CHAPTER 13

Hack the Clock: Changing the Clock Speed for Cool New Noises

You will need:

- The electronic toy from the previous experiment.
- Some hookup wire, stranded and solid, 22–24 gauge.
- Test leads with alligator clips.
- A few resistors of different values.
- A potentiometer, 1 megOhm or greater in value.
- Soldering iron, solder, and hand tools.

Wet fingers are fine for making the clock go faster. But we all know that the Third Law of the Avant-Garde states:

Slow it down, a lot.

Lower and slower always sounds cooler. To slow it down we need to make the resistance *larger* instead of smaller. Which means removing the clock resistor from the circuit board (once you are sure which one it is) and replacing it with a larger one, instead of bridging it with your finger as we did in the last chapter, which, by lowering the resistance, can only make the pitch go up.

1. Locate the clock resistor you identified in the previous experiment. Wedge a small flat-bladed screwdriver under it. Melt the solder on the underside of the circuit board at one end of the resistor, and lever the screwdriver to lift that end free from the solder connection (see Figure 13.1). Do this quickly but gently, so as not to damage the circuit board or components. Now grip the resistor with a pair of pliers and pull it free of the board as you melt the other solder joint. Put it somewhere safe and don't lose it! If the circuit already has some kind of pitch-control potentiometer ("pot"), de-solder and remove it entirely.
2. Strip and tin the ends of two pieces of hookup wire (approximately 3–6 inches long). Press the end of one into one of the holes left after removing the resistor from the component side of the circuit board. It's easier to do this with *solid* hookup wire, but in the long term it's better if you use thin stranded wire for this, so you

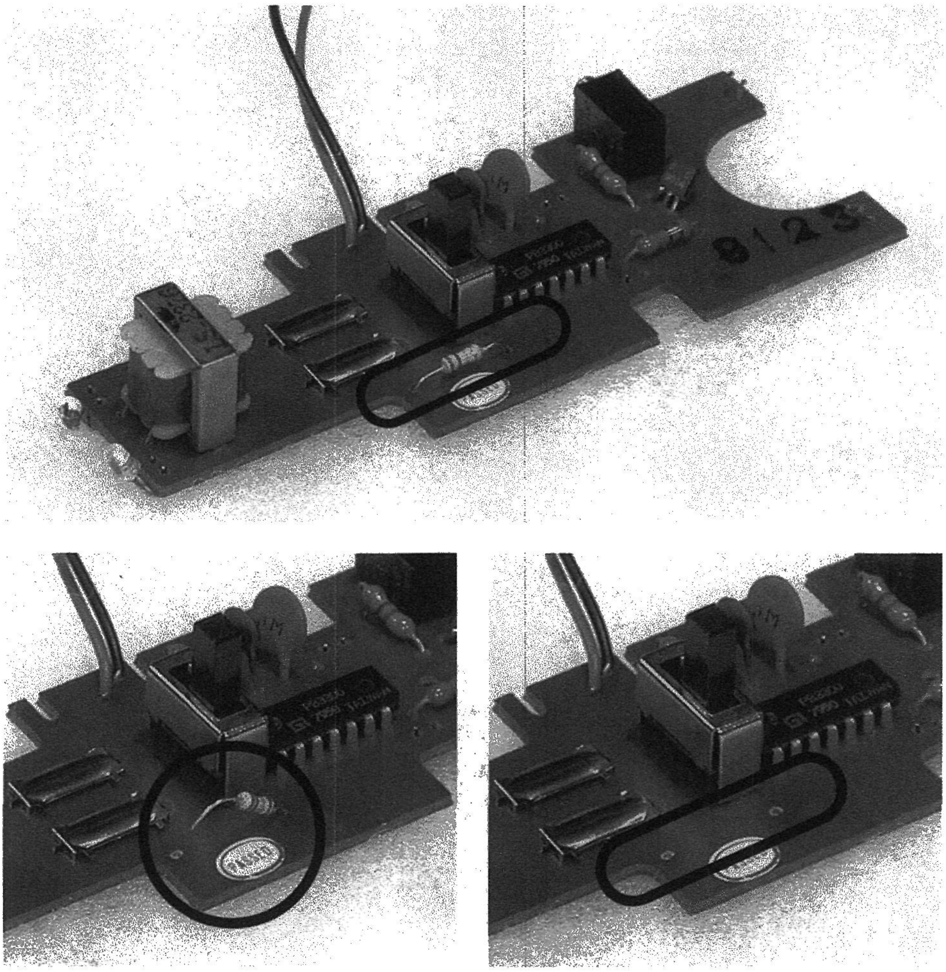

Figure 13.1 Removing a resistor.

might want to give it a try (twist the stranded wire before tinning and it will be more likely to pass neatly into the hole). Melt the solder on the solder side of the board as you press the end of the wire through the hole. Touch up the solder joint with a bit of fresh solder to make sure it is solid, but avoid excess solder "bridging" the gap between traces that are supposed to be separate. Repeat with the second wire into the other hole. Your circuit board should now have two colorful whiskers sprouting from among the other, vertically challenged components (see Figure 13.2). If you removed a pot from the board, there may be more than two holes; solder a wire to each of them. If you have problems fitting the wires through the holes you may have to clear out the old solder first—the best tool for this is the eerily cosmetological-looking "solder sucker" (see Figure 28.11 in Chapter 28), but an artfully wielded straight pin can work too.

The copper traces on printed circuit boards can be very delicate, and the twisting of the wires as you go through the following experiments can tear the trace,

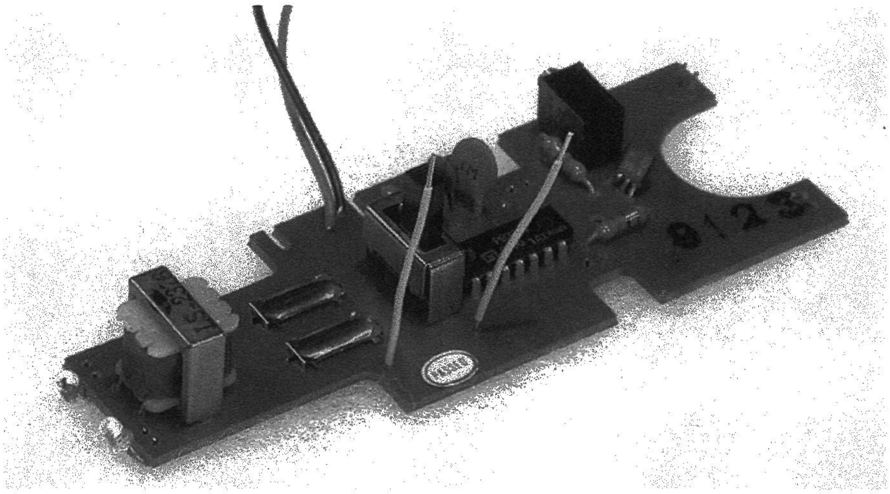

Figure 13.2 Resistor whiskers.

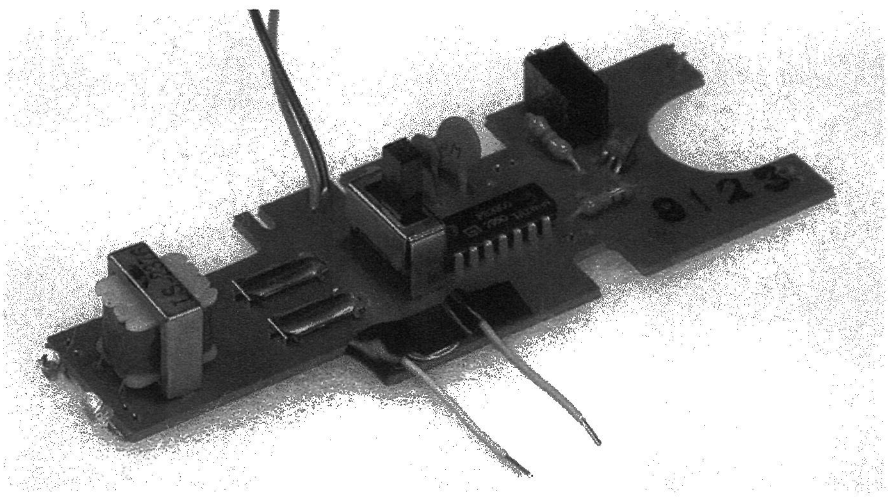

Figure 13.3 Whisker strain relief.

sometimes irreparably. Which is why the greater flexibility of stranded wire offsets the difficulty of forcing it though the holes. It is also a good idea to provide some kind of "strain relief" for your whiskers. The easiest method is to bend them gently so they lie flat against the board, and then tape them down with electrical tape to prevent them from moving at the point they pass through the board (see Figure 13.3).

3. Attach a clip lead to the free end of each of the wires. Clip the resistor you removed between the other ends of the clip leads, effectively re-inserting it to the circuit (see Figure 13.4). If you didn't damage anything in de-soldering, the circuit should behave as it did before the operation. If it doesn't, you may need to "restart" the toy by removing and reinstalling the batteries (see Rule #12, on p. 90).

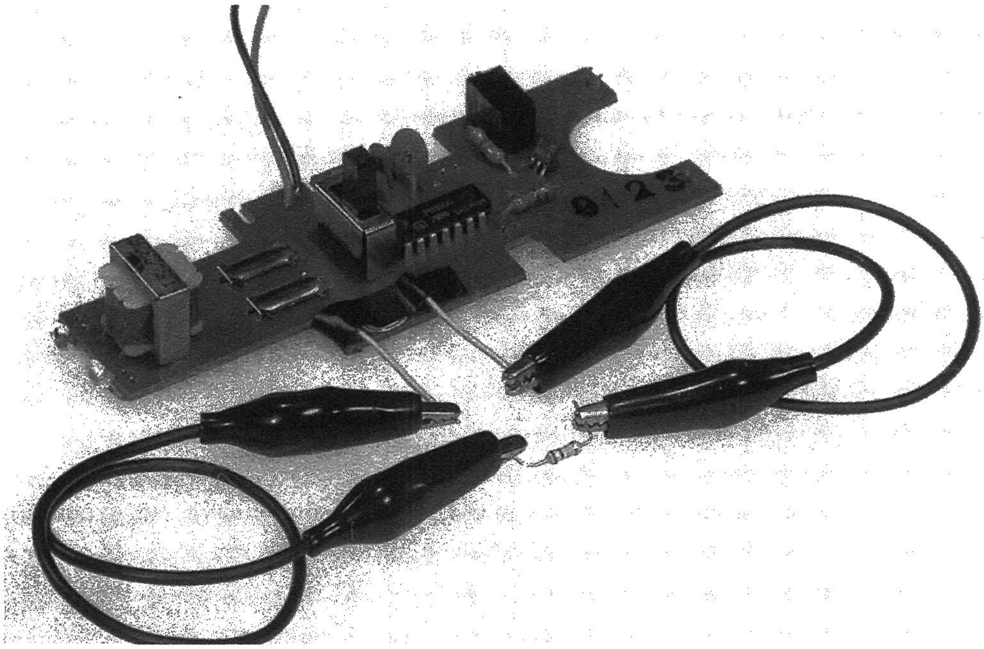

Figure 13.4 A remote resistor.

Table 13.1 Resistor color codes

Colour	*Value*	*Multiplier*
Black	0	1
Brown	1	10
Red	2	100
Orange	3	1,000
Yellow	4	10,000
Green	5	100,000
Blue	6	1,000,000
Violet	7	10,000,000
Gray	8	100,000,000
White	9	1,000,000,000

4. Those colorful stripes around the resistor indicate its value. Look at the decoder chart in Table 13.1 above.

   Study your resistor. The first two stripes represent number values directly, the third is a multiplier, and a final gold or silver band the tolerance. So if the bands go: brown, black, yellow, silver:

Brown = 1
Black = 0
Yellow = multiply by 10,000
Silver = ±10 percent tolerance
So we get: 10 × 10,000=100,000 Ohms (or 100kOhms) ±10 percent.

Another example: orange (3) orange (3) red (× 100) gold = 3,300 ±5 percent. Get it?

5. What are the color bands of the resistor you removed? __________
   What is its value? __________

6. Go to your resistor assortment and find a resistor at least twice as big, and one about 1/2 the value. Clip the larger one into the circuit and the pitch should go *down*. Replace it with the smaller one and the pitch should go *up*. If either one does not work it may be so extreme a value that the circuit shuts down, so replace it with one whose value is somewhere between the original resistor and the non-functional one. In the event of such a crash, observe the 12th Rule of Hacking:

Rule #12: After a hacked circuit crashes you may need to disconnect and reconnect the batteries before it will run again.
(Count to five before replacing them.)

Substituting resistors should give you a good idea of what values produce what kind of sound, but you will probably want to vary the pitch/speed more fluidly. A potentiometer is a continuously variable resistor. In order to extend the pitch downward you need a pot whose maximum value is *greater* than the resistor you removed. Since most clock circuits use rather large resistors (100 kOhm or larger) you will probably need a pot whose maximum value is 1 megOhm (1,000,000 Ohms) or greater.

Pots have three terminals—two "ears" and one "nose"—which are labeled A, B, and C in Figure 13.5. The resistance between the outer two ears (A and C) is fixed at the designated value of the pot, which is the pot's absolute maximum resistance (i.e. 1 megOhm). As you rotate the shaft of the pot clockwise the resistance between the center terminal (nose) B and the outer terminal A goes *up* from 0 Ohms to the maximum value, while the resistance between B and the other outer terminal C goes *down* from the maximum to 0—the two values change in contrary motion, like the ends of a seesaw. Reversing the pot's rotation tips the seesaw back the other way.

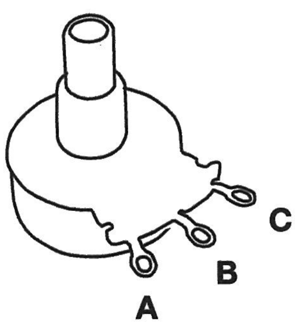

Figure 13.5
The three terminals of a potentiometer

Remove the resistor from the clip leads attached to the whiskers on your circuit board. Clip the free end of one of the leads to the center terminal (B) of your pot, and clip the other to the end terminal C (see Figure 13.6). Rotate the pot and listen. The circuit will probably crash if you raise the pitch past a certain point and you'll have to restart it (see Rule #12, above). But as long as you stay below that point in the pot's rotation you should be able to coax a pretty wide range of sounds out of your circuit. If the toy appears to shut down when the clock is at its slowest, but restarts on its own when the pitch is raised again, the problem may be simply that the sound is going too low to be heard on the built-in speaker; try putting a telephone pickup on the speaker and amplify it through a bigger speaker (as suggested for the radio in Chapter 11). Of course you can always use the center terminal B and the other ear, A, but in this case the response of the pot will be backwards: the pitch will go *down* as you turn it further clockwise, rather than up. Which is fine, except slightly counterintuitive if you have worked with most commercial electronic music devices—there's no time like now to start a revolution (or at least change its direction).

If there is no appreciable change in pitch or tempo you may have picked the wrong resistor as the clock timing component. Solder the part back into the board and start over at step 1 probing for the hot spot with your wet finger. Other common causes of failure include torn traces (as mentioned in step 2 above), or sloppy soldering accidentally joining points on the circuit board that should remain separated.

If you removed a pitch-varying pot (instead of a fixed resistor) from the circuit you will have to experiment with connecting the terminals of your new pot to various combinations of leads from the circuit board before you find the correct hookup—you can start by matching up the nose and ears of your replacement pot with those of the original part in the toy. Substituting a pot of larger value than the built-in one should give you a wider range of pitch/speed variation.

In case you were wondering, yes, you could also change the clock frequency by varying the *capacitor* in the clock circuit, rather than the resistor. But it is difficult to make a capacitor continuously variable over a wide range, and therefore this is a less practical approach to the problem of "playing" the clock. Later in the book we will substitute different size capacitors to set the frequency *range* of an oscillator, while a resistance is varied for continuous pitch change, but for now we'll limit ourselves to experiments with resistors of various kinds.

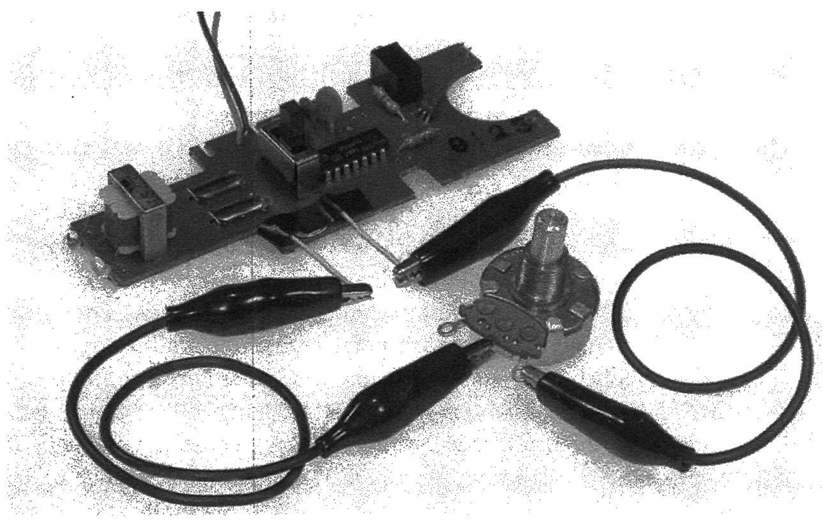

Figure 13.6
Pot substitute for a clock resistor.