is apparent that the isobars form shapes which illustrate characteristic movements of air masses. When the pressure decreases towards the centre of the shape this is known as a low pressure area or a depression. When pressure increases towards the centre, this is an area of high pressure or an anti-cyclone (Figure 1).

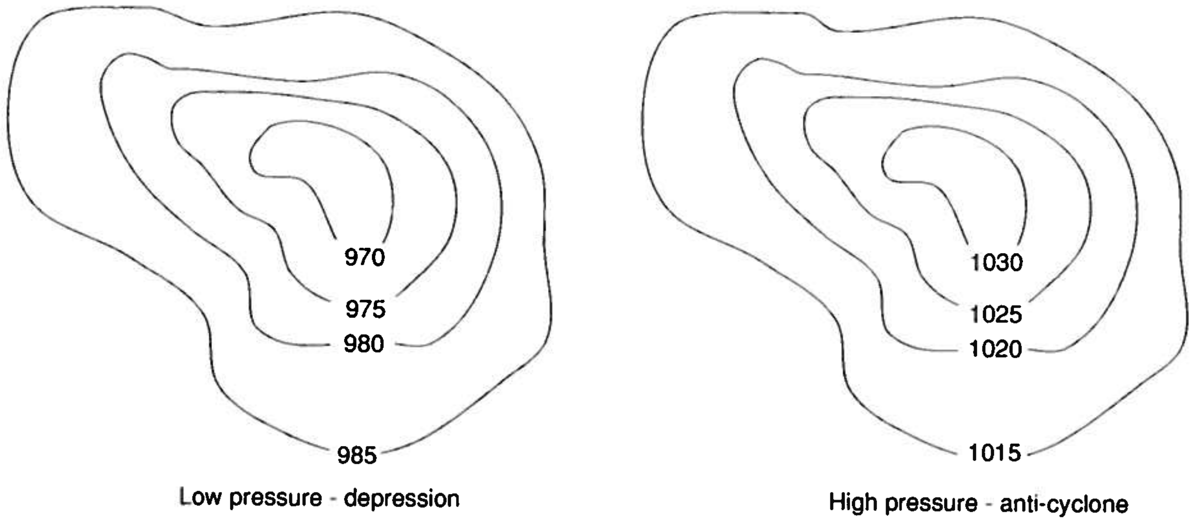

Figure 1 Examples of isobars and of typical patterns for low pressure systems (depressions or cyclonic systems) and high pressure areas or anticyclones.

Changes in the temperature of the Earth's surface including that of the oceans bring about changes in the pressure of the atmosphere (barometric pressure). This in turn may cause vast amounts of air to move across the Earth's surface. This moving air is what we call the wind. Air moves from where there is lots of it to where there is less. That is, it moves from high pressure areas to low pressure areas,

From television weather forecasts we are probably all aware of those imaginary lines drawn over maps of the United Kingdom. These lines join together points of equal barometric pressure. They are called isobars On weather charts or maps these are drawn at intervals of 5 millibars (1 bar being *normal* atmospheric pressure at sea level and 1 millibar being one thousandth part of a bar).

Like contour lines on an ordnance survey map or depths on a chart of the ocean, isobars provide a relief map of atmospheric pressure.

In the Northern hemisphere wind in low pressure areas moves in an anti-clockwise direction and in high pressure areas in a clockwise direction. Why doesn't air move in a straight line from a high to a low pressure area? (We're back to *Earth and Space* again!).

Little of this may impinge directly on the lives of most city dwellers. It is of great concern to farmers, fishermen, weather forecasters and producers of electricity by wind power! In the stratosphere, some 150 Km above the Earth's surface, winds of 300 Kmh^{-1} (kilometres per hour) are commonplace but our present technology makes it impossible to harness winds of such power. Hurricanes and typhoons, for example, which cause such great destruction rarely exceed 150Kmh^{-1}. But at the Earth's surface, winds are generally much gentler than that. They can be put to work. Harnessing the wind is by no means a recent idea. Who was the genius, or tired oarsman, who first hoisted a sail?

Harnessing the wind

Ancient Egyptian wall paintings show ships with simple sails and rigging. We also know that by the 7th century BC windmills already were in use in China, Persia and then in Afghanistan. These early windmills were fairly crude, with horizontal sails, the hub being the millstone itself. This was as far as the technology had advanced. Nonetheless people had already found ways to convert the energy contained within the wind into a mechanical movement grinding their wheat into flour.

It was not until the 12th century AD that the first vertically rotating mill sails appeared. These are familiar to us all from scenes in Dutch paintings. Technology had advanced sufficiently to enable the makers of the mills to use a simple crankshaft to change the rotary motion imparted by the sails to vertical motion of the connecting rod to operate a pump. In this manner the Dutch kept the sea at bay and were even able to drain and reclaim land from the North Sea.

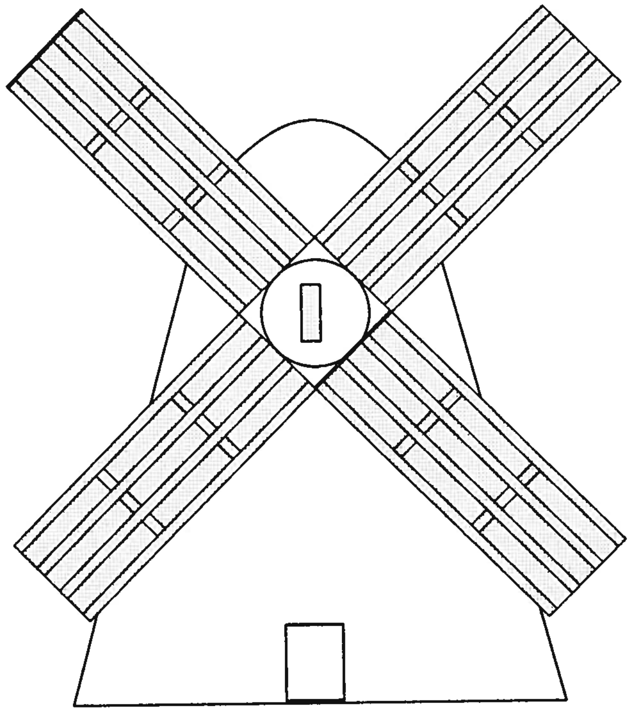

Figure 2 Diagrammatic representation of a vertical sail windmill. Not to scale.

Windmills of the mind

Further advances in technology brought gear wheels of sufficient size and strength to allow longer sails still to turn relatively slowly but with increased rotational speeds for the shaft. At the same time other improvements had been made in gearing to transfer power at right angles. These were probably extensions and adaptations of the wooden gears used in watermills.

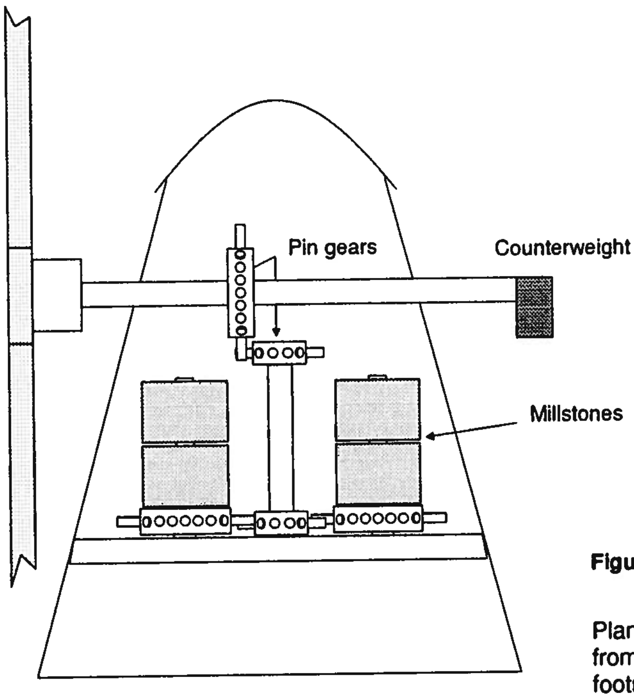

Figure 3 Vertical sail windmill, stylised diagrammatic section

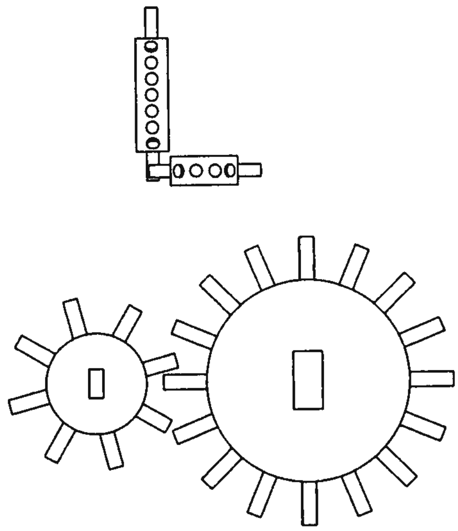

Figure 4 Detail - side view and section of wooden pin gears

Figures 2 and 3 depict in highly stylised forms a windmill with vertical sails. Note that these representations are not to scale and probably not at all accurate.

They do however illustrate one method for transferring power from the vertically rotating blades to the horizontally turning millstones. Early examples used simple pin gears or other wooden gearing (eg Preston Mill, East Linton in East Lothian. It is however a watermill, but one still in working condition). As technology advanced so the gearing became more complicated and much more efficient.

Plans and parts for building model windmills are obtainable from *Technology Teaching Systems* or *NES Arnold* (see footnote for addresses etc). If you intend building your own, then remember that you need some method of transmitting the power through 90°.

A number of simple gear kits like Brio or Hanse Tec (from NES) allow this to be done in a similar way as that shown in figures 3 and 4. These kits can be used to show the principles. They do not provide a smooth running gear box! Older children can probably build a working model using LEGO gear kits. Make sure any such kit you purchase does include gears of the proper sort, known as bevel gears.

Technology Teaching Systems, Unit 4, Park Road, Holmewood, Chesterfield, S42 5UY, Freephone 0800 318686.
NES Arnold, Ludlow Hill Road, West Bridgford, Nottingham, NG2 6HD; Telephone 0115 945 2325.

Blow the wind Southerly

Figure 5 provides a template for a simple DIY propeller. Draw or trace a similar shape onto a square of coloured paper or light card. A good size is 210mm x 210mm, which can be cut from a sheet of A4. Cut along the dotted lines as carefully as possible. Bring the four corners into the centre, try to place all of the corner circles accurately over the single central one. Using PVA or a similar glue (or a low melt Glue Gun - *see Be Safe!*) stick the corners into position. Push a hole through the centre. Fix the propeller to a suitable stick with a drawing pin or a map pin pushed through the central hole. You will need a reasonably long shaft on the pin.

Allowing the children to investigate how the propeller can be made to turn should prove successful. Some may even work in the real wind outside in the playground. This propeller is good fun to run round the classroom or to plant in the garden to keep the birds away from the seeds or lettuces. While in this form it is merely a toy, windmills of similar type are still used in Mediterranean countries where often they are known as *Cretan* mills. The manufacture of a Cretan mill could be a challenge for some older Primary pupils.

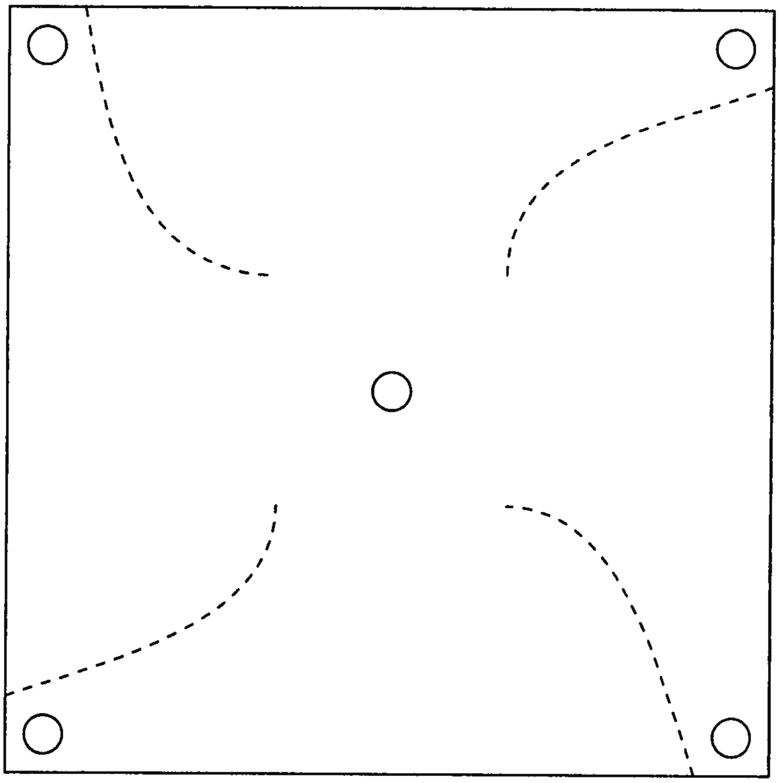

Figure 5 Template for a four bladed toy windmill

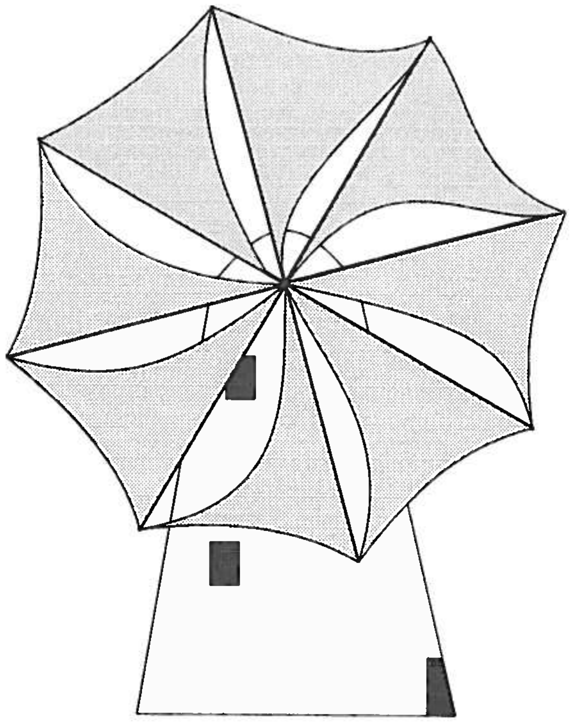

Figure 6 Cretan mill - note the resemblance to a simple toy windmill but with eight cloth sails instead of four in paper or plastic.

Seize the moment

Just when it was becoming enjoyable - is obviously the time for some more boring conventional science and technology.

The pictures of our windmills show them with very large sails, or arms. When considering the power produced by our windmill, or in modern times an electricity generator, it is a good time for a recap on the principle of the lever. In a simple lever you gain force as you loose distance towards the pivoting point. With a windmill or wheel the longer distance travelled by the sail or wheel-rim the shorter the distance but the greater the turning force at the hub or axle. Other good examples of this principle are a spanner and nut, or the steering wheel of a motor car (Figure 7).

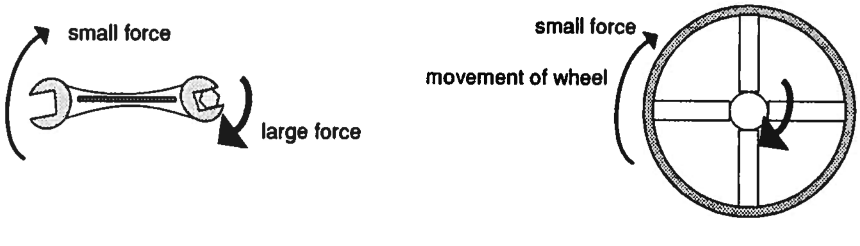

Figure 7 Illustrations of the principle of the lever and turning moments using a spanner and the steering wheel of a car as examples. The same principles are demonstrable in a windmill or a wind powered electricity generator.

Power from the wind

In the past, wind powered devices did useful, directly mechanical, work such as grinding corn or pumping water. Wind powered pumps are still to be seen on some Scottish farms today. Nowadays the emphasis tends to be on the potential of wind power for the generation of electricity. We can easily model such devices in the classroom. In our models we will of course be constrained by those propellers we can buy or have in the bits and pieces box. Now most propellers are meant to be just that, a means of propulsion. Will they be equally good on a wind generator? Can we devise a test to discover if one that is good at propulsion is as good on a wind generator?

Figure 8 below shows one way. Different propellers are used to drive a buggy and it is timed over a measured distance. The chassis of this buggy is a simple wood and paper frame. It makes use of 10mm square wood strip with the addition of A4 card. Fold the piece of A4 card lengthwise through the centre, then fold again. Cut the card through the folds into four pieces (keep the spare pieces). Using the long side of the card measure and cut two pieces of 10mm wood. Now measure and cut the two short ends. Remember they will fit inside the two long strips. Glue each strip to the outside edge of the card. Try to keep the frame as square as possible. Now, on the spare piece of card, mark off two 30mm squares, draw a diagonal through each square and cut into triangles. Glue these card triangles to the frame corners as shown in the diagram. With the remainder of the card mark, out eight equal rectangles each 30mm x 20mm, these will be used as axle bearings.

The hole size for the bearing will depend on the material chosen for the axle and the wheels. Make sure the block of wood is deep enough for the prop blades to clear the floor or table. The proportions of the finished shape of the axle bearings are shown in the diagram (Figure 8).

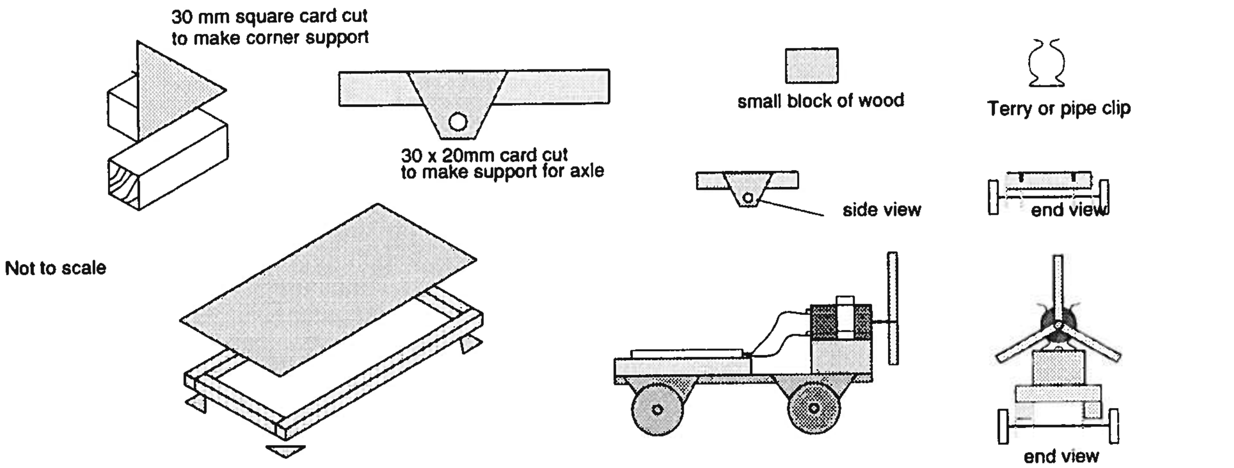

Figure 8 Constructional details for a wooden framed buggy (so-called, and fairly weel-kent, 'Jinks method' using 10 mm² section softwood).

The propeller and motor that have been chosen as the "best" by investigation can be tried in a wind generator (Figure 9). What you will need is a tower on which to mount it. This tower will have to be stable and strong to withstand wind pressure. The propeller can now be made to turn with the help of a hair dryer, on the cold setting. The low voltage produced by the generator can be read from a voltmeter or multimeter should the school have one. Failing that you can use the output of the generator to light an LED (light emitting diode or as one recent client charmingly called it a "little electrical device"). For this investigation an LED can be used on it's own, in other circuits it usually needs a current limiting resistor in series. LEDs in different colours (and advice on their use) are obtainable from SSERC, 24 Bernard Terrace, Edinburgh EH8 9NX Tel. 0131 668 4421. We also hold stocks of propellers, motors, wheels etc. - see previous editions of Science and Technology Equipment News.

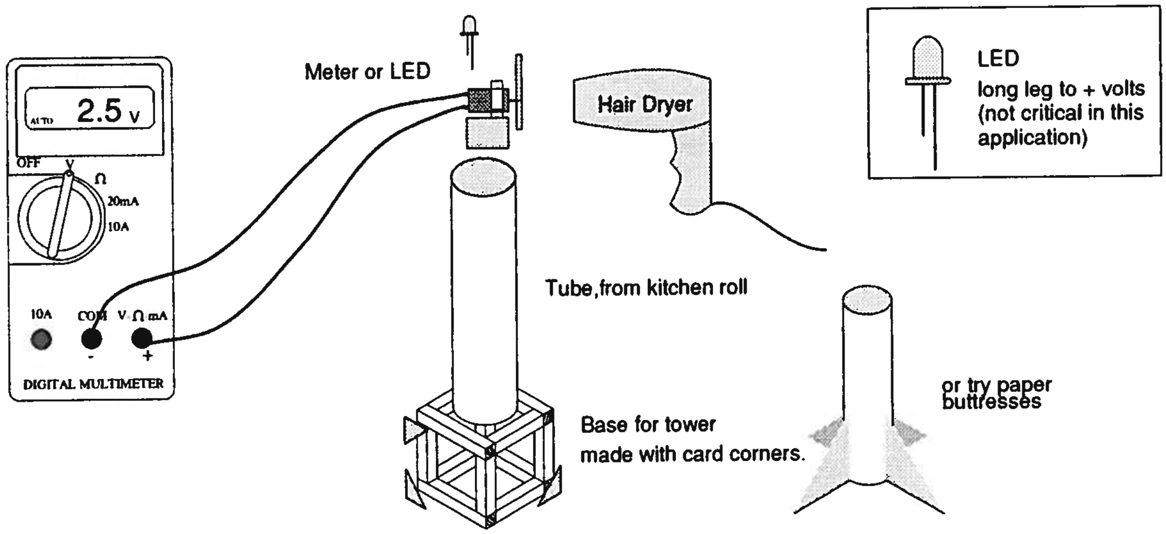

Figure 9 Tower for mounting and testing a model wind generator. Note that the output is almost certain to be insufficient to light a conventional torch bulb, even a miniature type. It should be capable however of driving a light emitting diode (LED). Use hair drier with care.