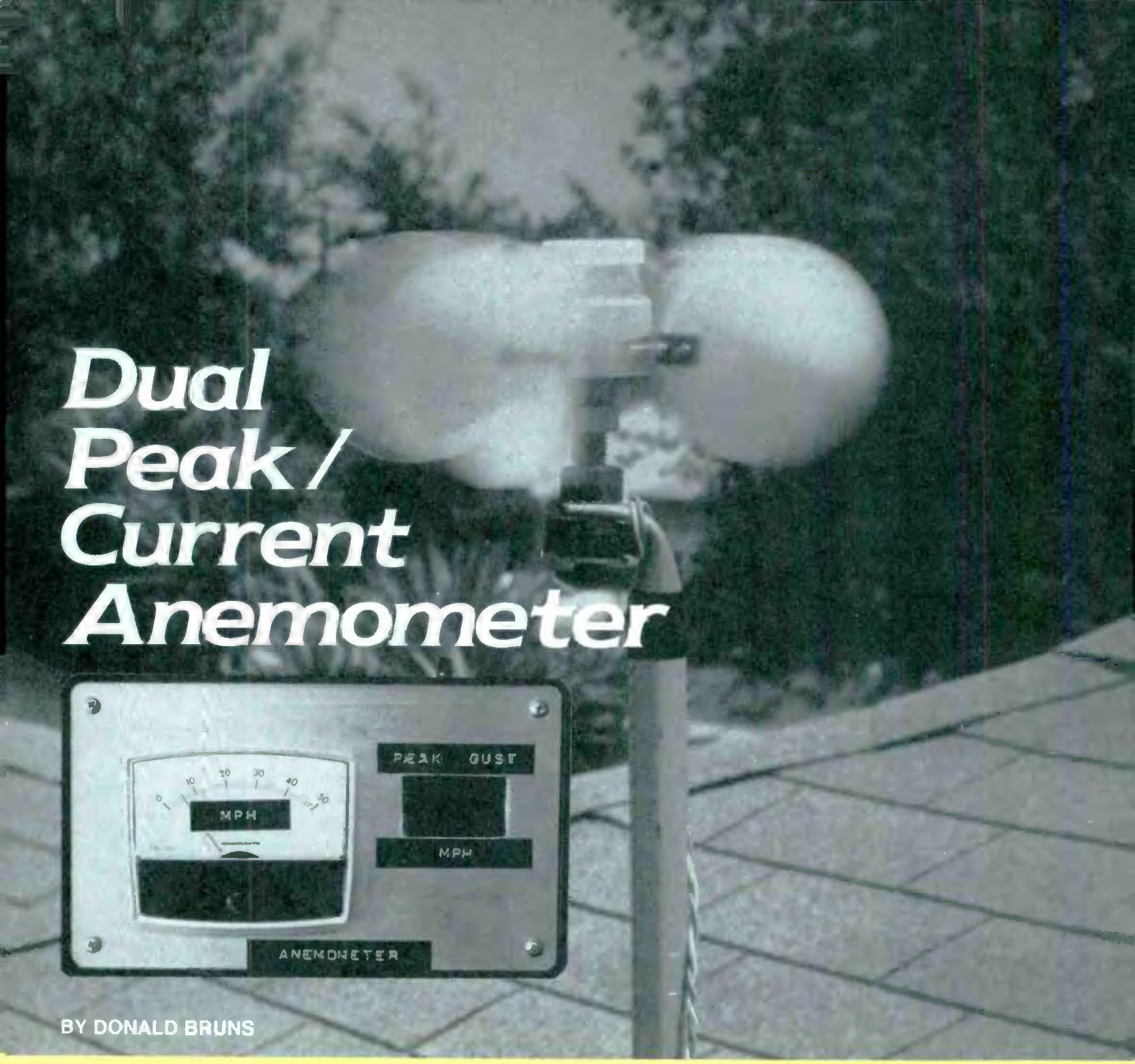
Dual Peak / Current Anemometer



BY DONALD BRUNS

Know at a glance what's happening with the wind through this easy-to-build project. Obtain current wind speeds and previous wind-gust high!

EVERYONE WANTS TO KNOW, "HOW HARD DID THE WIND blow last night?" That is especially true when lots of terrible noises have kept one up all night long! The present windspeed is easy to measure while one is looking at one of a number of inexpensive and simple wind gauges or anemometers. But a first-class weather-station setup with a 24-hour recorder chart is prohibitively expensive. For about $40, you can build the Dual Peak/Current Anemometer that will provide you with not only the current windspeed on an analog meter, but also a digital reading of the highest gust measured.

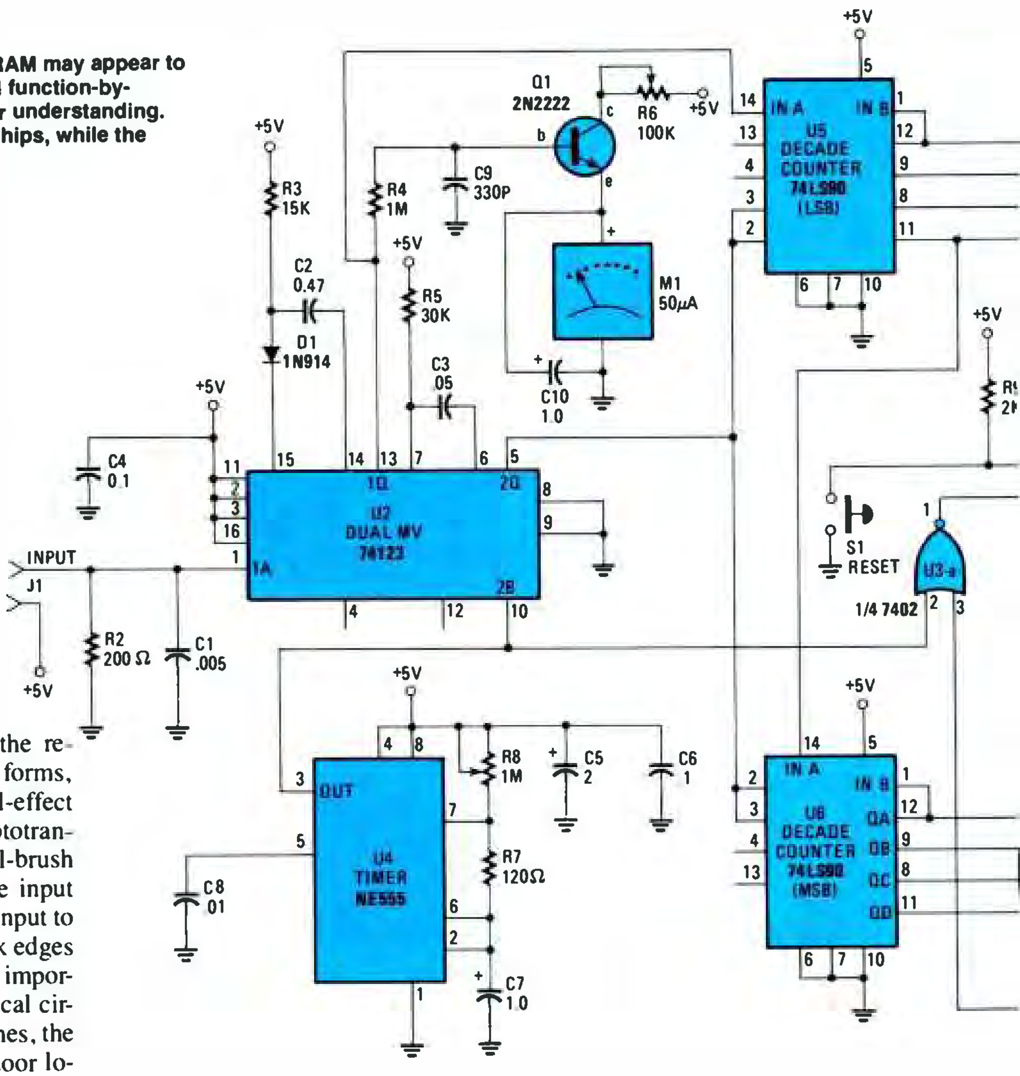
The panel-meter on the Dual Peak/Current Anemometer allows the observer to follow the windspeed as the wind blows, and gives a better feeling for gusts and average windspeed than a single digital display. The digital display, however, keeps a record of the highest windspeed measured since the display was last reset, so constant observation is not required. The anemometer can also be used as a peak-reading speedometer or tachometer if an appropriate input is supplied, and is easily calibrated. The anemometer is all TTL based so it can operate from a car battery as well as from a charger-type wall transformer for continuous operation.

Circuit Description

The entire Dual Peak/Current Anemometer electronic circuit consists of four sections: The remote transducer or anemometer head, the analog display, the digital display, and the power supply. Each of those sections will be discussed separately, since almost any combination of circuits can be used in order to modify the project to the builder's own desires.

The input circuit of the main circuit board, shown in Fig. 1,

FIG.1—MAIN BOARD SCHEMATIC DIAGRAM may appear to be complex; however, follow the detailed function-by-function discussion in the text for a clear understanding. The units count (LSB) is the top row of chips, while the tens count (MSB) is the bottom row.



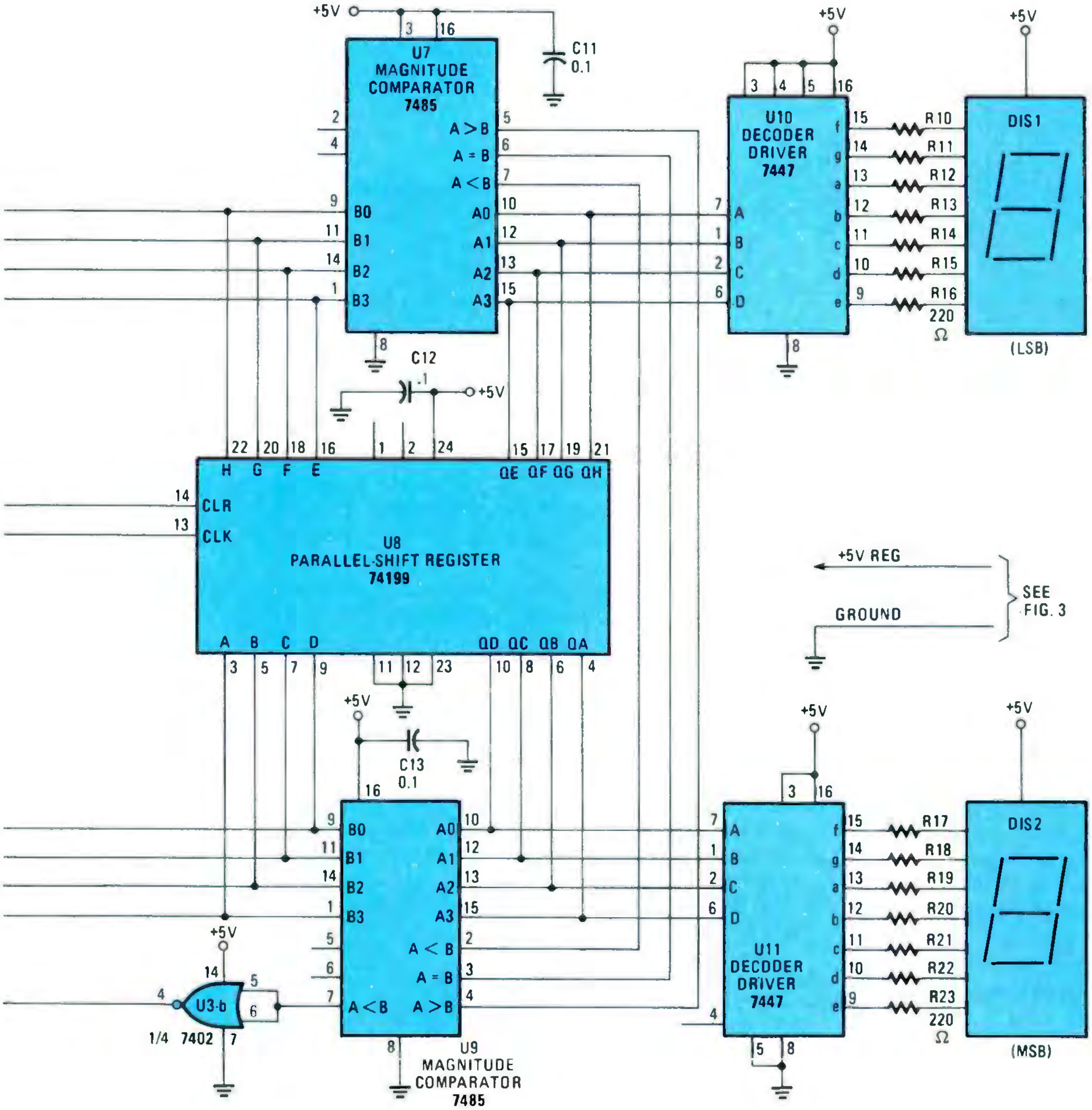
requires TTL-compatible pulses, so the remote transducer can take a number of forms, some of which are shown in Fig. 2. Hall-effect switches, magnetic reed switches, phototransistors, or diodes, or even mechanical-brush contacts are all permitted because the input effectively debounces and buffers the input to the rest of the circuit. Only falling-lock edges are counted, so pulse widths are not important. For indoor applications, the optical circuits may be best; or mechanical switches, the easiest and cheapest. For remote outdoor locations, magnetic devices are required. Because anemometers work best when made as light in weight as possible, the Hall-effect switch with lightweight magnets is the best choice.

The circuit shown in Fig. 2-B shows how to connect the Hall-effect switch with only two wires, rather than requiring three. When no magnet is nearby, the integrated circuit in the Hall-effect switch takes only a small amount of supply current. When the proper magnetic pole is nearby, however, the device must also supply the load resistor R1. While that extra current causes a larger drop across R2 in Fig. 1, and thus triggers the A section of the 74123 dual monostable multivibrator U2, it also reduces the supply voltage across the Hall-effect switch U1 to about 2½ volts. Although that is actually below the recommended operating voltage for the chip, the circuit still works, and saves sending a third wire to the remote transducer.

The analog and digital portions of the main circuit board (Fig. 1) share the same input circuit. The A section of the U2 (pin 1 input) is set to give one pulse for every input TTL transition, and the input pulse width is not critical. At the highest input pulse rates, U2 is triggered almost immediately after the previous pulse is gone, giving a high average-output voltage. At the lowest pulse rate the average-output voltage is nearly zero. The relationship is linear between those extremes. Those pulses (Q from pin 13, U2) are current-amplified by Q1 and drive the panel meter M1 directly, using trimpot R6 to calibrate the full-scale reading.

The pulse-count averaging is done by the slow mechanical response and damping of panel meter M1 directly. The averaging is done by the slow mechanical response of the panel meter, and is noticeably of a pulsed character only for the very lowest output rates, below a few per second. At that speed, the wind is so mild that it really doesn't make any sense to measure it.

The same pulses from pin 13 of U2 are sent to 74LS90 decade counters U5 and U6, which count up for a time period set by the NE555 timer U4, before being reset by the pulse from the B section of U2. That counting period is determined by capacitor C7 and the trimpot R6, which is varied to allow the digital side to be calibrated to the analog side. Before the decade counters are reset, their values are continually fed to the inputs of a 74199 (U8), an 8-bit parallel-shift register, and the B inputs of two 7485 magnitude comparators U7 and U9. The A inputs of U7 and U9 are connected to the outputs of U8



and to the digital displays, consisting of a pair of 7447 BCD-to-7 segment decoder/drivers U10 and U11 and a double-digit, 7-segment LED (DIS1 and DIS2). When the present count in U5 and U6 are smaller than the values in the display, then the outputs of U7 and U9 stay low and keep the shift pulse from U4 from turning on gate U3, and nothing else happens during the counting period. Decade counters U5 and U6, however, are reset every time. As soon as they record a larger value than that in the LED display, the outputs of U7 and U9 turn on U3 and allow the reset pulse from U4 to clock U8, and the new, higher value appears in the LED display. When the RESET switch S1 is pushed, all of the output lines of U8 are cleared; so the peak reading will disappear, to be filled with the next digital count. The comparison process is repeated every clock cycle.

Power

The current requirements are rather large, due to the standard TTL circuits and two large LED displays, DIS1 and DIS2. With all 14 LED segments in the two displays lit up, 300 mA of current is drawn from the 5-volt DC power supply,

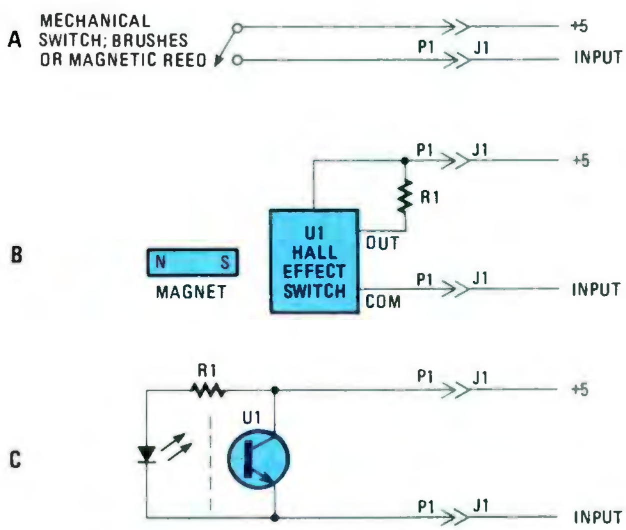


FIG. 2—SCHEMATIC DIAGRAMS of typical remote transducers or pickups that sense the rotational movement of the anemometer arms (see text).

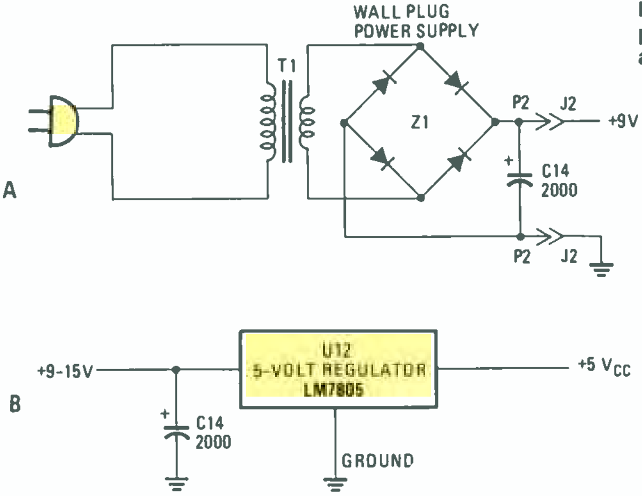


FIG. 3—SCHEMATIC DIAGRAM for bridge-rectifier power supply and five-volt regulator that powers the anemometer's electronic circuits.

so standard batteries would not last long. Either a large battery, or wall transformer—or the small power supply shown in Fig. 3, supplying at least that current at 7 to 18 volts—can be used with the 7805 regulator U12 to supply the only voltage needed for this project.

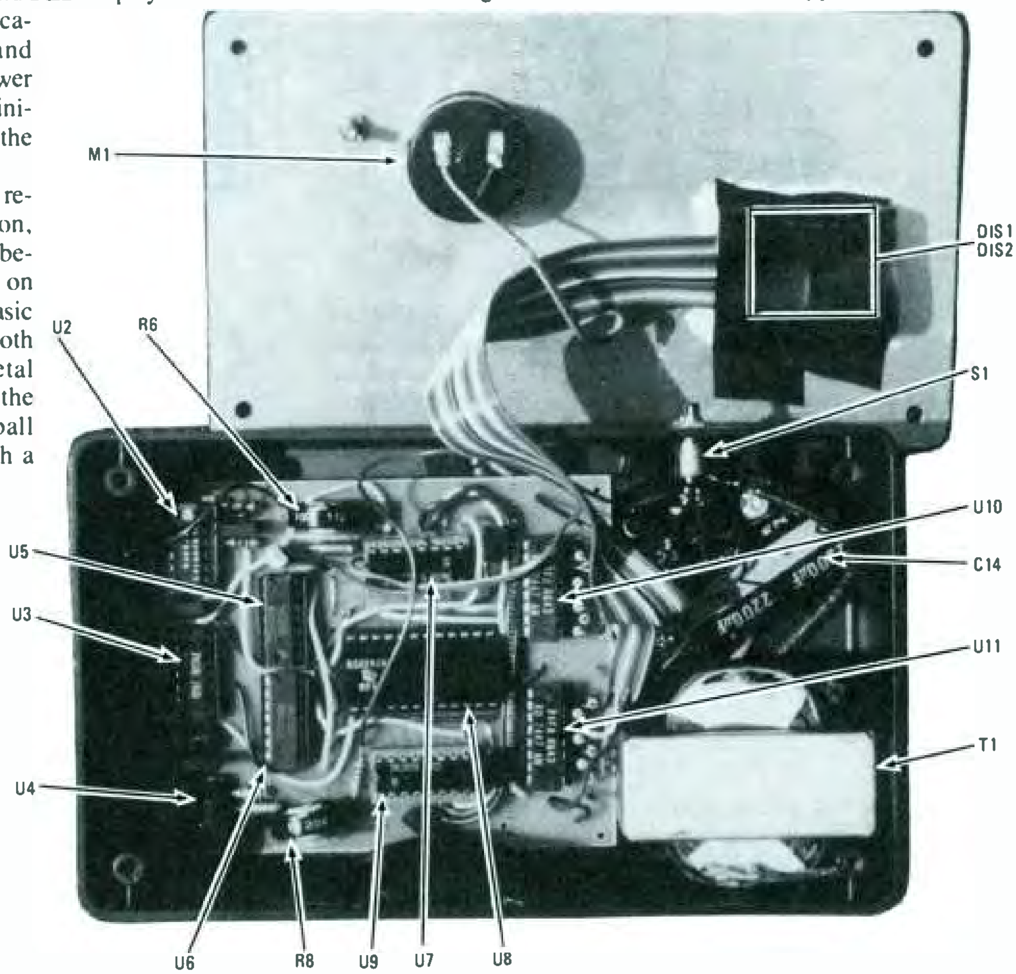
Construction

The construction of the circuit board is not critical, since only low frequencies are involved. The many parallel wires suggest the chip layout; wire-wrapping is probably the most convenient technique, although any other method should work. A metal case may also be used as the power-supply heat sink, so that might be more convenient than a case made entirely of plastic. The panel meter and LED displays are best connected with color-coded ribbon cable. Miniature polarized plugs and jacks were used to connect the power supply and remote sensor, and a miniature reset switch, S1, is placed near the digital LED displays.

The anemometer's remote sensor requires some mechanical construction, but the details are not given here, because they would depend too much on the scrap materials available. The basic design is shown in Fig. 4. Three smooth cups are rigidly attached to a metal shell, which in turn is epoxied to the outer race of a small, unsealed ball bearing. The inner race is held with a ⅜-inch bolt, which then mounts to a fixture on a fence or rooftop. Three magnets are also epoxied to the inside of the shell, with a Hall-effect switch U1 and R1 epoxied to the nut holding the bearing.

Construction materials, for the most part, are scrap items. The only guiding features are that the parts be weatherproof and lightweight. Plastic eggshells, either from a toy store or from pantyhose containers, seem fairly indestructable and very lightweight, and are preferred over ping-pong balls or aluminum funnels or spoons. The spherical shape is preferred, giving a better peak reading than cone-shaped cups, because they have a tendency to not slow down after a gust of wind dies down. That allows the digital counter to record a slightly higher average windspeed, closer to the peak gust velocity.

The ball bearings used in the prototype models were not sealed; to keep the starting friction very low, allowing very small windspeeds to start the anemometer cups rotating. The bearings were obtained for $1 from a local surplus house. The ratio of outside radius R, as shown in Fig. 4, to cup radius r is not too critical, but should be about 2 to 1. The overall length of R should be between 1½ and 2½ inches for best linearity and minimum response time. The smaller the arms, the faster the anemometer will spin, and the faster the digital display may be updated. In the interest of low weight, the prototypes used three magnets made of the rubberized type of material



THE BULK of the electronics for the Dual Peak/Current Anemometer is located in a plastic case with aluminum cover. The LED indicators, DIS1 and DIS2, and the meter, M1, mount on the cover. A ribbon cable provides the connection between the circuit and the LED indicators. The case may be replaced with a fancy cabinet or wall-mounted plate.

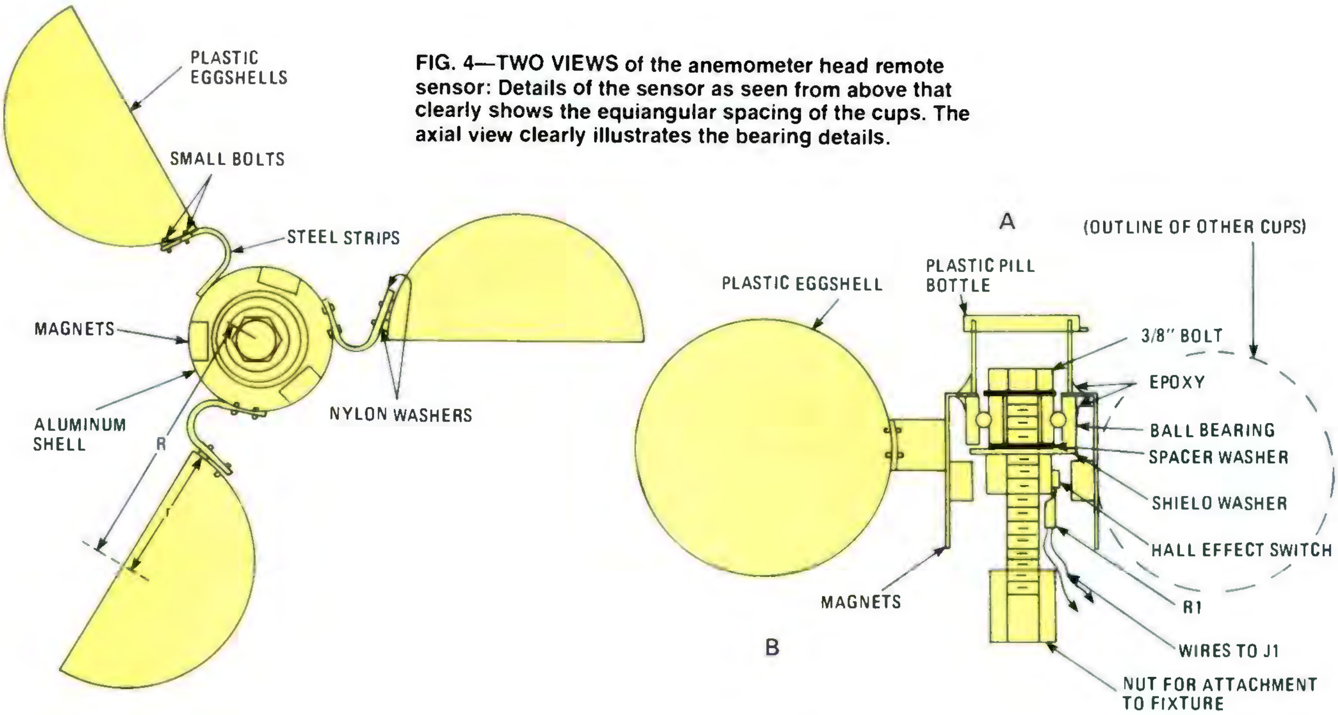
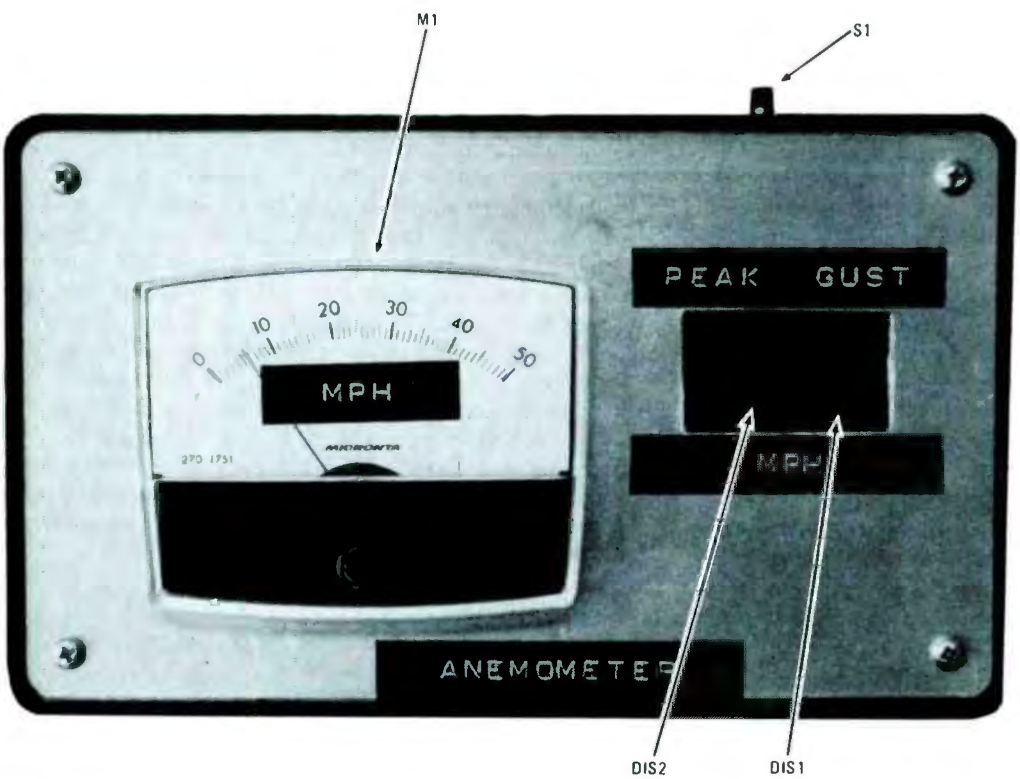


FIG. 4—TWO VIEWS of the anemometer head remote sensor: Details of the sensor as seen from above that clearly shows the equiangular spacing of the cups. The axial view clearly illustrates the bearing details.

used for magnetic bulletin boards, so that the head sent three pulses for every rotation. That technique permits the display to be updated frequently, so that short gusts will be captured. The rest of the parts were truly scrap items. The aluminum shell is actually the top cut off an old electrolytic capacitor, and the plastic eggs were bolted on with strips of 1/4-inch wide thin steel strips from a junkbox, using the smallest bolts available, cushioned with nylon washers. The top cover is made from a plastic pill bottle, cut in half and epoxied onto the aluminum shell.

Calibration

The calibration of the Dual Peak/Current Anemometer is most easily done by actually using a calibrated wind. The most convenient source is a car with the sensor attached to the front bumper. If the anemometer sensor is placed on a bracket in front of the car, and the tests are performed on a calm day with no other traffic, the calibration should be adequate for home use. The test is best performed with a helper. First connect the anemometer sensor to the display units, and either tap off the car battery or use a 9-volt alkaline battery



ALL INDICATIONS displayed on the front panel of the Dual Peak/Current Anemometer read in miles per hour. The meter, M1, indicates current wind speeds, and as the wind varies in speed, the meter pointer will be seen to drop and kick up. RESET switch S1 clears the peak reading of the display LED's, DIS1 and DIS2. The next clock cycle will provide an indication, and this indication will increase should the wind increase always indicating the highest gust since the RESET switch was last depressed.

PARTS LIST FOR DUAL PEAK/CURRENT ANEMOMETER

SEMICONDUCTORS
D1—1N914 rectifier diode
DIS1, DIS2—Seven-segment light-emitting-diode display
Q1—2N2222 NPN transistor
U1—Hall Effect Switch—see text (Radio Shack 276-1646)
U2—74123 dual retriggerable monostable multivibrator integrated circuit
U3—7402 quad 2-input NOR integrated circuit
U4—NE555 timer integrated circuit
U5, U6—74LS90 BCD decade counter integrated circuit
U7, U9—7485 magnitude comparator integrated circuit
U8—74199 8-bit shift register integrated circuit
U10, U11—7447 BCD-seven-segment decoder/driver integrated circuit
U12—LM7805 5-volt, 1-A, positive voltage-regulator integrated circuit
Z1—Full-wave, 50-PIV, 1-A, bridge-type rectifier (see text)

RESISTORS
(All fixed resistors are ¼-watt, 20% rated)
R1—120-ohm (see text)
R2—200-ohm
R3–15,000-ohm
R4—1-Megohm
R5—30,000-ohm
R6—100,000-ohm, trimpot
R7—120-ohm
R8—1 Megohm, trimpot
R9—2000-ohm
R10-R23—220-ohm

CAPACITORS
C1—.005-µF, ceramic or mylar
C2—.47-µF, mylar
C3—.05-µF, mylar or ceramic
C4, C6, C11, C12, C13—0.1-µF, mylar or ceramic
C5—2-µF, electrolytic
C7, C10—1-µF, tantalum
C8—.01-µF, ceramic or mylar
C9—330-pF, ceramic
C14—2000-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS
M1—0-50-uA, DC panel meter
T1—6.3-volt, 1-A line step-down transformer (see text)
P1, P2—Miniature 2-conductor plug
J1, J2—Miniature 2-conductor jack
S1—SPST, normally-open, momentary-contact, push-button switch
Printed-circuit or perforated-circuit board, IC sockets, chassis box or plastic case with metal cover, ribbon cable, steel strips, magnets, aluminum shell, wire, solder, hardware, nylon washers, epoxy cement, decals, etc. Refer to text for materials obtained from surplus sources.

wired to the input power jack. Have the driver of the car maintain a constant velocity of 50 mph, and adjust both trimpots so the displays read 50. (It takes 1.2 minutes—1 minute, 12 seconds—to travel a measured mile on a highway at 50 mph.) Then the digital display reads miles-per-hour directly, while the meter reads 1 mph per 1 microamp. The reset switch S1 will have to be pressed every second or so to read the digital speed, and whenever trimpot R8 is adjusted.

Although that completes the calibration, here's a caveat about the variablity of the wind. Wind velocity on a small scale is very turbulent and variable, so while a tree's branches may be wildly waving at one place, an anemometer placed only 20 feet away may be practically stationary. The effect of roof lines, trees, and other obstacles will cause variations in recorded windspeed, so that peak just recorded on your anemometer is not necessarily the same-speed gust that blew over your trash cans. The average over many gusts or many days, however, should be accurate, and the relative values from day to day are always interesting.

All that remains is to install the anemometer sensor at the remote site. Two-conductor wire is all that is required; but remember that neither is grounded, so proper insulation should be used. If the 5-volt line is accidentally grounded, the voltage regulator U12 will shut off, so that no permanent harm is done. Although rooftop installation will generally give the highest readings, the hazard of lightning strikes may exist if too high a pole is selected.

Troubleshooting

Although the circuit assembly and construction are straightforward, there are several easy tests which can be done if, because of the possible modifications, the circuit does not work properly. First of course, the power-supply voltage should be checked at each of the IC pins that require the 5 volts. To check the input circuit, measure the voltage on pin 1 of U2—it should oscillate between about 0.7 volts and 2.5 volts when the magnets are moved near and away from the U1. If nothing happens, the magnets may be reversed, or not strong enough. If the voltage does change, but not enough to trigger the U2, then the Hall-effect switch is working; but due to manufacturing tolerances, it may require a slightly different value for R1 or R2. That can be done by trial and error, by watching the output of U2 at pin 13. If those parts check out OK, then the analog meter should work. Individual variations in the current gain of different transistors may also require a lower value for R4 if full-scale meter indication cannot be reached. To troubleshoot the digital circuits, an oscilloscope is needed, but standard digital techniques will again suffice. Check the various pulse widths, making sure that they are near the expected RC values for each chip. The reset switch S1, when not pushed, should allow pin 14 of U8 to remain near 5-volts DC, and goes to zero only when contact is made, zeroing the display. Those hints should cover most of the probable difficulties; if all else fails, try substituting chips one at a time.

Modifications

Several circuit modifications are possible to alter the device to the particular requirements or parts on hand.

The panel meter can be 100-microamp full scale instead of 50 microamp, for a 0-to-100 range on the analog scale.

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DUAL PEAK/CURRENT ANEMOMETER

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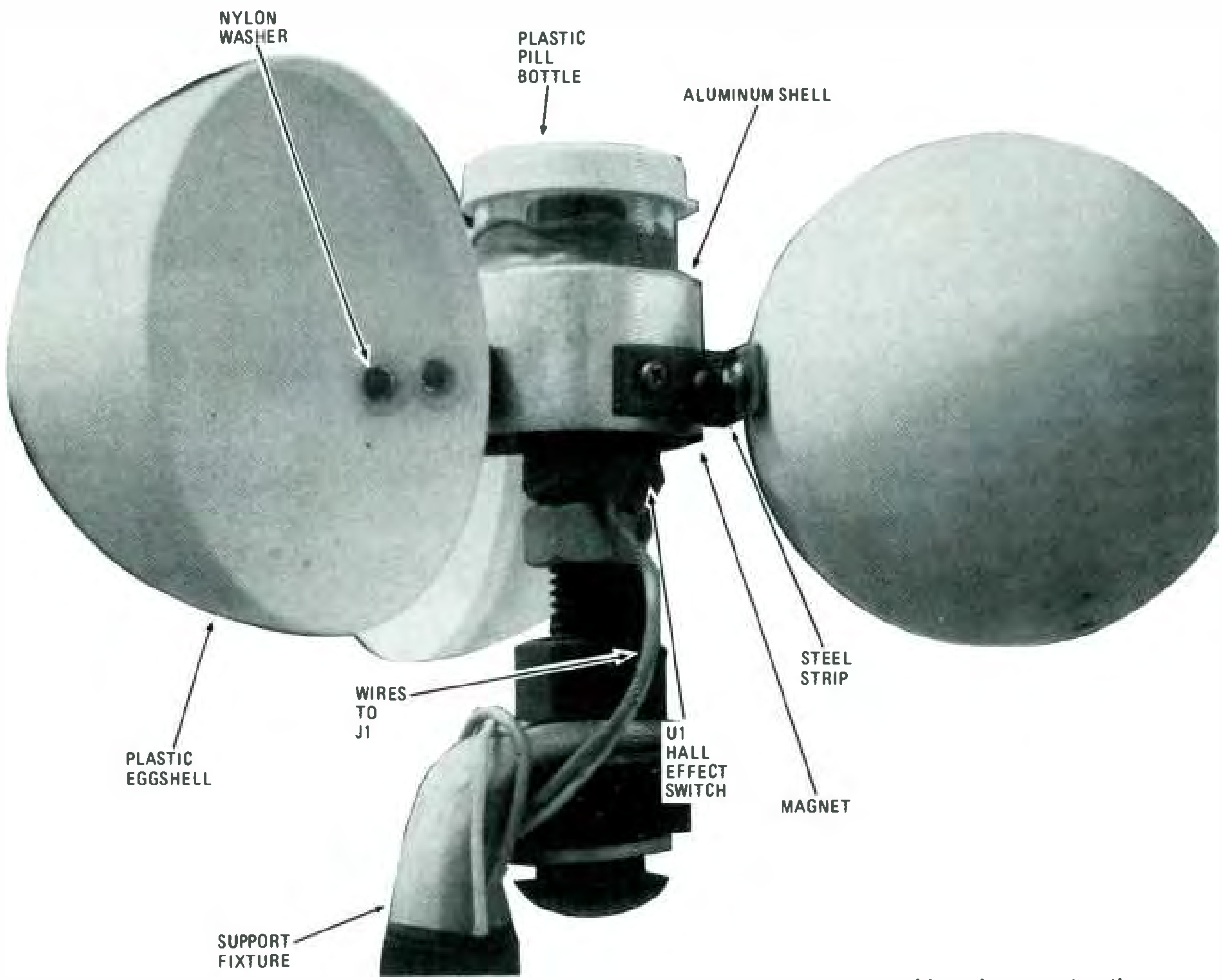
without relabeling the face. Low-power CMOS chips can be substituted for some of the chips directly, but extensive redesign must be done to replace the 8-bit shift register with two 4-bit CMOS chips. LCD displays can also be substituted for lower-power consumption and portable battery operation. Three or more of each of the decade counters, comparators, registers, and displays can be wired together to increase the dynamic range of the digital peak detector, although the analog portion will not be improved. Similarly, range switches may be incorporated, if the timing components of the input U2 are also adjusted accordingly. The update time of the digital display is set at about 2/3 second with the present component selection and that matches the response time of the anemometer head, but the different applications may require slight redesign.

Conclusion

The combination of both analog and peak reading digital readouts on the Dual Peak/Current Anemometer make it a most interesting and convenient instrument to use. It doesn't have to be watched continuously, nor is an expensive chart recorder necessary. Power consumption is less than an incandescent night light, so no on-off switch is even included, and it is on for 24 hours every day.

Once the anemometer is mounted, however, be prepared for friends to call up and ask, "Wow, the wind really blew hard tonight! What did your anemometer record?" But, if they are really friends, they will wait until the next morning to call you up! ■



THE ANEMOMETER REMOTE SENSOR requires parts that are not usually associated with project construction; nevertheless, acquisition of those materials should not be difficult. The most important aspects of the sensor's construction is balance and symmetry—both of which go hand in hand.