# BUILD THIS ROBOT BUG

***Our inexpensive robot is fun to build and fun to play with.***

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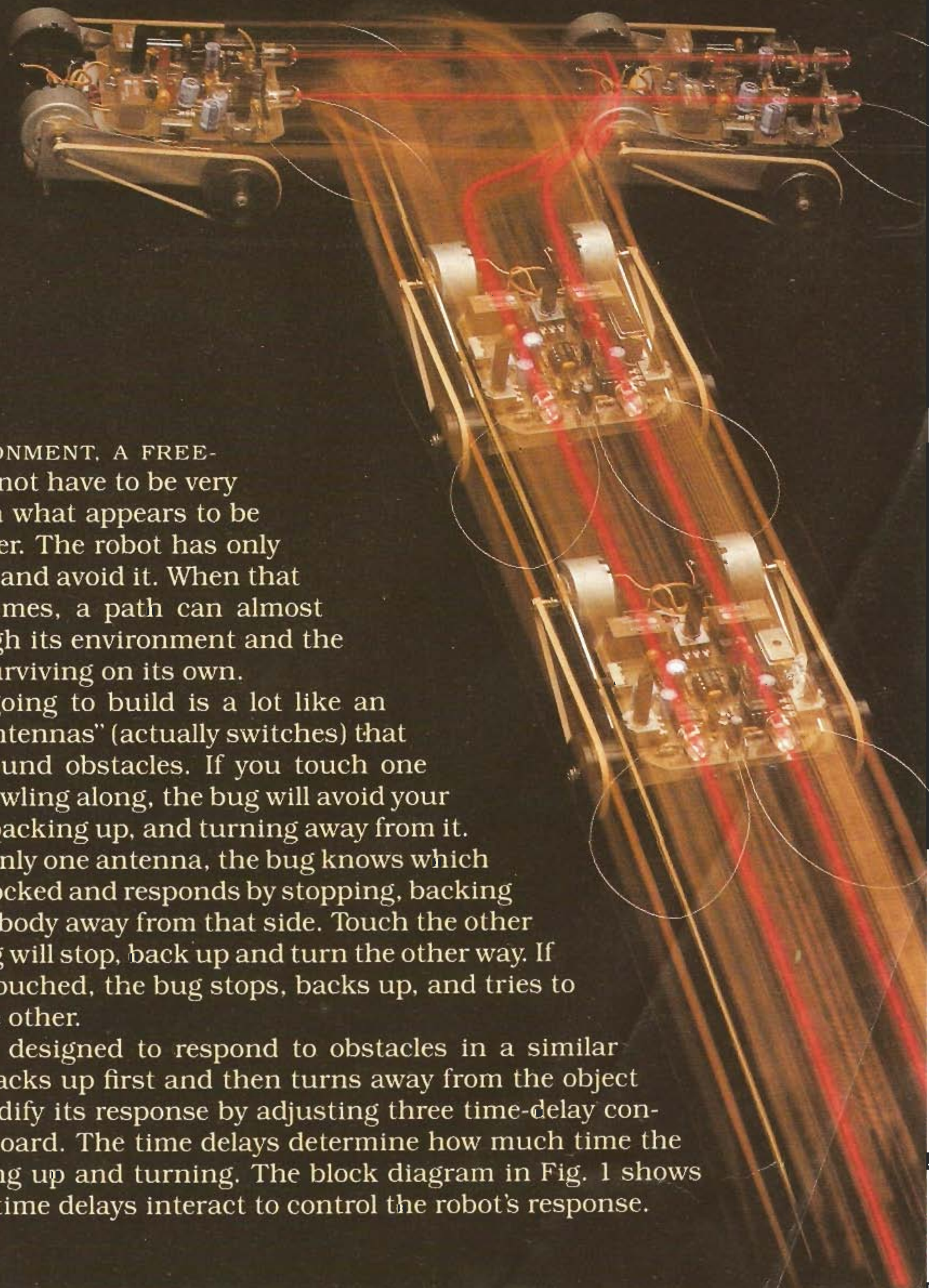


IN A SIMPLE ENVIRONMENT, A FREE-roaming robot does not have to be very smart to function in what appears to be an intelligent manner. The robot has only to sense an obstacle and avoid it. When that is repeated many times, a path can almost always found through its environment and the robot seems to be surviving on its own.

The robot we're going to build is a lot like an insect; it has two "antennas" (actually switches) that help it navigate around obstacles. If you touch one antenna of a bug crawling along, the bug will avoid your finger by stopping, backing up, and turning away from it. Because you touch only one antenna, the bug knows which side of his path is blocked and responds by stopping, backing up, and turning his body away from that side. Touch the other antenna and the bug will stop, back up and turn the other way. If both antennas are touched, the bug stops, backs up, and tries to go to one side or the other.

Our robot bug is designed to respond to obstacles in a similar manner. It always backs up first and then turns away from the object sensed. You can modify its response by adjusting three time-delay controls on its circuit board. The time delays determine how much time the robot spends backing up and turning. The block diagram in Fig. 1 shows how the adjustable time delays interact to control the robot's response.

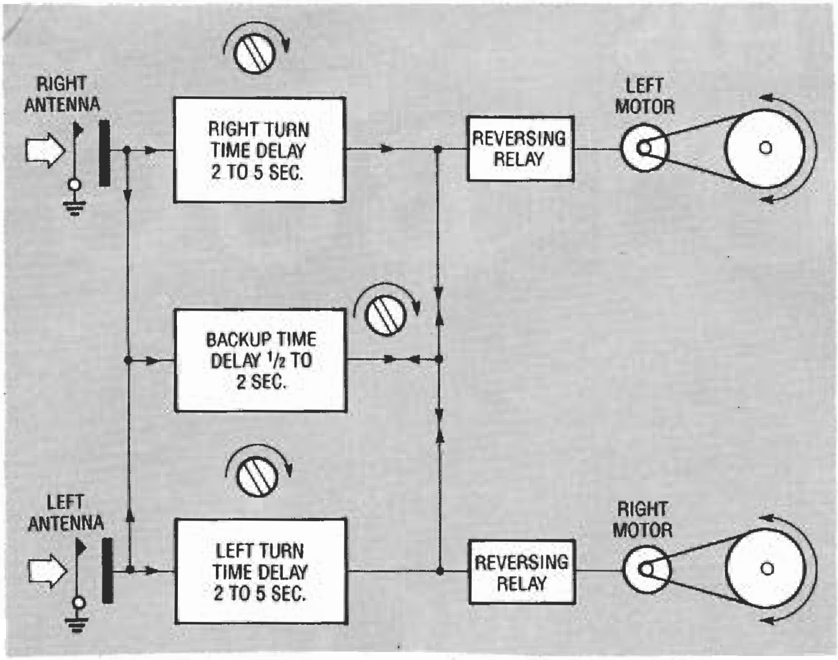



**FIG. 1—THREE ADJUSTABLE TIME DELAYS interact to control the robot's movement.**

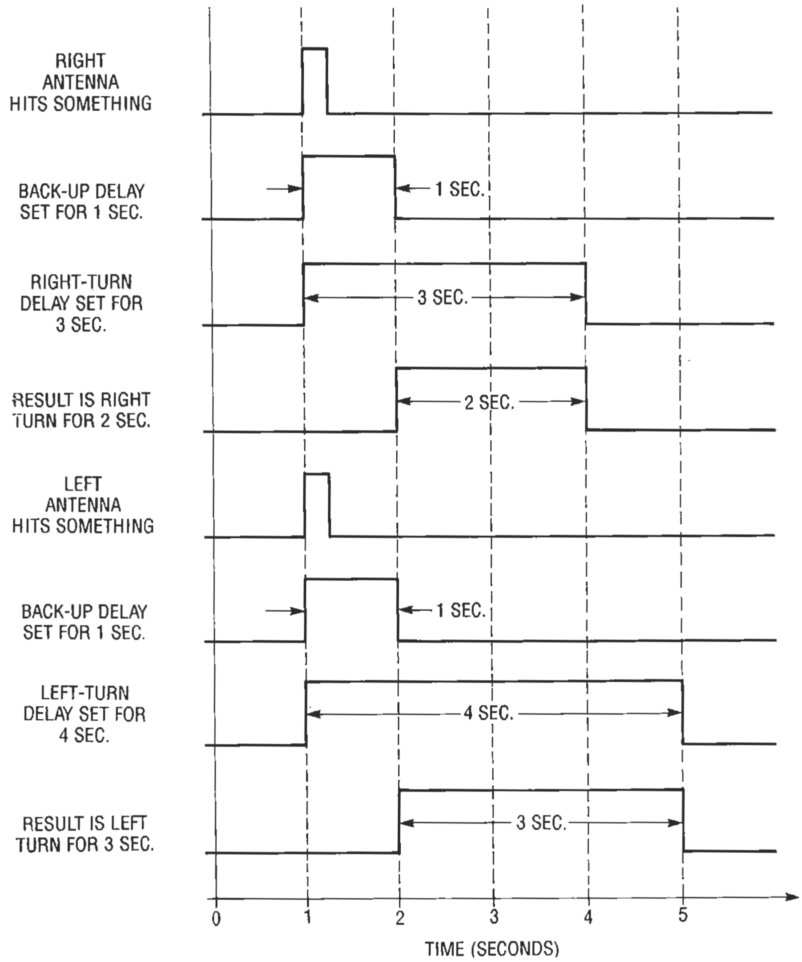



**FIG. 2—TIMING DIAGRAM. Either antenna will reverse both motors and the robot backs up. When the back-up time is over, one of the motors continues in reverse, causing the robot to turn away from the object.**

Three time-delay circuits share the control of two reversing relays. When the right antenna is triggered, it activates the back-up delay and the right-turn delay. When the left antenna is triggered, it activates the back-up delay and the left-turn delay. The back-up delay activates both reversing relays for a period of ½ to 2 seconds. During that time, the robot moves straight back, away from the obstacle. A turning delay (right or left) is set for period of 2 to 5 seconds. That keeps one motor in reverse after the other stops. If the left motor continues in reverse after the right motor stops, the robot turns to the left, and vice versa. The size of the turn depends on how long one motor continues in reverse after the other one stops. If both antennas are triggered, all three time delays are activated. The direction the robot turns is determined by whichever turn delay is longest.

The robot's control circuitry is based on simple "one-shots" that wait to receive a signal before turning on for a predetermined time. Three potentiometers let you adjust each one-shot separately. The timing diagram in Fig. 2 will help you visualize the different timing events. Either antenna (or both) will start the back-up one-shot which reverses both motors. One potentiometer sets the time that the robot spends going straight back. When the back-up time is over, one of the "turning" one-shots keeps one of the motors in reverse, causing the robot to turn away from the object. The direction of the turn is determined by the motor that stays in reverse; the size of the turn is determined by how long that motor stays in reverse after the back-up time is over.

## Circuitry

As shown in Fig. 3, three one-shots (IC1, IC2, and IC3) control two relays (RY1 and RY2). The backup time delay is controlled by IC3, and is variable between ½ and 2 seconds via R20. The left- and right-turn delays are controlled by IC1 and IC2, respectively, and are variable be-

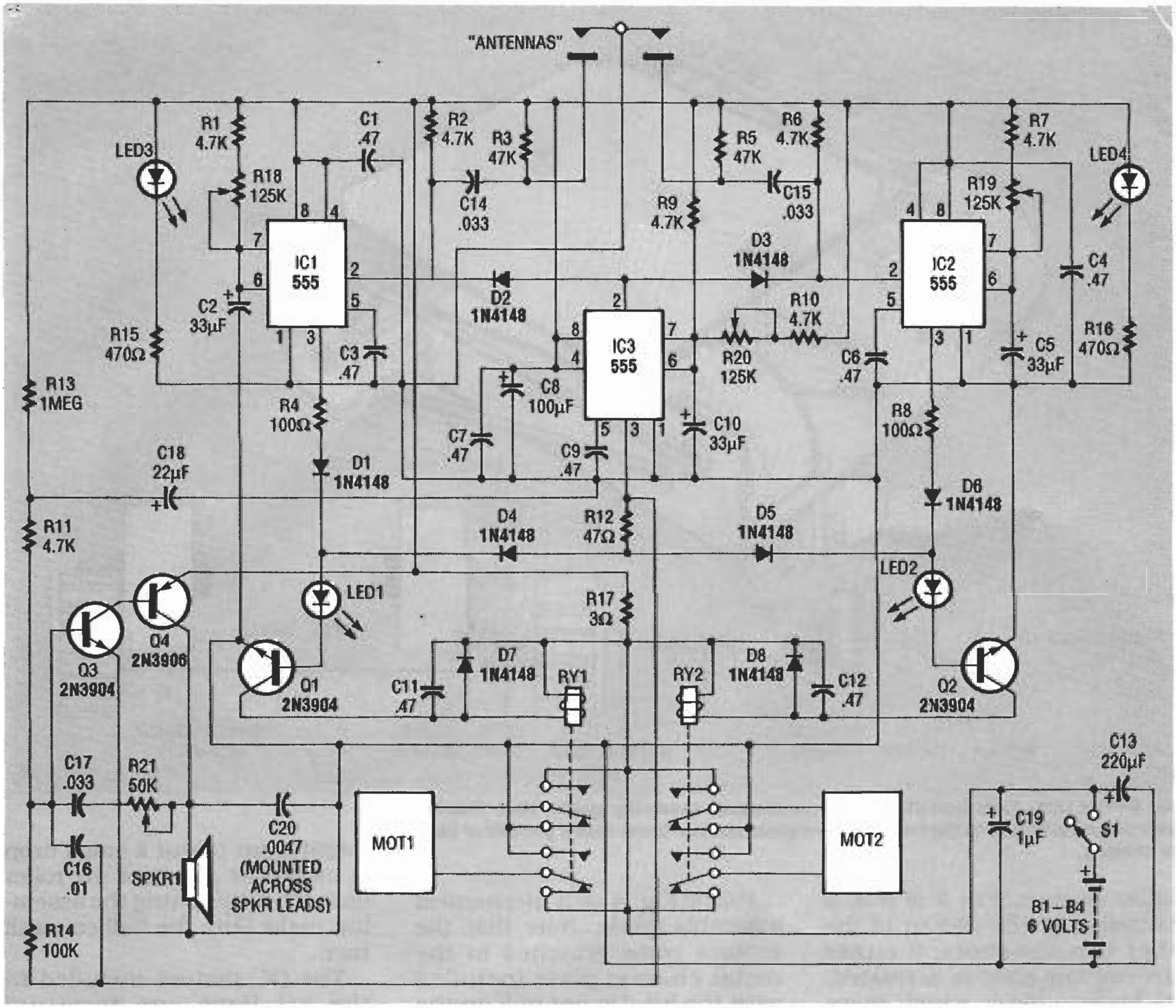



**FIG. 3—THE BACKUP TIME DELAY is controlled by IC3, and variable between ½ and 2 seconds via R20. The left- and right-turn delays are controlled by IC1 and IC2, respectively, and variable between 2 and 5 seconds via R18 and R19.**

## ELECTRONIC PARTS LIST

**All resistors are ¼-watt, 5%, unless otherwise noted.**

R1, R2, R6, R7, R9–R11—4700 ohms
R3, R5—47,000 ohms
R4, R8—100 ohms
R12—47 ohms
R13—1 megohm
R14—100,000 ohms
R15, R16—470 ohms
R17—3 ohms
R18–R20—125,000 ohms, potentiometer
R21—50,000 ohms, potentiometer

**Capacitors**

C1, C3, C4, C6, C7, C9, C11, C12—0.47 µF, monolythic
C2, C5, C10—33 µF, electrolytic
C8—100 µF, electrolytic
C13—220 µF, electrolytic
C14, C15, C17—0.033 µF, Mylar
C16—0.01 µF, Mylar
C18—22 µF, electrolytic
C19—1 µF, tantalum

**Semiconductors**

IC1–IC3—555 timer
D1–D8—1N4148 diode
Q1–Q3—2N3904 NPN transistor
Q4—2N3906 PNP transistor
LED1, LED2—red light-emitting diodes
LED3, LED4—jumbo round or rectangular light-emitting diodes

**Other components**

RY1, RY2—DPDT 5-volt relay
S1—SPST switch
SPKR1—Knowles electronics WO-360 speaker module or equivalent

**Miscellaneous:** IC sockets, PC board, two dual "AA" battery holders, all mechanical parts (see mechanical-parts list), wire, etc.

tween 2 and 5 seconds via R18 and R19.

To see how the 555 timers are used as one-shots, take a look at IC2 in the schematic. When a negative-going pulse is received from the right antenna at pin 2, the following timing cycle is started: pin 3 of IC2 goes high and turns on Q2 and RY2. At the same time, C5 charges through potentiometer R19. The charging time depends on the setting of the potentiometer. When C5 charges to approximately 4 volts, it begins to discharge through IC2. Pin 3 of IC2 returns to a low state and RY2 turns off. The one-shot now waits for the next pulse at pin 2. The circuit built around IC1 works in the same way.

The backup time-delay circuit built around IC3 differs from the other two one-shots in that it has four diodes added; D2 and D3 at pin 2 and D4 and D5 at pin 3. The diodes serve as an "OR function," causing pin 2 to respond if either antenna

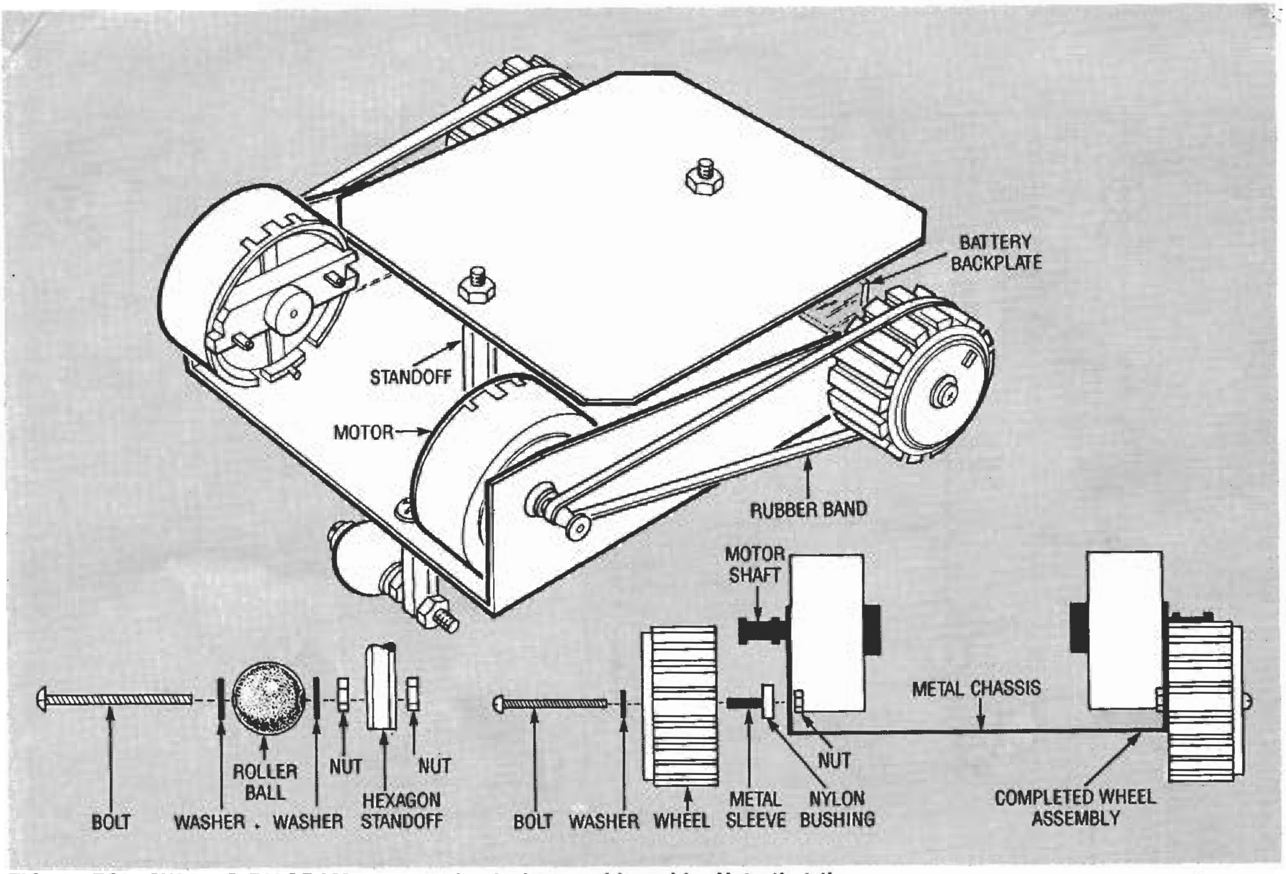



**FIG. 4—FOLLOW THIS DIAGRAM as a mechanical assembly guide. Note that the motors come attached to the metal chassis plate, and can break lose if you flex or bend the chassis.**

makes contact. Pin 3 of IC3 is controlled by the output of the other two one-shots; if either turning one-shot is activated, the backup delay, which takes precedence, is also activated.

### Mechanical assembly

The robot is assembled in three steps. The first step is to assemble the mechanical parts, the second is to assemble the circuit board, and the third is to join the two sections together. The robot kit available from the source mentioned in the Parts List includes all of the mechanical parts. If you wish to build the robot without buying the kit, we've provided a list describing all of the mechanical parts. If you can't find the exact parts we've specified, it's very easy to improvise using similar parts. All the robot really needs is two independent drive wheels and one trailing wheel, mounted on a chassis with enough room to accommodate the two motors, two battery holders, and the PC board.

Follow Fig. 4 as a mechanical assembly guide. Note that the motors come attached to the metal chassis plate included with the kit. Do not pull on the motors as they can break lose, and do not flex or bend the chassis as it will make the wheel alignment more difficult. Start the mechanical assembly by pressing the metal wheel sleeves into the nylon bushings. Then assemble each front wheel onto the metal chassis as shown, using a screwdriver to tighten the bolt while holding the nut with pliers. You might want to put a small drop of oil on the bushings, but do not get any oil on the outside surface of the wheels where the rubber band attaches.

Turn the chassis over and attach the rear-wheel hexagon standoff as shown, and tighten it securely. Note the position of the hole through the standoff; it should be aligned parallel to the back edge of the chassis. Assemble the roller ball as shown onto the standoff. Again you might want to put a small drop of oil on the inside of the roller ball. After tightening the assembly, make sure the ball can still turn.

The DC motors included in the kit have one terminal marked with a white dot. If you're using motors with no polarity markings, make the electrical connections temporary. Later, when testing, if both wheels do not turn in the forward direction while the robot is free-running, simply reverse the leads to the motor(s) running in the wrong direction. For now, though, we'll assume you're using the motors included in the kit.

Solder a 3-inch red wire to each motor terminal marked with a white dot and solder a 3-inch black wire to the other two motor terminals. Put two "AA" cells in one of the battery holders and put a rubber band over the wheel and motor pulley on each side. Temporarily twist the battery-holder wires to the right motor wires—red to red and black to black—and make sure the wheel turns and the rubber

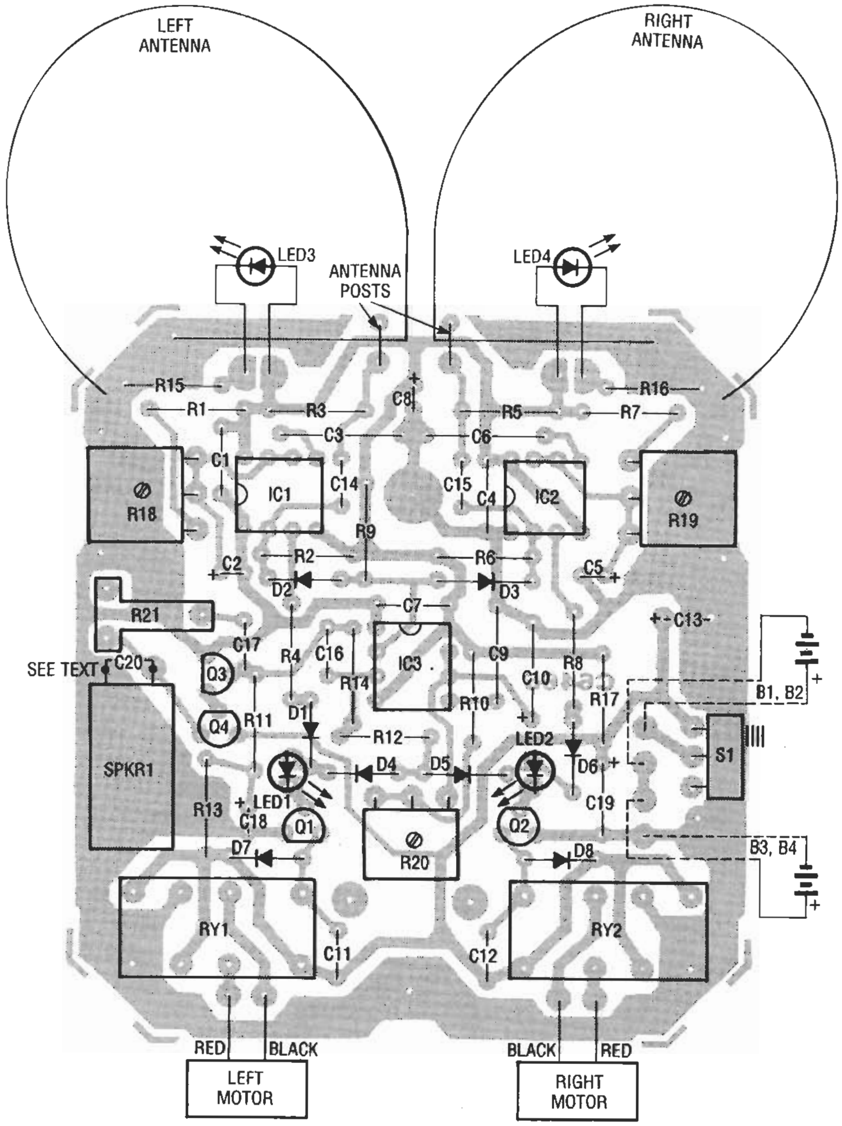



**FIG. 5—PARTS-PLACEMENT DIAGRAM. Install LED3 and LED4 bent forward like headlights.**

## MECHANICAL PARTS LIST

- Metal chassis plate, approx. 3⅛ inches wide (after the sides are bent up at 90° angles) × 3½ inches long, drilled to accommodate all other hardware
- Two DC motors with shaft pulleys
- Two front wheels (the kit uses two plastic knobs, 1¼-inch outside diameter, with ¼-inch shaft hole)
- Two nylon or metal wheel sleeves, ¼-inch outside diameter, ⅛-inch inside diameter, ¹¹⁄₁₆-inch long
- Two nylon bushings, ½-inch outside diameter, ¼-inch inside diameter, ⅛-inch thick
- Two 1-inch wheel screws with a nut and washer for each
- One ⅝-inch diameter roller ball with hole drilled through the diameter
- One roller-ball axle screw with two nuts and two washers
- One ¹¹⁄₁₆-inch threaded hex standoff for the roller-ball assembly, cross-drilled on the bottom end
- One mounting screw for roller-ball standoff
- Two spring-wire antennas/feelers
- Two antenna posts
- Two ¹³⁄₁₆-inch threaded hex standoffs and mounting screws for the PC board
- Rubber pads and adhesive-backed felt for the two battery holders
- Two rubber bands

**Note: The following items are available from The Electronic Goldmine, PO Box 5408, Scottsdale, AZ 85261 (602) 451-9495: (Add $3.50 shipping/handling)**

- **Complete robot kit (C6466, batteries not included)—$39.95**
- **PC board only—$10.00**

band stays in place.

If the rubber band comes off you must align the wheel by bending the chassis slightly. Run the motor again to see if the rubber band stays on. If it stays on, reverse the battery leads and check it again—you may have to readjust the wheel. (Never bend the chassis where the motors are attached and do not put any stress on the motors as they may come lose from their mounting.) When you finish aligning the right wheel, repeat the process for the left wheel.

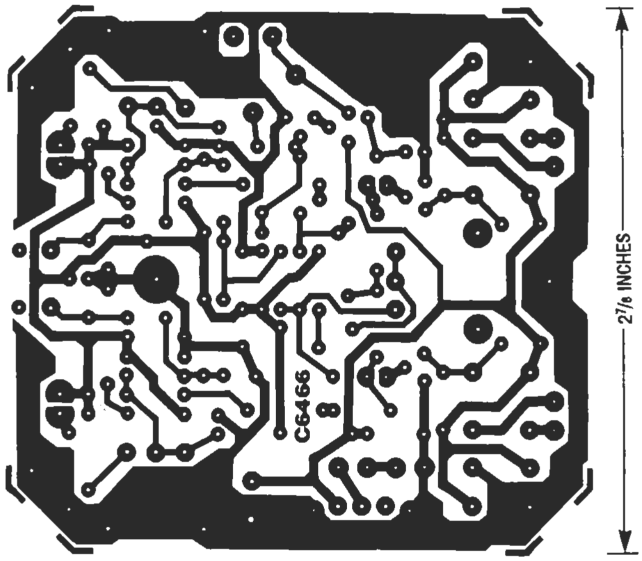
Two metal standoffs are installed on top of the chassis using bolts and washers through the bottom of the chassis. The bolts go up through the chassis, through the standoffs, through the PC board, and the board held down with the nuts as shown. But first we have to build the PC board.

### Electronic assembly

Assemble the circuit board as shown in Fig. 5. Watch the polarity of the IC's, electrolytic capacitors, and diodes. Note that the leads of LED3 and LED4 should be bent at 90° angles so that they look like headlights when mounted on the board. It's a good idea to insulate the exposed portions of the headlight LED's. Install SPKR1 as shown. DO NOT attempt to remove the capacitor soldered across the speaker terminals; the leads of the capacitor are used to connect the speaker to the board.

Now install feeler wires as shown in Fig. 6. Each feeler is made from a length of spring wire, bent as shown in Fig. 6. Fit the straight portion of the left feeler wire at the point shown until it is flush with the board. Bend the other end around and insert it into the other hole as shown and solder that end. Repeat those steps for the right feeler wire.

Now make two feeler posts by bending wire as shown in Fig. 6. After bending, solder the posts to the board in place over the feelers. Adjust the straight part of each feeler wire so that it's centered under the post. Mak-




**FOIL PATTERN FOR THE ROBOT** shown actual size.

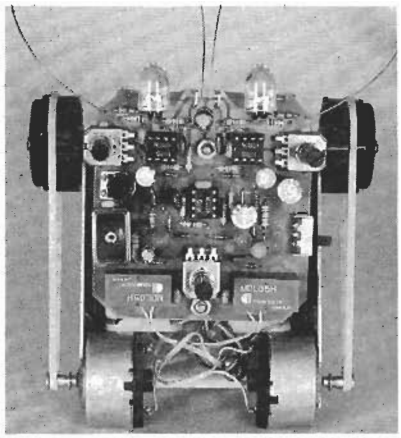


**FIG. 7—HERE'S WHAT THE ROBOT'S board looks like close up. You can also see how the feelers work.**

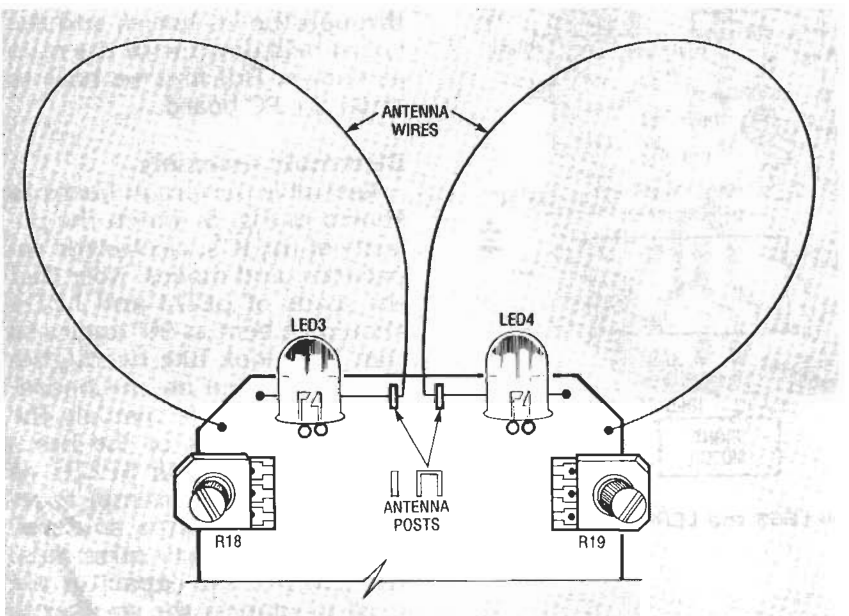



**FIG. 6—THE FEELER WIRES are installed as shown here. The feeler posts are soldered to the board over the feelers. with the straight part of each feeler centered under the post.**

ing sure the feeler is not touching the post, solder the straight end of the feeler to the board. The feelers must not touch any part of the posts after they're soldered in place; reheat the solder if necessary to reposition the feelers. Check the operation of the feeler by pushing on the circular part—the straight part of the feeler should hit the post. Figure 7 shows the finished robot.

Solder the battery-holder wires and the motor wires to the points shown in Fig. 5. Make sure S1 is in the "off" position and put four "AA" batteries in the holders. Hold the robot in your hand so that the wheels can spin freely, and turn on the power. Both wheels should be turning in the forward direction. If either wheel is turning in the wrong direction you'll have to reverse the leads going to that motor.

Set R18 and R19 fully clockwise and set R20 fully counterclockwise. With the motors running, bump the left antenna; LED1 should light and the left wheel should reverse direction for a short period of time (LED2 will also light for just a second). Now bump the right antenna; LED2 should light up and the right wheel should change direction. Bump both antennas; LED1 and LED2 should light up and both wheels should change direction.

## Final assembly

Install felt strips on the solder side of the PC board where the battery packs will come in contact with it. Lay the battery holders (with batteries installed) into chassis with the wires coming out on top near the motors. Set the board onto the standoffs and secure it with one nut on each standoff. Do not overtighten the nuts.

## Operating tips

Find a large area and turn on the robot. The robot works best on a smooth, hard floor. It does not work well on carpeting, cement, dirt, or asphalt. The back up time delay should always be much shorter than either the left or right time delays. If the left or right delay is really long, the robot will make loops and other strange movements. In small spaces all time delays should be kept short and in larger spaces longer time delays work better. Make sure that the obstacles the robot encounters are solid all the way down to the floor. When the rubber bands get dirty from prolonged use, they will begin to slip. Replace them whenever necessary. **R-E**