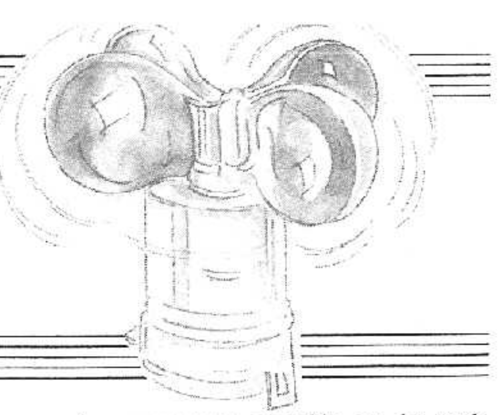


WINDICATOR

ALAN WINSTANLEY

LED to the bar for a good measure gets you simply blowing in the wind!

ONE of the more entertaining and interesting requests which came the author's way recently was an appeal for a wind speed indicator which had to be reasonably accurate but above all, simple to build. Quite a tall order! A good deal of experimenting has resulted in this simple design – a project nicknamed the "*Windicator*" – which the designer hopes will fit the bill precisely. Having shown the design to many ordinary non-electronics folk, they have been quite fascinated to see this simple project in action, so it's sure to have a wide appeal and will be especially useful for its educational and interest value.

You will probably have seen a wind speed measuring device – an *anemometer* – in use at one time or another, perhaps at an airport or a weather station. Those rotating cups whizzing round at a fair lick are propelled by gusts of wind from any direction and the rotating shaft drives a transducer to generate an electronic signal. This data has to be decoded ultimately to produce an intelligible measure of wind speed, which requires precision measuring equipment.

This Windicator design is not at all intended to be a precision device although the unit has been calibrated to give a surprisingly effective display of prevailing wind speeds. It is guaranteed to provide many hours of interest and entertainment for all ages, being simple and fun to build – and you don't need a personal computer to use it!

Of great importance to mariners, the *Beaufort Scale* is a measure of wind speed. Named after the Royal Navy Admiral Francis Beaufort (1774-1857), it was accepted in the late 1800s and was further adjusted in the 1920s to its present scale. A scale of zero is classed as Calm whilst at the other extreme, a reading of 12 signifies Hurricane Force, something very rarely witnessed in the United Kingdom, mercifully!

The basic relationship between wind velocities and the effects that varying levels of wind have on the environment is shown later in Table 1.

WINDICATOR CONSIDERATIONS

Having given the project some thought, it soon became apparent that the major problem likely to be encountered by constructors would be *mechanical* rather than *electronic* in nature. The idea of using rotating cups to detect velocity from any direction seemed the best approach, but implied that a rotating shaft assembly would need to be used somewhere along the line, perhaps being guided in bearings to ensure smooth running.

It is certainly possible to purchase all the required materials – ball-bearing races and round bar in plastic – from several specialist engineering or modelmaker's sources but having priced up such a design, it was not in the least cost-effective and parts would not be readily available to most readers. Also the success of the finished unit would ultimately rely on one's ability to construct the rotating cup assembly to quite a high degree of workmanship and accuracy.

SIMPLY CYCLING

A more economical and simple design was therefore called for. The final design is straightforward and does not require any complicated bearings or shafts, so that almost *anybody* can construct it. At the heart of the design is a good quality d.c. electric motor, used as a form of a wind-powered dynamo. As every schoolboy knows, when the shaft of an electric motor is rotated, this induces a voltage in the motor windings which can be used to power a load – just like a bicycle dynamo.

The use of the specified motor will give very effective results, but most importantly of all, it means that no bearings or drive shafts are necessary since the motor takes care of all these aspects, which vastly simplifies the construction.

An anemometer assembly can be made from four ordinary plastic measuring scoops, and these are used to spin the motor shaft directly. It is simple but highly effective. (Visions of ping-pong balls, cut in half, also sprang to mind but were quickly eliminated.)

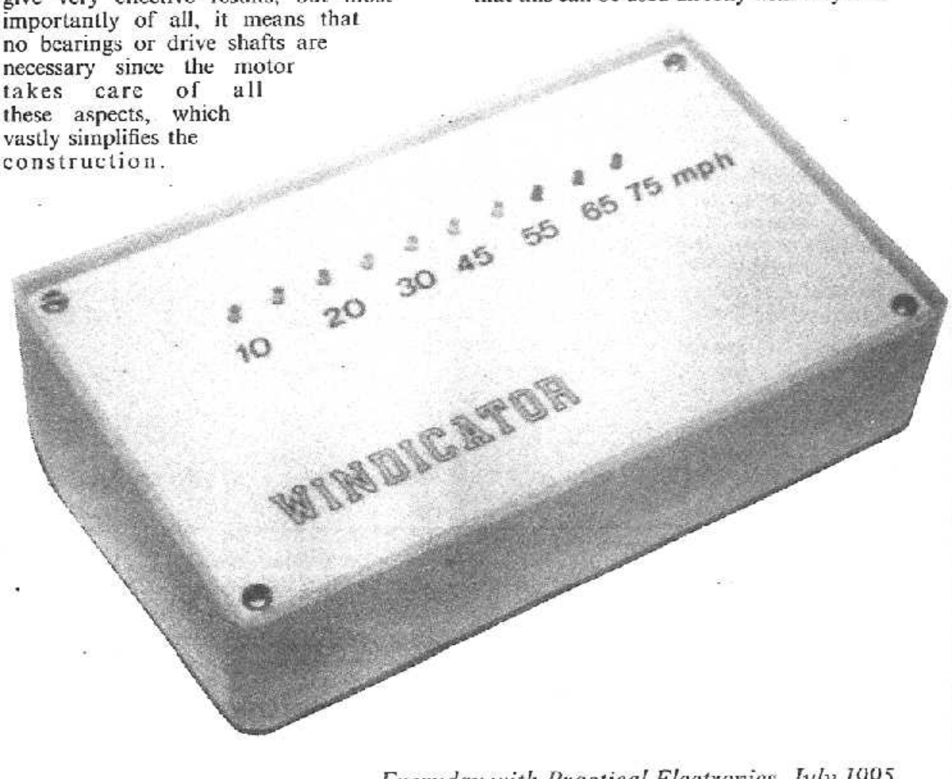
WINDY CIRCUIT

The circuit diagram for the Windicator is shown in Fig. 1. Component M1 is a quality 6V d.c. electric motor. This is used as a wind-powered dynamo, which has a rotating cup assembly fitted directly to its drive shaft.

Tests during the early days of development showed that the output is relatively linear – although not perfectly so it is considered more than adequate in this application to produce an acceptable display. If the specified motor is used readers will be able to build this design and use the calibrations copied from the prototype, so absolutely *no* calibration is needed (later, you are shown how to test the circuit by comparing it against a car speedometer).

GOOD MOTOR

Earlier prototypes used a simple cheap d.c. model motor but the output characteristic was very poor – generating only about 100mV at high wind speeds – and this necessitated further buffering and amplification. The arrival of a much better quality d.c. motor dispensed with the need for any initial amplification, since the d.c. output of the specified motor is so good that this can be used directly with very little



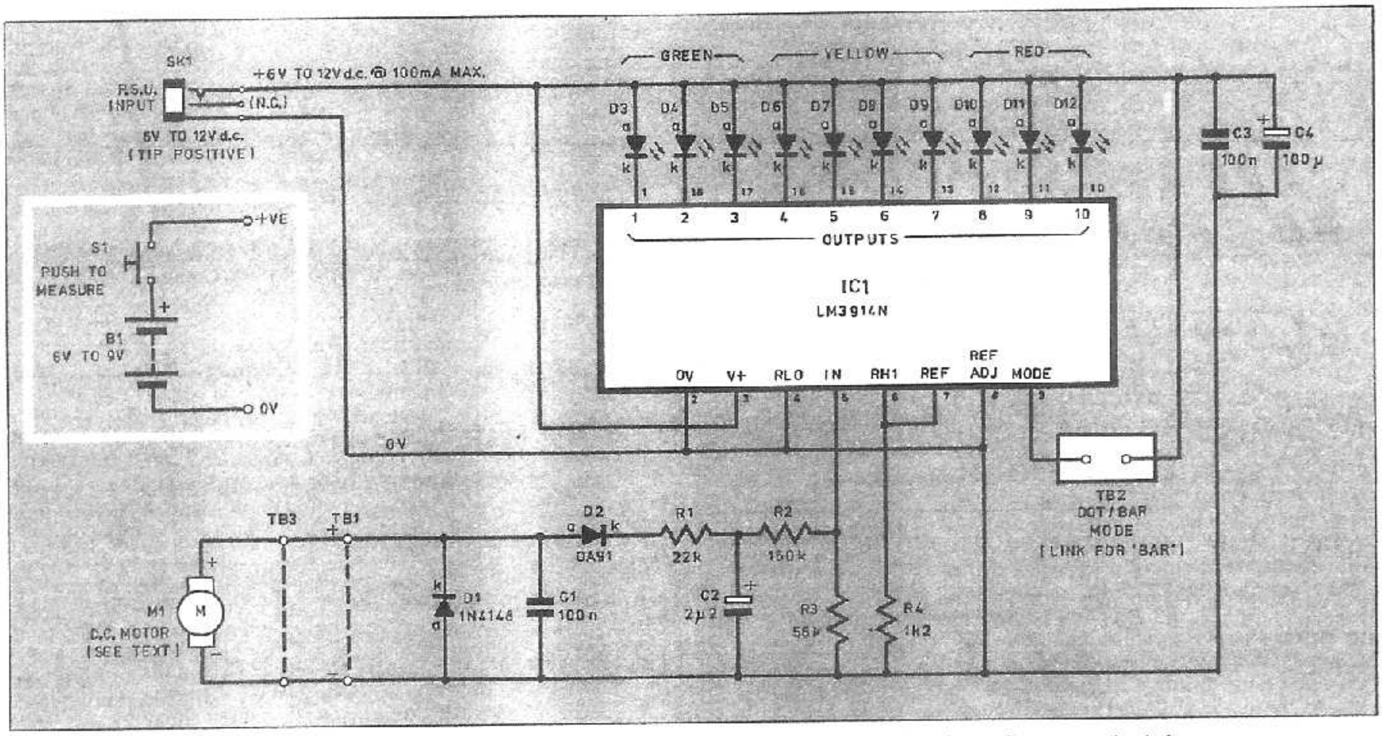


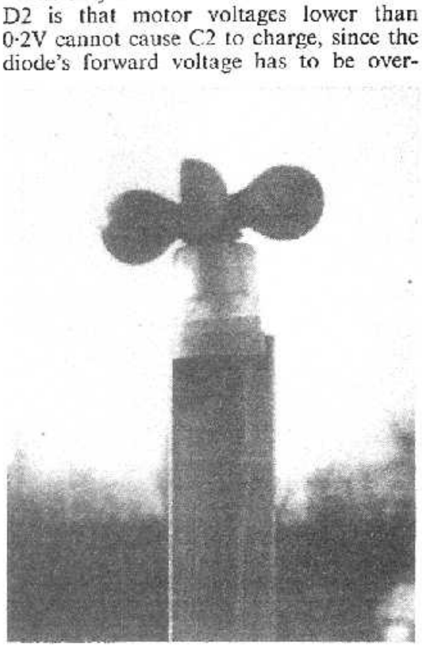
Fig. 1. Complete circuit diagram for the Windicator. See text regarding inset figure on the left.

further processing. The final circuit was a simplified version of earlier attempts, and works extremely effectively.

The output voltage generated by the motor is proportional to the prevailing wind speed. A motor voltage of up to 6V d.c. or more (as measured) is produced with varying levels of wind velocity. The back e.m.f. generated by the motor is shunted by rectifier D1 and noise spikes are filtered by capacitor C1.

Diode D2 is a *germanium* diode which has a 0·2V forward voltage drop (unlike a silicon type which is typically 0·6V). Again, the motor output voltage proved so high in use that the voltage drop across the diode had no particularly significant effect on the results. Resistor R1 and capacitor C2 form a pump in which C2 is progressively charged up by the voltage generated by the motor. Diode D2 prevents the capacitor (a tantalum type) from discharging anywhere except into resistors R2/R3.

The only drawback with the use of diode D2 is that motor voltages lower than 0·2V cannot cause C2 to charge, since the diode's forward voltage has to be overcome. In practical terms, this means that the minimum wind speed which the Windicator displays is approximately 10 miles per hour. It was thought there was little point in trying to make the circuit more sensitive in an effort to detect speeds under 10 m.p.h., though.



The result is that the potential across C2 rises when the motor rotates and decays again when the motor halts. The time constant here is quite low – well under half a second, so the circuit is quite responsive to changes in wind speed. Resistors R2/R3 actually form a voltage divider, with values selected for the motor, which steps down the generated voltage. Trials showed that the output voltage across R3 equated to an average of 200mV at a speed of 10 m.p.h., all the way up to roughly 1·5V at 70 m.p.h.

BARGRAPH DRIVER

This varying d.c. voltage is directly coupled to IC1, an LM3914N bargraph driver. The Windicator display is in the form of a multi-coloured array of ten light-emitting diodes, representing average wind speeds from 10 to 75 m.p.h.. This popular i.c. will power ten l.e.d.s directly, using just one external resistor (R4) to set the current levels flowing through them. The i.c. has an input buffer amplifier which is quite robust – protected for inputs ±35V d.c – and so absolutely no further signal processing is needed in this very simple application.

The LM3914N offers an internal precision 1·25V reference at its pin 7, and this is connected across a series of ten comparators within the device. Pin 6 represents the "top end" of the comparator chain which is connected to the 1·25V reference: the "bottom" of the chain is pin 4 which is connected to 0V.

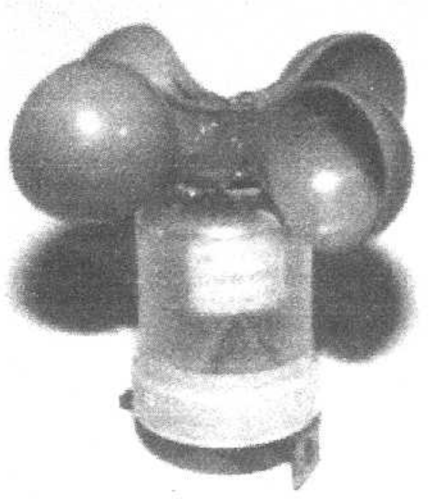
For each 125mV rise (1·25V /10) in input voltage at pin 5, an internal comparator will switch on, causing the relevant output pin to go *low*. The outputs (pins 1 plus 10 to 18, noting their order) are normally high and only when they go low do they sink current and enable the respective l.e.d.

SELECTABLE DISPLAY

Another useful feature of which the Windicator takes advantage is the ability to produce either a bargraph or "moving dot" display. If IC1 pin 9 is left open circuit, only one led will be on at a time. By linking it to the positive rail using TB2 (see later), a bargraph display will be produced. Capacitor C2 helps ensure that the display does not flicker too much.

To improve the display, the l.e.d.s on the prototype were colour-coded. The first three (D3 to D5) are green to indicate "normal" (up to 20 m.p.h.); D6 to D9 are yellow (up to roughly 55 m.p.h.) whilst the last three indicators, D10 to D12, are red (up to 75 m.p.h./ let's get out of here!).

At this point readers should be made aware that the calibrations shown on the prototype (see photographs) are the result of comparing various prototypes against a car speedometer when driving around deserted country lanes in calm weather. This was thought the most realistic and practicable way of simulating various speeds, since wind tunnels are a bit hard to come by. The calibrations are the averages taken from several test runs and are as



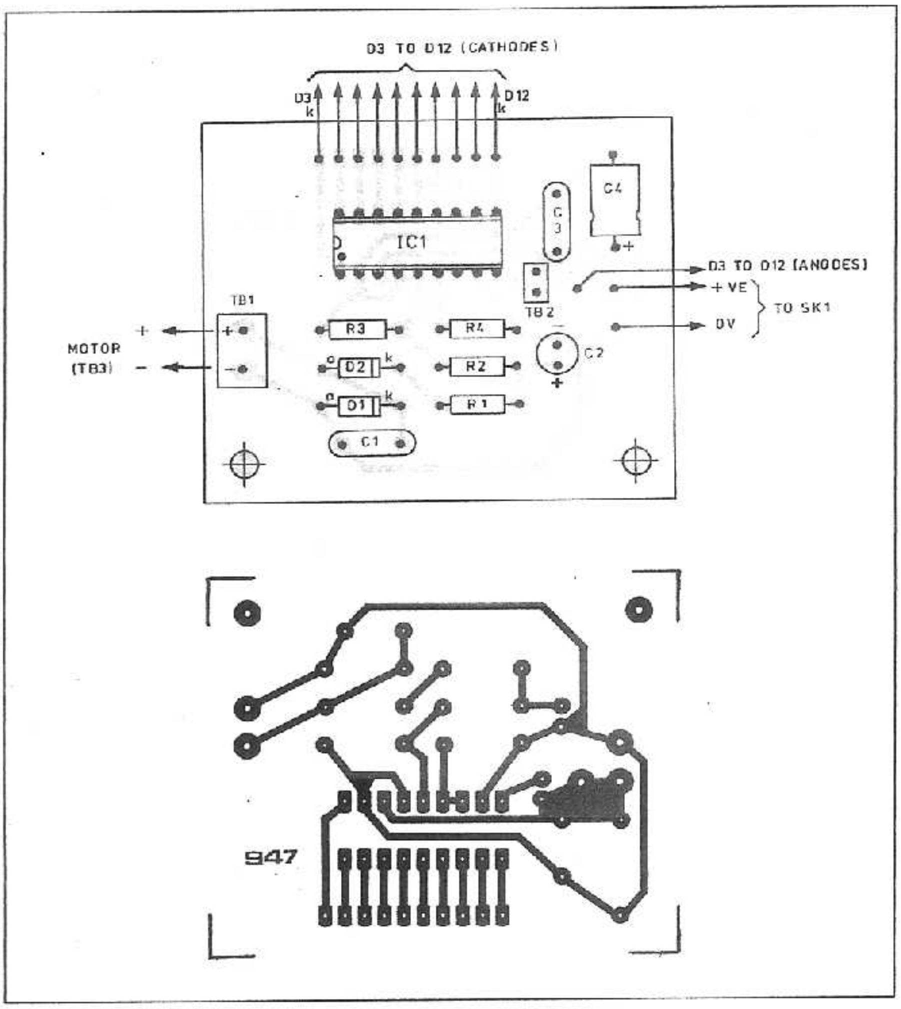


Fig. 2. Component layout and full size copper foil track master for the Windicator printed circuit board.

accurate as possible. The prototype was fitted to a car and the l.e.d. display was calibrated against the Speedo across the entire range of velocities shown. Naturally, a co-pilot was employed to jot down the readings, and speed limits were strictly adhered to!

The results which readers will obtain depend on their choice of motor. If you follow the details of the prototype as closely as possible and use the specified components then *there is no need to have to calibrate your own unit as the scale shown on the prototype unit should prove perfectly adequate.*

Finally, rather than build a separate mains power supply, the prototype Windicator uses an ordinary cheap 6V d.c. mains adaptor to run from the mains continuously. This is connected via the jack socket SK1. Capacitor C4 helps decouple the power supply, although the LM3914N is none too fussy about the quality of the d.c. rail. Correct polarity of the power supply is absolutely essential of course, or the bargraph chip will be permanently damaged. The supply voltage level is not critical and between 6V and 12V should be fine.

The unit could run directly from a 6V d.c. battery pack but then a continuous display will not be feasible (the Windicator may draw over 100mA maximum in bargraph mode) unless you use a set of NiCad rechargeable cells. As shown in the inset diagram of Fig. 1, a series pushswitch is the best option if using a battery, as is selecting "moving dot" mode (TB2 open circuit) to economise on battery life.

CONSTRUCTION

Assembly is very straightforward. The circuit is built onto a small printed circuit board (p.c.b.) size 61mm × 51mm available from the *EPE PCB Service*, Code No. 947. The Windicator was housed in an economical sloping-front case size 161mm × 96mm × 39/57mm, which had an aluminium front panel. There is plenty of room in the specified case to house the p.c.b., remembering that a power supply may be brought in from an external mains adaptor. Alternatively, the case will also house a battery (four × AA size) should you wish to run it from batteries.

Start by using the empty p.c.b. as a drilling template for the two 3mm diameter mounting holes, which need drilling through the base of the enclosure. Continue construction by assembling the p.c.b. in accordance with Fig. 3.

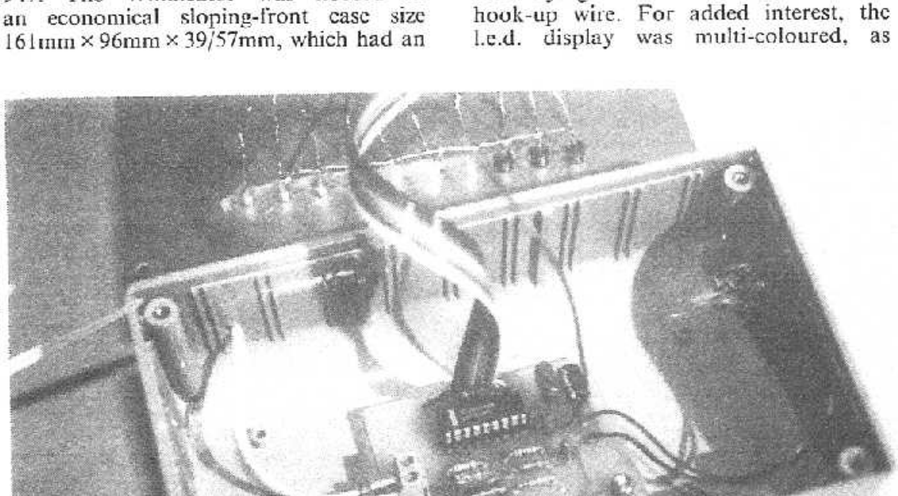
First of all, solder in an 18-pin dual-in-line (d.i.l.) i.c. socket to hold IC1, and continue with the rest of the discrete components, observing polarities for the tantalum and electrolytic capacitors.

The diodes require special mention: the polarisation of silicon rectifier D1 should be readily identifiable but the germanium glass diode D2 may be tricky to sort out. Look very closely at the glass body and there should be a band marked around the cathode end – this was extremely faint on the prototype. The germanium diode is also quite delicate: do not bend the leads too closely to the glass body and take care to solder it quickly into position without overheating it.

A two-way screw terminal block (TB1) was used to provide the connections for the twin-core motor wire (see motor details later). The bar/dot mode selector link (TB2) was a s.i.l. (single-in-line) header with push-on link. You might choose to hard-wire this with a link (bargraph display mode), or just use two short lengths of tinned copper wire – twist them together to produce a bargraph.

Lastly, fit IC1 into place. The chip is a bipolar type and does not need any particular anti-static handling precautions. As always, one end of the i.c. is identified by a notch or a dimple next to pin 1 (or both). It *must* go in the right way round or it will be damaged on power-up.

The flying leads for the ten l.e.d. cathodes (k) were formed with a short length of 10-way ribbon cable which was soldered directly to the board, and all other flying leads are made with standard hook-up wire. For added interest, the l.e.d. display was multi-coloured, as



Interior view of the Windicator assembled electronic components. Note how the l.e.d.s are connected.

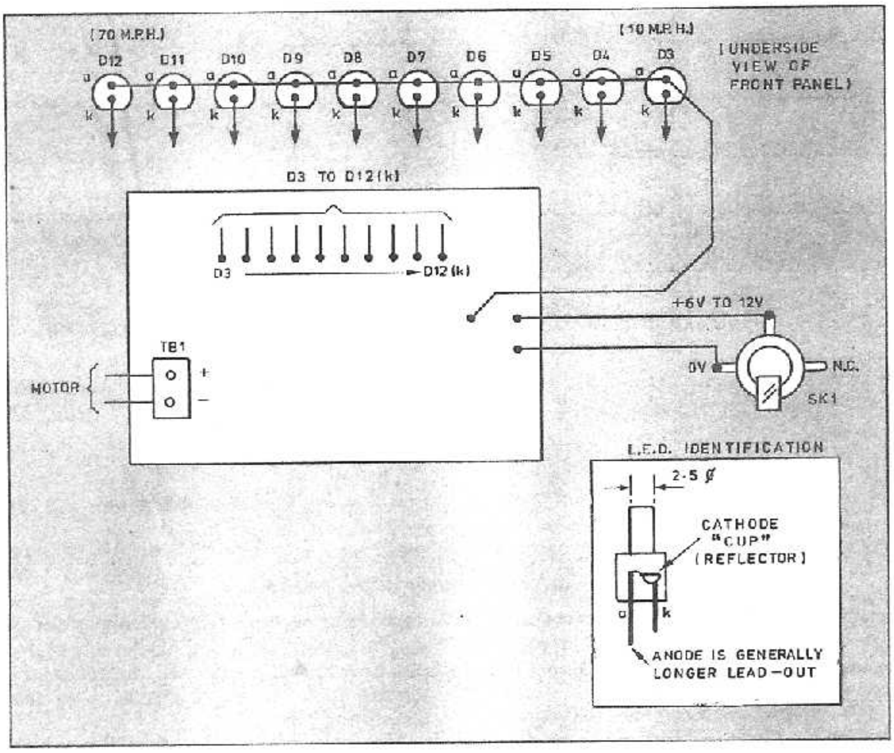


Fig. 3. Interwiring details for the Windicator.

COMPONENTS

Resistors — See SHOP TALK Page

R1	22k
R2	150k
R3	56k
R4	1k2

All 0·25W 5% carbon film

Capacitor

C1, C3	100nF polyester (2 off)
C2	2µ2 tantalum bead 16V
C4	100µ min. axial elect. 16V

Semiconductors

D1	1N4148 silicon diode
D2	OA91 germanium diode
D3 to D5	green l.e.d. (3 off)
D6 to D9	yellow l.e.d. (4 off)
D10 to D12	red l.e.d. (3 off)
IC1	LM3914N bargraph driver

Miscellaneous

M1	d.c. electric motor Matsushita MHN-5RG4E (see *Shoptalk*)
TB1	2-way p.c.b. terminal block
TB2	2-pin s.i.l. header with jumper (see text)
TB3	2-way electrical terminal block
SK1	3·5mm jack socket

Printed circuit board, available from the *EPE PCB Service*, code 947; sloping plastic housing, size 161mm x 96mm x 39mm/57mm; M3 p.c.b. mounting hardware; 18-pin d.i.l. socket; motor mounting hardware and plastic enclosure 35mm dia. x 50mm; plastic scoops, 15ml capacity approx. (4 off); plastic V-pulley 30mm dia. with grub screw hub; 6V to 12V d.c. 300mA unregulated mains adaptor; materials for mast; twin core zip wire, to suit; hook up wire, glue, grommet, solder etc.

Approx cost guidance only **£28**

mentioned earlier. The author chose 2·5mm diameter "flat top" types, for which a series of 2·5mm diameter holes were drilled in a line through the front panel.

A keen, sharp twist drill is needed for this method though, and it's essential to centre-punch the drilling spot beforehand, to prevent the drill from wandering about.

After drilling the holes, they can be de-burred with a larger diameter twist drill or a special tool, before the display is marked with the calibrations shown in the photographs. Ordinary rub down lettering is used to number the display, followed by a coat or two of protective spray-on lacquer.

On the prototype, the l.e.d.s were pushed through from behind, as a form of "invisible fixing". Small blobs of hot melt glue were also applied as an extra measure to secure them but the overall display is quite strong and appealing to look at. Needing no mounting clips, it's also cheap.

INTERWIRING

The interwiring is very straightforward and is depicted in Fig. 3. The l.e.d. anodes (a) can all be hard-wired together simply by bending their lead-outs carefully to make contact with those of their neighbours, then they can be soldered. The display is in effect a common anode arrangement and one separate wire connects the anode "rail" to the p.c.b.

It shouldn't be necessary to use any insulation as the hard-wired assembly should be relatively rigid and safe from short-circuits. The main point is of course to correctly orientate the l.e.d.s!

If in doubt, look through the translucent package: the "Cup" (reflector) is usually the Cathode. (One yellow l.e.d. resolutely refused to work in an early prototype – the l.e.d. had been moulded with the identification "flat" next to the anode!) Then solder the 10-way ribbon cable from the p.c.b. to the appropriate l.e.d. cathodes (k).

The case is finished off with a 0·25 inch diameter hole for the jack socket SK1 (if used), and a suitable hole to accept the connecting lead from the motor, for which a grommet should also be used.

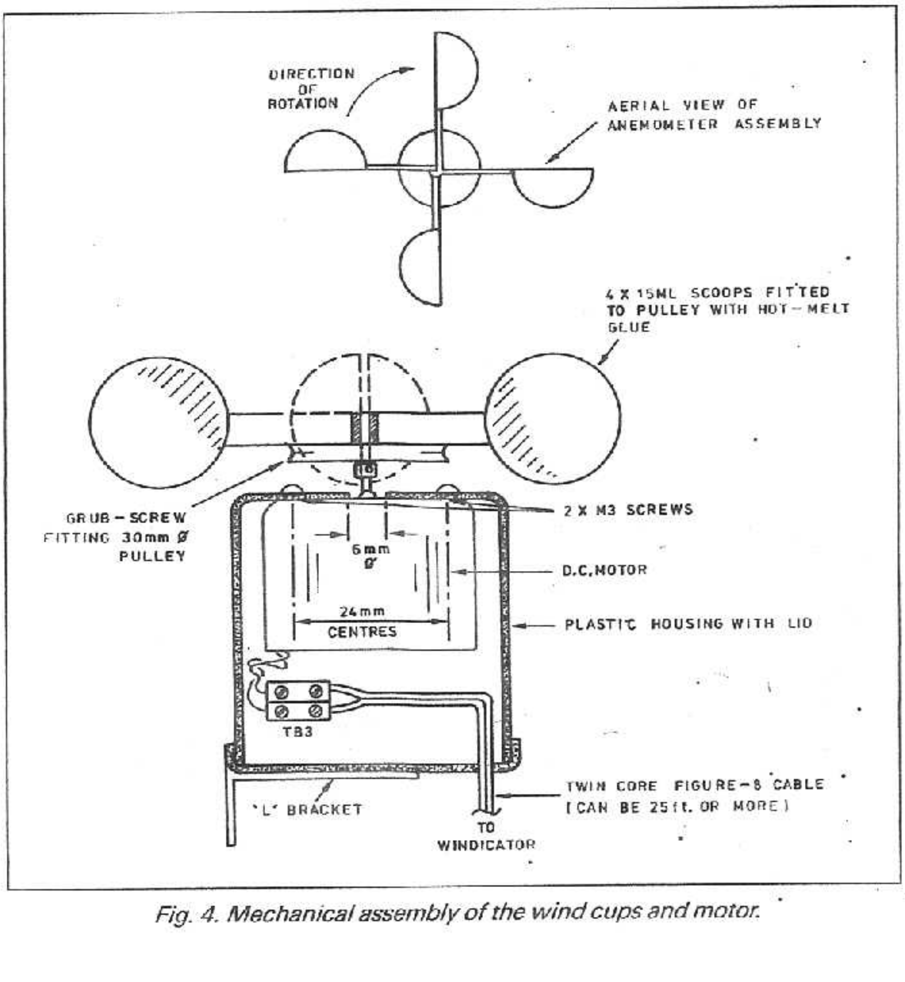


Fig. 4. Mechanical assembly of the wind cups and motor.

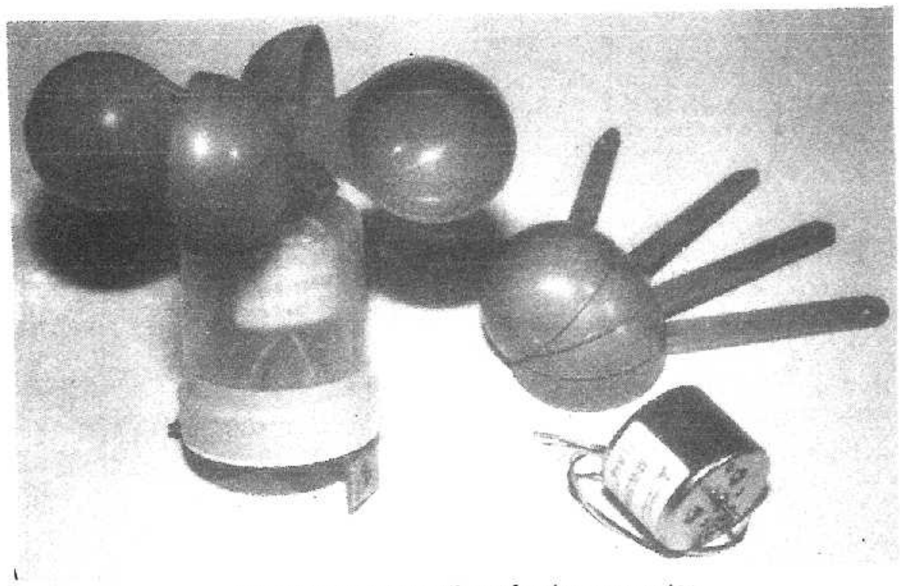
At this stage, the display can be quickly tested without using the motor. Link TB2 to select "bar" mode. Then ensuring that the power supply is of the correct polarity, apply a d.c. voltage (6V to 12V) to the power supply inlet. The light-emitting diodes will *all* illuminate when the LM3914N input pin 5, or even D2 cathode, is temporarily hooked up to the positive supply rail using a jumper lead. If some glow but not others, you've probably reversed the l.e.d. connections somewhere. With the main unit complete, attention turns to the anemometer section.

MOTOR-HEAD

The high output d.c. electric motor tested and approved by the author (see *Shoptalk* page) measures 30mm diameter × 25mm deep, with a 1·5mm diameter, 5mm long drive shaft. It is smooth running and generates a usefully high voltage. Fig. 4 summarises the assembly details for the prototype motor and wind-cup unit. A round plastic container with screw-on lid was used as a housing; you could perhaps improvise with a large Aspirin container or something slightly larger than a 35mm film container, to protect the motor from the elements.

Carefully drill the end of the container with three holes as shown – one 6mm diameter for the shaft along with two 3mm clearance fixing holes. The motor body can be secured end-on using two M3 × 6mm screws. Do not overtighten them or the plastic housing will eventually crack. A little light lubricant (the author used a Teflon-based cycle lube) applied near the shaft is likely to repel water and improve the smooth running.

The anemometer cups were formed from four 15ml plastic measuring scoops, with the "handles" slightly shortened. These were affixed to a plastic pulley (30mm diameter) using plenty of hot-melt glue (which is virtually the only way to glue certain plastics such as nylon or polythene



The principle ingredients for the aneometer.

together). Ensure that the cups all face the right way round – see photos – and try to ensure they are all level in relation to the pulley, to avoid "wobble".

The overall diameter of the cup assembly was about 120mm diameter on the prototype. Also, the pulley must have a *grub-screw* type fixing so that it can be screwed onto the motor shaft. Although the length of the motor shaft is minimal, it proved adequate enough to produce a very secure assembly. Obviously you can test to see how the motor assembly runs by applying a d.c. voltage.

A two-way terminal block (TB3) terminates the motor leads, this also fits within the round plastic housing. At this point, it's necessary to determine the polarity of the motor output, given that this depends on which way round the motor has been wired and which direction the cups will move when they spin in the wind. Save work: A quick practical test is simply to hook up a voltmeter and test the output when you blow on the (concave) scoops, then identify the polarity of the connecting wire.

You may wish to try the Windicator display by temporarily hooking up the motor to the p.c.b. (observe polarity). Blowing hard on the anemometer unit should cause probably four or five l.e.d.s to illuminate in bargraph mode; also try the dot mode. It will test your lung capacity if nothing else!

Lastly, ordinary cheap twin-core "zip" wire is all that's needed to hook up the motor once it has been sited in its resting place, and this wire could easily be 25 metres long or more. The connecting lead passes through a hole in the base of the housing, to the main Windicator unit.

The completed prototype motor assembly was fitted to a length of aluminium angle with a small L-shaped bracket screwed into the removable lid of the plastic housing, with insulation tape sealing the lid before the finished device was finally secured at the rear of the author's house. The unit shown in the photographs has been subjected to the most atrocious weather conditions (typical British weather, in fact!) over many months and is still operating perfectly.

SITE SEEING

The final location of the motor head is quite important and may be the subject of trial and error. Fortunately, a convenient balcony was available at *Chez Nous* and the motor was fixed to the railings, much to the intrigue of the neighbours. Earlier efforts produced poor results, and this was attributed to the house actually sheltering the anemometer from prevailing winds in certain directions. An open aspect away from walls and buildings, is a must.

It is probably a good idea to experiment with the finished project for a week or two, running it on a temporary basis before committing yourself to installing it permanently. The largest difficulty facing readers is the practicality of running a cable through into the house, or wherever the Windicator is to be used.

In the author's case, it was very easy to pass the twin-core wire through a wooden window frame, but others may not be so lucky (that's uPVC windows for you). Consider running the wire through door or

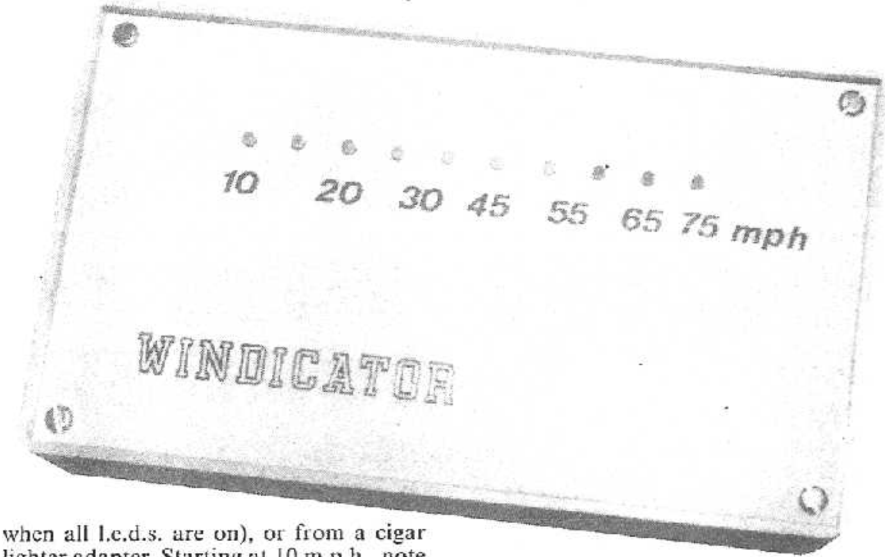
Table 1. Measuring Wind Force

Beaufort Number	Wind Description	Environmental Indicators	Wind Speed (m.p.h.)
0	Calm	Smoke rises vertically	<1
1	Light air	Rising smoke deflected	1-3
2	Light Breeze	Leaves rustle; wind felt on face	4-7
3	Gentle Breeze	Leaves and twigs move	8-12
4	Moderate Breeze	Litter, dust, small twigs move	13-18
5	Fresh Breeze	Small leafy trees sway	19-24
6	Strong Breeze	Overhead wires whistle; large branches move	25-31
7	Moderate Gale	Whole trees sway	32-38
8	Fresh Gale	Twigs break off trees	39-46
9	Strong Gale	Chimney pots and roof tiles dislodged	47-54
10	Whole Gale	Trees uprooted. Major structural damage	55-63
11	Storm	Serious structural and environmental damage	64-75
12	Hurricane	Catastrophic damage to the environment	75+

window frames, TV aerial inlet holes, air bricks, ventilator outlets, or up through the eaves. The twin-core cable is then screwed to TB1 on the p.c.b. and the main unit can be closed up. Then, unless you have the powers of Thor, you have to wait for a windy day!

The finished prototype Windicator will generally illuminate the 10 m.p.h. and 15 m.p.h. l.e.d.s when slight breezes are detected, and so far up to six l.e.d.s (45 m.p.h. gusts) have glowed during rough weather, with the colour-coded display proving invaluable. The display also gives an idea of wind patterns, responding well to gusts before settling down again. So, the Windicator will give you an at-a-glance idea of how the wind's blowing – but its responsiveness is very much determined by the positioning of the motor unit and you might need to experiment with this to get the best out of the design.

If you use an alternative high-output motor, or want to calibrate your own constructed unit, then one practical way is to compare the Windicator against a car speedometer. A calm day and deserted roads are essential; a sun-roof and an assistant would be handy too! Power the unit from a fresh 6V to 9V battery pack (to avoid supply voltage droop



when all l.e.d.s. are on), or from a cigar lighter adapter. Starting at 10 m.p.h., note the l.e.d. numbers (1 to 10) which illuminate as the car gradually increases speed towards a maximum of say 60-70 m.p.h.; perhaps make half a dozen test runs or more, and then take the average of all readings and calibrate your l.e.d. display accordingly.

The Windicator should last many years, with perhaps the odd squirt of light lubricant helping to maintain performance. As the author has found, the most enjoyable aspect is probably when everyone asks, "What's that, then?" as they see the Windicator in full swing! □

Ohm Sweet Ohm

Max Fidling

Cat Flapping

Rummaging around in the workshop the other day, I happened across a piece of white painted plywood propped up beside the bench, roughly two feet square and painted gloss white. It was no coincidence that there was a square hole of exactly the same dimensions in the kitchen door.

Although I'm an avid "Do-It-Yourself" fanatic, one thing I don't need, so I keep fooling myself, is exercise of any form. I'd much rather spend my spare hours beavering away in the workshop, constructing my latest brainchild or building a magazine project which might have caught my eye. Hence the eventual need to ensure that Piddles, my feline fun-filled assistant, was totally self sufficient so he could travel hither and thither unimpeded.

You see, I was forever having to open and close the kitchen door to allow Piddles back in after his daily round of mousing. By a perverse scheme of association behaviour, the moggie had learned that if he sat by the door and whined loudly enough at a particularly nerve-shattering frequency, I would eventually tire of this racket and *ouvre la porte* for said cat, who would then march through the door triumphantly, making a bee-line for his bowl!

Such behaviour, he had learned, was remarkably effective if I happened to be in the middle of soldering up a board in the nearby workshop, well within earshot of his cringe-worthy din. It was no good, this shenanigans kept interrupting top priority domestic electronic research! Something would have to be done. But what?

Cycling to my local DIY store next day, I spotted a cat flap for sale. *Perfect!* This would stop the pesky puss from pestering me, and I could then solder on in peace!

Eager to tackle this latest challenge, I'd soon marked out a square of suitable dimensions, using a felt-tip pen to outline where the cat flap would go on the back door. The thick black lines marked the route for me to tackle with the electric jigsaw.

As I started to slice through the woodwork, I had a brainstorm. Why not customise the cat flap so that Piddles could come and go as he pleased, but otherwise the flap would remain firmly shut? A plan formed, as I pondered the practicalities of another electronic labour-saving idea.

Reed on . . .

I propped up the resultant square of wood against the bench in the workshop, and started to root around for inspiration. Recently I had taken an old speaker to pieces and thus I had acquired a nifty magnet.

Stripped of the voice coil, it seemed to have pretty awesome pulling abilities. Now if I used this to operate a reed switch, and the reed switch drove a simple solenoid circuit, and the solenoid acted as a lock on the cat flap, we would be in business!

Thus was my reasoning as I returned to the scene of the crime and finished screwing the cat flap into place. The next week was spent in a futile effort to get Piddles accustomed to nosing his way through the cat flap – not one of my better moments.

In between times I developed a simple circuit which would respond munificently to the magnet. A surplus solenoid had been discovered on a shelf and I pressed it into service. Waving the rather large and powerful magnet near it, like Merlin casting a spell, the solenoid clicked over like a good'un, for a predetermined period derived from a 555 timer, before springing back into place.

Me too ↙

Just for good measure I added an l.e.d. and this blinked brightly whenever the solenoid was timing. If only it could speak, I mused, it would probably say "Quick, Moggie, Move It Or Else!" or words to that effect. Sadly, voice synthesis was beyond my abilities.

The cat flap then acquired some electronics which I don't think the manufacturers had quite anticipated when they designed it. D-Day came when at last I'd perfected the circuit and it was time for a trial run.

Piddles had just finished his breakfast and was feeling pretty content with life, i.e. he wouldn't know what had hit him until it was too late, I calculated. I'd fitted the magnet to a spare collar which I swiftly whisked around him, and then opened the kitchen door and encouraged him out with a gentle nudge or two.

Looking a bit like one of those Army-trained Dolphins carrying a homing beacon, I expected the magnetic moggie to trigger the timer and spring through the cat flap Mark Two any second now, accompanied by a flashing l.e.d. and throbbing solenoid! Nothing happened, though, except that I heard a metallic "CLANG!" from outdoors.

Hmmm, not what I expected . . . Peering out, there was the moggie all right, the magnet on his collar pinning him firmly to the steel dustbin!