LEARNING MADE EASY

2nd Edition

Welding

for dummies®

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Learn the newest welding techniques

Follow safety procedures

Complete simple DIY projects

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Certified Welding Educator and Inspector

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Welding For Dummies®, 2nd Edition

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Contents at a Glance

Table of Contents

Introduction

Welding has become one of the most important trades in the world, and that isn't likely to change anytime in the near future. So many of the objects people have and need are created either directly or indirectly by welding. If everyone woke up one morning and no one could remember how to join metals, the world would be a very different place by the afternoon.

But welding isn't just important — it's also fun. The idea of welding as a hobby is catching on more and more. It's an extremely versatile skill that can be quite rewarding after you get the hang of it. Something is very empowering about knowing that you can harness some pretty powerful forces — electricity and intense heat — to melt metals and join them together. Even experienced welders get a kick out of the fact that they can take a machine and a few pieces of metal and create something new, functional, and even beautiful. That's an extremely fulfilling feeling, and I think it's a product of welding that people don't always mention when they talk about the trade.

One quality of welding that people *do* talk about a lot is its usefulness. You can use welding skills to accomplish a lot, whether you want to eventually make a career out of welding or just have the ability to make and fix metal objects for your personal pursuits. Over the years I've taught and worked with both kinds of welders, and I know that after they really figured out the ins and outs of welding, they were able to do things that made their personal and professional lives a lot easier.

About This Book

Welding For Dummies helps you understand the basics of how welding works and lets you begin practicing several of the most prominent and useful welding techniques. I walk you through the fundamentals that hold true for all types of welding, and I dig into the details of specific welding processes — stick, mig, tig, and more — to show you how to practice those skills in a safe, productive way. Don't worry; I don't have you welding the Statue of Liberty's torch back onto her hand or anything, but I do hope this book puts you well on your way to achieving the welding goals you've set for yourself.

One of my favorite aspects of *Welding For Dummies* is that you can move around within it however you want and still end up with a huge amount of welding knowledge. You may initially be interested in one welding process but quickly discover you should be reading about a totally different process, and that's okay — you can jump to that other discussion without worrying that you've missed something important. Just beware of paper cuts from flipping back and forth between chapters.

Conventions Used in This Book

Here are a few conventions I use to make reading this book even easier:

- The world of welding is full of jargon, so I present new terminology in *italics* and make sure to give a definition nearby.
- **Bold** text highlights the action parts of numbered steps and also designates keywords in bulleted lists.
- I've tried to stick to welding standards supported by the American Welding Society (AWS), which is the largest and most prominent welding organization in the United States.
- All Web addresses appear in `monofont`. When this book was printed, some Web addresses may have needed to break across two lines of text. If that happened, rest assured that the address doesn't contain any extra characters (such as hyphens) to indicate the break. So when using one of these Web addresses, just type in exactly what you see in this book, pretending as though the line break doesn't exist.

What You're Not to Read

Far be it from me to tell you what you should read, but allow me to make one quick point. In several spots throughout this book, I include *sidebars* (gray shaded boxes) that contain interesting (and possibly entertaining, depending on what kind of mood you're in) information that you don't absolutely have to read in order to understand and practice welding. If the how-to, functional information in the book is the entrée, the sidebars are like garnish. Not parsley, though — I like to think that the sidebars are at least a little more interesting and useful than an herb that tastes funny and doesn't do much more than crowd a plate. You can also skip anything with a Technical Stuff icon; this information is more technically involved than the basics you need to weld.

Foolish Assumptions

I'm not really crazy about guesswork, but I did make a few assumptions about you as I wrote this book. (They're all nice, I promise.) If any of the following statements applies to you, this book is for you.

- You've never welded but want to know more about metals and how to join them by using welding.
- You've welded a little but really want to figure out how to improve and start taking advantage of all welding has to offer.
- You've done a fair amount of one type of welding but want to expand your skill set so you can weld with a variety of different processes and techniques.
- You understand a few basic tools (such as hammers and screwdrivers) and what they do.
- You know how important taking necessary safety precautions is to keep yourself (and others) out of harm's way.

How This Book Is Organized

This book is divided into six parts. Each part offers something different, but all of them are geared toward helping you figure out welding processes and put them to good use. Here's a quick look at what you can find in each part.

Part 1: Understanding Welding Basics

This part provides the kind of welding information that crosses all types of welding. If you're really just starting out in welding, this part is a good first stop for you because it gives you the lowdown on metals (especially the ones that are commonly used in welding), the tools and equipment you use for welding, and the kind of environment you need in order to weld successfully. It also includes the chapter that's without a doubt the most important one in the book. That's Chapter 3, and it's all about welding safety.

TIP

If you read only one chapter in the book, let it be Chapter 3. Welding is a fantastic skill, but it's not worth getting hurt over.

Part 2: Welding on a Budget: Stick and Tig Welding

Part 2 focuses on stick welding (the most commonly used welding process) and tig welding (also a great, useful technique). You can read all about the advantages and disadvantages of both stick and tig and understand how they work and what makes them unique. I explain the different equipment you need if you want to get into stick or tig welding, and I also give you plenty of information on how you can try out the techniques.

Part 3: Discovering Mig Welding

Mig welding is a fast, efficient welding process, and it's great for new welders because it's relatively easy to pick up and get started with. I devote Part 3 to the basics of understanding and executing mig welding.

Part 4: Getting Fancy: Plasma Cutting, Oxyfuel Cutting, and Other Processes

Arc welding isn't the only way you can weld — welding includes lots of other processes, such as soldering, brazing, and gas welding, that are all useful in their own distinct ways. I cover those processes in Part 4.

I also cover a few cutting processes in this part, because cutting is an important task in any welding shop, and you'll probably need to do some (or a lot) of it if you stick with welding for any extended period of time.

Part 5: Putting Welding into Action with Projects and Repairs

This part is probably the most fun because it gives you a chance to try out your welding skills and build some great, useful items. The chapters contain a welding project or two that are designed with the beginning welder in mind. You can read about how to build a portable welding table, a torch cart, a campfire grill, and more! This part also includes a chapter that helps you to figure out whether fixing something or buying (or building) it new makes more sense.

Part 6: The Part of Tens

If you've read a *For Dummies* book before, you already know all about this part. The Part of Tens is always a favorite; it features lists full of useful information in an extremely easy-to-read format. You can read about the advantages to becoming a certified welder, the tools that every welder wants, and more. There's also a glossary to help you with basic welding terminology.

Icons Used in This Book

Throughout the book, you'll occasionally notice little pictures in the margins. These icons help flag specific information I want to highlight; check out the following list for details on what those icons indicate.


TIP

When you see this icon, expect to find a helpful bit of information that will help save you time and money and keep you from making mistakes when you're welding.


REMEMBER

If I really want you to slow down and commit something to memory, I use this icon. It's important stuff, so take the time to read it!


WARNING

The last thing I want is for you to get hurt, or for you to hurt others or damage property. With that in mind, please pay attention to these icons so you can keep from hurting someone (yourself included) or damaging your equipment or surroundings.


TECHNICAL STUFF

This icon denotes technical or historical information that's more involved than what you need for your basic welding practice.

Where to Go from Here

I know what you're thinking: With all of this terrific, useful welding information, where do I begin?

I certainly don't want to tell you what aspect of welding you should want to read about first — that's for you to decide — but I do make one request. If you're new to welding, or if you aren't completely familiar with the practices of welding

safety, please go directly to Chapter 3 and read up on it. You really do need to know how to keep yourself safe as you start or continue your welding experience, and Chapter 3 goes a long way toward keeping you out of harm's way.

After you're done reading Chapter 3, please feel free to jump around in the book however you see fit. There's a whole world of welding out there, and *Welding For Dummies* is a great way for you to start exploring it.

1 Understanding Welding Basics

IN THIS PART . . .

Get familiar with metals — specifically, those you're likely to work with as a beginning welder.

Find out how to set up your welding shop (which may be trickier than you think).

Learn about important safety precautions you must take before trying any sort of welding operation.

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

Chapter 1

Diving Into the World of Welding

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.

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.


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?

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, whereas 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 5, 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 example) 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).


TIP

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.