. R. Fox

MEASURE THE WIND

Easy-to-wire, accurate, anemometer uses ICs and LED-readout.

Increasing energy costs have driven many people to thinking of alternate sources of power, such as solar energy and water power. But the technology for these natural energy sources is still quite expensive and complicated to install. It'll be at least several years before the cost of most natural energy systems comes down enough and the parts are easy enough for most people to install. Wind power for generating electricity, on the other hand, has been available for many years. For several decades farmers and others in rural areas have used windmill generators as standby electricity and in some cases, as their main power supply. Windmills and wind-driven electrical generators can be bought off the shelf by anyone, and require no expertise other than the usual home mechanic skills to set up.

Have you wondered if there's enough wind where you live to drive a windmill electrical generator? Do you know if there's enough wind to fly that big kite you've often thought of constructing? Is there enough wind coming over the hills near your area so you can get into hang-gliding? Or do you live in an area where tornadoes or hurricanes sometimes strike? If so, it could literally be a matter of life-and-death for you to read the wind-speed easily, with an accurate, easy-to-install anemometer (windspeed meter). That's what the Digital Wind-speed Meter is—an accurate anemometer using the latest digital TTL (transistor-transistor logic) integrated circuits.

Though this project isn't recommended for someone who's never built any solid-state projects before, it should be easy enough for anyone who has built one or two simpler projects such as most of those published in *Electronics Hobbyist*.

In addition, it's the sort of project which will get you started easily in digital logic circuitry, the circuits and components which are the basic building blocks of computers and most other advanced electronics today.

How Anemometers Work. There are two types of electronic anemometers in general use. One type uses air cups or a wind turbine to turn a tiny electric generator whose output is directly connected to a milliammeter. The faster the wind blows, the faster the generator turns and the higher the meter reads. This type of anemometer is simple and reliable but it usually is not accurate.

A more sophisticated type uses air cups to turn a shaft to produce electric pulses. The pulses are integrated by a capacitor and related circuitry to produce a DC voltage whose magnitude is directly proportional to the wind speed. This voltage is aso displayed on a meter. This method is easier to calibrate, and thus is more accurate than the simple generator method. By

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using state-of-the-art digital electronics, improvement can be made upon this method of measuring the wind's speed. Instead of the round-about method of adding up the electric pulses by charging up a capacitor, why not just count them directly? The digital anemometer described here does just that. The result is a more accurate sophisticated instrument that is easier to read and cheaper to build.

How It Works. The theory behind the digital anemometer is simple. See Fig. 1. The wind turns a shaft which has streamlined plastic cups attached to it. On one rod that holds two oppositely directed cups are placed two small magnets. A reed switch is mounted on the stationary base beneath the rotating cups so that it will be operated by the rotating magnets above. Each time the cups make a full revolution, the reed switch opens and closes twice. The pulses generated by this reed switch trigger a one-shot multivibrator (TTL-7412)

which cleans up the pulses, eliminating contact-bounce and other error pulses. The cleaned-up pulses are then fed to a TTL NAND gate which is controlled by the 555 one-shot multivibrator. The 555's one-shot output pulse is manually adjustable to let us calibrate the anemometer. Another 555 astable multivibrator provides automatic triggering pulses for the 555 one-shot as well as supplying reset and blanking pulses for the counters and decoders. The resulting controlled and cleaned up pulses (which originated in the reed switch) are counted on two TTL decade counters and displayed on two LED displays.

Construction. The rotating wind sensor is made up of 4 plastic cups, mounted with $\frac{3}{32}$-in. or $\frac{1}{8}$-in. rods to a slot-car motor or similar cheap and readily available bearing. (The brushes of the motor can be removed if desired.) The egg-shaped containers in which *Leggs* nylons are sold are ideal for the plastic cups which catch the wind.

The rods which support the cups can be steel welding rods or (better) copper or brass. One rod should be one foot

long and the other two should be six inches long.

Next, obtain a small cylindrical piece of a solid metal that is easily solderable —brass or copper is best. Drill two holes, using bits the same size as the rods, at right angles to each other through this cylinder of metal as shown in Fig. 2.

Now center the 12-in. rod in the cylinder. Insert the two shorter rods in the remaining two open holes in the cylinder, as shown in Fig. 3. Using acid-flux, solder the rods to the cylinder.

Mount the motor, which is used as the bearing, in a 2-in. long piece of two by-four. To mount the motor, drill and file a hole in the wood large enou: to take the motor. Cover the moto case with epoxy glue and insert it in hole as shown in Fig. 4.

Using a bit as close to the di of the motor's shaft as possibl hole about ½-in. deep in the of the cylinder (see Fig. 3) w' has rods soldered to it. Insert shaft into this hole and solde acid-core flux.
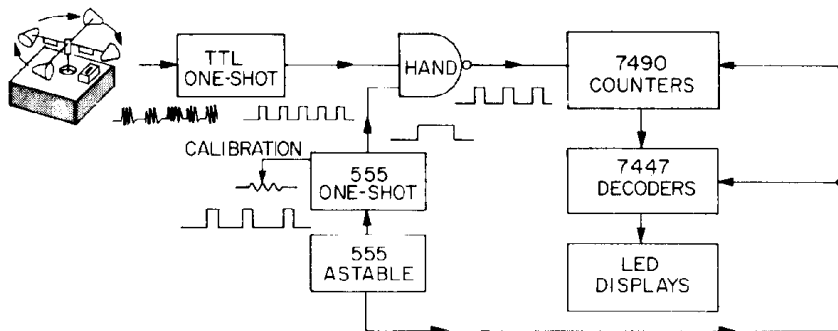
(If steel is used, secure wi glue.)

Fig. 1—Block diagram for digital anemometer. As the calibration control is varied it changes the duration of the pulse put out by the 555 one-shot. This acts as a variable window for the pulses coming from the windspeed sensor permitting accurate readout of the LEDs.
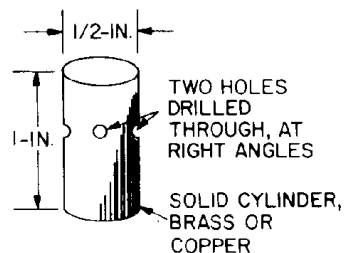

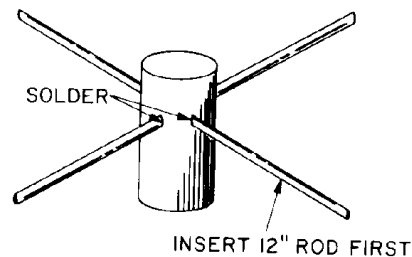Fig. 2—Centerpiece of windspeed sensor.

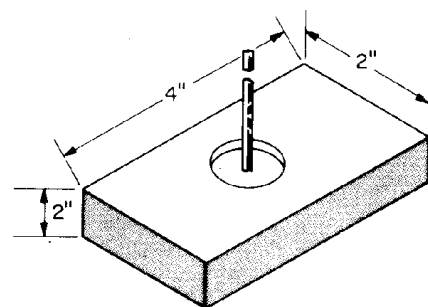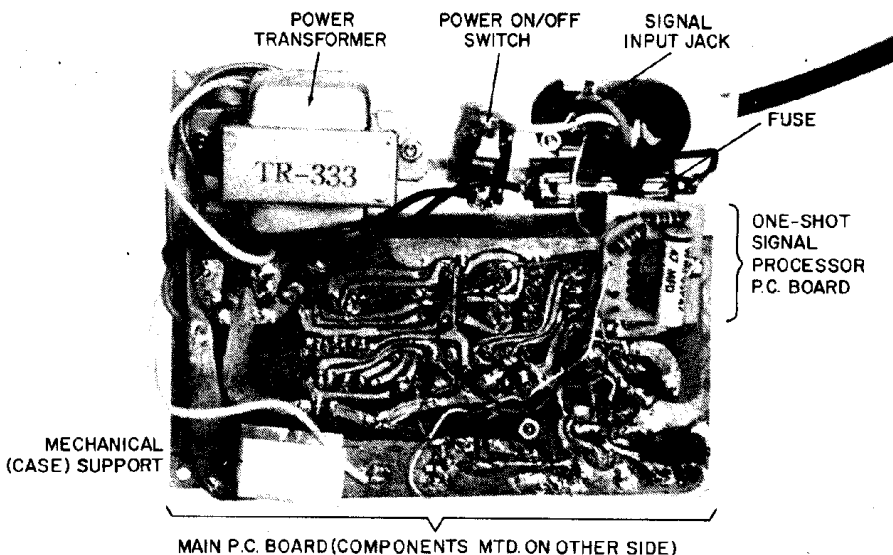Fig. 3—Assembly of rods and centerpiece to form rotor.

Fig. 4—Wood block mount with bearing.

Now mount the four plastic cups to the rod, taking care to correctly orient the cups. Drill holes in the cups and insert the rods in the holes. Keep the cups in place with epoxy or other good glue.

Next we mount the magnets on the rods. If copper or brass rods are used, great, just solder or glue the magnets to the undersides of two opposite rods, centering them one inch from the pivot. The reed switch is then mounted on the wood base so the magnets pass a quarter of an inch above it.

If the rod is iron or steel, we have a problem because it will distort the magnet's magnetic field. This problem is overcome by using a non-magnetic spacer between the magnet and the rod —¼-in. is enough space. A ¼-in. x 1-in. piece of wood is glued to the rod and then the magnet glued to the wood. Since there is very little weight involved, a good glue will hold the magnet fine. This completes the construction of the wind sensor.
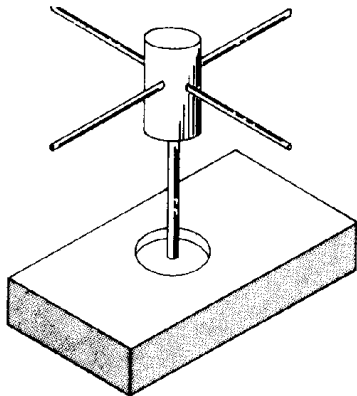
Circuit Assembly. To build the cir-
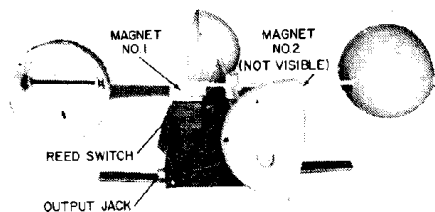

Fig. 5—Rotor in place on bearing.

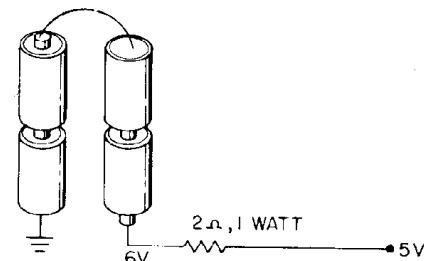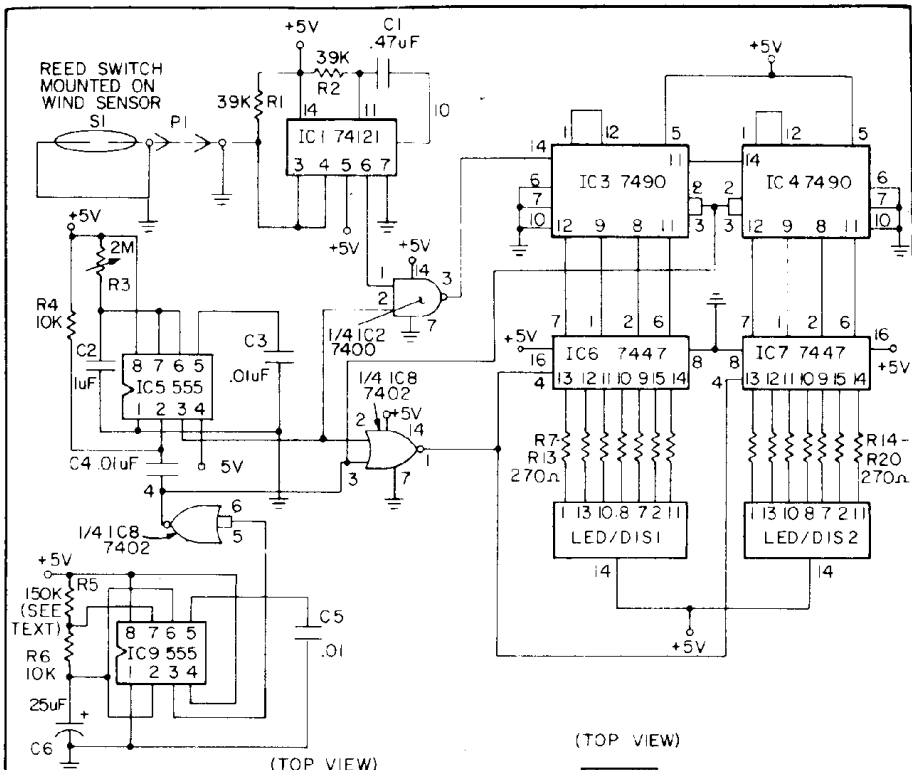Fig. 6—Completed unit. Adjust height of reed switch so magnets pass about ¼-in. over it or less.
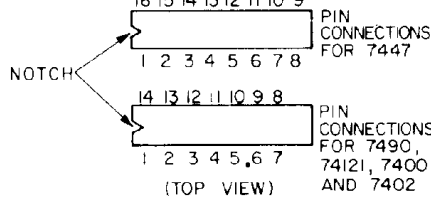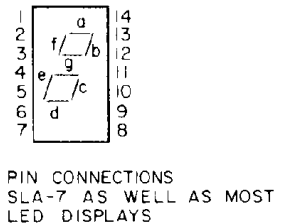

Fig. 7—Temporary battery power supply for use when calibrating the instrument in an automobile.

Be very careful when inserting ICs into their respective sockets. Be sure right types are inserted and oriented so that IC half-moon keys align correctly with sockets.

PARTS LIST FOR DIGITAL WINDSPEED METER

C1—0.47-uF, 50-VDC capacitor
C2—1.0-uF, 50-VDC capacitor
C3, C4, C5—0.01-uF, 50-VDC capacitor
C6—25-uF, 35-VDC or more electrolytic capacitor
LED1, LED2—LED display numerals (Radio Shack 276-053 or equiv.)
IC1—74121 monstable multivibrator integrated circuit, TTL type
IC2—7400 NAND gate integrated circuit, TTL type
IC3, IC4—7490 decade counter integrated circuit, TTL type
IC5, IC9—NE555 integrated circuit
IC6, IC7—7447 BCD-to-Decimal decoder, TTL type
IC8—7402 NOR gate, TTL type
P1—2-connector jack (& matching plug for cable) RCA-type phono plug recommended
R1, R2—39,000-ohm, ¼-watt resistor
R3—2-megohm printed circuit board-mounting potentiometer (Allied Radio 854-6287 or equiv.)
R4, R6—10,000-ohm, ¼-watt resistor
R5—150,000-ohm, ¼-watt resistor
R7–R20—270-ohm, ¼-watt resistor (14 needed)

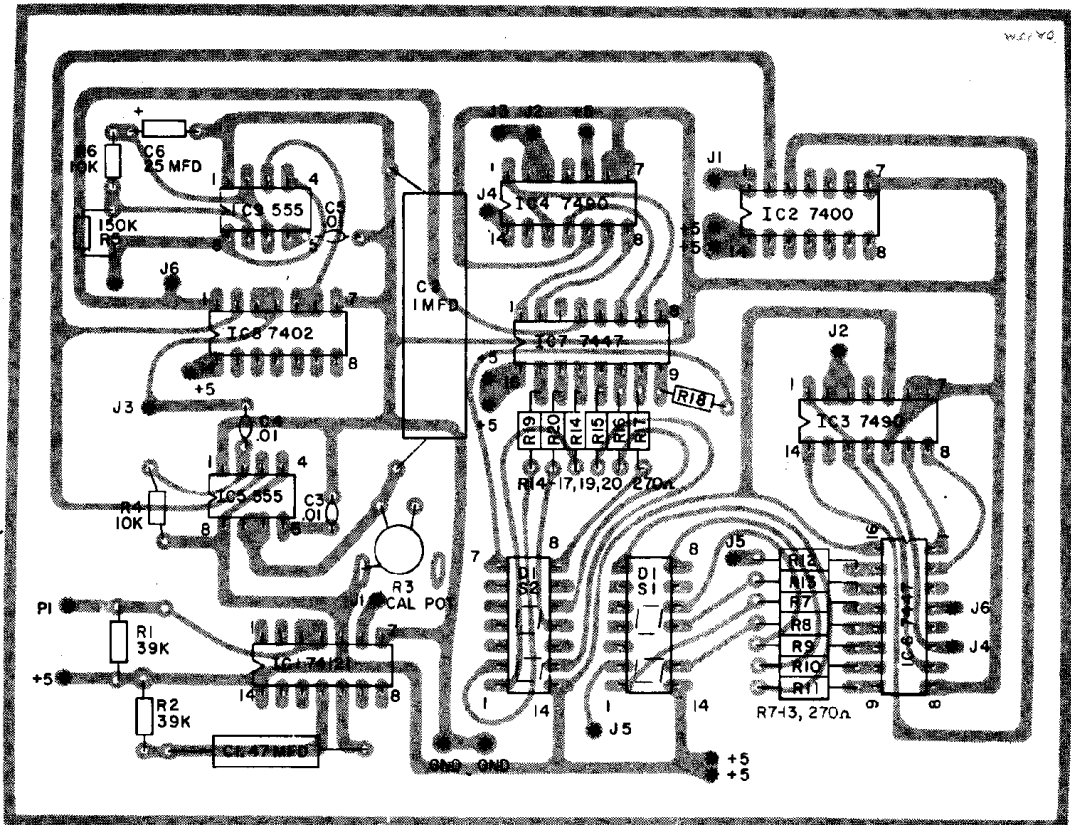S1—Miniature reed switch (Radio Shack 275-033 or equiv.)

Misc.—Four plastic cups such as the containers Leggs stockings come in. Two small magnets such as the "Magic" magnets most hardware stores carry. One 12-in. and two 6-in. pieces of copper or brasss rod, ⅛- or 3/32-in. diameter. One slot car motor or equiv.), for use as bearing. One piece of copper or brass rod about 1-in. long, ½-in. diameter (solid). One 2-in. piece of wood two-by-four. Epoxy glue, solder, mounting brackets (two) for wood block, screws. Ten IC sockets.

POWER SUPPLY

The Digital Windspeed Meter requires a regulated five-volt DC power supply. The easiest way to do this is to hook a 2-ohm resistor in series with a six-volt battery. This is also the safest power.

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The pictorial shows the location of compenents as seen from the bottom (the components are on the far side of the board, from the viewers perspective) with the foil-side up. It is best to secure the ICs by using IC sockets, although you can solder them directly by using a low-wattage soldering iron (25 watts would be good). You might use sockets when mounting the display sockets to allow easy replacement if necessary. Since the location of components isn't critical, this circuit can be assembled on perf board if that's easier.

cuit use any convenient layout on a perf board. The position of the components is not critical. If you haven't worked with ICs before you'll be better off soldering IC sockets in place on the perf board, and connecting the other components to the pins of the IC sockets. If you've had a fair amount of experience and can solder ICs directly into a circuit without overheating the pins (using a pair of long-nose pliers as a heat sink while soldering to each pin), do it that way.

The main job in wiring the anemometer lies in making the printed circuit board. The pattern shown can be made by using the simple resist method. Simply draw the pattern with a felt-tipped resist pen on the foil side of the printed circuit board, place in etching solution for an hour or so and drill the holes marked. The somewhat more sophisticated, yet still easy, non-camera photo method can also be used.

If a small 25-watt soldering iron is used, the *ICs* can be soldered directly to the board, although IC sockets are less risky. Be sure to orient the notch on the *ICs* as shown in the component layout diagram. It is always wise to use IC sockets when mounting display LEDs. Be sure to either bend back or cut off pin 12 on the socket which is used to mount Display No. 1.

Unless double sided PC boards are used, jumpers made up of hookup or bare wire are needed. Place jumpers be-

tween the two J1s, J2s, J3s, J4s, J5s and J6s. In addition, interconnect the +5 VDC points on the PC board with jumpers (6 needed).

Connect the two leads from the remote mounted reed switch to points P1 and to one of the two GNDs.

Connect the plus power supply lead to the +5 point at the top of the board. Connect the other supply lead to the other GND point which is also located at the top of the board.

The 5-volt regulated TTL power supply described by Herb Friedman on page 61 of this issue of Electronics Hobbyist is ideal for this project. This power supply is compact enough to easily fit in the same case as the logic unit.

The entire circuit can be mounted in any convenient size bakelite or aluminum case with aluminum panel. For a smart appearance, spray paint the panel with some auto-touch-up white lacquer. Use dry transfer decals for the lettering.

Cut a slot in the panel so the two digit LED display can be readily seen. If desired, the switch to turn on the power can be an inexpensive slide switch but a toggle switch is more reliable and easier to mount. The circuit board and all other components should be mounted to the back of the front panel for ease of accessibility.

If one desires a longer display time, increase R5 from the recommended

150k to 220k or even 270k.

Any type of two-conductor connecting jack can be mounted on the front panel (I used an RCA-type jack) as long as the appropriate plug is used. The two wire cable which connects the rotary wind sensor to the electrical unit must be long enough to reach from the roof to the place in your home where you want to keep the display unit. Any kind of shielded cable, including audio cable or microphone cable is OK. Coax such as RG-59/U is fine, but don't buy it special for this job because it costs much more than other (audio) cable.

Calibration. This anemometer is easily calibrated since there is just one pot to adjust. As an initial test, plug the unit in and connect the wind sensor to the display unit. After a few seconds warmup the unit should show 00 then go momentarily blank. Turn the cups by hand and a number should appear on the display for a second or two and then disappear for a second. Now turn the cups as fast as you can by hand and adjust the calibration pot to read as close as possible to 20. If everything so far works OK, it is time to take the anemometer for a ride. If not, go back to Square One and check your wiring and the seating of the LED display modules.

The anemometer should be calibrated against an accurate automobile's speedometer. Since the anemometer will be away from the regular house supply, you will have to take along a 5-volt

battery supply. In order to drop the voltage to the required 5 VDC, you must connect a 2 ohm resistor in series with a 6 volt battery.

With someone else driving, take the unit in an auto on a nearly calm day and drive as steadily as possible at a certain definite speed, say 30 mph. Drive up and down a quiet road, with the wind sensor held out the window and adjust the calibration pot so the display will read an average value of 30.

Use. The wind sensor should be mounted on a roof or other location where there are few obstructions. Because of the one-shot ahead of the NAND gate, the anemometer may suddenly go blank. when winds are of hurricane speed. So if the display one minute shows 75 mph and the next minute 00, don't stick your head out the window to see if something happened to the wind sensor on your roof, a tree might just be sailing by.

A simple way of checking your speedometer is to drive down an expressway at 55 and have someone time you betwen two mileposts. Then get your hand calculator out and divide 3600 by the number of seconds it took you to travel the mile. The result is your true speed. ∎
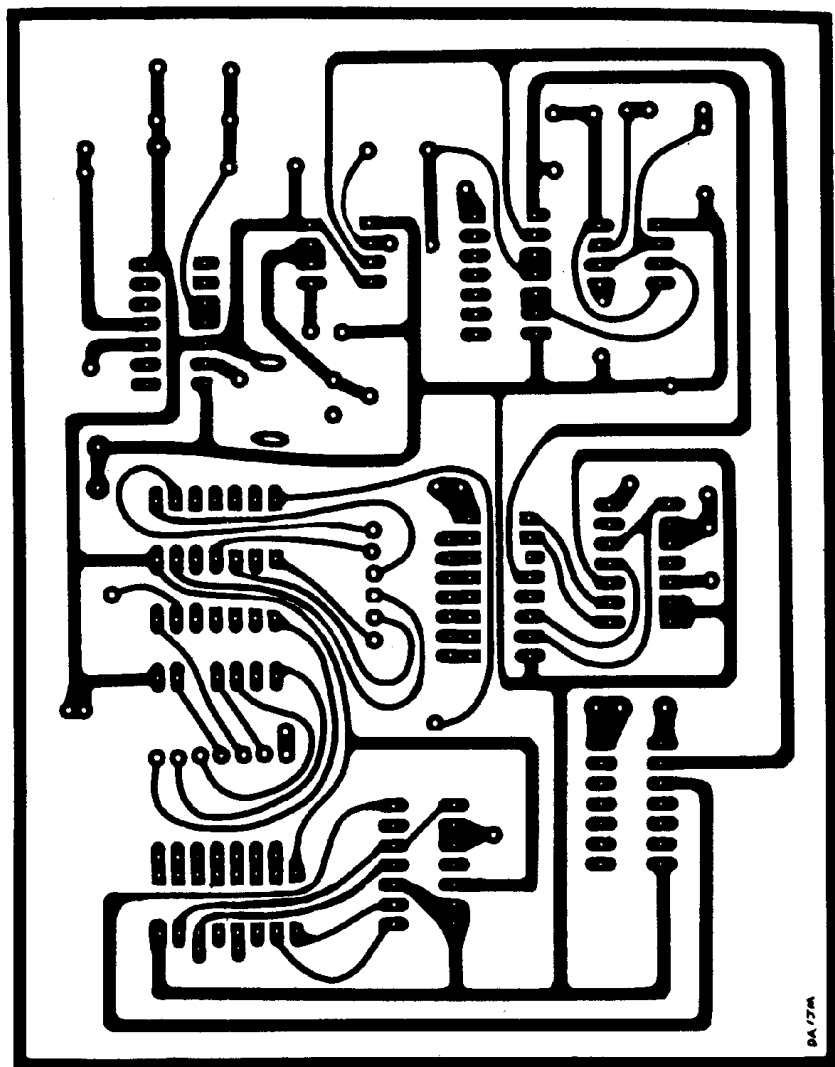
The key to building a successful Digital Windspeed Meter is the making of an accurate printed circuit board. As you can see, many of the foil strips are in close proximity to each other. Be sure not to let any of the lines touch where they aren't supposed to; the resulting short circuit would probably damage one of the integrated circuit chips. Probably the best method for this circuit, if you are not equipped to use a photo-etching technique, is to use a resist type felt tipped pen and sketch the patterns on the copperplated board. The board is then soaked in an acid etching solution for an hour or so. After the pattern is reproduced in copper you should drill all the holes. If you have a small drill-press, use it—a hand-held drill is likely to slip and damage the circuit.