From: Circuit Bending, Reed Ghazala

Solder, when heated and in liquid form, has properties you've seen often in water and other fluids. For example, just as water flows and is absorbed into crevices, so is liquid solder. The trick with solder is that the surfaces involved must be metal, must be clean, and must be *hot*. At least hot enough to melt the solder.

Speaking of hot, now's the moment to reinforce the fact that soldering involves temperatures at the tip of the iron hot enough to give you a nasty burn (500 to 800 degrees, typically). If you handle the soldering pencil carelessly, as in you leave it up against your gunpowder collection or on your original parchment document proving that the Chinese discovered America before the Europeans did, you'll be very, very sorry.

Always return the hot iron to its rest, and be sure that it's fully inserted, or the tip can heat the rest, which in turn can melt the handle of the iron. And *never* touch the hot tip of the iron, even just to see whether I'm kidding.

Practice Makes Perfect

Never is the statement "Practice makes perfect" more true than with soldering. With a little practice, you'll come to know the steamy personality of solder and soon find yourself using its subtleties to your advantage. I cover some unusual uses in a moment, but here are the basics.

- Use a 25–40 watt soldering pencil, as described in the tools section.
- Keep the tip wiped clean with a wet sponge or cloth.
- Keep the cleaned tip coated (tinned) with a little melted solder.
- Be sure that metals to be joined are bare and clean.
- Sand the traces on circuit boards to bare metal before soldering (see "Soldering to the Circuit Board," later in this chapter).
- Make sure that both metals to be joined are hot before the solder is fed into the junction. Be sure to heat the junction hot enough to easily melt the solder—a good joint looks almost chrome-like and very smooth; a bad or "cold" joint looks dull, is often "balled up," and can even be fragile.
- Be sure to keep wires *absolutely still* for a few seconds as the joint cools. Another sure-fire way to end up with a cold joint is to move the metals being connected before the solder hardens.
- Always place the flat side of the "screwdriver" or "chisel" tip against the metal you're heating, because doing so gives greater surface area contact.
- Use only enough solder to smoothly coat the junction and flow fully into the connection. Avoid using too much solder—big solder blobs are to be avoided.

How To Solder

A Beginning: Splicing Wires

If you're already solder savvy, great! Feel free to skip on ahead. If not, here are a couple of exercises to get you started.

1. Using your wire stripper, strip about ¼" of the insulation off the ends of a couple of short lengths of wire-wrap wire (see Figure 8-1).

FIGURE 8-1: Stripped 25-30 gauge wire-wrap wires

2. Twist the bare ends together, as illustrated in Figure 8-2.

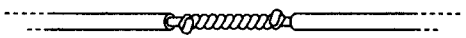

FIGURE 8-2: Twisted wire-wrap wires

3. Place the tip of your hot soldering pencil against the bare wire junction, about in the middle (see Figure 8-3).

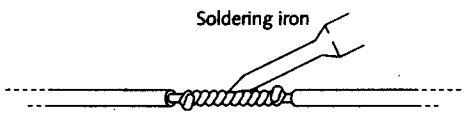

FIGURE 8-3: Heating the wires

4. After two to three seconds, touch the end of the solder strand to the hot junction (see Figure 8-4).

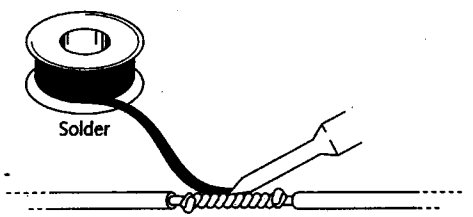

FIGURE 8-4: Applying solder

5. Keeping the soldering tip in place, feed the solder into the junction as it melts until the twisted wires are coated with solder (see Figure 8-5).

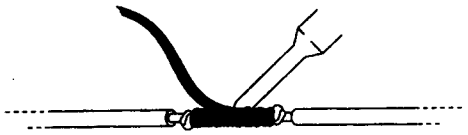

FIGURE 8-5: Solder melting into hot wires

6. Remove the solder and then the pencil tip; allow the junction to cool for a few seconds before moving.

   Remember, good connections use solder modestly, not excessively (see Figure 8-6).

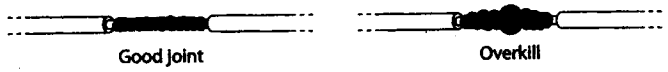

FIGURE 8-6: Solder should coat junction without much excess.

Keep practicing this connection with new sections of wire until you feel confident. When you have this down, you're over the hump.

In this example, the soldering time is quick because there's not very much metal to bring up to temperature. Be aware though that in many soldering applications, you'll have to warm much more metal than the thin wire-wrap wire you're practicing on in the preceding example. Still, the technique is the same.

Everyday Bent Soldering Needs

As you build the projects in this book and continue on your own, you'll employ all the common soldering techniques. Here are the most important ones to know.

What's "Tinning"?

A term you'll see often in electronics, tinning simply means to thinly coat with solder. Melting a little solder onto the tip of your soldering pencil after cleaning it is tinning it, a process that helps keep the tip in good condition and solder-ready.

More often, tinning is done to metals to be joined prior to actual soldering. This tinning makes the connection quicker, easier, and more electronically secure. Try the following if you're not already familiar with tinning.

1. Strip about ¼" of the insulation off the end of a multistrand wire (see Figure 8-7).

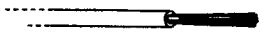

FIGURE 8-7: Stripped multistrand wire

2. Twist the bare wire strands tightly together by holding them still between thumb and forefinger and spinning the wire where the cut insulation begins with your other hand (see Figure 8-8).

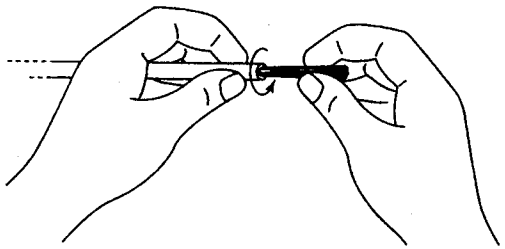

FIGURE 8-8: Twist insulation while holding stripped wires.

3. Hold the hot soldering tip against the bare twisted wire (see Figure 8-9).

FIGURE 8-9: Heating the twisted wires

4. After a few seconds, feed solder into the tip/wire junction until melted solder flows into the twisted bare wires (see Figure 8-10).

FIGURE 8-10: Solder flowing into twisted wires

5. Remove solder and then tip; allow tinned wire to cool (see Figure 8-11).

FIGURE 8-11: Tinned, stranded wire should be firm with even solder coating and penetration

6. Inspect tinned wire to confirm that solder has flowed evenly into the wire, providing a uniform coating.

The loose wires have now been joined together to prevent fraying and straying against other parts of the circuit next to where the wire is meant to be soldered. Important: *Always* tin *stranded* wire before soldering it to whatever.

Soldering to Switches and Pots

I already covered the wiring of switches and pots back in Chapter 6. The actual soldering is simple.

Both these components have soldering lugs ready for soldering to; some are even pre-tinned. Just run your stripped (and pre-tinned, in the case of stranded) wire through the hole in the lug and crimp it to hold it firmly in place (see Figure 8-12).

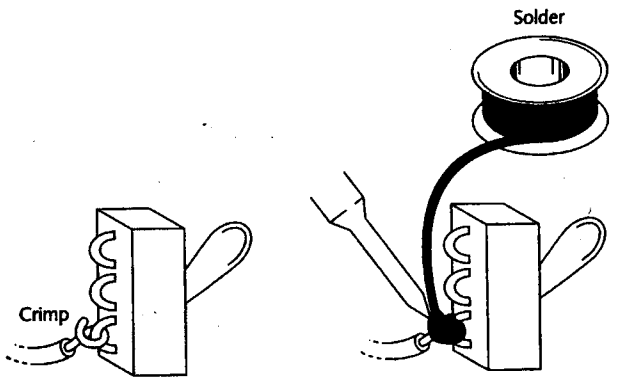

FIGURE 8-12: First crimp wire, then solder. Clip away any excess wire.

Solder this junction just as you did the wire connection in the first exercise.

Soldering to LEDs

Soldering wires to LEDs is just about the same as soldering wires to wires. The two leads of an LED are usually pre-tinned. Just wrap the stripped wire around the LED lead a few times and solder as usual. Here, though, be sure to solder as quickly as possible, because an LED is a heat-sensitive component and will fry if it gets too hot. In fact, the actual lead construction of LEDs is metal heavy in an attempt to absorb heat away from the actual light-emitting element.

Because we'll always be using thin wire to solder to LEDs, wire that heats quickly, heat build-up shouldn't be a problem. Soldering to the far ends of the LED's leads, away from the LED housing itself, will keep heat down. If you still want a little added protection, there's always the heat sink.

Heat Sinks

LEDs are not the only heat-sensitive components you'll be dealing with. Transistors, present in many circuits you'll be bending, are ready to fry as well. That's what clamp-style heat sinks are for.

It's not a bad idea to use a heat sink on transistor leads if you find a need to solder to one. If so, just clamp the heat sink to the lead between the body of the transistor and the soldering point and solder as quickly as possible, the same as if you were soldering to an LED (see Figure 8-13).

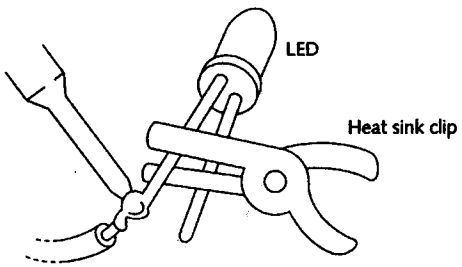

FIGURE 8-13: Heat sink goes between soldering iron tip and component.

The same position would go for regular diodes, which are also heat sensitive. Heat sink clamps always go between component body and the part of the lead you're soldering.

Soldering to Speakers

Often, you'll be deriving line outputs from speakers already built into the devices you're bending. This is accomplished by soldering wires to the speaker's two terminals (soldering lugs, again). The only new thing here is that the terminals will already have wires soldered to them. You simply need to take care that in soldering you don't de-solder any wires already there.

Soldering to the Circuit Board

At times you will need to solder wires directly to the thin metal traces on a printed circuit board. These intricate metal traces that connect components on the board are *delicate*. They're probably also coated with a transparent coating of some kind that must be removed before soldering to the trace is even possible. A careful approach is needed.

If you're good with your Dremel drill, you can remove the clear (sometimes colored) overcoating from the trace with a small burr bit running at medium speed. Too much pressure will cut through the trace! Be extremely cautious here. The burr bit may want to run across the board if not controlled well. Carefully and *lightly*, stroke the trace with the spinning burr just until bright metal is seen. Expose about ¼" of the trace in this way (see Figure 8-14).

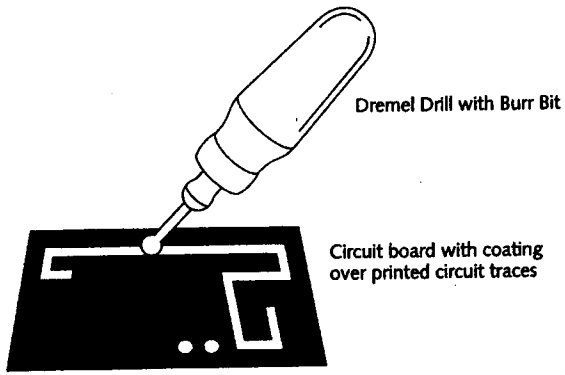

FIGURE 8-14: Use only the lightest pressure to remove a printed circuit's top coating.

The coating can also be removed by carefully scraping with a small blade, such as that of the chisel-tipped X-ACTO. Even if the trace doesn't seem to be coated, use fine sandpaper or steel wool to remove any top surface, including tarnish, before you attempt to solder.

After the trace is cleaned to shiny bright metal, hold the tip of your soldering pencil against it. Be sure to clean the tip first (very important—the more delicate the work, the more critical the need for a super-clean tip).

Apply a tiny bit of solder to the tip/trace junction, just enough to leave a small bulge of solder on the trace when you remove the soldering pencil tip (see Figure 8-15).

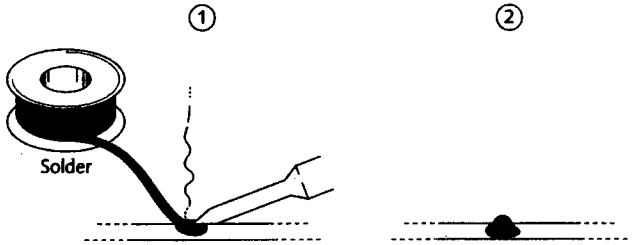

FIGURE 8-15: Leave a little bump of solder behind on the cleaned trace.

That's it! The little blob of solder will now serve as your soldering point. You'll need to heat it only a moment to be able to solder your 25–30 gauge wire-wrap wire to it (see Figure 8-16).

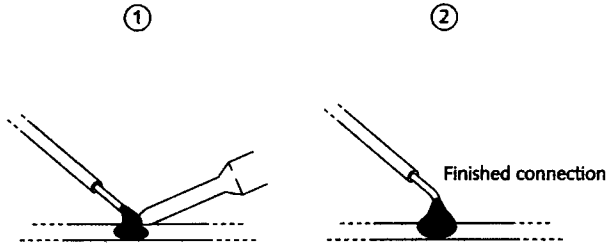

FIGURE 8-16: Solder your wire to solder bump on printed circuit trace.

Do remember that the actual metal of the printed circuit trace is fragile. If you leave too large a blob of solder on it and strike the solder accidentally, you can break the trace right off the board. Likewise, even with a small amount of solder on the trace, an accidental tug on the wire you soldered to it can tear the trace right from the board. Always treat these connections with care.

Soldering to Component Leads

As discussed in the preceding LED section, component leads are easy to solder to. Simply wrap your wire around the component's lead and solder as quickly as possible. A medium-sized jeweler's screwdriver will help you manipulate wires in tight places (such as on the short leads of an electrolytic capacitor already soldered to the circuit board) in case you have trouble wrapping the couple of needed turns by fingertips alone.

In the instance of heat-sensitive components, do use a small heat-sink clip, as described previously.

Follow That Trace!

This is cool. Say that you need to solder a wire to the lead of a component mounted so closely to the board that you can't get to the actual lead—not enough room for the soldering tip to get in. All you need to do is to visually follow the printed circuit trace and solder to the trace where it becomes better available elsewhere on the board. Even if you have to follow the trace to the far side of the board, soldering to the trace will be the same electronically as soldering to the hard-to-get component lead.

Let's make it easier. Say that as you follow the trace you see that it's connected to other component leads here and there. Yes, as you just guessed, soldering to any of these leads is the same as soldering to the hard-to-get lead. Now you don't have to scrape a circuit trace at all (see Figure 8-17).

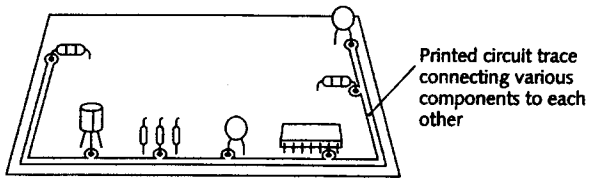

FIGURE 8-17: No matter where or to what component lead along a single printed circuit trace you solder a wire, you get the same electrical connection.

Soldering to IC Pins

Often you'll find great responses when IC pins are brought into the new wiring scheme. But soldering to IC pins is tricky at first. Don't worry—it will become routine.

First, follow the printed circuit trace that the IC pin runs into and see whether there's an easier place to solder to. As detailed previously, soldering to the actual trace to which the pin goes is the same as soldering to the IC pin itself. If you can't find a better place along the trace to solder to, then the pin it will be!

The trick here is not only to pre-tin the IC pin but also to leave a tiny blob of solder behind, just as I explained for soldering to the printed circuit trace. The operation is very fast because an IC pin is small and thin, contains very little metal, and therefore heats quickly. A quick connection is needed when soldering to ICs to help minimize overheating the IC's internal circuitry.

1. Tin your tip with a little solder.
2. Place the chisel side of the tip of the soldering pencil against the leg of the pin and almost immediately apply the solder to the pin exactly where the soldering tip meets the pin (see Figure 8-18).

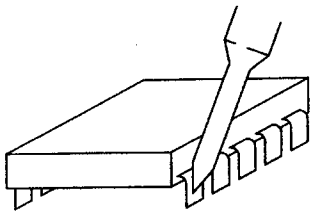

FIGURE 8-18: Heat the IC pin for just a moment before feeding solder to the tip/pin junction.

3. Remove the solder and tip just a moment after the solder begins to melt onto the IC pin, leaving a tiny bulge of solder behind (see Figure 8-19).

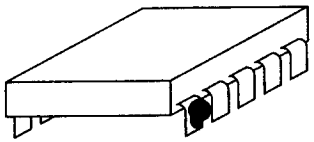

FIGURE 8-19: A small solder bump left behind on the IC pin

With a sufficiently heated tip, this entire procedure should take no more than a second.

4. Just as in the example of soldering to the cleaned printed circuit trace, the solder blob is heated and the stripped end of your wire-wrap wire is fed into the hot mass (see Figure 8-20).

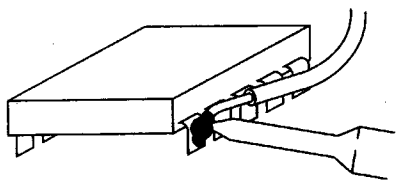

FIGURE 8-20: Feeding stripped wire wrap wire into reheated solder bump

5. Remove the tip and hold the wire absolutely still, as in all soldering, until the solder hardens (a second or two).

Another approach to IC pin soldering involves molten solder transport, discussed in a moment (see Figure 8-25)

It's also sometimes possible to solder to the IC pins emerging on the bottom of the board (see "Playing Hooky," which follows).

Special Soldering Tricks

Everyone develops his or her own techniques in tool using. Some of these techniques break cardinal rules, including one I'm about to teach you. Still, these little tricks can take you a long way.

The Stationary Iron

Rather than bring the soldering tip to your work, you might sometimes want to bring the work to the tip. This makes jobs such as tinning a bunch of wires a breeze.

Simply lay the hot iron on your workbench, tip pointing right at you. Now bring the solder and wires to be tinned to the hot tip. Touch the solder to the tip and feed the wire into the solder as it melts, right in the solder drop that forms under the tip (see Figure 8-21).

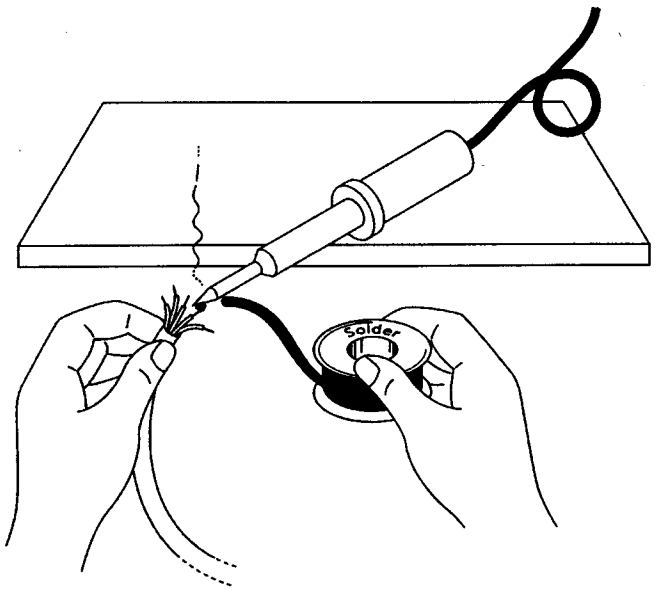

FIGURE 8-21: Using the stationary iron for tinning a series of wire ends

This will also streamline joining wires to each other, soldering wires to hard-to-position parts, and many other applications. After all, the soldering pencil is often the heavier and harder item to position within the soldering triad (iron, solder, and component). A corded tool only adds to the potential trouble. Keep this in mind—opportunities will arise.

Playing Hooky

Keeping wires where you want them while soldering can be a problem. Sometimes there's little room to wrap a wire around a soldering point (as in a mini resistor mounted flush with the board), or the point itself is just too small (such as an IC pin emerging from the back of a printed circuit board). Preshaping the end of the wire may be the solution.

Form the end of the stripped wire into a tiny hook that can be slipped over the target IC pin or component lead (see Figure 8-22).

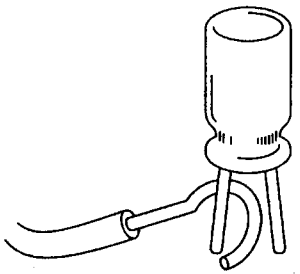

FIGURE 8-22: Make a hook on the end of the wire for locating it on difficult areas.

Slip it over, solder, and finally clip away any extra wire remaining.

Wrap That Wire!

Even with all the aforementioned techniques, sometimes the wire you're trying to solder just won't stay in place. If the wire is long enough, after hooking the stripped end over the target connection point you can wrap the wire's other end around a nearby component on the board. This will hold the wire in place for soldering (see Figure 8-23).

If you have no handy component for wrapping, you can always use a piece of masking tape to hold the wire still.

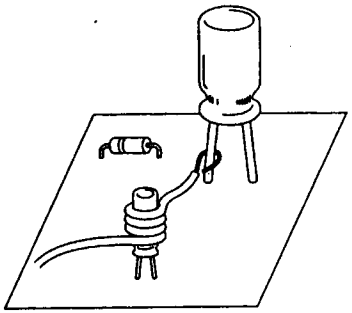

FIGURE 8-23: Use a nearby component to keep the hooked wire in place.

Molten Solder Transport (Don't Tell)

In traditional soldering, the idea of transporting melted solder around on the tip of a hot iron is unthinkable. The fear is that the solder will drop off the iron, falling onto the circuit and sending you directly to the repairs section that follows. It's a real concern, too. However, if used with care, molten solder transport is just fine.

Let's say that you're soldering a wire to an IC pin, just as described previously. But you fear that the solder you left on the pin in the tinning process wasn't built up enough to solder the wire when melted. You need a little more solder. Using the heat of the tip, you can "cut" a small section of solder, about 1/16" long, off the roll. This 1/16" section of solder will immediately draw itself onto the hot tip and remain there (see Figure 8-24).

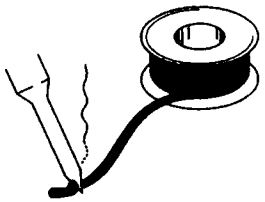

FIGURE 8-24: Cutting solder off the roll with your soldering tip

If you hold the wire against the IC pin and then bring the molten bit of solder to the wire/pin junction, the solder on the tip should flow onto the IC pin, soldering the wire nicely in place (see Figure 8-25).

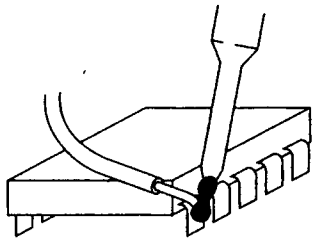

FIGURE 8-25: The small bit of transported solder will flow onto the IC pin.

I do this all the time. Even all by itself (without your pre-tinning the IC pin first), this molten solder transport works well for this type of small-area connection.

Keep in mind that the rosin in the core of the solder boils away as the solder is heated; you can see this smoky event if you watch. Because the rosin serves to help hot solder adhere to the metals being soldered together, the best connections are made while the rosin is still boiling. In molten solder transport, the rosin might boil away before the solder makes it to the connection.

The only answer here is to be quick in getting the freshly cut hot solder to the connection. Yes, this increases the chance of dropping hot solder on the board. Still, with practice, traveling molten solder is a legitimate soldering technique.

The key caution here is to never carry more solder on the tip than is needed for a connection. In *any* solder connection, think small over large: Use as little solder as needed to smoothly coat the joint, and no more.

Fixing the Inevitable Soldering Mistakes

So, you trusted my advice, tried the molten solder transport trick, and now have a glob of dropped solder on the circuit board. All is not lost.

Usually in the case of dropped molten solder, repairs are not too difficult, because the solder has fallen on cold surfaces upon which it will not fully adhere. Careful scraping and prying with an X-ACTO blade will usually remove these thin splobs (a splob is a splattered blob).

Two seat-of-the-pants methods exist for solder removal in the instance of too much solder having been applied to a single connection, or solder straying into easy-access areas where it doesn't belong. The first method is to see whether it will adhere to the cleaned tip of your hot soldering pencil. If so, remove the solder by drawing it up on the hot tip, cleaning the tip, and repeating until the solder is removed (or until the residual solder can be scraped away).

The second technique can be touchy to disastrous, depending on your standing with the gods of fortunate soldering. Heat the solder to liquid state and quickly, while the solder is still hot, sharply tap the board against the workbench in such a direction as to fling the solder off and

away from any other components on the board. Don't try this with circuits where the molten solder might run under ICs, into IC pins, or any other place that might complicate rather than solve the problem. Reserve it for simple circuits. Pretty radical solution, but it has worked for me many, many times.

For solder mistakes involving more difficult situations, such as solder accidentally flowing between two adjacent pins on an IC, specialized tools are made for this kind of touchy solder removal. The best of these is a simple "solder wick."

Made of braided wire, the wick will absorb molten solder the way a sponge absorbs water. In use, the wick is placed against the unwanted solder and then heated with the soldering iron tip (see Figure 8-26).

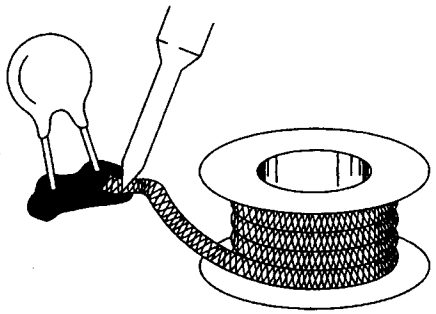

FIGURE 8-26: Heat the de-soldering braid against the solder overflow.

You'll see the solder melt into the braid, with any luck leaving only a small bit behind, easily scraped away. These braids can be trimmed to shape to fit in tight spaces, and after use you simply clip the solder-filled section away.

There are also small solder vacuum pumps that draw melted solder up and into their reservoir. I prefer the braid, but you might try both and see which system you feel best with.

Before you begin to work on the project section of this book, it would be a good idea for you to practice all the soldering techniques I've discussed. Splice wires, tin multistrand wire, solder to switches and pots, LEDs, speakers, circuit board (component leads such as resistors and capacitors as well as to printed circuit traces), and IC pins. Try the stationary iron, molten solder transport, and the solder removal techniques as well.

For this practice session, you'll need to use some of the components you've collected (pots, LEDs, and switches) as well as have a circuit to work on. Any sound toy with the batteries removed will probably do, as long as it has a circuit board and speaker. At secondhand shops,

such a toy will cost only a couple dollars. Try soldering wires to the circuit board in as many ways as possible and until you're comfortable with the procedures. Better yet, if you have a dead circuit of any type lying around, try soldering different kinds of wire to it, anywhere you can (see Figure 8-27).

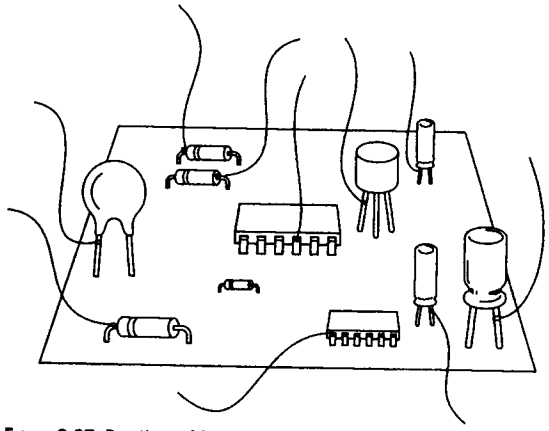

FIGURE 8-27: Practice soldering to everything on a dead circuit.