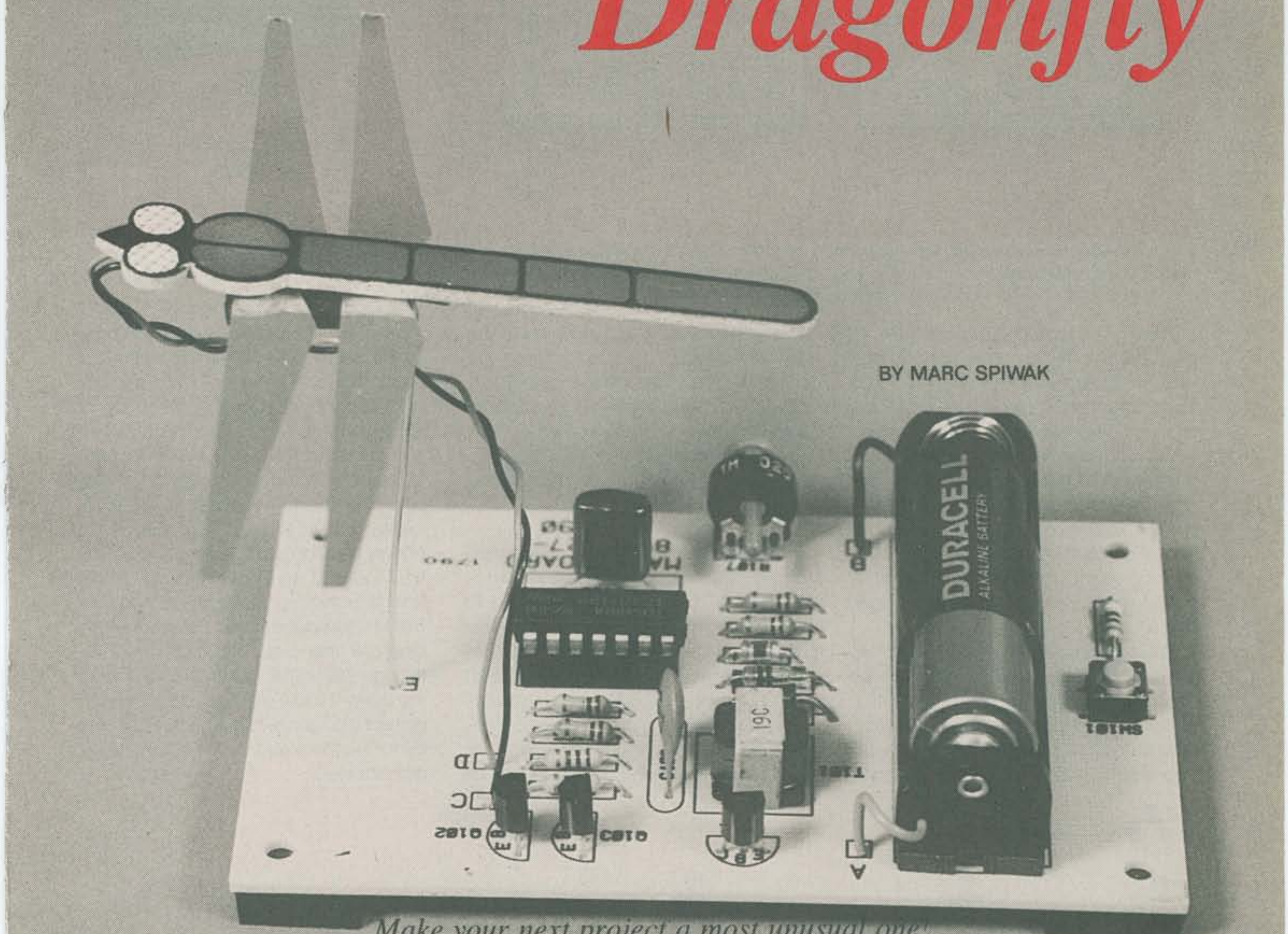
The Electronic Dragonfly



BY MARC SPIWAK

Make your next project a most unusual one!

Here's a riddle for you: What makes an excellent inexpensive gift for any electronics hobbyist, the perfect starter kit for the electronics beginner, a good way for anyone to brush up on their soldering skills, a clever demonstration piece for piezoelectric film, and an unusual conversation piece for the desk of an electronics buff? The answer is the *Electronic Dragonfly*.

The Electronic Dragonfly—designed by Heathkit and sold as kit SK-118 (see the ordering information in the Parts List)—is quite simple. Its body is a cardboard cutout with silver cellophane-like "wings" attached. The wings are made of a material called piezoelectric film—but we'll talk more about the film later. The wings of the Electronic Dragonfly are connected to a printed-circuit board that causes the wings to "flap" up and down when a button is pressed.

The circuit is powered from a single "AA" cell, and has a flap rate that is variable from full up-and-down motion to just a slight vibration. The circuit is certainly a critical component in the system, for without it, the wings would only flap in the breeze. However, this project would be impossible without the use of piezoelectric film. So, before we can begin to discuss how the circuit works, some familiarity with piezoelectric film is in order.

Piezoelectric Film. A piezoelectric material is one that can turn mechanical force into electrical energy and vice-versa—in other words, such materials also produce a mechanical force when subjected to electrical energy. The material can be a rigid ceramic or a flexible plastic, which is the case with our piezoelectric film. Keep in mind that the higher the mechanical force, the higher the generated voltage, and vice-versa.

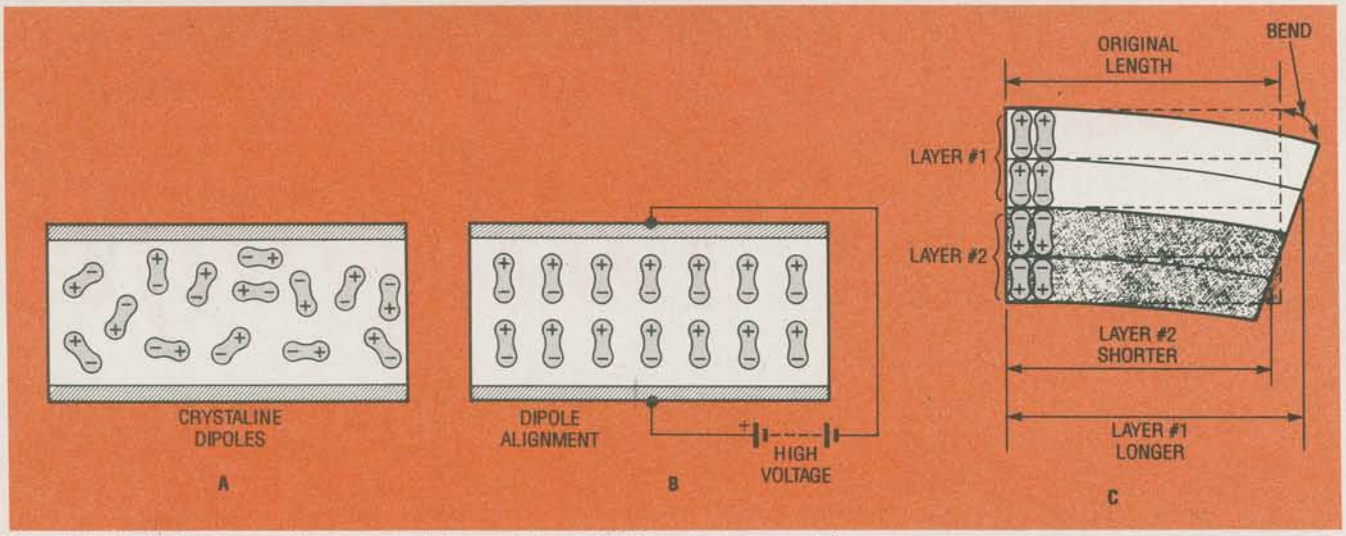


Fig. 1. A dipole has a natural opposite polarity on either end (A). A voltage potential causes the dipoles to align, and the material to change in shape (B). When a potential is placed across two layers of piezoelectric film, the film will bend (C).

The manufacturing procedure of piezoelectric film is such that *dipoles* are produced in the material's crystalline structure. A dipole is a molecule that has a natural opposite polarity on either end (see Fig. 1A). The film is then metallized on either side so that a voltage potential can be placed across the film. As shown in Fig. 1B, the application of a voltage causes the dipoles to align, and the material to change in shape (as it gets thinner, it gets longer and wider).

The dragonfly wings are made of two layers of the piezoelectric film with opposite dipole orientations (see Fig. 1C). Because the poles of the outer metallized surfaces are now the same, a voltage placed across the surfaces causes one layer to expand while the other contracts. That, in turn, causes the film to bend. When the voltage polarity reverses, the film bends in the opposite direction. Now that we know how the wings are made to flap, lets see how the circuit creates an AC signal that causes them to do so.

A Look At The Circuit. The schematic for the Electronic Dragonfly is shown in Fig. 2. An AC signal of approximately 10 kHz is created by battery B1, transistor Q1, transformer T1, resistor R1, and push-button S1 in the following manner. When S1 is pressed, Q1 turns on, drawing current from the primary side of T1. A rising pulse from pin 4 of T1's secondary (which is of higher voltage than that at T1's primary) is applied back to the base of Q1 via R1 and S1, turning it off. That stops the current in both the primary and secondary, allowing the base of Q1 to go low again. As long as S1 remains closed, the cycle will repeat itself.

Diode D2 and capacitor C1 rectify and filter the low-voltage AC from T1's center tap to provide +5 volts DC to power a 4011 quad 2-input NAND gate, U1. Diode D1 and capacitor C2 rectify and filter the high-voltage AC from pin 3 of T1 to produce about 260-volts DC to operate the piezoelectric wings. Although 260 volts is nothing to snicker at, the current is low enough so that there's no real danger; resistors R3 and R4 limit current in the event that T1 accidentally gets shorted.

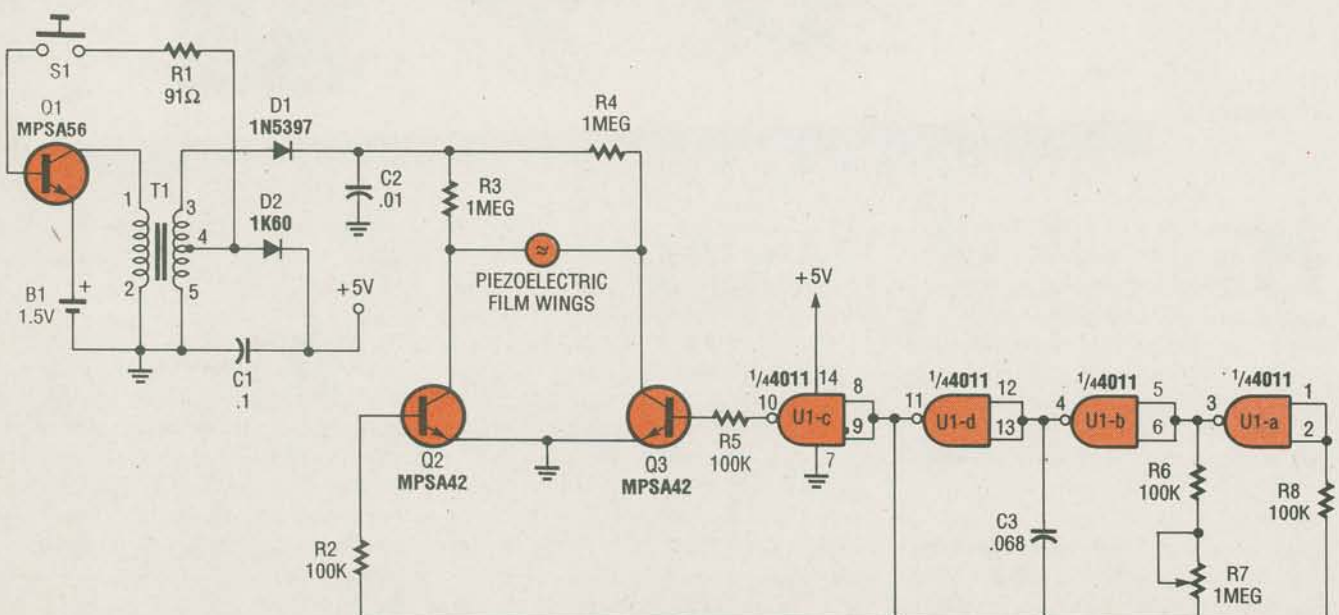


Fig. 2. The schematic for the Electronic Dragonfly. When S1 is pressed, the wings flap up and down.

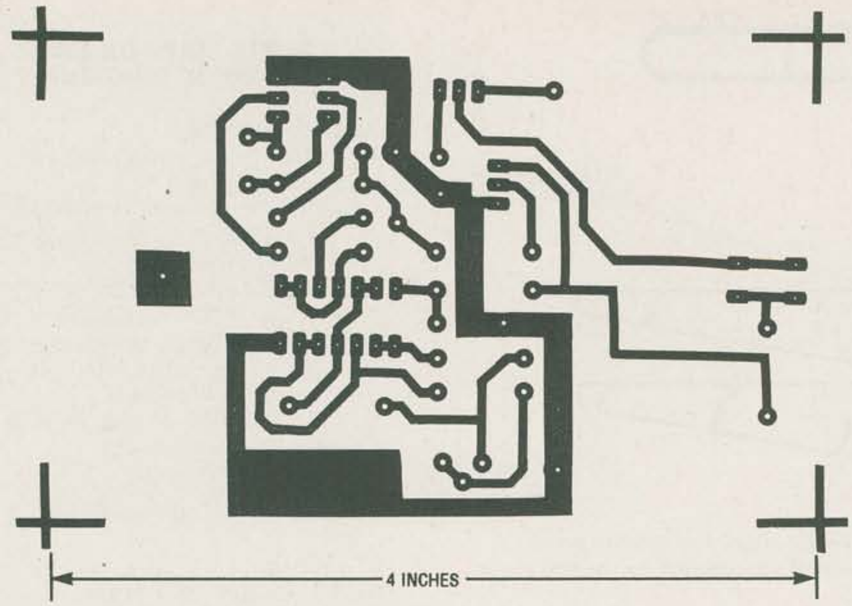


Fig. 3. You can make your own printed-circuit board from this foil pattern.

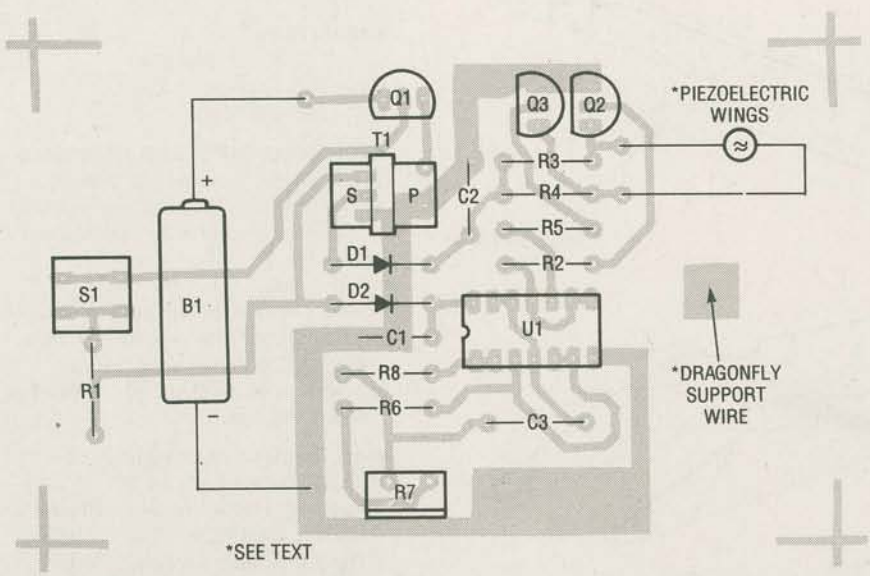


Fig. 4. Solder the parts to the printed-circuit board as shown here. Note where the support wire solders to the board.

A low-frequency oscillator circuit of about 10 Hz is formed from U1-a, U1-b, C3, and R6–R8. The frequency of the oscillator—which is the rate at which the wings will flap—is adjustable via potentiometer R7. The output of the oscillator is fed to the input of U1-d, which is configured as an inverting buffer. The output of U1-d is used to drive both the base of Q2 via R2 and the input to U1-c, which, like U1-d, is set up as an inverting buffer. The inverted output of U1-c is used to drive the base of Q3, causing its drive signal to be 180 degrees out of phase with that applied to Q2. Because the base inputs of transistors Q2 and Q3 are 180 degrees out of phase, they alternately pull opposite sides of the piezoelectric film wings low, which causes the dragonfly wings to flap up and down.

Construction. For mainly two reasons, it's best if you purchase the kit for the dragonfly. For one, the piezoelectric film will be pretty expensive in the quantities that are available. And two, the transformer used in the circuit is a very specific part. It must take the 1.5-volt input applied to its primary (at pins 1 and 2) and generate about 5 volts at pin 4, and about 260 volts at pin 3 (after being filtered and rectified, of course). Also, pin 4 supplies the feedback pulse that shuts off the transformer, thus causing the oscillation. Because of those requirements, the only alternative to using the transformer that comes with the kit (unless you can find one that provides the same outputs), is to wind one yourself, and that's going to be very difficult; plus, the wire will be expensive and hard to find. Two other advantages to purchasing the kit are that you'll get a pre-etched and drilled printed-circuit board and a colorfully laminated dragonfly body, as well as the piezoelectric-film wings.

For you die-hard do-it-yourselfers (who simply must "roll their own"), the transformer must be wound on a silicon-steel core; the windings are as follows:

- From pin 1 to pin 2, wind 6 turns of 24-gauge enameled wire.
- From pin 3 to pin 5, wind 12 turns of 33-gauge enameled wire.
- From pin 3 to pin 4, wind 1300 turns of 44-gauge enameled wire.

No, 1300 turns is not a misprint, and for those of you brave enough to take on the task of winding the transformer, good luck!

Whichever way you decide to go, it is recommended that the circuit be assembled on a printed-circuit board; printed-circuit construction makes assembling the project a lot easier and makes for a much neater finished appearance. For those of you who want to do everything from scratch, a full-size template for the printed-circuit pattern is shown in Fig. 3. Solder the parts to the printed-circuit board as shown in the parts-placement diagram in Fig. 4. Install them in the order that they're shown in the Parts List so that you can check off each part as it's installed.

Be sure to observe the proper polarity of all the transistors and U1. Because U1 is a CMOS device, we recommend that a socket (which is included in the kit) be provided for that component. If you are not assembling the project from a kit and can't locate the transistors and diodes shown in the schematic diagram, alternative units are listed in the Parts List. Proper soldering, as always, is a must. After the board is finished, carefully inspect it for any solder shorts, opens, cold-soldered leads, and heavy-flux buildups.

The battery holder is mounted to the board using some double-sided tape. Observing the proper polarity, the leads from the battery holder are soldered to the plus and minus pads (points A and B in the kit) on the printed-circuit board. The dragonfly body that comes with the kit is a colorfully lami-

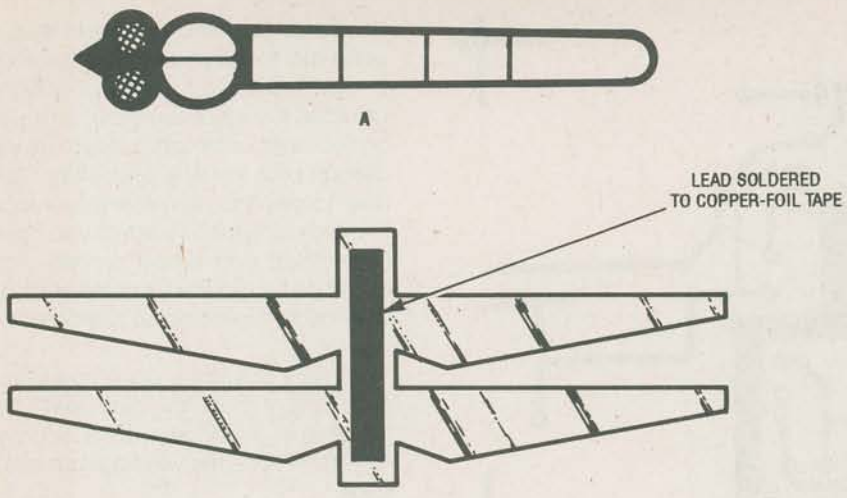


Fig. 5. If you're not building the project from a kit, an actual-size template for the dragonfly body is shown in A. Shown in B is an actual-size template for the wings. Remember to use double-layer piezoelectric film.

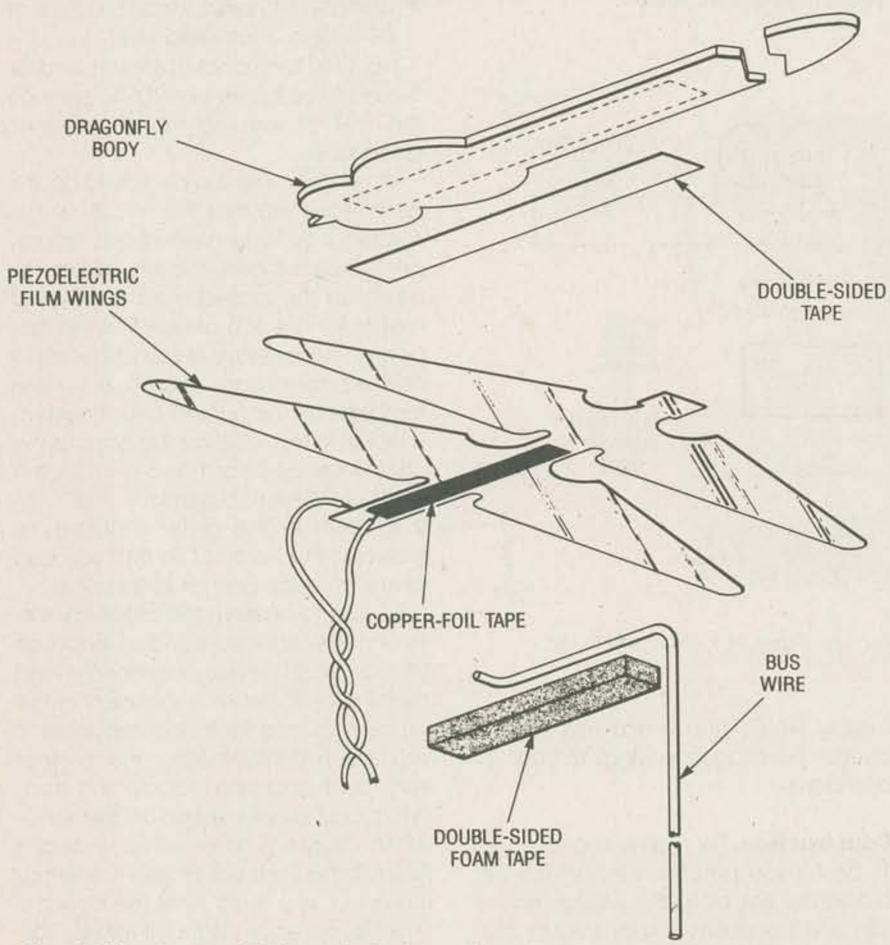


Fig. 6. The wings are held onto the body (as shown here) with double-sided tape, and the dragonfly is held onto the support wire with a piece of double-sided adhesive-backed foam rubber.

PARTS LIST FOR THE ELECTRONIC DRAGONFLY

SEMICONDUCTORS

U1—CD4011 quad 2-input NAND gate, integrated circuit
Q1—MPSA56, 2N5401, SK3466/159, TCG/NTE159, ECG159, or equivalent PNP silicon transistor
Q2, Q3—MPSA42, ECG287, SK3433/287, TCG/NTE287, or equivalent NPN silicon transistor
D1—1N5397 (or similar) 3-amp, 600-PIV silicon rectifier diode
D2—1K60, SK3090, 1N34A, 1N60, or similar germanium diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—91-ohm
R2, R5, R6, R8—100,000-ohm
R3, R4—1-megohm
R7—1-megohm, PC-mounted miniature potentiometer

CAPACITORS

C1—0.1-µF, ceramic-disc
C2—.01-µF, ceramic-disc
C3—.068-µF, Mylar

ADDITIONAL PARTS AND MATERIALS

T1—printed-circuit-mount step-up transformer with center tap (see text)
S1—printed-circuit-mount pushbutton switch
B1—1.5-volt AA battery
Printed-circuit materials, double-sided piezoelectric film, 14-pin IC socket, bus wire, hook-up wire, battery holder, double-sided tape, rubber feet, solder, hardware, etc.

Note: The Heathkit Dragonfly (kit SK-118) is available for $21.95 from Heathkit, Heath Company, Benton Harbor, MI 49022 (800) 253-0570. The kit includes everything in the Parts List except the AA battery.
Piezoelectric film is available from Atochem North America, 3 Parkway, Philadelphia, PA 19102. Contact them directly for pricing and other information.

nated piece of cardboard. It really spruces up the appearance of the finished project. If you're not building the project from a kit, you're going to have to improvise where the body is concerned—an actual-size template for the body is shown in Fig. 5A.

Also if you're not building the project from a kit, you're going to have to fashion the wings yourself. You'll need some double-layer piezoelectric film cut into the shape of dragonfly wings. We've provided a source for the film in the Parts List, and an actual-size template for the wings is shown in Fig. 5B. If you can't find double-layer film, try folding over a single-layer piece holding the two sides together with some adhesive. Then cut out the wings from that.

Making electrical contact to the film is a bit tricky. If you are making the wings yourself, you obviously can't solder a lead to the film—the solder will melt right through the film. To make electrical contact, you'll have to use some copper-foil tape. The tape, which is used to repair PC-board traces, has a

(Continued on page 93)

ELECTRONIC DRAGONFLY

(Continued from page 58)

conductive adhesive backing. First solder a thin-gauge lead to a piece of copper-foil tape, let it cool, and then stick it to the piezoelectric-film wings. Do the same on the opposite side of the wings in the same position.

As shown in Fig. 6, the wings are held to the body of the dragonfly with double-sided (cellophane) tape, and the leads to the wings are soldered to the appropriate pads (points C and D in the kit) on the printed-circuit board (in the kit, the red wing-lead goes to point D—for you do-it-yourselfers, that's the lower pad). The dragonfly is supported over the board by a stiff piece of bus wire, which is soldered to the pad that's indicated in Fig. 4. Be sure to bend about ¼ inch of the lower end of the wire at a 90-degree angle before soldering in place to increase the strength of the joint. About ¾ inch of the upper end of the wire is also bent at a 90-degree angle, as is about ⅛ inch of the very tip of the wire, to provide a resting place for the dragonfly, which is held on with double-sided adhesive-backed foam rubber (see Fig. 6). Four rubber, adhesive-backed feet are then placed in the corners on the foil side of the board, and some protective insulation is placed over the high-voltage traces to complete the project.

Now simply pop a battery into the holder, press S1, and watch the wings flap. You can adjust the rate at which the wings flap by varying R7. The dragonfly should come to life right away. If you have any problems, go back and check your work for proper parts placement, poor solder joints, etc.

Once you have the project working, the Electronic Dragonfly is ready to hover over your desk or mantle and entertain your friends. Perhaps the best thing to do is help a young hobbyist build the project, or build it yourself and give it to a youngster. ■