Digital Anemometer

Impress your neighbours with the very latest in CB antennae.

Contributed by L. H. Mc Cracken

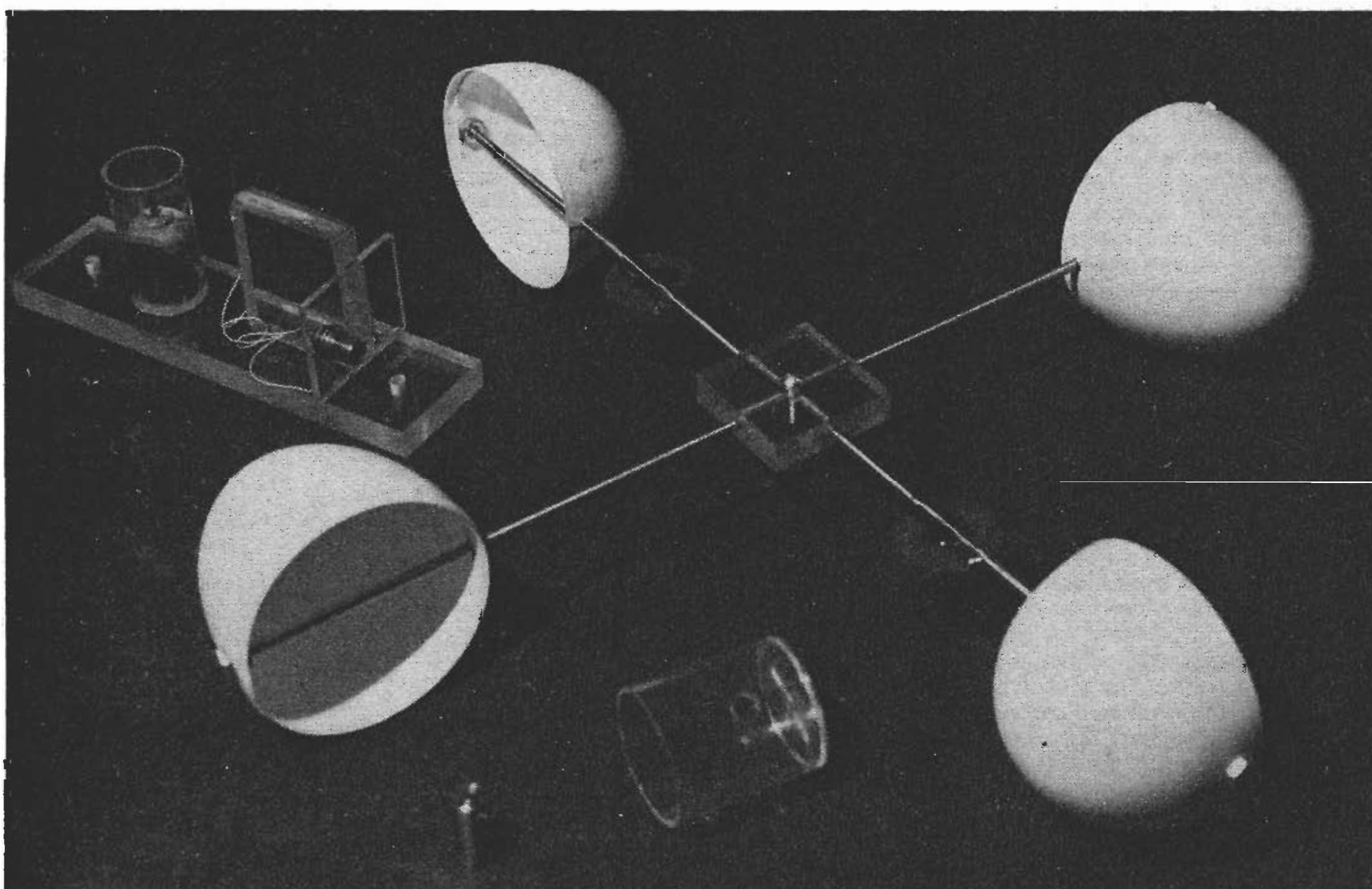
THE OCEANS AND SEAS make up about 75 to 80% of the earth's surface. Yet, there is another ocean that completely evelopes the planet. This is our atmosphere, and like the seas, it is seldom at rest. When certain physical conditions occur, it can be just as destructive as a violent ocean. Of course, this phenomenon is called wind. When both elements are in a highly agitated state, the results can be disastrous to those who dwell on land near the coast, fly in the air, or sail the seas.

Just as hydrographic and/or oceanographic agencies have sophisticated instruments to record and measure the diurnal vagaries of tides and currents, meteorological people have devices to observe properties peculiar to our atmosphere. One of these instruments is the anemometer, a device to measure wind velocities.

WIND SPEED

If you have never seen an anemometer, a visit to your local airport will satisfy your curiosity, look for a device with four cups turning in the breeze. You'll find them on the roof of the meteorological building or nearby. The control tower will certainly have one or two, while others will be strategically located near the ends of the runways, and may or may not have a vane as part of its mechanism to indicate wind direction. Weather ships, and other marine craft have them mounted on the bridge or mast. Depending where in the world you live, the wind speed is reported in knots, or in miles, or kilometers per hour.

Wind velocities are of paramount importance to aircraft pilots during landing and taking off. This is particularly so if the plane is small and a heavy cross-wind is present. Those who sail the wide open seas also have a



keen interest, as well as those who live in areas peculiarly prone to hurricanes and tornadoes. Other interested people, are the fast growing clan of amateur weather observers and kite flying buffs. Hang glider enthusiasts, just before stepping off a sheer mountain cliff, might find a final glance at a portable anemometer most reassuring to life and limb.

TWO TYPES

In general, 2 types of anemometers are commonly available, and although both use wind cups, their circuitry is quite different. The simplest of these, use a tiny D.C. generator whose voltage output is calibrated in terms of wind speed. A more sophisticated device, generates pulses and these are integrated by a capacitor and associated circuitry to produce a voltage proportional to the force of the wind. Both use a meter to indicate wind speeds. While an anemometer can be expensive, and one digital kit on the market can cost an arm and a leg, the project described here can be just as accurate, and with shrewd shopping, can be assembled under $50.00. The device generates pulses, but unlike the sophisticated manufactured type, instead of integrating them with complicated circuitry, it displays them digitally on an easy to read display board.

ABOUT THE PROJECT

The circuit is a simple 2 digit frequency counter. The display board contains all the logic to count from 0 to 99, recycle, and start over again. The larger board contains circuitry to condition the input, generate other logic, and a variable time base. The project can be applied to other counting requirements, see end of text for other suggested applications.

CONSTRUCTION

The wind sensor can be fabricated from a host of materials either found in the average household, or cheaply purchased. The 3/8 inch thick plexiglass used in this project amounted to fifty-cents, including cutting to size, plus 2 plastic vials from a local plastics outlet. The streamlined cups can be small plastic funnels (seal the small open end) or from certain round top spray cans ('Ban'). The prototype, used 'Leggs', the egg shaped containers in which ladies' hosiery is packaged. The rods that support the cups were fabricated from brass welding rod having a diameter of slightly less than 1/8 inch. The rotating shaft and bearing utilized Radio Shack's hobby motor with wiring and brushes removed.

With these ideas in mind, we are sure that constructors will have no difficulty using their ingenuity and materials at hand to make up an appropriate rotor. It should also be noted that a closest distance of 1/8 inch between magnet and reed switch appeared to be very effective.

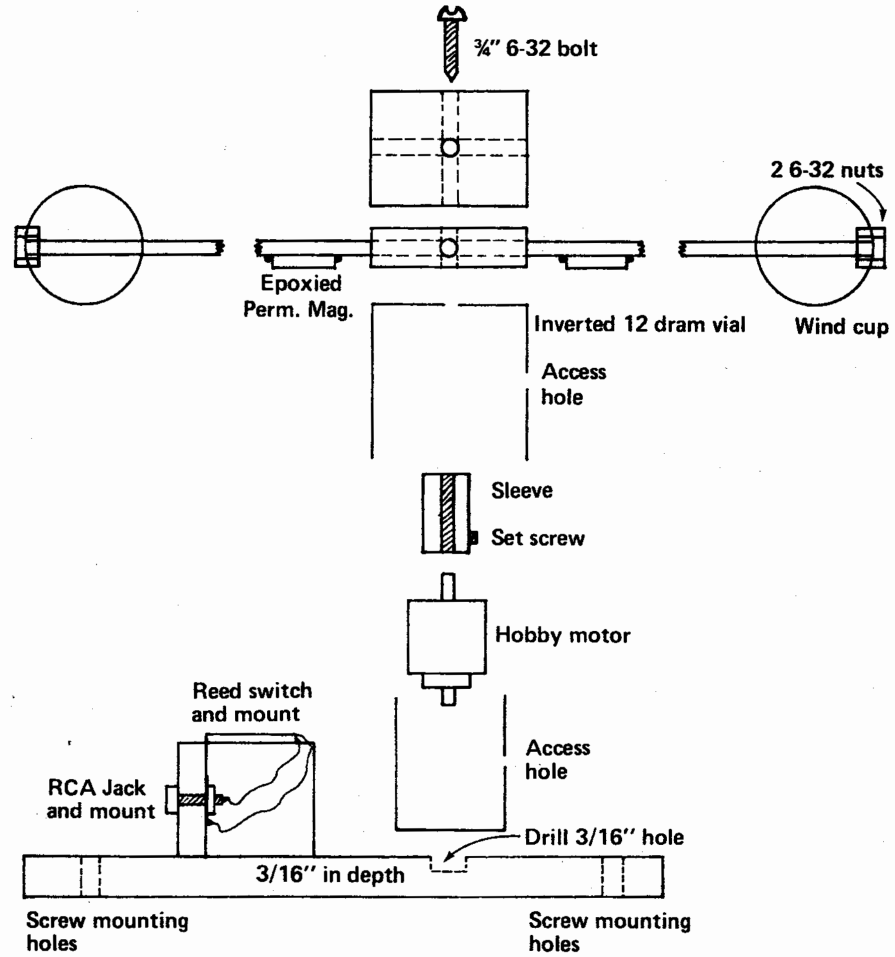
CIRCUIT ASSEMBLY

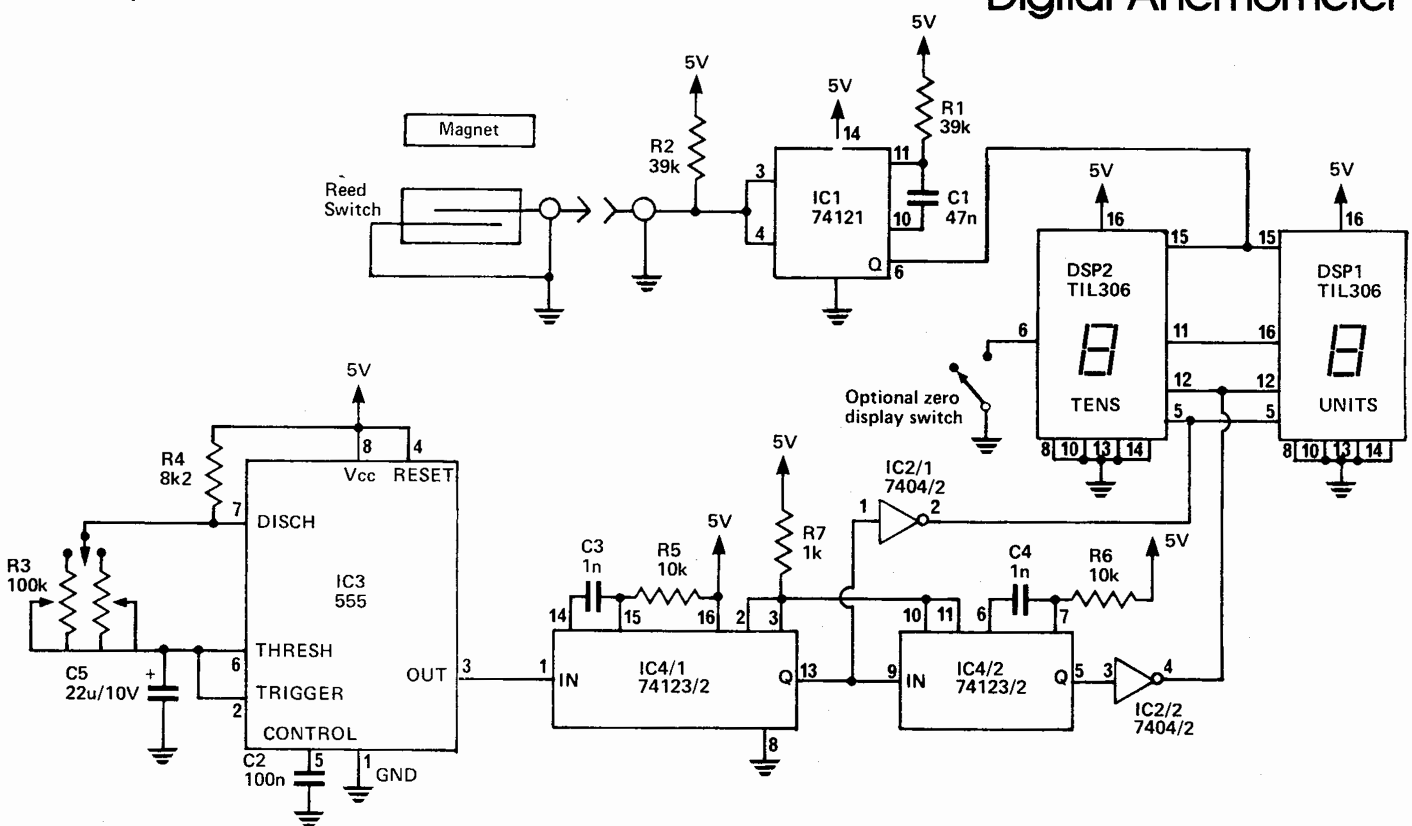
The circuit can be mounted on perf board using point to point wire wrapping techniques. The position of the components is not critical, and most any convenient layout will do. A good ground return is a consideration to be taken into account. All grounded components should be independantly wired to a central point. A narrow strip of copper can be used as a ground return bus, or a piece of heavy copper wire.

The use of the given printed circuit and drilling guides will make assembly an easy and straight forward one, and if you are careful, the project will get up and go the first time power is applied. Placement of parts have been etched on the foil sides of all boards. All resistors and electrolytic capacitors are end mounted, and be sure to correctly orientate all polarized components. Squeeze-throughs (traces between IC pads) have been used extensively, particularly on the display board. The use of a fine tipped low wattage soldering iron should be used to avoid solder bridges in these areas. IC sockets are recommended.

Calibration potentiometer R3 is mounted off board, the rear of the cabinet enclosure is a good place for it. Here, you can elaborate on the circuit. As discussed earlier, this pot is used to calibrate the device in terms of whatever wind speed units please you. By incorporating 2 or more R3s, and suitable switching, you can at will, switch between any of the commonly used methods of reporting wind speeds. The circuit diagram shows 2 calibration R3s with switching. The choice is yours.

Another option is the suppression or display of leading zeros. No connection to the BL pad on the display board results in leading zeros being displayed, and on a calm day, the display indicates 00. With a jumper to ground, leading zeros will be suppressed. Inserting a SPST switch





between the BL pad and ground, the display or suppression of leading zeros can be controlled at will. Again the choice is yours.

A regulated 5 volt supply is required. Two printed circuits are given, one for the house supply, and the other driven by a 7 to 24 volt D.C. source should you decide to have the benefit of an anemometer on board your marine vessel, or require a portable anemometer powered by batteries. The prototype has its sensor on the roof, and power is supplied by a wall type plug in transformer with a D.C. output of 9 volts at 600 milliamps. Using the D.C. driven regulated supply, the entire project was housed in a very small enclosure. In this case, Radio Shack's 270-260.

After installation of the components and you have carefully scanned all solder joints, interconnect both boards matching up the numerals 1,2, and 3 along with ground and 5V supplies. A short piece of 5 conductor ribbon wire makes a neat connection. Mount them in a housing of your choice along with whatever power supply you are using. An off-on switch and an in line fuse should be incorporated.

For an initial test, power up the unit. Temporary jumper the sensor to P1 and ground, and give the cups a spin with your hand. The display should now read out some count,

HOW IT WORKS

The wind force turns a shaft having streamlined cups fastened on four arms. Two diametrically opposed members have permanent magnets securely attached. A small reed switch mounted on a stationary base positioned so that the magnets pass over in close proximity. One complete revolution closes the reed switch twice. The pulses generated by the reed, trigger IC1, a 74121 monostable one shot. IC'1s output, free of contact bounce and other spurious pulses, is connected to the clock inputs of both TIL306 displays.

A variable time base is generated by IC3, a 555 timer connected in the astable mode. The associated circuitry and potentiometer R3 control the frequency output, and are used to calibrate the device against any convenient numerical standard. The time base triggers the first of 2 cascaded one-shots of IC4, a dual 74123 one-shot, generating a latch strobe or update pulse. To accommodate the logic of the TIL306(s), the pulse is inverted by 1/6 of IC2, a 7404 hex-inverter, and applied to the TIL306 latch inputs. Any counts stored in the latches are displayed by the read-outs.

Just after this sequence, the second half of IC4 is triggered, again, after being inverted by another 1/6th of IC2, resets or clears the TIL306 counters to 00, releasing the counter to gather new data (pulses). The net result is a steady flickerless display. Note, 00 is never displayed unless it is a calm day. The strobe and reset sequence takes only a few millionths of a second, hence the interval between the time base pulse, is spent counting the reed switch closures.

The displays may be Texas Instruments TIL306's or TIL307's, the only difference being a left or right hand decimal, and these are not used in this project. If left unconnected (high) the decimal is displayed, if grounded (low), they are blanked. Each TIL306 or 307 contains the four units necessary to display a counter frequency, that is, a BCD counter, a four bit latch, and decoder LED driver all contained in a 16 pin dip package.

Each display contains a feature called ripple blanking. If the number zero is detected in the latches, and the ripple blanking has been enabled (low) the display will be blanked. This function was incorporated to give leading zero suppresion in the counter. Starting from left to right (MSD to LSD), if zero is detected, that display will be blanked and the blanked data will be passed on to the right. Hence, a count of 5 will be displayed as 5, and not 05. The printed circuit board for the displays incorporates this feature and can be controlled at will. See text under options. The utilization of these TIL chips eliminates separate counters, latches, decoder/drivers, 2 LED displays, and 14 resistors, plus a maze of wiring or complicated printed circuit boards.

The use of a hand held calculator will be an aid in converting to other units of measurement. You may find it convenient to make up a table of M.P.H. versus knots or kilometers per hour, or any other combination beforehand.

MPH X 0.8684 = Knots
MPH X 1.6093 = km/h
km/h X 0.6214 = MPH
km/h X 0.5396 = Knots
Knots X 1.1516 = MPH
Knots X 1.8553 = km/h

gradually diminishing as the cups slow down. The rate of numerical change (up-date) will be a function of the setting of the R3 pot (s).

CALIBRATIONS

Securely mount the sensor on the roof of your car, and using temporary jumpers that are long enough to reach inside the car, connect to P1 and ground. If your unit is using the D.C. driven regulated supply, connect to a 12 volt lantern battery. Observe proper polarities. If you are using the house powered regulated supply, connect the positive side of the 12 volt lantern battery to pin 1 of the LM309K, and any convenient ground.

Have a friendly neighbor drive your car on a quiet street at a steady even rate when there is little or no wind. Adjust R3 until the display agrees with the speedometer, or if you are calibrating in knots or kilometers per hour, the readouts display the speedometer reading times the appropriate conversion factor. If more than one R3 pot has been incorporated into the circuit, switch it in, and carry on with your calibrations. When you are finished, apply a drop of epoxy to the rotor (s).

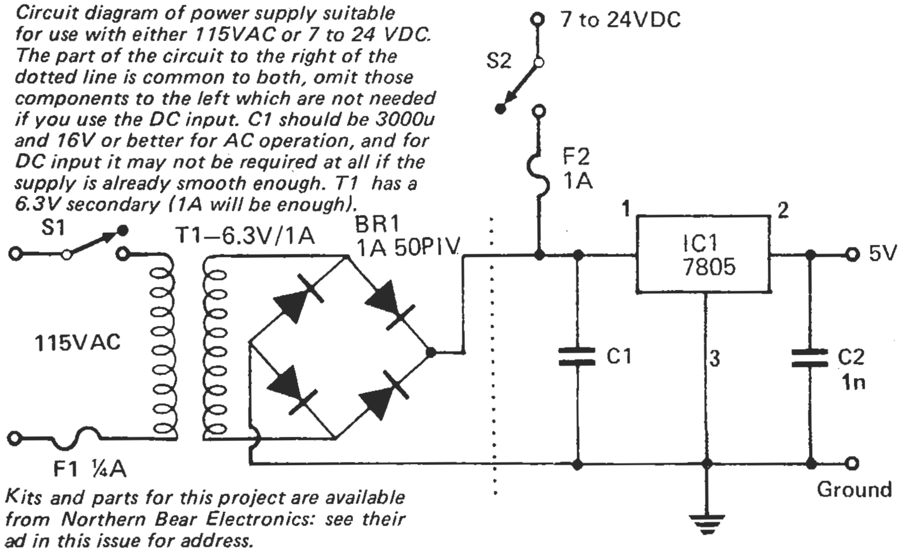
INSTALLATION

If you plan to use the device in your home, mount the sensor on the roof or in any other convenient location that will be free of obstructions. For marine use, mount the sensor on the bridge or mast. Terminate both ends of a suitable length of shielded audio cable with phono plugs and connect between the sensor and the enclosure. Be sure to weatherproof the plug and jack that is exposed to the elements.

OTHER USES

The circuit can be used in a great many other counting applications. If a digital anemometer is not for you, perhaps a digital speedometer for your car, motor bike, or that new ten speed bicycle might be of interest. No circuit changes are required, simply mount the perm mags on the rim of the wheel, and position the reed switch nearby. If the rim is ferrous, it will distort the magnetic field, hence an insulating block of wood or plastic should be inserted between the magnet and tire rim. Use a good strong adhesive. Calibrations are the same as previously outlined, only this time, wind is not a factor. You might find it convenient to calibrate in terms of kilometers per hour, since all speed limits will ultimately be posted using this portion of the metric system. Fifty miles per hour for all intents and purposes is equivalent to 80 kilometers per hour. When your bicycle reaches 100km/h., about 62.2 mph, the display will either blank or read 00, depending on the leading zero option. Simply add 100 to any reading thereafter.

Circuit diagram of power supply suitable for use with either 115VAC or 7 to 24 VDC. The part of the circuit to the right of the dotted line is common to both, omit those components to the left which are not needed if you use the DC input. C1 should be 3000u and 16V or better for AC operation, and for DC input it may not be required at all if the supply is already smooth enough. T1 has a 6.3V secondary (1A will be enough).



Kits and parts for this project are available from Northern Bear Electronics: see their ad in this issue for address.

PARTS LIST

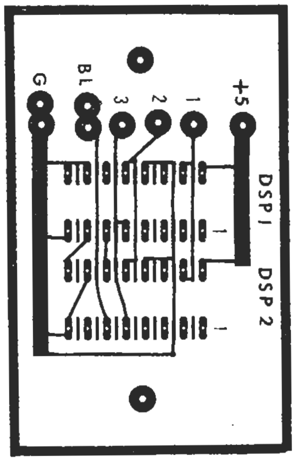
PARTS LIST FOR ANEMOMETER

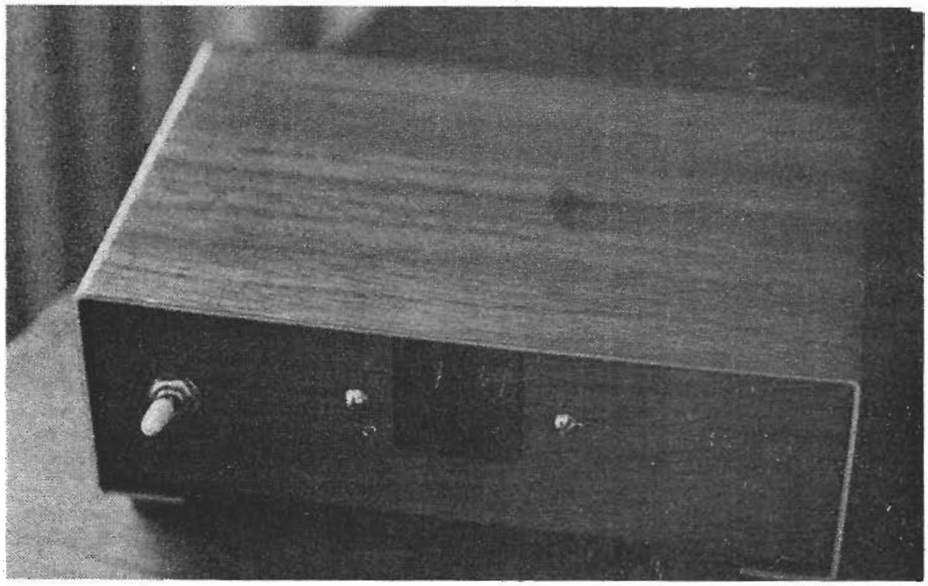
CAPACITORS	
C1	47n
C2	100n
C3,4	1n
C5	22u/10V
SEMICONDUCTORS	
DSP1,2	TIL306 Texas Instruments
IC1	74121
IC2	7404
IC3	555
IC4	74123
RESISTORS	
R1,2	39k
R3	100k pot or fixed resistor of your choice
R4	8k2
R5,6	10k
R7	1k

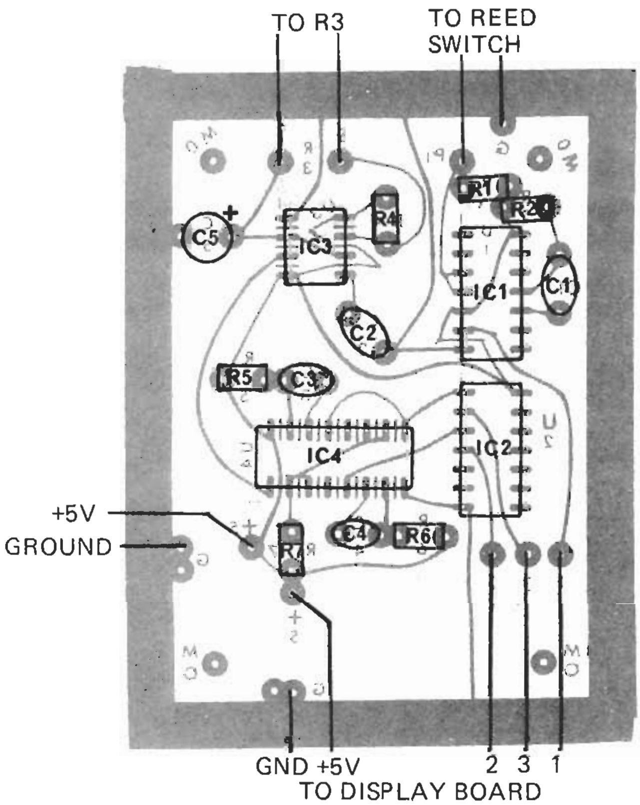
SWITCHES as required
MISCELLANEOUS hardware

Electrical Components of Anemometer Wind Rotor

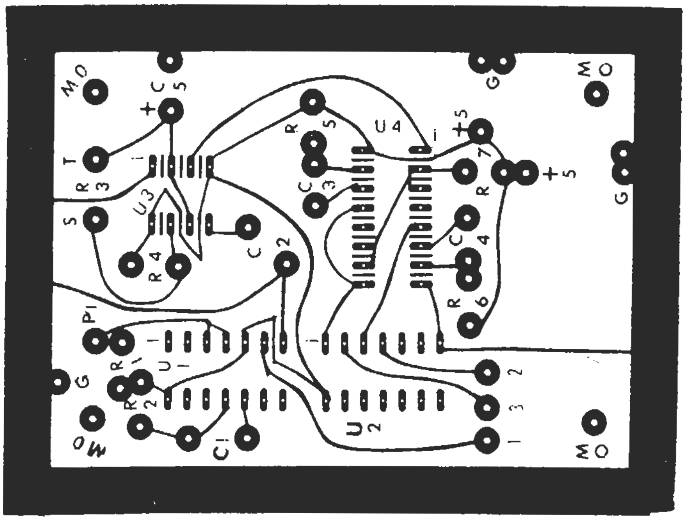
1	Reed Switch (Radio Shack 275-035)
1	'Hobby Motor' (Radio Shack 273-217
2	Magnets (Radio Shack 64-1885, or use those out of motor)

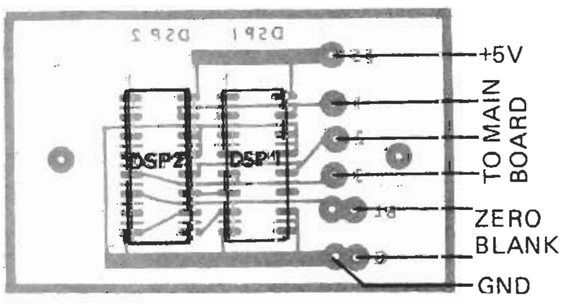






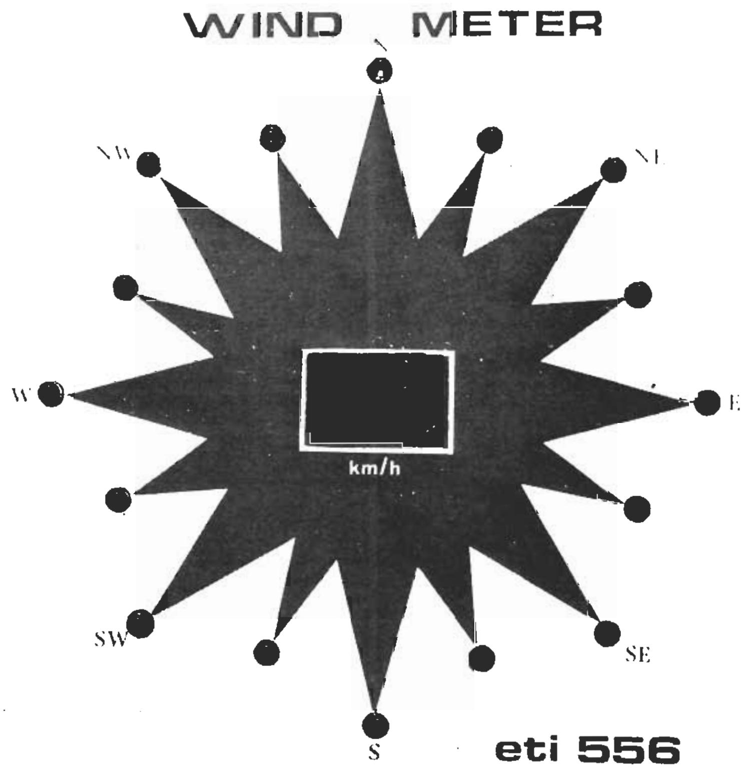
Component placement diagram for main and display boards.





WIND METER

Here is the project all you amateur meteorologists have been waiting for. When this meter gets the wind up you'll know how fast and where it's coming from.



TRADITIONALLY, THE FOUR primary elements are fire, earth, water and air. At ETI, we've designed projects concerned with the first three (temperature meters, soil moisture indicators, rain alarms), but not much for the last. The major property of the air, apart from the fact that it is necessary to support life, is the movement of the air — wind. Light winds generally aren't of terribly much significance except to meteorologists, but stronger winds can be useful as a source of power; for traditional milling, for electricity generation or as a means of propulsion for sailing yachts. Stronger winds such as hurricanes, can be destructive, causing damage to life or property.

So for all the private pilots, yachtsmen, amateur meteorologists and general weather watchers who read ETI, here is a device which will tell you the wind's speed and direction, with a remote indication of both quantities. Our design is, we'd like to think, both stylish and unusual, but there are simpler methods of mechanical construction which you can follow if you wish.

The Head

The drawings along with the photos will give the general design that we used. The actual dimensions have to be left to the individual constructor as components such as the ball races and light bulbs may vary in size.

While we used a single head for both speed and direction, it may be simpler to use separate heads.

The discs we used were 1.5mm thick clear plastic with a piece of photographic film glued onto it. It may be easier to make it out of thin aluminium and cut out the slots. For the speed disc simply drilling holes will suffice.

The most important part of the design, apart from ensuring that the discs rotate with a minimum of friction, is the shielding of the light and preventing light scatter striking a transistor which should be dark. As can be seen from the photos and diagram the bulbs and transistors are embedded in aluminium blocks with small holes providing a passage for the light beam.

The wiring of the head is shown in fig. 3. Note that the base lead is not used and can be cut off close to the body. Insulate the joints onto the transistors to ensure that they do not short on the aluminium blocks. The bulbs may touch the block with their outer connection but this is the 0 volt line and does no harm. In fact it provides some electrical shielding for the leads. The bulbs we used were 12V but they were bright enough on 6V giving a much longer life.

Design Features

When we started design on this project it was to have a digital readout of wind direction with a resolution of either one or two degrees. This would also make it useful in a sailing boat to tell the wind direction relative to the heading.

Difficulties however soon became apparent. The first of these was the sensor head. The only accurate method is a digital head, probably optical. Two methods could have been used, one using a disc with a single optical track of 360 slots and an updown counter and the second using eight or nine tracks in a grey code. The first is simpler in head design but the second is less prone to error. The problem, and the reason for rejecting both, is that with such resolution, the reading would move around so much when the wind is gusty to be unreadable. What is needed is an averaging circuit which unfortunately becomes ▶

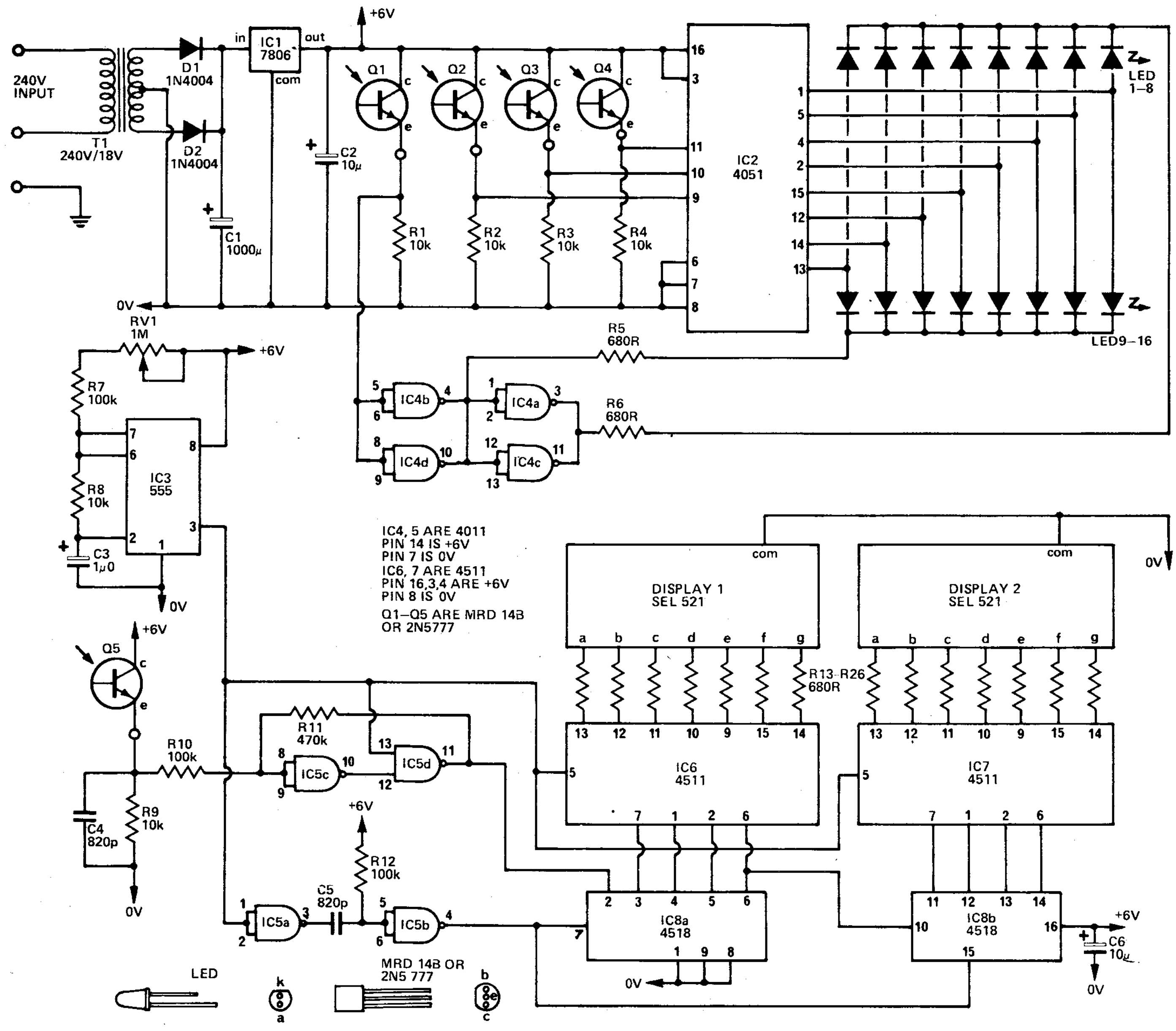


Fig. 1. Complete circuit diagram of the ETI Wind Meter

difficult when the wind is changing from just west of north to just east of north. i.e. 355 to 005. How do you average these (use a microprocessor?).

As this was intended to be a simple project we relaxed our original speification, deleting the use in a boat (we may get back to this. problem. A four track 'Grey' scale allows the wind to be given to within 11° of its true heading, without the complexity of a nine track one, and the use of LEDs to give direction solves the problem of averaging as the variations can be seen and averaged by the brain.

Construction

The electronics is relatively simple provided the PCB described is used. Due to a height limitation C1 should be mounted on the rear of the board. The LEDs should be mounted about 7mm from the board with care being taken not to damage them as the leads have to be bent out slightly. The regulator also has to lie down to give clearance.

We mounted the unit behind an aluminium front panel with the LEDs protruding through holes. If this is to be done it is preferable not to solder the LEDs until after alignment with the front panel.

The head is more difficult as some mechanical ability is necessary to ensure good results. The requirements are basically simple. A disc is to be allowed to rotate, either continuously with the wind or aligning it to the wind, with a bulb on one side and phototransistors on the other.

The method used by us is shown in fig 4 with the aluminium blocks providing the shielding necessary to give accurate results. As the unit will be exposed to the weather it must be made waterproof otherwise the ball races will corrode. The races used ▶

HOW IT WORKS

Wind Direction

Wind direction is indicated by a series of 16 equally spaced LEDs around a circle. These represent the main points on the compass. These are controlled by IC2 and IC4 which are in turn controlled by the direction sensor head.

The sensor head, which is described in fig. 3, consists of a disc which has four optical tracks and four bulbs and phototransistors. The phototransistors sense either a clear disc (logical "1") or a black disc (logical "0") and thus control IC2 and IC4. The code used is special in that only one bit is changed at each location eliminating gross errors which occur with the binary code if the heads are not perfectly aligned. An example of this is going from location 7 (0111) to location 8 (1000). If this is not done simultaneously almost any location can be specified. With the grey code the same change is from 0100 to 1100. Here there can be no ambiguity as only one bit is changed. Remember these bits are *not* weighted similarly to binary and a lookup table must be used to decide what number (decimal) a particular code is.

The decoder, IC2, is an eight output analogue demultiplexer with the common line joined to the +5V line. When a particular 3 bit code is presented to its control inputs one of the eight outputs will be joined to the +6V line. The fourth output from the sensor head controls IC4 which gives two, inverted, outputs to drive either bank of LEDs. The complete four bit code therefore specifies a particular LED to be lit. By placing the LEDs correctly around the circle the grey code is decoded.

Wind Speed

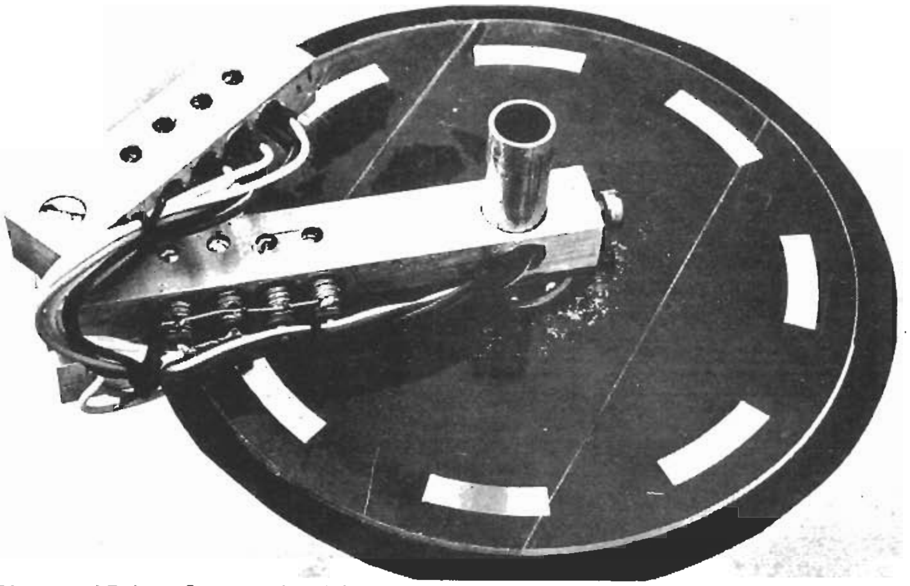
This is a simple frequency counter measuring pulses from the sensor head. The head consists of a disc with eight holes whichbreaksa light beam to its associated phototransistor. The output of this phototransistor is squared up by a schmitt trigger formed by IC5c, and IC5d.

The counting is done by IC8a and IC8b (a dual decade counter) with IC6 and IC7 providing the store and LED drivers necessary to drive the seven segment display. Time base is provided by IC3 which gives a 7 mS wide negative pulse about every one second. We say about as it is adjustable by RV1 as individual heads will have different responses and calibration will be necessary.

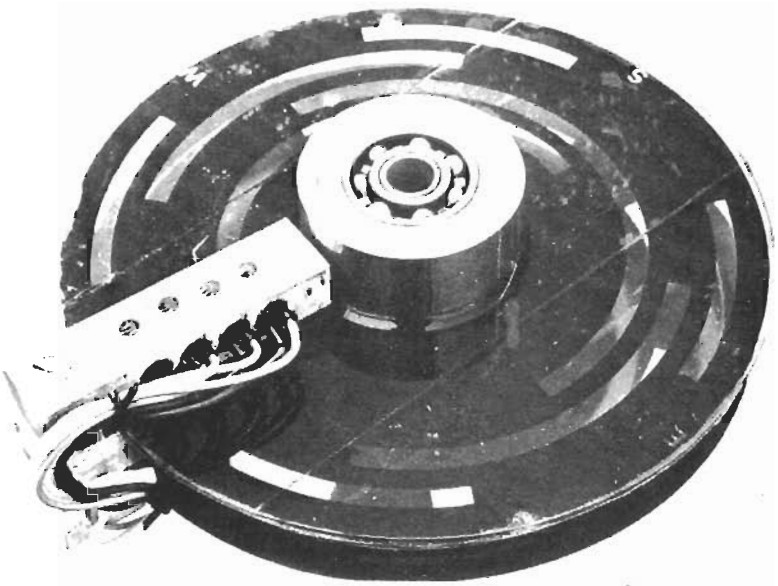
This negative pulse opens the store to allow the number reached by the counters to be displayed while simultaneously stopping any further counting by disabling the schmitt trigger. On the completion of the 7mS pulse IC5a, and IC5b generate a 50uS wide pulse which resets the counter ICs to recommence the sequence.

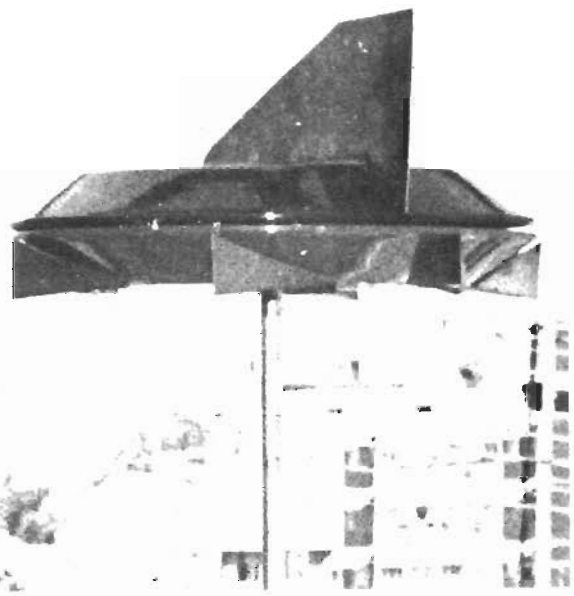
Power Supply

This is simply a full wave rectified supply with IC1 giving a regulated +6V output. This regulation is needed to ensure that the time base (IC3) remains accurate.



Above and Below: Constructional details of the sensor head





The finished unit in use