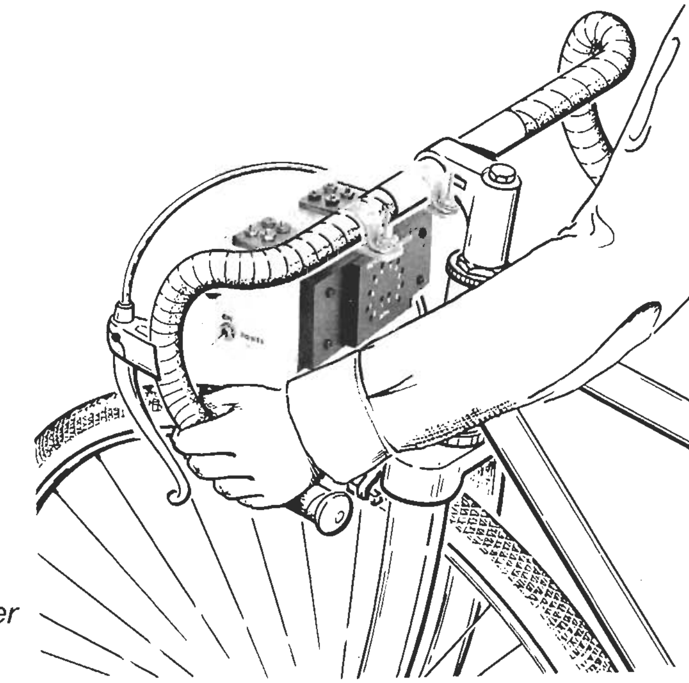
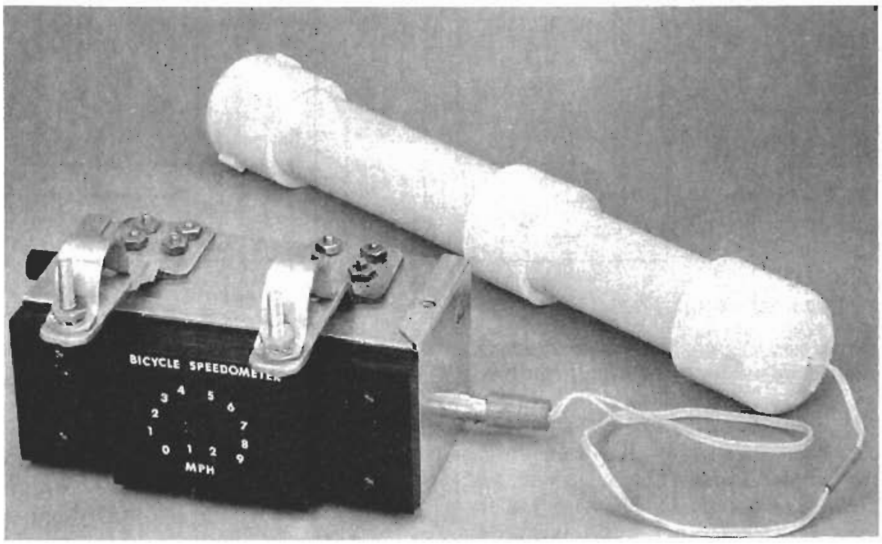
BUILD

Digital Bicycle Speedometer



An ideal gift for a young rider or an active bicyclist, this speedometer conserves battery power through the use of a motion sensor circuit.

ROBERT N. BEABER



DIGITAL BIKE SPEEDOMETER along with its plug-in battery-type power supply. PVC tubing houses the battery made by series-connecting five NiCad rechargeable cells.

BICYCLE RIDING HAS GAINED POPULARITY in recent years as a fun way to stay trim and healthy. This digital bicycle speedometer adds to that fun as well as providing an accurate indication of speed. It would make an ideal gift for that young boy in your life. Or, if you're not already an active bicyclist, you should become one. The digital bicycle speedometer uses rechargeable (NiCad) batteries and is designed to conserve power by using 12 discrete LED's as the speed indicators instead of two 7-segment LED's.

The drawings and photographs show the front panel of the speedometer. During normal operation with speeds up to 9 mph, only one LED is on at any given time. At a speed of 10 mph, both the "10" and "0" LED's are on. The "10" LED remains on and LED's "0" through "9" are on individually in the speed range of 10 to 19 mph. At 20 mph, LED's "20" and "0" are on. Above 20 mph, the rider sees LED "20" and one of the intermediate unit LED's. At 30 mph, LED's "10," "20" and "0" are on, and the counting sequence continues until the maximum of 30 mph is reached. The speedometer and speed sensing circuitry are controlled by the wheel switch. This switch consists of a magnetic reed switch on the bike frame and two magnets cemented to the wheel. This switch is S3 in the speedometer schematic in Fig. 1.

The wheel switch closes twice during each wheel revolution, and bicycle speed is indicated by the number of switch closures counted over a fixed period of time. To establish the number of switch closures per fixed period related to speed in miles per hour, we first determine the number of *one-half revolutions* the wheel makes *per mile.* For a 27-inch wheel, this is 1493.98 revolutions. At 1 mph, there is one switch closure (or one-half revolution) every 2.409 seconds. A count of 5 in 2.409 seconds equals 5 mph.

A calibration oscillator controls the fixed time interval during which wheel-switch closures are counted. The circuit is designed so that when the oscillator is adjusted correctly, closing the TEST switch causes the display to show the wheel size. For instance, the display should read "27" for a 27-inch wheel. The calibration-oscillator repetition rate is approximately 11.25 pps. This frequency was selected because it provides a simple standard for adjusting the time period to accommodate any wheel size without a calibration table or chart.

Circuit operation

The speedometer circuit (Fig. 1) consists of two 74C90 decade counters; a 74LS174 that contains six positive-edge triggered flip-flops operated as a 6-bit latch; a 7445 decimal decoder; and circuitry to strobe the latch, reset the counters and turn off the power when the wheel stops turning. Input pulses from wheel switch S3 enter at J2 and are applied to one-half of IC7, a 556 dual timer. IC7 is operated as dual one-shot multivibrators in series. The first multivibrator is a debounce circuit that conditions the wheel-switch pulses so that only one pulse is obtained each time a magnet causes the switch to close. It also triggers the second one-shot. The second circuit remains triggered as long as switch S3 is active—that is, opening and closing. When the bike stops and switch S3 no longer opens and closes, the second one-shot times-out after about 3 seconds and reverts to its stable state.

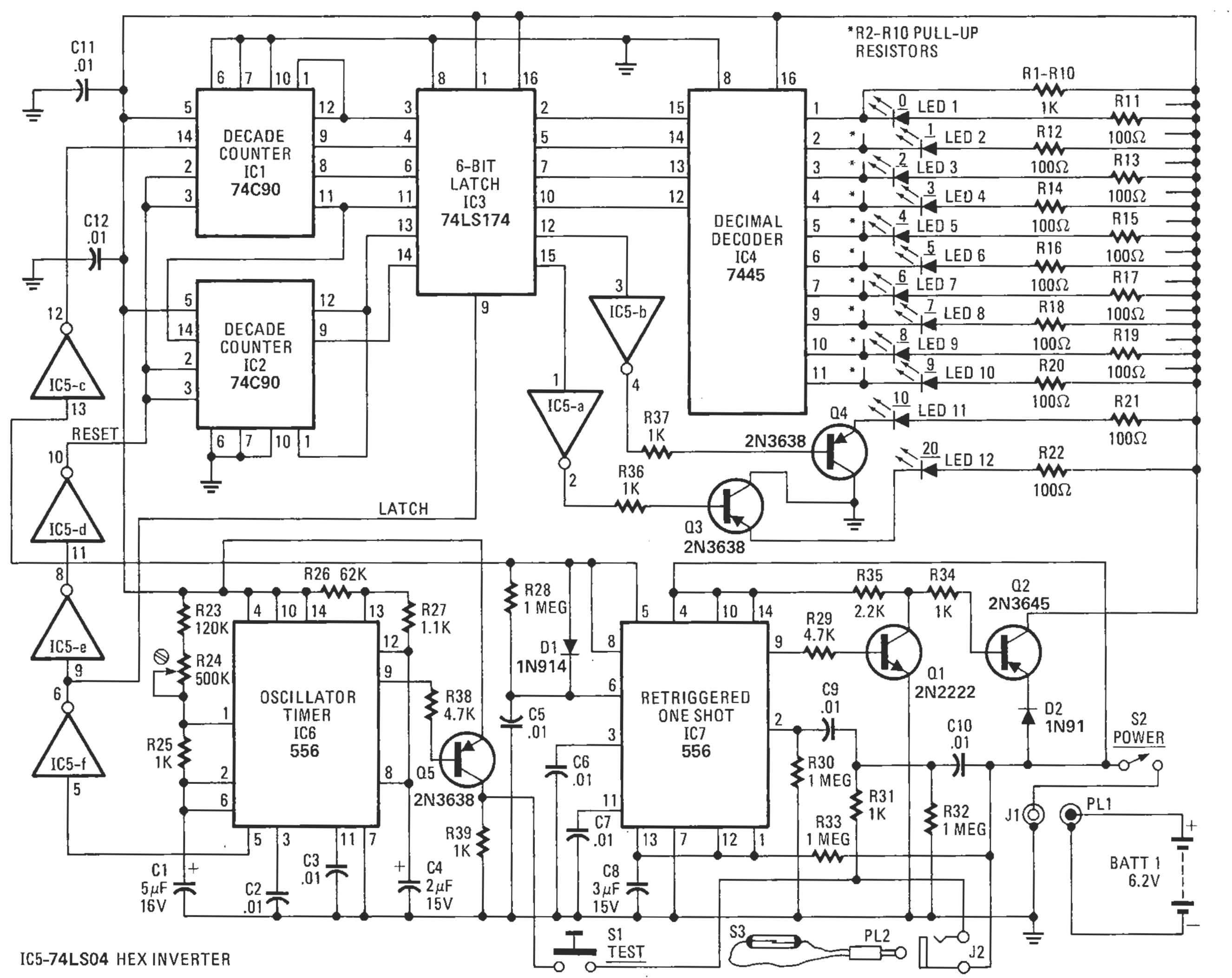
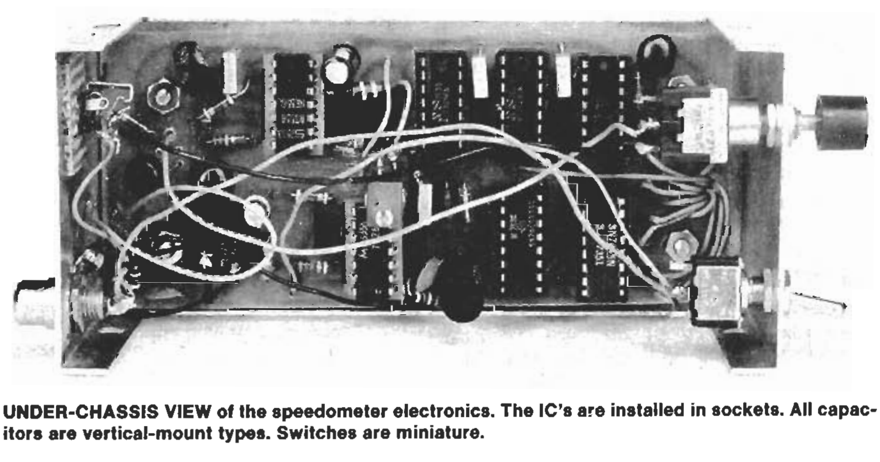


FIG. 1—BICYCLE SPEEDOMETER SCHEMATIC. Twelve miniature LED's instead of the 7-segment displays are used as the readout to minimize power drain and conserve battery life.



UNDER-CHASSIS VIEW of the speedometer electronics. The IC's are installed in sockets. All capacitors are vertical-mount types. Switches are miniature.

The output of the first one-shot, pin 5 of IC7, is inverted by IC5-a to provide the correct logical output to the first decade counter (IC1). The output of the second one-shot, pin 9 of IC7, is inverted by transistor Q1 and used to turn on Q2. Transistor Q2 is a solid-state switch that provides power to all speedometer circuitry except for IC7 and transistor Q1. Power to IC7 and Q1 is turned on and off by switch S2.

When S2 is closed, the first pulse from wheel switch S3 turns on Q2 and supplies power to the counter circuitry. Succeeding pulses are then counted by IC1 and fed to 6-bit latch IC3. The latch provides a constant output to the decoder for display during the fixed time interval. The latch is strobed at the end of the time period just prior to resetting the decade counters to zero.

The latch strobe and counter reset is provided by IC6. This dual timer IC is connected as two separate oscillators. One oscillator is slow and adjustable, delivering one pulse approximately every 2.5 seconds. The other operates at a fixed frequency and delivers 11.2 pulses per second.

The slow adjustable oscillator provides the fixed time interval for counting the pulses from S3. This output signal is from pin 5 and is inverted by IC5-f and used to strobe the latch line to pin 9 of IC3. This same signal goes through inverters IC5-e and IC5-d and is used to reset the counters. The double inversion provides an ample time delay between the strobe and reset so the output of the latch has settled before the inputs from the counter are reset to zero. If the time delay were not there, the latch output would reflect its input—which would be zero when the counter is reset to zero.

The fixed-frequency oscillator output signal is from pin 9 of IC6. It is inverted by transistor Q5 and sent through the test switch to input jack J2. The product of the number of pulses-per-second from this oscillator and the fixed time period yields a number that corresponds to the wheel size.

Decimal counter IC4 accepts the BCD output from the first 4 bits from IC3 to

PARTS LIST

All resistors ¼ watt, 5%.
R1-R10, R25, R31, R34, R36, R37, R39—1000 ohms
R11-R22—100 ohms
R23—120,000 ohms.
R24—500,000-ohm, 15-turn potentiometer (Bourns *Trimpot* or equal)
R26—62,000 ohms
R27—1100 ohms
R28, R30, R32, R33—1 megohm
R29, R38—4700 ohms
R35—1200 ohms
C1—5 μF, 16-volt electrolytic
C2,C3,C5-C7,C9-C12—.01 μF, disc
C4—4 μF, 15-volt electrolytic
C8—3 μF, 15-volt electrolytic
D1, D2—1N914
LED1-LED12—miniature red LED's, 1.6 volt, 50 mA (Radio Shack 276-026)
Q1—2N2222
Q2—2N3645
Q3-Q5—2N3638
IC1, IC2—74C90
IC3—74LS174
IC4—7445
IC6, IC7—556
J1-PL1—matching RCA-type phono plug and jack
J2-PL2—matching miniature phone jack and plug
S1—miniature, normally open pushbutton switch
S2—miniature SPST toggle switch
S3—reed switch, normally open (Radio Shack 275-035)
Misc.—Optional IC sockets; two 1-inch rectangular magnets (Radio Shack No. 64-1875); 5 × 2¼ × 2¼-in. metal utility box; handlebar clamps, assorted hardware; 2 × 5-inch PC board; 5 NiCad cells (surplus cells and batteries available from Poly-Paks and other surplus parts dealers); and rigid PVC pipe and 2 end caps.

provide a single output between 0 and 9, depending on the BCD inputs. The other 2 bits from IC3 are the resultant count from decade counter IC2. These bits are inverted by IC5-a and IC5-b and used to turn on transistors Q3 and Q4, which then turn on LED's "10" and "20."

Construction is simple

The speedometer is built on a PC board, the foil pattern is shown in Fig. 2 and components placement is shown in Fig. 3. Install the 17 jumpers as indicated in the table shown in Fig. 3. Install wire-wrap-type sockets for the IC's and then add all capacitors, resistors and other discrete components. Cut 17 lengths of No. 26 stranded hook-up wire that is approximately 6-inches long and solder them to the PC board for connection to the LED display, switches S1 and S2, and jacks J1 and J2.

Refer to Fig. 4 for the details of the faceplate in which the LED's are mounted. The faceplate is laminated from five pieces that are cut from ⅛-inch plastic to the dimensions shown. Three pieces measure 5 × 2 inches and two measure 2 × 2 inches. You can cut the

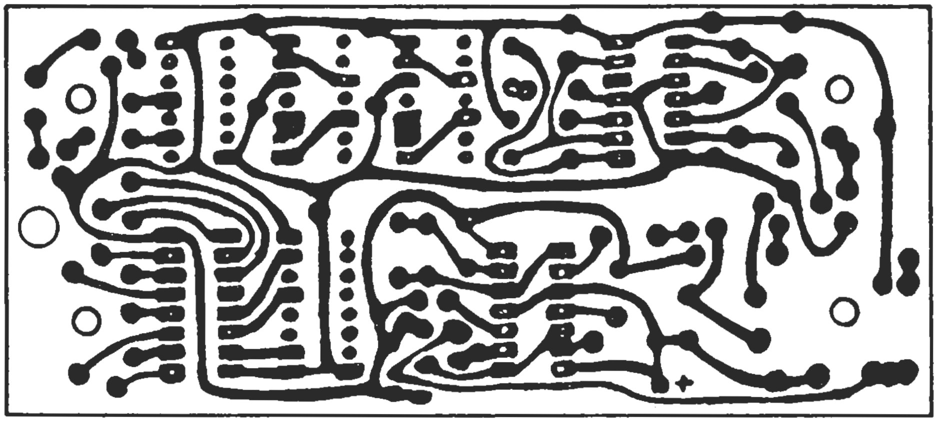
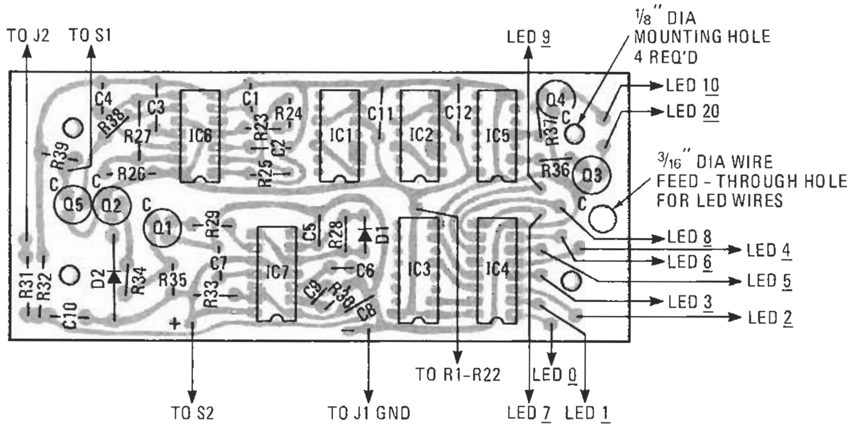


FIG. 2—FULL-SIZE FOIL PATTERN FOR PC BOARD. Use it or the drilling pattern on page 40.

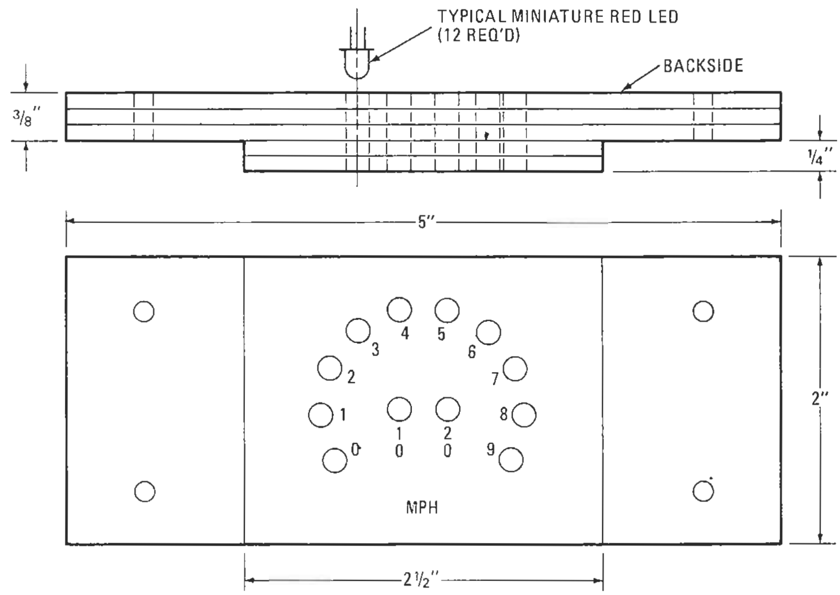


NOTE: R1 THROUGH R22 ARE ON BACK OF FACEPLATE. SEE FIG. 6

WIRE-WRAP JUMPERS

FROM	TO	FROM	TO	FROM	TO
IC5 - 1	IC3 - 15	IC5 - 10	IC2 - 2	IC2 - 14	IC1 - 11
IC5 - 3	IC3 - 12	IC2 - 3	IC1 - 3	IC1 - 11	IC3 - 11
IC5 - 5	IC6 - 5	IC5 - 13	IC7 - 5	IC1 - 8	IC3 - 6
IC5 - 6	IC5 - 9	IC5 - 12	IC1 - 14	IC1 - 9	IC3 - 4
IC5 - 9	IC3 - 9	IC2 - 9	IC3 - 14	IC1 - 12	IC3 - 3
IC5 - 8	IC5 - 11	IC2 - 12	IC3 - 13	IC4 - 12	IC3 - 10

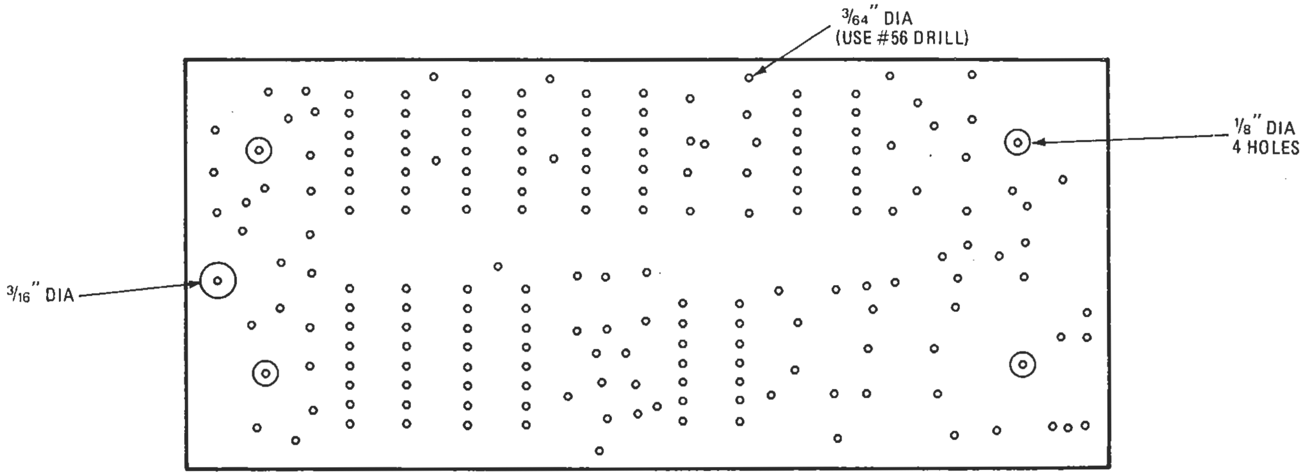
FIG. 3—PARTS LAYOUT. This drawing and the photo on preceeding page will prove helpful when constructing the bike speedometer. Add the eighteen jumpers listed in the table.



NOTE: THIS IS A TYPICAL LAYOUT. THE MATERIAL USED IS ⅛" PLASTIC. FIVE PIECES ARE LAMINATED TOGETHER USING CLEAR CEMENT FOR CHINA, GLASS, ETC. THE PLASTIC AND CEMENT CAN BE FOUND IN A HARDWARE STORE.

FIG. 4—HOW FACEPLATE IS CONSTRUCTED. Holes are drilled so LED's are snug.

ANOTHER PC BOARD CONSTRUCTION METHOD



If you don't have facilities for reproducing the PC board directly from Fig. 2, try this scheme, based on the full-size *drilling* pattern shown here.

Use carbon paper and trace the pattern or holes onto a sheet of paper. Rubber-cement this sheet onto a 2 × 5-inch PC board. With a No. 56 bit, drill a hole at each point indicated. When all holes have been drilled, use water and household cleanser to remove the paper and rubber cement residue. Burnish the copper with fine steel wool to remove all oxidation.

The next step is to draw the foil pattern on the copper surface. Use an etch-resist felt pen and Fig. 3 to make the drawing. If you start in the upper left-hand corner (that is, if you are right-handed), you can draw the connecting lines between corresponding holes without smudging them with the heel of your hand. When you finish, recheck the pattern against Fig. 3. Make sure that adjacent lines do not touch.

When the etch-resist has dried, immerse the PC board in a bath of etchant solution. Follow directions on the bottle and agitate the solution frequently. The etching process takes about 15 minutes. Inspect the board closely after removing it from the bath to make sure that all unnecessary copper has been etched away. Use nail polish remover or acetone to remove the etch-resist. Buff the copper with fine steel wool to provide a good clean surface for soldering. The board is now ready for mounting components.

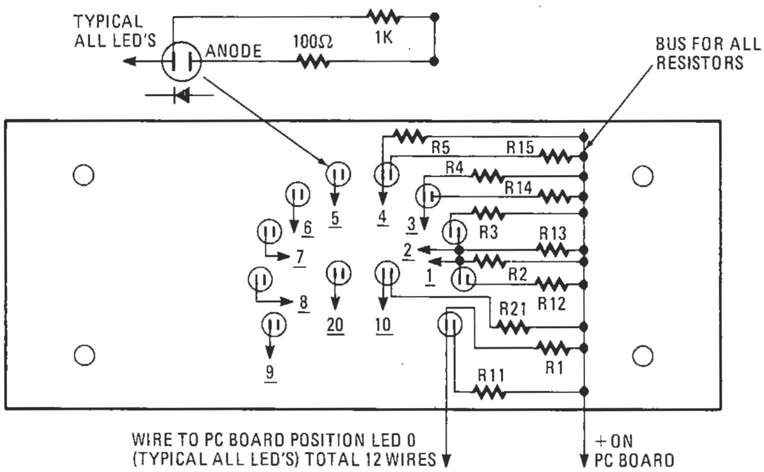


FIG. 5—HOW LED'S ARE INSTALLED along with their associated pull-up and current-limiting resistors. These parts are on rear of faceplate.

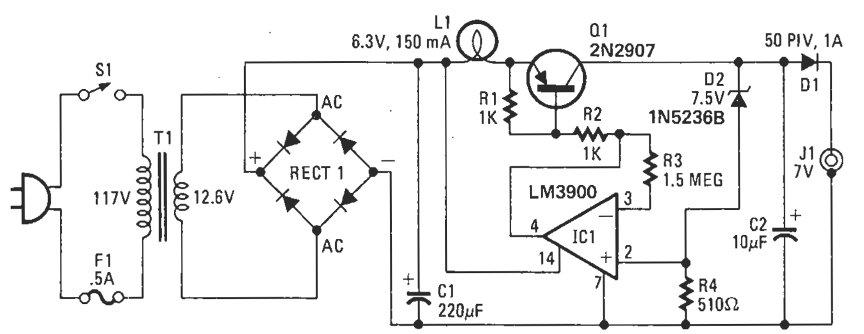


FIG. 6—BATTERY CHARGER keeps the five NiCad cells fully charged. Circuit is designed for optimum performance when charging the battery.

plastic using a fine-toothed handsaw. Cement the pieces together with a clear adhesive, and then file and sand the edges for a smooth finish.

The layout of the holes can be copied from Fig. 4 or you can use your own layout. To drill the 12 holes for the LED's, select a drill that will provide a snug fit when the LED is inserted. The four 1/8-inch-diameter mounting holes should align with the four mounting holes in the PC board. After drilling the holes, peel off the protective paper and spray the faceplate with flat black lacquer. Apply several thin coats on both sides and edges, being sure to spray the inside of each hole as well. If excess lacquer builds up on the surface, remove it with a cloth dipped in acetone. When the lacquer has dried, apply the press-on letters and numbers.

PARTS LIST
BATTERY CHARGER

R1, R2—1000 ohms, 1/4 watt
R3—1.5 megohm, 1/4 watt
R4—510 ohms, 1/4 watt
C1—220 μF, 35-volt electrolytic
C2—10 μF, 16-volt electrolytic
D1—50 PIV, 1.0 A diode (Radio Shack 276-1101)
D2—7.5-volt, 0.5-watt Zener diode, IN5236B or equivalent
Q1—2N2907 with heat sink
IC1—LM3900 Quad Norton amplifier (Radio Shack 276-1713)
J1—Shielded phono jack, chassis mount 1/4 inch (Radio Shack 276-346)
S1—SPST toggle switch, 3 A, 120 VAC
F1—1/2-A fuse slow blow
T1—117-volt pri. 12.6-volt sec. 300 mA (Radio Shack 273-1385)
RECT 1—50 PIV, 1.0 A full-wave bridge (Radio Shack 276-1151)
L1—6.3-volt, 150-mA lamp
Misc.—Fuse holder, case, lamp cord, PC board or perforated board

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BIKE SPEEDOMETER

continued from page 40

Figure 5 shows you how the LED's are installed. The 100-ohm resistors should be connected to the anode, and the 1000-ohm resistors to the LED cathodes. Wire them close together and trim the leads short since they will extend into the utility box used as the case. Otherwise, you can mount the resistors parallel to and against the back surface of the faceplate. In this case, cut a large hole in the front surface of the metal box so as to clear the resistors when the faceplate is installed.

Whether to mount the resistors parallel to or at right angles to the faceplate is up to you. Your choice, however, may be dictated by the amount of space available once the PC board is mounted inside the box. The limiting factor is the size of adjusting potentiometer R24. I used a 15-turn, 3/4-inch-long Bourns *Trimpot* and cemented it to the component side of the board. When the PC board is in place in the case, the adjusting screw comes close to the back of the case.

The case has two sections. Use the part with the lips on the front and end surfaces to mount all electrical components. Start by locating and drilling the four mounting holes for the faceplate and PC board. Use a full-size foil pattern of Fig. 4 to locate the mounting holes. Next, cut a rectangular hole in the front of the box to clear the resistors when the faceplate is mounted.

Drill the mounting holes for the two switches and two jacks. Place the switches on one end and the jacks on the other end. The holes are 3/4-inch from the back of the box and approximately 1-inch apart. The important thing is to position the holes so that the switches and jacks do not touch the PC board.

Use special care when mounting the jacks. They must be insulated from the chassis because its outer housing or shell is connected to the positive side of the battery. Use shoulder-type insulating washers or, as I did, mount J2 on a small piece of plastic and cement the plastic behind an oversized hole. Do not install the switches and J2 at this time. The handlebar clamps are mounted on the back section of the box, using No. 6-32 flat-head machine screws. The screw heads go inside the box.

Begin final assembly by attaching the faceplate to the box with four 6-32 × 1¼-inch machine screws. Next, solder the wires from the PC board to the corresponding LED's. Place ½- or ¾-inch spacers over the screws and mount the PC board on top, anchoring the board securely with four nuts and lock washers. Mount the switches and J1. Make the necessary connections to the switches and jacks. These are:

From	To
PC board B+ line	S2 arm contact
J1 center post	S2 fixed contact
PC board B− line	Shell of J1
Q5 collector	One S1 contract
J2 center post	Second S1 contact
Point J2 on PC board	J2 tip contact
J2 shell contact	S2 arm contact

Battery pack

The battery pack consists of five NiCad C cells connected in series. Solder four short pieces of wire to the positive and negative terminals and connect the cells in series. Wrap electrical tape around the cells to form a fairly rigid cylindrical package. Solder a 12-inch lead to the negative terminal and a 3-inch lead to the positive terminal. Cut a piece of 1-inch PVC plastic pipe approximately 12-inches long. Cement a pipe cap to one end and slip the battery inside the pipe, letting the two wires extend from the open end.

Drill a small hole for the two power leads in the end of the remaining pipe cap. A 12-inch piece of 24-gauge 2-conductor speaker cable is used for the power leads. Solder plug PL1 to one end of the cable and feed the other end through the hole in the end cap. Solder these wires to the battery leads and insulate

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the connections. Make sure that the positive battery lead goes to the center pin of PL1.

Wheel-switch assembly

Next, cement the reed switch to a 3/4 × 2-inch piece of plastic. Recess the switch in a shallow groove made with a small round file. Use Elmer's clear adhesive intended for glass and china or epoxy cement to anchor the switch to the plastic. Look through the glass envelope and note the two flat metal strips that make up the switch. These strips must lie parallel to the surface of the plastic when the switch is cemented in the groove. Solder a piece of No. 24, 2-conductor speaker cable about 20-inches long to the two leads of the reed switch. Connect the other end of this cable to plug PL2.

Testing the speedometer

Charge the battery and plug it into J1. Plug reed switch S3 into J2. Turn on the power and see if any of the LED's light up. If they do, then depress the TEST switch and hold it for at least 5 seconds. The 5-second delay insures that the signal pulses from IC6 are counted for at least one fixed time period.

At this point, connect a temporary jumper across the S1 terminals. This leaves both your hands free to hold the speedometer while you adjust potentiometer R24. Adjust R24 until the LED display reads the diameter of the bike's front wheel.

When you are satisfied that the display is stable, remove the jumper lead and observe the LED display. The LED's should go dark after about 3 seconds. Next, check the operation of reed switch S3 by bringing a magnet close to it—the "0" LED should light up. Simulate wheel movement by moving the magnet rapidly back and forth, opening and closing switch S3. The number displayed will change, but don't expect a display of "10" or more. Your hand isn't fast enough.

If the speedometer passes this test, assemble the case and fasten the halves together with sheet metal screws. Unplug the battery and wheel switch. Use epoxy cement to mount each of the two magnets on a piece of 3/4 × 2-inch plastic. Mount the magnets temporarily on the front-wheel metal rim of the bike between the spokes. The magnets should be diametrically opposite each other so that as the wheel turns, one magnet activates the reed switch every one-half revolution.

Now, place the reed switch on the inside of the fork in a position where a gap of 1/4 to 3/8 inch exists between it and the magnets. Adjust the switch and magnet positions to get proper switch action. Use a good bonding cement such as *Eastman 910* or *Krazy Glue* to fasten the magnets and the switch.

BATTERY POWER SUPPLY. NiCad "C" cells form power supply for speedometer.

Next, make sure that the battery is fully charged (you can use the battery charger shown in Fig. 6 for this purpose) and then mount the battery pack under the bicycle crossbars.

Plug in the battery pack and wheel switch. Close power switch S2 and press TEST switch S1. In approximately 5 seconds, the speedometer will read out the bicycle's wheel diameter. Release the pushbutton and the speedometer is ready for a trial run. **R-E**

BICYCLE SPEEDOMETER

0 — 99 MPH in sixty minutes — that's how long it will take you to build this all electronic solid-state speedometer

WITH FUEL getting more expensive, the world's oil supply running out and gas disappearing in a puff of smoke, it can't be long now before pedalpower makes a comeback. We can see it now; CB freaks with cycle mounted rigs and six-foot whips on the back. Of course there will be lots of research into optimum wheel size, cruising speed etc. That's where this dandy little project will come to your aid. Featuring a two-digit readout, bright red LED display with 1 MPH resolution updated every few seconds, it can be built in a trice (ideal if your bike has three wheels) and powered from a single 9 V battery.

Swift And Silent

There have been many bike speedometer designs published over the years but never before has so much been brought to so many with so little. Yes, only Electronics Today can do this for you! No, seriously, before this gets totally over done, we'll explain. Only three ICs are required plus the two displays and a handful of passive components. The whole thing is very easy to put together so you can assemble it whichever way you like best. The speedometer works by detecting each revolution of the bike's wheel using magnetically-sensitive reed switches with one or more bar magnets mounted on the wheel. The faster you go, the more pulses are counted and the speed displayed increases. The display blanks out while the counters are advancing to avoid a distracting flicker and the count period is set up by adjustment of a single resistor when the speedometer is mounted on your bike. Okay, so it doesn't tell your weight, but it won't burn a hole in your pocket either!

Construction/Setting Up

Nothing to cause any problems here. As usual we'd recommend you use sockets for the ICs. If you use our PCB design you should have success first time though the circuit is simple enough to