10

BUILDING A METAL PLATFORM

Metal is perhaps the best all-around material for building robots because if offers extra strength that other materials, such as plastic and wood, cannot. If you've never worked with metal before, you shouldn't worry; there is really nothing to it. The designs outlined in this chapter and the chapters that follow will show you how to construct robots both large and small out of readily available metal stock, without resorting to welding or custom machining.

Metal Stock

Metal stock is available from a variety of sources. Your local hardware store is the best place to start. However, some stock may only be available at the neighborhood sheet metal shop. Look around and you're sure to find what you need.

EXTRUDED ALUMINUM

Extruded stock is made by pushing molten metal out of a shaped orifice. As the metal exits it cools, retaining the exact shape of the orifice. Extruded aluminum stock is readily available at most hardware and home improvement stores. It generally comes in 12-foot sections, but many hardware stores will let you buy cut pieces if you don't need all 12 feet.

Extruded aluminum is available in more than two dozen common styles, from thin bars to pipes to square posts. Although you can use any of it as you see fit, the following standard sizes may prove to be particularly beneficial in your robot-building endeavors:

1-by-1-by-1/16-inch angle stock
57/64-by-9/16-by-1/16-inch channel stock
41/64-by-1/2-by-1/16-inch channel stock
Bar stock, in widths from 1 to 3 inches and thicknesses of 1/16 to 1/4 inch

SHELVING STANDARDS

You've no doubt seen those shelving products where you nail two metal rails on the wall and then attach brackets and shelves to them. The rails are referred to as "standards," and in a pinch they are well suited to be girders in robot frames. The standards come in either aluminum or steel and measure 41/64 by 1/2 by 1/16 inch. The steel stock is cheaper but considerably heavier, a disadvantage you will want to carefully consider. Limit its use to structural points in your robot that need extra strength.

Another disadvantage of using shelving standards instead of extruded aluminum are all the holes and "slots" you'll find on the standards. The holes are for mounting the standards to a wall; the slots are for attaching shelving brackets. Both can be troublesome when you are drilling the metal for bolt holes. The drill can slip into a hole or slot, and as a result the hole may not end up where you want it. For this reason, use extruded aluminum pieces when possible. It will yield more professional results.

MENDING PLATES

Galvanized mending plates are designed to strengthen the joint of two or more pieces of lumber. Most of these plates come preformed in all sorts of weird shapes and so are pretty much unusable for building robots. But flat plates are available in several widths and lengths. You can use the plates as is or cut them to size. The plates are made of galvanized iron and have numerous pre-drilled holes in them to help you hammer in nails. The material is soft enough so you can drill new holes, but if you do so only use sharp drill bits.

Mending plates are available in lengths of about 4, 6, and 12 inches. Widths are not as standardized, but 2, 4, 6, and 12 inches seem common. You can usually find mending plates near the rain gutter and roofing section in the hardware store. Note that mending plates are heavy, so don't use them for small, lightweight robot designs. Reserve them for medium- to large-sized robots where the plate can provide added structural support and strength.

RODS AND SQUARES

Most hardware stores carry a limited quantity of short extruded steel or zinc rods and squares. These are solid and somewhat heavy items and are perfect for use in some advanced projects, such as robotic arms. Lengths are typically limited to 12 or 24 inches, and thicknesses range from 1/16 to about 1/2 inch.

IRON ANGLE BRACKETS

You will need a way to connect all your metal pieces together. The easiest method is to use galvanized iron brackets. These come in a variety of sizes and shapes and have predrilled holes to facilitate construction. The 3/8-inch-wide brackets fit easily into the two sizes of channel stock mentioned at the beginning of the chapter: 57/64 by 9/16 by 1/16 inch and 41/64 by 1/2 by 1/16 inch. You need only drill a corresponding hole in the channel stock and attach the pieces together with nuts and bolts. The result is a very sturdy and clean-looking frame. You'll find the flat corner angle iron, corner angle ("L"), and flat mending iron to be particularly useful.

Working with Metal

If you have the right tools, working with metal is only slightly harder than working with wood or plastic. You'll have better-that-average results if you always use sharpened, well-made tools. Dull, bargain-basement tools can't effectively cut through aluminum or steel stock. Instead of the tool doing most of the work, you do.

CUTTING

To cut metal, use a hacksaw outfitted with a fine-tooth blade, one with 24 or 32 teeth per inch. Coping saws, keyhole saws, and other handsaws are generally engineered for cutting wood, and their blades aren't fine enough for metal work. You can use a power saw, like a table saw or reciprocating saw, but, again, make sure that you use the right blade.

You'll probably do most of your cutting by hand. You can help guarantee straight cuts by using an inexpensive miter box. You don't need anything fancy, but try to stay away from the wooden boxes. They wear out too fast. The hardened plastic and metal boxes are the best buys. Be sure to get a miter box that lets you cut at 45° both vertically and horizontally. Firmly attach the miter box to your workbench using hardware or a large clamp.

DRILLING

Metal requires a slower drilling speed than wood, and you need a power drill that either runs at a low speed or lets you adjust the speed to match the work. Variable speed power drills are available for under $30 these days, and they're a good investment. Be sure to use only sharp drill bits. If your bits are dull, replace them or have them sharpened. Quite often, buying a new set is cheaper than professional resharpening. It's up to you.

You'll find that when you cut metal the bit will skate all over the surface until the hole is started. You can eliminate or reduce this skating by using a punch prior to drilling. Use a hammer to gently tap a small indentation into the metal with the punch. Hold the smaller pieces in a vise while you drill.

When it comes to working with metal, particularly channel and pipe stock, you'll find a drill press is a godsend. It improves accuracy, and you'll find the work goes much faster. Always use a proper vise when working with a drill press. *Never* hold the work with your hands. Especially with metal, the bit can snag as it's cutting and yank the piece out of your hands. If you can't place the work in the vise, use a pair of Vise-Grips or other suitable locking pliers.

FINISHING

Cutting and drilling often leaves rough edges, called *flashing*, in the metal. These edges must be filed down using a medium- or fine-pitch metal file, or else the pieces won't fit together properly. Aluminum flash comes off quickly and easily; you need to work a little harder when removing the flash in steel or zinc stock.

Build the Buggybot

The Buggybot is a small robot built from a single 6-by-12-inch sheet of 1/16-inch thick aluminum, nuts and bolts, and a few other odds and ends. You can use the Buggybot as the foundation and running gear for a very sophisticated petlike robot. As with the robots built with plastic and wood we discussed in the previous two chapters, the basic design of the all-metal Buggybot can be enhanced just about any way you see fit. This chapter details the construction of the framework, locomotion, and power systems for a wired remote control robot. Future chapters will focus on adding more sophisticated features, such as wireless remote control, automatic navigation, and collision avoidance and detection. Refer to Table 10.1 for a list of the parts needed to build the Buggybot.

TABLE 10.1 PARTS LIST FOR BUGGYBOT

Frame:	
1	6-by-12-inch sheet of 1/16-inch thick aluminum
Motor and Mount:	
2	Tamiya high-power gearbox motors (from kit); see text
2	3-inch-diameter "Lite Flight" foam wheels
2	5/56 nuts (should be included with the motors)
2	3/16-inch collars with setscrews
1	Two-cell "D" battery holder
Misc	1-inch-by-6/32 stove bolts, nuts, flat washers
Support Caster:	
1	1 1/2-inch swivel caster
Misc	1/2-inch-by-6/32 stove bolts, nuts, tooth lock washers, flat washers (as spacers)
	See parts list in Table 8.3 of Chapter 8 for motor control switch

FRAMEWORK

Build the frame of the Buggybot from a single sheet of 1/16-inch thick aluminum sheet. This sheet, measuring 6 by 12 inches, is commonly found at hobby stores. As this is a standard size, there's no need to cut it. Follow the drill-cutting template shown in Fig. 10.1.

After drilling, use a large shop vise or woodblock to bend the aluminum sheet as shown in Fig. 10.2. Accuracy is not all that important. The angled bends are provided to give the Buggybot its unique appearance.

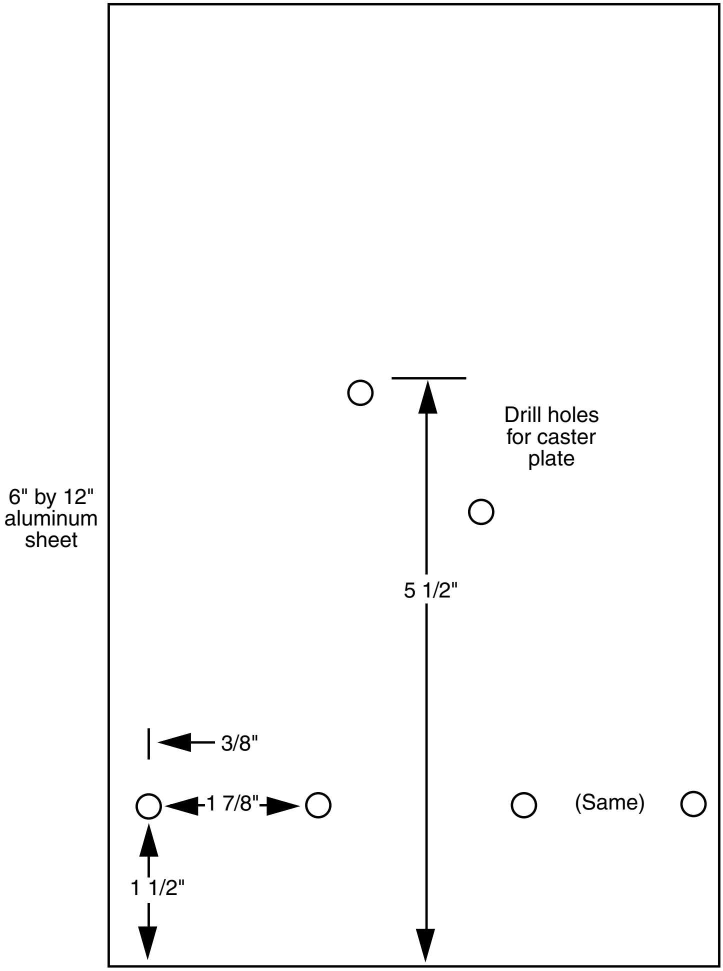

FIGURE 10.1 Drilling diagram for the Buggybot frame.

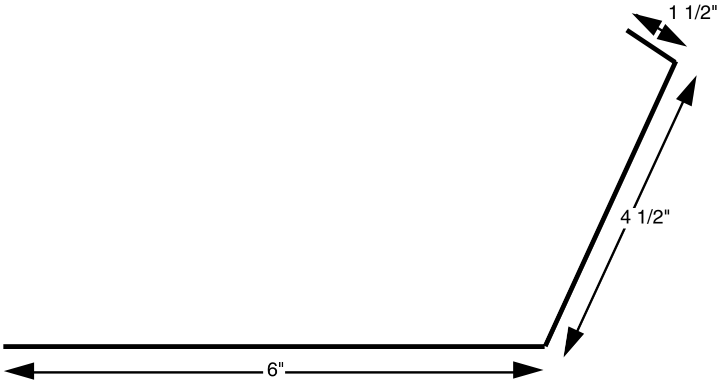

FIGURE 10.2 Bend the aluminum sheet at the approximate angles shown here.

MOTORS AND MOTOR MOUNT

The prototype Buggybot uses two high-power gearbox motor kits from Tamiya, which come in kit form and are available at many hobby stores (as well as Internet sites, such as TowerHobbies.com). These motors come with their own gearbox; choose the 1:64.8 gear ratio. An assembled motor is shown in Fig. 10.3. Note that the output shaft of the motor can be made to protrude a variable distance from the body of the motor. Secure the shaft (using the Allen setscrew that is included) so that only a small portion of the opposite end of the shaft sticks out of the gear box on the other side, as shown in Fig 10.3.

You should secure the gearboxes and motors to the aluminum frame of the Buggybot as depicted in Fig. 10.4. Use 6/32 bolts, flat washers, and nuts. Be sure that the motors are aligned as shown in the figure. Note that the shaft of each motor protrudes from the side of the Buggybot.

Figure 10.5 illustrates how to attach the wheels to the shafts of the motors. The wheels used in the prototype were 3-inch-diameter foam “Lite Flight” tires, commonly available at hobby stores. Secure the wheels in place by first threading a 3/16-inch collar (available at hobby stores) over the shaft of the motor. Tighten the collar in place using its Allen setscrew. Then cinch the wheel onto the shaft by tightening a 5/56 threaded nut to the end of the motor shaft (the nut should be included with the gearbox motor kit). Be sure to tighten down on the nut so the wheel won’t slip.

SUPPORT CASTER

The Buggybot uses the two-wheel drive tripod arrangement. You need a caster on the other end of the frame to balance the robot and provide a steering swivel. The 1 1/2-inch swivel caster is not driven and doesn’t do the actual steering. Driving and steering are taken care of by the drive motors. Refer to Fig. 10.6 on p. 131. Attach the caster using two 6/32 by 1/2-inch bolts and nuts.

Note that the mechanical style of the caster, and indeed the diameter of the caster wheel, is dependent on the diameter of the drive wheels. Larger drive wheels will require either a

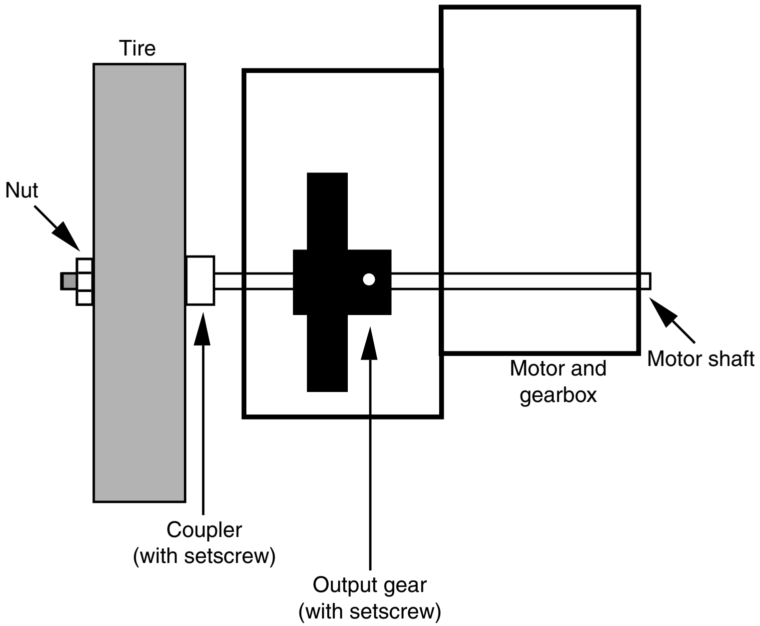

FIGURE 10.3 **Secure the output shaft of the motor so that almost all of the shaft sticks out on one side of the motor.**

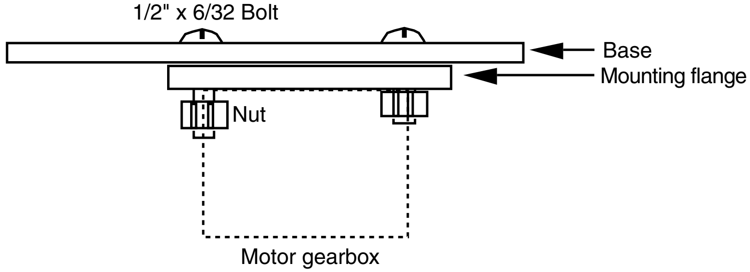

FIGURE 10.4 **The gearboxes and motors are attached to the frame of the Buggybot using ordinary hardware.**

different mounting or a larger caster. Small drive wheels will likewise require you to adjust the caster mounting and possibly use a smaller-diameter caster wheel.

BATTERY HOLDER

The motors require an appreciable amount of current, so the Buggybot really should be powered by heavy-duty “C”- or “D”-size cells. The prototype Buggybot used a two-cell “D” battery holder. The holder fits nicely toward the front end of the robot and acts as a

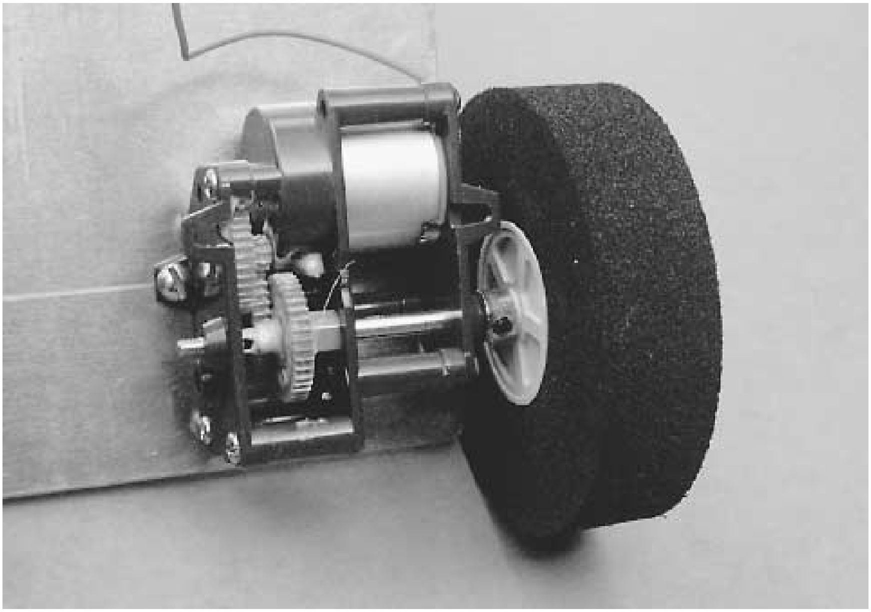

FIGURE 10.5 Attach the foam wheels (with plastic hubs) for the Buggybot onto the shafts of the motors.

good counterweight. You can secure the battery holder to the robot using double-sided tape or hook-and-loop (Velcro) fabric.

WIRING DIAGRAM

The basic Buggybot uses a manual wired switch control. The control is the same one used in the plastic Minibot detailed in Chapter 8, "Building a Plastic Robot Platform." Refer to the wiring diagram in Fig. 8.4 of that chapter for information on powering the Buggybot.

To prevent the control wire from interfering with the robot's operation, attach a piece of heavy wire (the bottom rail of a coat hanger will do) to the caster plate and lead the wire up it. Use nylon wire ties to secure the wire. The completed Buggybot is shown in Fig. 10.7.

Test Run

You'll find that the Buggybot is an amazingly agile robot. The distance it needs to turn is only a little longer than its length, and it has plenty of power to spare. There is room on the robot's front and back to mount additional control circuitry. You can also add control circuits and other enhancements over the battery holder. Just be sure that you can remove the circuit(s) when it comes time to change or recharge the batteries.

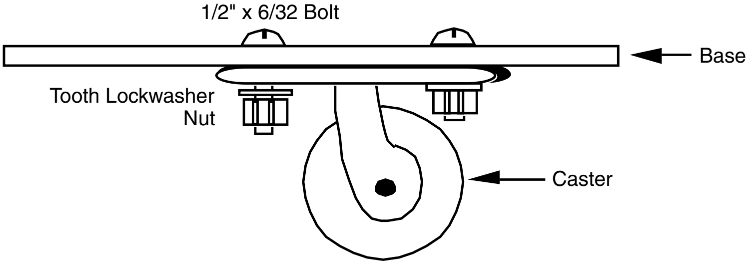

FIGURE 10.6 Mounting the caster to the Buggybot.

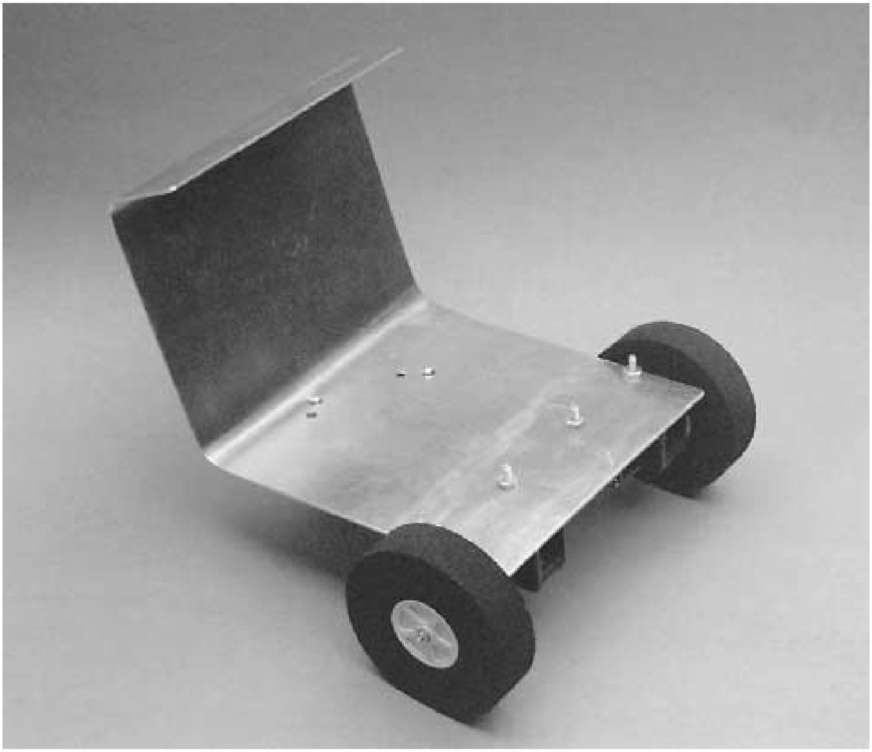

FIGURE 10.7 The completed Buggybot.

From Here

To learn more about...	***Read***
Plastic robots	Chapter 8, "Building a Plastic Robot Platform"
Metal robots	Chapter 9, "Building a Basic Wooden Platform"
Using batteries	Chapter 15, "All about Batteries and Robot Power Supplies"
Selecting the right motor	Chapter 17, "Choosing the Right Motor for the Job"
Using a computer or microcontroller	Chapter 28, "An Overview of Robot 'Brains'"