Chapter 1

Diving Into the World of Welding

In This Chapter

- Discovering the main uses for welding
- Examining common welding metals
- Paying special attention to welding safety
- Taking a look at welding methods
- Thinking about what's in store for welding in the future

Ever since our early ancestors starting making ornaments out of gold thousands of years ago, metal has played an important role in the lives of all people. Just take a second to look around and think about all the various kinds of metal that are nearby. Dozens (if not hundreds) of metal items are probably all around you, and the items that aren't made out of metal were likely manufactured by using metal equipment.

By and large, metal is tough stuff. (That's one of the reasons why it's so useful, of course.) Throughout history, humans have needed to come up with more and better ways to defy the strength of metals, bending, cutting, and joining it so they can take advantage of its many useful properties. One of the biggest and most important advancements on that front has been the advent and development of welding. Welding allows humans to connect pieces of metal in remarkably strong, sturdy ways, and it has opened up seemingly endless possibilities for what people can do with metallic materials.

This chapter introduces you to all things welding, including its importance, the materials, equipment, and methods you use to accomplish it, and the need for safety precautions while doing it. In addition, the chapter gives you a glimpse into welding's crystal ball.

If You Can't Beat 'Em, Join 'Em: Understanding Why Welding Matters

Welding is the process of using heat to join metals. When you're looking to join metals, you can find no easier or more cost effective way to get the job done than welding — it allows you to join metals in a way that's faster, more versatile, and more dependable than any other process (by a long shot). (And no, using duct tape doesn't count because that's not really fixing anything.) The availability and cost of so many of the items you depend on every day are kept within your reach because of the widespread use of welding processes. Just how prominent is welding? Well, it's estimated that half of the U.S. gross national product is affected by welding. That's about $7 or 8 trillion. How many other skills or trades can claim that much of an impact? Not many.

The uses of welding break down into two very broad categories: fabricating and repairing. The following sections offer a little more detail on both of those divisions.

Fabricating metal products

In welding, *fabricating* simply means that you're taking pieces of metal and welding them together to create something new. That can be as simple as welding a few pieces of metal together at a 90-degree angle to make a pair of bookends in the welding shop you set up in your backyard, or as complex as using underwater arc welding to help build a section of submerged pipeline off the coast of Angola. (Don't worry — you can expect a lot more of the former than the latter in this book!)

Most metals can be joined by one welding process or another, so in theory you don't have many limits when it comes to fabricating. However, for a new welder the amount of fabricating you do with your newfound welding skills is often limited to some degree by cost (some metals can be pretty expensive), time (if you're welding as a hobby, chances are your fabricating time takes a backseat to other obligations like your job and your family), and degree of difficulty. Because developing your welding skills takes time, some fabrication projects may be out of your reach in the short term.

Repairing metal pieces or products

The difference between fabricating and repairing is simple. When you weld to fabricate, you're making something new. When you weld to *repair,* you're welding on something that already exists but needs fixing or modifying.

Repairing can be as simple as welding to fix a tine on your favorite old rake, or welding to fix a crack in a helicopter fitting assembly. (Of course, I lean a lot more toward rake repair than helicopter maintenance in this book!) Although metals are durable and tough, they do break down because of damage or repetitive use, and when that happens, welding is the best way to fix them.

REMEMBER

The big question with repair work is whether it makes more sense (especially with regard to time and money) to make a repair or simply replace the broken part or product. That's not always an easy call to make, and I address the various facets of that question in Chapter 18.

REMEMBER

When you're welding to repair something, your goal should always be to produce a weld that's stronger than the original piece or product. If you're going to be working on something, why not improve it?

Tracing the history of welding

Welding is one of the newest metal-working trades; it can be traced back to about 1000 B.C. Most historians agree that the first kind of welding done by humans was the lap welding of gold, which was used to create simple gold ornaments. But welding really started to take shape when people figured out how to hammer brass and copper together to make bronze. Bronze was a real game changer, especially when it came to making basic types of farming equipment and tools, or weapons of war.

The next big jump in technology was during the Industrial Revolution (from the mid-1700s to the mid-1800s). That's when *hammer welding* (also known as *forge welding*) was developed. In hammer welding, metal is heated to its plastic state, and then two separate pieces are laid side by side and hammered together. (If you've ever seen a blacksmith at work, you've seen hammer welding in action.)

The next step was based on the discovery of acetylene in the middle of the 19th century. Controlled use of acetylene gas (combined with oxygen) allowed people to cut and melt metals in a way that wasn't possible before. But welding as you know it today came about in the early 20th century, after people had learned how to harness and use electricity. Very basic electric welding equipment and techniques were already being used across the globe at that point, and World War I made it clear that welding technology was going to be critically important for cranking out massive amounts of metal materials, tools, and machinery. Many of the prominent organizations and companies that loom large in the world of welding today got their start during that period. Improvements in welding processes and equipment came in leaps and bounds, and before the first half of the 20th century was over, the world had seen the creation of the major welding techniques that I cover in this book: stick welding, mig welding, tig welding, and oxyacetylene welding, as well as oxyfuel welding and cutting.

Getting Familiar with Metals

Any welding endeavor is much easier if you have a solid working knowledge of metals. The more you know about the metals you're using and how they're likely to respond to the intense heat involved in welding, the more likely you'll be able to manipulate and join them in the way you have in mind for a specific project.

You probably remember from your high-school science class that, like other materials, metals expand when you heat them and contract as they cool off. If you heat them enough, they start to get soft, and eventually (with more heat), they melt. I know that sounds simple, but it's awfully important for welding. Some metals melt at relatively low temperatures, and others have extremely high melting temperatures. A metal's *melting point* is just one of several important properties for welding.

Here are just a few others to consider.

- **Ductility** is a metal's ability to change shape (bend, stretch, and so on) without breaking. Gold has a high level of ductility, while tungsten isn't very ductile at all.
- **Electrical conductivity** is a measure of how well a metal can conduct a current of electricity. Copper conducts electricity really well; by comparison, stainless steel isn't a great conductor of electricity.
- **Strength** is pretty self explanatory: How much external force can a metal withstand without breaking? This one is very important for welding. Steel is a strong metal, but zinc isn't.

You can read up on many more properties of metal, and the more you know, the more easily you can make smart decisions about how to weld those metals effectively.

Not all metals are widely used for welding, of course, and you probably won't work with a huge range of metals in your welding shop until you've been welding for a while. That's completely fine, however, because plenty of exciting welding projects — both fabricating and repairing — involve only a few select metals. (See "If You Can't Beat 'Em, Join 'Em: Understanding Why Welding Matters" earlier in the chapter for more on those divisions.) For example, most of the welding practice exercises I walk you through in this book, as well as the welding projects I detail in Part V, focus on three metals: steel, stainless steel, and aluminum. These three are the most commonly used metals for beginning welders, and you should take the time to get to know them. In the following sections, I give you a quick look at each one.

Steel

Steel is a strong, versatile metal that you'll use all the time in your welding projects. You may not realize it, but steel is really an alloy made up of iron and less than 2 percent of another material. Carbon is often used in steel alloys, and you can find three different levels of carbon steel: low-, medium-, and high-carbon steel. The more carbon in the steel, the stronger the alloy is.

You should use steel in your welding projects when you're looking for a strong metal that's pretty easy to weld and doesn't break the bank when you're buying your materials. You can use any welding process I describe in this book on steel, so versatility is also one of its strong suits. But steel also has its downsides. For one, it's heavy. If you want your fabricated project to be light, steel probably isn't your best bet. Steel is also prone to rusting and *scaling* (flaking off due to oxidation), so you have to spend a fair amount of time cleaning it up (often with a grinder) before and sometimes during welding.

Stainless steel

Stainless steel is amazing stuff. It has a lot of the good qualities that regular steel has (see the preceding section), but it also offers one added bonus: It resists corrosion (rust, for instance) like a champ. You can put a piece of stainless steel out in the yard and let it get rained on for six weeks, and when you bring it back inside it probably won't have a single spot of rust on it. Incredible!

How does stainless steel provide such remarkable resistance to corrosion? Its alloy contains 10 to 30 percent chromium (the rest is iron, although sometimes other metals, such as nickel, are also added to the alloy).

You can weld stainless steel with all three of the major types of arc welding (stick, mig, and tig). It's a great choice if you want your project to resist rusting or to have *hygienic* surfaces (those that don't harbor bacteria and other microscopic critters).

Stainless steel is pretty expensive compared to other commonly welded metals, so be prepared to open your wallet a little wider if you choose stainless steel for a welding project.

Aluminum

Like stainless steel, aluminum is great at resisting corrosion. And aluminum offers another pretty terrific characteristic: It's lightweight. Compared to steel and stainless steel, aluminum is a real featherweight.

Pure aluminum is a popular choice for welders, but aluminum alloys are also frequently used. Copper, manganese, and zinc are just a few of the metals that are often alloyed with aluminum to produce enhanced characteristics in the finished product.

If you're going to be welding aluminum, I recommend going with tig welding. It just makes for a cleaner, easier job. If tig isn't an option, take mig welding; you *can* stick weld aluminum, but it's not ideal — your choices for stick electrodes are going to be limited, and you're probably going to have a difficult time maintaining the correct arc length.

Taking the Time to Understand Welding Safety

Welding utilizes some pretty extreme forces and materials. Most modern welding requires tremendous amounts of electricity, which of course can create a risk for electric shock. No matter what kind of welding you pursue, you're always going to be working around some incredible levels of heat, too, and those kinds of temperatures can harm you, other people, and your property in myriad ways. The metals you weld are sometimes sharp and often heavy, so with them you can get that rare and unfortunate double threat for lacerations and back injuries. Finally, you can't forget other potential hazards that welding can create, including rays that can do serious damage to your eyes and fumes that can hurt your lungs and make you very sick.

REMEMBER: Welding is a safe endeavor if you follow all the necessary precautions and respect the equipment, materials, and process. I know as well as anyone that welding involves a lot of potentially hazardous elements, but I also know that if you make maintaining a safe welding environment your first priority, you can weld for years and years without suffering any serious injuries or loss of property. You just have to follow the safety rules and keep your head on straight.

TIP: As you work your way through this book I ask only one favor of you: Please read Chapter 3 (on welding safety) carefully and thoroughly. Even if you think you understand welding safety, taking a few minutes to review the key steps for creating a safe welding environment for yourself and others can't hurt.

Exploring Welding Methods

You can use heat to join metals in several different ways, but by far the most common welding methods used today are the arc welding methods. *Arc welding* is really pretty simple in theory: A large amount of electricity creates an arc between an electrode and a base metal, and that arc generates enough heat to melt the materials in the weld area and join them together to make a weld. In practice, however, arc welding includes three different welding processes (stick, mig, and tig) and has many different variables. For example, some kinds of arc welding use a shielding gas, while others don't. The electrodes that you use in arc welding may be *consumable,* meaning they get melted and incorporated into the weld, or they may be non-consumable. The electricity used in arc welding is the source of many other variables, including amperage (which can vary a lot) and current (either alternating current or one of a couple different forms of direct current).

Because the three main types of arc welding are the most commonly used throughout the world and the easiest to pick up, those are the three that I devote the most attention to in the following sections (and throughout the book). However, they aren't the only game in town, so I also include some information on those other types in case you want to branch out a bit.

Stick welding

Stick welding (also called *shielded metal arc welding* or SMAW) is an arc welding technique that has the distinction of being the most commonly used welding practice in the United States today. (More than 40 percent of all welding done now in the United States is stick welding.) The prevalence of stick is even stronger in construction; more than half of all construction-related welding uses stick. And the percentage is even higher in the maintenance industry.

Stick welding enjoys such popularity for three primary reasons. First off, it's cheap. You can get into stick welding for less money than you'd spend to get started with tig welding. Secondly, stick welding is highly portable. The equipment is lightweight, and you can easily use it outdoors if the conditions allow it. Finally, stick welding is versatile. You can use it to work on metals with a wide range of thicknesses, and you can stick weld in just about any position that fits with your skill level.

Stick welding is great, but it isn't perfect. One main reason is that it's messy. Welding waste products, such as *slag* and *spatter,* get thrown around during a stick weld a lot more than they do when you're tig or mig welding. Because of that, you have to plan on spending some time cleaning up your welds and weld area after you're done stick welding. Another of stick's imperfections is its speed (or lack thereof). You have to be pretty good at stick welding to do it quickly (especially compared to, say, mig welding).

You can read all about the stick welding process in Chapters 5 and 6, but generally speaking, stick welding utilizes a consumable electrode with a solid metal rod in its core that melts down and forms part of the weld. Small globules of molten metal flow from the tip of the electrode through the electric arc to the molten weld pool. The electrodes have a coating of *flux* that protects the molten metal from impurities in the air that can contaminate the weld as it cools.

Mig welding

Mig welding is another arc welding technique. You may also hear mig welding referred to as *gas metal arc welding* (GMAW) or *wire welding.* Mig welding is becoming more and more popular, for several reasons. At the top of the list is the fact that most people find mig welding to be easier to pick up than stick and tig. Another big reason is the speed; done correctly, mig welding can be quite a bit faster than stick or tig welding thanks to its continuously fed wire electrode, which doesn't require changing nearly as often as the stick electrodes used in stick welding. You can just keep right on welding without having to stop and change your electrode. Over the course of a welding project, that can definitely save you quite a lot of time.

Proponents of mig welding also cite the low amount of slag and spatter that mig produces. That makes for a more pleasant welding experience, and a much more pleasant cleanup experience. The low chance of *distortion* (unwanted changes in a piece of metal's shape) is also trumpeted by those who love mig welding. Because the process is faster, you don't need to apply as much heat to the weld area for as long, so the metal is less likely to bend and twist in nasty ways.

Of course, mig welding also has its downsides. For starters, mig welding equipment is more complex than stick welding equipment, so it's quite a bit more expensive. The handheld part of the mig welding equipment (called the *mig gun*) is often big and bulky, so it's usually tough to mig weld in tight spaces. Mig welding also relies on the use of a shielding gas to keep atmospheric contaminants away from the weld area, so the process doesn't really work very well outdoors (especially with any kind of breeze).

I save the details of the mig welding process for Chapters 9 and 10, but generally speaking, here's how it works: A wire feeder continuously feeds the wire electrode to the weld area at a speed you control. That produces a steady molten stream that you can easily direct however you want on the surface of the metal you're welding. The weld is completely covered with a shielding gas (usually argon) to prevent impurities from fouling up the quality of the weld; you control the flow of the shielding gas to suit your project's needs.

Tig welding

The last type of arc welding is *tig welding,* which is sometimes called *gas tungsten arc welding* or GTAW. One major advantage to tig welding is that it's extremely clean. If you're tig welding correctly, you may very well go through an entire project without having to spend any substantial amount of time cleaning up. Tig is also extremely versatile. You can use tig welding to work on a lot of exotic metals that just aren't in play for, say, stick welding.

Tig welding has two big drawbacks. One is cost — you can definitely spend a pretty penny on tig welding equipment and supplies, even for start-up. The second drawback is lack of speed. You get a lot of precision out of tig welding, but you pay for it with time.

The tig welding process was originally developed in the 1940s to join aluminum and magnesium, but you can use tig welding to join all kinds of different metals. The big difference in tig welding is that it uses a non-consumable electrode that's almost always made of tungsten. It also requires the use of a water- or air-cooled torch, which holds the tungsten electrode and is connected to the welding machine by a power cable. Like stick welding (see the earlier section), tig uses an arc of electricity to heat metal to its melting point, and you manipulate the puddle to join metals together. The major difference is that tig welding uses a tungsten electrode. You can read more about tig welding in Chapters 7 and 8.

Other welding methods

There's more than one way to skin a cat, and there are more welding processes beyond the big three arc welding techniques (see the preceding sections). Here are a few to consider; check out Chapter 13 for more info.

- **Brazing** is unique among the welding processes because you can use it to join different materials (two different metals, for example). It uses gas rather than electricity, and the heat used in brazing surpasses 800 degrees Fahrenheit.

- **Soldering** is a form of welding that uses (relatively) low amounts of heat. You can solder at temperatures below 800 degrees Fahrenheit. (That's downright chilly when it comes to welding.) You can solder with gas or electricity, but the electricity you use in soldering isn't the same as the type of electricity you use in arc welding. Instead, soldering uses an electric soldering iron that heats up and melts the filler materials you're adding to the project you're working on.
- **Oxyfuel/oxyacetylene welding** is probably the most common gas welding process. You do it with a gas-powered flame that melts the base metal and any filler materials necessary to make the weld. The equipment used for this type of welding is the most portable and low cost in the welding world.

Looking at the Future of Welding

The need for skilled welders is huge right now, and it's only going to continue to grow. New metal alloys are being created and used for a wide range of purposes every day. The industries that rely on welding are expanding rapidly across the globe, and the need for metals to be joined in skillful ways isn't going anywhere in the near future. Welding is a versatile field that you can study in a number of different ways, from on-the-job training to education at a vocational or technical school. If you practice and develop your welding skills and work hard, you can more than likely make a career out of welding. And after you've been a welder for a while, you can very easily transition into a position as a foreman, inspector, or welding supervisor, just to name a handful of the possibilities.

But don't think that you need to make a career out of welding in order to enjoy and appreciate the process. You can weld to fix things around your house, yard, or farm. You can weld to create things that you use in your personal or professional life. You can weld to create works of art or gifts for friends and family. Or you can weld just because it's fun and rewarding (and there are few better reasons to weld than that).