CHAPTER 16

Switches: How to Understand Different Switches, and Even Make Your Own

You will need:

- The electronic toy from the previous experiments.
- Some hookup wire.
- A Single-Pole Double-Throw switch (SPDT), momentary or toggle.
- A plank of wood, some short nails, and a large ball bearing.
- Soldering iron, solder, and hand tools.

This is possibly the most boring chapter in the book. Skip over it if you wish, but don't tear it out, because it may prove useful later.

Switches are useful for turning power on and off to a circuit to save battery life, for turning on and off specific sounds or functions, and for resetting a circuit if it freezes up. They are often described in catalogs, on Web sites or in packaging by arcane abbreviations. Here are the main distinguishing features.

MECHANICAL STYLE

A switch can be *momentary* pushbutton, like a door bell, that changes state (turns something on) when you press it, and returns to its default state (off) when you release it; or it can be a push-on/push-off switch that alternates but holds its state (like the bypass switch on a stomp-box). It can be a *toggle* switch with a lever, like a traditional light switch, that stays where you put it until you switch it back (usually). There is also the *rotary* switch, like the cycle selector on a clothes washer or the pickup selector switch on a Stratocaster, with which you choose between several positions, rather than just on and off. *Slide* switches, like the rotary switch, can select between two or more positions (see Figure 16.1). There are a few other oddball switches we'll discuss when they become relevant.

NUMBER OF THROWS

A switch is also described by the number of mutually exclusive connections it makes when moved or "thrown." A simple pushbutton that turns something on in one

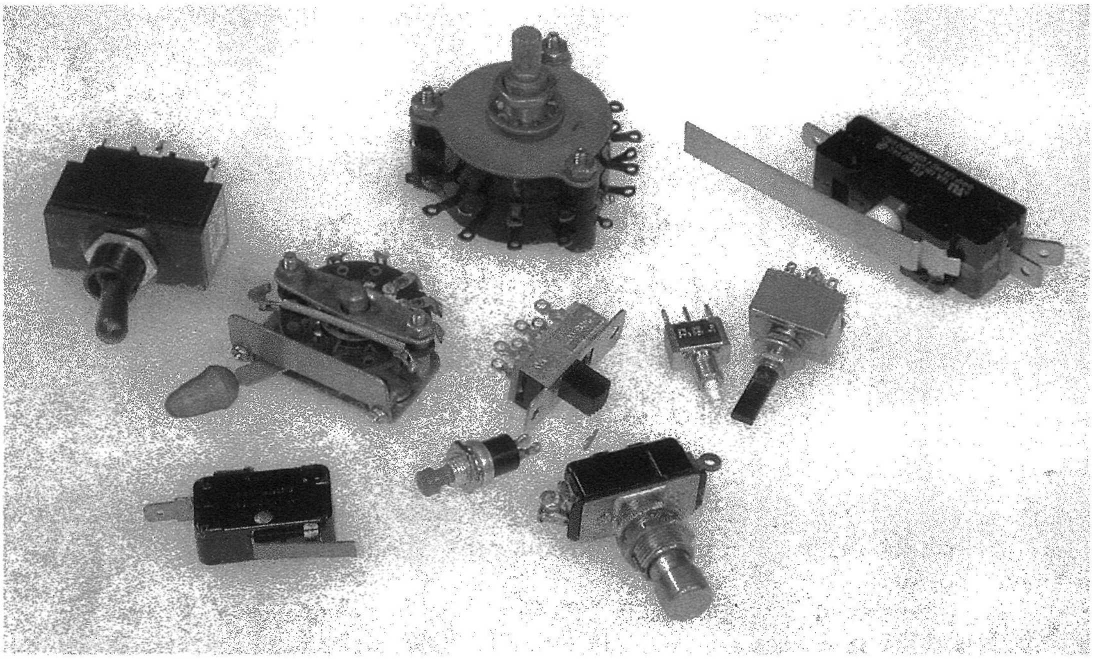

Figure 16.1 Assorted switches.

position, but does nothing in the other (beyond turning off), is called a "Single Throw" (ST) switch (see Figure 16.2a). If the switch alternates between two possible connections, it is a "Double Throw" (DT) switch (see Figure 16.2b)—this could be a pushbutton, a toggle, or a slide switch. Rotary switches that can make several different connections are classified by the number of connections, i.e. a five-position switch would be abbreviated as "5T" (see Figure 16.2c).

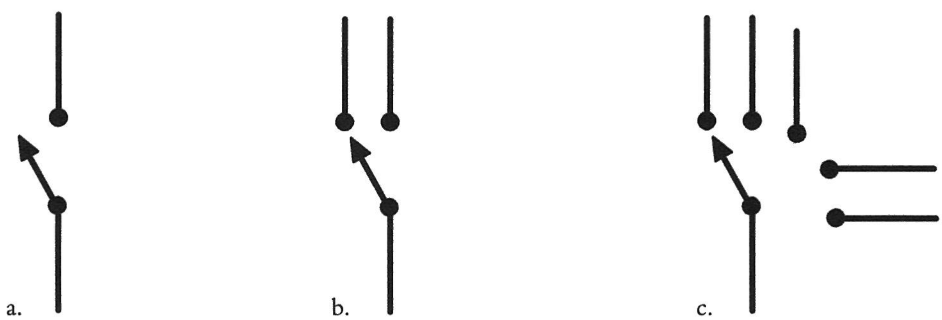

Figure 16.2
a. Schematic representation of a Single Throw (ST) switch.
b. Schematic representation of a Double Throw (DT) switch.
c. Schematic representation of a Five Throw (5T) switch.

NUMBER OF POLES

Sometimes a single lever or button can switch two or more separate circuits simultaneously (think of the huge double-bladed switches in *Frankenstein*, thrown by one ominous handle). Most pushbutton and toggle switches are either "Single Pole" (SP; see Figure 16.3a), meaning that they switch only one circuit, or "Double Pole" (DP; see Figure 16.3b), which switches two circuits. The dotted line on the schematic representation indicates that the two sections switch in tandem. Switches can have three, four, or more poles—they're just less commonly encountered.

TERMINAL DESIGNATIONS

In a Double Throw switch the solder terminal that is normally *off*, or unconnected, is designated "Normally Open" (NO). The one that is normally *on*, or closed, is the "Normally Closed" (NC). The terminal that is connected, by the movement of the button or toggle, alternately to the NO or NC terminals is the "Common" (C; see Figure 16.4).

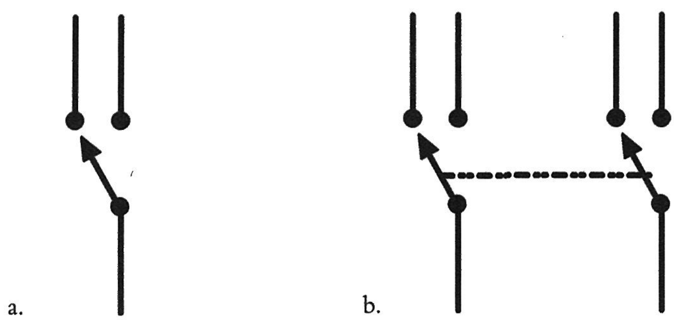

Figure 16.3
a. Schematic representation of a Single Pole (SP) switch.
b. Schematic representation of a Double Pole (DP) switch.

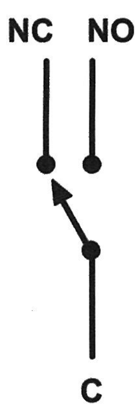

Figure 16.4
Switch terminal terminology:
"NC" = Normally Closed,
"NO" = Normally Open,
"C" = Common.

RESET SWITCH

You may have noticed that your toy occasionally freezes up, usually when the clock is run too high or too low, or you short out some part of the circuit. As per the 12th Rule of Hacking, momentarily removing the batteries will usually fix the problem. But this gets tiresome. The problem is that most modern toys do not have mechanical on/off switches—like televisions, they are usually only asleep when you turn them off. Current is still flowing through parts of the circuit, and the toy—like your computer—will not truly reset without *really* powering down and back on.

We can add a reset switch that lets you press a button or throw a toggle to disconnect the batteries temporarily, without the bother of actually removing them. You'll need a SPDT (Single Pole Double Throw) switch. It can be a *momentary* switch, if the toy already has a built-in power on/off switch; if you want to use the reset switch as a power switch as well, then get a toggle switch instead.

Cut one of the two wires connecting the batteries to the circuit board. Solder one end of the cut wire to the switch's Common terminal (C); solder the other end to the Normally Closed (NC) terminal. If the battery wire is very short you may want to extend one or both sections with some additional hookup wire. If the switch has more than three connectors, or they are unmarked, you should use a multimeter to figure out the switch logic.

With a momentary switch, the switch is normally *closed*, so the battery voltage flows into the C terminal and out through the NC terminal to the circuit; when you press the switch the C flips its connection to the NO terminal, breaking the connection to the NC terminal and disconnecting the batteries from your circuit. Next time your circuit crashes, return the clock speed pot to a middle setting, restore any other weird connections to their "safe" states, press the switch for a few seconds, and (hopefully) the circuit will "re-boot" when you release it—easier than removing the batteries, especially in front of a restless crowd at CBGBs or the Royal Albert Hall.

If you use a toggle switch the circuit will stay in the off state when switched, so it will function as a power on/off switch as well, saving battery life offstage.

Toggle or momentary switches can also be used to switch on and off the resistive jumpers you made in Chapter 15, or to switch between a fixed clock resistor and a variable one (or between two different variables resistors—such as a pot and a photoresistor).

HOMEMADE SWITCHES

Switches are useful, often essential, things. Unfortunately, they can also be the most expensive part of a hack: resistors, capacitors, wire, and many other electronic components you use in hacking typically cost fractions of a penny, but a switch can set you back several dollars. However, with a little mechanical ingenuity you can fabricate your own switches out of paperclips, springs, brass fasteners, and other scraps of metal—classic prison technology, like making a shiv from a bedspring. It's more of a mechanical problem than an electronic one: find two pieces of metal that conduct electricity, then figure out a practical way to move them in and out of contact with one another.

You can construct a nice multi-position tilt-switch by hammering a ring of brads into a piece of wood, soldering a wire between each nail and a point on the circuit

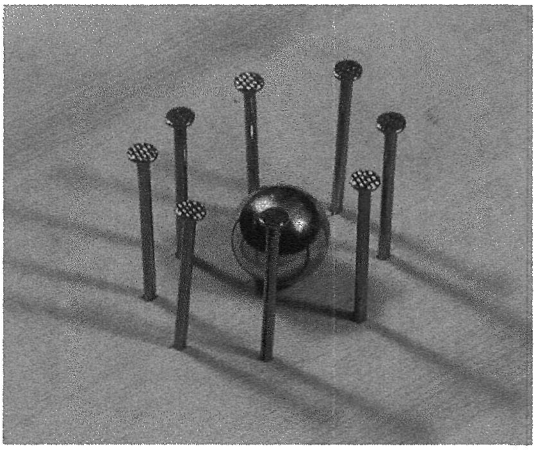

Figure 16.5
A homemade tilt switch.

board that needs switching, and dropping a big ball bearing into the corral (see Figure 16.5). You can use this switch to select different circuit jumpers (the almost-shorts you found in Chapter 15), or switch between the outputs of several toys to feed the input of your amp. Variations on this design can be made with loops of wire, strips of copper, or even blobs of mercury (once a common switch element, now banished behind the sign of a skull and crossbones—see Figure 16.6).

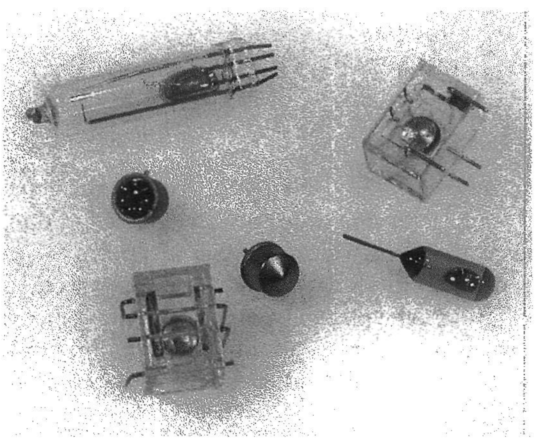

Figure 16.6
Some commercial tilt switches, using ball bearings and deadly blobs of mercury to connect contact points.